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Middle and Upper Devonian Conodont Biostratigraphy of the Torquay area, South Devon.

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ABSTRACT

Localities and conodont faunas in the Torquay region are described, and the latter are assessed in terms of standard European Devonian conodont zonations, demonstrating that many of the divisions from the Middle Devonian *partitus* Zone to the Upper Devonian *Ag.* *triangularis* Zone are represented here. The stratigraphical history of the area (that is, that of the Torquay Limestone Group) is then discussed in the light of this information. The conodont associations show that deposition of the Daddyhole Limestone, the oldest member of the Group, began in the early Eifelian (lower *partitus* Zone) and continued into the early Givetian (upper *ensensis* Zone), but was interrupted by two deeper water, transgressive episodes in the *c*.*costatus* and low-mid *ensensis* Zones respectively; volcanic activity was associated with the first of these events. Accumulation of the massive, stromatoporoid, reefal limestones of the succeeding Walls Hill Formation began in the early Givetian (upper *ensensis* Zone) and, following a further deeper water and partly volcanic episode, a second cycle of reef development occurred in the mid Givetian Lower *varcus* Subzone. Both phases of reef growth produced some degree of facies differentiation. Regression of the reef began in mid-late Givetian times, and the massive, bioclastic Barton Limestone capped the subsiding reef, with localised concentrations of shells (Lummaton Shell Bed Member) developing in the basal parts of this formation around the Lower-Middle *varcus* subzonal boundary. Accumulation of the Barton Limestone continued from the Middle *varcus* Subzone to the mid Frasnian Lower *asymmetricus* Zone, when the environment deepened and brought about the transition to the Babbacombe Slates. Some area(s) may have formed local topographical highs from the mid Givetian to the mid-late Frasnian, undergoing dissolution towards the end of this interval, but these area(s) subsided in the late Frasnian *Ag.* *triangularis* Zone and deeper water conditions then prevailed throughout the Torquay district. The deep water ostracod-slate facies became established and continued into the late Famennian, when there was again volcanic activity.

Comparable limestone developments elsewhere in South-east Devon and in Plymouth are discussed, and previous work on the geology of the Torquay region, on Devonian conodont zonations and on Devonian conodonts in South-west England is reviewed. The Torquay conodonts are given a detailed systematic treatment, largely in terms of a form taxonomy. Some fifty-five taxa are identified in the faunas, representative of the ancyrodellids, icriodids, palmatolepids, polygnathids, schmidtognathids and spathognathodids: these are described and illustrated on twenty plates. Details of the individual localities and conodont faunas are to be found in the Appendix.

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CHAPTER 1.

INTRODUCTION AND TECHNIQUES

Introduction

The Torquay area is geologically complex, made especially so by the extent of structural dislocation suffered during the Variscan (Hercynian) orogeny, when the Devonian strata were subjected to a considerable amount of folding, faulting and thrusting. As a result, the overall pattern of Middle and Upper Devonian outcrop is now one of structurally isolated blocks, with Lower Devonian Meadfoot Beds and Staddon Grits developed in the core of the promontory. Correlation across the district is hampered by the tectonic complexity, there being generally little recognisable continuity of succession between the blocks, and is made difficult also by the built-up nature of the inland parts of the town, although coastal exposure is good. The purpose of this research was to contribute towards the elucidation of the complex geological history of the Torquay area, by establishing a conodont biostratigraphy for the Middle and Upper Devonian limestones and associated sediments.

Calcareous horizons more or less throughout the promontory were sampled for conodonts (calcareous lithologies being most responsive to the processing techniques), and the faunas so produced were assessed in terms of Middle and Upper Devonian conodont zonations established in mainland Europe, especially by reference to German zonal schemes. The Torquay conodont associations are representative of many of the divisions from the Middle Devonian partitus Zone to the Upper Devonian Ag. triangularis Zone, and show that the main period of limestone development here spans an interval from the early Eifelian to the mid Frasnian, with further calcareous horizons forming in the late Frasnian. They provide timings also for other events, such as deeper water, transgressive episodes, during the Middle and Upper Devonian.

In the following pages, previous work on the geology of the

Torquay district, on Devonian conodont zonations, and on Devonian conodonts in South-west England is reviewed, followed by a description of the Torquay localities and conodont faunas, and an assessment of their ages. The stratigraphical history of the area is outlined in the light of the conodont information and, in the concluding chapter, comparable limestone developments elsewhere in South-east Devon and in Plymouth are briefly discussed. The conodonts are given a fairly detailed systematic treatment, and representative specimens are illustrated on Plates 1-20. Details of the localities and conodont associations are to be found in the Appendix.

Abbreviations used throughout the text include: A. = Ancyrodella, Ag. = Ancyrognathus, E. = Eognathodus, I. = Icriodus, K. = Klapperina, O. = Ozarkodina, Pa. = Palmatolepis, Pand. = Pandorinellina, Pel. = Pelekysgnathus, Po. = Polygnathus, Sch. = Schmidtognathus, Sp. = Spathognathodus, T. = Tortodus.

Techniques

The conodonts were extracted by a standard method described by, for example, Hass (1962) and Collinson (1963). A known weight (usually 0.5 kg) of each collected sample of limestone or calcareous shale was thoroughly washed to minimise the possibility of contamination, and placed in a bucket to which 7 litres of 12 % acetic acid were added. Large limestone blocks were generally mechanically broken into smaller, walnut-sized pieces to facilitate the acid digestion process. When the calcareous matrix of the rock was digested (about 10 to 15 days), the contents of the bucket were passed through a 16 mesh (1000 microns) sieve, collected in a 150 mesh (100 microns) sieve, and thoroughly washed. The coarse material was examined and discarded, while the fine residue was dried and then separated in 1,1,2,2 tetrabromoethane, diluted with acetone to a density of 2.75 (calcite just floats). The heavy liquid and residue were poured, in turn, into a separating funnel, well mixed, and left for several hours to achieve as clean a separation as possible. The heavy fraction and any particles in suspension were then collected, thoroughly washed with acetone and dried; the light fraction was treated in a similar manner. The former portion, if large, was further concentrated by use of the electromagnetic separator, which removes the Fe-dolomite, but no method was found for removing pyrite, which was abundant in some samples. The heavy material was picked under a binocular microscope and all conodonts, whether complete or incomplete, were extracted, together with any other microfauna such as ostracods, foraminifera, fish teeth and tentaculitids. It was sometimes subsequently possible to match-up broken conodont fragments. The light fraction was also briefly examined, and occasionally yielded additional microfaunal elements.

Conodonts were photographed on the S.E.M. (Cambridge S600). Specimens selected for photography were mounted on a 12.5 mm diameter aluminium stub using a mounting-medium of Kodaflat and acetone (mixed 1:1), and then sputter-coated with gold for good conductivity. It was found that the most satisfactory, smoothest background was achieved if the stub was first given a high degree of polish. Conodonts were arranged around the perimeter of the stub in an antero-postero, "nose-to-tail" manner, ensuring that none impeded the view of any other, and in such a way that all oral views could be systematically taken with the stub at minimum tilt, followed by all lateral views, if required, at maximum tilt. Specimens were remounted if the aboral view was needed. An S.E.M. setting of 7.5 kv was used for the majority of photographs, which were taken on standard film.

In total, about 300 kg of calcareous sediments, predominantly limestones, were processed for conodonts, represented in 243 samples. Of these, 90 were barren, while the majority (111 samples) yielded between 1 and 20 conodonts/kg. The remaining 42 samples produced larger faunas, the maximum yield being 142 conodonts/kg. Generally, the most productive lithologies were medium grey or grey-red, bioclastic and crinoidal limestones, while shaly, crinoidal lithologies were also sometimes fairly productive. In the Upper Devonian, as developed in the Petit Tor area, red slaty limestones, calcareous mudstones and nodular limestones occasionally yielded moderately large faunas. Pale grey, fine grained, sometimes flinty limestones and, especially in the Eifelian, dark, fine grained limestones tended to be barren of conodonts.

CHAPTER 2.

HISTORY OF PREVIOUS RESEARCH ON THE GEOLOGY OF THE TORQUAY AREA

Before 1950

The first detailed account of the area was written by De la Beche (1829), who studied the geology of the Tor and Babbacombe Bays. He recognised that the limestones were bedded and fossiliferous, and noted that "the most abundant organic remains are encrinites and corals". However, on palaeontological evidence he assigned the limestones to a Carboniferous age (De la Beche 1829, p.163; 1839, p.146).

A more extensive examination of the geology of South-east Devon was undertaken by Austen (1842), which was considered by Lloyd (1933, p.12) to be the foundation of all subsequent work in the area. Austen divided the strata "subjacent to the carbonaceous deposits" into five, the highest division being the coral limestones of the Newton, Barton and Torquay regions. He listed fossils found in Newton [Newton Abbot] Quarry and, having noted their similarity to faunas from Barton and Babbacombe, concluded that the localities were contemporaneous.

At this time one of the most important events in the elucidation of the geology of South-west England occurred. This was the recognition and establishment of the Devonian System by Sedgwick and Murchison in 1839, which resulted in the rocks of the Torquay area being placed in their correct stratigraphical position. Sedgwick and Murchison (1840, p.649-662) described the geological succession of South Devon and proposed a five-fold division of the strata. The limestones of Tor Bay, Babbacombe Bay and Plymouth were placed in the upper limestone unit of their second oldest division. Successions to the north of Dartmoor were also described and compared with those to the south, and the authors realised that certain of their divisions could be recognised in both areas. These observations led the writers to state that they believed the successions of North and South Devon to belong to one formation, and thus the name Devonian was constituted for the pre-Carboniferous rocks of these areas, the new system being distinct from the Cambrian, Silurian and Carboniferous systems (Sedgwick and Murchison 1840, p.689, 701-702).

In the first part of this important work, Sedgwick and Murchison (1840, p.656) wrote of the limestones of the Torquay area and noted the abundance of corals therein, and the presence of spiriferids, terebratulids and of "other shells, bivalve and univalve". In their illustrations the authors included some specimens from Torquay, but many more from Plymouth. Published with this paper was an article by Lonsdale on the subject of the age of the South Devon limestones. The work of this author is particularly important to the establishment of the Devonian System, for it was he who first realised that these strata were, on fossil evidence, "of an intermediate age between the carboniferous and Silurian systems, and consequently of an age of the old red sandstone" (Lonsdale 1840, p.727). This fact he communicated to Sedgwick and Murchison and, as they acknowledged (Sedgwick and Murchison 1840, p.690), Lonsdale thus provided a connecting link between the Silurian and Carboniferous faunas. Lonsdale's paper included a review of earlier opinions on the age of the South Devon limestones, and he also listed fossils from the region and indicated the age-ranges of the various species. The catalogue incorporated material collected by Austen, Sowerby and Phillips, and a few specimens were from Torquay localities.

One year after this brief but important palaeontological account by Lonsdale, the first extensive study of the Palaeozoic fossils of South-west England was published by Phillips (1841). He included descriptions and illustrations of fossils collected both by himself and by other workers, including Austen. Phillips (1841, p.142-153) gave a synopsis of the various species and their geographical distributions, and compared the Devonian faunas of South-west England with those of the Silurian and Carboniferous in Britain, and with their European equivalents. Many of the specimens mentioned were collected from within the Torquay promontory and the localities briefly described. The limestones of Torquay were included in Phillips' "Plymouth Group", one of his four divisions of the southern district of South-west England.

The theme of British palaeontology received considerable attention during the second half of the nineteenth century, with the publication of several Monographs in which Devonian faunas were well represented. Torquay, Plymouth and Newton Bushel [Newton Abbot] were the main localities for British Devonian corals studied by Edwards and Haime (1853). Two Middle Devonian stromatoporoids from Lummaton Quarry were illustrated in an examination of this group by Nicholson (1886-1892, pls.14, 20), and Torquay localities were mentioned in the fossil descriptions in a study of trilobites from the British Cambrian, Silurian and Devonian by Salter (1864-1865), but the author figured only one specimen from the area, from the Lower Devonian of Meadsfoot [sic].

The Torquay promontory provided many Devonian brachiopods for an extensive Monograph on this subject by Davidson (1864-1865). Whidborne, in the Supplement to this work (Davidson 1882-1884, p.5-8), listed those specimens which were from Lummaton and Hope's Nose, and gave details of the successions at the two localities.

Of particular importance to the study and recognition of the palaeontology of this region remains the Monograph by Whidborne (1888-1907) on the Devonian faunas of South-west England, in which volumes one and two were concerned exclusively with Lummaton, Wolborough, Chercombe Bridge and Chudleigh. The fossils from these localities, collected so assiduously by Whidborne, were described and beautifully illustrated. Lummaton and Wolborough were the source of almost all the Middle Devonian examples, which localities were recognised as being "almost exactly upon the same horizon" (Whidborne op.cit., p.ii), and it is surely because of this author's work that the faunas of these two places have become so well known, no other palaeontological record of the area either before or since having been so extensive and thorough.

The study of aspects of the geology of South Devon led to a controversy which was not satisfactorily resolved for fifty years. The problem concerned the age of the limestones of Torquay and Plymouth relative to, respectively, the Cockington and Staddon Grits. De la Beche (1829, p.164-165, 167) had observed that the limestones of the Torquay area graded down, through interstratified shales, into an underlying "considerable thickness of argillaceous shale". This relationship was apparent south of Meadfoot Sands where the author thought the compact red sandstone, seen below the argillaceous shale, to be equivalent to a similar lithology in the Cockington area, the Cockington Grits. Similarly, Austen (1842, p.462-463, 468) has correctly recognised the superposition of the Torquay limestones above arenaceous and slaty horizons, but he did not define their relationship.

However, further examination of the slates seen to the north and south of the limestones, particularly in the Plymouth area, caused De la Beche to modify his views some ten years later. In the Geological Survey report on South-west England (De la Beche 1839), the author thought there to be a normal, southward younging sequence to the south of Dartmoor, in which the limestones were overlain by slates followed by red sandstones and slates: the latter were contorted but traceable along the strike to Staddon Point. De la Beche was unsure of the relationship between the red sandstones of Cockington and the limestones of Torquay, but since he recognised the contemporaneity of the limestones of Torquay and Plymouth, and of the grits of Cockington and Staddon (De la Beche 1839, p.76, 78 respectively), one may surely infer the superposition of the Cockington Grits above the Torquay limestones, which is erroneous and contrary to De la Beche's correct opinion of 1829. Sedgwick and Murchison (1840, p.652) had considered their upper limestone group to be "fairly interpolated between two great groups of slate rock", and believed the whole succession in South Devon to young southward.

A further attempt at a classification of the stratigraphy of South Devon was made by Holl, in which the possibility of an inverted anticlinal structure in the Plymouth area, an idea proposed by Jukes-Browne, was discussed (Holl 1868, p.443-444). Holl favoured a succession similar to that put forward by Sedgwick and Murchison. He presented a geological map which showed an anticline in the Torquay area, in which the Cockington Grits were separated by limestones from the Lower Devonian strata in the core of the promontory. The last were placed in his Lower South Devon Group, while the Cockington Grits, and also the Staddon Grits, were in his Upper South Devon Group.

The correct succession was eventually described nine years later by Woodward (1877) as, in ascending order, Cockington red sandstone, slate and limestone. This was, as the writer acknowledged, the sequence recognised some fifty years before by De la Beche (1829).

Despite the solution to the problem of the age of the Cockington Grits, difficulties ensued. Champernowne (1878) accepted the succession proposed by Woodward, and believed the arenaceous rocks of Cockington, and of the Warberry and Lincombe Hills in Torquay, to be beneath the limestone. Unfortunately, he was dissuaded from this opinion by Ussher (1884) who, because of independent work in the Plymouth area, assigned the Cockington Grits to the Upper Devonian. It was not until 1890 that the age of these beds was irrefutably established. In that year Whidborne's hitherto unrealised discovery of Lower Devonian fossils from the Cockington Grits became known, through Ussher (1890, p.489, 497-499, text-fig.1), and they were then firmly and correctly placed in the Lower Devonian. Whidborne's findings, from Saltern railway cutting, had been recorded in Davidson (1882-1884, p.4-5).

The last quarter of the nineteenth century saw much detailed geological work in the Torquay area, a lot of it by Champernowne. This author was responsible for several palaeontological records (e.g. Champernowne 1874, 1884). In the former work he noted the presence of Calceola sandalina at the base of the limestone in Daddyhole Cove, and considered the sequence there to be inverted, the coral being found always upside down. Champernowne examined other aspects of the geology of Torquay and of the surrounding area. His study of the Ashburton Limestone is of note for placing these beds in their correct stratigraphical position, equivalent to the limestones of Ogwell, Ipplepen and Dartington (Champernowne 1881, p.410). Previous authors had placed the Ashburton strata at too low a level, beneath the limestones of Torquay and Plymouth, and with slates between the two calcareous units (e.g. Austen 1842, p.462; Sedgwick and Murchison 1840, p.662; Holl 1868, p.426-427).

Champernowne left his field maps to the Geological Survey and they became the foundation of the subsequent work by Ussher who, after Champernowne's death, took over the task of elucidating the complex geological history of the Torquay area. An extensive discussion of the geology of South-west England was provided by Ussher (1890), in which he reviewed the problems that had beset himself and Champernowne in their attempts to establish the age of the Cockington Grits. Ussher discussed the successions of South-east Devon, including those of the Torquay region, and gave broad lithological descriptions of the Lower, Middle and Upper Devonian strata. He considered that the Lower-Middle boundary could be defined palaeontologically, but that the Middle-Upper boundary could not (Ussher 1890, p.492, 507), and listed fossils from localities in the area. Much of this palaeontological material had been found in 1888, in which year Ussher had shown the geology of North and South Devon to several important European workers. This field trip had led one of the participants, Kayser, to write of their findings, and to assign the thin bedded limestones of Hope's Nose to the German Calceolen-Kalk (Kayser 1889).

The work of Ussher culminated in the Geological Survey Memoir of the Torquay area (Ussher 1903). The Newton Abbot Memoir was also his work, in which he presented faunal lists and lithological descriptions of Barton and Lummaton Quarries, and indicated those species which were common both to these localities and also to Wolborough Quarry (Ussher 1913, p.21-27).

During the early part of the twentieth century many geological investigations were undertaken by Jukes-Browne. In 1906 he described the stratigraphy of the area around Lummaton Quarry in some detail and listed the fauna from this locality, and in 1913 he compared a dark grey limestone facies, recorded in the Torquay promontory, with equivalents around Dartington. His other studies include physiographical discources (Jukes-Browne 1907, 1912, 1914) and again in 1914, this time with Newton, he described Middle Devonian fossils found on the site of the Torquay Museum. This fauna had previously been thought by Whidborne (1901) to be of Lower Devonian age.

In the 1920's diverse aspects of the geology of the Torquay area were discussed by Shannon, including palaeontology and igneous petrology (Shannon 1921, 1924 respectively). In 1928, in "a generalised survey of recent geological work on the sedimentary and igneous rocks of S.E.Devon", the Torquay area received particular attention from this author. He described the stratigraphy within the promontory and presented detailed large scale maps of several localities, including Redgate Beach, Long Quarry Point and Hope's Nose. Also included were discussions of the igneous rocks and the geological structures, accompanied by a tectonic map of the Torquay district with sections which showed tectonic features. Shannon attempted a zonation of the successions, in which he divided the sediments on lithological grounds and on the nature and quantity of insoluble mineral residues within them, rather than on palaeontological evidence. He did indicate (Shannon 1928, p.113), however, tentative palaeontological features by which different horizons might be distinguished. This work is interesting because it was the first attempt to establish a detailed stratigraphy in the Torquay area, but Shannon's criteria were only loosely defined, and the difference between amounts of mineral residues were not great.

The final work to be published before the hiatus of World War Two was the second edition of the Memoir of the Torquay area by Lloyd (1933). This was an expansion and revision of Ussher's fundamentally correct earlier appraisal of the geology of this region. Lloyd expanded, particularly, the section on the Middle Devonian strata, and designated the lower parts of the succession Couvinian and the upper parts Givetian. In a chapter entitled "Middle-Upper Devonian" he stated that, at certain localities, the "Givetian" levels might embrace also massive limestones of Frasnian age, and that the boundary between the two was largely indefinable. This work includes a useful bibliography, an extended version of the one given by Ussher (1903), and Shannon contributed a chapter on the igneous rocks of the region.

After 1950

After the publication of the revised Memoir in 1933, little was written about the geology of the Torquay area for almost thirty years. Subsequently many authors have studied various aspects of this subject, working towards an understanding of the geology in both its local and regional context.

Elliott (1961) described a new alga from the Lummaton Shell Bed. This work also included an elegant study of both the fauna, largely of brachiopods, and the matrix of the Shell Bed, which enabled the author to confirm earlier opinions as to its current-accumulated mode of formation. Elliott further interpreted the age of the Shell Bed by an assessment of the brachiopod evidence, and provided a thorough review of previous research on the locality.

The Lummaton Shell Bed featured in other palaeontological studies of the area. In a discussion of the Devonian ammonoid successions of South-east Devon and North Cornwall House (1963) wrote about both this, and other, Torquay localities. He described and assessed the goniatite faunas in terms of the standard ammonoid zones of the European Devonian, and showed that all the classical German ammonoid Stufen had equivalents in South-west England. The facies changes within the goniatite sequences were also examined. In particular, the author noted an important facies change between the Middle Devonian limestones of the Torquay area and, to the west, the synchronous developments of the Padstow area of North Cornwall, in which slates were dominant and limestones were just a minor lithology. House observed also a major facies change within the Upper Devonian of South-west England. A condensed sequence of nodular limestones and slates with nodules was described inland at Chudleigh, whereas in the Torquay region ostracod-bearing slates were developed. Both extended in age from the end of the Frasnian into the Upper Famennian, and were considered to represent, respectively, the schwellen and becken facies recognised in the German Rhenish Slate Mountains.

One year later, the same author (House 1964) described a goniatite fauna from Babbacombe Cliff in Torquay, and discussed the consequent implication of a structural inversion. Selwood (1966) referred to trilobites from Lummaton Quarry in a revision of certain forms from the British Devonian, and the coral faunas, mainly the Rugosa, of Torquay and elsewhere in South-east Devon have been amply dealt with by Scrutton (1965, 1967, 1968, 1975, 1977a). The palaeontology of the Torquay area, together with related published work, was reviewed and summarised by House (in House and Selwood 1964).

The geological structures of Torquay have been placed in a regional setting in several accounts of the structures of South-west England. Dearman (1963) discussed wrench-faults of Tertiary age in South Devon and Cornwall, and illustrated the effects of removing from the south-west peninsula the movement which had resulted. He calculated that a total dextral displacement of twenty one miles had occurred. The extensive faulting of the Middle Devonian exposures between Brixham and Torquay was considered by Dearman to belong to the overall wrench-fault pattern, in which the faults trended mainly north-north-west. The Sticklepath-Lustleigh Fault was thought to be one such dextral wrench-fault. The last named disturbance was examined by Blyth (1957), who recognised that the Lustleigh Fault was, in fact, an extension to the south-east of the more northerly Sticklepath Fault. Both crossed the Dartmoor granite and caused comparable displacements of the southern and northern margins respectively. Blyth observed that, if the line of the Lustleigh Fault were prolonged further to the south-east, it would meet the coast near Torquay, and noted that Austen (1842, p.488) had ascribed disturbances of the Permian outcrop near Tor Abbey Sands to a north-west trending displacement. The structures of the Variscan fold-belt of South-west England were the subject of a paper by Sanderson and Dearman (1973), who recognised twelve tectonic zones in the region. Torquay was at the eastern extremity of their Zone seven, which was characterised by north-north-west facing recumbent folds.

The structural geology of Torquay has received attention in a rather more local context. For example, Vachell (1963) presented a brief explanation of the tectonic history of the area. He believed there to be insufficient evidence for folds large enough to have caused the apparent field relationships of the Lower and Middle Devonian strata in and around Torquay, and suggested the idea of the Marldon-Beacon nappe: this was envisaged as a major overthrust of Lower Devonian rocks, which had travelled a considerable distance north over a Middle Devonian basement. Tectonic and volcanic aspects of the geological history of the Torquay district were discussed by Richter (1965), who examined also structural and metamorphic aspects in 1969, although observations in the later and more extensive account were confined largely to the west and south of the region, around Berry Pomeroy, Goodrington, Dartmouth and Brixham. Scrutton (1978b) analysed the structure and stratigraphy of Babbacombe Cliff, previously discussed by House (1964). Scrutton interpreted the structure in the cliff as a recumbent anticline-syncline couple which faced east-north-east to north-east, and was thus consistent with the overall structural trend in the Torquay promontory.

Recently, Shackleton et al. (1982) referred to the Torquay area in an examination and interpretation of Variscan structures throughout South-west England. They thought that the Lower Devonian rocks shown on high ground on Geological Survey maps of Torquay (Lloyd 1933) occupied a large open synform, which was believed to be a second structure because it folded cleavage as well as bedding, and proposed that the Lower Devonian strata formed a klippe. Mention was made of recumbent folds and thrusts in the promontory, as described at Babbacombe Cliff by Scrutton (1978b), and also of thrusts and related folds with axial plane cleavage well exposed at Hope's Nose. With regard to the overall structural development of South-east Devon, they took the view that the simplest picture involved just one major thrust in the Torquay-Dartmouth region together with several small imbricate faults, the underlying folds and thrusts in Torquay probably post-dating the major thrust.

Discussions of the facies and environments of the Torquay area have been incorporated into several studies. Dineley (1961) presented a review of the Devonian System of Devon and proposed a possible reconstruction of the depositional environment of the Middle Devonian carbonate complex of Tor Bay, in which ecological and sedimentological features of the limestones were represented. He envisaged a reef environment, now indicated by stromatoporoid limestones, in which occasional pockets of shells developed. Massive limestones formed behind the reef, where subsidence was negligible or slow, while to the fore were thinner bedded marginal limestones which became progressively more argillaceous as they went deeper into a more rapidly subsiding trough, in which shales eventually became dominant.

Braithwaite (1967) made an analysis of Middle Devonian carbonate environments in South Devon. He stated that the limestones "may have occupied a discrete marginal shelf or bank" but, in contrast with the model proposed by Dineley, thought that structures comparable with modern reefs never developed (Braithwaite 1967, p.318). He had previously examined the petrology of Middle Devonian limestones in the same region (Braithwaite 1966). Localities in the Torquay area featured in both studies, and the later work included some useful observations, although they were not placed in a stratigraphical framework.

More recently, Scrutton (1977a, 1977b) reconstructed, and discussed variations within, facies in South-east Devon. In the latter paper he proposed lithostratigraphical subdivisions of the Torquay strata, described the limestone successions both there and in the Lemon Valley near Newton Abbot, and assessed the faunal evidence, particularly that of the corals, for age determinations within these sequences. The concept of the Tor Bay Reef-Complex, comparable with Devonian reef-complexes known elsewhere in the world, was put forward to explain facies changes which he noted going inland from the Torquay promontory. In this carbonate development, Scrutton (1977b, p.183-187) envisaged the growth of barrier-reefs along parts of the platform margin during Givetian times, now represented in Torquay by massive coral-stromatoporoid limestones, while a restricted environment existed behind and to the north-west, which produced the characteristic back-reef facies successions of the Newton Abbot area. The fore-reef facies was not observed, but was expected to be present on the sea-floor of Tor Bay. This environmental reconstruction was an expansion of the earlier model of facies relationships illustrated by Scrutton (1975, text-fig. 4), in which dark, bedded limestones with a typical back-reef fauna were shown developed behind, and to the north-north-west of, stromatoporoid banks, while bioclastic limestones were deposited to the east and south in a deepening environment.

The lithostratigraphical sequence established by Scrutton (1977b) in the Torquay area is important, and the various units are described and discussed elsewhere. He called the whole succession the Torquay Limestone Group and the members are, in ascending order, the Daddyhole Limestone, the Walls Hill Limestone and the Barton Limestone.

The Tor Bay Reef-Complex featured also in a field guide to the eastern part of South Devon by Scrutton (1978a, p.27-49). In this he described the lithologies and faunas of localities in the Torquay promontory, in the southern part of Tor Bay, and further inland, around Newton Abbot. The first two areas illustrated his marginal reef facies, the third his platform interior facies. Further remarks on the nature of the reef, with particular reference to its development in the succession at Long Quarry Point and to the variation in stromatoporoid morphotypes therein, were recently made by Kershaw and Riding (1980).

CHAPTER 3.

DEVONIAN CONODONT ZONATIONS

Introduction

The European Middle Devonian is divided into the Eifelian and Givetian stages, while the lower part of the Upper Devonian is most commonly denoted by the name Frasnian, although the names Adorfian and, in North America, Senecan have also been used in a similar sense. In terms of the standard German ammonoid chronology, the Eifelian corresponds to the Anarcestes Stufe (but see House 1979, p.267, 269), and the Givetian and Frasnian are very approximately equivalent to the Maenioceras and Manticoceras Stufen respectively. The Belgian Couvinian roughly parallels the Eifelian, but at its base includes the highest part of the Emsian of German usage. Important discussions of subdivisions and boundaries within the Devonian were presented by House (1979) and Ziegler (1979).

Attempts at establishing a conodont zonation of the Devonian were initiated in North America, where Huddle (1934) and Hass (1947) examined black shale successions which included, in part, the Upper Devonian, but Europe was the first major scene for the application of conodonts as biostratigraphical tools. Such studies began in Germany in the early 1950's, and have since continued both there and elsewhere in Europe, and also on a world-wide basis. Particularly of note among the early German workers were Bischoff, Wittekindt and Ziegler (see full list in Ziegler 1971, p.229). Although many of the divisions of the Middle Devonian zonations erected by Bischoff and Ziegler (1957) and by Wittekindt (1965) have now been supplanted, they were important because of their general applicability throughout Europe, and because they provided a framework against which zonal schemes proposed for other areas could be compared. The Upper Devonian zonation established by Ziegler (1962b) was especially significant because, for the most part, it has been shown to be, and remains, of mondial use.

Various authors have reviewed the state of knowledge concerning Devonian conodont zonations (for example: Klapper et al. 1971; Orchard 1975a, p.11-47; Klapper and Ziegler 1979), and the following discussion is confined largely to an account of the more recent developments. Relationships between European zonal schemes in past and present usage are indicated on Text-fig. 1, as are possible levels for the various boundaries within the Devonian.

Lower part of Middle Devonian

(i). partitus to kockelianus Zones

Work in the type Eifelian area in Germany led Weddige (1977, p.336-346) to propose a new zonal scheme for the lower part of the Middle Devonian. This superseded the earlier zonation established by Wittekindt (1965) east of the Rhine, defects in which were outlined by Klapper (in Klapper and Ziegler 1979, p.206). In ascending order, Weddige's divisions of the Eifelian were the patulus (partim), c. costatus, kockelianus and ensensis (partim) Zones. With regard to correlations between the zonation in the Eifelian Hills and the area east of the Rhine, he placed the top of the Ballersbacher limestone

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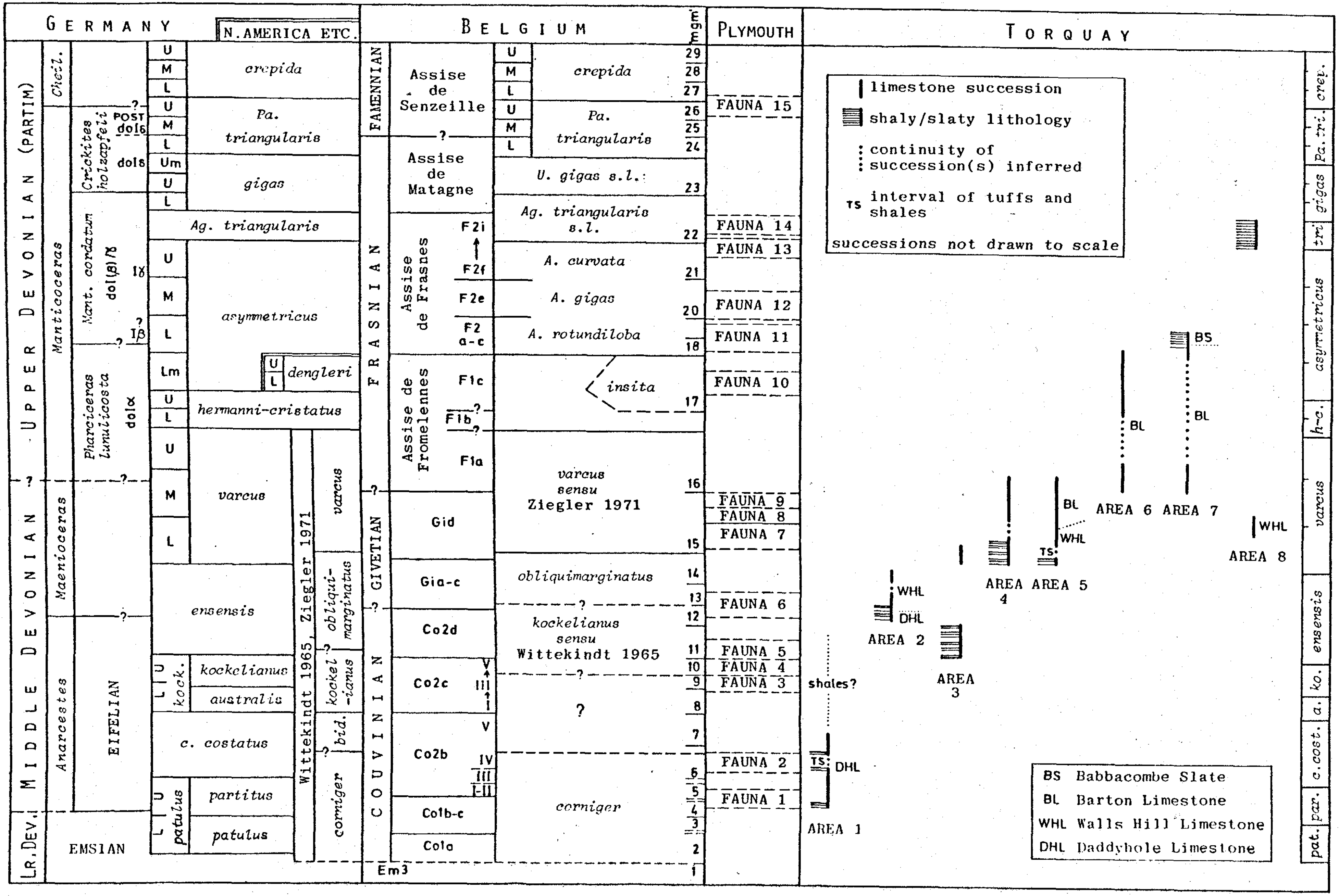
Text-fig. 1. Chart to show correlation of Middle and Upper (partim) Devonian conodont zonations and successions in Germany and Belgium, and possible levels for boundaries within the Devonian. The two right-hand columns indicate ages both of successions from the Torquay area, and of Faunas 1-15 from Plymouth described by Orchard (1978), in terms of the European zonal schemes. European correlations, divisions and boundaries are based mainly on Wittekindt 1965, Bultynck 1970, 1972, 1975, Ziegler 1971, 1979, Mouravieff and Bouckaert 1973, Bouckaert and Streel 1974, House and Ziegler 1977, Weddige 1977, Orchard 1978, Weddige et al. 1979. The position of the dengleri Zone, as recognised in, for example, North America, is based on Klapper and Johnson 1980. Abbreviations used are as in the main text, with the addition of bid. = bidentatus.


GERMANY
N. AMERICA ETC.
BELGIUM
Em
PLYMOUTH
TORQUAY
UPPER DEVONIAN (PARTIM)
MIDDLE DEVONIAN
LR. DEV.
Cheil.
Manticoceras
Maenioceras
Anarcestes
Crickites holzapfeli
POST dolδ
dolδ
Mant. cordatum dol(β)/γ
Iγ
Iβ
Pharciceras lunulicosta
dolα
EIFELIAN
EMSIAN
U
M
L
Um
Lm
crepida
Pa. triangularis
gigas
Ag. triangularis
asymmetricus
dengleri
hermanni-cristatus
varcus
ensensis
kock.
kockelianus
australis
c. costatus
patulus
partitus
Wittekindt 1965, Ziegler 1971
obliqui-marginatus
kockel-ianus
bid.
corniger
FAMENNIAN
FRASNIAN
GIVETIAN
COUVINIAN
Assise de Senzeille
Assise de Matagne
Assise de Frasnes
Assise de Fromelennes
F2i
F2f
F2e
F2 a-c
F1c
F1b
F1a
Gid
Gia-c
Co2d
Co2c
Co2b
Co1b-c
Co1a
Em3
V
III
IV
I-II
U. gigas s.l.
Ag. triangularis s.l.
A. curvata
A. gigas
A. rotundiloba
insita
varcus sensu Ziegler 1971
obliquimarginatus
kockelianus sensu Wittekindt 1965
?
corniger
29
28
27
26
25
24
23
22
21
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18
17
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15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
FAUNA 15
FAUNA 14
FAUNA 13
FAUNA 12
FAUNA 11
FAUNA 10
FAUNA 9
FAUNA 8
FAUNA 7
FAUNA 6
FAUNA 5
FAUNA 4
FAUNA 3
FAUNA 2
FAUNA 1
limestone succession
shaly/slaty lithology
continuity of succession(s) inferred
TS interval of tuffs and shales
successions not drawn to scale
BS
BL
WHL
DHL
TS
shales?
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
BS Babbacombe Slate
BL Barton Limestone
WHL Walls Hill Limestone
DHL Daddyhole Limestone
crep.
Pa. tri.
gigas
tri.
asymmetricus
h-c.
varcus
ensensis
ko.
a.
c. cost.
par.
pat.

Text-fig. 1.

(*sensu stricto*) at the boundary between his lower and upper portions of the *patulus* Zone, while the Gunteröder limestone straddled the *patulus*-*c*. *costatus* zonal boundary, and the Zwischenschichten roughly corresponded to the *kockelianus* Zone (Weddige 1977, p.337, 340, 342, 351-354, table 4). Goniatites associated with these various horizons have been listed by, for example, Wittekindt (1965, p.622-623) and Weddige (1977, p.337, 340, 342). The entire *patulus* Zone has now been divided into the *patulus* (restricted) and *partitus* Zones in the Barrandian area of Czechoslovakia and in the Eifelian Hills, because of the appearance there of *Po*. *c*. *partitus* in the upper part of the interval (Klapper *et al*. 1978; Weddige *et al*. 1979), and the *kockelianus* Zone is also now divided, into the *australis* and *kockelianus* (restricted) Zones (see Klapper 1977, p.45, 47, text-figs. 2, 6). The lower limits of the *patulus* (restricted), *partitus*, *c*. *costatus* and *kockelianus* (restricted) Zones are all defined by the entries of the respective eponymous taxa.

With regard to the delimitation of the Lower-Middle Devonian boundary, Klapper *et al*. (1978, p.107-108) indicated that the three main European contenders for this level were the lower boundary of the Couvinian (Belgium), the Heisdorf-Lauch boundary (Germany), and the lower Choteč boundary (Barrandian), which closely corresponded to the lower boundaries of the *patulus* (restricted), *partitus* and *c*. *costatus* Zones respectively. Work in the Barrandian (Klapper and Ziegler 1977; Klapper *et al*. 1978), in the Eifel and Ardennes areas (Weddige *et al*. 1979), and in the Aragón and Cantabrian regions of Spain (Carls 1979; García-Alcalde *et al*. 1979) resulted in the lower boundary of the *partitus* Zone being chosen as the series boundary of the Lower-Middle Devonian, and in the Wetteldorf Richtschnitt being recommended as the boundary stratotype (Ziegler *et al*. 1980). As thus placed, the boundary lies a little below the Heisdorf-Lauch junction, which is the historical lower limit of the Eifelian. Weddige *et al*. (1979) attempted to correlate the Heisdorf-Lauch boundary with the type Couvinian area in Belgium and showed that, on conodont evidence, it corresponded to the interval between the 17 and 19 horizons in the Eau Noire Formation (Co1b-c) in the Eau Noire section at Couvin, and to a level near the 179m point in the same formation at St. Joseph, which placements were supported by the occurrences of other fossil groups. The Lower-Middle Devonian boundary presumably falls slightly below these positions.

In addition to their identification in Europe, the *patulus* (unrestricted), *c. costatus*, *australis* and *kockelianus* Zones and their equivalents have been variously recognised in North America (for example: New York, Nevada), Alaska, Australia and southern Morocco (Klapper in Klapper and Ziegler 1979, p.206-207, text-figs. 3,4; Klapper and Johnson 1980, p.444-445, tables 7,8; Klapper 1981, p.59-60, text-fig. 1), and also in Malaysia (Lane *et al*. 1979, p.216-217, text-fig. 2). With reference to the recognition of the subdivisions of the *patulus* Zone (unrestricted) outside Europe, *Po. c. partitus* is known in succession below the first appearance of *Po. c. costatus* in east-central Alaska and in Malaysia (Lane and Ormiston 1979, p.45, table 2c; Lane *et al*. 1979, p. 214-216 respectively), but because *Po. c. patulus* has not yet been found below *Po. c. partitus* in these regions the base of the *partitus* Zone cannot be identified with certainty.

Sequences of informal faunal units have been implemented for lower Middle Devonian and older strata in parts of the North American continent and elsewhere in the world, where European early Middle Devonian conodont zones do not work well (see Klapper 1977, p.34, 36 for discussion of the rationale behind this approach). For example, Klapper (1971) proposed four faunal units for correlations within the lower Middle Devonian of New York. The European conodont zonation then in use was not applicable to the state, but it should be noted that the *patulus* (unrestricted), *c. costatus*, *kockelianus* and possibly also the *australis* divisions of the current zonal scheme have been recognised there (Klapper 1981, p.59-60, text-fig. 1). Klapper (in Perry *et al*. 1974, p.1065, text-fig. 4) further demonstrated that the Eifelian strata of the Ogilvie Mountains in the Yukon could be divided into a (lower) *c. costatus* Faunal Unit and an (upper) *pseudofoliatus* Faunal Unit. Chatterton (1979, p.168-169) subsequently identified the latter subdivision in the North-west Territories (District of Mackenzie) in Canada, just in the uppermost beds of the Nahinni and Hume Formations, and indicated that the former subdivision was represented by the brief appearance of *Po. c. costatus* in a limestone unit beneath the Funeral Formation (S25), and possibly also in the base of the same formation at Whittaker Anticline (S18), He described the informal *pedderi* and *curtigladius* Faunal Units, which both occurred in the Headless Formation where they overlapped in their upper and lower parts respectively, and showed the two divisions to be roughly equivalent to an interval which extended from a little above the base to the top of the *c. costatus* Faunal Unit, and questionably into the lower part of the *pseudofoliatus* Faunal Unit (Chatterton 1979, p.168-169, 180-181, text-fig. 3, tables 9-11). Uyeno (1979, p.236, 238, text-fig. 2, table 1) reported similar faunal units from the Powell Creek area in the Mackenkie District, where he found the *Pelekysgnathus pedderi*-*Polygnathus parawebbi* (early form) and *Parapolygnathus angusticostatus*-*Polygnathus curtigladius* Faunal Units in the middle and upper parts of the Hume Formation respectively. Although correlation between the Middle Devonian successions of the North-west Territories and the standard conodont zonations was made difficult by the pronounced faunal differences, Klapper (in Klapper and Ziegler 1979, p.207, text-fig. 4) indicated that the *pedderi* Faunal Unit might equate with the *australis* Zone as developed in Nevada, on the basis of the lowest occurrence of *Po. parawebbi* in the former division, and that the presence of *Po. angusticostatus* (with *Po. pseudofoliatus*) in the *curtigladius* Faunal Unit in the upper Hume Formation at Powell Creek (as recorded by Uyeno 1979) suggested an age no younger than the lower part of the *ensensis* Zone. He consequently depicted the *curtigladius* and *pseudofoliatus* Faunal Units straddling the *australis*-*kockelianus* and *kockelianus*-*ensensis* zonal boundaries respectively. The occurrences of the *c. costatus* Faunal Unit both in the North-west Territories and in the Yukon were taken to represent equivalence with the *c. costatus* Zone (Klapper in Klapper and Ziegler 1979, p.207, text-fig. 4; Klapper and Johnson

1980, p.444, table 7).

In Australia, sequences of faunal units have been proposed by Pedder *et al*. (1970) in the Middle Devonian Timor Limestone in New South Wales, and by Telford (1975) in the Lower and Middle Devonian successions of the Broken River Embayment in North Queensland. Fordham (1976) attempted to relate parts of Telford's scheme to beds in the Nogoa Anticline in Central Queensland, while, in the Frome Mountain Limestone of New South Wales, Pickett (1978) recognised the *c. costatus* Faunal Unit described by Klapper (in Perry *et al*. 1974) in the Yukon, as well as Klapper's two preceeding divisions. Klapper and Johnson (1980, p.444, 445, tables 7, 8) indicated that an equivalent of the *patulus* Zone (unrestricted) was present in Central Queensland (after Fordham 1976), and that equivalents of the *australis* and *kockelianus* Zones occurred in the Timor Limestone of New South Wales (after Pedder *et al*. 1970). The *kockelianus* Zone was represented also in the Moore Creek Limestone of the last state (after Philip 1966).

Upper part of Middle Devonian, and the Middle-Upper Devonian boundary

(i). *ensensis* Zone

The *ensensis* Zone, initially suggested by Ziegler *et al*. (1976, p. 114), was formally introduced by Weddige (1977, p.344-346) for the interval represented by the *eiflius* and (*partim*) *robusticostatus* Zones of Wittekindt (1965), and by the *obliquimarginatus* Zone of Ziegler (1971, p.257). The last division had itself been proposed to replace the aforementioned zones of Wittekindt (see discussion by Ziegler *loc. cit*., and Ziegler *et al*. 1976, p.114), but, as reported by Ziegler *et al*. (*loc. cit*.), the zonal taxon proved to have a lower stratigraphical range than was previously thought, being recognised in the exposed top of the Ense limestone at Blauer Bruch, which was believed to be of Eifelian age. They remarked on anomalies apparent in the distribution of species of *Icriodus* (see below), and indicated that species of *Polygnathus*, which had a more widespread geographical occurrence, might provide a more reliable basis for zonation. They were of the opinion that the appearance of Po. x. ensensis above the kockelianus Zone could be more significant than that of I. obliquimarginatus: Po. x. ensensis was a faunal associate of the icriodid at Blauer Bruch, and occurred also throughout the exposed Ense limestone at the locality. With regard to the anomalous distributional patterns within Icriodus, Ziegler et al. (1976, p.115) illustrated these with particular reference to I. l. latericrescens. They noted that the taxon was found only relatively rarely in Europe, where it was restricted to a short interval within the varcus Zone (q. v.), whilst abundant occurrences of the subspecies in eastern North America showed that there it had a longer time span, ranging from below the varcus Zone into the hermanni-cristatus Zone. They observed that the form had not been recorded in Cordilleran North America or in Australia: this remains the case.

Weddige (1977, p.344, 345, 361-362, tables 4, 5) defined the lower and upper limits of the ensensis Zone by the first appearances of Po. x. ensensis and Po. timorensis respectively, and depicted the zone spanning the Ahbach-Loogh boundary, which is the Eifelian-Givetian boundary in the type Eifelian area. With regard to the correlation of this level with the Couvinian-Givetian boundary as recognised in the Couvin district of the Belgian Ardennes, Ziegler (1979, p.37) thought that the conodont and macrofaunal evidence in Belgium suggested that the Ahbach-Loogh boundary might lie slightly below the Co2d/Gi limit. In the eastern part of the Rhenish Slate Mountains, the Oderhäuser limestone with Cabrieroceras crispiforme, a typical early Givetian ammonoid according to Erben and Zagora (1968), has traditionally been taken as the base of the Givetian, but Weddige (1977, p. 354-355, tables 4, 20) referred the conodont associations from this horizon to the lower (late Eifelian) portion of the ensensis Zone, while the lower levels of the discoides limestone were correlated with the higher (early Givetian) part of the same zone. House (1979, p.270) remarked that the ammonoid fauna of the discoides limestone, with Sellagoniatites discoides, might belong either in the

Maenioceras terebratum Zone or in a succeeding division.

Klapper and Johnson (1980, p.445, table 9) showed that the *ensensis* Zone and its equivalents had been identified in North America (Nevada, Ohio), in the North-west Territories of Canada, and in Europe (Eifelian Hills, Rhenish Slate Mountains, South-west England; also in the Ardennes according to Weddige 1977, p.357-358, table 4). Lane *et al*. (1979, p.217, text-fig. 2) recorded the zone in Malaysia, while Klapper (1981, p.61, text-fig. 2) thought that the interval might be represented in New York by the presence of *I. l. latericrescens* in the Skaneateles Formation, because the overlying Centerfield Member, at the base of the Ludlowville Formation, had produced the lowest evidence in the state for the *varcus* Zone. He thought that support for the interpretation was provided by the macrofaunal correlation of the Skaneateles with the upper Silica Shale in northwestern Ohio, because the conodont associations from the middle and upper limestones of the Silica included *I. l. latericrescens*, *I. obliquimarginatus* and *I. arkonensis*, and Weddige (1977) had shown the lowest occurrences of the last two taxa to be in the *ensensis* Zone.

(ii). *varcus* Zone

This zone was introduced as the *varcus* Subzone by Bischoff and Ziegler (1957) in the "Obere Stringocephalen Stufe" of the Rhenish Slate Mountains, where it was the lowest in a series of five such subdivisions which extended from the upper Middle Devonian into the Upper Devonian. The subzone was raised to zonal status by Ziegler (1962b, p.16), and subsequently modified by him such that the lower boundary was defined by the first abundant occurrence of *Po. varcus*, the upper boundary by the first appearance of *Sch. hermanni* (Ziegler 1971, p.258). He recognised that the division then corresponded to the Upper Givetian, and coincided with the higher part of the range of *Maenioceras terebratum* and species of *Agoniatites*, while more recent work by House and Ziegler (1977) has shown that the highest portion of the zone may be as young as lowest Upper Devonian in age (see below).

With regard to attempts at subdividing the varcus Zone, Ziegler (1971, p.258, 259) reported that, in the Rhenish Slate Mountains, the joint occurrence of Ancyrognathus walliseri and I. l. latericrescens provided a medial subdivision of the interval, because the two forms were found together at a special level, the Terebratula pumilio bed, throughout the region. This subdivision was similar to, although it extended lower than, the walliseri horizon of Wittekindt (1965), but is probably not applicable outside the Rhine area (see Ziegler et al. 1976, p.112-113). Wittekindt (1965, p.628, table 1) had proposed also the transversus Zone above the varcus Zone, based on the appearance of Po. l. transversus, but the idea was rejected by Ziegler (1965b; 1971, p.258) on the grounds that this subspecies indicated, in fact, the upper part of the latter interval.

An important revision of the varcus Zone was undertaken by Ziegler et al. (1976), who examined faunas of this age from Europe and North America. The work included a comprehensive discussion of previous usages of the concept (Ziegler et al. 1976, p.110, 112). They maintained the upper boundary of the zone at the entry of Sch. hermanni, but redefined the lower boundary by the first appearance of Po. timorensis, and proposed a tripartite subzonal division. The Lower, Middle and Upper Subzones were characterised by the first occurrences of Po. timorensis, Po. ansatus and Po. latifossatus respectively, the base of the oldest unit being coincident with that of the entire zone. The section in the Flinzkalk at Koppen was chosen as the main reference sequence for the new divisions, while, elsewhere in Germany, the Lower varcus Subzone was recognised in the lower part of the discoides limestone, which formation contained also the upper boundary of the varcus Zone at such sections as Bicken, Rhenert and Syring (Ziegler et al. 1976, p.112-114, 116, tables 7-12, text-figs. 2-4).

The varcus Zone has been identified on a mondial basis (see Ziegler et al. 1976, p.112), and the subzonal scheme is also of widespread application. Outside Germany, the Lower and/or Middle varcus Subzones have been recognised in North America (Nevada, Kentucky-Indiana, Iowa, New York), Canada (North-west Territories, South-west Manitoba), Australia (Timor Limestone of New South Wales), South-west England and southern Morocco, while the Upper *varcus* Subzone has been found in the last region, in Spain, and in New York State (Ziegler *et al*. 1976, p.113-114; Klapper and Johnson 1980, p.445-446, tables 10, 11). It is worthy of note that all three units are present in New York (Ziegler *et al*. *loc*. *cit*.;Klapper and Johnson *loc*. *cit*.; Klapper 1981, p.61-63, text-fig. 2). In the Givet district of Belgium, the *varcus* Zone (*sensu* Ziegler 1971) is represented by an interval from a little above the base of Gid in the Mont d'Haurs Formation, through into the Lower Member (F1a) of the Assise de Fromelennes (Bultynck 1972, 1975; Bouckaert and Streel 1974; see also House and Ziegler 1977, p.90). The individual subzones have not yet been positively identified in this area, but the last appearance of *Po*. *pseudofoliatus* in the lowest sample from the Assise de Fromelennes (Bultynck 1975, text-figs. 2, 5: sample 6) indicates that this level may be close to the Lower-Middle *varcus* subzonal boundary (see Ziegler in Klapper and Ziegler 1979, text-fig. 5 for age range of *Po*. *pseudofoliatus*).

(iii). *hermanni-cristatus Zone*

This zone was established by Ziegler (1965b), and represents the life span of the genus *Schmidtognathus* in the absence of the wide-platformed polygnathids, such as *Po*. *asymmetricus*. Informal lower and upper divisions were suggested: the lower limit of the former unit was placed at the entry of *Sch*. *hermanni*, while the appearance of such forms as *Sch*. *pietzneri*, *Sch*. *wittekindti*, *Po*. *cristatus* and *Po*. *ordinatus* characterised the base of the latter (Ziegler 1971, chart 3).

The *hermanni*-*cristatus* Zone is associated with the contentious issue of the Middle-Upper Devonian boundary, on which subject much has been written (for example: McLaren 1970; Orchard 1975a, p.40-45; House 1973, 1975, 1977; Ziegler 1971, 1979; House and Ziegler 1977). The main problem lies in the fact that the base of the Upper Devonian in Germany (that is, the base of the Manticoceras Stufe) has traditionally been defined by the first occurrence of Pharciceras lunulicosta, but no goniatites have been found in the Assise de Fromelennes, the base of which, since 1952, has been taken as the base of the Frasnian in Belgium (see discussion by House and Ziegler 1977, p.89). When Ziegler first proposed the hermanni-cristatus Zone, in 1965, there appeared to be a gap in the ammonoid record between the ranges of the characteristic Middle Devonian form Maenioceras terebratum and the early Upper Devonian P. lunulicosta. He placed a preliminary Middle-Upper Devonian boundary at the base of the upper portion of his new zone, immediately above the highest occurrence of the former goniatite and somewhat below the (then) lowest record of the latter. Information on the relative alignment of the conodont and ammonoid zonal scales was subsequently provided by the much reduced succession at Martenberg near Adorf (now Diemelsee), the type section of the German lower Upper Devonian. Goniatite collections from this important locality demonstrated the association of Pharciceras and Sympharciceras with the upper part of the hermanni-cristatus Zone, and of Maenioceras with the varcus Zone (Kullmann and Ziegler 1970), which led these authors to maintain that the Middle-Upper Devonian boundary could be drawn at the base of the upper part of the former division. However, House (1973, p.8-9; see also House and Ziegler 1977, p.88-89) observed that, even with the new evidence, the boundary could still, in fact, lie anywhere in an interval from within the higher part of the varcus Zone, through the lower portion of the hermanni-cristatus Zone, and even to within the lowest part of the upper portion of the hermanni-cristatus Zone. He favoured the oldest of these possibilities.

More recent work at Martenberg by House and Ziegler (1977) produced a significant reassessment and refinement of the ammonoid and conodont parachronologies, and is especially pertinent to the definition of the Middle-Upper Devonian boundary. Individual beds in several profiles were sampled for conodonts in order that they might be related to the conodont zonal scheme, and goniatite faunas from the same horizons were also appraised. The detailed collecting programme enabled the writers to show that conodonts of both the lower and upper portions of the *hermanni-cristatus* Zone were associated with ammonoids characteristic of the *lunulicosta* Zone (doIα). They discussed the implications resulting from the revised alignment of the ammonoid and conodont zonations for the international correlation of the Middle-Upper Devonian boundary, and indicated that, while the new evidence from Martenberg demonstrated the occurrence of *lunulicosta* Zone goniatites in beds of Lower *hermanni-cristatus* Subzone age, there was still some ambiguity over the exact position of the base of the *lunulicosta* Zone (that is, the traditional base of the German Upper Devonian), which could fall either within the late *varcus* Zone or in the earliest part of the Lower *hermanni-cristatus* Subzone. Support for the former interpretaion was forthcoming from Morocco and New York, where the junction between the ranges of *Maenioceras* spp. and *Pharciceras* spp. appeared to be associated with the higher part of the *varcus* Zone, the occurrence of *Pharciceras* (as *P. amplexum*) in the Moravia Bed of the Tully Limestone in New York being flanked above and below by horizons of Middle and Upper *varcus* Subzone age respectively (House and Ziegler 1977, p.88-92, text-figs. 3,4). They concluded with observations on the relative merits of three possible candidates for the international correlation of the Middle-Upper Devonian boundary, namely the base of the *lunulicosta* Zone, the base of the *hermanni-cristatus* Zone, and the base of the Lower *asymmetricus* Zone, the boundary possibly falling as low as within the late *varcus* Zone being implicit in selection of the first contender (House and Ziegler 1977, p.92). With regard to Belgium, the presence of conodont faunas of *varcus* Zone age in the lower part of the Lower Member (F1a) of the Assise de Fromelennes (see above) indicates that the base of the Frasnian here apparently lies in the late *varcus* Zone (see discussion by House and Ziegler 1977, p.89-90, 92).

Klapper and Johnson (1980, p.413-414) formally recognised Ziegler's lower and upper divisions of the *hermanni-cristatus* Zone as the Lower and

Upper Subzones. The base of the lower unit was characterised by the first appearance of Sch. hermanni, the base of the upper by the first occurrence of Po. cristatus, in conformity with the earlier definition of the informal subdivisions. The Lower and Upper hermanni-cristatus Subzones have both been identified in the Rhenish Slate Mountains, Nevada and Iowa, while the Upper Subzone has been recognised also in, for example, the Tully Limestone of New York, in southern Morocco, in the Ramparts Formation of the Canadian North-west Territories, and in the Marble Cliff Beds of North Cornwall (Klapper and Johnson 1980, p.445-446, table 11; Uyeno 1979, p.239, text-fig. 2; Mouravieff 1977, in Scrutton 1978a, p.62, text-fig. 23). In Belgium, faunas indicative of the hermanni-cristatus Zone occur in the Upper Member (F1c) of the Assise de Fromelennes, although the individual subzones have not yet been unambiguously identified there (Bultynck 1975; see also House and Ziegler 1977, p.90).

Upper Devonian

(i). Lowermost asymmetricus and younger Zones

The detailed conodont zonation of the Upper Devonian proposed by Ziegler (1962b) has been applied throughout the northern hemisphere and in Australia, and much of the scheme remains unsurpassed. A few minor nomenclatorial changes were described by Ziegler (1971, p.267-268). Refinements and revisions in the Famennian part of the zonation, in the rhomboidea and younger zones, have been introduced by, for example, Sandberg and Ziegler (1973, 1979), who emphasised the recognition of biofacies grouping by genera.

With regard to the zonation within the lower part of the Upper Devonian, discrepancies have become apparent between the expression of the Lowermost asymmetricus Zone in Europe and in North America, which interval Ziegler (1971, p.267) defined by the occurrence of Po. asymmetricus in the absence of A. rotundiloba. Klapper and Johnson (1980, p.414) noted that

K. disparalvea, *K. disparilis* (cited as *Pa. disparalvea* and *Pa. disparilis* respectively), *Po. dengleri*, *Po. caelatus* and *Po. pennatus* characteristically made their first appearances in the Lowermost *asymmetricus* Zone in the Rhenish Slate Mountains (that is, usually at the same time as, or above, that of *Po. asymmetricus*), whereas the entry of *Po. asymmetricus* (as *Po. a. asymmetricus*) was well after the first occurrences of *K. disparalvea*, *K. disparilis* and *Po. dengleri* in such areas of the North American continent as Nevada and the North-west Territories. They preferred to use the first appearances of the last three species, together with, but less importantly, that of *Po. pennatus*, for correlating western North America with the Lowermost asymmetricus Zone in Europe, and viewed *Po. a. asymmetricus* as a late entrant in the former region. The *dengleri* Zone was proposed as the North American equivalent of the European Lowermost *asymmetricus* Zone, and was divided into a Lower and an Upper Subzone, the lower boundary of the former portion being defined by the first occurrence of *K. disparilis*, the same as for the entire zone, the lower boundary of the latter by the entry of *Po. norrisi*. Associated taxa included *Po. dengleri*, which first appeared in the Lower Subzone, and *Po. a. asymmetricus* and *Pand. insita* (formerly *Sp. insitus*), which entered in the Upper Subzone in western North America (that is, west of the transcontinental arch). Both sub-zones were identified in Nevada, in the Powell Creek area of the North-west Territories, in southern Morocco and probably in North Cornwall, while just the lower subdivision was represented in Indiana, and just the upper in Iowa (see below), Alberta and southwestern Manitoba (Klapper and Johnson 1980, p. 414-415, 446, table 12).

As noted above, *Pand. insita* first appears in western North America (for example, in Nevada) in the Upper *dengleri* Subzone. By extrapolation to the east and across the transcontinental arch, Klapper and Johnson (1980, p. 415) considered the *insita* facies [*insita* Fauna] as developed within the Cedar Valley Formation of Iowa and Illinois to be, therefore, the presumed correlative of the Upper *dengleri* Subzone of the western region. The concept of the *insita* Fauna was informally introduced by Klapper *et al*. (1971, p.300), who defined it as that fauna dominated by the name-giver in strata below the first appearance of *A*. *rotundiloba* (all subspecies). In the North American continent the fauna has been identified in, for example, Missouri, Alberta and Manitoba, as well as in Iowa and Illinois (Klapper *et al*. *loc*. *cit*.; Norris and Uyeno 1971). In Belgium, Bultynck (1975) recorded the *insita* Fauna in the Upper Member (F1c) of the Assise de Fromelennes, and it is represented at Ny, again in F1c (Coen and Coen-Aubert 1971, p.17), and also at Ave et Auffe (Bouckaert and Streel 1974, Excursion E, p.12). The fauna is considered to be representative of a shallow water biofacies (Schumacher 1976), and, while thought to be equivalent to the Upper *hermanni*-*cristatus* Subzone and the Lowermost *asymmetricus* Zone in its oldest part, is now believed to occur throughout the *asymmetricus* Zone (see Ziegler in Klapper and Ziegler 1979, p.212). It should be noted that Johnson *et al*. (1980, p.97) largely discounted the equivalence of the oldest portion of the *insita* Fauna with the Upper *hermanni*-*cristatus* Subzone. They presented a discussion of the *insita* Fauna (as the *insita* biofacies) in a study of successions in the Antelope Range of central Nevada, and demonstrated the presence there of an early morphotype of *Pand*. *insita* in a diverse fauna from a presumed off-shore sequence. This was in contrast with the usual occurrence of the species elsewhere, in low diversity faunas from near-shore settings (Johnson *et al*. 1980, p.97, table 16: Collection V 1450).

With regard to the alignment of the goniatite and conodont zonal scales in the lower part of the Upper Devonian, House and Ziegler (1977) showed that, at Adorf, the top of the *Pharciceras* *lunulicosta* Zone fell within the *asymmetricus* Zone, although the Iα-Iβ boundary (that is, the *P*. *lunulicosta*-*Manticoceras* *cordatum* zonal boundary) could not be identified precisely, while the Iβ-Iγ boundary lay higher than was previously believed and in the *Ag*. *triangularis* Zone. Higher correlations were confirmed, such as the placing of the Iγ-Iδ boundary (that is, the boundary of the *M*.

cordatum and *Crickites holzapfeli* Zones) within the *gigas* Zone. The situation in Belgium was also discussed (House and Ziegler 1977, p.90, text-fig. 4). The presence of the *insita* Fauna in the upper part of the Upper Member (F1c) of the Assise de Fromelennes indicated equivalence with the Upper *hermanni*-*cristatus* Subzone and/or Lowermost *asymmetricus* Zone, while the base of the overlying Assise de Frasnes (F2) dated from the Lower *asymmetricus* Zone (Bultynck 1975). Mouravieff and Bouckaert (1973) reached a similar conclusion regarding the age of the lower Assise de Frasnes (F2a-c), and thought that its upper portion (F2e-i) correlated with the Middle *asymmetricus* to *Ag. triangularis* Zones. (The lower, middle and upper divisions of the *asymmetricus* Zone in Belgium were identified by *A. rotundiloba*, *A. gigas* and *A. curvata* respectively, as indicated on Text-fig. 1 herein). House and Ziegler (1977, p.90) noted that the Assise de Matagne was referable to the *gigas* Zone on the conodont evidence, while the Schistes de Matagne correlated with the *Crickites holzapfeli* Zone (or doIδ) on the goniatite evidence, and remarked that the work of Bouckaert *et al.* (1972) showed the Frasnian-Famennian boundary, usually taken at the base of the Assise de Senzeilles in Belgium, to lie approximately in the Middle *Pa. triangularis* Zone.

The world-wide application of many of the Upper Devonian conodont zones (that is, Lowermost *asymmetricus* and younger zones) may be illustrated by reference to, for example, Ziegler (1971, p.264), Klapper *et al.* (1971, p.300-311, text-figs. 3-6), Druce (1974, p.6-9, text-fig. 1), Lane *et al.* (1979), Klapper and Johnson (1980, p. 446, tables 12, 13), and Klapper (1981, p.63-65).

CHAPTER 4.

PREVIOUS WORK ON DEVONIAN CONODONTS IN SOUTH-WEST ENGLAND

The first description of Devonian conodonts from South-west England was presented by Dineley and Rhodes (1956). Of their fifteen productive samples one was from the Torquay area, from Old Wood's Pit: the association was questionably assigned to an Upper Givetian age, despite the presence of the acknowledged Upper Givetian genus Ancyrodella. The authors observed that the British faunas were "strikingly similar" to ones reported from Germany and North America, and noted the occurrence of "Ordovician" forms such as "Belodus" within their Devonian samples, which they attributed to derivation rather than to a possible extension of the stratigraphical range. They maintained the same view in the first systematic study of British Devonian conodonts (Rhodes and Dineley 1957a), in which material from a borehole at Bishopsteignton was figured and described. These faunas were thought to be of Frasnian and Famennian age, but the presence of Spathognathodus brevis [Ozarkodina brevis] and representatives of the Polygnathus varcus group suggests that the succession, at least in the lower part, may date from the Middle Devonian. In the supplement to this work, Rhodes and Dineley (1957b) recognised that the age range of "Belodus" extended into the Devonian.

With regard to other records of conodonts from the Torquay area itself, Austin (1967) briefly mentioned a fauna, predominantly of icriodids, from the Middle Devonian limestones at Hope's Nose, while Matthews (1970) described and illustrated a Middle Devonian varcus Zone association from the Lummaton Shell Bed. The latter work, as the author noted, did not clarify the stratigraphical position of either the Shell Bed or adjacent strata, but was significant for indicating the potential of the area for conodont studies. Faunas from Barton Quarry and Babbacombe Cliff were described by Castle (1977, 1978 respectively).

Several accounts have dealt with Devonian conodont faunas found inland from the Torquay promontory. House and Butcher (1962) reported a Famennian fauna from Mount Pleasant at Chudleigh, and Riddolls (1970) noted conodonts of a similar age from a borehole section near Newton Abbot. Again near Chudleigh, Tucker and van Straaten (1970a) showed that, on the evidence of Middle-Upper Devonian conodonts found therein, the Kiln Woods Beds were equivalent in age to the Lower Dunscombe Goniatite Bed, and concluded that the former had accumulated in a local deepening of the Chudleigh Schwelle.

The last two workers examined also conodonts from successions in the southern part of Tor Bay, and recorded Famennian specimens from Saltern Cove, found in and around the famous Saltern Cove Goniatite Bed (Tucker and van Straaten 1970b). That the age of the conodonts within this horizon was at variance with the Upper Frasnian age of the goniatites was tentatively ascribed to the goniatites having been derived. However, van Straaten and Tucker (1972) subsequently recovered Upper Frasnian conodonts from the Goniatite Bed, which accorded both with the age of the ammonoids and also with the ostracod evidence. Because of sedimentological and structural relationships, they concluded that the Goniatite Bed contained clasts of, and had been transported in its entirety to within, Famennian sediments.

Elsewhere in South Devon, Smythe (1973) mentioned an icriodid fauna of low Eifelian age from the Brixham limestone, but conodont records have otherwise been concentrated largely around Plymouth. Matthews (1962) described a Middle Devonian association fron Neal Point on the River Tamar, while Orchard (1972, 1975a, 1975b, 1977, 1978; in Scrutton 1978a, p.53-56) has thoroughly examined, and appraised the biostratigraphical significance of, the faunas of the Plymouth area. The various findings of the latter author are referred to and described elsewhere in the present study. Orchard (1979) was responsible also for the description of several associations of varcus Zone age from the Ilfracombe Slates, in the first record of Devonian conodonts from North Devon.

Various workers have reported Devonian faunas from Cornwall. For example, Hendriks et al. (1971) and Sadler (1973) described Lower, Middle and Upper Devonian associations from the Roseland district of South Cornwall, while Whiteley (1981) recently demonstrated the occurrence of Upper Famennian (and younger) conodonts in the Viverdon Down area, in the south-eastern part of the county. In North Cornwall the Padstow district is important for conodont studies, where Kirchgasser (1970) first showed that the Trevose Slates, Marble Cliff Beds and Longcarrow Cove Tuffs and Slates represented an interval about the Middle-Upper Devonian boundary. These successions were restudied by Mouravieff (1977), who extended his observations to older and younger horizons, and recorded several additional species. The last author incorporated his results in Scrutton (1978a, p.57-68), where they were presented with detailed sections and diagrammatic representations of Marble Cliff (Scrutton 1978a, text-figs. 23, 24). Elsewhere in North Cornwall, a detailed analysis of the conodont associations of the Launceston district was made by Stewart (1981), who demonstrated the presence there of Famennian and early Carboniferous faunas, and interpreted stratigraphical and sedimentological relationships in the area.

CHAPTER 5.

LOCALITIES AND CONODONT FAUNAS

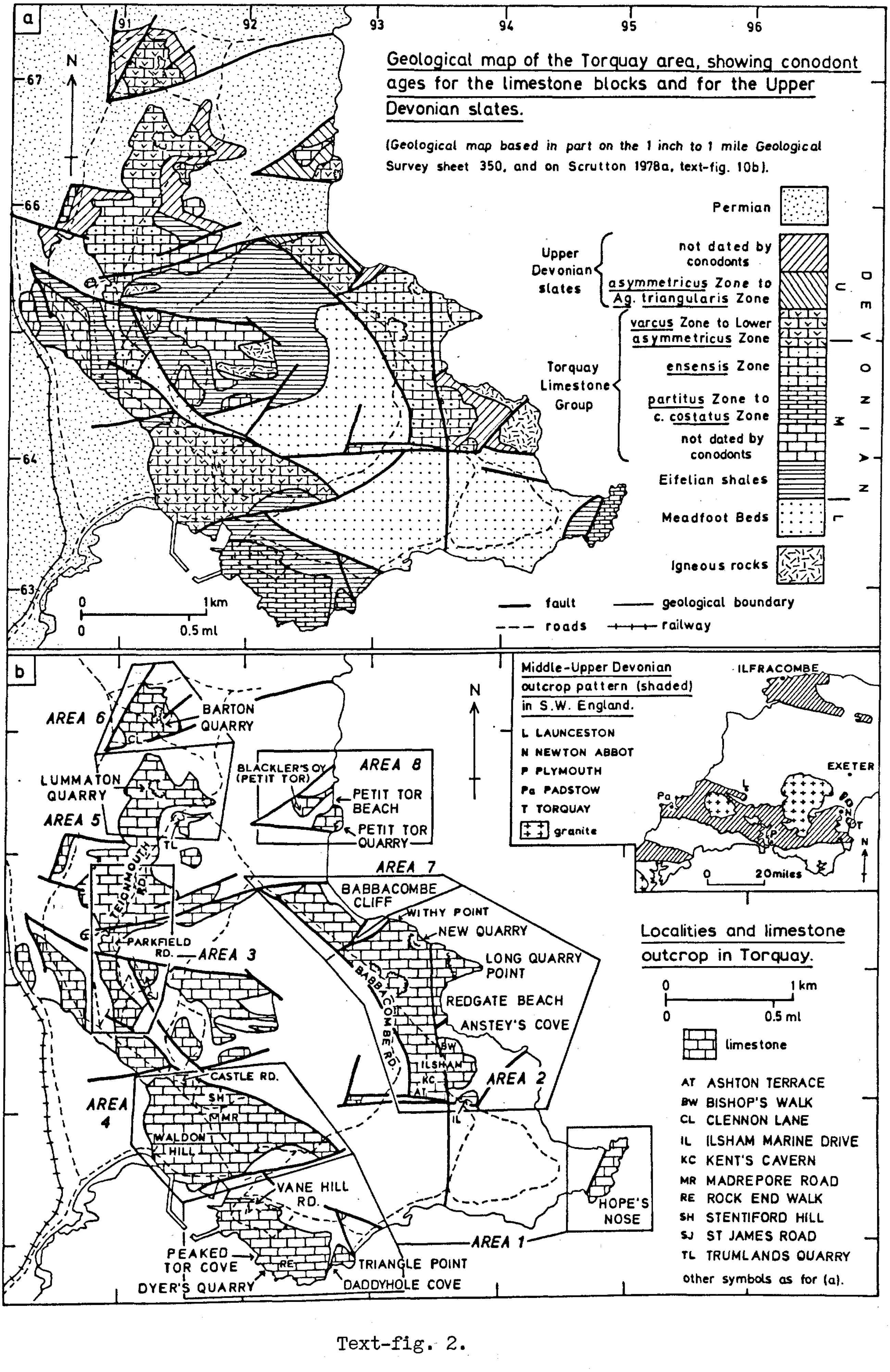
Introduction

Localities and conodont faunas in the Torquay promontory are described in terms of eight Areas, shown on Text-fig. 2b. There is a variable extent of tectonic separation both between and within each Area, but continuous, albeit short, successions are recognised in several. The Areas are presented in more or less stratigraphical order in the ensuing discussion, and the lithologies and macrofaunas of the individual localities within each are outlined, followed by a description of the conodont associations and an assessment of their age (and other) implications. Comparable faunas in the Plymouth region, described by Orchard (1978), are mentioned where appropriate.

Relationships between the Torquay successions, Orchard's Plymouth faunas, and European zonal schemes (specifically those evaluated in Germany and Belgium) are summarised on Text-fig. 1, while ages inferred for outcrops in the Torquay district are indicated on Text-fig. 2a. Text-figs. 3-14 give details of exposure and sample sites at the separate Torquay localities.

Area 1 (Daddyhole Cove, DH-1, 2; Triangle Point, TP-1-17, 20-28; Dyer's Quarry, DY-1-4; Peaked Tor Cove, PK-1-4; Rock End Walk, RE-1-3; Vane Hill Road, VH-1, 2; Hope's Nose, HN-1-7, 10-13; Text-figs. 4, 5).

Daddyhole Cove (SX926628; Text-fig. 4) is excavated in grey-green Eifelian shales, present in the core of a large anticline which is overturned to the east-north-east. The shales pass upwards into the Daddyhole Limestone, the base of which is placed at the base of the first limestone band of the 4.5 m sequence of transitional beds seen in the cliffs on the western side of the cove (SX92666277), on the rightway-up limb of the anticline (Scrutton 1977b, p.167). The transitional series comprises alternations of dark grey-red limestones and calcareous shales, with a fauna of corals, brachiopods,


a
91
92
93
94
95
96
N
67
66
64
63
Geological map of the Torquay area, showing conodont ages for the limestone blocks and for the Upper Devonian slates.
(Geological map based in part on the 1 inch to 1 mile Geological Survey sheet 350, and on Scrutton 1978a, text-fig. 10b).
Permian
Upper Devonian slates
not dated by conodonts
asymmetricus Zone to Ag. triangularis Zone
Torquay Limestone Group
varcus Zone to Lower asymmetricus Zone
ensensis Zone
partitus Zone to c. costatus Zone
not dated by conodonts
Eifelian shales
Meadfoot Beds
Igneous rocks
DEVONIAN
U
M
L
0 1km
0 0.5 ml
fault
geological boundary
roads
railway
b
AREA 6
BARTON QUARRY
CL
LUMMATON QUARRY
AREA 5
TL
TEIGNMOUTH RD.
BLACKLER'S OY (PETIT TOR)
AREA 8
PETIT TOR BEACH
PETIT TOR QUARRY
AREA 7
BABBACOMBE CLIFF
WITHY POINT
NEW QUARRY
LONG QUARRY POINT
REDGATE BEACH
ANSTEY'S COVE
BABBACOMBE RD.
PARKFIELD RD.
AREA 3
SJ
BW
ILSHAM
KC
AT
IL
AREA 2
CASTLE RD.
SH
MR
AREA 4
WALDON HILL
VANE HILL RD.
HOPE'S NOSE
AREA 1
PEAKED TOR COVE
RE
TRIANGLE POINT
DYER'S QUARRY
DADDYHOLE COVE
N
Middle-Upper Devonian outcrop pattern (shaded) in S.W. England.
L LAUNCESTON
N NEWTON ABBOT
P PLYMOUTH
Pa PADSTOW
T TORQUAY
granite
ILFRACOMBE
EXETER
Pa
L
P
N
T
0 20miles
N
Localities and limestone outcrop in Torquay.
0 1km
0 0.5 ml
limestone
AT ASHTON TERRACE
BW BISHOP'S WALK
CL CLENNON LANE
IL ILSHAM MARINE DRIVE
KC KENT'S CAVERN
MR MADREPORE ROAD
RE ROCK END WALK
SH STENTIFORD HILL
SJ ST JAMES ROAD
TL TRUMLANDS QUARRY
other symbols as for (a).

Text-fig. 2.

	DH·1	DH·2	TP·12	TP·14	TP·15	TP·16	TP·17	TP·22	TP·26	TP·27	TP·28	DY·2	PK·1	PK·2	PK·3	PK·4	RB·2	RB·3	RB·4	RB·5	RB·6	RB·10	RB·11	RB·12	RB·13	RB·14	LG·3	LG·4	LG·5	LG·6	LG·7	LG·8	LG·12	BR·1	BR·3	BR·7	BR·9	NQ·5	PF·5	PF·6	PF·9	TR·1	TR·2	SJ·2	CR·1	CR·2	CR·4
Po. timorensis																																												x		x	
Po. x. xylus																																												x			
Po. varcus gp. (indet. juvs.)																																												x	x		
I. arkonensis																																									x						
O. brevis																																								x							
Po. aff. x. xylus																														x														x			
Po. c. costatus																												cf.			cf.																
Po. l. alveolus																									cf.		x						x														
I. regularicrescens																								cf.																							
Po. linguiformis subsp. a																								x	x	x											x										
I. aff. obliquimarginatus																						x															x	x									
Po. x. ensensis																				x				x	x	x				x														x	x		
Po. linguiformis subsp. b																			x			x															x										
I. expansus group																	x			x	x			x						x					x						x	x					
Po. aff. pseudofoliatus																											x		x																		
Po. pseudofoliatus																	x	x	x	x			x		x			x	x			x						x	x		x						
Po. l. linguiformis																	x	x	x	x	x	x		x	x	x			x	x		x		x	x	?	x	x	x				x	x		x	x
T. aff. variabilis																	x																														
I. aff. introlevatus							x																																								
E. b. montensis			cf.									cf.			cf.	cf.																															
I. c. corniger			x	x		x	x	x	x	x	x		x	x	x	x																															
I. retrodepressus	x	x	x		x				x		x																																				
Po. l. bultyncki	x																																														

TEXT-FIG. 2c. DISTRIBUTION OF TAXA IN AREAS 1, 2, 3; 4 (PARTIM).

	LM·1	LM·3	LM·4	LM·5	LM·6	LM·7	LM·9	LM·10	LM·11	LM·13	LM·15	LM·16	LM·17	LM·18	WH·1	WH·2	WH·3	MR·1	TL·2	TL·3
Pa.hassi																				
Pa.subrecta																				
Pa.aff.proversa																				
A.lobata																				
A.aff.gigas																				
I.aff.brevis																				
I.symmetricus																				
Po.decorosus																				
Po.dengleri																				
Po.webbi																				
Po.aff.ordinatus																				
Po.a.subsp. A																				
Po.a.asymmetricus																				
Po.a.subsp.indet.																				
Po.a.ovalis																				
Po.cristatus																				
O.s.sannemanni																				
A.r.binodosa																				
A.r.rotundiloba																				
Po.dubius																				
Po.aff.dubius																				
Po.ovatinodosus																				
I.latecarinatus																				
Po.aff.webbi																				
Sch.n.sp. B																				
Sch.n.sp. A																				
Sch.aff.hermanni																				
Sch.? aff.gracilis																				
Sch.peracutus																				
Sch.pietzneri																				
Sch.wittekindti																				
I.expansus group																	x			
I.aff.obliquimarginatus																	x			
Po.varcus														?			x			
Po.aff.ovatinodosus													x				x			
Po.x.xylus											x						x	x		x
Po.l.linguiformis δ m't.										cf.										
Po.l.mucronatus									x							x		x		
Po.ansatus									x		x	x		x				x		
Sp.planus							x	x					x	x				x		
Po.varcus gp.(indet.juvs)						x						x	x	x		x		x		
Po.l.linguiformis ε m't.	x												x				x			
Po.timorensis	x	x	x	x			x	x	x	x				x				x	x	x
Po.l.linguiformis	x	x	x	x		x	x	x	x		x		x	x		x	x	x	x	x
O.brevis	x	x			x	x		x	x	x	x			x						
Po.pseudofoliatus															x					
Po.aff.x.ensensis															x					

	BQ·1	BQ·2	BQ·4	BQ·5	BQ·7	BQ·8	BQ·9	BQ·10	BQ·11	BQ·12	BQ·13	BQ·14	BQ·15	BQ·16	BQ·18	BQ·19	BQ·20	BQ·22	BQ·23	BQ·24	BQ·25	BQ·26	BQ·27	BQ·28	BQ·29	BQ·30	BQ·31	BQ·32	MH·1
Pa.hassi																													
Pa.subrecta																													
Pa.aff.proversa																													
A.lobata																													
A.aff.gigas																													
I.aff.brevis																													
I.symmetricus																													
Po.decorosus																													
Po.dengleri																													
Po.webbi																													
Po.aff.ordinatus																													
Po.a.subsp. A																													
Po.a.asymmetricus																													
Po.a.subsp.indet.																						x							
Po.a.ovalis															x														
Po.cristatus	x	x													x							x				x			
O.s.sannemanni															x				x										
A.r.binodosa																													
A.r.rotundiloba															x														
Po.dubius	x		x								x	x		x			x	x				x		x		x			
Po.aff.dubius		x	x	x	x		x	x		x			x	x	x	x	x	x	x			x	x	x	x	x	x		
Po.ovatinodosus	x				x			x	x	x	x				x	x	x	x	x			x	x	x	x	x			
I.latecarinatus	x														x					x									
Po.aff.webbi												x								x									
Sch.n.sp. B																						x							
Sch.n.sp. A																										x			
Sch.aff.hermanni															x														
Sch.? aff.gracilis							x																			x			
Sch.peracutus									x		x				x							x							
Sch.pietzneri									x						x							x		x	x	x			
Sch.wittekindti	cf.																												
I.expansus group						x											x			x	x								
I.aff.obliquimarginatus																													
Po.varcus																													
Po.aff.ovatinodosus																													
Po.x.xylus											x		x					x	x					x	x				
Po.l.linguiformis δ m't.																													
Po.l.mucronatus																													
Po.ansatus																													
Sp.planus																													
Po.varcus gp.(indet.juvs)																								x				x	x
Po.l.linguiformis ε m't.																													
Po.timorensis																												x	x
Po.l.linguiformis																												x	x
O.brevis									x	x															x				
Po.pseudofoliatus																													
Po.aff.x.ensensis																													

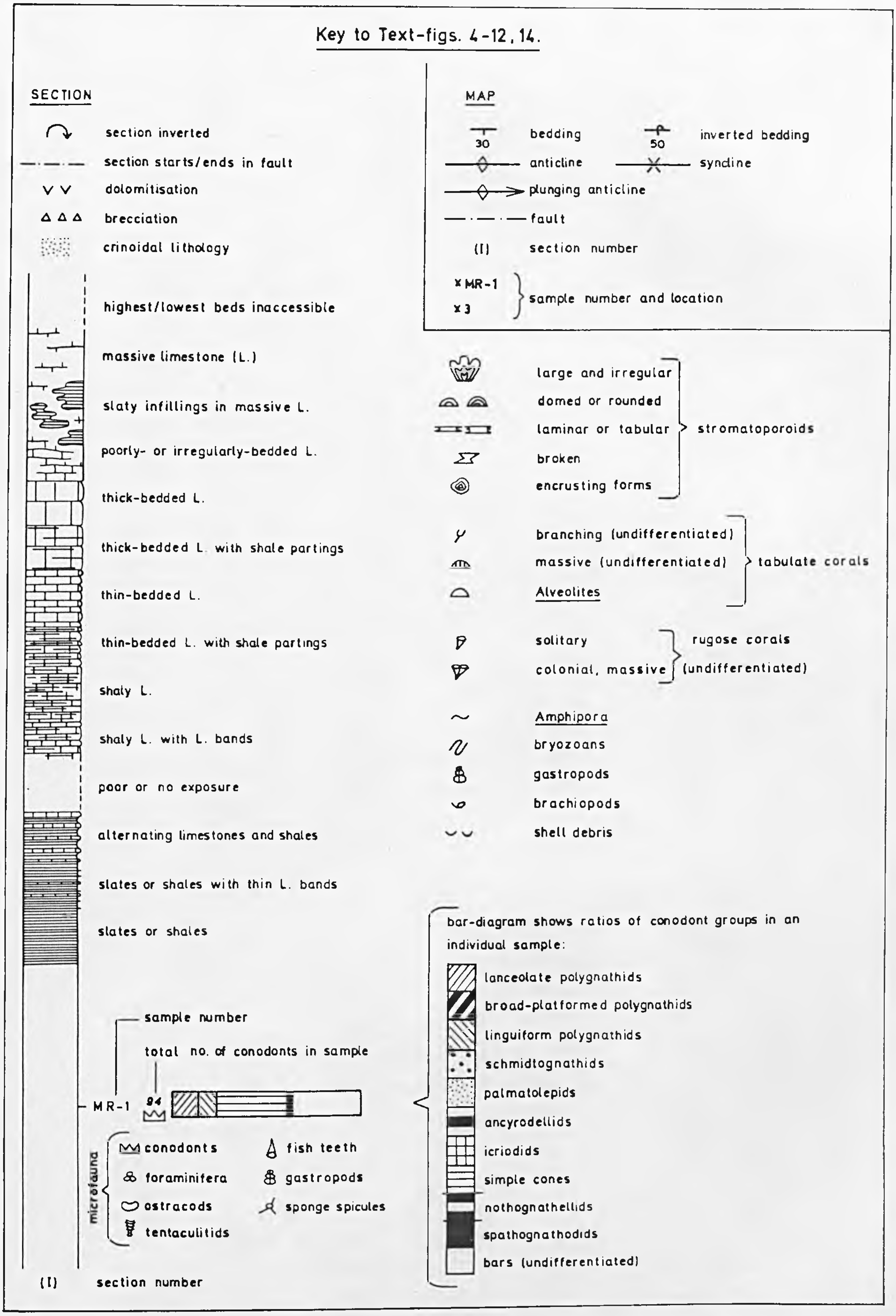
	BC·21	BC·22	BC·23	BC·32	BC·33	BC·34	BC·11	BC·13	BC·1	BC·2	BC·5	BC·8	BC·9	PB·10	PB·11	PQ·3	PQ·4	PB·1	PB·2	PB·3	PB·6	PB·12
Pa.hassi																		x	x			x
Pa.subrecta																	x	x	x			x
Pa.aff.proversa																		x				
A.lobata																		x	x			
A.aff.gigas																		x				
I.aff.brevis																		x	x	x	x	x
I.symmetricus													cf.			x	x	x	x		x	
Po.decorosus											x	x						x	x	x	x	x
Po.dengleri							x			x	x		x									
Po.webbi					x		x															
Po.aff.ordinatus					x		x															
Po.a.subsp. A																						x
Po.a.asymmetricus				x																		
Po.a.subsp.indet.				x																		
Po.a.ovalis																						
Po.cristatus				x	x																	
O.s.sannemanni					x		x															
A.r.binodosa				x									x									
A.r.rotundiloba																						
Po.dubius				x			x		x	x	x	x	x									
Po.aff.dubius					x	x	x	x														
Po.ovatinodosus				x	x		x		x	x	x	x	x									
I.latecarinatus				x																		
Po.aff.webbi																						
Sch.n.sp. B																						
Sch.n.sp. A																						
Sch.aff.hermanni																						
Sch.? aff.gracilis																						
Sch.peracutus																						
Sch.pietzneri																						
Sch.wittekindti																						
I.expansus group								x		x	x		x						x			
I.aff.obliquimarginatus																						
Po.varcus																						
Po.aff.ovatinodosus																						
Po.x.xylus				x							x											
Po.l.linguiformis δ m't.															x							
Po.l.mucronatus		x																				
Po.ansatus		x																				
Sp.planus																						
Po.varcus gp.(indet.juvs)																						
Po.l.linguiformis ε m't.																						
Po.timorensis		x	x																			
Po.l.linguiformis		x	x											x	x							
O.brevis	x																					
Po.pseudofoliatus																						
Po.aff.x.ensensis																						

TEXT-FIG. 2d. DISTRIBUTION OF TAXA IN AREAS 4 (PARTIM), 5, 6, 7, 8.

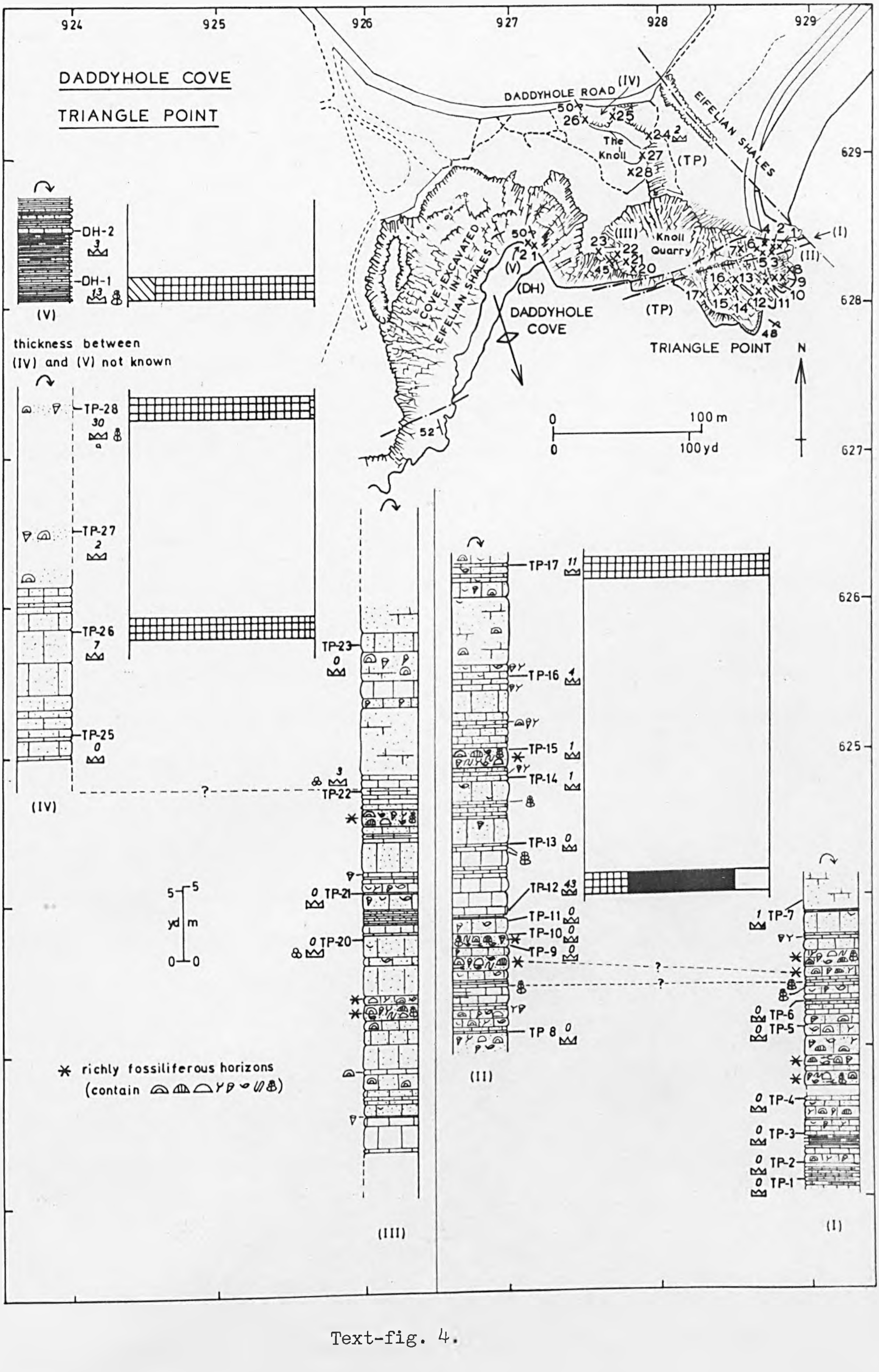
bryozoa and crinoid ossicles (sometimes articulated). Similar alternating limestones and calcareous shales are exposed at shore level in the north-eastern corner of the cove (SX92716284), on the inverted limb of the fold. The (inverted) lower horizons of the Daddyhole Limestone are seen on The Knoll and in the Knoll Quarry above Triangle Point, and on Triangle Point itself (SX92786290, SX92796283, SX92856281 respectively; Text-fig. 4). The limestone here is dark, well bedded and crinoidal, and bears corals and stromatoporoids with brachiopods, gastropods and bryozoa. Stratigraphically lower units tend to be thicker and more sparsely fossiliferous than higher levels, where some horizons contain a rich fauna. Intercalations of dark shale appear in the highest parts of the succession at the eastern end of Triangle Point, and the limestones are eventually succeeded by the shales exposed in the cliffs immediately above the Point (SX92856284). A tuff band is associated with the transition from limestone to shale, and crops-out at SX92876284. Further details of the stratigraphy and macrofaunal associations in the Daddyhole Cove-Triangle Point area were given by Scrutton (1977b, p.167-169; 1978a, p.32-34).

The oldest conodont faunas in the Torquay promontory were recovered from the alternations of limestones and calcareous shales in the north-eastern corner of Daddyhole Cove (DH-1, 2). The samples produced the distinctive I. retrodepressus, representatives of which include the "typical" forms recorded by Weddige (in Weddige et al. 1979, text-fig. 4) from within the lower part of the Wolfenbach Member (Libra I-III) of the Lauch Formation. An age within, but above the base of, the lower portion of the partitus Zone is indicated, and is supported by the presence of Po. l. bultyncki in DH-1. By inference, the underlying shales are no younger than lowest Eifelian in age.

I. retrodepressus occurs again close to the base of the Daddyhole Limestone on the western side of The Knoll (TP-28), this time with I. c. corniger. Thereafter the latter taxon is commonly encountered throughout the successions in The Knoll-Triangle Point area (TP-12, 14, 16, 17, 22, 26, 27),


Key to Text-figs. 4-12, 14.
SECTION
section inverted
section starts/ends in fault
dolomitisation
brecciation
crinoidal lithology
highest/lowest beds inaccessible
massive limestone (L.)
slaty infillings in massive L.
poorly- or irregularly-bedded L.
thick-bedded L.
thick-bedded L. with shale partings
thin-bedded L.
thin-bedded L. with shale partings
shaly L.
shaly L. with L. bands
poor or no exposure
alternating limestones and shales
slates or shales with thin L. bands
slates or shales
sample number
total no. of conodonts in sample
MR-1
94
microfauna
conodonts
foraminifera
ostracods
tentaculitids
fish teeth
gastropods
sponge spicules
(I)
section number
MAP
30
bedding
50
inverted bedding
anticline
syncline
plunging anticline
fault
(I)
section number
MR-1
3
sample number and location
large and irregular
domed or rounded
laminar or tabular
broken
encrusting forms
stromatoporoids
branching (undifferentiated)
massive (undifferentiated)
Alveolites
tabulate corals
solitary
colonial, massive
rugose corals (undifferentiated)
Amphipora
bryozoans
gastropods
brachiopods
shell debris
bar-diagram shows ratios of conodont groups in an individual sample:
lanceolate polygnathids
broad-platformed polygnathids
linguiform polygnathids
schmidtognathids
palmatolepids
ancyrodellids
icriodids
simple cones
nothognathellids
spathognathodids
bars (undifferentiated)

Text-fig. 3.


924
925
926
927
928
929
DADDYHOLE COVE
TRIANGLE POINT
DADDYHOLE ROAD
EIFELIAN SHALES
The Knoll
Knoll Quarry
COVE EXCAVATED INTO EIFELIAN SHALES
DADDYHOLE COVE
TRIANGLE POINT
(I)
(II)
(III)
(IV)
(V)
(DH)
(TP)
N
0 100 m
0 100 yd
629
628
627
626
625
DH-2
DH-1
thickness between (IV) and (V) not known
TP-28
TP-27
TP-26
TP-25
TP-23
TP-22
TP-21
TP-20
TP-17
TP-16
TP-15
TP-14
TP-13
TP-12
TP-11
TP-10
TP-9
TP 8
TP-7
TP-6
TP-5
TP-4
TP-3
TP-2
TP-1
5 yd m 0
5 0
* richly fossiliferous horizons (contain)

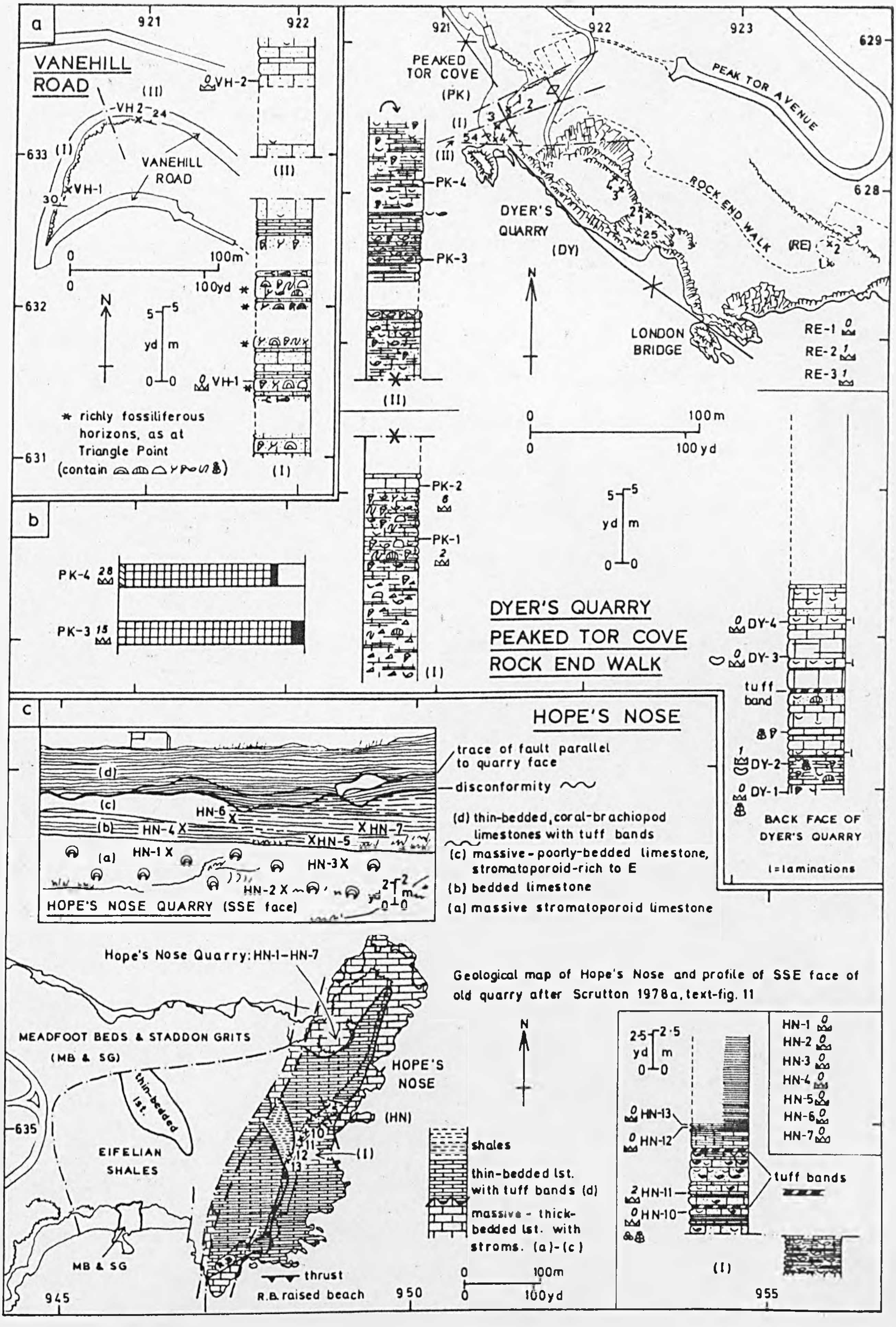
Text-fig. 4.

whereas the occurrence of the former becomes sporadic and sparse (TP-12, 15, 16). Abundant specimens designated *E*. cf. *b*. *montensis* occur towards the eastern end of Triangle Point in TP-12, in addition to the two icriodid taxa. The age range of *E*. *b*. *montensis* is restricted to within the *c*. *costatus* Zone in Germany, while *I*. *c*. *corniger* first appears there in the Wolfenbach Member (Libra II), in the lower *partitus* Zone and towards the top of the short interval occupied by *I*. *retrodepressus*, and ranges upwards into the lower *c*. *costatus* Zone (Weddige 1977, tables 2, 5; in Weddige *et* *al*. 1979, text-fig. 4). The mutual association of *I*. *c*. *corniger* and *E*. cf. *b*. *montensis* in TP-12 suggests that this fauna dates from within the lower part of the *c*. *costatus* Zone. The presence of *I*. *retrodepressus* in the same sample is not predicted by the time span of this species in Germany, where it disappears considerably before the *c*. *costatus* Zone (Weddige *loc*. *cit*.), but seems to be consistent with its age range in Belgium where, together with the relevant assemblage associates, the form is known from as high as Co2b (Bultynck 1972, text-fig.10; see also Systematic Palaeontology herein).

The presence of the last fauna in the stratigraphically higher levels of the Daddyhole Limestone in the Daddyhole Cove-Triangle Point area indicates that the successions here span an interval from within the lower *partitus* Zone, through this division, and into the early part of the *c*. *costatus* Zone. Scrutton (1978a, p.34) noted that Triangle Point is thrown down to the south relative to The Knoll by east-west trending normal faults and thought that, as a result, the western edge of the Point lay close to the base of the Daddyhole Limestone. If this is the case, almost all the *partitus* Zone and the lower part of the *c*. *costatus* Zone would be represented by the c.40 m thick succession of Triangle Point. Neither of the zonal subspecies has been found, polygnathids being anyway rare throughout Area 1, and there is an absence also of taxa which enter either within the *partitus* or in the lower *c*. *costatus* Zone (such as *Po*. *zieglerianus*, *Po*. *robusticostatus*, *Po*. *l*. *pinguis*, *O*. *bidentata*: see Weddige 1977, table 2). Consequently, the *partitus*-*c*. *costatus* zonal boundary cannot be recognised. Faunas from the western end of Triangle Point are inconclusive. Material referred to *I*. aff. *introlevatus* occurs in TP-17, but this species is long ranging and is consistent with an age either in the *partitus* or *c*. *costatus* Zone.

In Plymouth, Faunas 1 and 2 correlate with the *partitus* and *c*. *costatus* Zones respectively. The former grouping comprises the association of *I*. *c*. *corniger* and *I*. *retrodepressus* (Dunstone Point, MB23), the latter *I*. *c*. *corniger* with *I*. sp. A *sensu* ORCHARD 1978 and *Po*. aff. *porcillus* (Richmond Walk, RW39) (Orchard 1978, p.909, 913, text-fig. 2, table 1). Neither of the last two forms has been found in the Torquay area.

According to Scrutton (1977b, p.169), the upper levels of the Daddyhole Limestone are developed at Dyer's Quarry (SX92236277; Text-fig. 5b). Corals are particularly abundant in the lower part of the succession at this locality, although they become scarce in higher beds; thickets of fasiculate Rugosa are exposed in growth position in the quarry floor where they are interbedded with horizons rich in solitary Rugosa, some of the last forms also still standing in their position of growth (see Scrutton 1977b, p.169-170; 1978a, p.34-35 for full description of lithologies and macrofauna). Conodonts are rare here and just a single specimen of *E*. cf. *b*. *montensis* was yielded by the dark, bedded, micritic and generally poorly fossiliferous limestones in the back wall of the quarry, at about 4 m below the base of a distinctive c.12 cm thick tuff band (DY-2). Both this form and *I*. *c*. *corniger* occurred in the eastern face of Peaked Tor Cove (SX92146285; Text-fig. 5b, PK-1-4), in red-grey, rather shaly limestones which bear corals, brachiopods and bryozoa in a crinoidal and shelly matrix, seen on both the lower (right-way up) and upper (inverted) limbs of the faulted, overturned syncline. In the absence of *I*. *retrodepressus*, the Dyer's Quarry and Peaked Tor Cove faunas are judged to be younger than the youngest associations at Triangle Point, although they still date from within the *c*. *costatus* Zone. This supports Scrutton's contention that the Daddyhole Limestone at Dyer's Quarry is stratigraphically higher than that in the Triangle Point district.

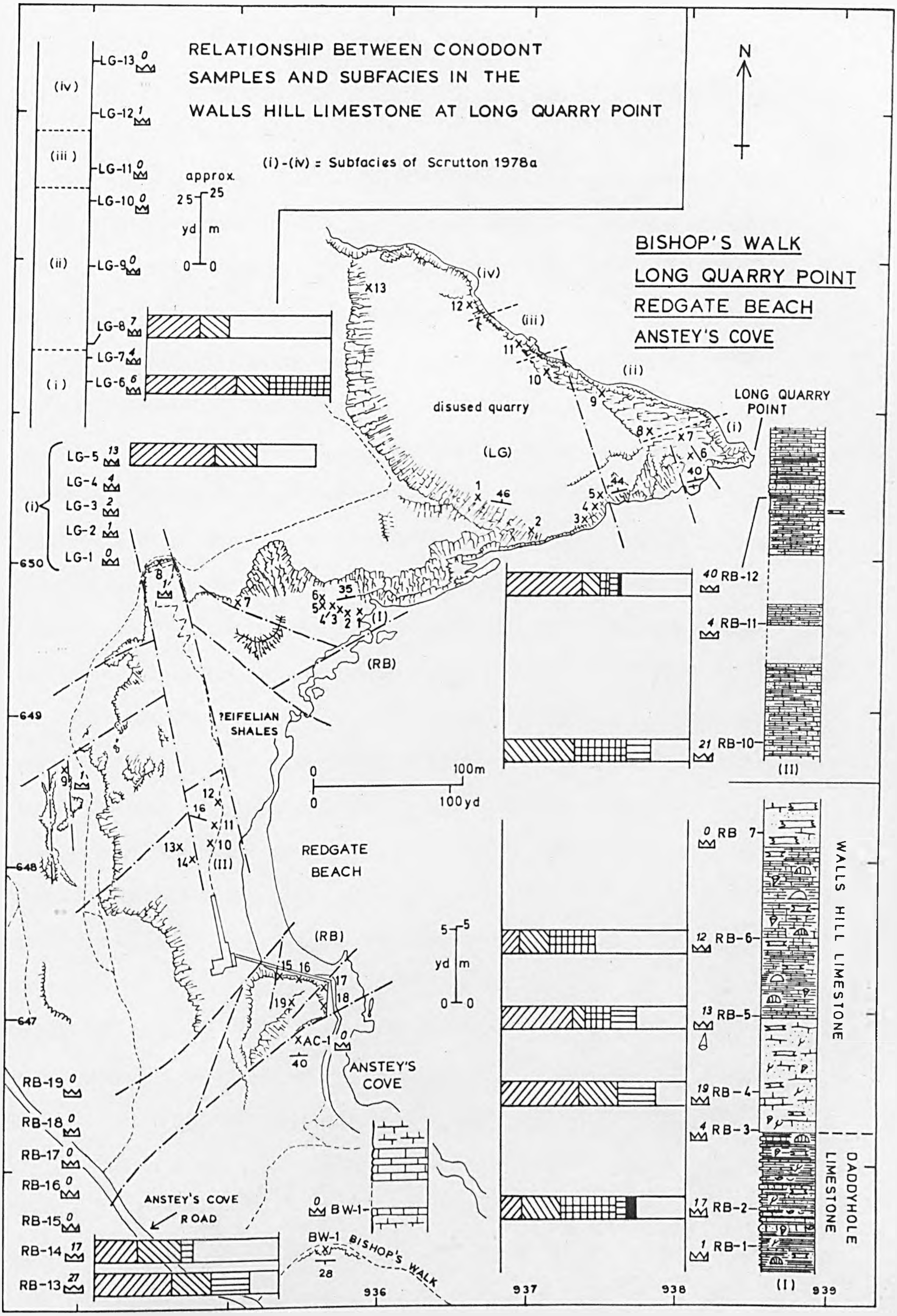

a
VANEHILL ROAD
921
922
633
632
631
(I)
(II)
VH-1
VH-2
24
30
VANEHILL ROAD
0
100m
0
100yd
N
5 yd m 5
0 0
* richly fossiliferous horizons, as at Triangle Point
(contain)
PEAKED TOR COVE
(PK)
PK-4
PK-3
PK-2
PK-1
8
2
(II)
(I)
923
629
628
PEAK TOR AVENUE
ROCK END WALK
(RE)
DYER'S QUARRY
(DY)
LONDON BRIDGE
RE-1 0
RE-2 1
RE-3 1
100m
100yd
DYER'S QUARRY
PEAKED TOR COVE
ROCK END WALK
DY-4
DY-3
DY-2
DY-1
tuff band
BACK FACE OF DYER'S QUARRY
l=laminations
b
PK-4 28
PK-3 15
c
HOPE'S NOSE
(d)
(c)
(b)
(a)
HN-1
HN-2
HN-3
HN-4
HN-5
HN-6
HN-7
HOPE'S NOSE QUARRY (SSE face)
trace of fault parallel to quarry face
disconformity
(d) thin-bedded, coral-brachiopod limestones with tuff bands
(c) massive-poorly-bedded limestone, stromatoporoid-rich to E
(b) bedded limestone
(a) massive stromatoporoid limestone
Hope's Nose Quarry: HN-1–HN-7
MEADFOOT BEDS & STADDON GRITS (MB & SG)
thin-bedded lst.
EIFELIAN SHALES
MB & SG
HOPE'S NOSE
(HN)
635
945
950
955
10
11
12
13
(I)
thrust
R.B. raised beach
shales
thin-bedded lst. with tuff bands (d)
massive - thick-bedded lst. with stroms. (a)-(c)
0 100m
0 100yd
Geological map of Hope's Nose and profile of SSE face of old quarry after Scrutton 1978a, text-fig. 11
2.5 yd m 2.5
0 0
HN-13 0
HN-12 0
HN-11 2
HN-10 0
HN-1 0
HN-2 0
HN-3 0
HN-4 0
HN-5 0
HN-6 0
HN-7 0
tuff bands

Text-fig. 5.

Massive, coral-bearing limestones cropping-out in the cliff top to the east of Dyer's Quarry failed to produce diagnostic taxa (Rock End Walk, SX92366276; Text-fig. 5b, RE-1-3), nor were any conodonts found in dark, bedded limestones seen in Vane Hill Road (SX92056330; Text-fig. 5a, VH-1, 2), where the horizons resemble those exposed on Triangle Point in the presence of several richly fossiliferous levels. The various lithologies at Hope's Nose (SX947635; Text-fig. 5c) were also largely barren of conodonts, apart from two indeterminate icriodids recovered from thin-bedded limestones at SX94856349 (HN-11). The thin limestones are very fossiliferous and contain brachiopods, corals, bryozoa, gastropods and trilobites, while the microfauna includes ostracods and foraminifera in addition to conodonts (see Scrutton 1977b, p.170; 1978a, p.29-32 for a full description of Hope's Nose).

Area 2 (Redgate Beach, RB-1-19; Long Quarry Point, LG-1-13; Babbacombe Road, BR-1-9; Withy Point, WP-1; New Quarry, NQ-1-6; Ilsham District [Bishop's Walk, BW-1; Ashton Terrace, AT-1; Kent's Cavern, KC-1; Ilsham Marine Drive, IM-1,2]; Anstey's Cove, AC-1; Text-figs. 6, 7).

Successions at Redgate Beach and Long Quarry Point (SX935649 and SX937650 respectively; Text-fig. 6) were described by Scrutton (1977b, p.171-172; 1978a, p.35-37). The top of the Daddyhole Limestone is exposed at the base of the sea cliffs at the northern end of Redgate Beach (SX93576497), where it is represented by about 10 m of dark, bedded, crinoidal limestones, with dark argillaceous bands and partings and with a fauna which includes corals, stromatoporoids and shell fragments. The base of the succeeding Walls Hill Limestone is defined as the base of the overlying c.8 m thick band of pale grey, massive limestone, which contains corals and stromatoporoids. This lithology is in turn overlain by about 12 m of red-grey, shaly, crinoidal limestone with corals and stromatoporoids, which underlies the thick, massive limestone development of Walls Hill itself. The Walls Hill Limestone is typified by a usually massive, pale-medium grey, white weathering


RELATIONSHIP BETWEEN CONODONT SAMPLES AND SUBFACIES IN THE WALLS HILL LIMESTONE AT LONG QUARRY POINT
(i)-(iv) = Subfacies of Scrutton 1978a
approx.
25 yd 25 m
0 0
N
BISHOP'S WALK
LONG QUARRY POINT
REDGATE BEACH
ANSTEY'S COVE
(iv)
(iii)
(ii)
(i)
LG-13 0
LG-12 1
LG-11 0
LG-10 0
LG-9 0
LG-8 7
LG-7 4
LG-6 6
LG-5 13
LG-4 4
LG-3 2
LG-2 1
LG-1 0
650
649
648
647
disused quarry
(LG)
LONG QUARRY POINT
(RB)
?EIFELIAN SHALES
REDGATE BEACH
ANSTEY'S COVE
ANSTEY'S COVE ROAD
BISHOP'S WALK
AC-1 0
BW-1
0 100m
0 100yd
5 yd 5 m
0 0
40 RB-12
4 RB-11
21 RB-10
(II)
0 RB 7
12 RB-6
13 RB-5
19 RB-4
4 RB-3
17 RB-2
1 RB-1
(I)
0 BW-1
WALLS HILL LIMESTONE
DADDYHOLE LIMESTONE
RB-19 0
RB-18 0
RB-17 0
RB-16 0
RB-15 0
RB-14 17
RB-13 27
936
937
938
939

Text-fig. 6.

limestone, in which the fauna is dominated by stromatoporoids in a crinoidal, micritic or sometimes sparry matrix.

The lower part of the Walls Hill Limestone is represented by the c.140 m thick succession of massive, stromatoporoid limestone exposed in the old quarry on Long Quarry Point, in which Scrutton (1977b, p.172; 1978a, p.37) recognised four subfacies. He observed a gradual change in shape and density of the stromatoporoids throughout the sequence, from abundant laminar to tabular coenostea in Subfacies (i) (the basal division), through less dense tabular and occasional large conical forms in Subfacies (ii), to small, irregular, more densely distributed coenostea in Subfacies (iii), and small, rounded, disorientated forms in pockets at the top of Subfacies (iii) and also in Subfacies (iv), where large laminar to tabular shapes were still present. Some degree of disorientation of the stromatoporoids was recorded also at lower levels. Scrutton noted that the associated fauna was of corals and, sometimes, brachiopods throughout the succession, and that the matrix was often crinoidal, while spar-filled cavities were common in Subfacies (i) but became less so in higher horizons. Corals were most diverse in Subfacies (iii), where tabulates were more common than elsewhere and some fasiculate forms (tabulate and rugose) were intergrown with stromatoporoids. Subfacies (iii) contained also bryozoa and the matrix was variable, being largely crinoidal but with micritic patches and sparry cavities. A finer crinoidal matrix was evident in the succeeding Subfacies (iv), where there was little associated fauna. Stromatoporoid morphotypes at Long Quarry Point were described also by Kershaw and Ridings (1980).

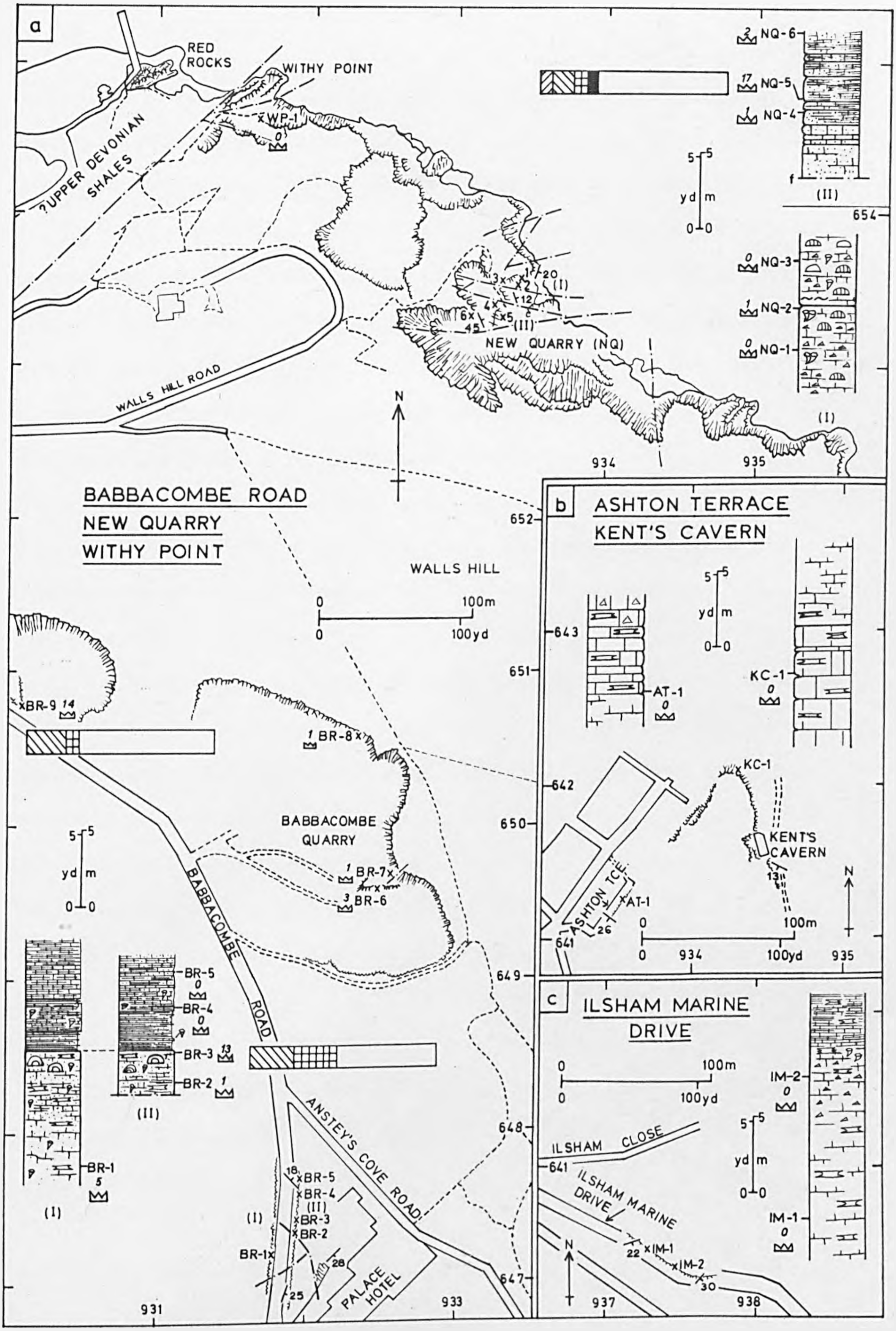
At Redgate Beach, conodonts were recovered from the Daddyhole Limestone and Walls Hill Limestone in the northern cliff (RB-1, 2 and RB-3-6 respectively), and from isolated outcrops of the last formation in the cliff slope to the west of the beach (red-grey shaly limestones around SX93496483, RB-10, 11, 12; massive limestones near SX93466481, RB-13, 14). Po. l. linguiformis, Po. pseudofoliatus, Po. x. ensensis (phyletically late forms) and specimens referred to the I. expansus group are common to many of the faunas, while I. aff. obliquimarginatus occurs just in the Walls Hill Limestone (RB-10). Together, these taxa characterise an interval from the mid ensensis Zone to the top of the Lower varcus Subzone. Other elements found are Po. l. subsp. a and Po l. subsp. b (Walls Hill Limestone, RB-12-14 and RB-4, 10 respectively), and T. aff. variabilis (Daddyhole Limestone, RB-2). The first form indicates that the age of the faunas is restricted to within the upper part of the ensensis Zone, which estimation is supported by the main time spans of the last two taxa (see Weddige 1977, tables 2, 5). A single specimen designated I. cf. regularicrescens is present in RB-12. This species attains only the lower part of the ensensis Zone in Germany (Weddige loc. cit.), but ranges higher in Belgium, into Gia (Bultynck 1972, text-fig. 12). T. aff. variabilis herein displays some similarities to Po. aff. variabilis which Orchard (1978, p.914-915, text-fig. 2, table 1) recorded in Fauna 6 at Princerock Quarry (PS3, 4), Cattedown Quarry (CQ10) and Gasworks Quarry (GQ16, 20). Faunal associates in the Plymouth samples included other forms seen at Redgate Beach, namely I. obliquimarginatus, Po. pseudofoliatus, Po. x. ensensis, Po. l. linguiformis and, more importantly, Po. l. subsp. a (as Po. l. linguiformis, ?epsilon morphotype). The last taxon and Po. aff. variabilis occurred together also at Cattedown Quarry (CQ8), this time with I. cf. regularicrescens. Orchard referred Fauna 6 to the (then) obliquimarginatus Zone. In terms of current terminology, the grouping dates from within the upper portion of the ensensis Zone.

Conodonts were found mainly in the lower part of the succession at Long Quarry Point (Subfacies (i) and (ii): see Text-fig. 6 for relationship between samples and subfacies). Forms common to Redgate Beach and Long Quarry Point are Po. l. linguiformis, Po. pseudofoliatus, Po. x. ensensis and I. expansus group (variously occurring at the latter locality in LG-4, 5, 6, 8), while Po. l. alveolus is identified both at Long Quarry Point (LG-3, 12) and in the Walls Hill Limestone at Redgate Beach (RB-13: Po. cf.

l. alveolus). The last subspecies was previously known only in Germany, where it was recorded in collections no younger than the kockelianus Zone in age (Weddige 1977, tables 2, 5, 11-15, 18). The occurrence in Torquay indicates that here Po. l. alveolus has a greater time span, and ranges upwards into the higher parts of the ensensis Zone. Other forms recovered from Long Quarry Point include Po. aff. pseudofoliatus, Po. aff. x. xylus and Po. cf. c. costatus (LG-3, 5; LG-6; LG-4, 7 respectively). Specimens referred to the last taxon are poorly preserved and are judged to be reworked, because this well established subspecies is known from no higher than the lower part of the australis Zone elsewhere (see Systematic Palaeontology).

Scrutton (1977b, p.171) thought that the red-grey shaly limestone unit of the Walls Hill Limestone in the northern cliff at Redgate Beach was exposed also inland, in the cutting near the Palace Hotel on Babbacombe Road (SX93196475; Text-fig. 7a). No conodonts were found in the shaly lithology in the cutting (BR-4, 5), while the massive limestone beneath yielded just Po. l. linguiformis and I. expansus group (BR-1-3). Further north along Babbacombe Road, disused quarries on the western edge of Walls Hill (around SX93226500) are developed in Walls Hill Limestone. Here the massive, stromatoporoid limestone contains abundant corals in a crinoidal matrix, and resembles Subfacies (ii)-(iii) at Long Quarry Point. Samples from the quarries themselves lacked diagnostic forms (BR-6-8), but a roadside outcrop at SX93016508 (BR-9) produced the same association of I. aff. obliquimarginatus, Po. l. linguiformis, Po. l. subsp. a and Po. l. subsp. b seen at Redgate Beach. This confirms that the Walls Hill Limestone in this district is upper ensensis Zone in age.

Fine grained, flinty and unfossiliferous limestones at Withy Point (SX93176548; Text-fig. 7a, WP-1) were barren of conodonts, and they were rare in fairly massive, fine grained limestones with Amphipora and Hexagonaria at the northern end of New Quarry (SX933653; Text-fig. 7a, Section I, NQ-1-3).


a
RED ROCKS
WITHY POINT
WP-1
0
?UPPER DEVONIAN SHALES
WALLS HILL ROAD
NEW QUARRY (NQ)
(I)
(II)
3x
x2
1
20
12
4x
6x
x5
45
N
934
935
654
NQ-6
NQ-5
NQ-4
NQ-3
NQ-2
NQ-1
2
17
1
0
1
0
f
5
5
yd
m
0
0
BABBACOMBE ROAD
NEW QUARRY
WITHY POINT
WALLS HILL
0
100m
0
100yd
652
651
650
649
648
647
BR-9
14
BR-8
1
BABBACOMBE QUARRY
BR-7
1
BR-6
3
BABBACOMBE ROAD
ANSTEY'S COVE ROAD
PALACE HOTEL
BR-5
0
BR-4
0
BR-3
13
BR-2
1
BR-1
5
(I)
(II)
18
25
28
931
933
b
ASHTON TERRACE
KENT'S CAVERN
643
642
641
AT-1
0
KC-1
0
KENT'S CAVERN
ASHTON TCE
26
13
0
100m
0
100yd
934
935
N
c
ILSHAM MARINE DRIVE
0
100m
0
100yd
ILSHAM CLOSE
641
ILSHAM MARINE DRIVE
IM-1
IM-2
22
30
0
0
937
938
N

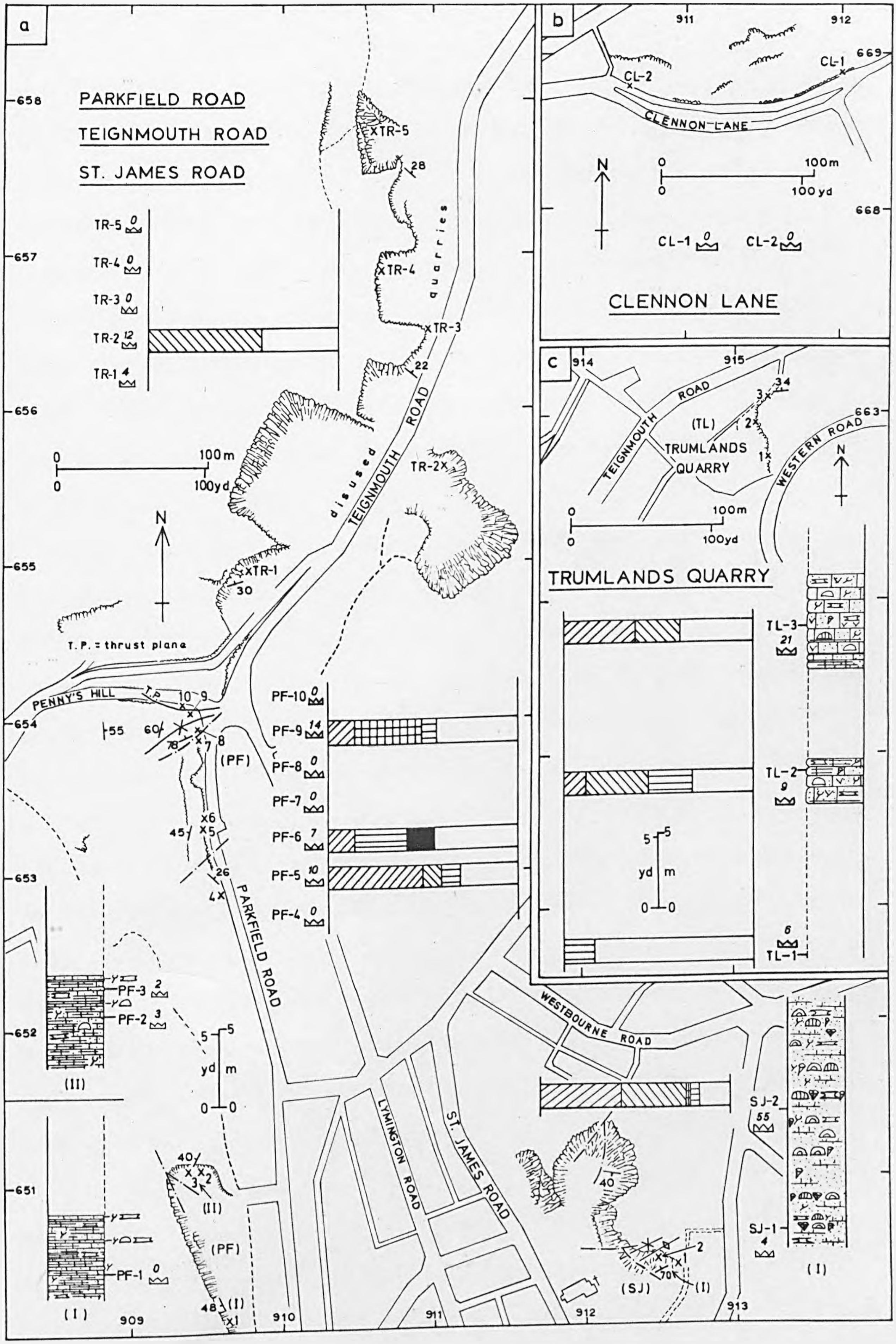
Text-fig. 7.

However, higher, bedded, crinoidal and slightly shaly limestones in the central part of the quarry were more productive, and *Po. pseudofoliatus* and *I.* aff. *obliquimarginatus* were identified there (Text-fig. 7a, Section II, NQ-4-6). The absence of *Po. l.* subsp. a suggests that these beds may be younger than the last appearance of this form, and thus may be of highest *ensensis* Zone or Lower *varcus* Subzone age. The latter estimation is discounted because the *Po. varcus* group itself is not represented, and a correlation is made with the uppermost part of the *ensensis* Zone. Scrutton (1977b, p.172; 1978a, p.38) thought that the Withy Point horizons were either above, or might be lateral equivalents of, those at Long Quarry Point, and were themselves succeeded by the New Quarry sequences. The conodont evidence supports his contention that the New Quarry beds are the youngest seen in the Walls Hill area.

No conodonts were found in thick-bedded and massive, micritic, sparsely fossiliferous limestones developed in the Ilsham district in Area 2 (Bishop's Walk, SX93566454, BW-1; Ashton Terrace, SX93346411, AT-1; Kent's Cavern, SX93426421, KC-1; Ilsham Marine Drive, SX93746403, IM-1, 2; Text-figs. 6, 7b, 7c), which were regarded as part of the Walls Hill Limestone by Scrutton (1977b, p.171). Also barren of conodonts were the massive, stromatoporoid and coral-bearing limestones at the southern end of Redgate Beach (SX93546471, RB-15-19), which are faulted against the slates with ash bands of Anstey's Cove (SX935646; Text-fig. 6). The ostracod evidence suggests that the Anstey's Cove beds are probably of *Clymenia* or *Wocklumeria* Stufen (late Famennian) age (House 1963, p.8-9; 1977, p.20). No conodonts were found here (AC-1).

Area 3 (Parkfield Road, PF-1-10; Teignmouth Road, TR-1-5; St. James Road, SJ-1, 2; Text-fig. 8a).

In Area 3, dark grey-pink, thin-bedded limestones and shaly limestones crop out along Parkfield Road (around SX909650 and SX909653), Penny's


a
PARKFIELD ROAD
TEIGNMOUTH ROAD
ST. JAMES ROAD
TR-5 0
TR-4 0
TR-3 0
TR-2 12
TR-1 4
0 100m
0 100yd
N
T.P. = thrust plane
PENNY'S HILL
T.P.
xTR-5
28
xTR-4
xTR-3
22
TR-2x
xTR-1
30
disused quarries
TEIGNMOUTH ROAD
10 9
55
60
78
8
7
(PF)
x6
45
x5
26
4x
PARKFIELD ROAD
PF-10 0
PF-9 14
PF-8 0
PF-7 0
PF-6 7
PF-5 10
PF-4 0
PF-3 2
PF-2 3
(II)
5 5
yd m
0 0
40
3 2
(II)
(PF)
PF-1 0
(I)
48
(I)
x1
LYMINGTON ROAD
ST. JAMES ROAD
WESTBOURNE ROAD
SJ-2
55
SJ-1
4
(I)
40
2
1
70
(SJ)
(I)
658
657
656
655
654
653
652
651
909
910
911
912
913
b
911
912
669
668
CL-1
CL-2
CLENNON LANE
N
0 100m
0 100yd
CL-1 0
CL-2 0
CLENNON LANE
c
914
915
663
TEIGNMOUTH ROAD
WESTERN ROAD
3
34
2
1
(TL)
TRUMLANDS QUARRY
N
0 100m
0 100yd
TRUMLANDS QUARRY
TL-3
21
TL-2
9
5 5
yd m
0 0
6
TL-1

Text-fig. 8.

Hill (SX90906541), and at the southern end of Teignmouth Road (for example, at SX90976549 and SX91106556). These horizons are crinoidal, and bear corals and laminar stromatoporoids. At the northernmost end of Parkfield Road and on Penny's Hill the beds are much disturbed and are in thrust relationship with massive, pale grey limestones. The latter contain occasional stromatoporoids (usually broken) with a few corals, and are exposed beneath the thrust-plane evident at the eastern end of Penny's Hill (SX90936541). Disused quarries further north along Teignmouth Road (SX9100-6555 to SX91066576) are developed in similar massive, often micritic, limestones.

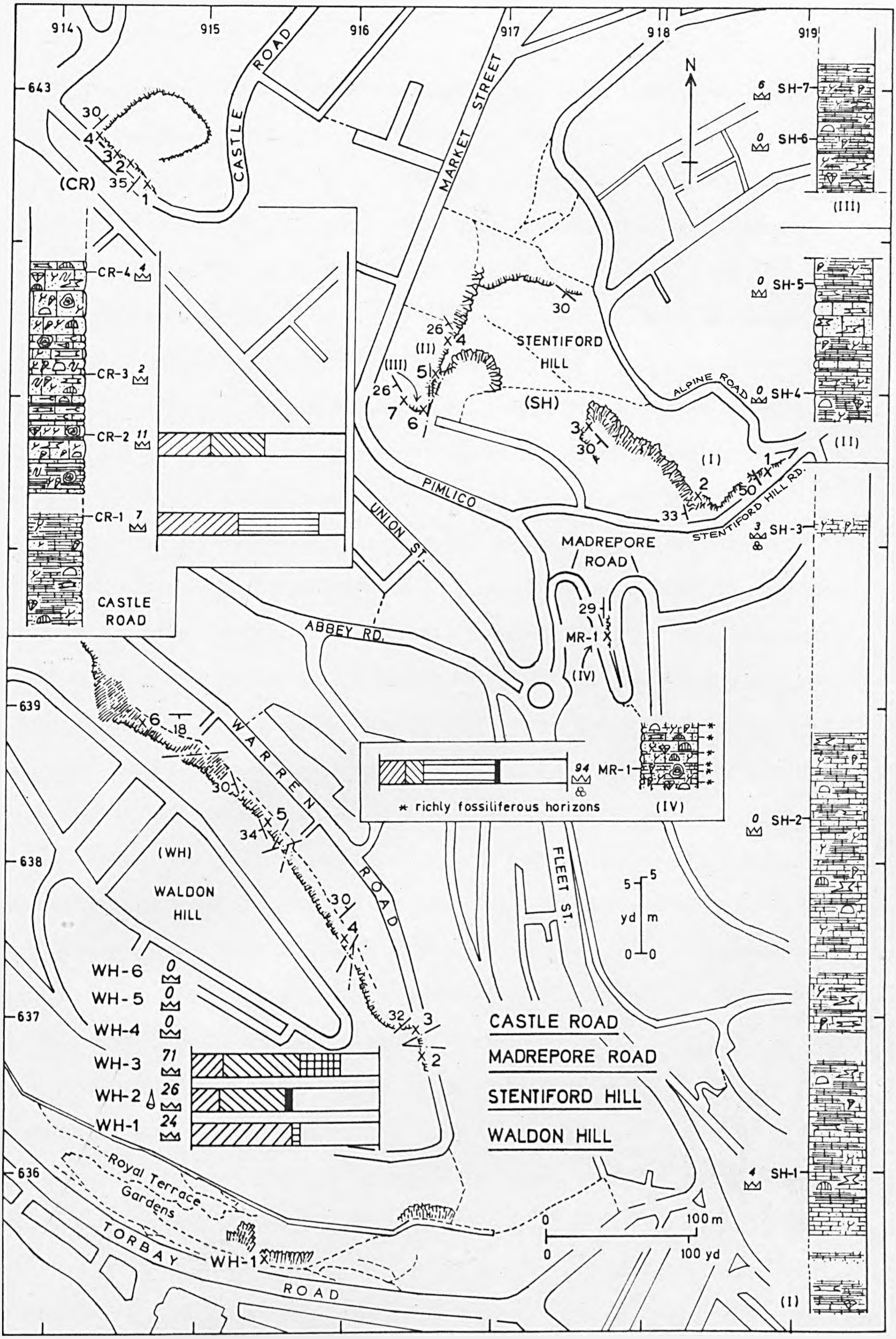
Faunas from the bedded and shaly limestones include I. arkonensis, I. expansus group, Po. l. linguiformis, Po. pseudofoliatus and O. brevis (PF-5, 6, 9; TR-1). The occurrence of the first species in Germany (Weddige 1977, tables 2, 5) implies that the strata date from the lower half of the ensensis Zone, and are no younger than late Eifelian in age. The other icriodids and the polygnathids are consistent with this estimation, although they all occur in both older and younger zones. The presence of O. brevis here lends further support to its age range extending below the Lower varcus Subzone (see discussion in Systematic Palaeontology). In Plymouth, Orchard (1978, p.915) indicated that I. arkonensis may be represented in Fauna 6 (Teat's Hill Quarry, TH47-49; Drake's Island, DI1-3; Gasworks Quarry, GW20), but he preferred to place the specimens within the broader concept of the I. expansus group. The massive limestones on Penny's Hill (PF-10) and Teignmouth Road (TR-1-5) were barren of conodonts.

In the eastern part of Area 3, medium-dark grey-red, bioclastic and crinoidal, massive limestones are exposed behind St. James Road (SX912-650). Corals (tabulate and rugose) and stromatoporoids (often rolled, rounded forms) are concentrated at several horizons, while intervening bands are rather less fossiliferous and appear paler grey in colour. The latter lithology produced a fauna in which Po. l. linguiformis, Po. x. ensensis and Po. x. xylus are identified, with juveniles of Po. timorensis and Po. varcus group sp. indet. (SJ-2). In the absence of taxa indicative of the Middle varcus Subzone (such as Po. ansatus: see discussion under Area 5), the association is linked to the Lower varcus Subzone.

Area 4 (Castle Road, CR-1-4; Stentiford Hill, SH-1-7; Madrepore Road, MR-1; Waldon Hill, WH-1-6; Text-fig. 9).

A section in Castle Road (SX914642) is developed in about 30 m of medium grey-red, bedded limestones with corals, stromatoporoids (laminar, encrusting and broken forms), and occasional bryozoa. The matrix may be crinoidal, sometimes coarsely so. The lower part of the section is shaly and rather less fossiliferous than higher parts, where some horizons are crowded with fossils. Conodonts are sparse here and tend to be fragmented, but Po. l. linguiformis, Po. timorensis, Po. x. ensensis and Po. varcus group sp. indet. are recognised (CR-1-4). The fauna is similar to that at St. James Road (see above), and is again referred to the Lower varcus Subzone.

About 300 m to the south-east, medium grey-red and often shaly crinoidal limestones are seen in sections on Stentiford Hill (SX917641). Corals and stromatoporoids (both groups as at Castle Road) are present and may be locally abundant, producing richly fossiliferous bands as in the bedded limestones cropping-out on the southern flanks of the hill on Madrepore Road (SX91776394). Conodont faunas from Stentiford Hill are, for the most part, sparse and lacking in diagnostic taxa (SH-1-7), but a coarsely crinoidal limestone in Madrepore Road (MR-1) yielded a well preserved collection which includes Po. ansatus, Po. timorensis, Po. x. xylus, Po. varcus group sp. indet., Po. l. linguiformis, Po. l. mucronatus and Sp. planus, and is characteristic of the Middle varcus Subzone. Comparable faunas occur in the higher part of the Shell Bed and in the Barton Limestone at Lummaton Quarry (Area 5, q.v.). The Madrepore Road and Lummaton


914
915
916
917
918
919
643
639
638
637
636
N
CASTLE ROAD
MARKET STREET
(CR)
CR-4
CR-3
CR-2
CR-1
CASTLE ROAD
STENTIFORD HILL
(SH)
ALPINE ROAD
STENTIFORD HILL RD.
PIMLICO
UNION ST.
ABBEY RD.
MADREPORE ROAD
MR-1
(IV)
WARREN ROAD
FLEET ST.
(WH)
WALDON HILL
WH-6
WH-5
WH-4
WH-3
WH-2
WH-1
Royal Terrace Gardens
TORBAY ROAD
SH-7
SH-6
SH-5
SH-4
SH-3
SH-2
SH-1
(I)
(II)
(III)
* richly fossiliferous horizons
100 m
100 yd
yd m
CASTLE ROAD
MADREPORE ROAD
STENTIFORD HILL
WALDON HILL

Text-fig. 9.

associations are similar also with regard to the total absence of icriodids and the abundance of simple cones.

Approximately 400 m to the south-west of Stentiford Hill, medium grey-red, irregularly bedded-massive, bioclastic and crinoidal limestones are exposed at various levels on Waldon Hill (SX915637). They contain a coral-stromatoporoid fauna which may be locally prolific and resembles that seen in the Castle Road and Stentiford Hill sections. *Po*. *pseudofoliatus* and *Po*. aff. *x*. *ensensis* were recovered from an isolated outcrop at the southern foot of Waldon Hill in Royal Terrace Gardens (SX91546354; WH-1). The latter form is thought to be intermediate between *Po*. *x*. *ensensis* and either *Po*. *timorensis* or, more probably, *Po*. *ansatus*. In view of the respective age ranges of these various taxa, the collection is judged to date from the upper half of the Lower *varcus* Subzone. Samples from the southern end of Warren Road at the top of Waldon Hill (SX91646368; WH-2, 3) produced both *Po*. *l*. *linguiformis* and its epsilon morphotype, *Po*. *l*. *mucronatus*, *Po*. *varcus*, *Po*. *x*. *xylus* and *Po*. aff. *ovatinodosus*, most of these forms being represented also in the upper portion of the Shell Bed and/or in the Barton Limestone at Lummaton (Area 5, *q*.*v*.). The Waldon Hill/Warren Road faunas are equated with the Middle *varcus* Subzone and, as at Lummaton, the presence of *Po*. aff. *ovatinodosus* suggests correlation with the higher part of this interval. In contrast with associations from the latter locality, simple cones are sparse at Waldon Hill, while icriodids occur and are referred to the *I*. *expansus* group and to *I*. aff. *obliquimarginatus*, both taxa being consistent with the estimation of the age.

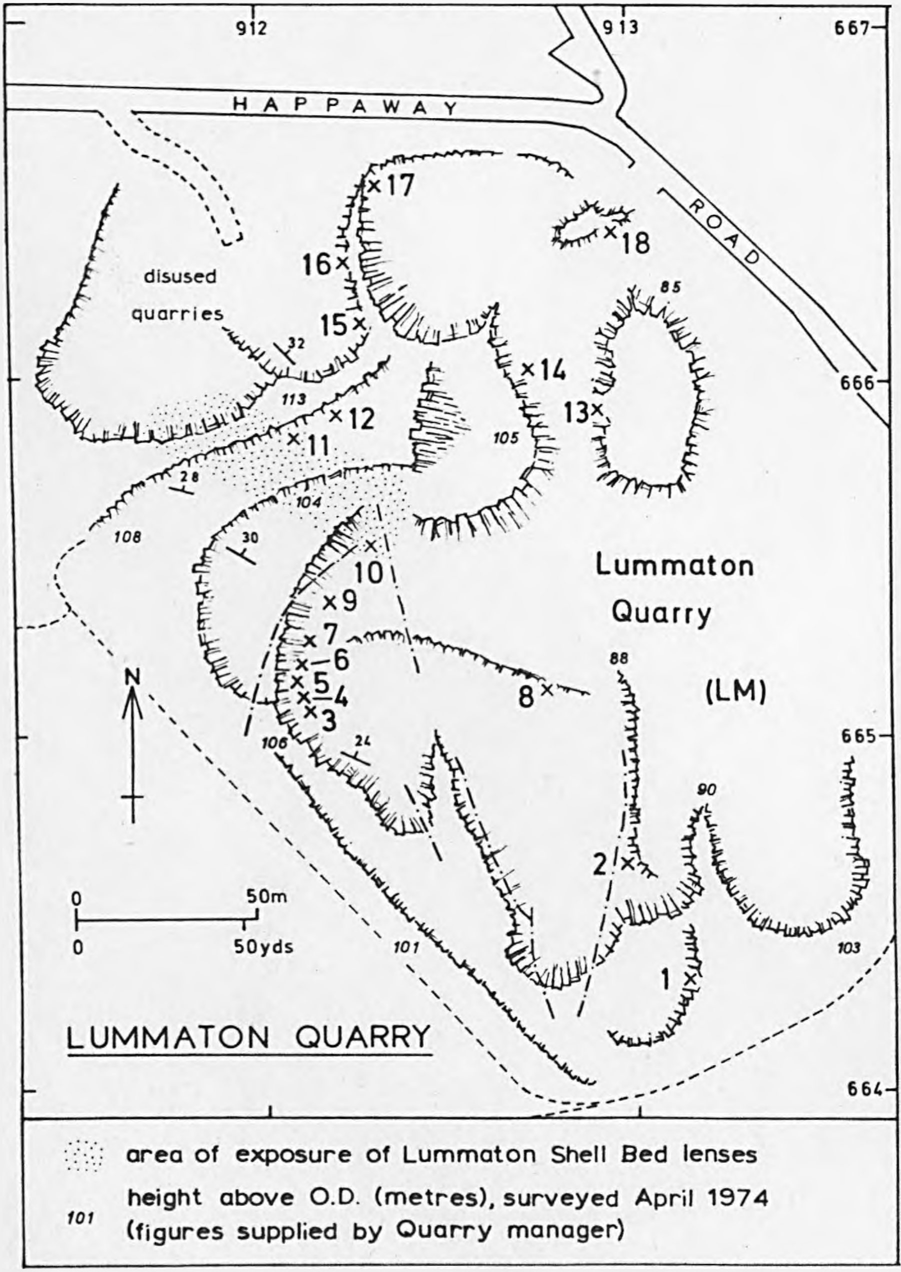
In Plymouth, Orchard (1978, p.915) reported Middle *varcus* Subzone collections in which the genus *Icriodus* was represented at Richmond Walk (RW-10-13, 25-28, ?41-44: Fauna 8). However, the icriodids there were referred to *I*. *l*. *latericrescens*, which subspecies, together with the mutually-occurring *Po*. *ansatus*, indicates an age within the lower half of the subzone (see Ziegler in Klapper and Ziegler 1979, text-fig. 5).

Area 5 (Lummaton Quarry, LM-1-18; Trumlands Quarry, TL-1-3; Text-figs. 8c, 10).

The top of the Walls Hill Limestone is exposed in the southern part of Lummaton Quarry (SX913665; Text-fig. 10), where it is represented by approximately 50 m of pale-medium grey, pale-weathering, massive limestone. Abundant stromatoporoids and scattered corals (rugose and tabulate) are contained in the crinoidal, sometimes sparry matrix, and dolomitisation is common. At the northern end of the quarry irregular lenses of the Lummaton Shell Bed are developed in still massive, pale-medium grey but rather less dolomitised limestone. The Shell Bed fauna is well documented (see Scrutton 1978a, p.39), and consists largely of brachiopods with bivalves, gastropods, trilobites, crinoids, ostracods and algae. Bryozoa also occur, and are dominant in the matrix (Elliott 1961, p.255). The Lummaton Shell Bed Member is the basal division of the succeeding Barton Limestone, which is present in the northern part of the quarry and comprises about 30 m of rather darker grey, massive, bioclastic limestone, with some areas of dolomitisation, and with a fauna of corals, small scattered stromatoporoids and brachiopods. The lithologies, stratigraphy and macrofaunas of Lummaton Quarry have been described by Scrutton (1977b, p.173, 174; 1978a, p. 39-40).

Po. timorensis, *Po. l. linguiformis* and *O. brevis* are commonly encountered in all horizons at Lummaton. Other representatives of the *Po. varcus* group, including *Po. x. xylus* (LM-15) and juveniles possibly of *Po. varcus* itself (LM-18), *Po. l. linguiformis* epsilon morphotype (LM-1, 17) and *Sp. planus* (LM-9, 10, 17, 18), were found rather more sporadically. *Po. ansatus* appears towards the top of the Shell Bed levels in LM-11, and thereafter is present more or less throughout the Barton Limestone in the quarry (LM-15, 16, 18). The distinctive *Po. l. mucronatus* occurs at the entry of *Po. ansatus* (LM-11), and a further linguiform polygnathid, *Po. l. linguiformis* delta morphotype, may also be represented in the Barton Limestone (LM-13). The occurrences of these various forms are shown on Text-fig. 10. It should be

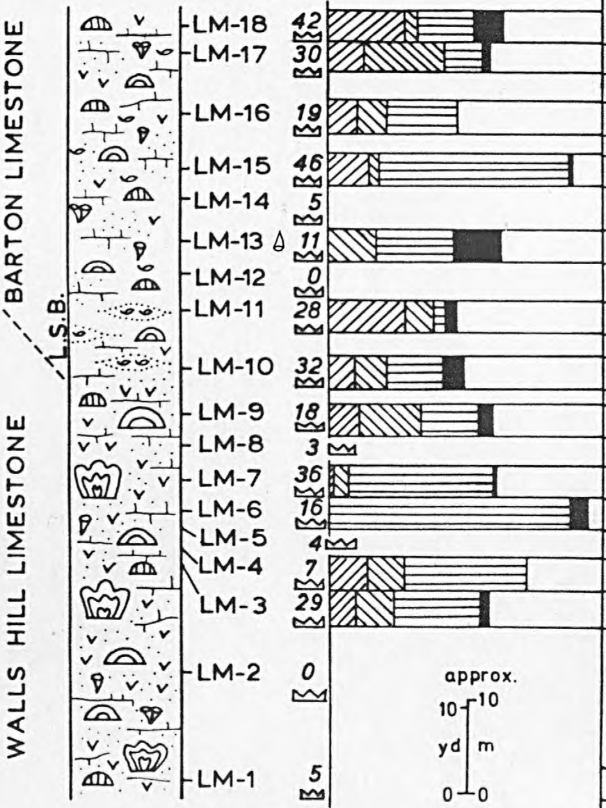
Text-fig. 10.


912
913
667
666
665
664
HAPPAWAY
ROAD
disused quarries
Lummaton Quarry (LM)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
32
28
30
24
85
88
90
113
104
105
108
106
101
103
N
0 50m
0 50yds
LUMMATON QUARRY
area of exposure of Lummaton Shell Bed lenses
101 height above O.D. (metres), surveyed April 1974 (figures supplied by Quarry manager)

RELATIONSHIP BETWEEN CONODONT SAMPLES AND STRATIGRAPHY AT LUMMATON QUARRY, AND OCCURRENCE OF TAXA

Shell Bed lenses (not drawn to scale)

L.S.B. Lummaton Shell Bed Member



Sample	Count	O. brevis	Po. timorensis	Po. l. linguiformis	Po. l. linguiformis ε m'type.	Po. varcus gp. (indet. juvs.)	Sp. planus	Po. ansatus	Po. l. mucronatus	Po. l. linguiformis δ m'type.	Po. x. xylus	Po. aff. ovatinodosus	Po. varcus
LM-18	42	×	×	×		×	×	×					?
LM-17	30			×	×	×	×					×	
LM-16	19					×		×					
LM-15	46	×		×		×		×			×		
LM-14	5												
LM-13	11	×		×						cf.			
LM-12	0												
LM-11	28	×	×	×				×	×				
LM-10	32	×	×	×			×						
LM-9	18		×	×			×						
LM-8	3												
LM-7	36	×		×		×							
LM-6	16	×											
LM-5	4		×	×									
LM-4	7		×	×									
LM-3	29	×	×	×									
LM-2	0												
LM-1	5	×	×	×	×								

noted that Po. ansatus, Po. timorensis and Po. l. linguiformis had previously been reported from the Shell Bed by Matthews (1970: cited as Po. cf. decorosa, Po. varca and Po. linguiformis respectively).

The first appearance of Po. timorensis characterises the base of the Lower varcus Subzone. Po. l. linguiformis, Po. l. linguiformis epsilon morphotype, Po. varcus, Po. x. xylus, O. brevis and Sp. planus either range upwards from below or enter within this interval, and all these taxa, including Po. timorensis, extend at least into the Middle varcus Subzone. The first occurrence of Po. ansatus defines the base of the last division, and Po. l. mucronatus appears simultaneously and ranges higher into the Upper varcus Subzone, whereas Po. ansatus only questionably attains this portion (Ziegler et al. 1976, p.113-114, tables 1-15; Ziegler in Klapper and Ziegler 1979, text-fig. 5). Faunas from the top of the Lummaton Shell Bed and from the Barton Limestone are therefore characteristic of the Middle varcus Subzone, while those from the underlying upper horizons of the Walls Hill Limestone, before the appearance of Po. ansatus, are referred to the Lower varcus Subzone. The Shell Bed levels themselves straddle the Lower-Middle varcus Subzone boundary.

Almost all the Middle varcus Subzone may be represented by the Barton Limestone at Lummaton. The possible occurrence of Po. l. linguiformis delta morphotype in LM-13 indicates that this and subjacent horizons of the Barton Limestone date from the lower half of the Middle varcus Subzone, this being the main age range of the delta form (Ziegler et al. 1976, p.113, tables 7, 8, 10-13; Ziegler in Klapper and Ziegler 1979, text-fig. 5). Material designated Po. aff. ovatinodosus occurs towards the top of the Barton Limestone in the quarry (LM-17), and may be transitional from Po. ansatus to Po. ovatinodosus. Po. ovatinodosus typically enters within the Middle varcus Subzone, after the disappearance of Po. l. linguiformis delta morphotype, while specimens intermediate between Po. ansatus and Po. ovatinodosus elsewhere are of low Upper, or possibly highest Middle, varcus Subzone age

(Ziegler *et al*. 1976, p.113, tables 5, 6, 13, 15; Ziegler in Klapper and Ziegler 1979, text-fig. 5; see also Systematic Palaeontology herein). However, because taxa which first appear at the base of the Upper *varcus* Subzone have not been found at Lummaton (such as *O*. *s*. *sannemanni*, *O*. *semialternans*, *Po*. *latifossatus*: see Ziegler *et al*. 1976; Ziegler in Klapper and Ziegler 1979, text-fig. 5), the top of the Barton Limestone here is correlated with the upper part of the Middle *varcus* Subzone. It is therefore possible that the uppermost horizons at Lummaton Quarry may date from the earliest Frasnian, but most of the succession is late Givetian in age (see House and Ziegler 1977, text-fig. 4).

A late Givetian age for the Lummaton Shell Bed has long been suggested by the macrofauna, which Kayser (1889, p.186) regarded as indicative of the upper horizons of the Middle Devonian. This opinion was subsequently confirmed by the brachiopod and trilobite evidence (Elliott 1961, p.258; Selwood 1966, p.195 respectively), and by the goniatites, which include typical Givetian agoniatitids together with the zonal ammonoid *Maenioceras terebratum* (House 1963, p.6; see also House 1977, p.20). It should be noted that Selwood (1966, p.195) believed the goniatite-bearing strata to be a fault-wedge. The conodonts both substantiate and refine these age estimations.

Similar Shell Bed developments are known at Wolborough Quarry near Newton Abbot and at Mount Wise in Plymouth. The Mount Wise conodont fauna (Orchard 1978, p.916-917, text-fig. 2, table 1: Fauna 9, MW36) compares closely with that from the higher part of the Lummaton Shell Bed. *Po*. *l*. *mucronatus*, *Po*. *l*. *linguiformis*, *Po*. *ansatus*, *Po*. *timorensis* and *O*. *brevis* occur in both associations, and *Po*. *varcus* and *Sp*. *planus* are also recorded at Mount Wise, which species are identified (the former only questionably) in other horizons at Lummaton. The Mount Wise fauna is considerably more prolific than any of those from the quarry, and includes taxa which are not known in Torquay (*Po*. *tuberculatus*, *Po*. aff. *tuberculatus*). However, the collections are similar in the complete absence of icriodids and in the abundance of simple cones which, at Lummaton, are dominated by Belodella spp. with occasional Coelocerodontus spp. and Neopanderodus spp..

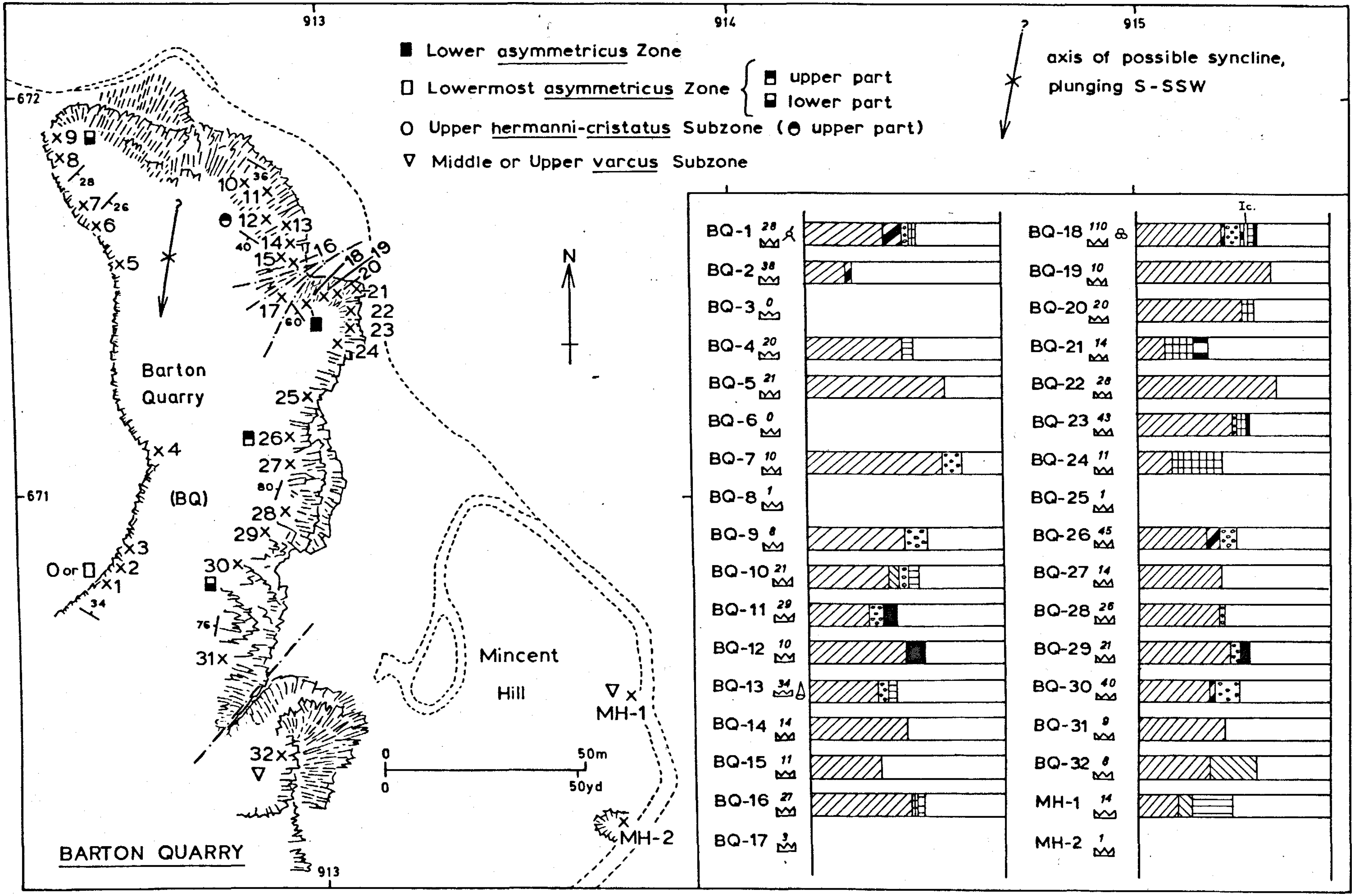
The Mount Wise association correlates with the Middle varcus Subzone, as Orchard (loc. cit.) indicated. He referred also Fauna 8 to this interval, which grouping embraced samples from Mutton Cove (MC32) and Botus Fleming (BF1-3): the former locality produced Po. l. linguiformis epsilon morphotype, while the latter yielded one specimen of the delta form together with Po. ansatus. Fauna 7 was equated with the Lower varcus Subzone and, in the presence of Po. timorensis, Po. l. linguiformis, O. brevis and abundant simple cones, is comparable with associations from the lower part of the succession at Lummaton (Orchard 1978, p.915, 916, text-fig. 2, table 1).

About 300 m to the south-east of Lummaton Quarry, Trumlands Quarry (SX91516628; Text-fig. 8c, quarry now disused and largely overgrown) is developed in c.25 m of medium grey-red, fairly thick-bedded and partly dolomitised limestone. Corals and laminar stromatoporoids are often abundant in the bioclastic and crinoidal matrix, and there are occasional shaly partings. Po. timorensis, Po. l. linguiformis and possible representatives of Po. x. xylus are recognised here (TL-1-3): the faunas are linked to the Lower varcus Subzone.

Area 6 (Barton Quarry, BQ-1-32, MH-1, 2; Clennon Lane, CL-1, 2; Text-figs. 8b, 11).

The Barton Limestone is typified at Barton Quarry (SX912671; Text-fig. 11) by medium grey, massive, often coarsely bioclastic and sparry limestone, which contains rugose and tabulate corals with usually small, scattered stromatoporoids. Various other groups have also been recorded, including brachiopods, bivalves, goniatites, gastropods and trilobites (see Scrutton 1977b, p.174; 1978a, p.40 for description of lithology and macrofauna).

Conodonts are relatively abundant throughout the quarry. The oldest faunas occur at the southern extremity of the eastern face and on Mincent Hill


Lower asymmetricus Zone
Lowermost asymmetricus Zone
upper part
lower part
Upper hermanni-cristatus Subzone (upper part)
Middle or Upper varcus Subzone
axis of possible syncline, plunging S-SSW
913
914
915
672
671
N
Barton Quarry
(BQ)
O or
Mincent Hill
MH-1
MH-2
0
50m
50yd
BARTON QUARRY
Ic.
BQ-1 28
BQ-2 38
BQ-3 0
BQ-4 20
BQ-5 21
BQ-6 0
BQ-7 10
BQ-8 1
BQ-9 8
BQ-10 21
BQ-11 29
BQ-12 10
BQ-13 34
BQ-14 14
BQ-15 11
BQ-16 27
BQ-17 3
BQ-18 110
BQ-19 10
BQ-20 20
BQ-21 14
BQ-22 28
BQ-23 43
BQ-24 11
BQ-25 1
BQ-26 45
BQ-27 14
BQ-28 26
BQ-29 21
BQ-30 40
BQ-31 9
BQ-32 8
MH-1 14
MH-2 1

Text-fig. 11.

(BQ-32 and MH-1, 2 respectively), where *Po. l. linguiformis*, *Po. timorensis* and other indeterminate juvenile representatives of the *Po. varcus* group were found. By inference from the age of the Barton Limestone at Lummaton Quarry, these associations are judged to be no older than the Middle *varcus* Subzone and, in the absence of schmidtognathids and other forms present in younger faunas at Barton (see below), no younger than the Upper *varcus* Subzone.

Elsewhere in the quarry (BQ-1-31), polygnathids referred to *Po. dubius*, *Po.* aff. *dubius* and *Po. ovatinodosus* are commonly encountered, and *Po. x. xylus* and *Po.* aff. *webbi* also occur. Icriodids are sparse, and are assigned to *I. latecarinatus* and to the *I. expansus* group. *O. brevis* and *O. s. sannemanni* are also recognised. Together, many of these forms characterise a broad interval from the late *varcus* Zone through to the Lowermost or Lower *asymmetricus* Zone, although *Po. dubius* is no older than the Upper *hermanni-cristatus* Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5). Important diagnostic taxa present are *A. r. rotundiloba*, *Po. asymmetricus* subspp., *Po. cristatus* and various species of *Schmidtognathus*. In the north-east corner of the quarry, *Sch. peracutus* occurs in BQ-13, and together with *Sch. pietzneri* in BQ-11. The latter form is most commonly found in the Upper *hermanni-cristatus* Subzone (Ziegler 1973, p.431), and the presence of the former means that these horizons correlate with the higher part of this division. The occurrence of *Po. cristatus* and *Sch.* cf. *wittekindti* in the south-west part of the quarry (BQ-1, 2 and BQ-1 respectively) indicates that the faunas here are of either Upper *hermanni-cristatus* Subzone or Lowermost *asymmetricus* Zone age, while material designated *Sch.*? aff. *gracilis* from the north-west corner (BQ-9) suggests that this sample dates from the lower half of the Lowermost *asymmetricus* Zone (equivalent to the Lower *dengleri* Zone: see Klapper and Johnson 1980, text-fig. 1). A similar interpretation is made for the age of a fauna recovered from the central part of the eastern face of the quarry (BQ-30), where *Sch.*? aff. *gracilis* occurs with *Po. cristatus*, *Sch.*

pietzneri and *Sch*. n. sp. A. A little further north, *Po*. *asymmetricus* (subsp. indet.), *Po*. *cristatus*, *Sch*. *peracutus*, *Sch*. *pietzneri* and *Sch*. n. sp. B are identified in BQ-26. In the absence of *Sch*.? aff. *gracilis*, this association is referred to the upper part of the Lowermost *asymmetricus* Zone (equivalent to the Upper *dengleri* Zone: Klapper and Johnson *loc*. *cit*.).

The youngest fauna at Barton occurs in the eastern face in BQ-18, where *A*. *r*. *rotundiloba* is represented and indicates that the collection is no older than the Lower *asymmetricus* Zone in age. This estimation is supported by the mutual occurrence of *Po*. *a*. *ovalis*, but it is not predicted by the known time spans of several schmidtognathids which are also present, namely *Sch*. *peracutus*, *Sch*. *pietzneri* and *Sch*. aff. *hermanni*. These three species have previously been recorded from no higher than the top of, or within, the Lowermost *asymmetricus* Zone, but the implication in Torquay is that they attain the succeeding zone.

The various interpretations of faunal ages at Barton Quarry are indicated on Text-fig. 11. The massive, strongly jointed and faulted nature of the limestone here frequently obscures bedding relationships, but attitudes in the northern and eastern parts point to the possible development of a synclinal structure which plunges south to south-south-west. In the central part of the eastern face beds on the eastern limb of the fold are steep, appear to be developed roughly parallel to the face, and, traced northwards, span an interval from the lower half of the Lowermost *asymmetricus* Zone, through the upper portion of this division, and into the Lower *asymmetricus* Zone. Dislocation at the southern end of the eastern face juxtaposes horizons of late *varcus* Zone age to the south, while faulting at the northern end brings levels which date from the higher part of the Upper *hermanni*-*cristatus* Subzone into the north-east corner. Beds referred to the lower half of the Lowermost *asymmetricus* Zone in the north-west corner belong to the western limb of the syncline. Strata in the south-west part of the quarry, which are either of Upper *hermanni*-*cristatus* Subzone or Lowermost *asymmetricus*

Zone age, have not yet been related to the overall picture.

The conodont evidence shows that most of the Barton Limestone at Barton dates from the Upper hermanni-cristatus Subzone to the Lower asymmetricus Zone and is thus early Frasnian in age, while just those horizons referred to the late varcus Zone in the south-east part of the quarry and on Mincent Hill may be as old as latest Givetian (see House and Ziegler 1977, text-fig. 4). The absence of the Lower hermanni-cristatus Subzone is predicted by the frequent occurrence of Po. dubius which, as noted earlier, does not range below the Upper Subzone. Neither the lower nor the upper division of the hermanni-cristatus Zone has been recognised in Plymouth, where the genus Schmidtognathus is completely absent (Orchard 1978).

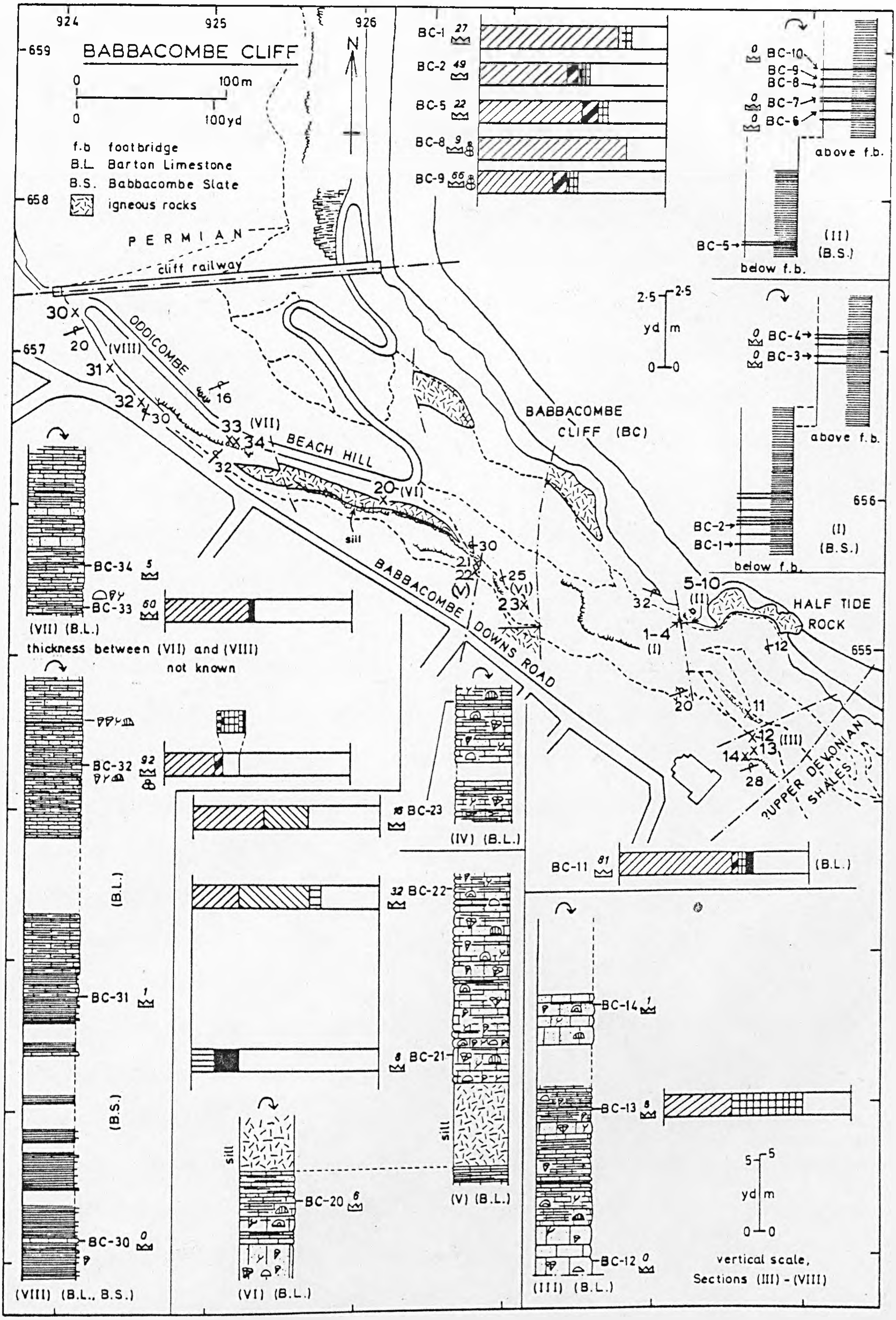
Barton Quarry is the type locality of the colonial rugose coral Phillipsastrea hennahi. This has been commonly used as a Frasnian guide-fossil on the continent but, by inference from the occurrence of the species elsewhere in Devon and from the goniatite evidence at Barton, House (1963, p.6) suggested that the type might be of Middle Devonian age. Scrutton (1968, p.188) reported that the coral could be found in the western wall of the quarry: the conodont faunas in this area indicate that the type of P. hennahi may, in fact, be Upper Devonian in age.

There is little exposure in the ground between Barton and Lummaton Quarry, about 600 m to the south. In this district, small outcrops of Barton Limestone in Clennon Lane (SX911668; Text-fig. 8b, CL-1, 2) failed to produce conodonts.

Further remarks concerning Barton Quarry are made under Babbacombe Cliff (Area 7, q.v.).

Area 7 (Babbacombe Cliff, BC-1-14, 20-23, 30-34; Text-figs. 12, 13).

The succession in Babbacombe Cliff (SX926656), described and discussed by Scrutton (1977b, p.173; 1978a, p.40-43; 1978b), is for the most part inverted, and comprises Barton Limestone which passes into the succeeding


BABBACOMBE CLIFF
924
925
926
659
658
657
656
655
N
0 100m
0 100yd
f.b footbridge
B.L. Barton Limestone
B.S. Babbacombe Slate
igneous rocks
PERMIAN
cliff railway
ODDICOMBE
BEACH HILL
BABBACOMBE DOWNS ROAD
BABBACOMBE CLIFF (BC)
HALF TIDE ROCK
?UPPER DEVONIAN SHALES
sill
30
31
32
33
34
20
21
22
23
5-10
1-4
11
12
13
14
28
16
25
(I)
(II)
(III)
(V)
(VI)
(VII)
(VIII)
BC-1 27
BC-2 49
BC-5 22
BC-8 9
BC-9 66
BC-10
BC-9
BC-8
BC-7 0
BC-6 0
BC-5
BC-4 0
BC-3 0
BC-2
BC-1
above f.b.
below f.b.
(II) (B.S.)
(I) (B.S.)
2·5 yd 0
2·5 m 0
BC-34 5
BC-33 60
(VII) (B.L.)
thickness between (VII) and (VIII) not known
BC-32 92
BC-31 1
BC-30 0
(B.L.)
(B.S.)
(VIII) (B.L., B.S.)
BC-23 16
(IV) (B.L.)
BC-22 32
BC-21 8
BC-20 6
(VI) (B.L.)
(V) (B.L.)
BC-11 81
(B.L.)
BC-14 1
BC-13 8
BC-12 0
(III) (B.L.)
5 yd 0
5 m 0
vertical scale, Sections (III) - (VIII)

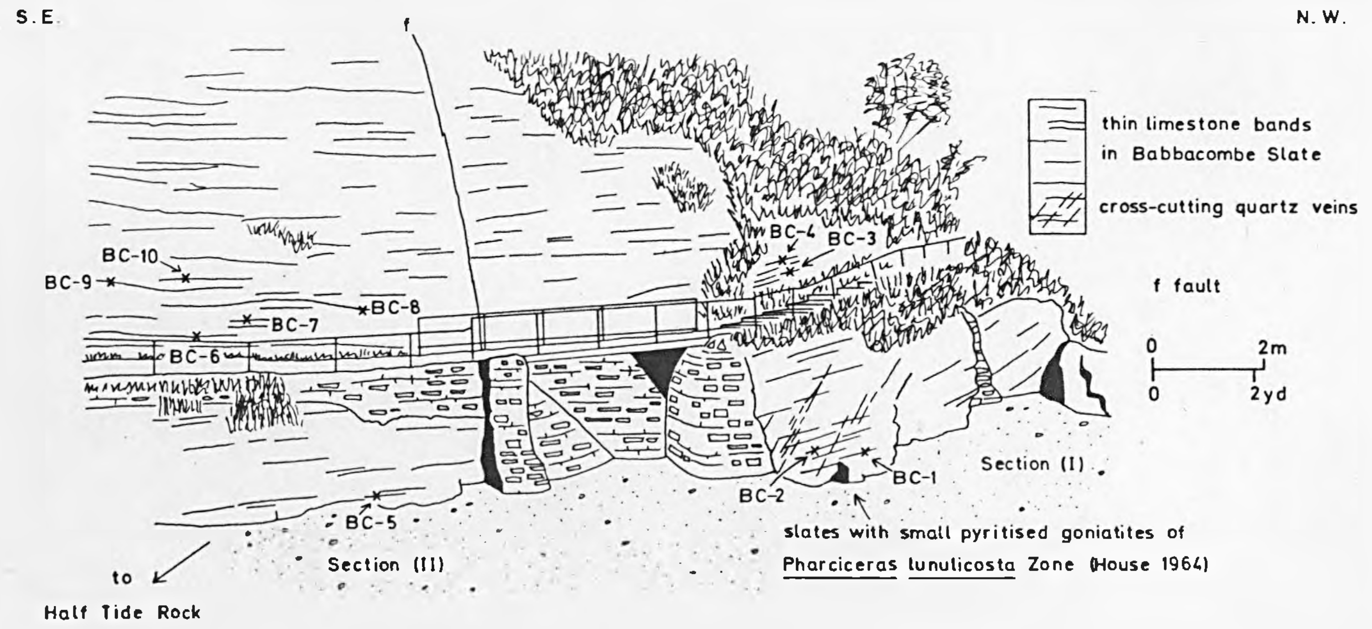
Text-fig. 12.

Babbacombe Slates. The Barton Limestone here is bedded, and at stratigraphically lower levels consists of medium grey, bioclastic limestones with occasional bands rich in corals with small, tabular and domed stromatoporoids, while stratigraphically higher beds are sometimes crinoidal but otherwise relatively unfossiliferous, darker grey and fine grained. The Babbacombe Slates are dark grey to black in colour, and contain thin (1-7 cm), dark, pyritic and often impersistent limestone bands. The transition between the two formations can be seen in a roadside exposure at the top of Oddicombe Beach Hill (SX92456566 to SX92406572), where the highest horizons of the Barton Limestone comprise dark grey limestone-slate intercalations which pass structurally downwards into the Babbacombe Slates. The cliff is cut by a number of faults, and igneous rocks crop-out at several places (see Text-fig. 12).

Both the Barton Limestone and the thin limestone bands in the Babbacombe Slates yielded conodonts, and include some of the most productive horizons in the Torquay area. The oldest faunas in the cliff occur in the stratigraphically lower levels of the Barton Limestone, seen above and below the sill around SX926655 (BC-20-23). Po. timorensis, Po. l. linguiformis, Po. l. mucronatus and O. brevis are variously represented here, indicating that these horizons date from the Middle, or possibly lowest Upper, varcus Subzone.

Many of the taxa present in the stratigraphically higher levels of the Barton Limestone in the cliff and in the Babbacombe Slates (BC-11-14, 31-34 and BC-1-10, 30 respectively) are common to faunas from Barton Quarry, namely Po. dubius, Po. aff. dubius and Po. ovatinodosus which are encountered fairly frequently at both localities, and I. expansus group and O. s. sannemanni which occur less often. Po. cristatus and I. latecarinatus are also identified both at Babbacombe (Barton Limestone only, BC-32, 33) and at Barton. Other taxa variously present in the higher parts of the Barton Limestone in the cliff, on Oddicombe Beach Hill (BC-32, 33) and in the wooded

Text-fig. 13.



CLIFF SECTION IN BABBACOMBE SLATE AT FOOTBRIDGE NEAR HALF TIDE ROCK, BABBACOMBE CLIFF, SHOWING LOCATION OF CONODONT SAMPLES AND OCCURRENCE OF GONIATITES (DRAWN FROM PHOTOGRAPHS).

(Generally, only the sampled limestone bands are indicated on Sections (I) and (II), Text-fig 12).

slope above Half Tide Rock (SX92866546; BC-11), are A. r. binodosa, Po. a. asymmetricus, Po. dengleri, Po. aff. ordinatus and Po. webbi. Samples BC-32 and BC-33 produced also bar elements of the early Upper Devonian multielemental species Elsonella rhenana (illustrated on Plate 20, figs. 1, 2, 6), which display the distinctive granular surface ornamentation characteristic of the grouping (see Lindström and Ziegler 1965). A. r. binodosa and Po. dengleri occur again in the Babbacombe Slates exposed at the footbridge near Half Tide Rock (SX92816551; Text-fig. 13, BC-2, 5, 8, 9), where Po. decorosus and I. cf. symmetricus are additional identifications. The main age range of A. r. binodosa indicates that both the upper horizons of the Barton Limestone in Babbacombe Cliff and the Babbacombe Slates are most likely referable to the lower part of the Lower asymmetricus Zone (see Ziegler in Klapper and Ziegler 1979, text-fig. 5). The majority of the other forms encountered are consistent with this interpretation, with the exception of Po. decorosus which, according to Klapper (in Ziegler 1973, p.351), does not range below the Ancyrognathus triangularis Zone. This apparent anomaly is not thought to be significant because, in view of the fact that Po. decorosus has been used as a broad concept in the literature (see Systematic Palaeontology), at least the lower limit of its time span cannot be known with certainty.

The slates exposed near Half Tide Rock were believed to be Eifelian in age (Ussher 1903, Lloyd 1933), until House (1964) showed that they dated from the Lower Frasnian. He correlated a collection of goniatites found in the slates below the footbridge with the Pharciceras lunulicosta Zone (see Text-fig. 13 herein). The highest part of this interval may be equivalent to the lower part of the Lower asymmetricus Zone (House and Ziegler 1977, text-fig. 4), and so the ages indicated by the goniatite and conodont faunas in the Babbacombe Slates fully substantiate each other. House (1964) also suggested that the succession in Babbacombe Cliff was inverted. The occurrence of late varcus Zone faunas in the Barton Limestone above and below the sill around SX926655 (BC-20-23), and of Lower asymmetricus Zone associations in structurally lower levels of the Barton Limestone on Oddicombe Beach Hill, close to the transition to Babbacombe Slates (SX92456566, BC-32; SX92516564, BC-33), and in the Babbacombe Slates themselves near Half Tide Rock (SX92816551, BC-2, 5, 8, 9), supports an inversion. Scrutton (1978b) interpreted the structure in the cliff as a recumbent anticline-syncline couple, and took the conodont evidence to confirm the inverted nature of the limestone sequence below the sill, the last feature being at the core of the anticline.

The Barton Limestone in Babbacombe Cliff appears to span a similar interval to that at Barton Quarry, from the Middle or possibly Upper varcus Subzone to the Lower asymmetricus Zone. The Lower hermanni-cristatus Subzone is not recognised at either locality, nor are the Upper hermanni-cristatus Subzone or Lowermost asymmetricus Zone represented at Babbacombe. The last two divisions are identified at Barton largely on schmidtognathid evidence, and this genus is virtually absent in the cliff apart from a single indeterminate specimen in BC-32. Further investigation at Babbacombe might reveal the presence of the missing divisions, but the fact that they have not yet been found suggests that representative horizons may be faulted-out. Many of the taxa recorded at Babbacombe and/or at Barton are common to conodont successions in North Cornwall described by Kirchgasser (1970) and Mouravieff (1977; in Scrutton 1978a, p.62-63, text-figs. 23, 24). Mouravieff recognised the Lower varcus Subzone in the Trevose Slates, the Upper hermanni-cristatus Subzone, Lowermost and Lower asymmetricus Zones in the Marble Cliff Beds. As in Torquay, there is no Cornish record of the Lower hermanni-cristatus Subzone.

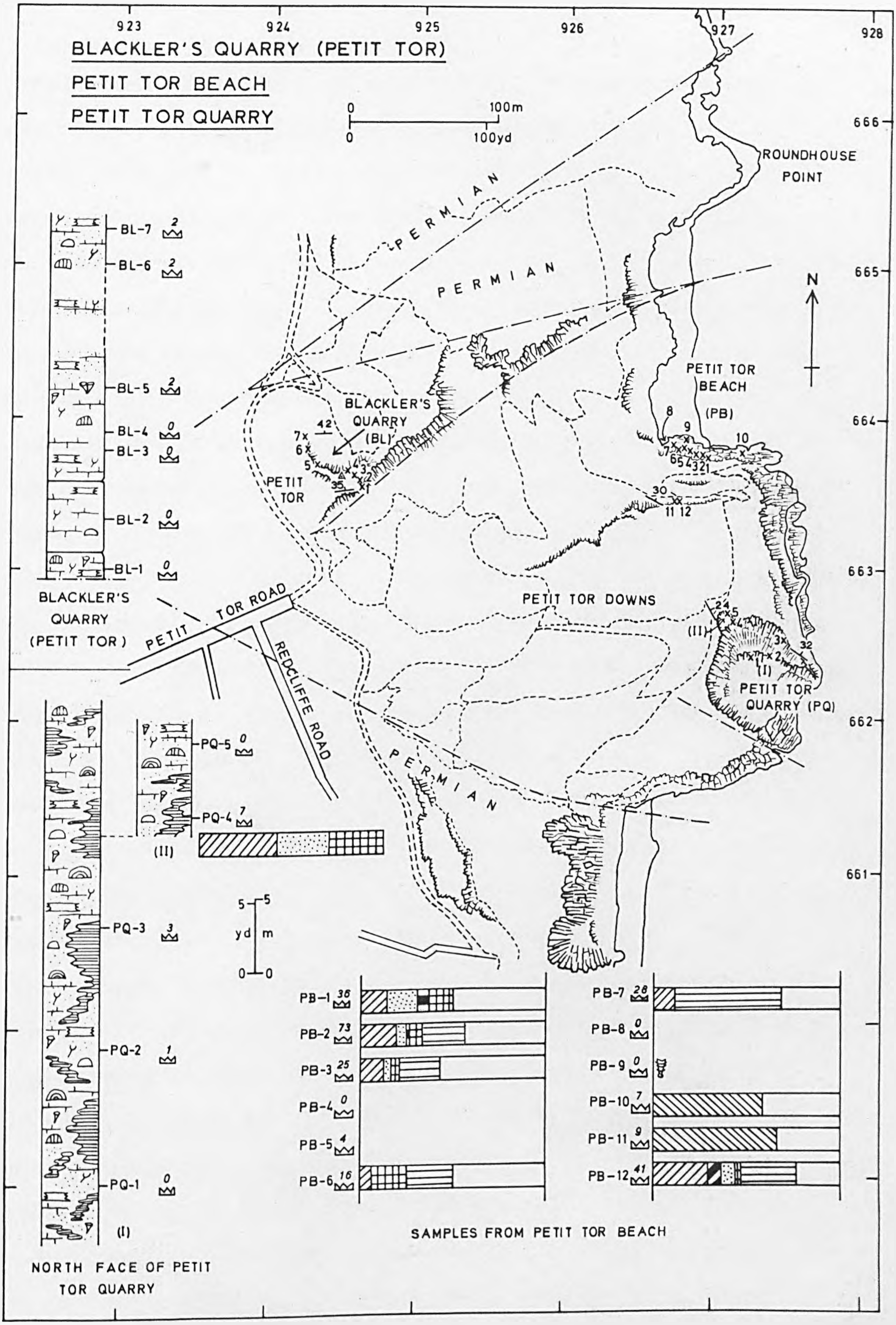
In Plymouth, Orchard (1978, p.917, text-fig. 2, table 2) correlated Faunas 10 and 11 with the Lowermost and Lower asymmetricus Zones respectively. Collections referred to the two groupings include taxa found at Barton Quarry and/or Babbacombe Cliff, namely Po. cristatus (Fauna 10: West Hoe, H1), and Po. a. ovalis, Po. dengleri and Po. dubius (Fauna 11: Radford Quarry, R117;

Western King, WK00, 02-04, 1, 2). A. rotundiloba occurs both in Fauna 11 and at Barton and Babbacombe, but the subspecies are not the same. Orchard (loc. cit.) identified A. r. alata at Western King (WK03, 04, 1, 2), whereas A. r. rotundiloba is recognised at Barton Quarry (BQ-18), and A. r. binodosa at Babbacombe Cliff (BC-9).

Area 8 (Petit Tor Quarry, PQ-1-5; Petit Tor Beach, PB-1-12; Blackler's Quarry, BL-1-7; Text-fig. 14).

Petit Tor Quarry (SX927662) is developed in white-weathering, pale grey, massive, stromatoporoid limestones, which bear also rugose and tabulate corals in the bioclastic and crinoidal matrix. A thickness of about 40 m is represented in the north face of the quarry. The lithologies and macrofauna here were described by Scrutton (1977b, p.173; 1978a, p.38-39), who referred these horizons to the Walls Hill Limestone. Samples from the quarry itself lacked diagnostic conodonts (PQ-1, 2, 5), but limestone ledges on the south side of, and overlooking, Petit Tor Beach (around SX92706636) yielded both Po. l. linguiformis and its delta morphotype (PB-9-11). The presence of the latter taxon indicates that the Walls Hill Limestone in Area 8 is either of early Middle, or possibly late Lower, varcus Subzone age (see Ziegler in Klapper and Ziegler 1979, text-fig. 5).

Various red sediments are frequently encountered both in the quarry and in the ledges overlooking the beach, where they form irregular areas within the massive, pale grey limestones. Red, slaty, sometimes crinoidal limestones from within these developments produced typical Upper Devonian conodonts, including Po. asymmetricus subsp. A, Po. decorosus, Pa. hassi, Pa. subrecta and I. symmetricus (PQ-3, 4; PB-12). The last four taxa occurred again in masses of red calcareous mudstones and nodular limestones exposed in the vertical wall behind the lowest ledge (SX92686637), where additional identifications include A. aff. gigas sensu ORCHARD, A. lobata and Pa. aff. proversa (PB-1-7). No conodonts were found in thin limestone bands in


923
924
925
926
927
928
BLACKLER'S QUARRY (PETIT TOR)
PETIT TOR BEACH
PETIT TOR QUARRY
0 100m
0 100yd
666
665
664
663
662
661
ROUNDHOUSE POINT
PERMIAN
PERMIAN
PERMIAN
N
PETIT TOR BEACH (PB)
BLACKLER'S QUARRY (BL)
PETIT TOR
42
35
30
24
32
(I)
(II)
PETIT TOR DOWNS
PETIT TOR QUARRY (PQ)
PETIT TOR ROAD
REDCLIFFE ROAD
BL-7 2
BL-6 2
BL-5 2
BL-4 0
BL-3 0
BL-2 0
BL-1 0
BLACKLER'S QUARRY (PETIT TOR)
PQ-5 0
PQ-4 7
(II)
PQ-3 3
PQ-2 1
PQ-1 0
(I)
NORTH FACE OF PETIT TOR QUARRY
5 5
yd m
0 0
PB-1 36
PB-2 73
PB-3 25
PB-4 0
PB-5 4
PB-6 16
PB-7 28
PB-8 0
PB-9 0
PB-10 7
PB-11 9
PB-12 41
SAMPLES FROM PETIT TOR BEACH

Text-fig. 14.

tightly folded red slates at SX92666638 (PB-8). Scrutton (1978a, p.38-39) described the various red lithologies at Petit Tor Quarry and Petit Tor Beach. As he noted, structural relationships between the pale, massive limestones and the red sediments on the south side of the beach are complex.

With regard to the interpretation of the age of the Upper Devonian faunas in Area 8, *A. lobata*, *I. symmetricus* and *Pa. proversa* range upwards from, or from below, the base of the Middle *asymmetricus* Zone, and extend to, or higher than, the top of the *Ag. triangularis* Zone. *Pa. subrecta* is sometimes found in the highest part of the Middle *asymmetricus* Zone but its main time span starts at the base of the succeeding interval, while the main range of *Pa. hassi* starts at the base of the *Ag. triangularis* Zone and the form is only rarely found at the top of the preceeding division. The span of *Po. decorosus* may not extend below the *Ag. triangularis* Zone (but see discussion under Area 7) (see Systematic Palaeontology for details of all age ranges). The occurrences of these various taxa in the red lithologies in Area 8 are judged to be indicative of, most likely, the *Ag. triangularis* Zone. The presence of *Po. asymmetricus* subsp. A in faunas of this age seems to be anomalous. Orchard (1978, p.917, text-fig. 2, table 2) first described the form from Durnford Street in Plymouth (DS1, Fauna 12), where it was found together with *A.* aff. *gigas* and several palmatolepids. He referred the association to the Middle *asymmetricus* Zone because the polygnathid occurred at this level in Belgium and elsewhere. The identification of *Po. asymmetricus* subsp. A in Area 8 may represent a younger occurrence of the taxon, but this is thought unlikely in view of the fact that the other, better established subspecies of *Po. asymmetricus* (*Po. a. ovalis* and *Po. a. asymmetricus*) are not known outside the *asymmetricus* Zone (see Ziegler in Klapper and Ziegler 1979, text-fig. 5). Instead, the presence of this form, and possibly also that of *A.* aff. *gigas sensu* ORCHARD (although *A. gigas sensu stricto* ranges from the base of the Middle *asymmetricus* Zone upwards to the top of the Lower *gigas* Zone: Ziegler *loc. cit.*), in associations of *Ag.*

triangularis Zone age is interpreted as the result of stratigraphical admixing.

Orchard (1978, p.918, text-fig. 2, table 2) noted the possibility of admixing in a collection of similar age from Western King in Plymouth, where red calcareous limestones yielded *Po*. *asymmetricus*, *A*. *rotundiloba* and *A*. *nodosa* (WK07-08, 56H; Fauna 13). The first species is restricted to the *asymmetricus* Zone, the second to the Lower and Middle portions of this interval, while the third does not occur below the *Ag*. *triangularis* Zone. Fauna 14 was also referred to the *Ag*. *triangularis* Zone. This grouping, which embraced the zonal species together with *A*. *curvata* and *Pa*. *subrecta*, was best developed at Fisons Quarry, where the red matrix of the conglomerate and associated red lithologies produced, in addition, *I*. *symmetricus* and *Po*. *webbi* (Orchard *loc*. *cit*.).

The age inferred for the younger (that is, Upper Devonian) conodont faunas in Area 8 is consistent with the goniatite evidence. House (1963, p.8) identified *Beloceras* cf. *sagittarium* and *Manticoceras* sp. among specimens which Ussher (1890, p.405; 1903, p.103) had collected from red, shaly, nodular limestones in the combe behind Petit Tor Beach, and correlated the association with the *Manticoceras* *cordatum* Zone (equivalent to most of the *asymmetricus* Zone, the *Ag*. *triangularis* Zone and the Lower *gigas* Zone according to House and Ziegler 1977, text-fig. 4).

Scrutton (1978a, p.39) noted that the goniatite-bearing lithologies are faulted against the north and south limestone walls defining the combe, the limestone mass on the northern side of the combe forming the knoll of Petit Tor itself (SX92446636). No diagnostic conodonts were found in pale grey, massive and thick-bedded limestones exposed in the disused quarry on the Tor (Blackler's Quarry, SX92446637; BL-1-7).

CHAPTER 6.

THE STRATIGRAPHICAL HISTORY OF THE TORQUAY AREA

Introduction and regional setting

The following account of the stratigraphical history of the Torquay area, specifically that of the Torquay Limestone Group, is based largely on the preceeding discussion of localities and conodont faunas within the district, and especially on conclusions reached regarding their ages. Observations on the possible palaeoenvironment are based, for the most part, on the work of Scrutton (1977b).

The marine rocks of South-west England occupy two broad east-west trending belts on the northern and southern flanks of the Cornubian synclinorium. The northern belt, which embraces North Devon and West Somerset, comprises a thick sequence of alternating continental and near-shore marine lithologies in which limestones play a minor role (see Webby 1966), while sequences in the southern belt, which occupies South Devon and much of Cornwall, are largely marine in character and include important carbonate developments in the Torquay area, elsewhere in South-east Devon, and in the Plymouth district. These various marine successions accumulated in the Amorican part of the Variscan geosyncline, which extended from South-west England through Central Europe, embracing northern France, Belgium and the German Rhineland, eastwards to the Black Sea. During Devonian times the north-western border of the geosyncline in Europe was delineated by the margin of the Old Red Continent, while the south-eastern border was formed by another landmass, the Central European crystalline rise ("Mitteldeutsche Kristallinschwelle"), which was an island archipelago of greatly variable size, composed of Pre-Variscan metamorphic and magmatic rocks (Krebs 1979, p.126). The south-eastern area of non-sedimentation has also been interpreted as the Franco-Alemannian Island (see, for example, Erben 1964, text-fig. 3; Erben and Zagora 1968, p.56, 58, text-fig. 2), and smaller landmasses, the

Rocroi and Stavelot Islands, are believed to have existed within the geosyncline in Belgium (see, for example, Tsien 1974, text-fig. 3). There were sea-connections southwards from the geosynclinal belt to the Barrandian Basin, and to Spain and North Africa; a trans-Arctic sea-link with western North America has also been clearly established (House 1968, p.1067; 1973). Recognition of these various connections has been based on distinct faunal relations.

Broad longitudinal divisions relating to the southward deepening have been recognised in the Variscan geosyncline in the Devonian, and the evolution of facies therein has been extensively studied (see Erben 1964; Erben and Zagora 1968). The longitudinal structural units of the Variscan orogeny lie parallel to the north-western margin of the geosyncline, and are thus superimposed on these divisions. Longitudinal structural units in South-west England follow this pattern, and trend roughly east-west. Shackleton _et al_. (1982) recently attempted to relate Variscan structures in South-west England to those in the Variscan fold-belt of western Europe. They noted that, apart from the high-level structures in the Culm synclinorium of North Devon, structures in the South-west were recumbent with an overall gentle southward dip of cleavage, thrusts and recumbent folds, and that translation was towards the north-north-west. These observed structures were interpreted on a thin-skinned tectonic model, with a basal décollement which dipped gently southwards from its outcrop at the Variscan front in the northern Mendips and South Wales, and was related to a southward-dipping subduction zone south of the Lizard (Shackleton _et al_. 1982, p.538-539).

Early-mid Eifelian (Area 1)

The shallow marine, clastic rocks of the Meadfoot Beds, which had accumulated in the Torquay region during Emsian times and are exposed, for example , in Meadfoot Bay (SX933633) and at Hope's Nose (SX947635), were succeeded by shales in the earliest Eifelian. Thin limestone bands appeared in the shales in early Eifelian times, during the lower partitus Zone, and marked the beginning of carbonate deposition in the district, the limestone/shale intercalations (seen in Daddyhole Cove, SX926628) being taken as the basal portion of the Daddyhole Limestone, the oldest member of the Torquay Limestone Group (Scrutton 1977b, p.167). The Daddyhole Limestone typically comprises dark grey, well-bedded, micritic limestones, which are variably fossiliferous and often crinoidal. Its lowest levels, represented by the at least 40 m thick succession in the Daddyhole Cove-Triangle Point area (SX927628-928628) date from the partitus and lower part of the c. costatus Zones (early-mid Eifelian). Probably comparable developments in Vane Hill Road (SX92056330) are, as yet, undated.

The sequences on Triangle Point and in the Knoll Quarry include several richly fossiliferous horizons, while some of the interbeds show grading of small crinoid ossicles, as noted by Scrutton (1977b, p.169; 1978a, p.34). Braithwaite (1967, p.299) recorded possible dessication cracks at one level. Scrutton (1977b, p.169) was of the opinion that these limestones had accumulated in shallow, occasionally turbulent waters, the high energy conditions being suggested by the evidence of reworking in the richly fossiliferous bands, such as the fragmentation of Thamnopora colonies and the inclusion in the sediment of small, disorientated masses of fossils and matrix, while he thought that the preservation of the macrofauna in the basal intercalated limestones reflected initial deposition in quiet conditions. The distribution of icriodid taxa here supports a change from quiet to turbulent conditions. Just I. retrodepressus is identified, and is relatively abundant, in the intercalated beds, but this species becomes numerically less important in stratigraphically higher faunas, where I. c. corniger is fairly common. According to Weddige and Ziegler (1979), the former taxon is associated with quiet regions in shallow shelfal waters, the latter with agitated to turbulent waters on the shelf, above wave base.

Deposition of the Daddyhole Limestone was interrupted by a brief transgressive phase, during which shales became intercalated with, and ultimately succeeded, the limestones of Triangle Point (Scruttton 1977b, p.169, 183). By inference from the age of the youngest conodont fauna on the Point, and from the age of the higher levels of the Daddyhole Limestone elsewhere (see below), the deeper water episode occurred during the c. costatus Zone (see Text-fig. 1, Area 1). Scrutton (1977b, p.170, 183) believed that the relatively pure, coral and stromatoporoid-rich limestone horizons of Hope's Nose were probably a shallow water development, penecontemporaneous with the Triangle Point beds. He considered the thin-bedded, fossiliferous limestones and succeeding shales evident above the disconformity at Hope's Nose to be part of the transgressive event, and equated them with the limestone-shale transition in the higher part of the sequence at Triangle Point. The temporal equivalence of the two localities has not yet been confirmed by conodonts, because of the absence of diagnostic faunas at Hope's Nose. However, the evidence of phacopid trilobites indicates that the thin-bedded limestones there date from the mid Eifelian (Burton, pers. comm. in Scrutton 1977b, p.170), which is consistent with the c. costatus Zone age proposed herein for the transgressive event.

Following the episode of deepening, carbonate deposition was re-established later in the c. costatus Zone, and is now represented by the higher levels of the Daddyhole Limestone at Peaked Tor Cove (SX92146287) and Dyer's Quarry (SX92236277), specifically by reddened, rather shaly crinoidal limestones with corals, brachiopods and some bryozoa at the former locality, and by dark, bedded, micritic limestones at the latter. The shaly lithologies of Peaked Tor Cove, in which the brachiopods are often articulated, suggest accumulation in relatively deep, quiet conditions, perhaps towards the end of the transgressive phase. With regard to the Dyer's Quarry succession, Scrutton (1977b, p.169-170, 183) interpreted the depositional environment of the lower beds, in which corals are abundant and sometimes in growth position, as one of fairly rapid but intermittent sedimentation in relatively quiet conditions, and noted signs of increased current activity in succeeding horizons, evidenced by the alignment of long, cylindrical corolla in the bedding plane and the presence of reworked carbonate lumps at one level. Higher beds still, which include shale partings and laminated horizons, and which are poorly fossiliferous apart from thin stringers of small shells (mainly bivalves with some gastropods) and lenses of crinoid ossicles, were believed to have formed in a probably shallow, rather restricted environment.

Intermittent volcanic activity occurred during early-mid Eifelian times, and is now indicated by the presence of thin tuff bands at various horizons in the Daddyhole Limestone in Area 1. Tuff bands are developed toward the top of the sequence at Triangle Point and in the thin-bedded limestones at Hope's Nose, where they are associated with the beginning of the short transgressive episode, and also in the higher horizons of the Daddyhole Formation at Dyer's Quarry.

Conodonts have a sporadic distribution in beds of early-mid Eifelian age. Faunas are usually of low diversity and tend to be dominated by icriodids, whereas polygnathids and simple cones are rarely encountered. Spathognathodids are represented by Eognathodus and may be locally abundant, as in the stratigraphically higher beds at Triangle Point. At Dyer's Quarry, where the succession is largely barren of conodonts, the associated microfauna includes pyritised ostracods. Conodont faunas of early-mid Eifelian age belong to the intermediate Biofacies II of Druce (1973), and probably represent the shallow, open marine Biofacies II of Chatterton (1976), which may be dominated by icriodids.

Late Eifelian-early Givetian (Areas 2, 3, 8 partim)

Early Givetian times are represented by the top of the Daddyhole Limestone and by the lower horizons of the succeeding Walls Hill Limestone in Area 2 (seen at Redgate Beach-Long Quarry Point, around SX936650; Babbacombe Road [Walls Hill Limestone only], SX93196475 and around SX9322-6500), which all date from within the upper part of the ensensis Zone. The total succession in the Redgate Beach-Long Quarry Point district is estimated to be at least 170 m thick. The highest part of the c. costatus Zone, the australis and kockelianus Zones have not yet been recognised in the Torquay promontory, nor has the lower (highest Eifelian) part of the ensensis Zone been identified in the coastal regions. However, the last interval is probably represented further inland in Area 3 (Parkfield Road-Teignmouth Road, SX909650-910655) by dark grey-red, thin-bedded limestones and shaly limestones, which bear a fauna of corals and stromatoporoids in a crinoidal matrix. Massive, pale grey, only sparsely fossiliferous limestones in Area 3 (exposed on Teignmouth Road, SX910655-910657) may be of a similar age, but have not yet been dated by conodonts.

Dark, argillaceous and sometimes shaly lithologies are evident in the highest levels of the Daddyhole Limestone, forming interbeds between, and partings within, the well-bedded, dark, crinoidal limestones, while the lowest horizons of the Walls Hill Limestone also include a band of reddened, shaly limestone (all seen in the northern cliff at Redgate Beach, around SX93566497). Scrutton (1977b, p.183-184) thought that these shaly intercalations were the result of a second transgressive event. The shaly limestones in Area 3 may belong to this second episode of deepening which, at least in its later part, is judged to date from the low-mid ensensis Zone (see Text-fig. 1, Areas 1-3).

The macrofauna of the highest and lowest levels, respectively, of the Daddyhole Limestone and Walls Hill Limestone in Area 2 includes corals (tabulates with some Rugosa) and stromatoporoids (mainly laminar to tabular forms). The various horizons all yielded conodonts, found together with fish teeth in the shaly unit of the Walls Hill Limestone (sample RB-5). The massive stromatoporoid limestones of the Walls Hill Formation now exposed on

Long Quarry Point represent prolific stromatoporoid growth, which began in early Givetian times, in the upper part of the ensensis Zone. Scrutton (1977b, p.172, 185) thought that these beds, which bear also a rich associated coral fauna, accumulated in conditions near-ideal for stromatoporoid growth, and interpreted the succession on the Point as representing the development of a stromatoporoid reef. He envisaged that the substrate was initially colonised by tabular coenostea in quiet conditions (Subfacies (i) of Scrutton 1978a), while the main episode of rapid sediment accumulation and substrate build-up was represented by higher horizons with large conical stromatoporoids (Subfacies ii), followed by the growth of smaller but more irregular coenostea in shallower, more agitated waters (Subfacies iii). The highest beds of all (Subfacies iv) were thought to have developed possibly adjacent to, or on the flanks of, the crest of the reefal structure. Kershaw and Riding (1980, p.21) commented that the highest horizons at Long Quarry Point could be reasonably considered as back-reef facies, and described the entire sequence as "a shallowing-up succession of reef-related zones". Overgrowth by stromatoporoids is a feature of Subfacies (iii) (Scrutton 1977b, p.172; 1978a, p.37), and is consistent with a change to a shallower, back-reef setting in the higher parts of the succession: Tsien (1974, p.23) viewed the encrusting morphology as an adaptation to increased salinity and decreased water circulation. The scarcity of conodonts in Subfacies (iii) and (iv) is taken to be a reflection of the change to a more restricted environment. It should be noted that Scrutton's environmental interpretation of the lower strata was questioned by Kershaw and Riding (1980), who preferred to regard Subfacies (i) and (ii) as the upper fore-reef and reef-crest zones respectively. Scrutton (1977b, p.185, 187) did not recognise the fore-reef facies anywhere in outcrop, and expected it to occur outside the present coastline.

Higher levels of the Walls Hill Limestone in Area 2 are developed at Withy Point (SX93176548) and New Quarry (SX933653). Unfossiliferous flinty limestones at the former locality, and apparently overlying Amphipora-bearing beds at the latter, were also regarded by Scrutton (1977b, p.172-173) as representative of a low energy back-reef or lagoonal environment, while the reappearance of stromatoporoids (mainly laminar forms) in higher beds at New Quarry, where they occur with scattered rugose and tabulate corals, was taken to indicate a possible slight regression of the reef-flat. Again, conodonts are rare or absent in the proposed back-reef horizons, while a fauna from the higher crinoidal limestones at New Quarry (associated with the coral-stromatoporoid facies) suggests that the slight regressive episode took place in late ensensis Zone times. Scrutton (1978a, p.39) noted similarities between the macrofaunal associations at New Quarry and those in the massive and thick-bedded limestones forming Petit Tor (Area 8; Blackler's Quarry, SX92446637). He recorded Amphipora at the latter locality, which is indicative of back-reef facies. Conodonts are scarce at Petit Tor/ Blackler's Quarry, and the age of the beds is not known.

Massive, micritic and only sparsely fossiliferous developments of Walls Hill Limestone in the Ilsham district in Area 2 (SX9364), and massive coral and stromatoporoid-bearing limestones at the southern end of Redgate Beach (SX93546471), perhaps also accumulated in the restricted back-reef environment. None of these horizons yielded conodonts but, by inference from the age of all other limestones in Area 2, it seems not unlikely that they date from the upper part of the ensensis Zone.

Conodont faunas of late Eifelian-early Givetian age are fairly diverse. Polygnathids (lanceolate and linguiform) are usually well represented and may comprise up to about two-thirds of a total fauna, while icriodids occur to a variable extent: they may be absent or, when found, their number may equal or sometimes exceed that of the polygnathids. Simple cones and, less often, spathognathodids are also encountered. The latter are represented by Tortodus and by the P element of the multielemental Ozarkodina. The associations are referable to the intermediate Biofacies II of Druce (1973) and probably to the shallow, open marine Biofacies II of Chatterton (1976). The latter grouping was defined as being usually dominated by species of Polygnathus but could be dominated by species of Icriodus, and included also such groups as the simple cones (Chatterton 1976, p.150, text-fig. 4).

Mid-late Givetian (Areas 4, 5; 3, 8 partim)

Mid-late Givetian times saw the end of deposition of the Walls Hill Limestone and the beginning of deposition of the Barton Limestone. At Lummaton Quarry in Area 5 (SX913665), the highest levels of the Walls Hill Limestone are represented by pale grey, massive, stromatoporoid limestones of Lower varcus Subzone age. Coenostea here vary in shape and size, and include large and irregular forms; corals (rugose and tabulate) are also present, scattered throughout the crinoidal, sometimes sparry matrix. Scrutton (1977b, p.173, 185) considered these horizons to belong to a second cycle of reef development in the Torquay region, when conditions were again near-perfect for stromatoporoid growth, although to a slightly lesser degree than at Long Quarry Point.

Elsewhere in Area 5 at Trumlands Quarry (SX91516628), thick-bedded, medium grey-red, crinoidal and bioclastic limestones, with shaly partings and with a fauna of corals and laminar stromatoporoids, also date from the Lower varcus Subzone. Ussher (1903, p.57-58) and Jukes-Brown (1906, p.295-296) noted that tuffs (no longer visible) overlay the limestones at the northern end of the quarry, and reported a similar relationship between tuffs, this time with associated shales, and limestones elsewhere in the district. They indicated that the Trumlands beds were stratigraphically below those at Lummaton, separated from them by an interval of tuffs and shales. These observations suggest that the Lummaton strata do represent a second phase of reef growth, as Scrutton thought, rather than reef development having been continuous from early into mid Givetian times (that is, from the late ensensis Zone into the early varcus Zone). Successive events during the mid Givetian were, therefore, the deposition of the darker, thick-bedded limestones with shaly partings (as seen in Trumlands Quarry) and the accumulation of tuffs and shales, presumably during an episode of deepening, followed by a return to shallower conditions and the resumption of reef growth: all took place in the Lower varcus Subzone. The total thickness of the darker, thick-bedded limestones at Trumlands Quarry is about 25 m, and of the pale, massive, stromatoporoid reefal limestones at Lummaton about 50 m. The thickness represented by the tuffaceous, shaly interval is not known.

In Area 3, massive, medium grey-red, bioclastic and crinoidal limestones exposed behind St. James Road (SX912650) also date from the Lower varcus Subzone. These developments have not yet been related to the successions in Area 5, but they may be penecontemporaneous with the Trumlands Quarry beds. Horizons at St. James Road are crowded with corals (rugose and tabulate) and stromatoporoids. The latter are often rounded, and have the appearance of having been rolled about on the seafloor, pointing to some degree of current activity. The same is suggested at Trumlands Quarry by the alignment of stick-like tabulate corals parallel to bedding.

Returning to Area 5, shell beds are developed at several levels in the highest parts of the Walls Hill Limestone at Lummaton. These localised, roughly lenticular concentrations, which now constitute the Lummaton Shell Bed Member (the basal division of the Barton Limestone), have been interpreted as a series of current-sorted accumulations of brachiopods and other groups in pockets on the reef surface (Elliott 1961, p.255; Scrutton 1977b, p.174, 185). Their formation, and thus the transition from the Walls Hill Limestone to the succeeding Barton Limestone, occurred during an interval around the Lower-Middle varcus Subzone boundary. As developed at Lummaton, the early part of the Barton Limestone is of Middle varcus Subzone age, and so dates from late Givetian and/or earliest Frasnian times. It consists there of about 30 m of massive, medium grey, coarsely bioclastic limestone with small stromatoporoids, corals and brachiopods. Scrutton (1977b, p.185) opined that the development of the shell beds and the beginning of accumulation of the Barton Limestone, with an overall decrease in the size and number of stromatoporoids, marked the final regression of the barrier reef, and that deposition of the limestones of the Barton Formation, which generally capped the reef, took place in conditions of continuing fairly high energy. The conodont evidence at Lummaton indicates that the final regressive event began in the latest part of the Lower varcus Subzone. Conodont associations from the Walls Hill Limestone in Area 8 (Petit Tor Quarry, SX927662 and Petit Tor Beach, SX92706636) point to the deposition of this formation there possibly extending into the Middle varcus Subzone, which suggests that the transition from Walls Hill to Barton Limestone, and the final regression of the reef, may not have been synchronous throughout the Torquay region. However, it should be noted that there is no evidence (either direct or indirect) for the Barton Limestone in Area 8, and the formation may, in fact, have not developed there (see Chapter 7).

Developments coeval with those in Area 5 are represented by the variably bedded and massive, medium grey-red, crinoidal and sometimes bioclastic limestones of Area 4. Exposures within this district are tectonically isolated and the succession is not continuous, but the total thickness is estimated to be at least 100 m. The oldest horizons here, seen at Castle Road (SX914642), date from the Lower varcus Subzone. Shaly limestones are present in the lower part of the sequence at this locality, and crop-out also in sections on Stentiford Hill (SX917641), for which a similar age is inferred. These shaly lithologies are judged to belong, at least in part, to the same interval which produced shales and tuffs in Area 5: the conodont evidence at Castle Road is taken to confirm that this episode occurred during the Lower varcus Subzone. Younger levels are exposed on Waldon Hill (SX915637), where the highest parts of the Lower and Middle varcus Subzones are recognised (Royal Terrace Gardens, SX91546354 and the southern end of Warren Road, SX91646368 respectively), and in Madrepore Road (SX91776394), where strata date from the Middle varcus Subzone. Corals (rugose and tabulate), stromatoporoids and occasional bryozoa occur, and are often locally prolific, throughout the limestones in Area 4, while Scrutton (pers. comm.) has recorded also Amphipora here, at Castle Road, and believes that the successions in the entire district accumulated in a restricted, lagoonal environment, developed behind the reef. This interpretation is supported by the frequent occurrence of stromatoporoids exhibiting an encrusting morphology (see discussion under late Eifelian-early Givetian), and probably by the scarcity, or absence, of conodonts throughout the area, especially in the older horizons (Castle Road, Stentiford Hill; Lower varcus Subzone). The presence of localised, large and fairly diverse faunas in younger beds (Waldon Hill, Madrepore Road; highest Lower varcus Subzone, Middle varcus Subzone), which are temporal equivalents of, and include taxa common to, the higher parts of the Shell Bed levels and/or the Barton Limestone at Lummaton, is taken to be a reflection of free circulation of waters into the back-reef environment, as the reef regressed.

Conodont associations of mid-late Givetian age are moderately diverse, and polygnathids (lanceolate and linguiform, the number of the latter type often exceeding that of the former) and simple cones are well represented in them. The last group is particularly abundant in the Lummaton succession, where it may comprise up to nearly 90% of a total fauna (in terms of individual elements). Spathognathodids are fairly commonly encountered, although never in large numbers, and are represented by Spathognathodus, Tortodus and the P element of the multielemental Ozarkodina, while icriodids are almost completely absent, apart from one occurrence in the younger horizons in Area 4 (Waldon Hill, WH-3; Middle varcus Subzone). The situation is the same in Plymouth, where Orchard (1978, p.915, 921) noted an absence of icriodids from virtually all limestones of varcus Zone age in his western district (Faunas 7-9), other than in Middle varcus Subzone horizons at

Richmond Walk (Fauna 8; "lastericrescens interval"). He thought that the total lack of the group in his extensive Mount Wise Shell Bed fauna was most likely due to some unspecified ecological control (Orchard 1978, p.917). Similar control(s) may have been effective in Torquay, at least during the formation of the shell beds at Lummaton, if not also during the formation of the rest of the succession there, and possibly also during the development of carbonates elsewhere in the entire region in mid-late Givetian times. Perhaps it is significant that the only record of icriodids of this age (that is, at Waldon Hill) occurs in an environment interpreted as one in which conditions were changing from restricted and back-reef to rather more open marine. Overall, conodont faunas of mid-late Givetian age belong to the intermediate Biofacies II of Druce (1973), while those with abundant simple cones, as at Lummaton, show a clear tendency toward his shallow water Biofacies I. The associations probably also represent, respectively, the somewhat older Biofacies II and Biofacies IA of Chatterton (1976). The former grouping (defined under late Eifelian-early Givetian, q.v.) was linked to a shallow, open marine environment, while the latter was associated with shallow, slightly restricted conditions and was defined as being characteristically dominated by species of Polygnathus and Belodella, with small numbers of Coelocerodontus and Panderodus (Chatterton 1976, p.150, text-fig. 4).

Early-late Frasnian, and Famennian (Areas 6, 7; 2, 8 partim)

Early-mid Frasnian times witnessed the continued deposition of the Barton Limestone, which dates from the Upper hermanni-cristatus Subzone, Lowermost and Lower asymmetricus Zones in Area 6 (Barton Quarry, SX912671), and from the last division in Area 7 (Babbacombe Cliff, SX926656). In both areas the oldest horizons are of latest Givetian or earliest Frasnian age (Middle or Upper varcus Subzone). As developed at Barton Quarry, the Barton Limestone is massive, often coarsely bioclastic and richly fossiliferous, bearing a varied fauna of corals (rugose and tabulate), small stromatoporoids, brachiopods, bivalves, gastropods, goniatites and trilobites, whereas at Babbacombe Cliff it is bedded, and older levels are bioclastic and sometimes rich in corals and small stromatoporoids, while younger strata are darker in colour, finer grained and sometimes crinoidal, but otherwise rather unfossiliferous. The limestones at the latter locality are judged to be at least 60-70 m thick, although estimation of the thickness is made complicated by faulting and folding. The total thickness at the former locality is not known. Intercalations of dark grey slates appear in the stratigraphically highest parts of the Barton Limestone in Babbacombe Cliff, and the formation passes into the succeeding Babbacombe Slates: conodont faunas from thin limestone bands within the slates show them to date from the early part of the Lower *asymmetricus* Zone. The transition from Barton Limestone to Babbacombe Slates represents the start of a further deepening of the environment, the conodont evidence indicating that this event happened early in the Lower *asymmetricus* Zone.

Younger, late Frasnian conodont faunas occur in Area 8 at Petit Tor Quarry (SX927662) and Petit Tor Beach (SX92706636), where various red calcareous sediments associated with pale, massive Walls Hill Limestone of late Givetian (latest Lower or earliest Middle *varcus* Subzone) age yielded collections representative of the *Ag*. *triangularis* Zone, with admixed elements indicative of the Middle *asymmetricus* Zone. Some of the red lithologies, including slates, slaty, sometimes crinoidal limestones and, less often, pale pink flinty limestones, form irregular developments within the massive limestones both in the quarry and in ledges overlooking the southern end of the beach. Scrutton (1978a, p.38) interpreted them as the infillings of solution cavities, and observed that some of the infills once produced abundant orthoceratids, although these were now rare. Braithwaite (1967, p.312) had previously reached the same conclusion, at least with regard to the origin of the flinty limestones which, he noted, contained small "stromatactis"-like structures, and had remarked on the occurrence of similar phenomena at Western King in Plymouth, where red and pink, banded, fine grained limestones occupied pockets within a light grey biomicrosparitic host lithology. These developments were also believed to be cavity infillings.

Orchard (1975b; 1978, p.917-919, 923, 925, Faunas 11, 13, 15) examined the various lithologies at Western King. He showed that conodonts from the infill material, although few, were no older than the Upper Pa. triangularis Zone (early Famennian) in age, while the host limestones and comparable horizons of pale red crinoidal limestone dated from the mid-late Frasnian (Lower and Upper asymmetricus and Ag. triangularis Zones; Faunas 11, 13), and associated red calcareous shales and other sediments bore admixed collections indicative of the early Famennian Middle and Upper Pa. triangularis Zones (Fauna 15). He discussed the genesis of the solution cavities and infillings, and thought that they developed as the result of dissolution of the Frasnian limestones before the subsidence represented by the associated lithologies bearing Fauna 15. By reference to the work of Krebs (1969) in Germany, he concluded that dissolution probably occurred at a time when the older, host limestones were in a very shallow water environment which might, at times, have been emergent. Older elements in Fauna 15, such as A. curvata and Ag. cryptus, were regarded as the residue of the dissolution. The latter species, which is restricted to the Middle Pa. triangularis Zone, was taken to be indicative of the age of the latest depositional episode, before dissolution became the dominant process in mid Pa. triangularis Zone times.

A similar model is proposed herein for the evolution of the somewhat older solution cavities and infillings in the Petit Tor area. The host, late Givetian Walls Hill Limestone there is envisaged undergoing dissolution in very shallow, possibly sometimes emergent conditions, prior to subsidence and the establishment of the deeper water environment which saw, in the Ag. triangularis Zone, the accumulation of material in the solution cavities (at least with regard to the red slaty infillings; the flinty limestones may have developed in shallow conditions), as well as the formation of the red nodular limestones and calcareous mudstones now exposed in the vertical wall behind the lowest ledge on the south side of the beach (SX92686637), and the red slates present in the combe behind the beach. It is assumed that the red developments in the wall and the combe originally overlay the Givetian limestones, although such a relationship cannot be directly observed in the field because of tectonic complications. The red sediments in the wall are partially incorporated in the older limestones in a manner which suggests that they have suffered post-depositional tectonic "squeezing" (cf. Orchard 1978, p.923).

By analogy with the situation at Western King, older conodonts in faunas from the red lithologies in Area 8 (Po. asymmetricus subsp. A, A. aff. gigas sensu ORCHARD) are interpreted as the residue of the dissolution process, and indicate that the latest period of deposition, before the emphasis changed to dissolution, was in the Middle asymmetricus Zone. The main dissolutional phase probably occurred in the Upper asymmetricus Zone. The absence of older residual elements, indicative of sedimentation during post-early Middle varcus Subzone to pre-Middle asymmetricus Zone times, and of such sediments themselves, suggests that this may well have been an interval of little or no sedimentation, and that the very shallow water, perhaps occasionally emergent conditions prevailed throughout much of this time.

The youngest dated Devonian horizons occur in Area 2 (Anstey's Cove, SX935646), where ostracod evidence has demonstrated that the deep water ostracod-slate facies was well established by the late Famennian. There was volcanic activity at this time, indicated by the development of ash bands in the slates.

Conodont faunas of Frasnian age include some of the most diverse in the Torquay area. Polygnathids tend to dominate associations from the low-mid parts of the interval (Barton Quarry, Babbacombe Cliff), and can comprise up to three-quarters of a total fauna (in terms of individual elements): they are of the lanceolate and, less often, broad-platformed type, while linguiform specimens are rare. Ancyrodellids, icriodids, simple cones, spathognathodids (represented by the P element of the multielemental Ozarkodina) and, mainly at Barton, schmidtognathids are also encountered, but generally make up only a small percentage of a total fauna. In late Frasnian collections from the Petit Tor district, polygnathids (largely lanceolate, with just a few broad-platformed specimens), icriodids and, this time, palmatolepids variously occur, sometimes in more or less equal numbers, while simple cones are generally more abundant than in the low-mid Frasnian faunas, and may occasionally be the dominant faunal element. Conodont associations of early-mid Frasnian age (Barton Quarry, Babbacombe Cliff) are referable to the intermediate Biofacies II of Druce (1973), while those of late Frasnian age (Petit Tor area) belong to his deeper water Biofacies III. In terms of biofacies described from Middle-Upper Devonian boundary beds by Schumacher (1976), the varcus and hermanni-cristatus Zone faunas at Barton probably represent his shallow to deep subtidal (but above wave base), narrow-Polygnathus biofacies, while younger associations at this locality, and Lower asymmetricus Zone faunas from Babbacombe Cliff, suggest the appearance of his deep subtidal Ancyrodella-Po. asymmetricus biofacies, which was well established by late Frasnian times (Ag. triangularis Zone) in the Petit Tor region.

CHAPTER 7.

SUMMARY AND CONCLUSIONS

The stratigraphical history of the Torquay Limestone Group began within the lower *partitus* Zone, in the early part of the Eifelian, by which time sediments of Rhenish aspect had given way to those of Hercynian type (*sensu* Erben 1962). Deposition of the dark, bedded, sometimes richly fossiliferous Daddyhole Limestone took place during early-mid Eifelian times (*partitus* and *c. costatus* Zones, Area 1), and persisted into the early Givetian (upper *ensensis* Zone, Area 2), although a continuous succession is not recognised. Accumulation of the Daddyhole Limestone, which is essentially a fairly shallow water development as is the entire Torquay carbonate complex, was interrupted by two transgressive, deeper water episodes: the first occurred early in the mid Eifelian, during the *c. costatus* Zone, and brought shales, shaly limestones and thin-bedded limestones into successions in Area 1, while the second, which at least in its later part dates from highest Eifelian-lowest Givetian levels (low-mid *ensensis* Zone), led to the formation of shaly lithologies in Area 2, and possibly also to the accumulation of shaly limestones further inland in Area 3. The latter event may have begun in late *c. costatus* Zone times, and continued through the *australis* and *kockelianus* Zones: none of these intervals has yet been identified in Torquay. Scrutton (1977b, p.184) thought the cyclicity of the transgressive events to be a reflection of "slight tectonic instability on the eastern margin of the developing carbonate platform". There was intermittent volcanic activity in early-mid Eifelian times, associated with the first period of deepening and with the following resumption of deposition of the Daddyhole Formation.

These various accumulations provided a foundation for subsequent reef growth and the build-up of the massive, stromatoporoid developments of the Walls Hill Limestone, which started in early Givetian times (upper ensensis Zone, Area 2). Stromatoporoid growth was prolific, and the reefal structure so formed (barrier reef: Scrutton 1977b) clearly resulted in some degree of facies differentiation. According to Scrutton (1977b, p.185), the presence of the back-reef or lagoonal facies above the stromatoporoid facies in the Long Quarry Point district suggested an advancing reef-crest in the mid Givetian. Conodonts are scarce or absent in horizons from the restricted back-reef environment as developed at Long Quarry Point (Subfacies iii and iv), Withy Point and New Quarry (all Area 2). A little later in the mid Givetian there was a further episode of deepening, in the Lower varcus Subzone, during which rather darker limestones (sometimes bedded) and shaly limestones, shales and tuffs variously accumulated in Areas 3, 4, 5. The reef was re-established during the Lower varcus Subzone (Area 5) and its development continued into the early part of the late Givetian, when the final regression began. Shell beds developed in pockets on the surface of the subsiding reef in Lower-Middle varcus subzonal boundary times (Lummaton Shell Bed Member), and the reef was capped by the massive, coarsely bioclastic and richly fossiliferous Barton Limestone (Area 5). The second cycle of reef growth again resulted in facies differentiation, and grey-red, bedded-massive, crinoidal and bioclastic limestones in Area 4, of mid-late Givetian age, are interpreted as the back-reef or lagoonal equivalents of the successions in Area 5. Conodonts are generally few in number or absent in the older horizons in Area 4, which formed at the time when there was active reef growth and the reef was most effective as a barrier to circulation, while large and fairly diverse, if localised, faunas developed in the youngest levels as the reef finally regressed and its effectiveness as a barrier waned. The latter associations provide the only record of mid-late Givetian icriodids in the Torquay area.

Deposition of the Barton Limestone continued from late Givetian into mid Frasnian times (Middle varcus Subzone to Lower asymmetricus Zone, variously in Areas 5, 6, 7), until the further deepening of the environment which brought about the transition to the Babbacombe Slates in the mid Frasnian (Lower asymmetricus Zone, Area 7). This event effectively marked the end of major carbonate development in the Torquay region. Indirect evidence (residual conodonts) in Area 8 points to ?carbonate sedimentation occurring there later in the mid Frasnian, in the Middle asymmetricus Zone, but this was probably negligible. In the absence of older residual faunas and on the evidence of dissolution of the older, Givetian limestones in this district, it seems likely, in fact, that sedimentation here was very slow between the late Givetian and mid-late Frasnian and may, at times, have ceased altogether, an unknown thickness of limestone perhaps being removed during such period(s) of cessation. The older (Walls Hill) limestone in Area 8 is thus envisaged as a "topographical high" - possibly one of several? - in the late Givetian to mid-late Frasnian seas in the Torquay area, while bioclastic limestones and, subsequently, shales were accumulating elsewhere. By late Frasnian times (Ag. triangularis Zone), with the subsidence which led to the development of red slaty (and other) lithologies in Area 8 as cavity infillings within, and associated with, the Givetian limestones, deep water conditions were probably widespread throughout the entire region. The basinal ostracod-slate facies became established and continued into the late Famennian, when there was contemporaneous volcanic activity (Area 2).

The reef developments in Torquay are part of the Tor Bay Reef-Complex proposed in South-east Devon by Scrutton (1977b). He envisaged that they constituted a barrier reef, which grew along part of the platform margin in the Givetian and may have taken the form of a "linear belt of shoal conditions" without a well defined reef edge (Scrutton 1977b, p.185). Growth of the barrier clearly affected environmental conditions in the immediate area, resulting in facies differentiation in the Torquay district, and, according to Scrutton (1977a, 1977b), also had a considerable influence on the environment of the interior platform. He observed that, concurrent with the establishment of the barrier reef on the platform margin at Torquay in the early-mid Givetian, most corals and stromatoporoids disappeared from sequences around Newton Abbot and horizons of Amphipora became dominant in dark, well-bedded micrites. These and associated strata were interpreted as the back-reef facies developed behind the barrier, while the barrier itself was believed to have extended possibly some distance to the north or north-east of Torquay, suggested by the presence of similar back-reef facies horizons to the north of Newton Abbot at, for example, Chudleigh. He took late Givetian developments of richly fossiliferous, coarsely bioclastic East Ogwell Limestone in the Lemon Valley section, the interior platform facies equivalent of the Barton Limestone at Torquay, to indicate the rapid spread of this facies north-westwards following its establishment above the subsiding reef on the platform edge. He considered further that free circulation of waters into the back-reef regions might have been possible at an earlier stage, evidenced by the late middle Givetian age suggested by several workers for the East Ogwell Limestone at Wolborough Quarry near Newton Abbot (Scrutton 1977b, p.185-186).

During Frasnian times the centre of carbonate deposition moved to the interior of the platform, and the development of massive, bioclastic limestones south-west of Newton Abbot culminated in the formation of bioherms, as at Ransley Quarry, which are of mid-late Frasnian age (Scrutton 1977a, p.127; 1977b, p.186). The bioherms subsided before the end of the Frasnian, and were capped by red slates with associated nodular limestones. This facies was well established at the platform margin by this time, as in the Petit Tor district and probably also at Saltern Cove, in the southern part of Tor Bay (see Scrutton 1977a, 1977b; 1978a, p.43-45).

Many of the conodont faunas from Plymouth described by Orchard (1978) (see Text-fig. 1 herein) compare closely with associations from Torquay, and there is a fair degree of similarity between the stratigraphical histories of the two areas. Carbonate deposition began in both districts in the early Eifelian, with the appearance of calcareous horizons in Eifelian shales during lower partitus Zone times (Fauna 1 of Orchard 1978), and initial carbonate development in Plymouth seems to parallel the Daddyhole Limestone, dark, bedded and platy, crinoidal limestones, sometimes with a good deal of interbedded shale, forming there from early to late Eifelian times (partitus to lower ensensis Zone; Faunas 1-3, 5). There appears to have been considerably more volcanic activity during this interval than in Torquay, evidenced by the 17.5 m thickness of tuffs recorded by Orchard (1978, p.920) at Faraday Road, associated with carbonates referred to Faunas 3 and 4.

The main period of build-up of massive stromatoporoid limestones, as developed in the Cattedown district in the east of Plymouth (Fauna 6; upper ensensis Zone) began in both regions in the early Givetian, but it appears to have continued later there, into the Frasnian: Orchard (1978, p.917, 922, 925) reported a Lowermost asymmetricus Zone association from massive stromatoporoid limestones at West Hoe (Fauna 10), and thought that there were undated equivalents in southern Cattedown. It is interesting to note that there was a brief phase of stromatoporoid limestone accumulation in Plymouth in the Eifelian (Fauna 4; kockelianus Zone), associated with and perhaps facilitated by the development of the tuffs in Faraday Road. Stromatoporoids seem to have played a smaller part in the total "coralline growth" in Plymouth than in Torquay, and the framework so produced probably had a rather different morphology in the two areas. Orchard (1978, p.925) indicated that the overall "biogenic" development there did not constitute a wave resistant structure, but it nevertheless resulted in some extent of facies differentiation, and limestones in the east and south-east of the region (at Saltram-Pomphlett and Hooe respectively), where Amphipora occurred but conodonts were absent, were interpreted as having formed in a partially restricted, back-reef environment. Developments of varcus Zone age in the western part of Plymouth, including bedded, sometimes coarsely bioclastic limestones at Richmond Walk (Faunas 7, 8; Lower and Middle *varcus* Subzones respectively) and shell beds at Mount Wise (Fauna 9; Middle *varcus* Subzone), were envisaged as having accumulated on the seaward side of the shallow water carbonate complex which was well established in the Plymouth area by this time, and which may have spread westwards and/or perhaps north-westwards during the Givetian (Orchard *loc. cit.*). The Mount Wise shell beds are similar to those developed at Lummaton, and are temporal equivalents at least of the higher parts of the Lummaton Shell Bed Member.

An interval of deepening occurred in mid Frasnian times in Plymouth, and is represented by thin, pale red, crinoidal limestones with red shale interbeds and partings developed on both the western and eastern flanks of the limestone complex (Fauna 11; Lower *asymmetricus* Zone). This episode is coeval with the deepening of the environment which saw the transition from Barton Limestone to Babbacombe Slates in Torquay. However, whereas deeper water conditions probably continued throughout much of the Torquay region, there was a shallowing of the environment in Plymouth in the Middle *asymmetricus* Zone, represented by massive limestones in the western district (Fauna 12), before a return to deeper water conditions and further deposition of the thin red beds in the Upper *asymmetricus* Zone, at least in the west (Fauna 13); massive limestones continued to be developed in the east at this time, and persisted into the *Ag. triangularis* Zone (Fauna 14; Radford Quarry and Durnford Street). Fauna 14 occurred also at Fisons Quarry, in red calcareous sediments associated with massive mid-late Givetian limestones. The red sediments included the red lime-mud matrix of the Fisons Quarry Conglomerate, which Orchard (1978, p.923) interpreted as the infilling of a crevasse within the older limestones. Fauna 14 demonstrates that red calcareous lithologies accumulated in close association with older Givetian limestones in both Plymouth and Torquay in *Ag. triangularis* Zone times. The youngest conodont associations in Plymouth, of Famennian age, came from red calcareous shales and other sediments at Western King, where there was clear evidence of limestone dissolution (as discussed in Chapter 6, q.v.). Orchard (1978, p.923, 926) took the evidence of this dissolution and the presence of admixed elements in collections from the youngest limestones in the eastern district (for example, in Fauna 14 at Radford Quarry) to indicate that there was a period of time when active sedimentation ceased and an unknown thickness of limestone (Plymouth Limestone) may have been removed. This led him to suggest (also Orchard 1975b) that the Plymouth Limestone persisted as a topographical high in late Devonian seas, while pelagic ostracod-slates were accumulating in regions to the north and west. This picture is analagous to the situation envisaged in Torquay somewhat earlier in the Upper Devonian.

Matthews (1977, p.108) proposed that the massive Devonian carbonates of South Devon, as developed in the Torquay and Plymouth areas, accumulated near the southern margin of what he termed the Trevone Basin. This was a structurally active, locally unstable development, the basinal character of which was already in existence during Eifelian times. Orchard (1978, p.926) noted that his interpretation of facies disposition within the Plymouth Limestone, in which open marine conditions apparently existed on the west and/or north-west side of the complex during the Givetian, while a partially restricted, back-reef environment lay behind to the east and south, supported Matthews' proposal. Unfortunately, it has not proved possible to construct a coherent picture of facies distribution in the Torquay promontory as envisaged herein, although, in view of the fact that the region has suffered a considerable amount of structural dislocation and disturbance, it seems rather unlikely that the present configuration of facies will bear any strong resemblance to the original. This is probably especially true with regard to the relationship between reefal developments in Area 5 and proposed back-reef equivalents in Area 4. However, consideration of facies distribution within the broader context of the Tor Bay Reef-Complex, as envisaged by Scrutton (1977b), suggests that the restricted back-reef environment lay approximately to the north-west of the barrier reef at Torquay during the Givetian, while open marine conditions existed immediately to the south, south-west and west, with deeper water lithologies (thin-bedded limestones and shales, followed by just shales) appearing in the last direction (see also Scrutton 1977a, text-fig. 3). The relative positions of facies in the Tor Bay Reef-Complex is at variance with the comparable model of facies disposition in the Plymouth area proposed by Orchard (1978), but it can probably still be reconciled with the idea of the Torquay limestones accumulating on the southern (or perhaps south-eastern?) margin of such a development as the Trevone Basin.

CHAPTER 8.

SYSTEMATIC PALAEONTOLOGY

Introduction

Huddle (1972) presented an authoritative discussion on the subject of conodont taxonomy, in which he described the two systems of nomenclature that have grown up in the field, both a single element, form taxonomy and a multielemental classification being in use. Usage of the latter approach, in which form taxa are placed in multielemental assemblages reflecting the true biological nature of the conodont-bearing animal, is desirable because it will ultimately lead to a unified, natural conodont classification but, as Huddle observed, the former approach continues to find favour in biostratigraphical studies.

Multielemental assemblages in the Devonian have been proposed by Klapper and Philip (1971, 1972), whose work was applied and modified by Philip and McDonald (1975) and Sparling (1981), and by Ziegler (1972). Bultynck (1972) suggested possible icriodid assemblages in the Belgian Couvinian. Klapper and Philip (1971) described four basic types of apparatus, which they subsequently related to a familial classification (Klapper and Philip 1972). Many of the recognised form genera were incorporated in their four multielemental families and, with the exception of Icriodus, one platform (form) element, such as Ancyrodella, Palmatolepis and Polygnathus, was associated in one apparatus (or assemblage) with several ramiform elements. The fundamental difference between this approach and that of Ziegler (1972) is that the last author preferred to envisage platform elements of the polygnathid type (e.g. Polygnathus, Ancyrodella, Palmatolepis, Schmidtognathus) forming an apparatus that was devoid of ramiform elements. He proposed this scheme because he was of the opinion that, if platform elements were assigned to apparatuses in which they were associated with several ramiform types, a great deficiency of the last group became apparent in isolated

Devonian conodont faunas.

Recognition of multielemental assemblages is difficult within the conodont collections from Torquay. Faunas are generally small and have doubtlessly undergone some degree of post-mortem sorting and mixing, indicated by the fact that many of the conodont-producing lithologies reflect high energy depositional environments, and by the fact that specimens, especially the ramiform (bar) elements, are often fragmented. The associations probably bear little relationship, therefore, to original populations, and for this reason, and also because the study is of a biostratigraphical rather than a taxonomic nature, a single element, form taxonomy is used in describing the conodonts, in preference to a multi-elemental approach. The one exception to this is within the description of the morphologically rather variable spathognathodid group, where the multielemental genus Ozarkodina is introduced because of the distinct nature of its P (spathognathodontan) skeletal element. In order to be consistent with other studies, ramiform elements in the Torquay associations are identified in terms of the system of symbols put forward by Klapper and Philip (1971: O1, N, A1, A2, A3 etc.).Representative specimens are illustrated on Plates 18-20 where some possible multielemental groupings of the type proposed by Klapper and Philip (1971, 1972) are indicated, but it should be noted that bar elements invariably make up too small a proportion of a total fauna, with regard to the percentage of platform elements, to satisfy the requirements of Klapper and Philip's apparatuses.

Classifications of conodonts have been attempted by several authors, such as Hass (1962) who produced a utilitarian classification based on form taxonomy, in which he described some twenty families within the order Conodontophorida. Lindström (1970) presented a detailed, if rather preliminary, suprageneric classification based on multielemental taxonomy, and divided conodonts into two orders, the Westergaardodinida and the Conodontophorida. One family was recognised in the former division, while the latter grouping (conodonts proper) embraced eight superfamilies and twenty families. Most of the genera recognised herein belong to the families Icriodontidae, Polygnathidae and Spathognathodontidae.

Diagnoses for the majority of conodont genera described in the following pages are to be found in the first three volumes of the Catalogue of Conodonts (Ziegler 1973, 1975, 1977); the diagnosis of *Tortodus* is given by Weddige (1977).

Form genus Ancyrodella ULRICH & BASSLER

Type species: Ancyrodella nodosa ULRICH & BASSLER 1926

Remarks: The genus is short ranging, confined to the lower Upper Devonian, and is stratigraphically important, as Ziegler (1958) first recognised. The origins of the group have been considered by various authors to lie within either the polygnathids or the (then) spathognathodids. Ziegler (1962a, text-fig.2) envisaged a phylogenetic sequence in which the earliest representative of the genus, A. rotundiloba, evolved from a broad-platformed polygnathid, probably Po. a. asymmetricus. Forms transitional between the two gradually developed lobes by a progressive constriction of the anterior platform,and the entire platform became simultaneously thicker and the ornament coarser. Aborally, the distinctive keels of Ancyrodella formed as the undulations of the lower surface became increasingly more distinct and sharper.

Ethington and Furnish (1962, p.1260) suggested a spathognathodid ancestry for the genus. They examined a complete series of growth stages of A. curvata (BRANSON & MEHL) and observed, in juvenile specimens, a marked similarity to Spathognathodus insitus STAUFFER [Pandorinellina insita]. However, as Glenister and Klapper (1966, p.798) noted, A. curvata is a phylogenetically late form, its stratigraphical position suggesting a derivation from A. lobata.

Studies of the conodonts of the Waterways Formation of Alberta led Uyeno (1967, p.4-5) to establish A. rotundiloba binodosa, a form which appears to be a little older than the nominate subspecies, and to favour also a spathognathodid-type ancestry for the ancyrodellids. Because of their relative positions in the succession, and because of morphological similarities between the forms, he proposed a phylogenetic series from Sp. insitus [Pand. insita] through his "Sp.? sp." to A. r. binodosa and, probably, to his A. r. subsp. A (Uyeno 1967, p.5, 11; 1974, p.23, 26, 43, 44). He considered that juvenile specimens of A. r. binodosa resembled "Sp.? sp." in their incipient platform development, whilst the last form lacked the platform of Ancyrodella, and bore nodes as outgrowths of the lateral sides. Uyeno observed that his suggested sequence indicated "a possible phylogeny and origin of Ancyrodella, relating it with Spathognathodus."

Ziegler (1973, p.22, 35) preferred to relate juvenile forms of A. r. binodosa to Sp. sannemanni [Ozarkodina sannemanni]. He thought that this ancyrodellid evolved from the spathognathodid stock perhaps by "expanding the lateral bulges and by developing a node on either side of these lateral expansions". As Orchard (1975a, p.59) noted, there is an analogy to the possible spathognathodid-ancyrodellid relationship in the Silurian, where Walliser (1957, p.34) recorded a phylogenetic sequence between his Sp. fundamentatus [O. fundamentatus] and Kockelella.

Within the ancyrodellids, the overall outline of the platform is considered the most important feature for specific differentiation, and the development of secondary carinae and keels is also significant, as Ziegler (1973, p.21-22) noted. He indicated the synonymy of, and described, the genus, and a description of Ancyrodella was presented also by Huddle (1968, p.6).

With regard to the multielemental position of Ancyrodella, Klapper and Philip (1972, p.99) placed the genus in a Type 1 apparatus, in which the P,O1',N,A1,A2 and A3 elements were ancyrodellan, bryantodontan, neoprioniodontan, hindeodellan, angulodontan and hibbardellan respectively. Ziegler (1972, p.94-95) suggested that the apparatus might instead be mono-elemental, composed of paired ancyrodellids, or that Ancyrodella might have formed a two-platformed apparatus, associated with Ancyrognathus.

Ancyrodella gigas YOUNGQUIST

*1947 Ancyrodella gigas n.sp. - YOUNGQUIST, p.96-97, pl.25, fig.23 (= holotype).
1957 Ancyrodella gigas YOUNGQUIST-MÜLLER & MÜLLER, p.1091, pl.141, fig.8, pl.142, fig.1.
v1958 Ancyrodella gigas YOUNGQUIST-ZIEGLER, p.41-42, pl.11, figs.8, 10, 17.

v1965 Ancyrodella gigas YOUNGQUIST - KREBS & ZIEGLER, pl. 2, fig. 7.

v1965 Ancyrodella gigas MILLER & YOUNGQUIST [sic] - ZIEGLER (a), pl. 1, fig. 1.

1966 Ancyrodella gigas YOUNGQUIST - ANDERSON, p. 403, pl. 48, figs. 10, 14.

1968 Ancyrodella gigas YOUNGQUIST - MOUND, p. 470, pl. 65, figs. 17, 18.

·1970 Ancyrodella gigas YOUNGQUIST - SEDDON (b), pl. 7, figs. 6, 7.

1971 Ancyrodella gigas YOUNGQUIST - SZULCZEWSKI, p. 12, pl. 2, fig. 3, pl.4, fig. 1.

1974 Ancyrodella gigas YOUNGQUIST - UYENO, p. 23-24, pl. 1, figs. 1, 8, 9.

·1978 Ancyrodella gigas YOUNGQUIST - ORCHARD, p. 926, pl. 114, fig. 4.

·1979 Ancyrodella gigas YOUNGQUIST - LANE, MÜLLER & ZIEGLER, p. 217, pl. 2, fig. 20.

Diagnosis: A species of Ancyrodella in which the platform has an elongated, triangular outline and bears an ornament of fairly robust, more or less regular nodes. Secondary carinae and, aborally, secondary keels are developed and reach the pointed tips of the anterior lobes.

Remarks and comparisons: See under A. aff. gigas.

Range: A. gigas extends from the base of the Middle asymmetricus Zone to the top of the Lower gigas Zone (Ziegler 1971, chart 5; in Klapper and Ziegler 1979, text - fig. 5).

Ancyrodella aff. gigas sensu ORCHARD 1978

Plate 16, figs. 12, 16.

·1947 Ancyrodella sp. - MILLER & YOUNGQUIST, p. 503-504, pl. 74, fig. 13.

·1978 Ancyrodella aff. gigas YOUNGQUIST - ORCHARD, p. 926, 928, pl. 114, figs. 1, 11, 12.

Remarks and comparisons: In contrast to the platform of A. gigas, that of A.

aff. gigas either lacks or has only a slight posterior constriction, and has less well developed anterior lobes; consequently the platform is relatively broader and shorter in the latter.

A solitary juvenile specimen from Torquay is assigned to this form on the basis of a short equitriangular platform, similar in size and outline to one illustrated by Miller and Youngquist (1947, pl. 74, fig. 13). However, unlike the latter example, which bears an ornament of several pairs of regular nodes, the material from Plymouth (Orchard 1978, pl. 114, figs. 1, 12) and from Torquay is less ornamented. The Plymouth specimens bear large random nodes, the nodes of the secondary carinae being similar in size; the specimen to hand bears just a few rounded nodes which are smaller than those of the secondary carinae. The platform of the Torquay example is rather asymmetrical. the outer half is wider than the inner, the free blade meeting the anterior edge two-thirds of the way in from the outer margin. The platform of the form shown by Miller and Youngquist is more or less bisected by the blade-carina, as appears to be the case in the Plymouth material, although the latter is badly sheared.

Compared to A. gigas, A. buckeyensis STAUFFER has a rather short equitriangular platform, in which it resembles A. aff. gigas. However, the anterior platform of A. buckeyensis exhibits a deep V-shaped indentation which is bisected by the free blade, and because of this feature the anterior lobes of this species appear attenuated in contrast with those of A. aff. gigas. In the latter, the anterior platform margin is somewhat straighter. The ornament of A. buckeyensis is distinctive, of ridges and nodose ridges which are arranged perpendicularly to the platform margins. Ziegler (1962a, text - fig. 2) derived A. buckeyensis from A. gigas and, in platform configuration, A. aff. gigas appears to lie somewhere between these two forms.

A. nodosa may also have an equitriangular platform which is similar anteriorly to that of A. buckeyensis, but is considerably more reduced overall, especially posteriorly where a constricted posterior process is developed.

A. gigas may exhibit a restricted posterior platform. This feature is most pronounced in the holotype but is rather less well developed in subsequent designations, as Orchard (1975a, p.61) discussed. However, the posterior constriction is always less, and the entire platform is relatively longer, in A. gigas than in A. nodosa. Compared with both A. gigas and A. aff. gigas, the ornament of A. nodosa is rather subdued and may become ridge-like as in A. buckeyensis. In evolutionary terms, Ziegler (1962a, text - fig. 2) placed A. nodosa between A. buckeyensis and A. ioides ZIEGLER, while Szulczewski (1971, p. 14) suggested that A. nodosa was probably polyphyletic and may have been derived also from A. gigas.

Orchard (1978, p. 928) observed that specimens assigned to A. gigas by Szulczewski (1971) and Uyeno (1974) differed from the holotype in their aboral configuration. These individuals have a relatively longer platform than A. aff. gigas and are maintained herein under A. gigas. The ornament of the material illustrated by Uyeno (1974, pl. 1, figs. 1, 8, 9) consists of numerous nodes which are aligned in longitudinal rows and is similar to that of A. rugosa. A similar tendency was noted by Szulczewski (1971, p. 12) within his specimens of A. gigas, and the ornament of A. aff. gigas illustrated by Miller and Youngquist (1947, pl. 74, fig. 13: cited as Ancyrodella sp.) also resembles that of A. rugosa. However, A. rugosa has a longer platform than A. aff. gigas, similar to that of A. gigas, but the anterior lobes are rather more rounded than in the latter, and are better developed overall than in A. aff. gigas. Aborally, the secondary keels of A. rugosa are well developed but, unlike those of A. gigas and A. aff. gigas, do not reach the anterior lobe tips.

Range and occurrence: The full stratigraphical range of A. aff. gigas is not known. In Plymouth, Orchard (1978, p. 917, text - fig. 2, table 2) recorded the form from Durnford Street (sample DS1): Fauna 12, assigned by him to the Middle asymmetricus Zone. Similar material occurs in the Belgian Frasnian (Mouravieff, pers. comm. in Orchard 1978, p. 928).

In Torquay, A. aff. gigas was found at Petit Tor Beach (sample PB-1).

Ancyrodella lobata BRANSON & MEHL

Plate 16, figs. 10, 11, 13-15.

*1934 Ancyrodella lobata n. sp. - BRANSON & MEHL, p.239-240, pl.19, fig.14, pl.21, figs.22,23 (pl.21, fig.22 = lectotype, designated by ZIEGLER 1958, p.43).

v·1958 Ancyrodella lobata BRANSON & MEHL - ZIEGLER, p. 43, pl. 11, figs. 6, 9.

·1966 Ancyrodella lobata BRANSON & MEHL - FLAJS, pl. 23, fig. 2.

·1967 Ancyrodella lobata BRANSON & MEHL - WIRTH, p. 203, pl. 19, figs. 3, 4.

·1970 Ancyrodella lobata BRANSON & MEHL - SEDDON (a), pl. 16, fig. 2.

·1970 Ancyrodella lobata BRANSON & MEHL - SEDDON (b), pl. 7, figs. 8-11, 14-17.

·1971 Ancyrodella lobata BRANSON & MEHL - SZULCZEWSKI, p. 13-14, pl. 3, figs. 1-4, pl. 4, figs. 2, 3 (see synonymy).

·1971 Ancyrodella lobata BRANSON & MEHL - SCHUMACHER (b), pl. 12, fig. 8.

Diagnosis: A species of Ancyrodella in which a postero-lateral process is present but is not well developed, and bears a secondary carina which is usually incomplete. Aborally, a corresponding secondary keel may be either completely or only incipiently developed, or may be absent. The oral surface of the platform bears a nodose ornament.

Remarks and comparisons: A. lobata is a highly variable species, as Szulczewski (1971, p.13) noted. The variability is manifest in the development both of the postero-lateral process and of the whole platform, and in the development of the secondary keel and carina. The species most closely resembles A. curvata, which is distinguished by a better differentiated postero-lateral lobe which bears a usually more distinct secondary carina. The secondary carina of A. lobata is often incipient and indistinct, or may sometimes become better developed (compare Szulczewski 1971, pl. 3, fig. 4, pl. 4, fig. 3 with his pl. 3, fig. 3). Aborally, A. curvata always has a prominent secondary keel which is either developed throughout the entire length of the postero-lateral lobe, or may stop a little short of the outer margin. The secondary keel of A. lobata does not always attain the full length of the postero-lateral process, or is sometimes absent or, occasionally, may be as fully developed as in A. curvata. Within any one specimen of A. lobata, the secondary keel and carina do not necessarily exhibit a similar extent of development.

Orally, both A. lobata and A. curvata show a variety of ornament, from fine to coarse nodes which may become more or less longitudinally aligned. In both species the finer nodes sometimes may be slightly fused to produce short ridges arranged perpendicularly to the platform margins, and thus the ornament may resemble that of A. buckeyensis.

Because of the considerable range of morphological variation shown by A. lobata, some forms may be transitional to A. curvata. Ziegler (1962a, text-fig. 2) derived the latter species from A. gigas by way of the former. Specimens of A. lobata in which the secondary keel and carina are only incipient or more or less absent, and the postero-lateral process only faint, show a tendency toward A. gigas. Orchard (1975a, p. 60) observed a transitional sequence within examples illustrated by Szulczewski, from A. gigas through various forms of A. lobata to A. curvata (Szulczewski 1971, pl. 4, fig. 1; pl. 4, fig. 3, pl. 3, figs. 3, 4; pl. 4, fig. 4 respectively). In this series, the postero-lateral process becomes gradually better differentiated, and bears a progressively better developed secondary carina and keel.

The specimens to hand have only a poorly differentiated postero-lateral process which bears, aborally, a well developed secondary keel which reaches the outer margin. Orally, the process bears only an indistinct secondary carina. The platform ornament is of fine nodes which become rather ridge-like anteriorly, where they are arranged normal to the margins.

Range and occurrence: A. lobata ranges from the base of the Middle asymmetricus Zone through into the lower, or possibly middle, part of the Upper gigas Zone

(Ziegler 1971, chart 5; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, the species occurs at Petit Tor Beach (samples PB-1,2).

Ancyrodella rotundiloba (BRYANT)

1921 Polygnathus rotundilobus spec. nov. - BRYANT, p. 26-27, pl. 12, figs. 1-6, text-fig. 7 (pl. 12, fig. 1 = lectotype, designated by ZIEGLER 1958, p. 44).

Diagnosis: A species of Ancyrodella with a triangular or rather oval-shaped platform which bears at least two, and often numerous, coarse, rounded nodes. Aborally, the basal cavity is of variable size and up to two secondary keels may be developed from it, although neither reaches the rounded anterior platform margins.

Remarks: Four subspecies of A. rotundiloba have been recognised. A. r. binodosa appears to be the earliest representative, and A. r. subsp. A sensu UYENO, A. r. rotundiloba and A. r. alata GLENISTER & KLAPPER subsequently appear. The validity of A. r. subsp. A has been questioned by, for example, Szulczewski (1971, p. 15) and Ziegler (1973, p. 30) both of whom considered the form synonymous with A. r. rotundiloba. Only A. r. binodosa and the nominate subspecies are recognised in the Torquay faunas.

For further remarks and discussions, see Glenister and Klapper (1966, p. 799), Müller and Clark (1967, p. 908-909) and Ziegler (1973, p. 25-26). The work of Müller and Clark included a study of the ontogeny of A. r. rotundiloba (as A. rotundiloba).

Ancyrodella rotundiloba binodosa UYENO

Plate 16 figs. 17, 18, 20-22, 24.

*1967 Ancyrodella rotundiloba binodosa n. subsp. - UYENO, p. 4-5, pl. 1, figs. 2, 4, 5 (figs. 2a, 2b = holotype).

1970 *Ancyrodella prima* n. sp. - CHALYMBADSCHA & TSCHERNYSHEVA, pl. 1, figs. 1, 2.
1970 *Ancyrodella pristina* n. sp. - CHALYMBADSCHA & TSCHERNYSHEVA, pl.1, figs.3-8.
·1973 *Ancyrodella rotundiloba binodosa* UYENO - ZIEGLER, p. 35-36, *Ancyrodella* - pl. 1, figs. 4a, 4b (originals of UYENO 1967, pl. 1, figs. 2a, 2b respectively).
·1974 *Ancyrodella rotundiloba binodosa* UYENO - UYENO, p. 24-25, pl. 1, figs. 2, 4-6, pl. 2, figs. 2, 3, 5 (see synonymy).
·1975 *Ancyrodella rotundiloba binodosa* UYENO - BULTYNCK, p.17-18, pl.1, figs.1-3.
·1976 *Ancyrodella rotundiloba binodosa* UYENO - GARCIA - LOPEZ, pl.2, fig. 1.

Diagnosis: A subspecies of *Ancyrodella rotundiloba* with a triangular platform which bears a pair of large nodes, one on either side of the carina. A few incipient nodes may also be present. Aborally, secondary keels are only incipiently developed from the relatively large basal cavity.

Remarks and comparisons: *A. r. binodosa* is distinguished from *A. r. rotundiloba* and *A. r. alata* by the lesser development of the platform, particularly posteriorly, and by the distinctive ornament of one prominent node on either side of the carina, sometimes accompanied by a few incipient nodes. Aborally, as Uyeno (1974, p. 25) observed, *A. r. binodosa* has an oval-shaped basal cavity, larger than the diamond-shaped cavity of both *A. r. rotundiloba* and *A. r. alata*, and compared to the latter, secondary keels are only incipiently developed.

Mouravieff (in Bouckaert and Streel 1974, Excursion F, p. 1) described forms from level F2a at Fromelennes in Belgium, which he considered to be transitional between *A. r. binodosa* and *A. r. rotundiloba*. The specimens occurred above the first appearance of the former subspecies, and their platforms bore several additional nodes of a smaller diameter than the two main nodes. In the same area Bultynck (1975, p. 17, text - figs. 3-5) noticed a progressive change from *A. r. binodosa* to *A. r. rotundiloba* in the Zone de

Monstres at the base of F2a at Sourd d'Ave and at Doische. He observed that transitional examples had up to ten smaller nodes, of almost the same height as the two main nodes, but the platform was not as well developed posteriorly as in A. rotundiloba. These intermediate forms may all be referrable to A. r. subsp. A, although the specimens illustrated by Bultynck (1975, pl. 1, figs. 1-3), all from Sourd d'Ave, appear to be consistent with A. r. binodosa. Mouravieff (pers. comm. in Orchard 1975a, p. 64) has questioned whether the morphological variations might represent an ecological response rather than a true evolutionary trend.

Compared with A. r. binodosa, A. r. subsp. A has both a better developed platform, although not as well developed as in A. r. rotundiloba and A. r. alata, and ornament. The last is often of numerous coarse nodes and, while one node on either side of the carina may be larger than the rest, the size difference is not as marked as in those specimens of A. r. binodosa which bear incipient nodes in addition to the two main nodes. Also, the basal cavity of A. r. subsp. A is often larger than that of A. r. binodosa and may show bifurcation at one or both ends. As Uyeno (1974, p. 26) noted, juvenile examples of A. r. subsp. A may resemble A. r. binodosa. However, in small forms of the latter nodes in addition to the two main nodes are not so well developed.

The larger of the two specimens of A. r. binodosa from Torquay, shown on Plate 16, figs. 20, 21, 24, resembles one illustrated by Uyeno (1974, pl. 2, fig. 5), although the basal cavity of the form to hand is somewhat larger, but lacks the bifurcation sometimes seen in A. r. subsp. A. The very small example on Plate 16, figs. 17, 18, 22 is close to juvenile specimens which Uyeno (1974, pl. 1, fig. 4, pl. 2, fig. 3) recorded from the base of the Christina Member of the Waterways Formation. The basal cavity of these forms is large and occupies almost all of the aboral surface of the platform. In contrast, the basal cavity of the smallest growth stage of A. r. rotundiloba figures by Müller and Clark (1967, text - fig. 5a) is relatively smaller and diamond-shaped. Uyeno (1974, p. 25) noted that his juvenile specimens were similar to his "Sp.? sp.". Although the platforms of the former are relatively less well developed than in more mature forms, the platform of the latter is somewhat less distinct, the lateral denticles existing rather as outgrowths from the blade. The nodes of the individual to hand resemble, in lateral view, the high pointed denticles of "Sp.? sp." but they are developed from the platform, the form of which is consistent with A. r. binodosa.

Range and occurrence: Ziegler (in Klapper and Ziegler 1979, text - fig. 5) showed the first appearance of A. r. binodosa possibly in the upper part of the Lowermost asymmetricus Zone, the main occurrence in the lower part of the Lower asymmetricus Zone. Uyeno (1974, table 1) showed the subspecies ranging throughout the last Zone. Chalymbadscha and Tschernyscheva (1969, text - fig. 1) recorded A. prima and A. pristina (junior synonyms of A. r. binodosa: see Ziegler 1973, p. 35) below A. r. rotundiloba, A. prima from the uppermost Givetian.

In Torquay, A. r. binodosa occurs at Babbacombe Cliff (samples BC-9, 32).

Ancyrodella rotundiloba rotundiloba (BRYANT)

Plate 16, figs. 19, 23.

*1921 Polygnathus rotundilobus n. sp. - BRYANT, p. 26-27, pl. 12, figs. 1-6 (fig. 1 = holotype).

1933 Polygnathus tuberculata HINDE-BRANSON & MEHL(a),p.148,pl.11,fig.9 (only).

1934 Polygnathus rotundiloba BRYANT - HUDDLE, p. 102-103, pl. 8, figs. 36, 37.

non1947 Polygnathus rotundiloba BRYANT - YOUNGQUIST, p. 110, pl. 26, fig. 6.

·1956 Ancyrodella rotundiloba (BRYANT) - HASS, pl. 4, fig. 21.

v·1957 Ancyrodella rotundiloba (BRYANT) - BISCHOFF & ZIEGLER, p. 42, pl. 16, figs. 5, 7, 8, 10, 15 (non figs. 6, 9, 11, 12, 16, 17 = A. r. alata).

v·1958 Ancyrodella rotundiloba (BRYANT) - ZIEGLER, p. 44-45, pl. 11, figs. 11, 12.

1959 *Ancyrodella rotundiloba* (BRYANT) - KREBS, pl. 1, fig. 15.

1966 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - GLENISTER & KLAPPER, p. 799, pl. 85, figs. 9-13.

•1967 *Ancyrodella rotundiloba* (BRYANT) - CLARK & ETHINGTON, p. 29-30, pl. 2, figs. 6(?), 15 (non figs. 4, 8-10, 13, 14 = *A. r. alata*; non fig. 7 = *A. r. binodosa*).

1967 *Ancyrodella rotundiloba* (BRYANT) - MÜLLER & CLARK, p. 908, pl. 115, fig. 8, pl. 116, figs. 1-5.

1969 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - PÖLSLER, p.404, pl. 4, figs. 5-8.

1969 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - CHALYMBADSCHA & TSCHERNYSCHEVA, pl.1, figs. 9-12.

1970 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - KIRCHGASSER, p. 343-344, pl. 65, figs. 5, 6, 8, 9.

1970 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - SEDDON (b), pl. 7, fig. 1.

•1971 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - SZULCZEWSKI, p. 15, pl. 1, fig. 3 (non fig. 4 = *A. r.* subsp. A *sensu* UYENO?; non pl. 2, fig. 6 = ?).

1971 *Ancyrodella sinecarina* n. sp. - SZULCZEWSKI, p. 16-17, pl. 1, figs. 5, 6.

•1972 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - KLAPPER & PHILIP, p. 99, pl. 2, fig. 1 (only).

•1973 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - ZIEGLER, p. 29-31, *Ancyrodella* - pl. 1, figs. 1, 2 (originals of BRYANT 1921, pl. 12, fig. 1; ZIEGLER 1958, pl. 11, fig. 12b respectively).

•1975 *Ancyrodella rotundiloba* (BRYANT) - GUPTA, p. 158-159, pl. 1, figs. 7, 8.

•1976 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - GARCIA - LOPEZ, p. 176, pl. 2, figs. 2-4.

•1980 *Ancyrodella rotundiloba rotundiloba* (BRYANT) - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, figs. 34, 35.

Diagnosis: A subspecies of *A. rotundiloba* with a triangular platform which bears an ornament of coarse nodes. Aborally, secondary keels are only incipiently developed. Neither keel, if present, reaches the crimp.

Remarks and comparisons: A. r. rotundiloba is distinguished from A. r. alata by the poor development, and sometimes absence, of the secondary keels. In A. r. alata both are pronounced, the inner keel extending anteriorly to the crimp, the outer keel being shorter and directed laterally or sometimes posteriorly. Also, as Glenister and Klapper (1966, p. 799-800) noted, the oral surface ornament of A. r. rotundiloba is coarser compared to that of A. r. alata, the free blade is both higher and composed of fewer denticles, and the anterior lobes of the platform are directed anteriorly rather than laterally. It is the pronounced lateral extension of the anterior lobes of A. r. alata that produces the distinctive alate outline.

In outline and in oral surface configuration, the platform of A. r. rotundiloba may resemble A. rugosa, a species which is not well established, as Szulczewski (1971, p. 16) discussed. He observed that, according to Ziegler (1962a, text - fig. 2) this form has an evolutionary position between A. rotundiloba and A. gigas. A. rugosa may be distinguished from A. r. rotundiloba aborally by the stronger and more uniform development of the secondary keels, which extend close to the anterior lobe tips.

The small specimen from Torquay, illustrated on Plate 16, figs. 19, 23 resembles similar sized examples which Garcia-Lopez (1976, pl. 2, figs. 3,4) figured from the Candas Limestone at Luanco in northern Spain. Aborally, the form to hand exhibits a typically poor development of secondary keels. The outer keel is a little longer than the inner and bifurcates slightly, a feature noted by Uyeno (1974, p. 25, pl. 2, fig. 6) in his A. r. subsp. A, although the basal cavity of Uyeno's illustrated specimen is relatively larger than in the one from Torquay.

A. r. rotundiloba may be distinguished from A. r. subsp. A by the coarser ornament of the latter, in which one node on either side of the carina may sometimes be larger than the others, a feature not seen in the former. As Uyeno (1974, p. 25) described, the platform of A. r. subsp. A may be oval in outline compared to the triangular outline of A. r. rotundiloba, and the basal cavity larger (e.g. Uyeno 1974, pl. 2, fig. 7) with, as is noted above, the incipient secondary keels sometimes showing bifurcation. Other examples of A. r. subsp. A (e.g. Uyeno 1974, pl. 2, figs. 1, 8) resemble the nominate subspecies in their triangular platform outline and diamond shaped basal cavity, but the platform is always less well developed compared to the latter, especially in the posterior part of the unit.

Range and occurrence: A. r. rotundiloba extends from the base of the Lower asymmetricus Zone to the top of the Middle asymmetricus Zone (Ziegler 1971, chart 5; 1973, p. 30; in Klapper and Ziegler 1979, text - fig. 5).

In Torquay, A. r. rotundiloba occurs at Barton Quarry (sample BQ-18).

Form genus Icriodus BRANSON & MEHL

Type species: Icriodus expansus BRANSON & MEHL 1938.

Remarks: Icriodus is usually not a major component of the Torquay faunas. An exception to this is found in the oldest of the samples to hand, in which the genus is stratigraphically important, and faunas may consist almost entirely, and sometimes totally, of icriodids.

Taxonomic problems are frequently encountered within Icriodus. Descriptions of new species have sometimes been based on inadequate and often broken specimens, some of which, such as the holotype of I. nodosus (HUDDLE), are now lost. Also, a lack of information concerning ontogenetic and phylogenetic relationships within the genus has resulted in the establishment of dubious species and in incorrect identifications. For example, the original description of I. cymbiformis by Branson and Mehl (1938, p. 164) was based on very small specimens which are now lost. Bischoff and Ziegler (1957, p. 62) believed that juvenile growth stages of various species were included in the concept, and Schumacher (1971b, p. 102, text-fig. 18) indicated that such individuals might be small forms of I. alternatus, while Klapper (in Ziegler 1975, p. 89) suggested that at least some of the designations of I. cymbiformis in the literature were synonymous with I. brevis.

Schumacher (1971a, p. 90) noted the need for monographic revision of the genus, which Rhodes et al. (1973, p. 130) referred to as a "nomenclatorial jungle", and studies of the icriodids made by both Klapper and Ziegler (in Ziegler 1975) and by Weddige (1977) are particularly important in this respect, because they have provided a considerable degree of reassessment of Icriodus. Despite their work, it is frequently difficult to make unambiguous identifications within the Torquay material, because specimens are not abundant, are often incompletely and sometimes poorly preserved, and may also be tectonically deformed. Also, a considerable degree of morphological gradation appears to exist between species. For these reasons several designations herein are only tentative, while others are made in terms of a rather broad Icriodus complex, the I. expansus group.

With regard to the criteria used for taxonomic differentiation, the aboral configuration was once favoured as one of the most significant diagnostic features, and in the original diagnoses of I. c. corniger and I. introlevatus (Wittekindt 1965, p. 629; Bultynck 1970, p. 113 respectively) this was the sole diagnostic character. The overall appearance of the basal cavity was considered to be important, and special regard was also given to the presence or absence in the aboral margins of such developments as a sinus, a spur and an antispur, and to the form of the posterior margin of the basal cavity. However, in any one taxon these are not always consistent features. For example, a variable development of all four characters is evident in the type material of I. c. corniger and is described under the I. corniger group. Orchard (1978, p. 930) noted that I. alternatus, as described and illustrated by Schumacher (1971b, p. 102, pl. 13, figs. 1-7), may or may not have a spur, and a similar variation is exhibited within the I. expansus group as envisaged by the former author and herein. Bultynck (1972) preferred to evaluate both oral and aboral features in order to subdivide, and to establish possible phylogenetic trends within, the genus, and, more recently, Weddige and Ziegler (1979, p. 161) stated that they believed the nature of the basal cavity to be no longer of prime significance in specific differentiation. They considered the following characters to be the critical diagnostic features within the icriodids: proportions (ratio of length to breadth) of the entire unit, and the course of the length axis; outline and proportions of the middle platform plus growth point ["spindle" of Weddige (1977)]; configuration of the oral surface ornament of the unit in both plan and lateral view, including that of the blade, and the number of denticles in each longitudinal row of the middle platform; inclination (in lateral view) and outline of the lower margins. The authors noted that a specific combination of these characters, none with priority, was "taxonomically significant for each taxon or morphotype".

Weddige and Ziegler also made several observations concerning the ontogeny of the icriodids. They noted that the cross-section of the denticles showed a continuous increase in size during ontogeny and that "crests", or transverse and longitudinal bridges, became increasingly more commonly developed. They recorded also that additional denticles were sometimes formed in adult growth stages, and could be located in the median row, on and on either side of the blade, and on the oral surface of the inner spur. At least some of these developments are evident in the Torquay individuals, as in the large specimen shown on Plate 3, figs. 1-3 which is referred to, and described under, I. latecarinatus.

As has been noted above, the Torquay icriodids show much gradation between species. It is noteworthy in this respect that Druce (pers. comm. in Orchard 1975a, p. 201) considered the configuration of the icriodid denticulation, especially with regard to the cross-section of the denticles and the extent of their alignment and fusion, and the proportions of the entire icriodid unit to be variable and facies dependent. Weddige (1977) and Weddige and Ziegler (1979) thought that Middle Devonian icriodids favoured shallow water areas, and suggested that their overall morphologies might reflect adaptive changes to the varied habitats therein. The idea was illustrated with reference to the I. corniger group which, according to these authors, had originated in the late Lower Devonian and had become dominant in the Middle Devonian. It was believed that representatives of the group had undergone, and had adapted to, considerable environmental changes between the two, from a pelagic and deeper water habitat in the late Lower Devonian to various environments, which included quiet to agitated or turbulent conditions, in the shallower waters of the shelf in Middle Devonian times. The morphological adaptations within the *I. corniger* group to the varied habitats of the last were evaluated and illustrated by Weddige and Ziegler (1979, text-fig. 3), and they described and depicted a phylogeny for the icriodids also in terms of ecophenotypic groups (Weddige and Ziegler 1979, p. 162-163, text-fig. 2). They envisaged that, following its adaptive phase, the *I. corniger* group gave rise to the *struvei* and *regularicrescens* branches. Like the *I. corniger* group, the former branch was thought to have developed in various habitats, and the latter branch was found associated with crinoidal and coral limestones, which represented a weakly agitated to turbulent shallow water environment. The *werneri* branch paralleled these developments, and was correlated with a quiet, shallow water habitat.

Several interpretations of the multielemental *Icriodus* have been attempted. Klapper and Philip (1971, 1972) incorporated the genus within the multielemental family Icriodontidae in a Type 4 apparatus, which was composed of an icriodontan (I) element and an acodinan (S2) element. This proposed apparatus and a similar, albeit coprolitic, association recorded by Lange (1968) have been discussed by Bultynck (1972), who examined the position of the simple cone *Acodina*. His evidence did not support the idea of the mutual occurrence of *Icriodus* and *Acodina* in one apparatus, and he preferred to envisage a natural association purely of icriodids. He distinguished and described eight *Icriodus* assemblages in the lower Middle Devonian and five in the upper Middle Devonian, which were composed either of one form-species or of a morphological transition series of two or three form-species. With regard to *Acodina*, the form is rare in the Torquay faunas and, whilst it is true to say that it is never found without icriodids, the latter often occur without *Acodina*. Similar observations have been recorded by Chatterton (1974, p. 1467-1469, 1478) and by Orchard (1975a, p. 70).

Ziegler (1972) involved *Icriodus* in his Lower Devonian Apparatus b which, like the Type 4 apparatus of Klapper and Philip, comprised both icriodiform and acodiniform elements. He noted that the numbers of the former probably exceeded those of the latter, and a similar point was made by Klapper and Philip (1971, p. 439).

The age range of the genus was considered by Ziegler (1975, p. 68) to extend from the latest Silurian into, and through, the Devonian. The terminology used herein follows that introduced by Bultynck (1972, p. 74).

Icriodus arkonensis STAUFFER

Plate 2, figs. 29-32, 34.

*1938 Icriodus arkonensis n. sp. - STAUFFER, p. 429, pl. 52, figs. 10, 15 (fig. 15 = lectotype, designated by KLAPPER in ZIEGLER 1975, p. 77).

·1977 Icriodus arkonensis STAUFFER - WEDDIGE, p. 284-285, pl. 2, figs. 26-29 (see synonymy).

·1980 Icriodus arkonensis STAUFFER - KLAPPER in KLAPPER & JOHNSON, pl. 3, fig. 24.

Diagnosis: A species of Icriodus, in which the platform is biconvex and sometimes lachryform in outline. Each half of the middle platform bears many (eight to ten) narrow, but distinct and close spaced, transverse bridges, which connect often well aligned lateral and median denticles. In oral aspect the laterals are transversely elongated and wedge or drop-shaped, the medians rounded. The blade is short. Aborally, the strong basal expansion occupies at least the posterior half of the unit. A spur and corresponding sinus are usually developed in the inner margin of the basal cavity.

Description (Torquay material): In outline the platform is biconvex and broadest in the posterior half of the unit (e.g. Pl. 2, fig. 29) or may be rather more plano-convex (e.g. Pl. 2, fig. 32). The length axis is incurved, sometimes strongly so anteriorly, as in the former example. Variation in curvature and in platform outline are probably due, to some extent, to tectonic deformation. Each half of the middle platform bears eight or nine fairly narrow, distinct and close spaced transverse bridges. Because the denticulation is well aligned, the last are developed at right angles to the somewhat weaker longitudinal bridges. In oral aspect the median denticles are rounded, the lateral denticles transversely elongated and usually wedge-shaped. A few of the lateral denticles are rather more drop-shaped, the marginal part of each of these denticles being swollen and subcircular in outline. The growth point comprises at least two denticle series. The anterior platform may be abruptly constricted, and the growth point strongly tapered and narrow (e.g. Pl. 2, fig. 29). The posterior extremity is always blunt. The blade is composed of one denticle which is stout in oral aspect, but is not higher than the upper surface of the rest of the unit in profile.

Aborally, the basal cavity is well preserved only in the specimen on Plate 2, figs. 29-31. There is a conspicuously wide basal expansion which occupies the posterior two-thirds of the unit. The inner margin of the basal cavity is broken, but there is some indication of a spur-like development. Anteriorly, the basal cavity tapers fairly abruptly and narrowly to the tip, corresponding to the thin, ridge-like form of the anterior platform in oral view.

Remarks and comparisons: The material from Torquay is assigned to I. arkonensis on the basis of the outline and configuration of the oral surface. The example shown on Plate 2, figs. 29-31 most closely resembles one illustrated by Weddige (1977, pl. 2, fig. 28) in the form of the thin, tapering growth point and the lateral denticles, which are rather wedge-shaped in plan view. Other specimens shown by Weddige (1977, pl. 2, figs. 26, 27, 29) have a growth point similar to that of the individual to hand on Plate 2, figs. 32, 34. The last-mentioned of Weddige's examples, and those figured by Klapper (in Ziegler 1975, pl. 1, figs. 3b, 4a), exhibit a strong development of the drop-shaped lateral denticles sometimes seen in the available material.

As described above, the basal cavity is well preserved only in one Torquay specimen, in which the broad aboral expansion occupies the posterior two-thirds of the unit. In this respect the individual is rather unusual, because in the material figured by Weddige (1977) and by Klapper (in Ziegler 1975: includes lectotype) the basal expansion is less pronounced and occupies more or less the posterior half of the unit.

Klapper (*op.cit.*, p. 77) distinguished *I. arkonensis* from *I. expansus* by the presence of a spur and sinus in the inner margin of the basal cavity of the former. The *I. expansus* group (*q. v.*) embraces forms both with and without a spur and, as discussed in the introduction to the genus, the apparently variable development of the basal cavity in any one taxon considerably diminishes its value as a criterion for specific differentiation. Therefore, disregarding the aboral configuration, *I. arkonensis* may be distinguished from representatives of the *I. expansus* group by the presence of many narrow and close spaced, but conspicuous, transverse bridges on the oral surface of the middle platform in the former (up to nine such bridges in each half of the specimens to hand), and by the distinct alignment of the denticulation. Also, the blade in members of the *I. expansus* group, in contrast with that of *I. arkonensis*, is relatively longer, better developed and, in lateral view, may be higher posteriorly.

These differences being stated, there appears to be some degree of morphological gradation between those specimens assigned to *I. arkonensis* and those referred to the *I. expansus* group, as is manifest in the examples shown on Plate 2, figs. 18, 25, 27, which are assigned to and discussed under the latter (*q. v.*). Orchard (1978, p. 930) noted that the two forms have been placed in synonymy, and observed that, in his Plymouth representatives of the *I. expansus* group, larger specimens resembled *I. arkonensis*. However, none of his figured individuals appear to be better referred to the latter species, which is maintained herein separately from the *I. expansus* group.

A conspicuously large basal cavity, which occupies up to two-thirds of total unit length, is strongly constricted anteriorly and has a weak spur on the inner side is developed in I. norfordi a species erected by Chatterton (1979, p. 202-203). In the morphology of the basal cavity, I. norfordi is similar to the specimen from Torquay on Plate 2, figs. 29-31, but is distinguished both from this form, and from rather more typical examples of I. arkonensis in which the basal cavity is relatively smaller, by its very different oral configuration. I. aff. expansus sensu CHATTERTON 1979 also has a large basal expansion, and the oral surface of the middle platform may bear transverse bridges (e.g. Chatterton 1979, pl. 6, fig. 2), but these are neither as close spaced nor as abundant as in I. arkonensis and, compared to the last species, the blade of Chatterton's forms is better developed.

Differences between I. arkonensis and their I. difficilis were outlined by Ziegler and Klapper (in Ziegler et al. 1976, p. 118). The margins of the latter species are subparallel, whereas the platform of the former is often distinctly wider behind unit mid-length, because the lateral denticles are strongly expanded sideways. The blade of I. difficilis is longer and better developed than that of I. arkonensis, and the median and lateral denticles sometimes alternate and transverse bridges are not always developed, whereas in I. arkonensis the denticulation is usually aligned and transverse bridges are commonly present.

Range and occurrence: According to Klapper (in Ziegler 1975, p.77) I. arkonensis is of late Middle Devonian (Givetian) age. In the Eifelian Hills of Germany, Weddige (1977, tables 2, 7) indicated that the species was restricted to high Eifelian levels. He showed I. arkonensis to range from the base of the ensensis Zone to higher within this division.

In Torquay, I. arkonensis occurs at Parkfield Road (sample PF-9).

Icriodus brevis STAUFFER

Plate 3, figs. 24, 26-29, 31 (aff.).

*1940 Icriodus brevis n. sp. - STAUFFER, p. 424, pl. 60, figs. 36, 43, 44, 52 (fig. 44 = lectotype, designated by KLAPPER in ZIEGLER 1975, p. 89).

?1970 Icriodus brevis brevis STAUFFER - SEDDON (a), p. 735-736, pl. 12, figs. 12-15.

?1970 Icriodus brevis angustulus subsp. nov. - SEDDON (a), p. 736, pl. 11, figs. 13-24.

1974 Icriodus brevis brevis STAUFFER - UYENO, p. 29-30, pl. 6, figs. 3, 11, 12.

·1975 Icriodus eslaensis BOOGAERT - TELFORD, p. 23, pl. 4, figs. 7, 8.

·1977 Icriodus brevis STAUFFER - WEDDIGE, p. 285, pl. 2, fig. 37 (see synonymy).

·1978 Icriodus brevis STAUFFER - UYENO, p. 18, pl. 4, figs. 28-30, 36-44 (only).

·1979 Icriodus brevis STAUFFER - UYENO, p. 248, pl. 2, figs. 4-6.

·1979 Icriodus latecarinatus BULTYNCK - ORCHARD, pl. 1, figs. 14, 17, 20, 22 ("Small growth stages which correspond to I. brevis").

Remarks and comparisons: Klapper (in Ziegler 1975, p. 89) considered I. eslaensis to be a junior synonym of I. brevis. I. obliquimarginatus was envisaged by Bultynck (1972, text-fig.17) as the precursor of I. eslaensis [I. brevis], which was itself the predecessor of his I. aff. I. eslaensis [I. latecarinatus]. A similar relationship was indicated by Weddige (1977, text-fig. 3), with his I. lindensis as a possible intermediate form.

Compared to I. brevis, I. obliquimarginatus tends to have a relatively longer blade in which, in profile, both the backward inclination of the posterior edge and the upward curvature of its upper surface are stronger. The unit is also narrower overall than in I. brevis. The denticulation of the last species may be irregular, the denticles of the two lateral rows not always being equal in number, and intercalated denticles sometimes being present in the median row, but the irregularity of the denticulation of I. obliquimarginatus is more pronounced.

The Torquay specimens are only tentatively referred to I. brevis, which species they resemble in their narrow outline and relatively long blade. The type material of I. brevis (see Klapper in Ziegler 1975, pl. 3, figs. 1-3) bears discrete, rounded denticles which are pointed in lateral view, and those of the lateral rows alternate with the median denticles. Each longitudinal row of the middle platform comprises between two and five denticles. Compared to such forms, the individuals to hand have a stronger degree both of alignment of the three to five denticles of the median and lateral rows, and of transverse and longitudinal bridge development, while the growth point is less well differentiated. The blades of these specimens bear two to three partly fused denticles, which are high in lateral view, especially posteriorly. This is fewer blade denticles than in examples of I. brevis in the literature, in which they number up to five, and the blade, in profile, is highest at or just before the posterior extremity, and its oral edge traces a convex upward curve.

In plan view the length axis of the Torquay individuals is either straight or, as in the specimen shown on Plate 3, figs. 24, 26, 27, may be rather sinuous. Only in the last example is the basal cavity more or less fully preserved. The bowl of the basal cavity occupies the posterior four-fifths of the unit, is symmetrical and roughly oval in outline, and has a rounded posterior margin. A similar aboral development is displayed by one example from the Waterways Formation of Canada illustrated by Uyeno (1974, pl. 6, fig. 3).

The specimens from Torquay designated I. aff. brevis are all small. Examples referred to I. brevis in the literature are often small, but Klapper (in Ziegler 1975, p. 89) noted that the type material of the species included both very small and larger growth stages, and Seddon (1970a, p. 735-

736) observed the characters diagnostic of I. brevis in early and more mature growth stages in his faunas from the Canning Basin of Western Australia. The last author described two subspecies, I. b. angustulus and I. b. brevis, which were distinguished by the complete fusion of the blade denticles in the former. Both are questionably placed in synonymy with I. brevis herein. Klapper (in Ziegler 1975, p. 149) referred some of Seddon's representatives of both subspecies to I. subterminus YOUNGQUIST because the two posteriormost denticles in each were remarkably high, a feature evident in the holotype of the last species.

Of particular relevance to the Torquay material is an observation made by Seddon (1970a, p. 729, 735), who noted that I. brevis appeared to be a member of "an intergrading Icriodus complex" and that forms intermediate between this species and I. symmetricus were common in his Western Australian material. The specimens to hand may represent similar transitional stages, the aligned denticulation and the presence of transverse and longitudinal bridges suggesting a tendency toward I. symmetricus. Also, the faunas associated with the Torquay examples indicate that they are somewhat younger than the upper age limit of I. brevis, and are more consistent with the age of I. symmetricus. However, in contrast with comparably small examples of the last species (e.g. Pl. 3, fig. 17), the blade of the forms designated I. aff. brevis occupies a greater proportion of total unit length, and the unit usually has a less distinctly parallel sided outline.

An important diagnostic feature of I. brevis is the high blade, the character of which is described above. A high blade is present in several other species of Icriodus, including the Middle Devonian I. angustus STEWART AND SWEET and I. obliquimarginatus, the Middle-Upper Devonian I. difficilis and I. latecarinatus, and the Upper Devonian I. alternatus BRANSON AND MEHL, I. cornutus SANNEMANN, I. costatus (THOMAS), and I. subterminus.

I. obliquimarginatus is compared with I. brevis above. In contrast with the latter, the median and lateral denticles of I. angustus are aligned posteriorly and are connected by transverse bridges. The basal cavity is pointed at both ends and has a postero-lateral projection at the posterior extremity, where the expansion is only slight and the aboral outline is narrow overall. In profile, the blade of I. angustus is much higher than that of I. brevis, and bears denticles which, for the most part, are fused and posteriorly inclined.

Both I. difficilis and I. latecarinatus have a relatively broader platform, a shorter blade and a generally more robust appearance than I. brevis. Also, transverse bridges are a more common development in the first two and, at least in I. difficilis, the denticulation tends to be rather less alternating.

I. alternatus shares with I. brevis, and with other species, an alternating denticulation but, as Klapper (in Ziegler 1975, p. 69) noted, the most important feature of the denticulation of the former is, in fact, the extreme lateral compression and/or rather poor development of the middle row denticles. The blade of I. alternatus is both shorter and rather less well differentiated compared to that of I. brevis.

The entire unit of the holotype of I. subterminus (see illustrations by Klapper op. cit., pl. 3, figs. 4a, 4b) is relatively shorter than I. brevis and, in lateral view, the two denticles of the blade are more abruptly and more conspicuously higher than the rest of the upper surface of the specimen. The oral surface denticulation of I. subterminus may resemble that of I. brevis in its alternating and sometimes irregular configuration.

In contrast with I. brevis, the posterior part of the unit of both I. cornutus and I. costatus is clearly arched downwards in profile, and the blade of the last two forms is distinctive in its prominent horn-like development. I. cornutus and I. costatus may be distinguished from each other by the extent of downward arching, which is stronger and affects a greater proportion of the unit in the latter, and by the relative development of the median and lateral denticles. In *I. cornutus* they are discrete and alternating, whereas in *I. costatus* they are aligned and joined by transverse bridges.

Range and occurrence: *I. brevis* ranges from the upper part of the Lower *varcus* Subzone to the top of the Lower *hermanni-cristatus* Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5). In Belgium, Bultynck (1972, text-fig. 14) recorded *I. brevis*, as his *I. eslaensis* assemblage, from the base of Gic through Gid and into F1a.

In Torquay, *I.* aff. *brevis* occurs at Petit Tor Beach (samples PB-1, 2, 3, 6, 12).

The *Icriodus corniger* Group

Icriodus corniger was first described from the German Ballersbach Limestone by Wittekindt (1965), and was characterised by the presence of a postero-lateral development ("antispur" of Ziegler 1975, p. 95) in the posterior part of the outer margin of the basal cavity. Subsequent designations have considerably broadened Wittekindt's original concept and, as Bultynck (1976, text-fig. 9) illustrated, the posterior margin of the basal cavity exhibits a variable configuration, even in the type material. Traced from the inner to the outer side, the posterior margin is directed backwards, and may be developed obliquely to the length axis of the unit, or may be more or less at right angles to it, and show an embayment in the middle. Other of the type specimens have a development between these extremes. The antispur itself is weakly to strongly developed, and has an angular to more broadly rounded outline.

Weddige (1977) described two new subspecies of *I. corniger*, *I. c. ancestralis* and *I. c. leptus*. He also treated two established species, *I. rectirostratus* and *I. retrodepressus*, as subspecies of the same form, and the nominate subspecies corresponded to I. corniger sensu WITTEKINDT. The present author does not fully concur with Weddige's practice. All the forms he described are not found in Torquay, and of those that are, I. retrodepressus is considered sufficiently distinct to be maintained at specific level, but still within the I. corniger group. Weddige (1977, p. 287-288, 290) placed I. introlevatus in synonymy with both I. c. corniger and (his) I. c. retrodepressus. This form is treated here as a separate species which, because specimens to hand referred to it (designated I. aff. introlevatus) show some gradation towards I. retrodepressus, is also included in the I. corniger group.

Aborally, members of the group are characterised by an antero-lateral inner spur and a postero-lateral antispur, both being variably developed in the margins of the basal cavity. The expansion of the last may be wide and subsymmetrical, and occupies between one-third and one-half of total unit length. In oral aspect, the platform is biconvex, concavo-convex, or rather more parallel sided in outline, and bears rounded or, in the case of the laterals, sometimes transversely elongated denticles. The three longitudinal rows of the middle platform each comprise between five and seven denticles, and the denticulation is often aligned at platform mid-length. Posteriorly, the median denticles may be displaced relatively anteriorward of the laterals, and may become suppressed. Transverse bridges are either absent, or are weakly to more strongly developed, and longitudinal bridges may be present, connecting the median denticles. Both the growth point and blade are usually well differentiated. The latter feature is of one to three denticles, which are variably fused and developed. In profile, the posterior end of the blade may be high, cusp-like, and posteriorly inclined.

In the Belgian Couvinian, Bultynck (1972) identified four Icriodus assemblages which involved the I. corniger group, each with a distinct stratigraphical range. In ascending order, these were the I. aff. I. corniger - I. fusiformis - I. rectirostratus assemblage, the I. corniger - I. aff. I.

fusiformis - I. rectirostratus assemblage, the I. corniger - I. curvirostratus - I. introlevatus assemblage, and the I. curvirostratus - I. introlevatus assemblage. He observed (Bultynck 1972, p. 72, 74) a morphological transition series between the members of each assemblage, which exhibited also vertical gradation, and thought that the components of each assemblage could be viewed as variants, with time, of I. corniger. He consequently proposed that the assemblages should be considered as subspecies of the last form. Bultynck's work has been comprehensively discussed by Ziegler (1975, p. 95-98) who, because of insufficient nomenclatorial and taxonomic details within the I. corniger group, preferred to regard I. rectirostratus, I. aff. I. fusiformis and I. curvirostratus as junior synonyms of I. corniger. As noted above, Weddige (1977) considered I. rectirostratus to be a subspecies of I. corniger, and I. aff. I. corniger sensu BULTYNCK corresponded to his I. c. ancestralis.

Bultynck (1972, p. 79, 80) recognised a further assemblage which incorporated the I. corniger group as visualised herein, the I. expansus - I. retrodepressus assemblage. Again, transitional forms connected the end members. The position of I. expansus as envisaged by Bultynck has been questioned by subsequent workers. Ziegler (1975, p. 143-144) suggested that, until better understood, most of the specimens designated I. expansus in Bultynck (1970) were better referred to I. retrodepressus, along with the I. expansus - I. retrodepressus assemblage, and the stratigraphically younger I. expansus assemblage of Bultynck (1972). Other examples of I. expansus in Bultynck (1970) were referred to I. introlevatus (Ziegler 1975, p. 124).

In Plymouth, Orchard (1978, p. 928) considered that his specimens of I. corniger corresponded to Bultynck's third morphotype of the species from the I. corniger - I. curvirostratus - I. introlevatus assemblage, but the state of preservation was too poor for definite identification of the last two forms. Because of redesignation of the constituents, it is difficult to assess whether or not Bultynck's assemblages are still applicable, and difficult anyway to relate them to the Torquay faunas. The presence of I. retrodepressus in the material to hand indicates Bultynck's I. expansus - I. retrodepressus assemblage, while specimens tentatively assigned to I. introlevatus suggest the I. corniger - I. curvirostratus - I. introlevatus assemblage, as does the morphology of those individuals referred to I. c. corniger. However, certain aspects of the material designated I. aff. introlevatus (described thereunder) suggest a strong tendency toward I. retrodepressus. Bultynck (1972, text-fig. 17) indicated that the I. expansus - I. retrodepressus assemblage may have arisen from the I. corniger - I. curvirostratus - I. introlevatus assemblage, and I. aff. introlevatus herein suggests that an assemblage intermediate between the last two may be present in the Torquay faunas.

Stratigraphical and distributional anomalies exist within the I. corniger group, as Weddige (1977) observed. He noted (Weddige 1977, p. 286, tables 6-10) that, in the "left rhenish shelf-facies" of the Eifel and Ardennes areas, the ranges of his I. c. rectirostratus and I. c. corniger were vertically separated by that of I. retrodepressus (as I. c. retrodepressus). The last taxon was recorded from the Sauerland area of the "right-rhenish facies" but was otherwise absent from this region, and Weddige (1977, p. 286, tables 16-18) indicated that here I. c. corniger appeared to succeed I. c. rectirostratus either directly, or after just a short gap. He proposed that the distributional pattern of the various forms was governed by ecological controls on morphology, which was the basis of taxonomic separation. Weddige and Ziegler (1979, text-fig. 3) interpreted diagrammatically ecophenotypic relationships between morphotypes of the I. corniger group. (See also the introductory remarks to the genus).

Icriodus corniger corniger WITTEKINDT

Plate 1, figs. 12, 14-20; Plate 2, figs. 1, 2, 6(?).

*1965 Icriodus corniger n. sp. - WITTEKINDT, p. 629, pl. 1, figs. 9-12 (figs. 11, 12 = holotype).

1967 Icriodus corniger WITTEKINDT - ADRICHEM BOOGAERT, p. 180, pl. 1, figs. 5, 6.

non1969 Icriodus corniger WITTEKINDT - CARLS & GANDL, p. 187, pl. 17, figs. 20-22, pl. 18, fig. 1 (pl. 17, fig. 22, pl. 18, fig. 1 = I. c. rectirostratus).

1970 Icriodus corniger WITTEKINDT - PEDDER, JACKSON & ELLENOR, pl. 15, fig. 24, pl. 17, figs. 1, 2.

·1970 Icriodus corniger WITTEKINDT - BULTYNCK, p. 103, pl. 1, fig. 8, pl. 2, figs. 1-6, 8, 9 (?), 10 (non fig. 7 = I. retrodepressus).

1970 Icriodus curvatus BRANSON & MEHL - BULTYNCK, p. 103-104, pl. 5, fig. 8 (only).

1970 Icriodus nodosus curvirostratus n. subsp. - BULTYNCK, p. 108, pl. 3, figs. 3, 4, 9 (only), pl. 4, figs. 1, 2, 5, 6.

1972 Icriodus nodosus (HUDDLE) s. l. - MCGREGOR & UYENO, pl. 5, figs. 33-35 ("form approaching Icriodus corniger WITTEKINDT").

·1972 Icriodus corniger WITTEKINDT - BULTYNCK, text-fig. 2, assemblages 2B, 3B.

·1972 Icriodus curvirostratus BULTYNCK - BULTYNCK, text-fig. 2, assemblage 3D (only).

·1972 Icriodus corniger - I. aff. I. fusiformis - I. rectirostratus assemblage - BULTYNCK, p. 77, text-fig. 7B (only).

·1972 Icriodus corniger - I. curvirostratus - I. introlevatus assemblage - BULTYNCK, p. 77, text-figs. 8D, E (only).

·1975 Icriodus corniger WITTEKINDT - TELFORD, p. 22-23, pl. 4, figs. 9, 10 (only).

·1975 Icriodus corniger WITTEKINDT - ZIEGLER, p. 95-99, Icriodus - pl. 7, figs. 1a, 1b, 2, 3, 4, 5 (originals of WITTEKINDT 1965, pl. 1, figs. 11, 12, 9; BULTYNCK 1970, pl. 3, figs. 1, 3, pl. 30, fig. 7 respectively).

·1976 Icriodus corniger WITTEKINDT - BULTYNCK, p. 54, 56, pl. 10, fig. 2, text-fig. 8, nos. 2, 3.

·1977 Icriodus corniger corniger WITTEKINDT - WEDDIGE, p. 287-288, pl. 1, figs. 16-20.

·1978 Icriodus corniger WITTEKINDT - ORCHARD, p.928, pl.107, figs.6,8,10,11,29.

.1979 Icriodus corniger corniger WITTEKINDT - GARCIA-LOPEZ in ARBIZU et al., p. 114, pl. 3, figs. 22, 23.

.1981 Icriodus corniger corniger WITTEKINDT - WANG & ZIEGLER, pl. 1, fig. 11.

Diagnosis: A subspecies of I. corniger, in which the platform is biconvex to concavo-convex and weakly incurved in plan view, and flat in profile. Both the growth point and blade are well differentiated, and the latter comprises two or three denticles which are often fused. Transverse and longitudinal bridges are commonly developed, and connect more or less rounded and equisized denticles. The lateral and median denticles may or may not be aligned. An anteriorly directed spur is variably developed in the inner margin of the basal cavity. The aboral posterior margin is also variable and, in lower plan view, may be arranged obliquely or perpendicularly to the length axis of the unit, and exhibits a weak to strong postero-lateral antispur.

Remarks and comparisons: The specimens to hand all have incomplete aboral surfaces. An inner spur, a variable feature as Ziegler (1975, p. 95) noted, is present in the two examples shown on Plate 1, figs, 14, 15, 20 and fig. 19. In the first individual, the posterior margin of the basal cavity is developed at right angles to the length axis of the unit, is embayed in the middle and an outer postero-lateral expansion is indicated. Transverse bridges seem to become better developed with increased specimen size (compare, for instance, examples on Pl. 1, figs. 16, 17 with the one on Pl. 1, figs. 14, 15, 20), and the lateral denticles tend to become transversely elongated and rather more aligned with the median denticles. In small growth stages the lateral denticles are usually located relatively posteriorward of the medians. In the configuration of the denticulation and in the development of transverse bridges, the larger representatives of *I. c. corniger* available resemble *I. retrodepressus*. However, the latter taxon is distinguished from the former by the suppression of the median denticles posteriorly, and by the presence of a median depression. In profile, the posterior edge of the blade in both forms may be similarly inclined backwards, but the posteriormost blade denticle of *I. retrodepressus* is more prominent and cusp-like than that of *I. c. corniger*, often conspicuously so.

Both the growth point and blade in the Torquay examples of *I. c. corniger* are well differentiated from the middle platform. The first feature consists of up to two denticle series, the second of two or three denticles which are sometimes fused. The blade appears longest in the specimen shown on Plate 1, fig. 18.

Several individuals are referred to *I. c. corniger* with some uncertainty. The one illustrated on Plate 2, fig. 1, 6 approaches *I. c. leptus* in its rather narrow and roughly parallel sided middle platform, but the blade is relatively shorter than in this subspecies, and the inner spur is located less far posteriorward. In profile, the upper edge of the posterior half of the unit in *I. c. leptus* typically follows a convex upward curve, whereas the upper surface of the example from Torquay is more or less flat apart from the first blade denticle behind the middle platform, which stands slightly higher than the rest of the unit. The individual shown on Plate 2, fig. 2 has well developed transverse bridges and an aligned denticulation, in which respects it resembles material referred to *I.* aff. *introlevatus*. However, because the aboral preservation is poor, the specimen is maintained in *I. c.*

corniger.

In terms of the assemblages envisaged by Bultynck (1972), and in comparison with the first *I*. *c*. *corniger* morphotype in his *I*. aff. *I*. *corniger* - *I*. *fusiformis* - *I*. *rectirostratus* assemblage, the second morphotype in his *I*. *corniger* - *I*. aff. *I*. *fusiformis* - *I*. *rectirostratus* assemblage had a less clearly biconvex outline, but a better differentiated growth point. Also, the three longitudinal rows of the middle platform in the latter morphotype each contained fewer (up to six) denticles, there was a weaker development of transverse bridges, and the blade was simpler and of fewer (usually two) denticles. In contrast, the third *I*. *c*. *corniger* morphotype in the *I*. *corniger*-*I*. *curvirostratus* - *I*. *introlevatus* assemblage had a concavo-convex platform outline, a curved length axis, and a clearly differentiated growth point. The middle platform bore three longitudinal rows, each of four to five equisized and rounded denticles. Transverse bridges were no longer developed, and the median denticles were displaced slightly anteriorward of the lateral denticles. The Torquay representatives of *I*. *c*. *corniger* have features in common with Bultynck's second and third morphotypes, but appear to lie closer to the latter.

Range and occurrence: In terms of earlier terminology, *I*. *c*. *corniger* extended from the Upper Emsian, through the *corniger* Zone and into the *bidentatus* Zone (Ziegler 1971, charts 1, 2). In current terminolgy, Weddige (1977, tables 2, 5) showed the nominate subspecies to range from the Upper *patulus* Zone [*partitus* Zone of Weddige *et* *al*. (1979)] into the *c*. *costatus* Zone in the Eifelian Hills of Germany. In Belgium, Bultynck's second and third morphotypes of *I*. *c*. *corniger*, together with their respective assemblage associates (described above), ranged throughout Co1a, and from the base of Co1b into Co2b respectively. His first morphotype [now *I*. *c*. *ancestralis*] occurred in the upper part of Em3 (Bultynck 1972, text-figs. 6-8). In terms of correlations made by Weddige (1977, table 4), Bultynck's second and third morphotypes together span an interval from the base of the Lower patulus Zone [patulus Zone of Weddige et al. (1979)] into the c. costatus Zone.

In Torquay, I. c. corniger occurs at Peaked Tor Cove (samples PK-1, 2, 3, 4) and at Triangle Point (samples TP-12, 14, 16, 17, 22, 26, 27, 28). Specimens questionably referred to I. c. corniger occur also at Triangle Point (sample TP-28).

Icriodus introlevatus BULTYNCK

v1957 Icriodus symmetricus BRANSON & MEHL - BISCHOFF & ZIEGLER, p. 64, pl. 6, figs. 1, 4.

v1957 Icriodus nodosus (HUDDLE) - BISCHOFF & ZIEGLER, p. 62, pl. 6, figs. 2, 3 (only).

*1970 Icriodus symmetricus introlevatus n. subsp. - BULTYNCK, p. 113-114, pl. 4, figs. 7-11, pl. 5, figs. 1, 2 (pl. 4, fig. 11 = holotype).

1970 Icriodus nodosus curvirostratus n. subsp. - BULTYNCK, p. 108, pl. 3, figs. 2, 8 (only).

1970 Icriodus expansus BRANSON & MEHL - BULTYNCK, p. 105, pl. 6, figs. 6, 9 (only).

•1970 Icriodus symmetricus n. subsp. a - BULTYNCK, p. 114, pl. 5, figs. 3-5, 7.

1972 Icriodus introlevatus BULTYNCK - BULTYNCK, text-fig. 2, assemblages 3E, 4E.

1972 Icriodus curvirostratus BULTYNCK - BULTYNCK, text-fig. 2, assemblage 4D (only).

•1972 Icriodus symmetricus n. subsp. a BULTYNCK - BULTYNCK, text-fig. 2, assemblage 3F.

•1972 Icriodus corniger - I. curvirostratus - I. introlevatus assemblage - BULTYNCK, p. 77, text-figs. 8A-C, F (only).

•1972 Icriodus curvirostratus - I. introlevatus assemblage - BULTYNCK, p. 77, text-figs. 9A-C.

·1975 Icriodus introlevatus BULTYNCK - ZIEGLER, p.123-124, Icriodus-pl.7, figs. 6,7 (originals of BULTYNCK 1970, pl.4, fig.11, pl.5, fig.2 respectively).

.1981 Icriodus introlevatus BULTYNCK - WANG & ZIEGLER, pl. 1, fig. 6.

Diagnosis: A species of Icriodus, in which the platform is biconvex in outline, and is pointed at both ends. The rounded median denticles tend to be displaced slightly anteriorward of the lateral denticles, and may be subdued posteriorly. The lateral denticles are also rounded and some may be transversely elongated, but transverse bridges are never prominently developed, and are often absent. The wide expansion of the large basal cavity occupies the posterior half of the unit aborally, and is rather asymmetrical to more or less symmetrical in outline. An outer postero-lateral process (antispur) and an inner antero-lateral spur may be variably developed.

Remarks and comparisons: See under I. aff. introlevatus.

Range: I. introlevatus, together with associated forms in the I. corniger - I. curvirostratus - I. introlevatus and I. curvirostratus - I. introlevatus assemblages, ranges from the base of Co1b to the top of Co2d in Belgium, according to Bultynck (1972, text-figs. 8, 9). Weddige (1977, table 4) correlated this span with an interval from within the Lower patulus Zone [patulus Zone of Weddige et al. (1979)] into the ensensis Zone.

Icriodus aff. introlevatus BULTYNCK

Plate 1, figs. 21-29.

Description (Torquay material): The platform is pointed at both ends, and is either biconvex in outline and widest at a point one-third of total unit length from the posterior extremity, or the sides of the middle platform are subparallel. The length axis is straight or weakly incurved, sometimes particularly so anteriorly. The lateral denticles are transversely elongated, the median denticles rounded, and both are largest around unit mid-length, becoming smaller posteriorward. In the anterior part of the middle platform, and at its mid-length, the denticulation is aligned, and transverse bridges are well developed at right angles to the length axis. The transverse bridges may become a little less well developed posteriorly. The final median denticle of the middle platform tends to be displaced slightly anteriorward with respect to the corresponding lateral denticles, and may also be weakly suppressed and, sometimes, fused with the penultimate median denticle. Longitudinal bridges are never conspicuously developed, and are usually absent. The growth point comprises two or three denticle series, which are clearly more separated than are the transverse denticle rows of the middle platform. The blade consists of two partly fused denticles. In profile, the final blade denticle may be higher than the upper surface of the rest of the unit, and both it and the entire posterior edge of the blade are inclined backwards. The posterior border is either more or less straight, or is weakly curved inwards.

The broad, subsymmetrical expansion of the basal cavity is developed in the posterior half of the unit. The transition from the bowl to the gully is abrupt on both the inner and outer sides. The aboral margins are never completely preserved, but a spur appears to be variably developed in the inner margin. The posterior border tends to be embayed, and there is an indication of an antispur.

Remarks and comparisons: In the wide, subsymmetrically developed basal expansion, which occupies one-half of total unit length, the specimens to hand resemble I. introlevatus as conceived by Bultynck (1970). He subsequently placed the form in his I. corniger - I. curvirostratus - I. introlevatus assemblage, and in his younger I. curvirostratus - I. introlevatus assemblage. In the first of these associations, the basal cavity of I. introlevatus lacked the antispur developed in I. curvirostratus, whereas I. corniger had an oblique posterior border, and there was a gradual transition between these extremes (Bultynck 1970, 1972). However, in view of the variability of basal cavity development evident in other icriodid taxa, as described in the introductory remarks to the genus, it is thought that specimens designated I. curvirostratus by Bultynck are more appropriately considered synonymous with I. c. corniger and with I. introlevatus, after Ziegler (1975, p. 98, 124). The diagnosis of the last form has been amended to embrace the similarly large, but rather asymmetrical, basal cavity of Bultynck's concept of I. curvirostratus, together with the possible development of an antispur.

The individuals to hand are only tentatively referred to I. introlevatus because of the aligned denticulation and the presence of strong transverse bridges, neither aspect being exhibited by material placed in synonymy with the species herein. It is possible that these characters are indicative of mature growth stages, according to observations made by Weddige and Ziegler (1979, p.161). However, the largest of the Torquay specimens are comparable in size with the holotype of I. introlevatus (Bultynck 1970, pl. 4, fig. 11), and neither of the above features is characteristic of Bultynck's assemblages which involved I. introlevatus, which might be expected to have incorporated a range of ontogenetic stages. Instead, the features are rather more typical of his I. expansus - I. retrodepressus assemblage, and of I. retrodepressus itself, and the oral surface morphology of the Torquay individuals appears to be intermediate between that of the last species and of I. introlevatus. A tendency toward I. retrodepressus is also suggested by the slight suppression of the posteriormost median denticle in the material to hand, which is sometimes accompanied by fusion with the penultimate median denticle (e.g. Pl. 1, fig. 23). However, a similar suppression is apparent both in the holotype of I. introlevatus, and in other specimens in the literature referred to the species, but neither in these forms, nor in those from Torquay, is the median depression as well developed as in I. retrodepressus. In profile, the posterior margin and the final blade denticle tend to be inclined backwards both in I. introlevatus and I. aff. introlevatus, and in I. retrodepressus, but the posteriormost blade denticle of the first two is never as high, nor as prominently cusp-like, as in the last. All representatives of I. introlevatus may be further distinguished from I. retrodepressus by the fact that the broad basal expansion occupies a greater proportion (one-half) of total unit length in the former, compared with one-third in the latter.

One Canadian specimen which Chatterton (1979, pl. 6,fig. 2) illustrated and referred to his I. aff. I. expansus exhibits some similarity to I. aff. introlevatus, in the development of strong transverse bridges, and in the configuration and alignment of the denticulation. In oral aspect, Chatterton's individual is closest to the example shown on Plate 1, figs. 25-27 herein, but the median denticles are not reduced posteriorly as in the last, and the basal cavity is both less broadly expanded, and more asymmetrical. Further, in all Chatterton's specimens designated I. aff. I. expansus, the greatest platform width is located relatively more anteriorward compared to that of I. aff. introlevatus herein, closer to unit mid-length. Returning to the aboral features, the basal expansion of Chatterton's individuals on (his) Plate 6, figs. 1, 3, 5 occupies up to two-thirds of total unit length, at least on the outer side. In this respect, the material resembles I. n. sp. A sensu ORCHARD 1978.

The stratigraphically older species I. fusiformis also has a conspicuously wide basal cavity, but this possesses a stronger postero-lateral development than is seen in either I. introlevatus or I. aff. introlevatus. The first may be further differentiated from the last two by, in oral view, the configuration of the posterior part of the unit, where the lateral denticle rows extend as far posteriorward as the median row.

Occurrence: In Torquay, I. aff. introlevatus occurs at Triangle Point (sample TP-17).

Icriodus retrodepressus BULTYNCK

Plate 1, figs. 1-11, 13.

1956 *Icriodus nodosus* (HUDDLE) - ZIEGLER, p. 102, pl. 6, figs. 18-19.

*1970 *Icriodus retrodepressus* n. sp. - BULTYNCK, p. 110-111, pl. 30, figs. 1-6 (fig. 1 = holotype).

1970 *Icriodus corniger* WITTEKINDT - BULTYNCK, p. 103, pl. 2, fig. 7 (only).

1970 *Icriodus expansus* BRANSON & MEHL - BULTYNCK, p. 105-106, pl. 6, figs. 4, 5, 7 (only).

1971 *Icriodus nodosus* (HUDDLE) - SCHUMACHER (a), p. 93, pl. 9, figs. 1-6 (only).

•1971 *Icriodus nodosus* (HUDDLE) - ORR, p. 38-39, pl. 2, figs. 20-23.

•1972 *Icriodus expansus* - *I. retrodepressus* assemblage - BULTYNCK, p. 80, text-figs. 10A, B, C(?), F (only).

1975 *Icriodus retrodepressus* BULTYNCK - ZIEGLER, p. 143-144, *Icriodus* - pl. 8, figs. 4, 5 (originals of BULTYNCK 1970, pl. 30, figs. 1, 4 respectively).

•1977 *Icriodus corniger retrodepressus* BULTYNCK - WEDDIGE, p. 290-291, pl. 1, figs. 10-12.

•1978 *Icriodus retrodepressus* BULTYNCK - ORCHARD, p. 930, pl. 107, figs. 1, 2, 4, 5, 33 (only).

Diagnosis: A species of *Icriodus* in which the platform is biconvex in outline, the lateral and median denticles are well aligned, and transverse bridges are commonly developed. The median denticles become partly or completely suppressed posteriorly, where they are located in a central depression. The posteriormost and/or penultimate denticle of at least the outer lateral row is strongly laterally developed. The posteriormost denticle of the blade is a high and prominent cusp which, in profile, is often strongly posteriorly inclined, as is the posterior edge of the blade. The aboral expansion is fairly broad, and is developed in the posterior third of the unit. The outer side is rounded, and a spur is variably developed in the inner margin.

Remarks and comparisons: *I. retrodepressus* is characterised by the morphology of the posterior part of the middle platform, which is locally depressed where the median denticles are either subdued or, sometimes, are completely absent. This feature is well developed in all the individuals available. Weddige (1977, p. 291) observed that, during the short stratigraphical range of *I. retrodepressus* in Germany, the median depression becomes progressively clearer. In early forms the final median denticle of the middle platform is reduced, or may be fused with the penultimate denticle, whereas in later forms up to three median denticles, including the first denticle of the blade, have become extremely reduced, and may disappear. The specimens herein on Plate 1, figs. 1, 13 and Plate 1, figs. 4, 5, 9 appear to be of the early and late types respectively, but are not stratigraphically distinct. Weddige (*loc. cit.*) noted a further tendency, among his stratigraphically younger forms, for the lateral denticles on either side of the median depression to be clearly enlarged outwards. One of his examples (Weddige 1977, pl. 1, fig.12) is strongly developed in this manner, and the platform is roughly equitriangular in outline as a result. The Torquay specimen on Plate 1, fig. 4 approaches this morphology to some extent. Sometimes, as Bultynck (1970, p.111) recorded, only the outer lateral row is affected, and either the final or the penultimate denticle of this row is conspicuously enlarged and posterolaterally directed, as in the example on Plate 1, fig. 9 herein. This feature is not consistent within the species, as Ziegler (1975, p. 143) noted.

The blades in the material to hand are developed into a high cusp posteriorly. This is characteristic of *I. retrodepressus* as is, in lateral view, the strong posteriorward inclination of both the cusp and the posterior edge of the blade (*e.g.* Pl. 1, figs. 10, 11), although sometimes these features may be, less typically, erect (*e. g.* Pl. 1, fig. 7).

Range and occurrence: In the Eifelian Hills of Germany, Weddige (1977, tables 2, 5) recorded *I. retrodepressus* (as *I. c. retrodepressus*) from the lower part of the Lauch Formation, and showed it to range through basal Eifelian levels, from just below the Lower - Upper *patulus* Zone boundary into the lower part of the Upper *patulus* Zone [*patulus* - *partitus* Zone boundary into the *partitus* Zone of Weddige *et al*. (1979)]. Weddige (in Weddige *et al*. 1979, text-fig. 4) showed this range to be that of "*I. c. retrodepressus s. l.*", "*I. c. retrodepressus* - typ." (*i.e.* forms with the typical median depression) being restricted to within the lower part of the *partitus* Zone. In Belgium, Bultynck (1972, text-fig. 10) indicated the range of his *I. expansus* - *I. retrodepressus* assemblage to be from the upper part of Co1c into the lower part of Co2b, which is from just below the Lower - Upper *patulus* Zone boundary into the *c. costatus* Zone, according to correlations made by Weddige (1977, table 4). Ziegler (1975, p. 144) put Bultynck's *I. expansus* assemblage into synonymy with *I. retrodepressus*, in which case the range of the latter would extend considerably higher, to near the top of Co2d (Bultynck 1972, text-fig. 11).

In Torquay, *I. retrodepressus* occurs at Daddyhole Cove (samples DH-1, 2) and at Triangle Point (samples TP-12, 15, 26, 28).

Icriodus expansus BRANSON & MEHL group

Plate 2, figs. 9, 10, 17-28, 33;
Plate 3, figs. 10-12, 14-16, 21, 25, 30.

*1938 *Icriodus expansus* n. sp. - BRANSON & MEHL, p. 160-161, pl. 26, figs. 18, 19 (only: fig. 19 = lectotype, designated by KLAPPER in ZIEGLER 1975, p. 109).

1956 *Icriodus expansus* BRANSON & MEHL - STEWART & SWEET, p. 267-268, pl. 33, figs. 1, 3, 9, 13 (only).

·1965 *Icriodus expansus* BRANSON & MEHL - KREBS & ZIEGLER, pl. 2, figs. 8-10.

non1967 *Icriodus expansus* BRANSON & MEHL - CLARK & ETHINGTON, p. 39, pl. 3, figs. 1, 2 (= *I. cornutus*?).

non1967 *Icriodus expansus* BRANSON & MEHL - WIRTH, p. 215-216, pl. 20, figs. 20, 21.

1970 *Icriodus expansus* BRANSON & MEHL - SEDDON (a), p. 736, pl. 11, figs. 30-32, pl. 12, figs. 1, 2.

•1970 *Icriodus expansus* BRANSON & MEHL - SEDDON (b), pl. 4, fig. 12.

?1972 *Icriodus expansus* - *I. retrodepressus* assemblage - BULTYNCK, p. 80, text-figs. 10D, E. (only).

?1972 *Icriodus expansus* assemblage - BULTYNCK, p. 80, text-fig. 11A (only).

1974 *Icriodus expansus* BRANSON & MEHL - UYENO, p. 30, pl. 6, figs. 1, 2, 5.

•1975 *Icriodus expansus* BRANSON & MEHL - KLAPPER in ZIEGLER, p. 109-111, *Icriodus* - pl. 1, figs. 1a, 1b, 2 (new photographs of STAUFFER 1940, pl. 60, figs. 62, 63; BRANSON & MEHL 1938, pl. 26, fig. 19 respectively) (see synonymy).

•1978 *Icriodus expansus* BRANSON & MEHL - ORCHARD, p. 928, 930, pl. 109, figs. 2-5, 7, 10, 14, 15, 20, 23.

•1979 *Icriodus expansus* BRANSON & MEHL - CHATTERTON, p. 201-202, pl. 5, figs. 1-3, pl. 6, figs. 13-18, pl. 9, figs. 19-21.

•1980 *Icriodus expansus* BRANSON & MEHL - KLAPPER in KLAPPER & JOHNSON, pl. 3, figs. 9, 10.

.1981 *Icriodus expansus* BRANSON & MEHL - WANG & ZIEGLER, pl.2, figs. 18, 19.

Description (Torquay material): Both Middle and Upper Devonian specimens are referred to this group, and are described together. In Middle Devonian individuals the platform is usually biconvex in outline, and the length axis is either straight or weakly incurved. The outline is occasionally rather concavo-convex (*e.g.* Pl. 2, fig. 22), but this may be the result of tectonic deformation. The middle platform bears three longitudinal rows, each of between four and seven (sometimes eight) denticles. In plan view, the median denticles are rounded, as are the lateral denticles in juvenile or small specimens (e.g. Pl. 2, figs. 10, 23, 24), but the latter tend to become transversely elongated and oval in outline in larger growth stages (e.g. Pl. 2, figs. 25-27). The median denticles are usually displaced slightly anteriorward of the laterals in small forms, but the denticulation is better aligned in mature specimens. Transverse bridges commonly develop with maturity and may be pronounced, whereas longitudinal bridges are rare and are never distinct. In all growth stages, the growth point is generally well differentiated from the middle platform, and usually comprises two denticle series. The blade is composed of two or three denticles and, in profile, its posterior edge is often inclined backwards. Also, the upper edge may increase in height posteriorly. The aboral margins are not well preserved, but the basal expansion appears to be broad, and occupies the posterior half (or less) of the unit. The outer side is rounded, and there may or may not be an indication of a spur on the inner side.

Upper Devonian examples have a biconvex to rather more plano-convex outline. The platform may be elongated and narrow (e.g. Pl. 3, fig. 10), or may be somewhat shorter and broader (e.g. Pl. 3, fig. 15). There are between six and nine denticles in each longitudinal row of the middle platform. As in the Middle Devonian specimens, the denticulation generally becomes better aligned with maturity, and transverse bridges become prominently developed, whilst longitudinal bridges are never strong. In the large example on Plate 3, figs. 14-16, the median and lateral denticles are aligned only at the anterior end of the middle platform, behind which point the lateral denticles are located increasingly posteriorward of the medians. This individual is unusual also in the rather irregular configuration of the denticulation at the posterior end of the unit. The final denticle of the inner lateral row is enlarged, and an additional denticle is developed on the inner side of the rather sinuous blade. In all specimens, the blade comprises one or two denticles, the growth point usually one or two denticle series, and both features tend to be shorter and less well developed than in Middle Devonian examples. In profile, the blade denticles are not higher than the upper surface of the rest of the unit, and the posterior edge of the blade is either erect or, more usually, inclined backwards.

The basal cavity is well preserved in two of the Upper Devonian individuals, and has a rather different morphology in each. In the specimen on Plate 3, figs. 14-16 there is a broad aboral expansion, which occupies the posterior half of the unit and is roughly symmetrical in outline. The transition from bowl to gully is similar in both the inner and slightly wider outer halves, and is located relatively further forward in the latter. Both the inner and outer margins of the expansion have some degree of angular antero-lateral development, but neither exhibits a true spur. Behind these developments, the outer margin is broadly rounded, and the inner margin curves slightly inwards. The posterior margin is more or less straight. In the example on Plate 3, figs. 10-12 the basal expansion is again broad, and occupies the posterior half of the unit. Compared with the previous specimen, the outer half of the expansion is relatively wider than the inner, and the bowl-gully transition is more abrupt on the inner side than on the outer, but is still located a little further anteriorward in the outer half. A broad spur is developed in the inner margin, behind which there is a weak embayment. The outer margin is broadly rounded, and the posterior border shows a slight degree of inward curvature, but again is more or less straight.

Remarks and comparisons: The concept of I. expansus has been used in a broad sense by various authors (e.g. Orchard 1978, Chatterton 1979), as it is herein. It is thought appropriate to view this widened concept as the I. expansus group, after Orchard (1978, p. 928).

As evidenced in the above description and in the illustrations, the Torquay specimens exhibit a range of morphological expression. However, there is an overall conformity with the description Orchard (loc. cit.) gave for his Plymouth representatives of the I. expansus group, which also included both Middle and Upper Devonian examples. He noted that the stratigraphically older individuals were more strongly biconvex compared with the younger forms, while the platforms of the latter tended to be narrower and longer, with a more regular and closer spaced denticulation. He also reported that the anterior and posterior denticles tended to be more prominent in the Middle Devonian individuals. These observations are applicable to some extent to the faunas to hand, although Middle Devonian specimens with platforms as strongly biconvex as in several of the Plymouth examples (Orchard 1978, pl. 109, figs. 3, 5, 7) have not been found. However, the Torquay material is sparse. The Upper Devonian individuals on Plate 3, figs. 10-12, 21, 25 herein are close to the Upper Devonian example figured by Orchard (1978, pl. 109, figs. 20, 23).

The position of I. nodosus (HUDDLE) with respect to this group is not clear. In the literature (e.g. Seddon 1970a, Uyeno 1974), this species has been distinguished from I. expansus by the presence of a prominent antero-laterally directed spur, and a corresponding sinus, in the inner margin of the basal cavity of the former. In contrast, Schumacher (1971a, p. 94) proposed that the two be placed in synonymy as I. nodosus, the range of intraspecific variation embracing a variable spur development. Klapper (in Ziegler 1975, p. 109-110) has authoritatively discussed the problems surrounding the designation of I. nodosus, and preferred to consider it a nomen dubium. For this reason, the present author has not placed the last species and the I. expansus group in synonymy, but does not exclude the possibility that such an action might prove to be appropriate. It should be noted that, as envisaged by Orchard (1978) and herein, the I. expansus group includes forms both with and without a spur in the inner margin of the basal cavity.

Ziegler and Klapper (in Ziegler et al. 1976, p. 118) distinguished I. difficilis from I. expansus by the presence of a spur and sinus in the inner margin of the basal cavity of the former. However, the aboral configuration in members of the I. expansus group, and in other icriodid taxa, is variable and, as described elsewhere, is not a reliable character for specific differentiation. The outline of the two forms is thought to provide a better means of distinction. In I. difficilis, the margins of the middle platform are often parallel, compared with the biconvex outline of the I. expansus group. At least in the Upper Devonian representatives of the latter taxon to hand, the oral surface of the entire unit is flat in profile. In contrast, this part of the former taxon tends to increase in height posteriorward, because a few median denticles just before the blade are commonly higher than the lateral denticles, and because the blade itself is rather high, and is also relatively longer, and somewhat sharper, than in the I. expansus group. With regard to the configuration of the upper surface of the entire unit in lateral view, one late Middle Devonian specimen from Waldon Hill (Pl. 2, figs. 17, 20) shows tendencies toward I. difficilis. However, the individual has a clearly biconvex outline, and is maintained in the I. expansus group.

I. latecarinatus typically has a more alternating, sometimes irregular denticulation, and a lesser development of transverse bridges, compared with the I. expansus group. Specimens from Torquay designated I. latecarinatus (described thereunder) tend to have a rather less alternating denticulation, and a better development of transverse bridges, than in the Belgian type material (Bultynck 1975), and in these respects approach the I. expansus group. However, the denticulation and transverse bridges are usually even better aligned and developed respectively in the latter taxon and, compared with all representatives of the former, the outline is more clearly biconvex, with the greatest width often located a little closer to, or at, unit mid-length. The two taxa may be further distinguished in profile. The posterior edge of the blade may be inclined backwards in the I. expansus group, as in *I. latecarinatus*, but the blade denticles are not as high nor, at least in contrast with the Belgian examples of the last species, is the blade as long.

The Upper Devonian specimen on Plate 3, figs. 14-16 is rather unusual compared with other Torquay representatives of the *I. expansus* group of this age, and resembles *I. latecarinatus* both in its somewhat alternating denticulation, and in the irregularity of the same in the posterior part of the unit. However, the overall outline of the example is consistent with the *I. expansus* group, as is the form of the blade, and the basal cavity is rather more symmetrical than in the type material of *I. latecarinatus*. Also, the individual is quite large, and the nature of the oral surface irregularity conforms with mature features which Weddige and Ziegler (1979, p. 161) noted in the icriodids.

Comparisons between this group and *I. symmetricus* are made under the latter taxon. The juvenile Upper Devonian representative of the *I. expansus* group on Plate 3, fig. 30 exhibits tendencies toward *I. symmetricus*, because the biconvexity of outline is less pronounced than in larger growth stages of the former, and the growth point is composed of only one very small denticle. In contrast, however, the juvenile specimen of *I. symmetricus* on Plate 3, fig. 17 has a more distinctly parallel sided platform outline, together with a well aligned denticulation, and a better development of transverse bridges. The configuration of the upper surface of the unit in profile is important in differentiating between the two taxa, but the former example is now lost, and this feature cannot be assessed.

In some of the Middle Devonian representatives of the *I. expansus* group there is a tendency toward *I. arkonensis*. For example, the individual on Plate 2, figs. 25, 27 has a rather better aligned denticulation than in other members of the group, and eight close spaced, well developed transverse bridges are present in each half of the middle platform. However, as this specimen demonstrates, the blade is better developed in the I. expansus group than in I. arkonensis. Further discussion is presented under the last species.

Weddige (1977) described several new Eifelian species of Icriodus, and thus effectively subdivided the concept of I. expansus as envisaged by Bultynck (1972, 1975). With regard to Middle Devonian examples of the I. expansus group to hand, those shown on Plate 2, figs. 23, 24 and fig. 26 resemble Weddige's I. struvei and I. n. sp. E respectively. However, a greater degree of morphological variation seems to be apparent in the icriodid taxa than in those of other contemporaneous genera, because of which it is thought that these incomplete, single specimens cannot provide an evaluation of the taxonomic and stratigraphical positions of Weddige's new species. Consequently, until these aspects can be clarified, it is preferred that these particular Torquay individuals be maintained within the broad concept of the I. expansus group.

Range and occurrence: Klapper (in Ziegler 1975, p. 110) stated that I. expansus ranged from the late Middle Devonian (Givetian) to the early Upper Devonian (Frasnian). In Plymouth, Orchard (1978, p. 914-915, text-fig. 2, tables 1, 2) recorded the wider concept of the I. expansus group from Teat's Hill (samples TH 46, 47, 49), Drake's Island (samples DI 1-3), Cattedown Quarry (sample CQ 10), and Gasworks Quarry (sample GQ 20): all fauna 6, correlated by him with the (then) obliquimarginatus Zone. Upper Devonian representatives of the group occurred at Western King (samples WK 4, 5). In the Northwest Territories of Canada, Chatterton (1979, p. 169-170) recorded his broad concept of I. expansus from as low as within the Po. curtigladius Faunal Unit, and in the succeeding Po. pseudofoliatus and Po. aff. Po. dubius - "Sp." ormistoni Faunal Units. Klapper (in Klapper and Ziegler 1979, text-fig. 4) correlated this span with an interval starting as low as within the australis Zone, which extends considerably downward the lower limit of the range given by him in Ziegler (1975).

In Torquay, Middle Devonian representatives of the I. expansus group occur at Babbacombe Road (sample BR-3), Long Quarry Point (sample LG-6), Parkfield Road (sample PF-9), Redgate Beach (samples RB-2, 5, 6, 12), Teignmouth Road (sample TR-1), and Waldon Hill (Warren Road, WH-3). Upper Devonian forms occur at Babbacombe Cliff (samples BC-2, 5, 9, 13), Barton Quarry (samples BQ-8, 20, 24, 25) and Petit Tor Beach (samples PB-2).

Icriodus latecarinatus BULTYNCK

Plate 3, figs. 1-9, 13, 18-20.

*1975 Icriodus eslaensis latecarinatus n. subsp. - BULTYNCK, p. 19-21, pl. 2, figs. 7, 8, pl. 3, figs. 1-7, pl. 4, figs. 1-9 (pl. 3, fig. 5 = holotype) (see synonymy).

?1976 Icriodus eslaensis ADRICHEM BOOGAERT - GARCIA - LOPEZ, p. 176, pl. 1, fig. 1.

·1979 Icriodus latecarinatus BULTYNCK - ORCHARD, pl. 1, figs. 1-8 (only).

Diagnosis: See Bultynck 1975, p. 19.

Description (Torquay material): The greatest platform width is situated in the posterior half of the unit, from which point the margins taper slowly anteriorward, and somewhat more abruptly posteriorward. The platform is rather plano-convex in outline, the convexity of the outer side becoming more pronounced in large specimens (e.g. Pl. 3, figs. 1-3). The length axis is usually weakly incurved, but is sinuous in the example on Plate 3, figs. 7-9. The three longitudinal rows of the middle platform each contain between six and eight denticles. Usually, the median denticles are rounded and discrete, and longitudinal bridges are absent. The anterior lateral denticles are rounded, often becoming transversely elongated posteriorly, where transverse bridges are usually developed. In large specimens, these may also be developed in the anterior part of the platform. The denticulation is subalternating in small growth stages, most strongly so anteriorly, but tends to become better aligned in larger forms. The growth point is always at least fairly well differentiated, and consists of two to three denticle series. The blade usually comprises two denticles, which may be partly fused and somewhat laterally enlarged. In profile, the blade denticles tend to stand higher than the oral surface of the rest of the unit, the posteriormost denticle sometimes conspicuously so. In the same aspect, the posterior border of the blade, including the final denticle, is weakly to strongly inclined backwards, and is either straight or is gently incurved.

The basal cavity is never well preserved, but there appears to be a broad aboral expansion which occupies most of the posterior half of the unit. The transition from bowl to gully is fairly abrupt and opposed on both the inner and outer sides, and the posterior margin seems to be straight. The aboral features are best preserved in the specimen on Plate 3, figs. 1-3, which is rather unusual in the configuration of the oral surface. Irregularities are present in the denticulation at both the anterior and posterior extremities. At the latter, additional denticles are developed on either side of the blade, with which they transversely coalesce. The median and lateral denticles, ten in each longitudinal row of the middle platform, are well aligned. In plan view, the lateral denticles exhibit a variable morphology. They are either elongated and slender, or are rather swollen and circular at the margins, and are always connected by narrow, conspicuous transverse bridges to the median denticles. The latter are joined by well developed longitudinal bridges, but are themselves much reduced, being indicated only by a slight swelling at each right angled junction of the transverse and longitudinal bridges. In profile, the posterior edge of the blade is strongly inclined posteriorly. Compared both to other individuals from Torquay, and to those which Bultynck (1972, 1975) illustrated from

Belgium, this specimen is very large.

Remarks and comparisons: I. latecarinatus was originally described as a subspecies of I. eslaensis by Bultynck (1975, p. 19-21) and, as envisaged by him, was a rather variable form. The material to hand is also variable, as the above description and figured examples illustrate.

The Torquay specimens, particularly those shown on Plate 3, figs. 4-9, are close to individuals from North Devon, which Orchard (1979) illustrated and referred to I. latecarinatus. A feature common to both the Torquay and the North Devon examples is the form of the blade, which is relatively shorter than in the Belgian type material figured by Bultynck (1975, pl. 2, figs. 7, 8, pl. 3, figs. 1-7, pl. 4, figs. 1-9). In the last, the blades bear between three and five denticles. Both Orchard's specimens, and those to hand, also have a better development of transverse bridges and a rather less alternating denticulation than in those from Belgium, although neither feature is as well developed as in the I. expansus group (q.v.). However, both the plano-convex outline and weakly incurved or sinuous length axis of all these individuals are typical of I. latecarinatus, as are, in profile, the strong backward inclination of the posterior edge of the blade, and the nature of the oral surface of the entire unit, which tends to become higher posteriorly. The form of the basal cavity also appears to be consistent with the species.

Many of Bultynck's figured individuals show irregularities in their denticulation. Additional denticles are developed in the median row, and the denticles of one or both lateral rows may vary considerably in size. The denticulation is irregular in the posterior part of the Torquay specimen on Plate 3, figs. 13, 18, in which the posteriormost denticle of the outer lateral row is enlarged. The large specimen on Plate 3, figs. 1-3 also has an irregular denticulation, as described above. In fact, the irregularity is rather more apparent in this individual than in the Belgian material, and the pronounced formation of transverse and longitudinal bridges throughout the middle platform is atypical of I. latecarinatus. However, these features are all consistent with developments which Weddige and Ziegler (1979, p. 161) observed in mature icriodids.

The blade of I. difficilis may be similar to that of I. latecarinatus, but tends to be shorter and less posteriorly inclined in the former. The latter species has a plano-convex or, sometimes, rather biconvex outline, and the length axis is either incurved or sinuous. In contrast, the middle platform of I. difficilis has subparallel margins and, although the length axis may sometimes be slightly sinuous, it is often straight. The two species may be differentiated in profile, several median denticles just before the blade in I. difficilis often being higher than the lateral denticles, whereas in I. latecarinatus the equivalent lateral and median denticles are at the same height. The growth point in the former species is typically shorter and less well differentiated than in the latter, and the denticulation is usually better aligned, and transverse bridges better developed. In the last two respects, and in their rather short blades, the Torquay specimens, especially the one shown on Plate 3, figs. 13, 18, approach I. difficilis. However, their appearance in lateral aspect is not consistent with this species, and the overall outline is characteristic of I. latecarinatus.

Range and occurrence: In Belgium, I. latecarinatus first appears at the base of the Assise de Fromelennes, ranges from the base of F1a into F1b and occurs also in the Lower asymmetricus Zone (Bultynck 1972, text-fig. 15; 1975, text-figs. 2, 5; pers. comm. in Orchard 1979, p. 131). In terms of correlations made by House and Ziegler (1977, text-fig. 5), this range begins as low as within the Middle varcus Subzone.

In Torquay, I. latecarinatus occurs at Babbacombe Cliff (sample BC-32) and Barton Quarry (samples BQ-1, 18, 24).

Icriodus obliquimarginatus BISCHOFF & ZIEGLER

Plate 2, figs. 3-5, 7, 11-16 (aff.).

v*1957 Icriodus obliquimarginatus n. sp. - BISCHOFF & ZIEGLER, p. 62-63, pl. 6, fig. 14 (= holotype).

?1970 Icriodus regularicrescens n. sp. - BULTYNCK, p. 111-112, pl. 8, figs. 2, 4, 6-8 (only).

1975 Icriodus obliquimarginatus BISCHOFF & ZIEGLER - ZIEGLER, p. 135-137, Icriodus - pl. 3, figs. 9, 10a, 10b (figs. 9, 10a = originals of WITTEKINDT 1965, pl. 1, fig. 13; BISCHOFF & ZIEGLER 1957, pl. 6, fig. 14 respectively; fig. 10b = new photograph of last specimen) (see synonymy).

1976 Icriodus obliquimarginatus BISCHOFF & ZIEGLER - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 118, pl. 1, figs. 8, 9.

·1977 Icriodus obliquimarginatus BISCHOFF & ZIEGLER - WEDDIGE, p. 294, pl. 2, figs. 33-35.

·1978 Icriodus obliquimarginatus BISCHOFF & ZIEGLER - ORCHARD, p. 930, pl. 107, figs. 7, 9, 13, 14, 17, 18, pl. 109, figs. 1, 8.

Diagnosis: An elongated and slender species of Icriodus, in which the blade is conspicuously long, and may comprise one-half or more of total unit length. In profile, the upper surface of the blade forms a convex upward crest, which is clearly higher than the upper surface of the rest of the unit, and the posterior edge is distinctly inclined backwards. The denticulation of the oral surface of the entire platform is often irregular.

Remarks and comparisons: In the original diagnosis of Bischoff and Ziegler (1957, p. 63), I. obliquimarginatus was characterised by the backward inclination of the posterior margin of the blade, evident in lateral view. In contrast, both Seddon (1970b, p. 54) and Weddige (1977, p. 294) preferred to exclude this feature from their respective diagnoses of the species. Although not consistently developed in the material to hand, the character is retained herein and, together with the convex upward curve traced by the oral edge of the blade, which is higher than the upper surface of the rest of the unit, serves to distinguish I. obliquimarginatus from I. regularicrescens. Further, the former species typically has a relatively longer blade, and often a more irregular denticulation over the oral surface of the entire unit, in comparison with the latter.

None of the specimens to hand is well preserved, and all exhibit dissimilarities both toward each other, and toward I. obliquimarginatus. For these reasons, it is thought that none may be unambiguously referred to the species. The blade is longest in the juvenile individuals on Plate 2, figs. 3, 4 and 5, 13, in which it comprises at least one-half of total unit length. Only in the former is the posterior edge of the blade inclined backwards in profile, and then not strongly so. In the latter, this part of the blade is slightly inclined forwards. The upper edge of the blade is broken in both specimens, and its nature cannot be discerned. In oral view, neither example has a distinctly irregular denticulation, the apparent irregularity in the first-mentioned specimen being caused by the presence of adhering particles. Because of the discrepancies between these individuals and I. obliquimarginatus, it is considered that they may represent transitional stages between this species and I. regularicrescens. Both Bultynck (1970, p. 112; 1972, text-fig. 17) and Weddige (1977, text-fig. 3) have suggested that the former taxon may have arisen from the latter. Orchard (1978, pl. 107, fig. 23) assigned a rather similar juvenile specimen to I. regularicrescens but, because of the long blade, it is preferred that at least the available example be tentatively referred to I. obliquimarginatus.

Only in the specimen on Plate 2, figs. 15, 16 does the blade exhibit, in profile, the convex upward curve of the upper edge, and the distinct backwards inclination of the posterior border, characteristic of I. obliquimarginatus. However, the blade occupies a lesser proportion of total unit length than is typical of the species, and the middle platform is somewhat broader, and bears a better developed denticulation, than is usual. Further, a spur is present in the inner margin of the basal cavity, which is also a development uncharacteristic of the taxon. Bultynck (1972, p. 81) described specimens from Belgium which occurred in the same stratigraphical horizons as, but not together with, I. obliquimarginatus. In comparison with this species, they had a relatively broader platform, more denticles in the three longitudinal rows of the middle platform, and a relatively shorter blade. With regard to the aboral features, the transition from the bowl to the gully of the basal cavity was rather more abrupt in these individuals, and a distinct spur was developed in the inner margin. He designated the forms I. aff. I. obliquimarginatus, and suggested that the last character indicated a possible connection with the I. corniger group. The specimen to to hand on Plate 2, figs. 15, 16 resembles Bultynck's I. aff. I. obliquimarginatus, but differs in having a clear development of transverse bridges. Bultynck (loc. cit.) considered these to be characters of I. regularicrescens rather than of I. obliquimarginatus, but transverse bridges are present in several examples of the last species in the literature, including the holotype (see illustrations by Ziegler 1975, Icriodus-pl. 3, figs. 10a, 10b).

Specimens from Waldon Hill on Plate 2, figs. 7, 11, 12, 14 are tentatively assigned to I. obliquimarginatus on the basis of their slender form and irregular denticulation. In profile, neither individual has the blade configuration typical of the species, but this may be due to the fact that the material has been tectonically distorted. The blade is longest in the example on Plate 2, figs. 12, 14, in which it comprises over one-third of total unit length. In this specimen, the denticles of the lateral rows are much reduced in number, and just two denticles are developed on either side of the median row, which is itself irregularly configured. In the last respect, and because of the strongly reduced lateral denticulation, the individual approaches the genus Pelekysgnathus, especially Pel. elevatus (BRANSON & MEHL). Compared with Icriodus, the platform of this genus comprises just one longitudinal row of irregular, poorly defined denticles, on the oral surface of which impersistent cross ridges are often developed. Further, the cusp of some pelekysgnathids tends to be more prominent than that of the icriodids.

Range and occurrence: I. obliquimarginatus ranges from a little above the base of the ensensis Zone, almost to the top of the Middle varcus Subzone (Weddige 1977, table 2; Ziegler in Klapper and Ziegler 1979, text-fig. 5). In Belgium, Bultynck (1972, text-fig. 13) showed the species, as the I. obliquimarginatus assemblage, to range from the base of Gia to the middle, and possibly to the top, of Gib. According to correlations made by Weddige (1977, table 4), this range starts within the upper part of the ensensis Zone. In the Eifelian Hills of Germany, the last author recorded forms transitional from I. regularicrescens to I. obliquimarginatus from the Nims and Giesdorf Members in the lower part of the ensensis Zone (Weddige 1977, p. 295).

In Torquay, I. aff. obliquimarginatus occurs at Babbacombe Road (sample BR-9), New Quarry (sample NQ-5), Redgate Beach (sample RB-10) and Waldon Hill (Warren Road, sample WH-3).

Icriodus regularicrescens BULTYNCK

Plate 2, fig. 8 (cf.).

1965 Icriodus n. sp. - BULTYNCK, p. B70-71, pl. 1, fig. 1.

*1970 Icriodus regularicrescens n. sp. - BULTYNCK, p. 111-112, pl. 7, figs. 1-7 (fig. 2 = holotype; non pl. 8, figs. 2,4,6-8 = I. obliquimarginatus?).

1972 Icriodus regularicrescens assemblage - BULTYNCK, p. 80-81, text-figs. 12A-C.

1975 Icriodus regularicrescens BULTYNCK - ZIEGLER, p. 139-140, Icriodus - pl. 8, figs. 1-3 (originals of BULTYNCK 1970, pl. 7, figs. 2, 7a, 5 respectively).

·1977 Icriodus regularicrescens BULTYNCK - WEDDIGE, p.295, pl.2, figs.30-32.

·1978 Icriodus regularicrescens BULTYNCK - ORCHARD, p. 930, pl. 107, figs. 15, 21-22, 23 (?), 26-28, 31, 32.

·1981 Icriodus regularicrescens BULTYNCK - WANG & ZIEGLER, pl. 1, figs. 4, 5.

Diagnosis: A species of Icriodus which is relatively long and slender in oral view, and has pointed anterior and posterior extremities. The outer expansion of the basal cavity is fairly broad, with a regularly crescent-shaped outline.

Remarks and comparisons: A single specimen from Torquay appears to correspond to this species in oral aspect but, because preservation is poor, a "cf" designation is preferred. The median and lateral denticles are rounded in oral view. The former are displaced relatively anteriorward of the latter, most strongly so in the posterior part of the unit, and are connected by transverse bridges. The lateral denticles show a slight increase in size anteriorward. These features are consistent with characters which Weddige (1977, p. 295-296) observed in I. regularicrescens. He further noted that the middle platform tended to become broader anteriorly. This is not apparent in the example to hand, in which the sides of the middle platform are more or less concentric. The bowing of the length axis in this individual is far more pronounced than in the material illustrated by Weddige (1977, pl. 2, figs. 30-32), and is thought to have been tectonically induced, at least in part.

Range and occurrence: In Belgium, Bultynck (1970, pl. 38) recorded I. regularicrescens from the base of Co2c1V/R, to as high as Gib. He subsequently lowered the upper limit of this range, and depicted the species (as the I. regularicrescens assemblage) spanning an interval from the upper half of Co2c, to just into Gia (Bultynck 1972, text-fig. 12). In the Eifelian Hills of Germany, Weddige (1977, tables 2, 5) showed I. regularicrescens to range from within the c. costatus Zone into the lowest part of the ensensis Zone. Correlations made by the last author (Weddige 1977, table 4) indicate that the lower and upper limits of his age range for the species are both displaced downwards with respect to the age ranges given by Bultynck.

In Torquay, I. cf. regularicrescens occurs at Redgate Beach (sample RB-12).

Icriodus symmetricus BRANSON & MEHL

Plate 3, figs. 17, 22, 23.

*1934 Icriodus symmetricus n. sp. - BRANSON & MEHL, p. 226, pl. 13, figs. 1-3 (fig. 3 = lectotype, designated by KLAPPER in ZIEGLER 1975, p. 151).

1938 Icriodus symmetricus BRANSON & MEHL - BRANSON & MEHL, p. 161, pl. 26, figs. 1-3.

?1951 Icriodus sp. - HASS, pl. 1, fig. 17.

1957 Icriodus symmetricus BRANSON & MEHL - MÜLLER & MÜLLER, p. 1106, pl. 138, figs. 1-3, pl. 142, fig. 8.

?1967 Icriodus curvatus BRANSON & MEHL - CLARK & ETHINGTON, p. 38, pl. 3, fig. 13.

1971 Icriodus symmetricus BRANSON & MEHL - SZULCZEWSKI, p. 23, pl. 7, fig. 5 (only: fig. 4 = ?) (see synonymy).

•1975 Icriodus symmetricus BRANSON & MEHL - KLAPPER in ZIEGLER, p. 151-153, Icriodus - pl. 3, figs. 7, 8 (new photographs of BRANSON & MEHL 1938, pl. 26, fig. 25; BRANSON & MEHL 1934, pl. 13, fig. 3 respectively) (see synonymy and regional occurrences).

•1978 Icriodus symmetricus BRANSON & MEHL - ORCHARD, p. 932, pl. 109, figs. 17, 22, 24, 26, 32, 34.

•1979 Icriodus symmetricus BRANSON & MEHL - LANE, MÜLLER & ZIEGLER, p. 217, pl. 2, fig. 22.

•1980 Icriodus symmetricus BRANSON & MEHL - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl.3, fig.4.

•1981 Icriodus symmetricus BRANSON & MEHL - DUFFIELD & WARSHAUER, pl. 1, fig. 11.

Diagnosis: A species of Icriodus, in which the entire unit is elongated and rather narrow in outline, and the margins of the middle platform are parallel. The length axis is weakly bowed. The median and lateral denticles are well aligned, and are connected by transverse bridges. Longitudinal bridges join the denticles of the median row which, in profile, is distinctly higher than the lateral rows. Aborally, the basal expansion is subcircular and asymmetrical in outline, being wider on the outer side, and occupies between one-third and one-half of the unit posteriorly.

Remarks and comparisons: Klapper (in Ziegler 1975, p. 151-153) has thoroughly discussed the species. Both he and Glenister and Klapper (1966, p. 805) placed in synonymy with it I. curvatus, as conceived by Branson and Mehl (1938).

The specimens from Torquay possess the parallel sided middle platform characteristic of I. symmetricus, and are consistent with the species also with regard to the aligned denticulation, the development of transverse bridges, and the morphology of the median denticle row. The median denticles are connected by longitudinal bridges, and are developed into a fused ridge which, in profile, is higher than the lateral denticle rows. These characters are all clearly displayed by the example on Plate 3, figs. 22, 23, which has six rounded (in plan view) denticles in each of the three longitudinal rows of the middle platform. The blade and growth point are both short in all representatives of the species to hand, as in the lectotype (Branson and Mehl 1934, pl. 13, fig. 3). The blade is usually composed of two elongated, fused denticles, while the growth point comprises two or, in the juvenile specimen on Plate 3, fig. 17, only one denticle series.

I. difficilis has a rather parallel sided middle platform, in which it resembles I. symmetricus. However, the entire platform of the latter is relatively narrower in outline, while the former has a slightly less well aligned but more closely spaced denticulation, and a lesser development of transverse bridges. The two species may be distinguished in lateral view. In I. difficilis, a few median denticles anteriorward of the blade are usually higher than the lateral denticles, but longitudinal bridges are not formed, and the median denticle row does not attain the high fused ridge developed throughout most of the middle platform in I. symmetricus. Again in profile, the blade of the former species tends to be higher than that of the latter. Further, the basal expansion of I. difficilis seems to be relatively broader and more angular in outline. It is noteworthy that I. difficilis is a rather variable species which, as this and preceeding comparisons demonstrate, seems to take a position intermediate between several taxa.

I. symmetricus may be differentiated from members of the I. expansus group by the character of the upper surface of the unit in lateral view. In contrast with the high median denticle row of the former taxon, the denticles of the three longitudinal rows of the middle platform in the latter are at the same height. Further, as Glenister and Klapper (1966, p. 806) noted, the lateral rows of I. symmetricus are developed concentrically to the inwardly bowed median row. In I. expansus, the length axis is generally straighter and the outline biconvex. The last feature results from the lateral denticles increasing in size posteriorward, and attaining their maximum development in the central or posterior part of the middle platform.

Range and occurrence: I. symmetricus is of Frasnian age (Klapper in Ziegler 1975, p. 152). Klapper cited many regional occurrences of the species, which embraced records from the Lower and Middle asymmetricus Zones (Glenister and Klapper 1966; Szulczewski 1971 respectively), the *Ancyrognathus triangularis* Zone (Youngquist 1947; Klapper and Furnish 1963), and the Lower and Upper *gigas* Zones (Müller and Müller 1957; Klapper and Furnish 1963). In Plymouth, Orchard (1978, p. 917-918, text-fig. 2, table 2) recorded *I. symmetricus* in Faunas 11-14, which ranged from the Lower *asymmetricus* Zone to the *Ancyrognathus triangularis* Zone. In Perak, Malaya, Lane *et al.* (1979, p. 217, 224, text-fig. 2) noted a single example of the species in sample 1382, which they assigned to the Middle or Upper *asymmetricus* Zone. Johnson *et al.* (1980, table 22) recorded *I. symmetricus* from samples TA 1V 40 and TA 1V 63 in the Antelope Range of central Nevada, which they referred to the Lower and Middle *asymmetricus* Zones respectively.

In Torquay, the species occurs at Petit Tor Beach (samples PB-1,2, 6) and at Petit Tor Quarry (samples PQ-3, 4). Material designated *I.* cf. *symmetricus* occurs at Babbacombe Cliff (sample BC-9).

Form genus Palmatolepis ULRICH & BASSLER

Type species: Palmatolepis perlobata ULRICH & BASSLER 1926.

Remarks: The genus is restricted to the Upper Devonian, where it has considerable biostratigraphical significance, as Ziegler (1962b) first recognised. His zonations of the German Upper Devonian were based on many species and subspecies of Palmatolepis. Detailed phylogenies for the genus have been suggested by various authors, including Ziegler (1962a, 1962b), Helms (1963), Müller (1956), and Sandberg and Ziegler (1973). Ziegler (1962a, text-fig. 8) envisaged that Palmatolepis arose from a broad-platformed Polygnathus stock at the base of the Upper Devonian, and depicted Pa. martenbergensis MÜLLER [Pa. punctata (HINDE)] as the central ancestor of most of the palmatolepids which evolved during the early part of this interval.

Lane et al. (1979, p. 217) described a new form genus, Klapperina, and assigned to it K. disparilis (ZIEGLER & KLAPPER) and K. disparalvea (ORR & KLAPPER), species which had previously been referred (only questionably in the case of the latter) to Palmatolepis. In oral aspect, the palmatolepid-like platform of Klapperina resembles that of the last genus. However, the central node of Klapperina is only poorly developed, or may be absent, whereas this feature is better differentiated in many representatives of Palmatolepis. The two genera are easily differentiated with regard to their aboral features. Not all species of Palmatolepis have a basal cavity, which, when present, is just a very small slit developed in the keel. In contrast, Klapperina is characterised by the development of a large, triangular or L-shaped basal cavity, the margins of which stand above the lower surface of the platform. It should be noted that Klapper (in Johnson et al. 1980, p. 100-101) has questioned the taxonomic position and validity of Klapperina.

The last genus has not been found in the Torquay faunas, and Palmatolepis is not well represented. Only three species are recognised, and there is some degree of morphological gradation both toward each other, and toward other forms. The three taxa recorded from Torquay were present among the eight which Rhodes et al. (1973, p. 121) found in abundance in the Chudleigh area. It is interesting to note that they, too, observed complete transition between almost all their species.

With regard to the separation of taxa within Palmatolepis, the following characters have been considered by various writers (e.g. Ziegler 1962a, 1973; Glenister and Klapper 1966) to be the most useful: platform outline, and the nature of the oral surface ornamentation; position and configuration of the outer lobe; character of the blade-carina; position and form of the parapet, if developed; profile of the posterior platform.

The synonymy of Palmatolepis was given by Ziegler (1973, p. 255), who thoroughly discussed evolutionary, taxonomic and other aspects of the genus, and also reviewed its multielemental position. Klapper and Philip (1972, p. 100) involved Palmatolepis as the platform (P) element in a Type 1 apparatus (multielemental family Polygnathidae, genus Palmatodella), in which the O1, N, A1, A2 and A3 elements were nothognathellan, palmatodellan, smithiform, angulodontan and scutulan respectively. This apparatus was modified by Philip and McDonald (1975), such that the O element became either ozarkodinan or, more usually, palmatodellan, and the N element became lippertiform. They also considered that the A3 element became highly variable. Ziegler (1972, p. 94) preferred a mono-elemental apparatus for Palmatolepis, which comprised at least one pair of left and right palmatolepids.

Palmatolepis hassi MÜLLER & MÜLLER

Plate 17, figs. 7, 9-12.

*1957 Palmatolepis (Manticolepis) hassi n. sp. - MÜLLER & MÜLLER, p. 1102-1103, pl. 139, fig. 2, pl. 140, figs. 2-4 (pl.140, fig. 4 = holotype).

·1973 Palmatolepis hassi MÜLLER & MÜLLER - ZIEGLER, p. 281-282, Palmatolepis - pl. 2, fig. 4 (original of ZIEGLER 1958, pl. 7, fig. 6) (see synonymy).

·1975 Palmatodella hassi (MÜLLER & MÜLLER) - PHILIP & MCDONALD, text-fig. 6P (only).

Diagnosis: See Müller and Müller 1957, p. 1103; Ziegler 1973, p. 281.

Remarks and comparisons: Pa. hassi has been discussed by Szulczewski (1971, p. 34), and by Ziegler (1973, p. 281). Both authors preferred to maintain the form as a distinct species, whereas Mound (1968, p. 499) had thought it to be a junior synonym of Pa. gigas MILLER & YOUNGQUIST, and Anderson (1966, p. 409) had considered the type material of Pa. hassi to be either very similar to, or identical with, Pa. subrecta.

Compared with Pa. subrecta, the platform of Pa. hassi is relatively larger and wider, the course of the blade-carina is less sigmoidal, and the outer lobe is situated relatively further anteriorward. Also, the ornament of the latter species tends to be rather more coarsely nodose, and more evenly distributed over the oral surface of the platform.

According to Ziegler (1962a, text-fig. 8), Pa. hassi was the phylogenetic connection between the earlier Pa. martenbergensis [Pa. punctata], and the later Pa. rhenana [Pa. gigas]. Compared to Pa. hassi, Pa. punctata is more robust in appearance, has a less well differentiated outer lobe, and the blade-carina is not as distinctly sigmoidal in plan view. Further, the central node of the latter taxon is often not well differentiated from the other nodes of the carina. In the former, the central node tends to be rather more prominent. Also in contrast with Pa. hassi, Pa. gigas has a better defined and more distinct outer lobe, and, in lateral view, the anterior part of the free blade is both higher and more steeply inclined.

In the specimens to hand, the course of the blade-carina is straighter than in individuals referred to Pa. subrecta, and the outer lobe is usually developed relatively further anteriorward. The example on Plate 17, figs. 7, 10 is an exception with regard to the last feature, and here the position of the lobe suggests a tendency toward Pa. subrecta. The outer lobe is well differentiated in the individual on Plate 17, fig. 11, and especially in the deformed example on Plate 17, fig. 12. In this respect, both specimens approach Pa. gigas.

Range and occurrence: Pa. hassi ranges from the base of the Ancyrognathus triangularis Zone, into the upper part of the Lower gigas Zone, and possibly into the lowest part of the Upper gigas Zone. Only a few examples have been recorded from as low as the Upper asymmetricus Zone (Ziegler 1971, chart 5; 1973, p. 282; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Pa. hassi occurs at Petit Tor Beach (samples PB-1, 2, 12).

Palmatolepis proversa ZIEGLER

Plate 17, fig. 13 (aff.).

v*1958 Palmatolepis proversa n. sp. - ZIEGLER, p. 62-63, pl. 3, figs. 11, 12, pl. 4, figs. 1-14 (pl. 4, figs. 11a, 11b = holotype).

·1973 Palmatolepis proversa ZIEGLER - ZIEGLER, p. 289-290, Palmatolepis - pl. 2, figs. 5a, 5b (fig. 5b = original of ZIEGLER 1958, pl. 4, fig. 11b; fig. 5a = new photograph of same specimen) (see synonymy).

·1981 Palmatolepis aff. P. proversa ZIEGLER - DUFFIELD & WARSHAUER, pl.1, fig.10.

Diagnosis: See Ziegler 1958, p.62; 1973, p.289 (translation of original German).

Remarks and comparisons: A single specimen from Torquay, shown on Plate 17, fig. 13, is closest to examples illustrated by Klapper and Furnish (1963, text-fig. 2, fig. 8), and by Szulczewski (1971, pl. 10, fig. 2). In the available specimen, the outer lobe is well differentiated, developed in the anterior part of the platform, and directed forwards. The anterior margin of the lobe is bent upwards, and approaches the blade obliquely. These features are all typical of Pa. proversa, as is the overall slender appearance of the unit. The last character has been accentuated by deformation, which has resulted in the specimen becoming laterally compressed and longitudinally stretched. Distortion may also be at least partly responsible for the course of the blade-carina, which is straighter than is usual in Pa. proversa. Because of this discrepancy, the individual is referred to the species with some uncertainty.

Compared to Pa. punctata, Pa. proversa has a slimmer form, a narrower and more anteriorly directed outer lobe, and, typically, a more strongly sigmoidal blade-carina. In the rather straight nature of the last feature, the Torquay specimen approaches Pa. punctata, and may represent a transitional stage between this species and Pa. proversa. Ziegler (1962a, text-fig. 8) derived Pa. proversa from Pa. punctata, the latter as Pa. martenbergensis.

Range and occurrence: Pa. proversa ranges from the base of the Middle asymmetricus Zone into the lower, and possibly middle, parts of the Lower gigas-Zone (Ziegler 1971, chart 5; 1973, p. 289; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Pa. aff. proversa occurs at Petit Tor Beach (sample PB-1).

Palmatolepis subrecta MILLER & YOUNGQUIST

Plate 17, figs. 1-6, 8.

*1947 Palmatolepis subrecta n. sp. - MILLER & YOUNGQUIST, p. 513-514, pl. 75, figs. 7-11 (fig. 8 = lectotype, designated by MÜLLER & MÜLLER 1957, p. 1104).

·1967 Palmatolepis subrecta MILLER & YOUNGQUIST - ADRICHEM BOOGAERT, p. 183, pl. 2, fig. 32.

.1969 Palmatolepis subrecta MILLER & YOUNGQUIST - PÖLSLER, p.417, pl.5, fig.8.

.1971 Palmatolepis subrecta MILLER & YOUNGQUIST - SCHUMACHER (b), pl.14, figs. 1-3, 6-15.

.1971 Palmatolepis subrecta MILLER & YOUNGQUIST - SZULCZEWSKI, p. 41, pl. 10, figs. 8, 9, pl. 12, figs. 4-8 (see synonymy).

.1978 Palmatolepis subrecta MILLER & YOUNGQUIST - ORCHARD, p. 936, pl.115, figs. 28-30, 34, 40.

.1981 Palmatolepis subrecta MILLER & YOUNGQUIST - DUFFIELD & WARSHAUER, pl. 1, fig. 8.

Diagnosis: See Glenister and Klapper 1966, p. 823.

Remarks and comparisons: Ziegler (1962a, 1962b) considered that Pa. subrecta was related phylogenetically to several other species of Palmatolepis, and observed features transitional to the last in the wide range of morphological variation exhibited by specimens referred to the first taxon. Szulczewski (1971, p. 41) also noted much variation amongst his examples of Pa. subrecta, especially with regard to platform outline, to the direction of the outer lobe, to the presence or absence of a secondary carina on the lobe, and to the distribution of the nodose ornament on the oral surface of the platform.

The specimens to hand have a variable morphology, but a secondary carina is never developed. The blade-carina is usually sigmoidal in form, although in the example on Plate 17, figs. 1-3 it is somewhat straighter, and suggests a tendency to Pa. hassi. However, neither in this individual, nor in the others assigned to Pa. subrecta, is the outer lobe located as far anteriorward as in the last species. Further comparisons with Pa. hassi are made thereunder.

In contrast with Pa. subrecta, Pa. gigas has a better differentiated outer lobe, and the denticles of the free blade are strongly variable in size. In the former species, the blade denticulation is more uniformly developed, a feature which Szulczewski (loc. cit.) thought distinguished this form also from Pa. unicornis MILLER & YOUNGQUIST.

Range and occurrence: Ziegler (1971, chart 5; in Klapper and Ziegler 1979, text-fig. 5) showed the main age range of Pa. subrecta to be from the base of the Upper asymmetricus Zone to the top of the Uppermost gigas Zone. He indicated that the lower limit of this span may extend downwards into the highest part of the Middle asymmetricus Zone, while the upper limit may extend upwards through the Lower, and just into the Middle, Pa. triangularis Zones.

In Torquay, Pa. subrecta occurs at Petit Tor Beach (samples PB-1, 2, 12) and Petit Tor Quarry (sample PQ-4).

Form genus Polygnathus HINDE

Type species: Polygnathus dubius HINDE 1879

(subsequent designation by Miller 1889, p.520, fide Ziegler 1973, p.333).

Remarks: Huddle (1970, p.1030-1033) presented a comprehensive account of the genus, in which he discussed the problems surrounding the designation of the type-species, and proposed the lectotype of Po. foliatus (figured by Bryant 1921, pl. 10, fig. 16) as the neotype of Po. dubius. He also gave the synonymy of Polygnathus (Huddle 1968, p.37). The genus has a long age range, and occurs throughout the Devonian and in the Lower Carboniferous.

Within the polygnathids, the following characters are used for specific differentiation: size and nature of the platform, often with special reference to anterior and posterior developments; on the oral surface of the platform, the development or absence of adcarinal grooves and the form of the ornament; on the aboral surface, the configuration and position of the basal cavity. The length of the free blade relative to total unit length is a further diagnostic feature, but in the Torquay material this is often difficult to assess, specimens frequently being recovered with the free blade either partially broken or completely absent.

Possible evolutionary trends within the genus were indicated by Bultynck (1970, text-fig. 16) in the Belgian Couvinian, by Telford (1975, text-fig. 4) in Emsian and early Couvinian faunas from Queensland, Australia, and by Chatterton (1979, text-fig.7) in late Emsian to low Givetian horizons in Canada. A more extensive phylogeny in the Lower and Middle Devonian was proposed by Weddige (1977, text-fig.4). He based relationships between Eifelian forms on observations made on his own abundant German material, and incorporated also Lower Devonian evolutionary lineages put forward by Klapper and Johnson (1975), and Givetian trends suggested by Ziegler et al. (1976). Weddige envisaged that the basic dehiscens stock gave rise to his serotinus, linguiformis, robusticostatus, trigonicus and costatus branches around the Lower-Middle Devonian boundary, and derived the majority of Middle Devonian forms which were then known in terms of the last four lineages.

With reference to the multielemental Polygnathus, Klapper and Philip (1971, 1972) incorporated the genus in two of their multielemental families, the Polygnathidae and the Cryptotaxidae, which were characterised by a Type 1 and Type 2 apparatus respectively. Two genera were distinguished within the former family, Polygnathus and the Upper Devonian Mesotaxis. This was essentially a separation of the slender polygnathids from the more broad platformed Upper Devonian forms, and the two differed also in their O1, N and A1 elements. The multielemental Mesotaxis apparatus was slightly amended by Philip and McDonald (1975) with respect to the non-platform components, but the distinction remains valid. Klapper and Philip (1971,1972) thought that the multielemental Polygnathus possessed five ramiform elements, of which A2 was either angulodontan or plectospathodontan, whereas Sparling (1981) believed that both of the last forms were represented, making a total of six bar elements. In contrast, Ziegler (1972,p.93,95) suggested that both the narrow, conservative polygnathids and the more advanced, broad platformed types may have occurred in an apparatus devoid of ramiform elements. He proposed this because he observed a constant deficiency of the last in faunas of Middle and, especially, early Upper Devonian age.

The Polygnathus asymmetricus Group

Representatives of this group characteristically possess a broad and elongated platform, which is oval to subquadrate in outline. The oral surface is covered by numerous small nodes, and the free blade is short. Aborally, a variably developed basal cavity is located in the anterior half, or at mid-length, of the platform, and the keel is sharp throughout.

Bischoff and Ziegler (1957) recognised two subspecies of Po. dubia HINDE, then called Po. d. dubia and Po. d. asymmetrica. However, dissatisfaction surrounded the designation of Po. dubia (see Huddle 1970). Ziegler et al. (1964) regarded the lectotype as an "indeterminate fragment" and considered Po. dubia as a nomen dubium, and Po. asymmetrica was thus the first available name for Bischoff and Ziegler's concept of Po. dubia.

The subspecies were originally differentiated from each other on platform outline (see Bischoff and Ziegler 1957, p. 88, 89: original diagnoses of *Po. a. ovalis* and *Po. a. asymmetricus* respectively), but, as Orchard (1975a, p. 109) observed, there is considerable gradation between the two. He thought that the form of the basal cavity provided a useful additional criterion for distinction. As thus envisaged by Orchard (1975a, p. 109-112; 1978, p. 938), the platform of *Po. a. asymmetricus* is typically subquadrate in outline and bears a minute, pit-like basal cavity aborally. *Po. a. ovalis* has an oval platform and a symmetrical, tear-drop shaped basal cavity, which is both relatively larger than that of *Po. a. asymmetricus* and is often located a little further posteriorward, but still in the anterior half of the platform. Frequently the overall appearance of *Po. a. asymmetricus* is more robust, and the ornament coarser, in comparison with *Po. a. ovalis*.

The nature of the aboral surface seems to provide a fairly reliable means of differentiation between the two subspecies, although there still tends to be some degree of gradation between the two and, as Orchard (1975a, p. 109-110) indicated, problems arise when a specimen in the literature is not shown in lower view. For example, the holotype of *Po. a. asymmetricus* is illustrated only in oral aspect (Bischoff and Ziegler 1957, pl. 16, fig. 20).

A third subspecies is now known, *Po. a.* subsp. A *sensu* ORCHARD 1978, in which the basal cavity is larger than in either *Po. a. asymmetricus* or *Po. a. ovalis*, shows strong asymmetry and is located at platform mid-length. The other two subspecies may exhibit transition toward this form. The holotype of *Po. a. ovalis* (Ziegler 1958, pl. 1, figs. 1, 2a, 2b, by subsequent designation of Ziegler *et al*. 1964, p. 423) has a rather large and posteriorly displaced basal cavity, which is slightly asymmetrical and is directly related to platform outline, and thus approaches *Po. a.* subsp. A *sensu* ORCHARD.

Po. dengleri may show gradation towards *Po. asymmetricus* subspp. and is included in this group.

Polygnathus asymmetricus asymmetricus BISCHOFF & ZIEGLER

Plate 14, figs. 1, 2; 3(cf.).

v*1957 *Polygnathus dubia asymmetrica* n. subsp. - BISCHOFF & ZIEGLER, p. 88-89, pl. 16, figs. 18, 20-22, pl. 21, fig. 3 (pl. 16, fig. 20 = holotype).

v1957 *Polygnathus dubia dubia* HINDE - BISCHOFF & ZIEGLER, p. 88, pl. 21, fig. 2 (only).

v1958 *Polygnathus dubia asymmetrica* BISCHOFF & ZIEGLER - ZIEGLER, pl. 1, figs. 4-6, 8, 10.

v1958 *Polygnathus dubia dubia* HINDE - ZIEGLER, pl. 1, fig. 3 (only).

?1966 *Polygnathus asymmetrica asymmetrica* BISCHOFF & ZIEGLER - FLAJS, p. 230-232, pl. 26, figs. 1-3, 8, 9 (non figs. 4-6 = *Po. a.* subsp. A *sensu* ORCHARD 1978).

1967 *Polygnathus dubia dubia* HINDE - CLARK & ETHINGTON, p. 60-61, pl. 7, fig. 14 (only).

non1970 *Polygnathus asymmetrica asymmetrica* BISCHOFF & ZIEGLER - SEDDON (b), pl. 10, figs. 2a, 2b (= *Po. a.* subsp. A *sensu* ORCHARD 1978).

1970 *Polygnathus asymmetricus asymmetricus* BISCHOFF & ZIEGLER - KIRCHGASSER, p. 345-346, pl. 63, fig. 9.

1971 *Polygnathus asymmetricus asymmetricus* BISCHOFF & ZIEGLER - SZULCZEWSKI, p. 45, pl. 16, figs. 3, 5 (non fig. 4 = *Po. a. ovalis*) (see synonymy).

1971 *Polygnathus asymmetricus* BISCHOFF & ZIEGLER - KLAPPER & PHILIP, p. 434, 449, fig. 3P (only).

1972 *Mesotaxis asymmetrica asymmetrica* (BISCHOFF & ZIEGLER) - KLAPPER & PHILIP, p. 100, pl. 1, fig. 20 (only).

1974 *Polygnathus asymmetricus asymmetricus* BISCHOFF & ZIEGLER - UYENO, p. 37, pl. 3, figs. 1, 3 (?), 4, 6.

•1975 *Mesotaxis asymmetrica asymmetrica* (BISCHOFF & ZIEGLER) - PHILIP & MCDONALD, p. 100, fig. 3P (only).

·1978 Polygnathus asymmetricus cf. asymmetricus BISCHOFF & ZIEGLER - ORCHARD, p. 938, pl. 109, fig. 35.

·1979 Polygnathus asymmetricus asymmetricus BISCHOFF & ZIEGLER - LANE, MÜLLER & ZIEGLER, p. 218, pl. 2, fig. 15.

Diagnosis: A subspecies of Po. asymmetricus in which the platform is broad, asymmetrical and usually subquadrate in outline. The oral surface bears many moderately coarse or, sometimes, finer nodes. Aborally, a minute basal cavity is located in the anterior half of the platform.

Remarks and comparisons: The specimen to hand illustrated on Plate 14, figs. 1, 2 conforms to the subspecies in platform outline and in the minute basal cavity. The broken platform shown on Plate 14, fig. 3 has an upturned margin, particularly in the anterior part of the platform, and the carina does not reach the posterior tip. In oral aspect the individual resembles Klapperina disparilis, but the slightly larger central node seen in this species is not evident and, although the preservation of the lower surface is poor and is not illustrated, there is no indication of any aboral development other than the very small basal cavity of Po. a. asymmetricus.

Range and occurrence: Po. a. asymmetricus ranges from the base of the Lowermost asymmetricus Zone to the top of the Upper asymmetricus Zone (Ziegler 1971, chart 5; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. a. asymmetricus and Po. cf. a. asymmetricus occur at Babbacombe Cliff (sample BC-32). Po. asymmetricus subsp. indet. is found both in this sample and at Barton Quarry (sample BQ-26).

Polygnathus asymmetricus ovalis ZIEGLER & KLAPPER

Plate 14, figs. 6, 7, 10.

v1957 *Polygnathus dubia dubia* HINDE - BISCHOFF & ZIEGLER, p. 88, pl. 16, fig. 19, pl. 21, fig. 1 (non fig. 2 = *Po. a. asymmetricus*).

v*1958 *Polygnathus dubia dubia* HINDE - ZIEGLER, pl. 1, figs. 1, 2, 7 (figs. 1, 2 = holotype; non fig. 3 = *Po. a. asymmetricus*).

v1965 *Polygnathus asymmetrica ovalis* ZIEGLER & KLAPPER - ZIEGLER (a), pl. 1, figs. 3, 4.

1966 *Polygnathus asymmetrica ovalis* ZIEGLER & KLAPPER - FLAJS, pl. 25, figs. 1-3.

·1967 *Polygnathus dubia dubia* HINDE - CLARK & ETHINGTON, p. 60-61, pl. 7, fig. 15, pl. 8, fig. 9 (non pl. 7, fig. 14 = *Po. a. asymmetricus*; non pl. 8, fig. 8 = *Po. dengleri*).

1969 *Polygnathus asymmetrica ovalis* ZIEGLER & KLAPPER - PÖLSLER, p. 420, pl. 4, figs. 17, 18.

1970 *Polygnathus asymmetricus ovalis* ZIEGLER & KLAPPER - SEDDON (a), pl. 13, figs. 16, 17 (only).

1970 *Polygnathus asymmetrica ovalis* ZIEGLER & KLAPPER - SEDDON (b), pl. 10, fig. 1.

1971 *Polygnathus asymmetricus ovalis* ZIEGLER & KLAPPER - SZULCZEWSKI, p. 45-46, pl. 17, figs. 1, 2 (see synonymy).

·1971 *Polygnathus asymmetricus asymmetricus* BISCHOFF & ZIEGLER - SZULCZEWSKI, p. 45, pl. 16, fig. 4 (only).

1974 *Polygnathus asymmetricus ovalis* ZIEGLER & KLAPPER - UYENO, p. 37, pl. 3, figs. 2, 5, 7, pl. 4, figs. 1, 3.

·1975 *Mesotaxis asymmetrica ovalis* (BISCHOFF & ZIEGLER) [*sic*] - PHILIP & MCDONALD, p. 100, fig. 4P (only).

·1976 *Polygnathus asymmetricus* BISCHOFF & ZIEGLER - GARCIA - LOPEZ, p. 176, pl. 1, figs. 4A, 4B.

•1978 Polygnathus asymmetricus ovalis ZIEGLER & KLAPPER - ORCHARD, p. 938, pl. 115, figs. 15, 22, 41-44.

•1980 Polygnathus asymmetricus ovalis ZIEGLER & KLAPPER - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 4, fig. 29.

Diagnosis: A subspecies of Po. asymmetricus in which the platform is a symmetrical oval in outline, and bears on the oral surface an ornament of numerous fine nodes. Aborally, a fairly small and symmetrical, tear-drop shaped basal cavity is located in the anterior half of the platform.

Description (Torquay material): In outline the platform is a symmetrical oval, which is widest at mid-length and tapers evenly and smoothly anteriorward to the free blade and posteriorward to the tip. The oral surface ornament is of numerous small, discrete nodes and granules. In lateral view the platform is gently arched, and in plan view the entire unit is weakly incurved. The free blade is low in profile and is short, comprising about one-fifth of total unit length. The carina consists of about seven quite large nodes, which are pointed in lateral view and rounded but slightly elongated in oral view. The carinal nodes are fused anteriorly but become increasingly more separated posteriorly, where the carina extends a little beyond the posterior limit of the platform. Aborally, a small, symmetrical basal cavity is located in the anterior half of the platform, slightly before platform mid-length. A sharp keel reaches the posterior tip and extends anteriorly under the free blade.

Remarks and comparisons: A single, well preserved specimen from Torquay, shown on Plate 14, figs. 6, 7, 10, is referred to this subspecies. The projection of the carina beyond the posterior limit of the platform is exhibited, but is rather more pronounced, in an individual figured by Uyeno (1974, pl. 4, figs. 3a, 3b) from the Moberly Member of the Waterways Formation. This feature is sometimes apparent in other polygnathids such as Po. dengleri, and a strong development of it characterised Po. n. sp. D as described by Pollock (1968). In aboral view, Uyeno's specimen shows a relative posteriorward displacement of the basal cavity compared both with his other illustrated examples of Po. a. ovalis (Uyeno 1974, pl. 3, figs. 2, 5, 7, pl. 4, fig. 1) and with the form to hand.

Range and occurrence: The subspecies ranges from the base of the Lowermost asymmetricus Zone into the higher part, but not to the top of, the Upper asymmetricus Zone (Ziegler 1971, chart 5; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. a. ovalis occurs at Barton Quarry (sample BQ-18).

Polygnathus asymmetricus subsp. A sensu ORCHARD 1978

Plate 13, figs. 23, 24, 28, 29.

•1978 Polygnathus asymmetricus subsp. A nov. - ORCHARD, p. 940, 942, pl. 115, figs. 18, 19 (see synonymy).

Diagnosis: A subspecies of Po. asymmetricus in which the platform is elongated and more or less oval in outline. The oral surface ornament is of fine granules which may become fused into short marginal ridges. Aborally, a large, asymmetrical and triangular-shaped basal cavity is situated at platform mid-length.

Remarks and comparisons: Po. a. subsp. A is distinguished from other broad platformed polygnathids by its large and clearly asymmetrical basal cavity, in which it resembles Schmidtognathus hermanni (compared thereunder) and representatives of the genus Klapperina. The form may be distinguished from the latter by its finer ornament, better development of the carina posteriorly and the absence of a lobe-like projection of the outer platform, seen in some of the palmatolepid-like klapperinids. The basal cavity of Klapperina spp. has a wider lateral development than that of Po. a. subsp. A and may be conspicuously L-shaped, particularly in K. disparalvea, in which the cavity may also be displaced relatively posteriorward. The overall morphology of Po. a. subsp. A, especially with regard to the aboral surface, appears to be intermediate between that of the broad polygnathids and Klapperina spp.

The Torquay specimens are preserved only as incomplete platforms but their outline, at least in the middle and posterior part of the platform, is typical of the subspecies as is their ornament, which is of granules and fine ridges. The posterior part of the carina seems to be rather better developed than is usual. In the original description, Orchard (1978, p. 940) observed that the carina became gradually lower posteriorward from the fixed blade, and that the carinal nodes were best developed a little posterior of platform mid-length. To the posterior, two or three small, discrete and increasingly more separated nodes represented the carina. The nodes of the carina of the examples to hand are slightly elongated, high and fused at a point corresponding to the position of the basal cavity. They become only a little separated posteriorly and remain high, resembling the posterior carina of the specimen of Po. a. ovalis illustrated by Lane et al. (1979, pl. 2, fig. 19).

The juvenile individual on Plate 13, figs. 28, 29 has a relatively larger basal cavity which occupies much of the aboral surface of the platform. The platform itself is quite strongly laterally expanded, especially in the outer half which is wider than the inner, and directly reflects the shape of the basal cavity. As Orchard (1978, p. 940) noted, such features are particularly distinct in juvenile growth stages.

Range and occurrence: In Plymouth, Orchard (1978, p. 917, text-fig. 2, table 2) recorded Po. a. subsp. A from Durnford Street, sample DS1: Fauna 12, considered by him to be of Middle asymmetricus Zone age. As Orchard reported, the form occurs in faunas of a similar age in Austria (Flajs 1966), in America

(Pollock 1968) and in Belgium. In the Llano region of Texas, Seddon (1970b, p. 36, 100) recorded the form (as Po. a. asymmetricus) from the Houy Formation (Zone 1, locality TF-294) from crack infillings in the Pillar Bluff area. He considered the specimens to indicate an (undifferentiated) asymmetricus Zone age.

In Torquay, Po. a. subsp. A was found at Petit Tor Beach (sample PB-12).

Polygnathus dengleri BISCHOFF & ZIEGLER

Plate 14, figs. 4, 5, 8, 11, 13, 17.

v*1957 Polygnathus dengleri n.sp. - BISCHOFF & ZIEGLER, p. 87-88, pl. 15, figs. 14, 15, 17-24, pl. 16, figs. 1-4 (pl. 15, fig. 18 = holotype).

1959 Polygnathus dengleri BISCHOFF & ZIEGLER - KREBS, pl. 1, figs. 1, 4, 5, 9.

v1965 Polygnathus dengleri BISCHOFF & ZIEGLER - ZIEGLER (b), p. 671, 673, pl. 6, figs. 1-6.

1967 Polygnathus dengleri BISCHOFF & ZIEGLER - CLARK & ETHINGTON, p. 60, pl. 7, figs. 3, 8.

•1967 Polygnathus dubia dubia HINDE - CLARK & ETHINGTON, p. 60-61, pl. 8, fig. 8 (only).

1967 Polygnathus dengleri BISCHOFF & ZIEGLER - MÜLLER & CLARK, p. 916, pl. 115, figs. 3, 7.

1968 Polygnathus dengleri BISCHOFF & ZIEGLER - ORR & KLAPPER, pl. 139, figs. 5-7.

1969 Polygnathus dengleri BISCHOFF & ZIEGLER - PÖLSLER, p. 421, pl. 4, figs. 13, 14.

1970 Polygnathus dengleri BISCHOFF & ZIEGLER - SEDDON (a), p. 739, pl. 13, figs. 20-23.

1970 Polygnathus dengleri BISCHOFF & ZIEGLER - KIRCHGASSER, p. 348-349, pl. 63, fig. 2, pl. 65, fig. 4, pl. 66, fig. 2.

non1971 Polygnathus dengleri BISCHOFF & ZIEGLER - SZULCZEWSKI, p. 48, pl. 16, figs. 1, 2, 6, 7.

•1978 Polygnathus dengleri BISCHOFF & ZIEGLER - ORCHARD, p. 942, pl. 115, figs. 20, 21, 24.

•1979 Mesotaxis cf. Mesotaxis dengleri (BISCHOFF & ZIEGLER) - UYENO, p. 247, pl. 2, fig. 22.

•1980 Polygnathus dengleri BISCHOFF & ZIEGLER - KLAPPER in JOHNSON, KLAPPER & TROJAN, p. 102, pl. 4, figs. 24-28, 30(?).

Diagnosis: A species of Polygnathus in which the platform is an elongated, narrow and symmetrical oval and has upturned rims. The free blade is fairly short and high. The ornament may be strong and consists of transverse and sometimes nodose ridges, which are separated from the carina by smooth, shallow adcarinal grooves. The carina is high and may extend a little beyond the posterior limit of the platform. Aborally, a small oval basal cavity is located in the anterior half of the platform.

Remarks and comparisons: The specimens from Torquay illustrated on Plate 14, figs. 11, 13, 17 compare closely with an individual from Plymouth shown by Orchard (1978, pl. 115, figs. 20, 21, 24). In all these forms the ornament is of distinct but rather fine ridges, similar to that of the early growth stages figured by Kirchgasser (1970, pl. 63, fig. 2, pl. 65, fig. 4, pl. 66, fig. 2) from North Cornwall. The rather coarse and sometimes nodose ridges of some examples of Po. dengleri, such as those illustrated by Bischoff and Ziegler (1957, pl. 15, figs. 14, 15, 17, 18, 20-24, pl. 16, figs. 1-4) from Germany, do not appear to be developed in the South-west England specimens. The last appear to correspond to stratigraphically late forms of Po. dengleri which Klapper (in Johnson et al. 1980, p. 102) described from Upper dengleri Subzone and Lower asymmetricus Zone faunas from the Antelope Range of central Nevada.

Klapper's specimens bear an ornament of finer nodes and fewer, weaker transverse ridges compared to his stratigraphically earlier forms in the Lower dengleri Subzone, in which the ornament is of rather coarse and irregular nodes and transverse ridges. He noted that both types lay within the range of intraspecific variation originally described by Bischoff and Ziegler within Po. dengleri, and he observed gradation between the two morphologies in the stratigraphically higher levels.

In the smallest example to hand, shown on Plate 14, figs. 4,5,8, the greatest platform width is located closer to the anterior end of the platform than is usual. One specimen illustrated by Kirchgasser (1970, pl. 65, fig. 4) is similar. Aborally, both exhibit a relatively large basal cavity which, in the Torquay individual, is both displaced and elongated further posteriorward.

Compared to Po. asymmetricus subspp., Po. dengleri has a narrower, trough-shaped platform, adcarinal grooves which extend the length of the platform, and a higher carina and blade. The strong transverse ridges of some forms of Po. dengleri are not developed in Po. asymmetricus subspp.

Specimens illustrated by Szulczewski (1971, pl. 16, figs. 1, 2, 6, 7) are, as he observed, broader than is typical of Po. dengleri. At least some of Szulczewski's examples exhibit an asymmetrical basal cavity which is located at platform mid-length, and in these respects approach Po. a. subsp. A.

Range and occurrence: Po. dengleri ranges from within the Lowermost asymmetricus Zone into the Lower asymmetricus Zone (Ziegler 1971, chart 5; in Klapper and Ziegler 1979, text-fig. 5). Only in the first reference is the species shown attaining the top of the Lower asymmetricus Zone.

In Torquay, Po. dengleri occurs at Babbacombe Cliff (samples BC-2, 5, 9, 11).

The Polygnathus costatus Group.

This group was established by Klapper (1971, p. 62-64) and then embraced the following:

Polygnathus costatus costatus KLAPPER
Polygnathus costatus patulus KLAPPER
Polygnathus pseudofoliatus WITTEKINDT
Polygnathus eiflius BISCHOFF & ZIEGLER

To these can now be added:

Polygnathus costatus oblongus WEDDIGE
Polygnathus costatus partitus KLAPPER, ZIEGLER & MASHKOVA

The representatives of the group are characterised by the outline of the outer platform which forms a regular curve, the radius of which is greater than the platform width. The oral surface of the posterior platform is ornamented by nodes, sometimes transversely aligned and occasionally partially fused, or by transverse ridges. Adcarinal grooves separate the ornament from the carina; the last attains at least the posterior third of the platform. Aborally, a small basal cavity is located about halfway between the anterior end and mid-length of the platform.

There is gradation between the various subspecies of Po. costatus and between these forms and Po. pseudofoliatus, both in terms of stratigraphical and morphological expression, which suggests a phylogenetic series connecting them. Po. pseudofoliatus most closely resembles Po. c. costatus, which it succeeds stratigraphically in New York, Nevada, Belgium and Germany. Weddige (1977, text-fig. 4) derived Po. pseudofoliatus from Po. c. costatus, and he derived also Po. eiflius from the costatus lineage, by way of his Po. benderi.

Both Po. pseudofoliatus and Po. eiflius can be distinguished from other members of the Po. costatus group by their relatively longer free blade (one-third to one-half of total unit length, compared to one-third or less in the rest of the Po. costatus group) and by the greater constriction of the anterior platform. Po. eiflius and Po. pseudofoliatus show gradation towards each other. Klapper (1971, p. 63) described an intermediate form from the lower part of the Middle Devonian of New York, which he designated Po. aff. Po. eiflius.

Representatives of the Po. costatus group differ from those of the Po. linguiformis group by a combination of all or some of the following features: the smooth curvature of the outer platform; the less pronounced inward inflexion of the posterior platform; the absence of transverse ridges on the posterior platform. In its similar platform outline, Po. l. cooperi KLAPPER resembles members of the Po. costatus group, but is distinguished by the presence of transverse ridges on the posterior platform, although these are not always completely developed. Klapper (1971, p. 65) recognised specimens transitional from Po. c. patulus to Po. l. cooperi in which the transverse ridges were fewer and weaker than in the latter subspecies.

Polygnathus costatus costatus KLAPPER

Plate 4, figs. 10-12, 15-17 (cf.).

*1971 Polygnathus costatus costatus subsp. nov. - KLAPPER, p. 63, pl. 1, figs. 30-36, pl. 2, figs. 1-7 (figs. 5-7 = holotype) (see synonymy).

•1972 Polygnathus costatus costatus KLAPPER - BOOGAARD, p. 6, pl. 1, figs. e-h.

•1977 Polygnathus costatus costatus KLAPPER - WEDDIGE, p. 309, pl. 4, figs. 75, 76 (see synonymy).

•1977 Polygnathus costatus costatus KLAPPER - SAVAGE, p. 1350, 1352, pl. 3, figs. 13-16.

•1978 Polygnathus costatus costatus KLAPPER - KLAPPER, ZIEGLER & MASHKOVA, pl. 2, figs. 10-12.

•1979 Polygnathus costatus costatus KLAPPER - LANE, MÜLLER & ZIEGLER, p. 218, pl. 1, fig. 12.

•1979 Polygnathus costatus costatus KLAPPER - CHATTERTON, p.192,pl.8, figs.2-4.

.1980 Polygnathus costatus costatus KLAPPER - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 4, figs. 14, 15, 17.

.1981 Polygnathus costatus costatus KLAPPER - SPARLING, p. 312-313, pl. 1, figs. 25-27 (only).

.1981 Polygnathus costatus costatus KLAPPER - WANG & ZIEGLER, pl. 1, figs. 2,3.

Diagnosis (after Klapper 1971): A subspecies of Po. costatus in which the platform is widest in the posterior third and is rather constricted near the anterior end. The carina attains the posterior tip.

Remarks and comparisons: A few tectonically flattened and probably derived specimens from Long Quarry Point are assigned to the Po. costatus group, and appear to lie closest to Po. c. costatus. In this form the anterior platform is rather more constricted than in the other subspecies, but not as strongly so as in either Po. pseudofoliatus or Po. eiflius. Po. c. patulus has wider adcarinal grooves and a narrower platform, in which the greatest width is developed further anteriorly than in the nominate subspecies. The carina of the former may be less well developed than in the latter, but this is variable, as Klapper, Ziegler and Mashkova (1978, p. 109) discussed. Po. c. oblongus has a narrower, more symmetrical and more inwardly bowed platform compared to Po. c. costatus and, in contrast with the same, Po. c. partitus has less curved outer and inner posterior platform margins, which converge posteriorly to produce a sagittate platform outline.

Range and occurrence: In the Eifelian Hills of Germany, Po. c. costatus ranges from the base of the c. costatus Zone into the lower part of the australis Zone (Weddige 1977, tables 2, 5; Klapper 1977, p. 45), and has a similar but interrupted range in New York (Klapper in Klapper and Ziegler 1979, text-fig. 4). In the Barrandian area of Czechoslovakia, and in Nevada and Canada, Po. c. costatus is confined to within the c. costatus Zone (Klapper *op. cit.*, text-figs. 3, 4), and occupies a similar interval, Co2b, in Belgium (in Bouckaert and Streel 1974).

Po. cf. *c. costatus* occurs in Torquay at Long Quarry Point (samples LG-4, 7).

Polygnathus pseudofoliatus WITTEKINDT

Plate 4, figs. 9, 13, 14, 20-24; 1-8 (aff.); Plate 5,figs.13,14,18,23.

v1957 *Polygnathus foliata* BRYANT - BISCHOFF & ZIEGLER, p. 90, pl. 4, figs. 1-4.
1965 *Polygnathus* n.sp. - BULTYNCK, p. B70, pl. 1, figs. 6a, 6b.
*1965 *Polygnathus pseudofoliata* n. sp. - WITTEKINDT, p. 637-638, pl. 2, figs. 20-23 (only; fig. 20 = holotype).
1966 *Polygnathus* sp. nov. B - PHILIP, p. 158-159, pl. 2, figs. 4-9.
1970 *Polygnathus xyla* STAUFFER - BULTYNCK, p. 131, pl. 15, fig. 5 (only).
1971 *Polygnathus pseudofoliatus* WITTEKINDT - ORR, p. 52-53, pl. 4, figs. 18-22.
•1975 *Polygnathus pseudofoliatus* WITTEKINDT - BULTYNCK, p. 23, pl. 5, fig. 4.
•1976 *Polygnathus pseudofoliatus* WITTEKINDT - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pl. 3, figs. 2, 3, 12, 13.
•1977 *Polygnathus pseudofoliatus* WITTEKINDT - WEDDIGE, p. 317-318, pl. 4, figs. 68-70 (see synonymy).
•1978 *Polygnathus pseudofoliatus* WITTEKINDT - ORCHARD, p. 949, pl. 108, figs. 1, 3-5, 7, 8.
•1979 *Polygnathus pseudofoliatus* WITTEKINDT - UYENO, p. 245, pl. 1, figs. 26-28.
•1979 *Polygnathus pseudofoliatus* WITTEKINDT - CHATTERTON, p. 199, pl. 3, figs. 1-10, 15-18.
1979 *Polygnathus xylus*? STAUFFER - CHATTERTON, p. 199-200, pl. 3, figs. 19-22.
non1979 *Polygnathus pseudofoliatus* WITTEKINDT - LANE & ORMISTON, pl. 9, fig. 9 (= *Po. benderi*?)

Diagnosis: A species of Polygnathus in which the anterior platform is constricted to produce a distinct rostrum, behind which the platform is moderately broad and the outer half slightly wider than the inner. The oral surface ornament is either of nodes which may sometimes be transversely aligned, or of transverse to oblique ridges. Adcarinal grooves separate the ornament from the carina. The free blade comprises one-third to one-half of total unit length.

Remarks and comparisons: A rostrum similar to that of Po. pseudofoliatus is developed in the younger (Upper Devonian) Po. dubius. The latter species may be distinguished from the former by its narrower, longer platform and relatively shorter free blade.

Comparisons between Po. pseudofoliatus and Po. costatus subspp. are made in the introduction to the group. Po. pseudofoliatus most closely resembles Po. eiflius, and the validity of maintaining the two as separate species has been doubted. As conceived by Bischoff and Ziegler (1957, p. 89-90), Po. eiflius was characterised by the development of diagonal rostral ridges on the anterior platform, and by an oral surface ornament of dense, fine nodes. This species was differentiated from Po. pseudofoliatus by, in the latter, the narrower platform and lack of rostral ridges. Bultynck (1970, p. 124) first observed the discrepancy between this definition and that given by Wittekindt (1965, p. 633), who preferred to distinguish the two species on platform outline alone and disregarded the presence or absence of rostral ridges. As Klapper (1971, p. 63) noted, there is considerable gradation in platform outline between Po. eiflius and Po. pseudofoliatus and, if the development of rostral ridges were to be ignored, these two would probably fall into synonymy. In fact, Telford (1975, p. 50-51) considered that, because forms with distinct rostral ridges were rare and were completely absent from both his Australian Broken River Embayment collections and Klapper's large North American faunas, Po. eiflius was perhaps better placed in synonymy with Po. pseudofoliatus.

The Torquay material does not help to clarify the position of Po. eiflius. Specimens assigned to Po. pseudofoliatus show considerable morphological variation and include individuals, designated Po. aff. pseudofoliatus, which have some of the features of Po. eiflius and are described below. None exhibits the development of rostral ridges but, on the other hand, the material is not abundant. It should be noted that some forms, for example Po. l. linguiformis epsilon morphotype, embrace late growth stages both with and without rostral ridges, and this character may prove to be an unsuitable criterion for specific differentiation.

In the examples to hand, the outer half of the platform is always at least a little wider than the inner, but the early growth stage illustrated on Plate 4, figs. 9, 13, 14 has a rather parallel sided platform, as have small forms figured by Ziegler and Klapper (in Ziegler et al. 1976, pl. 3, fig. 12, 13) and Orchard (1978, pl. 108, figs. 5, 8). In this respect these specimens resemble Po. xylus and are compared thereunder. During ontogeny the platform of Po. pseudofoliatus becomes relatively broader behind the rostrum. At the rostrum the margins are upturned and the adcarinal grooves deepest, but the latter features are always shallower posteriorward, which is apparent even in small growth stages. The carina may or may not reach the posterior tip, even in specimens of a similar size, as comparison of the examples shown on Plate 4, figs. 20-24 illustrates. The ornament is of fairly fine nodes in all the Torquay specimens. These are sometimes transversely to obliquely aligned or elongated to produce nodose ridges, but these are never pronounced (e.g. Pl.5, figs. 13, 14). The individual on Plate 4, figs. 20-23 shows a tendency toward Po. x. ensensis, particularly toward one example of the latter figured by Weddige (1977, pl. 4, fig. 65), because the nodes at the anterior end of the platform of the former specimen are obliquely enlarged and the margins appear slightly serrated. In profile, the specimen shown on Plate 5, figs. 18, 23 also resembles Po. x. ensensis because the posterior platform is strongly arched. However, this feature is thought to have been tectonically induced, the free blade having been also affected and arched upwards. In aboral view the basal cavities of all the individuals to hand are displaced a little anteriorward in comparison with the definition of the Po. costatus group given by Klapper (1971, p. 62).

Several specimens from Long Quarry Point (Pl. 4, figs. 1-8) have a thick platform, which has a somewhat stronger degree of anterior constriction than is considered to be typical of Po. pseudofoliatus, especially on the inner side, and the rostrum is rather short. Also, the extent of lateral expansion of the platform behind the rostrum seems to be greater than is usual. This is particularly evident in the example on Plate 4, figs. 1-3 in which the inner platform attains more or less the same width as the outer, and the specimen has a rather squat appearance overall. Weddige (1977, pl. 4, figs. 66, 67) illustrated individuals with a thick platform of similar outline which he designated Po. eiflius, because they bore the rostral ridges and dense, finely nodose ornament of this species. The Long Quarry Point specimens lack rostral ridges and so are referred, albeit tentatively, to Po. pseudofoliatus. The ornament is of fine nodes, as in Po. eiflius, although these may become transversely aligned or elongated to produce weak nodose ridges (compare Pl. 4, fig. 4 with fig. 1).

Broad platformed individuals with a rather dense, fine Po. eiflius-type of ornament have been assigned to Po. pseudofoliatus by Chatterton (1979). Chatterton (1979, pl.3, fig.8) most closely resembles the specimens available, although the constriction of the anterior platform in this particular example is not as strongly developed as in the Torquay forms, particularly with regard to the inner platform.

Range and occurrence: In the Barrandian area of Czechoslovakia, *Po. pseudofoliatus* ranges from the base of the *australis* Zone into the *kockelianus* Zone, in Nevada from the base of the *australis* Zone to the top of the Lower *varcus* Subzone, and in the Eifelian Hills of Germany from near the base of the *kockelianus* Zone again to the top of the Lower *varcus* Subzone, but in New York the species is restricted to the *kockelianus* Zone (Klapper 1977, text-fig. 6; Klapper and Ziegler 1979, text-figs. 3-5). In Belgium, the form extends from Co2c (lower part or base of the *australis* Zone: see Weddige 1977, table 4), sporadically into the *varcus* Zone (in Bouckaert and Streel 1974).

In Torquay, *Po. pseudofoliatus* occurs at Long Quarry Point (samples LG-4, 5, 8), New Quarry (sample NQ-5), Parkfield Road (samples PF-5, 9), Redgate Beach (samples RB-2, 3, 4, 5, 11, 13) and Waldon Hill (sample WH-1). *Po.* aff. *pseudofoliatus* occurs at Long Quarry Point (samples LG-3, 5).

Polygnathus cristatus HINDE

Plate 13, figs. 17-22, 25-27.

*1879 Polygnathus cristatus n. sp. - HINDE, p. 366, pl. 17, fig. 11 (=lectotype, designated by ZIEGLER 1965b, p. 670).

1933 Polygnathus cristata HINDE - BRANSON & MEHL(a),p.147,pl.11,fig.10.

1934 Polygnathus ectypa n. sp. - HUDDLE, p. 103, pl. 8, fig. 38.

1947 Polygnathus retrorsa n. sp. - YOUNGQUIST & PETERSON, p. 251, pl. 38, fig. 11.

v1957 Polygnathus cristata HINDE - BISCHOFF & ZIEGLER, p. 86-87, pl. 15, figs. 1-13, 16, pl. 17, figs. 12, 13.

1959 Polygnathus cristata HINDE - KREBS, pl. 1, fig. 16.

1964 Polygnathus cristata HINDE - ORR, p. 13-14, pl. 3, figs. 4-8, 10, text-fig. 4.

v1965 Polygnathus cristata HINDE - ZIEGLER (b), p. 670-671, pl. 4, figs. 17-23, pl. 5, figs. 1, 2, 5 (only).

1967 Polygnathus cristata HINDE - CLARK & ETHINGTON, p. 59-60, pl. 7, figs. 16, 17.

1966 Polygnathus cristata HINDE - FLAJS, pl. 23, fig. 8, pl. 25, fig. 4.

1967 Polygnathus cristata HINDE - ADRICHEM BOOGAERT, p. 184, pl. 2, fig. 41.

1968 Polygnathus cristatus HINDE - ORR & KLAPPER, pl. 139, figs. 1-4, 8, 9.

1969 Polygnathus cristata HINDE - PÖLSLER, p. 421, pl. 5, fig. 22.

·1970 Polygnathus cristatus (?) HINDE - KIRCHGASSER, p. 346-347, pl. 63, figs. 3, 7, 10.

1971 Polygnathus cristatus HINDE - ORR, p. 48, pl.6, figs. 1, 2.

·1971 Polygnathus cristatus HINDE - SCHUMACHER (a), p. 98, pl. 10, figs. 1, 2.

·1976 Polygnathus cristatus HINDE - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pl. 4, fig. 18.

·1978 Polygnathus cristatus HINDE - ORCHARD, p. 942, pl. 115, fig. 23.

·1979 Polygnathus cristatus HINDE - UYENO, p. 241, pl. 2, figs. 12, 13.

·1980 Polygnathus cristatus HINDE - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, fig. 36.

Diagnosis: A species of Polygnathus, in which the platform is fairly broad, and is symmetrically oval to rather more subcircular in outline. The oral surface bears an ornament of coarse and longitudinally aligned nodes, which may become more densely and more irregularly distributed in large specimens. The free blade is short and high. Aborally, a fairly small, oval basal cavity is located in the anterior half of the platform.

Description (Torquay material): The platform is symmetrically oval to more nearly circular in outline, and is broadest in the anterior half. From the widest part, the platform tapers evenly posteriorward in all growth stages, and also tapers evenly anteriorward to the free blade in small specimens. In larger forms, the anterior platform is rather blunt, because the anterior platform margins curve to meet the free blade at steep angles, of up to ninety degrees. The oral surface usually bears an ornament of coarse, rounded nodes, which are more or less aligned into longitudinal rows. These are parallel to the carina throughout much of the platform, but tend to diverge from it anteriorly, to produce short, fairly deep, triangular (in plan view) adcarinal troughs. Smooth bands extend posteriorward on either side of the carina, and the platform is fairly flat beneath the ornament. In the latest growth stages, the nodes become relatively smaller, and more closely and irregularly distributed. They also exhibit a partial tendency to fuse with each other. The rounded nodes of the carina are larger than those of the platform ornament in all individuals, and are slightly elongated and fused at platform mid-length, becoming increasingly more separated posteriorly to the pointed tip. The free blade is never sufficiently well preserved to be described.

In oral view, the length axis of the entire unit is gently curved, whilst in profile the platform is weakly arched. Aborally, a fairly small, oval basal cavity is developed roughly at the mid-point of the anterior half of the platform. A keel extends both anteriorward and posteriorward from the cavity, and is grooved in the former direction.

Remarks and comparisons: The lectotype of Po. cristatus (Hinde 1879, pl. 17, fig. 11) has an ornament of coarse, rounded or sometimes obliquely elongated nodes, which are aligned in longitudinal rows, parallel to the carina. The material available includes several growth stages with strong, rounded nodes which are arranged in this manner (illustrated on Pl. 13, figs. 17, 18, 21, 22, 25-27). Orr (1964, text-fig. 4) depicted an ontogenetic series of similar examples from the Alto Formation of southern Illinois, which indicated that the platform became better developed and relatively broader with ontogeny, and bore increasingly more longitudinal rows of nodes on the oral surface, as the ornament itself became better formed. These tendencies are apparent in the specimens to hand. The anterior platform is of a somewhat variable nature in Orr's material, and is usually less blunt (in plan view) than in the larger of the Torquay individuals (e.g. Pl. 13, figs. 17, 22, 25).

The larger of the specimens which Bischoff and Ziegler (1957) referred to Po. cristatus sometimes exhibit variation with regard to the overall morphology of their platforms, and/or to the configuration of their ornament. These features are most apparent in Bischoff and Ziegler (1957, pl. 15, figs. 8, 9, 11-13, 16), in which individuals the platform margins may be more irregular and less evenly curved than is often seen in the species. Further, the ornament in these examples is of rather less coarse but more profuse nodes, which may fuse either partially or more fully, to produce an irregular network of ramifying ridges. The ornament of the large Torquay specimen shown on Plate 13, figs. 19, 20 is considerably obscured by the effects of dolomitisation, but tends towards this manner of development. The platform margins of this individual are regularly and smoothly curved.

Representatives of Po. cristatus with a somewhat finer, more densely nodose and, often, distinctly fused ornament approach Po. a. asymmetricus. However, their ornament is still rather more coarse than in the latter taxon, in which the nodes are usually discrete, and display no more than a weak degree of fusion, if any. The oval to subcircular, symmetrical platform of Po. cristatus also distinguishes the form from the subquadrate, asymmetrical platform of Po. a. asymmetricus. Aborally, the basal cavity of the former species is relatively larger than that of the latter, and may be located a little further anteriorward. The morphology of the anterior platform seems to provide an additional character for separating the two taxa. The anterior platform of Po. a. asymmetricus usually tapers toward the free blade, and does not have the blunt configuration sometimes seen in Po. cristatus. This criterion cannot always be applied, because, as noted above, the anterior platform of the last species exhibits a variable development. A range of variation is apparent in all the material which Bischoff and Ziegler assigned to Po. cristatus. The anterior platform is clearly blunt in Bischoff and Ziegler (1957, pl. 15, fig. 1b), but tapers toward the free blade and may be rather pointed in other of their examples (e.g. Bischoff and Ziegler 1957, pl. 15, figs. 8, 10-13, 16).

Po. limitaris has a strongly nodose ornament, in which it resembles Po. cristatus, but Ziegler and Klapper (in Ziegler et al. 1976, p. 122) thought that the two could be distinguished by the more nearly circular platform outline of the latter. They indicated the existence of specimens intermediate between Po. limitaris and Po. cristatus, and suggested that the latter may have been derived from the former, which idea had been propounded earlier by Ziegler (1965b, p. 669: Po. limitaris as Po. sp.). With further regard to the evolutionary position of Po. cristatus, several authors (e.g. Lane et al. 1979, p. 217, after Helms and Ziegler in press) have considered the species to be, itself, ancestral to the genus Klapperina. Orr and Klapper (1968, p. 1072, pl. 139, figs. 8, 9) had previously recorded individuals which they thought were transitional between the former taxon and K. disparalvea (the latter as Pa.? disparalvea).

Further remarks concerning Po. cristatus are made under Po. ordinatus.

Range and occurrence: Po. cristatus ranges from the base of the Upper hermanni-cristatus Subzone into, but only questionably to the top of, the Middle asymmetricus Zone (Ziegler 1971, chart 3; in Klapper and Ziegler 1979, text-fig. 5). In Torquay, the species occurs at Babbacombe Cliff (samples BC-32, 33) and Barton Quarry (samples BQ-1, 2, 18, 26, 30).

Polygnathus decorosus STAUFFER

Plate 13, figs. 5-7, 9-13, 15, 16.

*1938 Polygnathus decorosus n. sp. - STAUFFER, p. 438, pl. 53, figs. 5, 6, 10, 15, 16 (only; fig. 6 = lectotype, designated by HUDDLE 1970, p. 1034).

non1964 Polygnathus decorosa STAUFFER - ORR, p. 14, 16, pl. 1, figs. 3-5, 7, pl. 3, fig. 2 (pl. 1, fig. 4 and pl. 3, fig. 2 = Po. ovatinodosus?; pl. 1, fig. 3 = Po. xylus xylus); pl. 1, figs. 5, 7 =?).

non1966 Polygnathus decorosa STAUFFER - ANDERSON, p. 411, pl. 50, figs. 6-8, 10, 11, 13, 15, 19.

?1968 Polygnathus decorosa STAUFFER - MOUND, p. 505-506, pl. 69, figs. 19, 21, 29.

·1970 Polygnathus decorosus STAUFFER s. l. - KIRCHGASSER, p. 347-348, pl. 64, figs. 2, 7 (?), 8(?) (only).

non1971 Polygnathus decorosus STAUFFER - ORR, p. 48, 49, pl. 4, figs. 1-5 (= Po. ovatinodosus).

·1973 Polygnathus decorosus STAUFFER - KLAPPER in ZIEGLER, p. 351-352, Polygnathus - pl. 1, fig. 5 (original of KLAPPER, PHILIP & JACKSON 1970, pl. 3, fig. 5 and same specimen as STAUFFER 1938, pl. 53, fig. 6) (see synonymy).

?1975 Polygnathus dubius HINDE - BULTYNCK, p. 22-23, pl. 1, fig. 4 (only).

·1981 Polygnathus decorosus STAUFFER-DUFFIELD & WARSHAUER, pl. 1, fig. 13.

Diagnosis: See Klapper, Philip and Jackson 1970, p. 653.

Remarks and comparisons: Po. decorosus was first described by Stauffer (1938, p. 438), and was reassessed by Klapper et al. (1970, p. 652-654). The species has been used in a broad sense by several authors (e.g. Ziegler 1965b, Kirchgasser 1970), but Ziegler and Klapper (in Ziegler et al. 1976, p. 124) preferred to include several of these forms in synonymy with their Po. ovatinodosus.

Po. decorosus is used "sensu stricto" herein. Specimens from Torquay assigned to the species, and those of authors cited in the synonymy, have a narrow, elongated and symmetrical platform, and are consistent with Po. decorosus as envisaged by Klapper et al. (1970). In the examples on Plate 13, figs. 5, 9, 10, 15, the anterior platform margins taper smoothly toward the free blade, whilst in the individual on Plate 13, fig. 6 the anterior platform margins turn in rather more angularly and abruptly, to produce a more sagittate platform outline. Adcarinal grooves are developed in all specimens, but there is variation in the nature of the oral surface ornament. This may consist of a row of nodes on each platform margin, as in the examples on Plate 13, figs. 5, 6. In contrast, the specimen on Plate 13, figs. 9, 10, 15 has an ornament of more numerous but somewhat smaller nodes, which form transverse nodose ridges anteriorly, but become discrete and randomly distributed posteriorly.

The ornament of the individual on Plate 13, figs. 7, 12 is rather ridge-like. The ridges are arranged normal to the carina anteriorly, but become inclined to it posteriorly, a feature which Stauffer (1938, p. 439) noted in Po. webbi. However, in comparison with the example to hand, the last species bears more numerous and better developed ridges, and the platform outline makes the form readily distinguishable from all representatives of

Po. decorosus.

With regard to platform outline, the last-mentioned Torquay specimen, and those on Plate 13, figs. 11, 13, 16, have more or less parallel platform margins, and thus show a tendency toward *Po. x. xylus*. However, the adcarinal grooves of *Po. x. xylus* are deeper posteriorward compared to those of *Po. decorosus*, and the Torquay material referred to the former taxon is more robust than that assigned to the latter. In both *Po. x. xylus* and *Po. decorosus* the free blade typically comprises about one-half of total unit length. Klapper *et al.* (1970, p. 653) thought that the denticles of the free blade were of equal height in *Po. decorosus*, but declined posteriorly in *Po. x. xylus*, although the last feature is evident to some extent in individuals from Torquay designated *Po. decorosus* (*e.g.* Pl. 13, figs. 12, 16).

In comparison with *Po. ovatinodosus*, the platform of *Po. decorosus* is more slender, a rostrum is not developed, and the ornament is finer. The first two characters allow *Po. decorosus* to be distinguished also from *Po. dubius*, as do the symmetrical platform and relatively longer free blade of the former species.

Range and occurrence: *Po. decorosus* ranges from the *Ancyrognathus triangularis* Zone, through to the Uppermost *gigas* Zone (Klapper in Ziegler 1973, p. 351).

In Torquay, *Po. decorosus* occurs at Babbacombe Cliff (samples BC-5, 8) and Petit Tor Beach (samples PB-1, 2, 3, 6, 12).

Polygnathus dubius HINDE

Plate 12, figs. 1-16; 17-27 (aff.).

?1967 *Polygnathus ordinata* BRYANT - CLARK & ETHINGTON, p. 63, pl. 7, fig. 5 (only).

·1967 *Polygnathus foliata* BRYANT - CLARK & ETHINGTON, p. 61, pl. 5, fig. 7, pl. 7, fig. 7(?).

*1970 Polygnathus dubius HINDE - HUDDLE, p. 1037-1038, pl. 138, figs. 1-17 (figs. 5, 6 = neotype: originally illustrated by BRYANT 1921, pl. 10, fig. 16; selected by Huddle as the lectotype of Po. foliatus BRYANT and as the neotype of Po. dubius) (see synonymy).

•1970 Polygnathus foliatus BRYANT - SEDDON (a), pl. 13, fig. 6.

1973 Polygnathus dubius HINDE - KLAPPER in ZIEGLER, p. 353-354, Polygnathus-pl. 1, fig. P (only: original of KLAPPER & PHILIP 1971, fig. 12P) (see synonymy).

•1975 Polygnathus dubius HINDE - BULTYNCK, p. 22-23, pl. 5, fig. 3 (non pl. 1, fig. 4 = Po. decorosus?; non pl. 15, fig. 2 = ?).

?1979 Polygnathus dubius HINDE - UYENO, p. 244, pl. 2, fig. 11.

?1979 Polygnathus sp. - UYENO, p. 246, pl. 2, figs. 23-25.

?1980 Polygnathus dubius HINDE - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 4, fig. 32.

Diagnosis: See Huddle 1970, p. 1037.

Remarks and comparisons: The problems surrounding the designation of Po. dubius have been thoroughly discussed by Huddle (1970), who also described the species. Of the specimens to hand, those shown on Plate 12, figs. 1-9, 14-16 appear to correspond most closely to Huddle's examples. In these Torquay individuals, a distinct rostrum is developed, behind which the platform is clearly asymmetrical, the outer platform being wider and more broadly rounded than the inner. The ornament is characteristic of the species, and is of nodes which may be transversely aligned, and sometimes partially fused, to produce nodose ridges. Adcarinal grooves are present, and are fairly shallow. In the example on Plate 12, figs. 4-6 the adcarinal grooves are exceptionally, and possibly atypically, wide. However, this specimen is very large compared both to the other Torquay forms and to Huddle's figured material, and it is thought that this could be a mature development. The moderately large example on Plate 12, figs. 1-3 is also rather unusual, in that the carina does not attain the posterior tip. Aborally, the basal cavity is always oval in outline. In large growth stages, it is fairly small and is located at the posterior end of the rostrum, whereas in smaller specimens (e.g. Pl. 12, figs. 8, 9, 14-16) the basal cavity is relatively larger, and may occupy the entire length of the lower surface of the rostrum.

Po. dubius has been compared with Po. ovatinodosus by Ziegler and Klapper (in Ziegler et al. 1976, p. 124). They noted that the free blade of the former is relatively shorter, occupying one-third of total unit length, and is relatively higher at the anterior end. In contrast, the free blade of the latter comprises about one-half of total unit length, and is more uniform in height. They also observed that the rostrum is obviously longer in Po. dubius, and that adcarinal grooves extended posteriorward of it. However, they included in synonymy with Po. ovatinodosus specimens in which the adcarinal grooves are rather well developed behind the rostrum. A similar development is exhibited by some individuals to hand referred to this species, and this aspect is discussed further under Po. ovatinodosus.

The present author considers that the overall platform outline, including the extent of formation of a rostrum, provides a useful criterion for differentiating between the last two taxa, especially when dealing with material in which the free blade is not intact. Typically, Po. ovatinodosus has a symmetrically oval platform with a very short rostrum, whereas the platform of Po. dubius is clearly asymmetrical and wider in the outer half, and the rostrum is obviously longer. These criteria may be difficult to apply to small growth stages. Huddle (1970, p. 1037) noted that a rostrum was not present in specimens of Po. dubius less than 0.4mm long, and perusal of his illustrations of this species indicates that platform asymmetry is not always distinct in small forms (e.g. Huddle 1970, pl. 138, fig. 11). Further, in examples of Po. ovatinodosus of a similar size (e.g. Ziegler and Klapper in Ziegler et al. 1976, pl. 2, fig. 1), the platform is not as clearly symmetrically oval as in larger growth stages. However, in small examples of Po. dubius from Torquay (e.g. Pl. 12, figs. 8, 9, 14-16), both the platform asymmetry and the rostrum tend to be rather more apparent than in small specimens referred to Po. ovatinodosus (e.g. Pl. 11, figs. 20, 27).

Several individuals to hand, shown on Plate 12, figs. 17-27, have a well developed, long rostrum, and the free blade, when intact, comprises about one-third of total unit length and is highest anteriorly. In these respects, the specimens are consistent with Po. dubius. However, they are only tentatively assigned to this species because of the configuration of the platform behind the rostrum, where it is more or less symmetrically oval in outline, is sometimes rather broad, and the adcarinal grooves may be very shallow. In these features, the examples approach Po. ovatinodosus. The specimens include several growth stages and, in the largest (Pl. 12, figs. 22, 23), the platform is conspicuously broad and flat. Individuals shown by Clark and Ethington (1967, pl. 7, figs. 5, 7: cited as Po. ordinata and Po. foliata respectively), and by Uyeno (1979, pl. 2, figs. 23-25: cited as Po. sp.), are similar to those to hand, and are only questionably included in synonymy with Po. dubius herein. Both the first-mentioned specimen figured by Clark and Ethington, and the one illustrated by Uyeno, exhibit rostral ridges, which features are not evident in the Torquay examples.

The specimens shown on Plate 12, figs. 10-13 seem to have a morphology intermediate between those referred to Po. dubius and those designated Po. aff. dubius. Their platforms are somewhat broader than those of the former, but are still asymmetrical, and lack the better developed oval outline of the latter. Kirchgasser (1970, pl. 65, figs. 1, 2) figured similar individuals from North Cornwall (designated Po. foliatus). Ziegler and Klapper (in Ziegler et al. 1976, p. 124) placed Kirchgasser's material in synonymy with Po. ovatinodosus, and themselves assigned to this species a specimen in which the rostrum is rather long, the platform is asymmetrical, and the free blade comprises between one-third and one-half of total unit length (Ziegler and Klapper op.cit., pl. 2, fig. 9). In these respects their individual conforms with Po. dubius, and, to some extent, resembles those from Torquay shown on Plate 12, figs. 10-13. It is preferred that, because of their well developed rostrum and asymmetrical platform, at least the latter specimens be referred to Po. dubius rather than to Po. ovatinodosus. However, both these examples, and those designated Po. aff. dubius, suggest that there may be morphological gradation between the two species.

Range and occurrence: The range of Po. dubius extends from the base of the Upper hermanni-cristatus Subzone, into the lower part of the Lower asymmetricus Zone (Klapper in Ziegler 1973, p. 354; Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. dubius occurs at Babbacombe Cliff (samples BC-1, 2, 5, 8, 9, 11, 32) and Barton Quarry (samples BQ-1, 4, 13, 14, 16, 20, 22, 26, 28, 30). Specimens designated Po. aff. dubius occur at the same two localities (samples BC-11, 13, 33, 34 and BQ-2, 4, 5, 7, 9, 10, 12, 15, 16, 18, 19, 20, 22, 23, 26, 27, 28, 29, 30, 31 respectively).

The Polygnathus linguiformis Group

Po. linguiformis was first described by Hinde (1879, p. 367). Various forms have subsequently been assigned, both as subspecies and morphotypes, to what has become the Po. linguiformis group.

Wittekindt (1965) established two subspecies, Po. l. mucronatus and Po. l. transversus. Compared with Po. l. linguiformis, which equated with Hinde's original concept, the first taxon was characterised by the absence of ridges on the strongly constricted tongue, the second by the form of the anterior platform, on which nodes were aligned to produce diagonal rostral ridges.

Po. l. foveolatus and *Po. l. dehiscens* were erected by Philip and Jackson (1967). The two taxa were distinguished from the nominate subspecies both by the oral and aboral configuration of the cross-section at platform mid-length, and by the form of the basal cavity aborally. Within their discussion of the first features, Philip and Jackson (1967, text-fig. 3c) depicted the characteristically deeply troughed outer platform of *Po. l. linguiformis*. Klapper (1969, p. 13-15) raised the two new subspecies to specific level, as *Po. dehiscens* and *Po. foveolatus*, because of the very different nature of their aboral morphology, in contrast with that of the nominate subspecies.

Bultynck (1970) established the alpha, beta and gamma morphotypes of *Po. l. linguiformis*, which were distinguished from each other largely by the breadth and degree of flatness of the posterior outer platform, and by the outline of the outer platform-tongue. Klapper (1971) described *Po. l. cooperi*, in which the outer margin of the platform-tongue is fairly regularly curved, the platform is relatively flat, and the transverse ridges on the tongue tend to be irregularly developed.

To some extent, Ziegler and Klapper (in Ziegler *et al*. 1976, p. 122-124) revised the nomenclature of the group. *Po. l. mucronatus* and *Po. l. transversus* were redefined as the zeta and eta morphotypes, respectively, of *Po. l. linguiformis*, because of their "relative rarity and sporadic vertical and geographic occurrence". The authors considered that the gamma morphotype of Bultynck (1970) was identical with Hinde's holotype of *Po. l. linguiformis*, recognised Bultynck's alpha morphotype, and also described two new taxa, the delta and epsilon morphotypes. It should be noted that the eta and delta morphotypes differ only in the development of rostral ridges in the former, and that the epsilon morphotype includes forms both with and without these features.

Ziegler and Klapper (in Ziegler *et al*. 1976, p. 122) regarded *Po*.

parawebbi CHATTERTON as a member of the Po. linguiformis group. However, they treated it as a subspecies of Po. linguiformis (Po. l. parawebbi) rather than as a morphotype of Po. l. linguiformis, because in North America it was "an abundant and vertically consistent element of late Eifelian and early Givetian faunas". Klapper (in Ziegler 1977, p. 477) subsequently returned the form to specific status. He observed that, while Po. parawebbi and Po. l. linguiformis gamma morphotype (Po. l. linguiformis herein) were similar with regard to their overall outline and to the deeply troughed outer platform, they differed in that the posterior part of the unit in the former lacked the strong development of transverse ridges seen in the latter, and bore instead a more or less complete carina. He also considered that the multielemental apparatuses of Po. parawebbi and Po. l. linguiformis, as reconstructed by Chatterton (1974, pl. 2, figs. 1-9) and by Klapper and Philip (1971, text-fig. 2) respectively, differed sufficiently with respect to the nature of the other elements present, especially with reference to O1, for Po. parawebbi to be more appropriately maintained at specific level. It is the present author's opinion that the last is not, at the moment, a valid criterion for separating this form from the Po. linguiformis group, because "apparatuses" are not well established, and a multielemental approach is not applicable everywhere. Further, the definition of the Po. linguiformis complex used herein (see below) contains those features which Klapper thought set Po. parawebbi apart from the group, as represented by Po. l. linguiformis. Consequently, it is considered that Po. parawebbi should be regarded as Po. l. parawebbi, consistent with the view of Ziegler and Klapper.

With regard to other members of the Po. linguiformis complex, Weddige (1977) described several forms from Germany, including Po. l. bultyncki and Po. l. pinguis (synonymous with Bultynck's alpha and beta morphotypes of Po. l. linguiformis respectively), and three new subspecies, Po. l. alveolus, Po. l. subsp. a and Po. l. subsp. b. Klapper (in Johnson et al. 1980, p. 102) reported two new taxa from the Antelope Range of central Nevada, which he designated as the theta and iota morphotypes of Po. l. linguiformis.

The various representatives of the Po. linguiformis group show a considerable range of morphological variation, wider than is encompassed by the original definition of Po. linguiformis given by Hinde (1879, p. 367: q. v.). The following definition is based on that presented by Orchard (1978, p. 944), and is preferred because it embraces all the subspecies and morphotypes assigned to the complex both then and now. The Po. linguiformis group comprises rather elongated polygnathids, in which the posterior part of the unit, or tongue (see Bultynck 1970, p. 126, footnote 1), is variably developed, but is always bent inwards and downwards, and bears transverse ridges and/or a carina. Aborally, a fairly small basal cavity is located at mid-length, or in the anterior half, of the platform (minus tongue).

Those members of the Po. linguiformis complex which are represented in the Torquay faunas all seem to have a distinct morphological and stratigraphical position. The subspecific designation is favoured where it is already established, being comparable in meaning to this taxonomic level elsewhere in the polygnathids, and also in other genera under consideration. The meaning of subspecies is also considered to carry more weight than that of morphotype, but it is acknowledged that this distinction is apparent rather than real, the difference between the two being artificial. The Torquay material is neither sufficiently abundant nor well enough preserved to create subspecies where these are not already recognised, in which case the morphotype designation is used.

With respect to the phylogeny of the group, Weddige (1977, text-fig. 4) envisaged that the Po. linguiformis lineage arose from the basic Po. dehiscens stock, by way of Po. perbonus (PHILIP) and Po. inversus KLAPPER AND JOHNSON. The last three species are consistent with the Po. linguiformis group in the outline and oral surface configuration of their platforms, as are such forms as Po. serotinus TELFORD and Po. foveolatus. However, these taxa are all readily distinguished from the complex in aboral view, by the very distinct morphology of their often much larger basal cavities. The Famennian species Po. semicostatus BRANSON AND MEHL also resembles some members of the Po. linguiformis group, but it, too, may be distinguished aborally, the basal cavity being just a small depressionin a thickened part of the keel. Further remarks concerning the complex are presented under the Po. c. costatus group.

Polygnathus linguiformis alveolus WEDDIGE

Plate 8, figs. 3, 4, 8; 2 (cf.).

*1977 Polygnathus linguiformis alveolus n. ssp. - WEDDIGE, p. 312-313, pl. 5, figs. 85-87 (fig. 85 = holotype).

Diagnosis: A subspecies of Po. linguiformis with an abruptly constricted, extremely short and narrow tongue, which bears either the small nodes of the posterior part of the carina, or a few very short transverse ridges. The platform bears an ornament of short, weak to slightly stronger ridges. These are arranged at right-angles or rather obliquely to the margins, and are separated from the carina by adcarinal grooves. The outer adcarinal groove is relatively deeper and wider than the inner, and the outer platform appears troughed, because the margin is upturned.

Description (Torway material): The platform is more or less rectangular in plan view, and is weakly arched in profile. The outer platform is broader and a little longer than the inner. Followed posteriorward from the anterior extremity, the former becomes slightly wider, and is then deflected inwards to the tongue, the border forming an approximate, broadly rounded right-angle. In contrast, the margin of the inner platform-tongue is more nearly straight throughout its entire length. The tongue itself is abruptly constricted, is conspicuously short and narrow, and bears one or two short transverse ridges. The inner platform is ornamented with a few weak nodes or short ridges, because of which it appears slightly thickened anteriorly. The outer margin bears longer ridges which are not strong, tend to be roughly parallel to each other, and are arranged either obliquely or normally to the margin, which may be weakly serrated. The ornament is separated from the carina by adcarinal grooves, of which the outer is deeper and wider than the inner. Both grooves deepen anteriorly, because the platform margins are upturned in that direction. The outer margin is upturned more strongly than the inner, and the outer half of the anterior platform appears rather trough-shaped in cross-section.

The free blade is never fully preserved and cannot be described. The fixed blade becomes gradually lower, in profile, behind the anterior platform border, and continues posteriorward as a low, fused carina. Because of the greater development of the outer platform, the carina lies increasingly closer to the margin of the inner platform (in plan view), and dies out at, or soon after, platform-tongue mid-length. The final nodes of the carina are sometimes fairly discrete. One or two short ridges tend to be developed in the central part of the platform behind the carina but before the tongue. The ridges are parallel to those of the tongue, and roughly normal to the course of the carina. Aborally, an elongated, oval-shaped and rather thick rimmed basal cavity is developed in the anterior half of the platform. In small growth stages the cavity is moderately large, and is located close to the anterior margin of the platform.

Remarks and comparisons: The specimens on Plate 8, fig. 2 and figs. 3, 4, 8 herein closely resemble one illustrated by Weddige (1977, pl. 5, fig. 86) with regard to their overall outline. The first of the individuals to hand is designated Po. cf. l. alveolus because of its incomplete nature. In the second, the outer platform is somewhat flatter posteriorly than in Weddige's example, and the carina is rather shorter. These differences are attributed to the former specimen representing an earlier growth stage than the latter. Because of the flatter platform, the second of the figured Torquay individuals approaches Po. l. cooperi. The last subspecies may be distinguished from all representatives of Po. l. alveolus by its more symmetrical platform-tongue, which is also more strongly deflected inward posteriorly. Also, the tongue of the former is broader and less constricted than that of the latter, and occupies more (about one-third) of total platform-tongue length.

An abruptly constricted tongue is developed in the younger forms Po. l. linguiformis iota morphotype and Po. l. mucronatus, but in both the tongue is relatively longer and better developed than in Po. l. alveolus. The first two taxa are more robust in overall morphology compared with the last, and their ornament is coarser, because of which their platform borders often appear strongly serrated. The platform margins of Po. l. mucronatus are upturned, as in Po. l. alveolus, whereas the platform of the iota morphotype is rather flat. Further, the basal cavity of the last form is somewhat larger in comparison with that of Po. l. alveolus, and also with that of other members of the Po. linguiformis group. With regard to the size of the basal cavity, the iota morphotype is atypical of the complex.

Po. l. alveolus resembles Po. l. linguiformis with respect to the deep, wide outer adcarinal groove. However, the outer platform tends to be rather less deeply troughed in the former than in the latter, because the outer platform margin of Po. l. alveolus is usually less strongly upturned compared with that of Po. l. linguiformis, and does not exhibit the flange-like development typical of the last subspecies. Also, the tongue of Po. l. linguiformis is broader, better developed, and more clearly deflected inwards than that of Po. l. alveolus, and is relatively longer, comprising one-third or more of total platform-tongue length.

Range and occurrence: In the Eifelian Hills of Germany, Po. l. alveolus ranges from the upper part of the c. costatus Zone into the lower part of the kockelianus Zone, and possibly into the higher part of the latter Zone (Weddige 1977, tables 2, 5).

In Torquay, Po. l. alveolus occurs at Long Quarry Point (samples LG-3, 12), while material designated Po. cf. l. alveolus occurs at Redgate Beach (sample RB-13).

Polygnathus linguiformis bultyncki WEDDIGE

Plate 8, fig. 6.

*1977 Polygnathus linguiformis bultyncki n. ssp. - WEDDIGE, p. 313-314, pl. 5, figs. 90-92 (fig. 91 = holotype) (see synonymy).

•1977 Polygnathus linguiformis linguiformis HINDE alpha morphotype BULTYNCK - KLAPPER in ZIEGLER, p. 462, 466, Polygnathus - pl. 9, figs. 6, 8a, 8b (originals of BULTYNCK 1970, pl. 9, figs. 2, 1b, 1a respectively) (see synonymy).

•1978 Polygnathus linguiformis bultyncki WEDDIGE - KLAPPER, ZIEGLER & MASHKOVA, pl. 1, figs. 21, 22, 26-29.

•1979 Polygnathus linguiformis bultyncki WEDDIGE - LANE, MÜLLER & ZIEGLER, p. 219, pl. 1, fig. 22.

•1979 Polygnathus linguiformis bultyncki WEDDIGE - LANE & ORMISTON, pl. 7, figs. 1, 2, 34, 38, 39, pl. 8, figs. 11, 12, 23, 24.

•1979 Polygnathus linguiformis linguiformis forma alpha BULTYNCK - CHATTERTON, p. 194, pl. 1, figs. 26-29.

Diagnosis: See Klapper in Ziegler 1977, p. 462; Weddige 1977, p. 313-314.

Remarks and comparisons: Po. l. bultyncki most closely resembles Po. l. pinguis. However, the tongue occupies a lesser proportion of total platform-tongue length in the latter, and the two subspecies may be further distinguished by the configuration of the outer half of the unit. In Po. l. pinguis there is a distinct lateral expansion, arcuate in outline, on the outer side of the platform-tongue junction, whereas Po. l. bultyncki lacks such a development.

The tongue is similar in both the last form and in Po. l. linguiformis, but the two taxa may be differentiated by the morphology of their platforms. In the former, the platform margins tend to be more nearly parallel than in the latter, and the outer platform is flatter posteriorly, lacking the deeply troughed cross-section and the strongly upturned, flange-like margin characteristic of Po. l. linguiformis.

A single specimen from Torquay, illustrated on Plate 8, fig. 6, is assigned to Po. l. bultyncki. The platform is broken anteriorly, but the tongue appears to occupy a proportion of the estimated total platform-tongue length consistent with the subspecies, as is the morphology of the outer half of the unit.

Range and occurrence: In the Eifelian Hills of Germany, Po. l. bultyncki ranges from the lower part of the serotinus Zone, through into the lower part of the c. costatus Zone (Weddige 1977, tables 2, 5). In the Barrandian area of Czechoslovakia, the subspecies has been recorded from the base of the serotinus Zone to the top of the c. costatus Zone; in New York, Nevada, and in the Northwest Territories of Canada, within the c. costatus Zone; and also in the serotinus Zone in Nevada (Klapper in Klapper and Ziegler 1979, text-figs. 2-4). At the Eau Noire section at Couvin in Belgium, the form (as Po. l. linguiformis alpha morphotype) was shown to range from within Co1b - Co1c into Co2bII (Bultynck in Bouckaert and Streel 1974, Excursion G, p. 5, 6).

In Torquay, Po. l. bultyncki occurs at Daddyhole Cove (sample DH-1).

Polygnathus *linguiformis* *linguiformis* HINDE

Plate 9, figs. 1-20, 23-25; 21,22(?); Plate 10, figs.1-22.

*1879 *Polygnathus* *linguiformis* n. sp. - HINDE, p. 367, pl. 17, fig. 15 (= holotype).

1959 *Polygnathus* *linguiformis* HINDE - HASS, pl. 50, fig. 11.

1963 *Polygnathus* *linguiformis* HINDE - SCHRIEL & STOPPEL, p. 87, pl. 3, fig. 11 (only).

v1965 *Polygnathus* *linguiformis* HINDE - ZIEGLER (a), pl. 1, figs. 7, 10 (only).

1967 *Polygnathus* *linguiformis* HINDE - CLARK & ETHINGTON, p. 62-63, pl. 7, fig. 10.

•1971 *Polygnathus* *linguiformis* HINDE - MIRAUTA, p. 24, pl. 4, fig. 11 (only).

1971 *Polygnathus* *linguiformis* *linguiformis* HINDE - SCHUMACHER (a), pl. 10, fig. 11.

•1975 *Polygnathus* *linguiformis* HINDE - GUPTA, p. 160, 162, pl. 1, figs. 1, 2.

•1976 *Polygnathus* *linguiformis* *linguiformis* HINDE - GARCIA - LOPEZ, p. 176, pl. 1, fig. 2.

•1976 *Polygnathus* *linguiformis* *linguiformis* HINDE - FORDHAM, pl. 5, figs. 19-22, 24, 25.

1977 *Polygnathus* *linguiformis* *linguiformis* HINDE gamma morphotype BULTYNCK - KLAPPER in ZIEGLER, p. 463-464, 466, *Polygnathus* - pl. 10, figs. 2a, 2b, pl. 11, figs. 4, 7 (only: originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl. 4, figs. 13, 9; KLAPPER & PHILIP 1971, text-fig. 2P; BULTYNCK 1970, pl. 11, fig. 2a respectively) (see synonymy).

•1977 *Polygnathus* *linguiformis* *linguiformis* HINDE - WEDDIGE, p. 315-316, pl. 5, figs. 80-82.

•1978 *Polygnathus* *linguiformis* *linguiformis* HINDE - ORCHARD, p. 948, pl. 110, figs. 18, 22, 24, 27, pl. 114, figs. 24, 27, 28, 31, 33-37.

•1978 *Polygnathus* *linguiformis* *linguiformis* HINDE gamma morphotype BULTYNCK - KLAPPER in JOHNSON & KLAPPER, pl. 1, fig. 12.

- .1979 Polygnathus linguiformis linguiformis HINDE gamma morphotype BULTYNCK - SAVAGE & AMUNDSON, pl. 1, figs. 25-29 (fig. 25-28 = transitional to epsilon morphotype?).
- .1979 Polygnathus linguiformis linguiformis HINDE, gamma morphotype - LANE, MÜLLER & ZIEGLER, p. 219, pl. 2, fig. 5.
- .1979 Polygnathus linguiformis linguiformis HINDE (= gamma morphotype BULTYNCK) - ORCHARD, pl. 1, fig. 27.
- .1979 Polygnathus linguiformis linguiformis forma gamma BULTYNCK - CHATTERTON, p. 194-195, pl. 1, figs. 16-22, pl. 9, figs. 17, 18.
- .1981 Polygnathus linguiformis linguiformis HINDE-SPARLING,text-fig.3A (only).
- .1981 Polygnathus linguiformis linguiformis HINDE, gamma morphotype - WANG & ZIEGLER, pl. 1, fig. 12, pl. 2, fig. 25.

Diagnosis: See Ziegler and Klapper in Ziegler, Klapper and Johnson (1976, p.122).

Description (Torquay material): The outer platform is trough-shaped in cross-section, because the outer platform margin is regularly upturned and flange-like, producing a deep adcarinal groove which extends from the anterior extremity of the platform to just before the tongue. The margin of the inner platform is a little shorter than the outer, and is upturned only anteriorly, where there is a moderately deep inner adcarinal groove. In the anterior part of the platform, the outer margin, inner margin and carina are developed at a similar height to each other, but the first feature is higher than the last two posteriorly, because the inner platform becomes flat in this direction, sometimes with a slight degree of lateral expansion. In plan view the inner platform-tongue border describes a smooth, fairly regular curve throughout its entire length. Traced behind the anterior end of the platform, the outer platform margin is often more or less straight until the inward flexure to the tongue, and is initially parallel to the inner border, but then tends to diverge from it, because the outer platform commonly becomes gradually wider until immediately before the tongue.

In all but very small growth stages, the tongue is flat and well developed, occupies one-third or more of total platform-tongue length, and is bent inwards and downwards to a variable but usually strong extent, while variably tapering to the rather pointed posterior tip. At the point of flexure, the outer platform-tongue border may be sharp and rather angular in outline, or may be more broadly rounded, and sometimes approaches a right-angle. The outer margin of the tongue itself is approximately straight, but may show a weak inward curvature, sometimes followed by a slight outward expansion, a little after the beginning of the tongue.

The outer platform bears an ornament of usually fine, often numerous ridges. These tend to be parallel to each other, and are arranged normally or somewhat more obliquely to the margin, to which they are restricted. The margin may sometimes be serrated, but generally only weakly so. The inner platform margin appears slightly thickened anteriorly, where a serrated marginal ridge is developed, parallel to the carina. The ridge dies out posteriorly, and thereafter very short transverse ridges or random nodes are present, where the inner platform is flat and slightly outwidened. Transverse ridges cross the entire width of the tongue, and may be continuous or interrupted, straight or, especially anteriorly, curved. A few rather short ridges may be present in the central part of the platform, at the platform-tongue junction. They may attain the inner margin but not the outer, are developed behind and roughly parallel to, or concentric with, the ridges of the tongue, and are more or less normal to the course of the carina. The carina either terminates before the central ridges, or may extend weakly into this area and, sometimes, into the anterior part of the tongue, but never reaches the posterior tip.

The free blade comprises about one-quarter of total unit length. The blade denticles, up to eight in number, are laterally compressed with pointed free tips, and appear to be highest a little before blade mid-length. The fixed blade-carina decreases evenly and slowly in height behind the anterior platform margin, its course being approximately parallel to the border of the inner platform. The carina consists of fused, somewhat elongated nodes, which may become rather more discrete and rounded (in oral view) posteriorly, as they become lower in this direction.

Aborally, the basal cavity is elongated and oval to slightly more triangular in outline. In large growth stages, the cavity is fairly small and is located at platform (minus tongue) mid-length, whereas the cavity of smaller examples is developed a little before this position, and is relatively larger. In all specimens, the keel extends posteriorly to the tip of the tongue, and is furrowed anteriorly along the lower edge of the free blade.

Remarks and comparisons: As defined by Weddige (1977, p. 315) and Orchard (1978, p. 948), Po. l. linguiformis is synonymous with the gamma morphotype of Bultynck (1970), and with Hinde's holotype of Po. linguiformis. Ziegler and Klapper (in Ziegler et al. 1976, p. 122) had previously stated that they considered the last forms to be identical, as noted in the introductory remarks to the Po. linguiformis group herein. Po. linguiformis is the most commonly illustrated member of the complex, and is distinguished from all other representatives by the high flange-like development of the outer platform margin.

Within the Torquay material, certain morphological differences are noted between stratigraphically older and younger specimens. Examples from late Eifelian and low Givetian levels, illustrated on Plate 9, figs. 16-18, 24, 25 may have more or less parallel platform margins, and/or the outer platform-tongue border may be sharply and rather abruptly deflected inwards. Orchard (1975a, p. 135) reported the last feature in material of a similar age from Plymouth, and Weddige (1977, pl. 5, figs. 81, 82) figured individuals from equivalent horizons in Germany, which closely resemble the available specimens shown on Plate 9, figs. 17, 18. Both of Weddige's examples, and the second of those to hand, share the development of a thickened outer platform margin. In contrast with the stratigraphically older material, younger specimens from middle-upper Givetian and possibly higher strata in Torquay are sometimes relatively less narrow and elongated in overall appearance, and their outer platform is usually distinctly expanded posteriorly, as a result of which the platform margins are rather less parallel. Further, the outer platform-tongue border is often rounded in the younger material, and may approximate to a right-angle in outline. A separation of the early variants from the later forms may prove to be feasible.

Representatives from all stratigraphic horizons in Torquay may exhibit a slight lateral expansion of the flat posterior section of the inner platform, where the oral surface ornament is of very short ridges or randomly distributed nodes. These features are all consistent with Po. l. linguiformis, although the expansion is never as pronounced in the examples to hand as in one of the specimens from Mount Wise in Plymouth, figured by Orchard (1978, pl. 114, fig. 34). Also, the nodes of the Torquay individuals generally appear to be less profuse than in the Mount Wise material.

Specimens recovered from Waldon Hill in Torquay show a considerable diversity of morphological expression within one fauna. For example, the ornament is noticeably coarse in the form on Plate 9, fig. 2, and the outer platform-tongue margin is strongly serrated at the point of flexure. Because of the features, the individual resembles Po. l. subsp.b. The specimen on Plate 9, fig. 1 exhibits a strong inward curvature of the outer border of the tongue, which results in the development of an apparent extension of the posterior part of the outer platform. The tongue of the example on Plate 9, fig. 6 is rather constricted and narrow, and approaches in morphology the tongue of some representatives of Po. l. mucronatus.

The individual on Plate 9, figs. 21, 22 is only questionably assigned to the nominate subspecies, being unusual in that both the incipient posterior carina, and the nodose ornament of the posterior inner platform, extend some distance onto the tongue. A few transverse and rather irregular ridges are developed only at the tip.

Remarks concerning juvenile examples of *Po. l. linguiformis* are made under the delta morphotype.

Range and occurrence: *Po. l. linguiformis* has a long age range, extending from as low as within the *c. costatus* Zone (in New York, Kentucky-Indiana, Nevada, and in the Eifelian Hills of Germany), to at least as high as the upper boundary of the Upper *hermanni-cristatus* Subzone (Klapper and Ziegler 1979, text-figs. 3-5). In Belgium, the nominate subspecies first appears in the upper part of Co2b in the Couvin area (in Bouckaert and Streel 1974: as *Po. l. linguiformis* gamma morphotype), which level Weddige (1977, table 4) correlated with the higher part of the *c. costatus* Zone. With regard to the upward extent of the age range in the last country, Bultynck (1975, text-figs. 3, 5) recorded *Po. l. linguiformis* in the Lower *asymmetricus* Zone at Sourd d'Ave and Doische-Wellin. In Torquay, the form is commonly encountered in faunas of late Eifelian to high Givetian, and possibly younger, age.

Polygnathus linguiformis linguiformis HINDE,
delta morphotype ZIEGLER & KLAPPER

Plate 8, figs. 9, 10, 12; 5 (cf.).

*1976 *Polygnathus linguiformis linguiformis* HINDE delta morphotype nov. - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 123, pl. 4, figs. 4-8 (see synonymy).

·1977 *Polygnathus linguiformis linguiformis* HINDE delta morphotype ZIEGLER & KLAPPER-KLAPPER in ZIEGLER, p. 464-465, 466, *Polygnathus* - pl. 10, figs. 1a, 1b, 3 (originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl. 4, figs. 7, 8, 6 respectively).

•1978 Polygnathus linguiformis HINDE, delta morphotype ZIEGLER & KLAPPER - ORCHARD, p. 944, pl. 110, figs. 21, 23 (only).

•1979 Polygnathus linguiformis linguiformis HINDE delta morphotype ZIEGLER & KLAPPER - SAVAGE & AMUNDSON, pl. 1, figs. 9-11.

•1979 Polygnathus linguiformis linguiformis HINDE, delta morphotype - LANE, MÜLLER & ZIEGLER, p. 219, pl. 2, fig. 16.

Diagnosis: A morphotype of Po. l. linguiformis, in which the platform is relatively flat, and the trace of the entire outer margin forms a regular and broadly rounded curve. Both the inner and outer platform margins bear normal to oblique ridges, which are separated from the carina by shallow adcarinal grooves. A tongue is either absent, or is only poorly developed. A few weak transverse ridges may be present on the oral surface of the posteriormost part of the unit, and/or the carina extends to the posterior tip.

Remarks and comparisons: In their original diagnosis, Ziegler and Klapper (in Ziegler et al. 1976, p. 123) observed that the delta morphotype lacked the development of a tongue. The present author considers that a tongue is in fact developed, albeit only incipiently, in those representatives of the morphotype which bear weak transverse ridges on the posterior tip of the unit, sometimes together with the posterior extension of the carina (e.g. Orchard 1978, pl. 110, figs. 21, 23; Savage and Amundson 1979, pl. 1, figs. 9, 10), and has amended the diagnosis to conform with this opinion. Orchard (1978, p. 944, pl. 110, figs. 9, 10, 28, 30) questionably referred to the delta morphotype large specimens which had well developed, conspicuous tongues. Similar individuals are not seen in the Torquay faunas, but mature growth stages of the delta form might well bear a distinct tongue, as he suggested.

The relatively flat platform of the delta morphotype, together with the absence of a high flange-like development of the outer platform margin, and of a corresponding deep outer adcarinal trough, easily distinguishes the form from the nominate subspecies. Further, the absence, or only poor development, of a tongue in the former taxon enables it to be readily differentiated both from the latter, and from all other members of the Po. linguiformis group. The older Po. l. cooperi resembles the delta morphotype with regard to its rather flattened platform and evenly curved outer border, but the tongue of the former is well developed, and comprises up to one-third of total platform-tongue length.

The epsilon morphotype has a well developed, clearly deflected tongue, together with platform margins which are more strongly upturned than in the delta form, especially anteriorly, and deeper adcarinal grooves. The lateral expansion of the posterior outer platform is rather more pronounced in the former, and the curvature of the entire outer border is stronger than in the latter, the flexure to the tongue approaching a right-angle in outline. The representative of the delta morphotype shown on Plate 8, figs. 9, 10, 12 herein exhibits tendencies towards the epsilon form. The outer margin is a little more bluntly rounded than is typical of the former taxon, and the rather coarse marginal ridges give the outer border the serrated aspect evident in some examples of the latter (e.g. Ziegler and Klapper in Ziegler et al. 1976, pl. 4, fig. 3). However, the individual is consistent with the delta morphotype in the flat platform, and in the configuration of the posterior part of the unit. The carina reaches the posterior extremity, where two short transverse ridges are developed, and an incipient tongue is formed. The ridges do not extend over the full width of the tongue.

The broken juvenile specimen on Plate 8, fig. 5 is only cautiously referred to the delta morphotype, resembling the nominate subspecies in several respects. In this example the outer platform is clearly better developed than the inner, which is the case even in juvenile representatives of the latter taxon, whereas the two halves of the unit are typically of more nearly equal development in the former. The carina attains the posterior tip of the unit, where the final carinal nodes are transversely enlarged, and there is a slight indication of a tongue. The posterior features are thus consistent with the delta morphotype, but the tongue is only incipiently developed also in juvenile growth stages of Po. l. linguiformis, in which the carina may reach the posterior extremity. However, the platform of the individual under consideration is fairly flat, whereas the outer platform is upturned even in small examples of the nominate subspecies, although the margin is less distinctly flange-like than in more mature forms. Also, the trace of the outer border of this specimen follows a more or less uniform curve, as in the delta morphotype. In contrast, the outer margin in juvenile and small growth phases of Po. l. linguiformis from Torquay (e.g. Pl. 9, figs. 14, 19, Pl. 10, figs. 15, 18, 19, 21, 22) is rather more abruptly curved inwards, and is closer to a right-angle in outline.

Range and occurrence: Po. l. linguiformis delta morphotype occurs in the lower half of the Middle varcus Subzone, and questionably extends downwards into the upper part of the Lower varcus Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. l. linguiformis delta morphotype occurs at Petit Tor Beach (sample PB-11), while Po. cf. l. linguiformis delta morphotype occurs at Lummaton Quarry (sample LM-13).

Polygnathus linguiformis linguiformis HINDE,
epsilon morphotype ZIEGLER & KLAPPER

Plate 8, figs. 11, 14-18, 20.

*1976 Polygnathus linguiformis linguiformis epsilon morphotype nov. - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 123-124, pl. 4, figs. 3, 12, 14, 24.

1977 Polygnathus linguiformis linguiformis epsilon morphotype ZIEGLER & KLAPPER - KLAPPER in ZIEGLER, p. 465, 466, Polygnathus - pl. 10, figs. 5, 9, 10 (originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976,pl.4,figs.3,24, 14 respectively) (see synonymy).

•1977 Polygnathus linguiformis linguiformis HINDE - SAVAGE, p. 1352, pl. 3, figs. 5-8 (only).

•1978 Polygnathus linguiformis linguiformis HINDE - UYENO, p. 17, pl. 4, figs. 50-52.

•1978 Polygnathus linguiformis HINDE, epsilon morphotype ZIEGLER & KLAPPER - ORCHARD, p. 946, pl. 110, figs. 14, 17, 20, 26, 29 (only) (see synonymy).

•1979 Polygnathus linguiformis linguiformis HINDE epsilon morphotype ZIEGLER & KLAPPER - SAVAGE & AMUNDSON, pl. 1, figs. 19-24.

Diagnosis: See Ziegler and Klapper in Ziegler, Klapper and Johnson 1976, p. 123-124.

Remarks and comparisons: The development of the tongue in the epsilon morphotype is comparable with that of the nominate subspecies, although the tongue of the former is sometimes relatively broader than that of the latter, tapering less sharply to a rather more blunt posterior tip. The adcarinal grooves tend to be deeper in Po. l. linguiformis, and the high flange-like outer platform margin characteristic of this form is not developed in the epsilon morphotype. Also, the outer border at the flexure to the tongue is often broadly rounded in the latter taxon, whereas the outline in the former may be more angular and sharper. Individuals which Savage and Amundson (1979, pl. 1, figs. 25-28) designated Po. l. linguiformis (as Po. l. linguiformis gamma morphotype) may, in fact, be transitional to the epsilon morphotype. They have the rather broader, less pointed tongue of the latter taxon, while the adcarinal grooves are deep anteriorly, as in the former. The outer platform margin is not as high and flange-like as in typical examples of Po. l. linguiformis, approaching instead the flatter and more rounded (in outline) development seen in the epsilon morphotype.

This morphotype displays a considerable range of morphological expression, as the material from Torquay illustrates. The individual on Plate 8, figs. 11, 16 closely resembles one figured by Ziegler and Klapper (in Ziegler et al. 1976, pl. 4, fig. 3), and has a serrated outline, particularly with regard to the outer platform margin, and a rather short tongue. The example on Plate 8, figs. 17, 20 also has a serrated outer platform border, together with more or less parallel platform margins, and a well developed tongue, which comprises roughly one-half of total platform-tongue length. This specimen is similar to one of the representatives of the epsilon morphotype from Mutton Cove in Plymouth, illustrated by Orchard (1978, pl. 110, fig. 17). He noted that the basal cavities in his Plymouth examples of this form were slightly larger than those of the nominate subspecies. This observation seems to be true with regard to the last-mentioned of the Torquay examples of the epsilon form, but not to others, in which the basal cavity is somewhat smaller. In Orchard's Mount Wise individuals, and especially in the comparable specimen to hand, the outer border is rather angular in outline at the flexure to the tongue. In contrast, the flexure is broadly rounded in the material figured by Ziegler and Klapper (in Ziegler et al. 1976, pl. 4, figs. 3, 12, 14, 24).

The largest of the Torquay representatives of the epsilon morphotype, shown on Plate 8, figs. 14, 15, 18, is poorly preserved, but a rostral ridge is apparent on the anterior inner platform, parallel to the carina (the anterior outer platform is broken). Rostral ridges were observed by Ziegler and Klapper (*op. cit.*, p. 124) in large growth stages of the morphotype. This particular specimen to hand resembles a large individual which they illustrated (Ziegler and Klapper *op.cit.*, pl. 4, fig. 24), although the latter example is somewhat larger, and has a more strongly deflected tongue, compared with the former.

As observed above, the outline of the epsilon morphotype may appear serrated, in which respect the form approaches *Po. l. mucronatus*. However, the serrations tend to be better developed in the latter, because the marginal ridges are coarser than in the former. In further comparison with the epsilon morphotype, *Po. l. mucronatus* has a more constricted and narrower tongue, before which the border of the posterior outer platform turns inward more sharply. Also, the latter taxon lacks the development of rostral ridges, which are seen in some mature representatives of the former.

The epsilon morphotype is discussed further under the delta morphotype, *Po. l.* subsp. a, and *Po. l.* subsp. b.

Range and occurrence: *Po. l. linguiformis* epsilon morphotype ranges from the upper part of the *ensensis* Zone into the lower part of the Upper *varcus* Subzone, and questionably through into the Lower *hermanni-cristatus* Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, *Po. l. linguiformis* epsilon morphotype occurs at Lummaton Quarry (samples LM-1,17) and Waldon Hill (Warren Road, sample WH-3).

Polygnathus linguiformis mucronatus WITTEKINDT

Plate 8, figs. 19, 21-30.

*1965 *Polygnathus linguiformis mucronata* n. subsp. - WITTEKINDT, p. 636, pl. 2, figs. 13-15 (fig. 15 = holotype).

non1971 *Polygnathus linguiformis mucronatus* WITTEKINDT *s. l.* - UYENO in NORRIS & UYENO, pl. 3, fig. 4 (= *Po. l. parawebbi*).

non1972 *Polygnathus linguiformis mucronatus* WITTEKINDT *s. l.* - UYENO in MCGREGOR & UYENO, pl. 5, figs. 22, 23 (= *Po. l. parawebbi*).

non1975 *Polygnathus linguiformis* cf. *mucronatus* WITTEKINDT - TELFORD, p. 48, 50, pl. 7, figs. 25, 26.

·1977 *Polygnathus linguiformis linguiformis* HINDE zeta morphotype ZIEGLER & KLAPPER - KLAPPER in ZIEGLER, p. 465, 466, *Polygnathus* - pl. 10, figs. 4, 8, 7 (originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl. 4, figs. 20, 21; WITTEKINDT 1965, pl. 2, fig. 15) (see synonymy).

·1978 *Polygnathus linguiformis linguiformis* HINDE zeta morphotype ZIEGLER & KLAPPER - KLAPPER in JOHNSON & KLAPPER, pl. 1, fig. 14.

·1978 *Polygnathus linguiformis mucronatus* WITTEKINDT - ORCHARD, p. 948, pl. 113, figs. 6, 7, 10-12, 14, 15, 17-20, 22, 24 (see synonymy).

Diagnosis (after Orchard 1978): A robust subspecies of *Po. linguiformis*, in which the platform margins bear short, coarse ridges and often appear serrated. The ornament is separated from the carina by narrow adcarinal grooves. The tongue is conspicuous, abruptly constricted and narrow, and is strongly reduced in juvenile growth stages. The oral surface of the tongue bears either the posterior part of the carina, or transverse ridges, or a combination of the two.

Description (Torquay material): The unit is thick and is strongly constricted posteriorly, where the tongue is narrow but conspicuous, and comprises a little less than one-third of total platform-tongue length in all but very small individuals. In the last, the tongue is much reduced. The constriction is more pronounced in the outer platform, which is wider and slightly longer than the inner. In plan view, the inner platform-tongue margin is more or less straight throughout its entire length. Followed behind the anterior end of the platform, the outer border is also roughly straight, until it is abruptly and rather sharply turned inwards to the tongue. The outer platform margin is either developed parallel to the inner, or may diverge slightly from the latter posteriorly, in those specimens in which the outer platform becomes a little broader in this direction. The platform margins are both upturned to more or less the same height, and bear perpendicular to a little more oblique, short, coarse ridges, because of which they usually appear distinctly serrated. The ornament is separated from the carina by rather narrow adcarinal grooves. The carina itself consists of fairly low, slightly elongated and partly fused, rounded nodes, and lies closer to the inner platform border, especially posteriorly, because of the greater development of the outer platform. The tongue is weakly to more strongly bent inwards and downwards, and may bear either just the posterior extension of the carina, or a combination of carina and short transverse ridges. In large specimens with a relatively broader tongue, the ridges become better developed, and the carina terminates before them.

The fixed blade rises evenly in height behind the carina to the free blade. The last comprises six or seven oval (in cross-section) denticles, is highest at mid-length, and occupies roughly one-third of total unit length. Aborally, the basal cavity is rather oval in outline, and has thickened rims. The cavity is of moderate size in large specimens, and is located in the anterior half of the platform. It is conspicuously larger in juvenile growth stages, and is developed relatively further forward, just behind the anterior end of the platform. A fairly sharp keel runs behind the basal cavity to the posterior tip, and a rather broad groove extends anteriorward, onto the lower edge of the free blade.

Remarks and comparisons: Ziegler and Klapper (in Ziegler et al. 1976, p. 124) amplified the original diagnosis of Po. l. mucronatus, given by Wittekindt (1965, p. 636). They considered that the form (their Po. l. linguiformis zeta morphotype) was characterised by a carina which extended to the posterior tip, and that there was a complete absence of any lateral development in the posterior part of the unit, comparable with the tongue of other members of the group. Orchard (1978, p. 948) revised the diagnosis to include the development of an abruptly constricted tongue, either with or without a carina. The diagnosis thus embraced those specimens he observed in his Mount Wise fauna, which otherwise resembled each other, and were consistent with Po. l. mucronatus, in their robust nature, oral surface ornament, and platform cross-section. Orchard thought that Ziegler and Klapper may have included only juvenile growth stages in their zeta morphotype, because he noted that the tongue became relatively broader in more mature individuals, although the posterior part of the unit was still strongly constricted. The Torquay representatives of Po. l. mucronatus display a range in variation of tongue development similar to that evident in Orchard's Plymouth material, and his broadened concept of the subspecies is followed herein.

In the available specimens the tongue is narrow, conspicuous, and abruptly and strongly constricted, although it comprises rather less of total platform-tongue length than in Orchard's examples, in which the tongue may be equal in length to the platform. With regard to the range of morphological expression shown by the posterior part of the unit in the Torquay individuals, the tongue of the specimen on Plate 8, figs. 24, 29, 30 bears only the carina, which attains the posterior tip. The example on Plate 8, figs. 19, 22, 23 has a tongue which bears a combination of carina and short transverse ridges, and closely resembles one form illustrated by Orchard (1978, pl. 113, figs. 10, 14). The individual on Plate 8, fig. 25

is somewhat larger than the first two of the representatives to hand, and has a relatively broader tongue, which bears interrupted transverse ridges. Orchard (1978, pl. 113, figs. 11, 20) figured a similar specimen, and the Torquay example supports ontogenetic trends which he reported (noted above).

The platform margins in the Torquay material are usually distinctly serrated, even in the juvenile growth stage on Plate 8, figs. 27, 28. In this specimen, the marginal ornament is of very short, coarse, node-like ridges. The carina consists of rather large nodes, and reaches the posterior tip, where the unit is constricted and the tongue incipiently developed. The example on Plate 8, figs 21, 26 is unusual in lacking a strongly serrated outline, and is similar to forms illustrated by Wittekindt (1965, pl. 2, fig. 14), and by Orchard (1978, pl. 113, figs. 19, 22). Short perpendicular marginal ridges are absent in the Torquay individual, the thickened platform borders having instead the appearance of two rather blunt, fairly smooth longitudinal ridges throughout most of their length, developed parallel to the equally ridge-like carina. The last feature attains the posterior tip of the tongue. A few rather weak serrations are developed in the posterior part of the outer platform margin, at the abrupt flexure to the tongue.

Po. l. mucronatus is readily distinguished from most other members of the *Po. linguiformis* group by its robust nature, typically distinctly serrated margins, and strongly constricted, well developed and conspicuous tongue. These features are all evident in the older iota morphotype, which taxon is easily differentiated from *Po. l. mucronatus* by the morphology of the platform. In the latter, the platform is rather elongated and the margins are clearly upturned, whereas the platform of the former is relatively broader and flatter. Also, the basal cavity of the iota morphotype is rather large, as is discussed under *Po. l. alveolus*. Further remarks concerning *Po. l. mucronatus* are made under the last subspecies, and under Po. l. linguiformis epsilon morphotype and Po. l. subsp. b.

Range and occurrence: Po. l. mucronatus ranges from the base of the Middle varcus Subzone, to within the Upper varcus Subzone (Klapper in Ziegler 1977, p. 466; Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. l. mucronatus occurs at Babbacombe Cliff (sample BC-22), Lummaton Quarry (sample LM-11), Waldon Hill (Warren Road, sample WH-2) and Madrepore Road (sample MR-1).

Polygnathus linguiformis subsp. a sensu WEDDIGE 1977

Plate 8, fig. 1.

•1977 Polygnathus linguiformis ssp. a - WEDDIGE, p. 316-317, pl. 5, fig. 83.

?1979 Polygnathus linguiformis ssp. a WEDDIGE - LANE, MÜLLER & ZIEGLER, p. 220, pl. 2, fig. 4.

Remarks and comparisons: This subspecies is characterised by the development of a broad tongue, which appears to occupy between one-third and one-half of total platform-tongue length, and bears distinct transverse ridges. The platform margins have an ornament of moderately strong, sometimes rather irregular ridges, which do not reach the carina. Adcarinal grooves are fairly deep anteriorly but are shallow posteriorly, in which direction the platform becomes noticeably flat. The carina terminates before the tongue, and is high.

Po. l. subsp. a is similar to the epsilon morphotype with regard to the morphology and ornament of the tongue. However, compared with the former taxon, the carina of the latter is lower posteriorly, the outer platform appears to be slightly wider at the point of flexure to the tongue, and the tongue itself is more strongly deflected. In Po. l. subsp. a, the inner platform-tongue margin is more nearly straight. Weddige (1977,

p. 317, text-fig. 4) suggested that the last subspecies may have been an earlier development of the phylogenetic lineage which produced the epsilon morphotype.

The older theta morphotype, which Klapper (in Johnson et al. 1980, p. 102) recorded from the c. costatus Zone, exhibits a superficial resemblance to Po. l. subsp. a. The two taxa are readily distinguished by the nature of the carina, which is again lower in the former, and extends relatively further posteriorward, onto the tongue. Also, the tongue appears to be rather less well differentiated from the platform in the theta morphotype than in Po. l. subsp. a.

The example to hand shown on Plate 8, fig. 1 is incomplete, but displays a strong similarity to the representative of Po. l. subsp. a from Germany illustrated by Weddige (1977, pl. 5, fig. 83). Lane et al. (1979, p. 220, pl. 2, fig. 4) assigned to the taxon a form which is rather more elongated and narrow in overall appearance, and has a relatively shorter tongue, compared with both the Torquay and German specimens. Because of these differences, the individual shown by Lane et al. is only questionably included in synonymy herein, but it should be noted that Weddige (1977, p. 317) referred to "aberrant forms" of Po. l. subsp. a which showed considerable variation with respect to platform width, and their specimen may be an example of such material.

Range and occurrence: In the Eifelian Hills of Germany, the age range of Po. l. subsp. a is short, the form being restricted to within the upper part of the ensensis Zone (Weddige 1977, tables 2, 5). In Perak, Malaya, Lane et al. (1979, p. 215, 216, text-fig. 2) recorded the subspecies in samples 1466, 1849 and 1850, which they correlated with the ensensis Zone.

In Torquay, Po. l. subsp. a occurs at Babbacombe Road (sample BR-9) and Redgate Beach (samples RB-12, 13, 14).

Polygnathus linguiformis subsp. b sensu WEDDIGE 1977

Plate 8, figs. 7, 13.

?1966 Polygnathus linguiformis HINDE - PHILIP, p. 158, pl. 1, figs. 12-14.

•1977 Polygnathus linguiformis ssp. b - WEDDIGE, p. 317, pl. 5, fig. 84.

•1978 Polygnathus linguiformis HINDE, ? epsilon morphotype ZIEGLER & KLAPPER - ORCHARD, p. 946, pl. 113, figs. 27, 29.

Diagnosis: A small subspecies of Po. linguiformis, in which the platform margins bear normal to oblique, short, coarse ridges, and appear serrated. The ornament is separated from the carina by relatively deep, wide adcarinal grooves. The outer groove is better developed than the inner, and the outer platform has a trough-shaped cross-section. The tongue comprises about one-quarter to one-third of total platform-tongue length, is clearly deflected inwards and downwards, and bears a few coarse transverse ridges orally.

Remarks and comparisons: The specimens from Plymouth illustrated by Orchard (loc. cit.) were small, and were identified as possible juvenile growth stages of the epsilon morphotype. The examples of Po. l. subsp. b from Germany, described and figured by Weddige (1977, p. 317, pl. 5, fig. 84), were small compared to Po. l. linguiformis, as he noted. He also observed that the basal cavities were large with respect to the overall size of the individuals, and suggested that they might be juvenile growth phases. The specimens from Torquay are of a similar size to those from Plymouth and Germany, but the basal cavities of the former (not illustrated) are not large relative to total platform-tongue size. This indicates that, rather than being juveniles of other forms, they represent mature growth stages of a small subspecies.

The available material comprises only incomplete specimens, but the tongue development is characteristic of the subspecies, as are the platform morphology, the short, coarse ridges of the marginal ornament, and the serrated platform margins. The outer platform is widest at the inward flexure to the tongue, at which point the serrations are best developed.

Individuals from the Moore Creek Limestone of New South Wales, shown by Philip (1966, pl. 1, figs. 12-14), are questionably referred to *Po*. *l*. subsp. b herein. They resemble the taxon in the nature and ornament of the platform, and in the serrated outline, but differ because the marginal ridges seem to be rather less coarse than is typical of the subspecies, and because they include specimens which are larger than the Torquay, Plymouth and German examples. Also, the tongue tends to be better developed in the Australian material, comprising relatively more (up to one-half) of total platform-tongue length, and the carina extends further posteriorward, at least to tongue mid-length. In *Po*. *l*. subsp. b, the carina usually terminates in the anterior half of the tongue.

Po. *l*. subsp. b resembles the nominate subspecies in the trough-shaped outer platform, but although the outer platform margin of the former is upturned, it lacks the flange-like development diagnostic of the latter. Mature specimens of *Po*. *l*. subsp. b are thought to be noticeably smaller than equivalent growth stages of *Po*. *l*. *linguiformis*, and also tend to have a relatively coarser ornament, and a more strongly serrated outline. The tongue of *Po*. *l*. subsp. b may occupy a little less of total platform-tongue length than in the nominate subspecies.

The stratigraphically younger *Po*. *l*. *mucronatus* shares with *Po*. *l*. subsp. b a serrated outline and upturned platform margins, but representatives of the former are larger and more robust overall compared with the latter. Further, the platform margins tend to be more nearly parallel in *Po*. *l*. *mucronatus*, the posterior outer platform usually showing a lesser degree of lateral expansion at the flexure to the tongue than in *Po*. *l*. subsp. b, and the tongue itself is much narrower and more conspicuously constricted. The very small example of *Po*. *l*. subsp. b illustrated by Orchard (1978, pl. 113, fig. 29: cited as *Po*. *l*. *linguiformis*, ?epsilon morphotype), approaches *Po*. *l*. *mucronatus* in its rather narrow and constricted tongue. However, in contrast with a somewhat larger but juvenile representative of the last subspecies also figured by Orchard (1978, pl. 113, figs. 6, 7), the former individual has a better developed tongue and ornament, a wider posterior outer platform, and a more distinctly serrated outline. These differences are true also with regard to early growth stages of *Po*. *l*. *mucronatus* to hand (*e*.*g*. Pl. 8, figs. 27, 28).

Weddige (1977, p. 317, text-fig. 4) considered there to be an affinity between *Po*. *l*. subsp. b and *Po*. *l*. *linguiformis* delta morphotype, and depicted the former giving rise to the latter. Compared with *Po*. *l*. subsp. b, the delta morphotype has a flatter platform, the outer platform margin follows a more smoothly rounded curve, and the tongue is either poorly developed or absent. Some specimens of the epsilon morphotype (*e*.*g*. Pl. 8, figs. 10, 11 herein; Ziegler and Klapper in Ziegler *et* *al*. 1976, pl. 4, fig. 3) have a serrated outline and a similar tongue development to *Po*. *l*. subsp. b, and this taxon may be better related to such representatives of the epsilon form, rather than to the delta morphotype.

Range and occurrence: In the Eifelian Hills of Germany, *Po*. *l*. subsp. b ranges from the base to the upper part of the *ensensis* Zone, and may extend sporadically into the Lower *varcus* Subzone (Weddige 1977, tables 2, 5). The Plymouth material appears to be of a similar age, and was found at Cattedown Quarry (sample CQ10), Gasworks Quarry (sample GQ20), and Princerock Quarry (sample PS3): all Fauna 6, within the (then) *obliquimarginatus* Zone (Orchard 1978, p. 913-914, text-fig. 2, table 1: specimens designated *Po*. *l*. *linguiformis*, ?epsilon morphotype). The form was recorded again in Fauna 5 (Princerock Quarry, sample PS02), which

Orchard thought to be possibly a little older, and at least in part in the (then) kockelianus Zone. The individuals from the Moore Creek Limestone of Australia, questionably assigned to Po. l. subsp. b herein, were also of (then) kockeliana Zone age (Philip 1966, p. 152). Both the Australian and the oldest of the Plymouth examples therefore appear to be older than Weddige's German material.

In Torquay, Po. l. subsp. b occurs at Babbacombe Road (sample BR-9) and Redgate Beach (samples RB-4, 10).

Polygnathus ordinatus BRYANT

Plate 14, figs. 12, 18, 21, 27 (aff.).

*1921 Polygnathus ordinatus spec. nov. - BRYANT, p. 24, pl. 10, fig. 10 (= lectotype, designated by HUDDLE 1970, p. 1039; non fig. 11 = Po. pennatus).

1957 Polygnathus ordinata BRYANT - BISCHOFF & ZIEGLER, p. 94, pl. 18, figs. 25, 26, 27, 31 (non fig. 28 = Po. limitaris; non figs. 29, 30 = ?).

1965 Polygnathus ordinata BRYANT - ZIEGLER (b), p. 670, pl. 4, figs. 7, 8, 12, 13.

1967 Polygnathus ordinata BRYANT - WIRTH, p. 231, pl. 21, fig. 27.

·1967 Polygnathus ordinata BRYANT - CLARK & ETHINGTON, p. 63, pl. 7, fig. 13 (non fig. 5 = Po. dubius?)

·1970 Polygnathus ordinatus BRYANT - HUDDLE, p. 1039, pl. 138, figs. 18 - 21.

·1970 Polygnathus ordinata BRYANT - SEDDON (b), p. 60-61, pl. 15, fig. 4.

?1971 Polygnathus ordinatus BRYANT - SCHUMACHER (a), pl. 10, figs. 9, 14.

Diagnosis: See Huddle 1970, p. 1039; Seddon 1970 (b), p. 60.

Remarks and comparisons: Ziegler and Klapper (in Ziegler et al. 1976, p. 122) thought that Po. ordinatus was closely related to their Po. limitaris. They considered that the two could be distinguished by platform width, the platform of the former being relatively narrower than that of the latter, and by the arrangement of the ornament, which is strongly nodose in both taxa. In Po. limitaris, the nodes are often randomly distributed over the oral surface of the platform, but there may sometimes be a weak degree of longitudinal alignment of the nodes closest to the carina, which produces roughly two, rather impersistent rows. In contrast, the nodes of Po. ordinatus are characteristically aligned into at least four longitudinal rows, parallel to the carina. Often, the nodes exhibit either partial or complete coalescence along the length of the platform, especially in the anterior part, and the rows become ridge-like.

Rather robust anterior platform fragments from Babbacombe Cliff, illustrated on Plate 14, figs. 12, 18, 21, 27 closely resemble specimens from the Milwaukee Formation of Wisconsin, which Schumacher (1971a, pl. 10, figs. 9, 14) referred to *Po. ordinatus*. In their rather narrow platforms all these individuals lie closer to this taxon than to *Po. limitaris*, but their ornament, which is of stout, rounded nodes, appears to be somewhat coarser and less well aligned than is typical of the former. To some extent, the alignment of the nodes is masked by their tendency to fuse both transversely and obliquely and, in fact, four or more longitudinal rows do appear to be present. However, the nodes do not coalesce along the length of the platform, as a result of which there is an absence of the longitudinal ridges often seen in *Po. ordinatus*. Because of the apparent discrepancies between this species and the Torquay and North American specimens, it is thought that none of the last two may be unambiguously assigned to the taxon.

The material to hand is inconsistent with *Po. ordinatus* also in aboral view, in which aspect Schumacher did not illustrate his examples. In the Torquay specimens, the lips of the basal cavity are rather thickened and broadly flared, to produce a wide, shallow, subcircular structure. This is located close to the anterior margin of the platform, where it occupies roughly one-third of platform width. In comparison, the basal cavity of representatives of *Po. ordinatus* in the literature (*e.g.* Ziegler 1965b, pl. 4, figs. 7, 12) is situated about halfway between the anterior end and mid-length of the platform, and is much narrower and rather oval in outline. Ziegler (1965b, pl. 2, figs. 26-29) illustrated rather unusual examples of *Sch. pietzneri*, which are similar to the individuals to hand with regard to their thick platforms, coarse, fused ornament, and large, flat, wide basal cavities. However, the cavities are asymmetrical in outline in the former, and are located relatively further posteriorward than in the latter.

Ziegler (1965b, pl. 4, figs. 19-21) figured also a representative of Po. cristatus in which the basal cavity is rather large and approaches that of the Torquay material, although the cavity is again developed further posteriorward than in the latter. The specimens to hand, and rather more typical examples of Po. ordinatus in the literature, resemble the last species in the coarse, rounded nodes of their ornament. However, the longitudinal ridges sometimes displayed by Po. ordinatus are not developed in Po. cristatus, and the two taxa may be distinguished also by their platform outline. All representatives of the former have a fairly narrow, lanceolate platform, whereas the platform of the latter is rather wider and more nearly circular in plan view.

Range and occurrence: Po. ordinatus ranges from within the Lower hermanni - cristatus Subzone, into the Lower asymmetricus Zone (Ziegler in Klapper and Ziegler 1979, text-fig. 5). The species had previously been shown to extend from the base of the former division, to somewhat higher within the latter (Ziegler 1971, chart 3).

In Torquay, Po. aff. ordinatus occurs at Babbacombe Cliff (samples BC-11, 33).

Polygnathus ovatinodosus ZIEGLER & KLAPPER

Plate 11, figs. 3-6, 8-27, 29-33; 1, 2, 7, 28(?).

?1964 Polygnathus decorosa STAUFFER - ORR, p. 14, 16, pl. 1, fig. 4, pl. 3, fig. 2 (only).

·1968 Polygnathus n. sp. B - POLLOCK, p. 437-438, pl. 62, fig. 34.

?1970 Polygnathus xylus STAUFFER - SEDDON (a), p. 740, pl. 12, figs. 20,21 (only).

*1976 Polygnathus ovatinodosus n. sp. - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 124-125, pl. 2, figs. 1-9 (figs. 5, 6 = holotype) (see synonymy).

•1976 Polygnathus webbi STAUFFER - GARCIA - LOPEZ, p. 177, pl. 1, fig. 5.

1977 Polygnathus ovatinodosus ZIEGLER & KLAPPER - KLAPPER in ZIEGLER, p. 473-475, Polygnathus - pl. 7, figs. 1, 4a, 4b (originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl.2, figs.4,5,6 respectively) (see synonymy).

?1978 Polygnathus decorosus STAUFFER s. l. - UYENO, p. 15, pl. 4, figs. 15-17 (only).

Diagnosis: See Ziegler and Klapper in Ziegler, Klapper and Johnson 1976, p. 124.

Description (Torquay material): In plan view, the platform is a rather elongated, more or less symmetrical oval. The greatest width is developed at platform mid-length, and the length axis of the entire unit is weakly incurved. Anteriorly, a short rostrum is usually formed, behind which the adcarinal grooves may or may not persist. The oral surface of the platform is covered by nodes, which may become transversely aligned to produce nodose ridges, at least in the anterior and middle parts of the platform. An ornament of rather more distinct ridges is sometimes developed. The nodes of the carina are larger than those of the rest of the platform, and achieve their greatest size at platform mid-length, where they are fused. Posteriorly, the carinal nodes either remain fused or become slightly separated, and decrease evenly in size towards the pointed platform tip, which the carina attains. The fixed blade rises only slowly in height anteriorward to the free blade, the latter comprising between two-fifths and one-half of total unit length. The upper edge of the free blade is never fully preserved, but the blade denticles appear to be fairly even in height in lateral view (although not conspicuously high), and are either erect or, sometimes, posteriorly inclined. Again in profile, the platform is often gently arched, and its upper surface rather flat.

Aborally, the basal cavity is fairly small and shallow in large specimens, and is located a little behind the rostral area. In smaller examples the cavity is deeper, and is located closer to the anterior end of the platform. A keel attains the posterior platform tip, and is furrowed anteriorly beneath the free blade.

Remarks and comparisons: Several of the specimens from Torquay, such as those shown on Plate 11, figs. 3-6, 8-12, compare closely with the type material illustrated by Ziegler and Klapper (in Ziegler et al. 1976, pl. 2, figs. 1-9). The individual on Plate 11, figs. 1, 2, 7 has the flat, oval platform and nodose ornament characteristic of Po. ovatinodosus, but is only questionably referred to the species because it has no rostrum. In their original diagnosis, Ziegler and Klapper (op. cit., p. 124) observed that a "remarkably short rostrum" is commonly present, but none of their figured examples is without this feature.

The specimens to hand include rather narrow forms, as figured on Plate 11, figs. 13-33. Compared both to the other Torquay examples, and to the type material, the adcarinal grooves of the more slender individuals often extend clearly posteriorward of the rostrum. Ziegler and Klapper (loc. cit.) indicated that the adcarinal grooves of Po. ovatinodosus were restricted to the rostral area, but they included in synonymy specimens figured by Kirchgasser (1970, pl. 64, figs. 4, 5: cited as Po. decorosus s. l.), in which these features are rather well developed behind the rostrum. Kirchgasser's individuals, from the Longcarrow Cove Tuffs and Slates, closely resemble the rather narrow examples to hand, and therefore it is thought that the latter lie within the range of intraspecific variation of Po. ovatinodosus. One slender form, on Plate 11, fig. 28, lacks a rostrum, and is assigned to the species with some doubt.

As described above, the ornament in all the Torquay material exhibits several morphologies, and varies from discrete nodes and nodose ridges, to rather more distinct ridges. The last variation seems to attain its strongest development in the narrower individuals. In comparison, although the nodose ornament of the type specimens shows some degree of transverse and oblique alignment into nodose ridges, ridges as pronounced as in, for example, the individuals on Plate 11, figs. 13-16, 21-23 herein are not developed. With regard to their ornament, the last Torquay examples approach *Po. webbi* and *Po. pennatus*, but the symmetrical, oval platforms both of these specimens, and of representatives of *Po. ovatinodosus* with a rather broader outline and/or a more typical ornament, are readily differentiated from those of the last two species. The platform of *Po. webbi* is clearly asymmetrical in plan view, the length axis is more strongly incurved, especially posteriorly, and the greatest platform width is located relatively further posteriorward. The platform of *Po. pennatus* tends to be symmetrical, but it is lanceolate in outline, and has a blunt, distinctive anterior end. The last feature is produced by the anterior platform margins turning abruptly inwards at about ninety degrees, and meeting the free blade at a similar angle. In *Po. ovatinodosus*, the anterior platform tapers evenly toward the free blade, which is relatively longer than in either *Po. pennatus* or *Po. webbi*. Garcia - Lopez (1976, p. 177, pl. 1, fig. 5) referred material from northern Spain to the last species. However, her illustrated example is similar to the narrow Torquay representatives of *Po. ovatinodosus*, and it is preferred that it be placed in synonymy with the last taxon.

Further remarks concerning *Po. ovatinodosus* are made under *Po. dubius*. As discussed thereunder, there is some evidence of gradation between the two species. This is further indicated in a specimen shown by Uyeno (1978, pl. 4, figs. 15-17: cited as *Po. decorosus s. l.*), questionably included in synonymy herein.

Range and occurrence: *Po. ovatinodosus* ranges from the upper part of the

Middle varcus Subzone, through to the Lower asymmetricus Zone, according to Klapper (in Ziegler 1977, p. 474). Ziegler (in Klapper and Ziegler 1979, text-fig. 5) showed the species attaining only the upper boundary of the Lowermost asymmetricus Zone.

In Torquay, Po. ovatinodosus occurs at Babbacombe Cliff (samples BC-1, 2, 5, 8, 9, 11, 32, 33; Po. ovatinodosus (?) occurs also in BC-9, 11) and at Barton Quarry (samples BQ-1, 7, 10-13, 18-20, 22, 23, 26-30).

Polygnathus aff. ovatinodosus ZIEGLER & KLAPPER

Plate 5, figs. 10, 15-17.

Description (Torquay material): The specimens are found only as broken platforms, none with the free blade intact. The platform is moderately broad and roughly oval in outline, and is widest a little behind its mid-length. The outer platform is slightly wider than the inner. Posteriorward of the broadest part, the platform tapers smoothly towards, sometimes with a slight constriction before, the pointed posterior tip. Anteriorly, the platform margins are upturned to produce short, fairly deep, smooth adcarinal troughs, and are constricted at a point about two-thirds of total platform length from the posterior tip. The constriction is stronger in the outer platform than in the inner, the latter being either less constricted or not at all. The outer anterior trough margin is distinctly bowed outwards before the constriction, and the margin of the inner anterior groove shows a similar or somewhat lesser degree of bowing, but neither trough is as strongly expanded laterally as is the posterior platform. The anterior trough margins meet the free blade opposite each other. The oral surface of the platform is covered by rounded nodes. These tend to be smallest and randomly distributed posteriorly, but become a little larger in the broadest part of the platform, where they may be aligned into nodose ridges, arranged radially to the carina. The last feature comprises fused but rounded (in plan view) nodes, which are largest around platform mid-length, and become gradually smaller towards the posterior tip, which the carina attains. The nature of the free blade is not known.

In lateral view, the platform is gently arched. Aborally, the basal cavity is small and is located in the area of the anterior platform constriction. The keel extends posteriorward to the tip, and is furrowed anteriorly.

Remarks and comparisons: The Torquay specimens resemble Po. ovatinodosus in the more or less symmetrical, oval-shaped platform, the oral surface ornamentation, and the short anterior troughs. However, they are only tentatively referred to the species because of the otherwise atypical configuration of the anterior platform where, as described above, there is a constriction, before which the anterior trough margins are bowed outwards, both features being best developed in the outer half of the platform. With regard to the anterior developments, the individuals, designated Po. aff. ovatinodosus, approach representatives of Po. ansatus. However, the platforms are relatively broader, more nearly symmetrical, and flatter in the former, the last difference resulting from the adcarinal grooves being better developed and deeper posteriorly in the latter. Also, the platform is more heavily ornamented with nodes in the Torquay material than is characteristic of Po. ansatus.

Ziegler and Klapper (in Ziegler et al. 1976, p. 124) described forms which exhibited a moderate outward bowing of the outer anterior trough margin, but which were otherwise typical of Po. ovatinodosus. They suggested a derivation of Po. ovatinodosus from Po. ansatus, and illustrated a specimen which they thought to be transitional from the latter species to the former (Ziegler and Klapper op.cit., pl. 2, fig. 10). The Torquay material may represent stages within such an evolutionary trend, but it should be noted that Ziegler and Klapper's example appears to lie closer to Po. ansatus than do those to hand.

Range and occurrence: Ziegler and Klapper (op. cit., table 13) recorded specimens intermediate between *Po*. *ansatus* and *Po*. *ovatinodosus* in samples 16 and 16b at Koppen in the Rhenish Slate Mountains. Ziegler (in Klapper and Ziegler 1979, text - fig. 5) showed the occurrence of such transitional forms to be in the lowest part of the Upper *varcus* Subzone, possibly extending lower into the highest part of the Middle *varcus* Subzone. As depicted by him, the beginning of this range is more or less coincident with the last appearance of *Po*. *ansatus*, but is a little higher than the entry of *Po*. *ovatinodosus*, the last species ranging upwards from lower within the Middle *varcus* Subzone. In Torquay, *Po*. aff. *ovatinodosus* occurs at Waldon Hill (Warren Road, sample WH-3) and Lummaton Quarry (sample LM-17).

The *Polygnathus* *varcus* Group

A revision of the group was undertaken by Klapper *et* *al*. (1970), who studied both the type material of Stauffer (1940), and comparative specimens from Germany, North America and Australia. Their concept of the group embraced Stauffer's *Po*. *varcus* and *Po*. *xylus*, together with two new species, *Po*. *rhenanus* and *Po*. *timorensis*. Ziegler and Klapper (in Ziegler *et* *al*. 1976, p.125). subsequently thought *Po*. *rhenanus* to be a junior synonym of *Po*. *timorensis*, because they believed that the former had been based on juvenile growth phases of the latter. They also established *Po*. *ansatus* which, because of its similarity to *Po*. *timorensis*, is included in the *Po*. *varcus* group herein.

Members of the group all have an elongated, often narrow and more or less parallel sided platform. The platform margins are either smooth, or bear subdued nodes, or may become more strongly ornamented. Deep adcarinal grooves are developed throughout the length of the platform, and are deepest anteriorly. The free blade is long, representing at least one-half of total unit length, and appears subquadrate in lateral view.

The above description is based on that given by Klapper *et* *al*. (1970,

p. 651), who stated that important features for specific differentiation within the group were the size of the platform relative to the entire unit, the morphology of the anterior platform, the nature of the oral surface ornamentation and, aborally, the position of the basal cavity. These criteria are thought to be valid but, when applied, should be considered in relation to the growth stage of the specimen. In juvenile representatives of the _Po_. _varcus_ group from Torquay, the free blade tends to be relatively longer than in more mature individuals, and the basal cavity is located further anteriorward, often at the free blade-platform junction. With growth, the platform becomes both broader and longer, usually with a corresponding reduction in free blade length, and the ornament may become better developed. In juvenile and small examples the platform margins are either smooth, or are only weakly nodose.

Orchard (1978, p. 950) observed similar ontogenetic trends in his Plymouth collections. He noted that there was considerable variation in the development of the anterior trough margins even in otherwise similar specimens, which is the case also in the material available, and thought that the form of the anterior platform was not a particularly useful character for specific differentiation within the _Po_. _varcus_ complex. The relative positions of the geniculation points have been used for taxonomic distinction within the group but, again, these are variable features in both the Torquay and Plymouth individuals, so would also seem to be inappropriate as diagnostic characters if applied too rigidly.

Because of the range of morphological variation evident within the _Po_. _varcus_ group, and because features important for distinction are not well developed in juvenile representatives, it is often difficult to assign such specimens to any one taxon. In the faunas from Torquay, some juvenile growth phases are just questionably assigned to a species, whilst others are identified only in terms of the wider concept of the group itself (_e.g_. pl. 5, figs. 21, 22, 24-29).

Polygnathus ansatus ZIEGLER & KLAPPER

Plate 7, figs. 1-16, 19, 21, 23; 17, 18, 20, 22, 24 (?).

•1957 Polygnathus varca STAUFFER - BISCHOFF & ZIEGLER, p. 98-99, pl. 18, fig. 34 (only).

•1970 Polygnathus cf. decorosa - MATTHEWS, pl. 1, fig. 10.

•1971 Polygnathus varcus STAUFFER - ORR, p. 53-54, pl. 5, figs. 4-8.

*1976 Polygnathus ansatus n. sp. - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 119-120, pl. 2, figs. 11-26 (figs. 19, 20 = holotype).

•1977 Polygnathus ansatus ZIEGLER & KLAPPER - KLAPPER in ZIEGLER, p. 443-445, Polygnathus - pl. 7, figs. 6a, 6b, 7a, 7b, 8 (originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl. 2, figs. 19, 20, 22, 23, 17 respectively) (see synonymy).

•1978 Polygnathus ansatus ZIEGLER & KLAPPER - ORCHARD, p. 938, pl. 112, figs. 1, 3, 5, 6, 8-12, 16, 19-24, 26, 27, 29-31, 33, 34, 36-38;? 2, 4, 7.

•1978 Polygnathus timorensis KLAPPER, PHILIP & JACKSON - ORCHARD, p. 949, pl. 108, figs. 11, 15, 39, 42, 43 (only).

Diagnosis: A species of Polygnathus with an elongated, variably asymmetrical platform, which is about twice as long as wide. The margins may be smooth, weakly nodose or bear strong ridges. The outer margin is clearly constricted at the geniculation point, while the inner margin displays either a lesser constriction, or is more or less straight. The anterior trough margins are bowed, the outer usually more strongly than the inner. They may meet the free blade at the same position, and the geniculation points may be opposed, but both characters are variable. The free blade comprises one-half or more of total unit length. Aborally, the basal cavity is developed close to, or at, the anterior end of the platform.

Remarks and comparisons: The diagnosis is modified after Ziegler and Klapper (in Ziegler _et_ _al_. 1976, p. 120) who noted that _Po_. _ansatus_ and _Po_. _timorensis_ closely resembled each other in the outward bowing of the outer anterior trough margin. The two species were differentiated also by their platform proportions, the former having a relatively broader platform (including the anterior developments) than the latter. The platform of the holotype of _Po_. _ansatus_ (Ziegler and Klapper _op_._cit_., pl. 2, figs. 19, 20) is a little more than twice as long as broad. The platforms in the other type specimens may be slightly wider or narrower than this, but they are never as narrow as in _Po_. _timorensis_, in which the platform is at least three times as long as broad. With regard to their platform proportions, the Torquay examples of _Po_. _ansatus_ all fall within the range of variation evident in the type material, as do other individuals included in synonymy with the taxon herein.

Adcarinal grooves are always well developed in the specimens to hand, and there is considerable variation in the platform ornament. The platform margins may be smooth (_e_._g_. Pl. 7, figs. 7, 16) or weakly to more strongly nodose (_e_._g_. Pl. 7, figs. 21, 1 respectively), but the strong ridges mentioned in the original diagnosis are seen neither in these examples, nor in those from Plymouth figured by Orchard (1978). The anterior trough margins are variable in their development relative to each other in the Torquay forms, although the outer anterior trough margin is always bowed outwards more than the inner, usually strongly so. They meet the free blade either opposite each other, consistent with the original diagnosis (_e_._g_. Pl. 7, figs. 1,21), or at slightly different positions (_e_._g_. Pl. 7, figs. 4, 7, 13). The geniculation points may or may not be opposed (compare, for example, Pl. 7, fig. 1 with Pl. 7, fig. 4).

As Ziegler and Klapper (in Ziegler _et_ _al_. 1976, p. 120) indicated, juvenile growth stages of _Po_. _ansatus_ and _Po_. _timorensis_ are not easily distinguished from each other. The juvenile specimens on Plate 7, figs. 17, 18, 20, 22, 24 herein are questionably assigned to the former species on the basis of their platform proportions. In these particular individuals the basal cavity is located at the free blade - platform junction, and the free blade comprises up to two-thirds of total unit length, whereas the basal cavity is developed a little further posteriorward in more mature forms, and the free blade occupies about three-fifths of total unit length.

Range and occurrence: *Po. ansatus* ranges throughout the Middle *varcus* Subzone, and may questionably extend into the Upper *varcus* Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, *Po. ansatus* occurs at Babbacombe Cliff (sample BC-22), Lummaton Quarry (samples LM-11, 15, 16, 18; juvenile specimens questionably referred to the species occur also in LM-15), and Madrepore Road (sample MR-1).

Polygnathus timorensis KLAPPER, PHILIP & JACKSON

Plate 6, figs. 1-23, 31.

*1970 *Polygnathus timorensis* n. sp. - KLAPPER, PHILIP & JACKSON, p. 655-656, pl. 1, figs. 1-3, 7-10 (figs. 7-10 = holotype) (see synonymy).

1970 *Polygnathus rhenanus* n. sp. - KLAPPER, PHILIP & JACKSON, p. 654-655, pl. 2, figs. 13-15, 19-22.

1970 *Polygnathus varca* - MATTHEWS, pl. 1, figs. 7-9.

1970 *Polygnathus varcus* STAUFFER - KIRCHGASSER, p. 351-352, pl. 66, figs. 9-11.

1973 *Polygnathus timorensis* KLAPPER, PHILIP & JACKSON - KLAPPER in ZIEGLER, p. 385-386, *Polygnathus* - pl. 2, fig. 3 (original of KLAPPER, PHILIP & JACKSON 1970, pl. 1, fig. 8) (see synonymy).

·1975 *Polygnathus rhenanus* KLAPPER, PHILIP & JACKSON - BULTYNCK, p. 23, pl. 5, fig. 1.

·1976 *Polygnathus timorensis* KLAPPER, PHILIP & JACKSON - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 125, pl. 2, figs. 27-32, pl. 3, fig. 10.

·1978 *Polygnathus timorensis* KLAPPER, PHILIP & JACKSON - ORCHARD, p. 949, pl. 108, figs. 12, 16-18, pl. 112, figs. 13-15, 17, 18, 25, 28, 32, 35 (non pl. 108, figs. 11, 15, 39, 42, 43 = *Po. ansatus*).

·1979 Polygnathus timorensis KLAPPER, PHILIP & JACKSON - LANE, MÜLLER & ZIEGLER, p. 220, pl. 2, figs. 1-3, 8, 21.

·1980 Polygnathus timorensis KLAPPER, PHILIP & JACKSON - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, fig. 38.

Diagnosis: An elongated, slender species of Polygnathus, in which the platform is at least three times as long as wide. The outer margin is weakly to more strongly constricted at the geniculation point, and the platform outline varies from roughly symmetrical to asymmetrical, depending on the degree of outward bowing of the outer anterior trough margin in front of the constriction. The inner platform margin is more or less straight throughout. Behind the geniculation points, which may or may not be opposed, the platform margins are smooth or weakly to more strongly nodose. The free blade comprises up to two-thirds of total unit length in juvenile specimens, and at least one-half in more mature forms. Aborally, the basal cavity is located at the free blade-platform junction in the former, and a little behind the anterior end of the platform in the latter.

Remarks and comparisons: The examples from Torquay referred to Po. timorensis, and those placed in synonymy with the species, all have a platform which is at least three times as long as wide. This character has been added to the diagnosis, which is based on that presented by Klapper et al. (1970, p. 655). In contrast with Po. timorensis, Po. ansatus has a relatively broader platform, and tends to have a more sinuous inner margin, which often shows some degree of constriction at the geniculation point. In contrast, the inner margin of the former taxon is more nearly straight throughout its length.

The Torquay material has deep adcarinal grooves, and displays a similar variation in platform ornament to that observed in specimens assigned to Po. ansatus. The platform margins may be more or less smooth (e.g. Pl. 6, fig. 4), but usually bear weak to stronger nodes. The form of the anterior platform is variable, but generally only the outer anterior trough margin is bowed outwards, although rather less strongly than in Po. ansatus, and tends to meet the free blade in front of the inner anterior trough margin. The geniculation points may or may not be opposed. The outer margin is constricted at the geniculation point, and the posterior outer platform may be laterally expanded behind the constriction, but neither feature is as well developed as in Po. ansatus. The free blade is fully preserved only in the fairly small growth stage on Plate 6, figs. 1-3, in which it occupies about two-thirds of total unit length. The basal cavity is rather large and is located at the anterior end of the platform in this example, but becomes relatively smaller and is developed a little further posteriorward in more mature specimens (e.g. Pl. 6, figs. 18, 19, 21).

Range and occurrence: Po. timorensis ranges from the base of the Lower varcus Subzone, through into the Lower hermanni - cristatus Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. timorensis occurs at Babbacombe Cliff (samples BC-22, 23), Barton Quarry (sample BQ-32 and Mincent Hill, sample MH-1), Castle Road (sample CR-2), Lummaton Quarry (samples LM-1, 3, 4, 5, 9, 10, 11, 18), Madrepore Road (sample MR-1), St. James Road (sample SJ-2), and Trumlands Quarry (TL-2, 3).

Polygnathus varcus STAUFFER

Plate 6, figs. 28; 24-27, 29-30 (?).

*1940 Polygnathus varcus n. sp. - STAUFFER, p. 430, pl. 60, figs. 49, 55, (fig. 49 = lectotype, designated by BISCHOFF & ZIEGLER 1957, p. 98; non fig. 53 = Po. sp. indet.).

1957 Polygnathus varca STAUFFER - BISCHOFF & ZIEGLER, p. 98-99, pl. 18, figs. 32, 33, 35, pl. 19, figs. 7-9 (non pl. 18, fig. 34 = Po. ansatus).

1970 *Polygnathus varcus* STAUFFER - KLAPPER, PHILIP & JACKSON, p. 657-658, pl. 2, figs. 1-3, 23-25 (see synonymy).

non1970 *Polygnathus varcus* STAUFFER - KIRCHGASSER, p. 351-352, pl. 66, figs. 9-11 (= *Po. timorensis*).

non1971 *Polygnathus varcus* STAUFFER - ORR, p. 53-54, pl. 5, figs. 4-8 (= *Po. ansatus*).

•1973 *Polygnathus varcus* STAUFFER - KLAPPER in ZIEGLER, p. 391-392, *Polygnathus* pl. 2, fig. 5 (original of KLAPPER, PHILIP & JACKSON 1970, pl. 2, fig. 24).

•1975 *Polygnathus varcus* STAUFFER - BULTYNCK, p. 23-24, pl. 5, figs. 6, 7.

•1978 *Polygnathus varcus* STAUFFER - ORCHARD, p. 950, pl. 109, fig. 29.

Diagnosis: An elongated, slim species of *Polygnathus* in which the anterior trough margins are more or less similarly developed and the platform is symmetrical. The geniculation points may or may not be opposed. The platform margins are often smooth apart from a node at each geniculation point, or they may bear subdued nodes in mature specimens. The free blade comprises about two-thirds of total unit length. The basal cavity is located at the free blade-platform junction in juvenile growth stages, but is developed a little further posteriorward in larger forms.

Remarks and comparisons: In contrast with the revised diagnosis of *Po. varcus* given by Klapper *et al*. (1970, p. 657), in which the platform margins were typically smooth except for one node which might be developed at each of the opposed geniculation points, the Torquay specimen on Plate 6, fig. 28 exhibits a subdued marginal ornament, and the inner geniculation point is located relatively posteriorward of the outer. However, this individual is considerably larger than representatives of *Po. varcus* illustrated by Klapper *et al*.(1970, pl. 2, figs. 1-3, 23-25) and, in view of observations made throughout the *Po. varcus* group, it seems reasonable to suggest that the variations are due to ontogenetic developments. The diagnosis has been amended further, to incorporate these features.

Compared with *Po*. *xylus* subspp., *Po*. *varcus* has a relatively longer free blade. The two taxa may be distinguished also by the character of the anterior trough margins, which are steeper in profile in the former, and are more elongated and tend to appear rather "stretched" in plan view in the latter.

Po. *varcus* has similar platform proportions to *Po*. *timorensis*. By definition, the anterior trough margins may be asymmetrical in the latter but, as is noted elsewhere, the development of the anterior platform is variable in all members of the *Po*. *varcus* group, and is probably not a useful criterion for specific differentiation. Orchard (1978, p. 938) made the point that, in his Mount Wise collection, *Po*. *varcus* and *Po*. *timorensis* may be "intraspecific variants of one natural species". With reference to this observation, it is perhaps significant that *Po*. *varcus* is a rare component of the Torquay faunas and is unambiguously identified in only one sample, which lacks *Po*. *timorensis* (Waldon Hill/Warren Road WH-3: Pl. 6, fig. 6). In a second sample which does contain *Po*. *timorensis*, only very small specimens are (questionably) assigned to *Po*. *varcus* (Lummaton Quarry LM-18: Pl. 6, figs. 24-27, 29, 30). The small forms may display a weak asymmetry of the anterior platform, but this is usually less pronounced than in juveniles of either *Po*. *timorensis* or *Po*. *ansatus*, and they tend to lack the constriction at the outer geniculation point which is typically developed in the last two taxa.

Range and occurrence: *Po*. *varcus* ranges from within the Lower *varcus* Subzone, through to within the Upper *varcus* Subzone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, *Po*. *varcus* occurs at Waldon Hill (Warren Road, sample WH-3). Very small specimens questionably referred to the species occur at

Lummaton Quarry (sample LM-18).

Polygnathus xylus STAUFFER

Diagnosis: Representatives of Po. xylus have an elongated, more or less symmetrical and parallel sided platform. The margins are either smooth or bear subdued nodes, and may become serrated anteriorly. The adcarinal grooves are deep, and one or both anterior groove margins declines steeply downwards. The geniculation points may or may not be opposed. Aborally, the basal cavity is located close to or at the anterior end of the platform in small growth stages, and is developed a little further posteriorward in larger forms. The free blade comprises about one-half of total unit length.

Remarks and comparisons: Ziegler and Klapper (in Ziegler et al. 1976, p. 125) presented an amended version of the original diagnosis of Klapper et al. (1970, p. 660). This is slightly modified herein to include the variable positions of the geniculation points with respect to each other.

Compared with both Po. ansatus and Po. timorensis, Po. xylus subspp. has steeper anterior trough margins, and tends to have a weaker ornament. The free blade may be a little longer in the first two species and the platform is usually asymmetrical, especially anteriorly, whereas the platform in the last form is often symmetrical and parallel sided throughout its length. The platform outline and weaker ornament usually distinguish Po. xylus subspp. also from Po. decorosus. The former taxon is discussed further under the latter.

Large specimens of Po. pseudofoliatus are readily differentiated from Po. xylus subspp. by the outline and oral surface configuration of the platform. In the former, the platform has an anterior constriction and a distinct, rather asymmetrical posterior lateral expansion, and the adcarinal grooves are less deep posteriorly than in the latter. The platform may be rather more parallel sided in juvenile growth phases of Po. pseudofoliatus, which consequently display a superficial resemblance to Po. xylus subspp., although the adcarinal grooves are still relatively shallower posteriorly in the former. Small forms of Po. pseudofoliatus may be further distinguished from Po. x. ensensis by the absence both of marginal serrations in the anterior platform, and of a strong downward arching of the posterior platform (in profile), both features being characteristic of the latter taxon. Klapper (in Johnson et al. 1980, p. 103, pl. 4, fig. 4) illustrated and described material from the Antelope Range of central Nevada which had the marginal anterior serrations and clearly downarched posterior platform characteristic of Po. x. ensensis, together with the distinct, asymmetrical expansion of the posterior platform typical of Po. pseudofoliatus. He thought that the specimens were transitional between the two forms, and proposed that individuals which Weddige (1977, pl. 4, figs. 62, 63, 65) had referred to Po. x. ensensis might take a similar intermediate position. The posterior platform is especially broad in the last of Weddige's examples, and suggests a tendency towards Po. eiflius. The material figured by both Klapper and Weddige is placed in synonymy with Po. x. ensensis herein.

Polygnathus xylus ensensis ZIEGLER & KLAPPER

Plate 4, figs. 18, 19; Plate 5, figs. 8, 9; 1-6 (aff.).

·1970 Polygnathus xyla STAUFFER - SEDDON (b), p. 62-63, pl. 6, figs. 10-12.

*1976 Polygnathus xylus ensensis n. subsp. - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 125-127, pl. 3, figs. 4-9 (figs. 4, 5 = holotype) (see synonymy).

·1977 Polygnathus xylus ensensis ZIEGLER & KLAPPER - WEDDIGE, p. 321-322, pl. 4, figs. 62-65.

·1978 Polygnathus xylus ensensis ZIEGLER & KLAPPER - ORCHARD, p. 951, pl. 108, figs. 2, 21, 25.

·1978 Polygnathus xylus STAUFFER - UYENO, p. 17-18, figs. 1-3 (only).

·1979 Polygnathus xylus xylus STAUFFER - SAVAGE & AMUNDSON, pl. 1, figs. 12-18.

·1980 Polygnathus xylus ensensis ZIEGLER & KLAPPER - KLAPPER in JOHNSON, KLAPPER & TROJAN, p. 103, pl. 4, fig. 4 (cited as Po. pseudofoliatus transitional to Po. x. ensensis).

Diagnosis: See Ziegler and Klapper in Ziegler, Klapper and Johnson 1976, p. 126.

Remarks and comparisons: In all the material from Torquay referred to the subspecies, the inner margin of the anterior platform bears two to three serrations behind the geniculation point, while the corresponding part of the outer margin bears either one serration, or is smooth. In profile, the outer anterior trough margin declines less steeply downwards than the inner, and is also rather more curved (concave upwards). Ziegler and Klapper (loc. cit.) indicated that these particular features were all characteristic of "phyletically late forms" of Po. x. ensensis. In contrast, they noted that three to five marginal serrations were typically developed on both sides of the anterior platform in early forms, and that both anterior trough margins declined straight down. Their example from the exposed top of the Ense Kalk at Blauer Bruch (Ziegler and Klapper op.cit., pl. 3, figs. 6. 7) is of the "late" type, and is of mid-ensensis Zone age according to correlations made by Weddige (1977, table 4). The last author also illustrated an individual with "late" anterior platform serrations, which is from the Lahr horizon in the Ahbach Formation, and is again of mid-ensensis Zone age (Weddige 1977, table 5, pl. 4, fig. 64).

The individuals shown on Plate 5, figs. 1-6, designated Po. aff. x. ensensis, conform with the material described above in their anterior platform serrations, but exhibit a moderately strong constriction at the outer geniculation point, before which the outer anterior trough margin is clearly bowed outwards, and behind which the outer posterior platform is laterally expanded. In these respects the specimens approach Po. timorensis and, especially, Po. ansatus, although the inner anterior trough margin is rather less well developed than in either of the last species. Ziegler and Klapper (op. cit., p. 125, table 7) suggested a derivation of Po. timorensis from Po. x. ensensis, because they observed material apparently intermediate between the two forms in Bicken II, sample 10. In these examples the platform was rather more elongated than was typical of the latter taxon, while the outer anterior trough margin did not yet display the outward bowing characteristic of the former. Weddige (1977, p. 321) reported variants of Po. x. ensensis with a bowed outer anterior trough margin from the Oderhäuser Kalk, which may represent a ?later stage in such an evolutionary process. The available examples indicate that there may be a possible evolutionary connection between Po. x. ensensis and Po. ansatus.

Range and occurrence: Po. x. ensensis ranges from the base of the ensensis Zone, through to the top of the Middle varcus Subzone (Weddige 1977, table 2; Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. x. ensensis occurs at Castle Road (sample CR-1), Long Quarry Point (sample LG-6), Redgate Beach (samples RB-5, 12, 13, 14) and St. James Road (sample SJ-2). Po. aff. x. ensensis occurs at Waldon Hill (sample WH-1).

Polygnathus xylus xylus STAUFFER

Plate 4, figs. 25-27 (aff.); Plate 5, figs. 7,
11, 12; 19, 20 (aff.); Plate 12, figs. 28-33.

*1940 Polygnathus xylus n. sp. - STAUFFER, p. 430-431, pl. 60, figs. 54, 66, 72-74 (fig. 72 = lectotype, designated by WITTEKINDT 1965, p. 642; non figs. 42, 50, 65, 67, 69, 78, 79 = Po. sp. indet.).

·1964 Polygnathus decorosa STAUFFER - ORR, p. 14, 16, pl. 1, fig. 3 (only).

·1970 Polygnathus xyla STAUFFER - BULTYNCK, p. 131, pl. 15, figs. 2, 8 (non fig. 5 = Po. pseudofoliatus) (see synonymy).

·1970 Polygnathus xylus STAUFFER - SEDDON (a), p. 740, pl. 13, figs. 3-5, 11-13 (non pl. 12, figs. 20, 21 = Po. ovatinodosus?)

·1974 Polygnathus xylus STAUFFER - UYENO, p. 40-41, pl. 4, figs. 6, 8.

·1975 Polygnathus xylus STAUFFER - BULTYNCK, p. 24, pl. 5, fig. 5.

1976 Polygnathus xylus xylus STAUFFER - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, p. 125, pl. 3, fig. 1 (see synonymy).

·1978 Polygnathus xylus STAUFFER - ORCHARD, p. 951, pl. 108, figs. 9, 13.

·1978 Polygnathus xylus STAUFFER - UYENO, p. 17-18, pl. 4, figs. 9-14 (only: non figs. 1-3 = Po. x. ensensis).

non1979 Polygnathus xylus xylus STAUFFER - SAVAGE & AMUNDSON, pl. 1, figs. 12-18 (= Po. x. ensensis).

Diagnosis: See Ziegler and Klapper in Ziegler, Klapper and Johnson 1976, p. 125.

Remarks and comparisons: The anterior platform of Po. x. xylus lacks the distinct marginal serrations characteristic of Po. x. ensensis, and the posterior platform is arched downwards less strongly (in profile) than in the latter. The two taxa may be distinguished in lateral view also by the nature of the anterior trough margins. In the nominate subspecies, both anterior trough margins decline steeply downwards in a concave upwards curve. In Po. x. ensensis, the inner anterior trough margin is again steep but declines straight down, while the outer margin is similarly configured in phyletically early forms, but is curved (concave upwards) and, sometimes, rather less steep in later variants.

The Torquay specimens referred to the nominate subspecies all have the narrow, elongated and parallel sided platform typical of the form. Adcarinal grooves are well developed throughout the platform, and their anterior margins are steep in profile. The platform margins may be more or less smooth (e.g.

Pl. 5, fig. 12), bear subdued nodes only posteriorly (e.g. Pl. 5, fig. 7), or be weakly nodose throughout their length (e.g. Pl. 12, fig. 30). The geniculation points are more or less opposed, and one weak serration may be developed immediately to the anterior of the outer geniculation point, as in the last-mentioned example. The basal cavity tends to be fairly large, and is developed close to, or at, the anterior end of the platform.

Two juvenile growth stages illustrated on Plate 4, figs. 25-27 and Plate 5, figs. 19, 20 are tentatively assigned to Po. x. xylus because of their more or less parallel sided platforms. The first specimen approaches Po. pseudofoliatus because the adcarinal grooves are rather shallow posteriorly, but both individuals lack the constricted anterior platform typical of this species. Instead, the anterior margins of the adcarinal grooves appear somewhat flared in plan view in both specimens, especially in the outer half of the platform.

Range and occurrence: Po. x. xylus ranges from within the Lower varcus Subzone, through to within the lower part of the Lower asymmetricus Zone (Ziegler in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Po. x. xylus occurs at Babbacombe Cliff (samples BC-5, 32), Barton Quarry (samples BQ-13, 15, 22, 23, 28, 29), Lummaton Quarry (sample LM-15), Madrepore Road (sample MR-1), St. James Road (sample SJ-2), Trumlands Quarry (sample TL-3) and Waldon Hill (Warren Road, sample WH-3). Po. aff. x. xylus occurs at Long Quarry Point (sample LG-6) and St. James Road (sample SJ-2).

Polygnathus webbi STAUFFER

Plate 13, figs. 8, 14; 1-4 (aff.).

*1938 Polygnathus webbi n. sp. - STAUFFER, p. 439, pl. 53, figs. 25, 26, 28, 29 (figs. 28, 29 = lectotype, designated by WITTEKINDT 1965, p. 641).

·1965 Polygnathus webbi STAUFFER - WITTEKINDT, p. 641, pl. 3, figs. 15(?), 17.

·1967 Polygnathus webbi STAUFFER - CLARK & ETHINGTON, p. 64, pl. 7, fig. 11.

·1967 Polygnathus normalis MILLER & YOUNGQUIST - WOLSKA, p. 415, pl. 14, figs. 9-11.

·1967 Polygnathus normalis MILLER & YOUNGQUIST - WIRTH, p. 230, pl. 22, figs. 8, 9.

·1967 Polygnathus normalis ssp. - WIRTH, p. 230, pl. 22, figs. 5-7.

·1968 Polygnathus webbi STAUFFER - MOUND, p. 511-512, pl. 70, figs. 6-8.

·1968 Polygnathus normalis MILLER & YOUNGQUIST - MOUND, p. 509-510, pl. 70, figs. 1, 2, 5 (non pl. 69, figs. 30, 31 = Sch. peracutus).

·1971 Polygnathus "webbi" STAUFFER - ORR, p. 54-55, pl. 4, figs. 9, 10.

·1971 Polygnathus webbi STAUFFER - SCHUMACHER (a), pl. 10, figs. 7, 8 (only).

·1973 Polygnathus webbi STAUFFER - KLAPPER in ZIEGLER, p. 393-394, Polygnathus pl. 2, fig. 7 (original of KLAPPER 1971, pl. 1, fig. 25) (see synonymy).

·1974 Polygnathus webbi STAUFFER - UYENO, p. 40, pl. 5, fig. 7.

non 1976 Polygnathus webbi STAUFFER - GARCIA - LOPEZ, p. 177, pl. 1, fig. 5 (= Po. ovatinodosus).

·1980 Polygnathus webbi STAUFFER - KLAPPER in KLAPPER & JOHNSON, pl. 4, fig. 9.

Diagnosis: See Stauffer 1938, p. 439.

Remarks and comparisons: Klapper (1971, p. 66) proposed that Po. normalis should be considered synonymous with Po. webbi. He thought that the two represented, respectively, the right-curved and left-curved elements of a pair which corresponded to Class IIIb symmetry as envisaged by Lane (1968, p. 1260).

The specimen from Torquay illustrated on Plate 13, figs. 8, 14 resembles an individual from the Firebag Member of the Waterways Formation figured by Uyeno (1974, pl. 5, fig. 7). In both examples the platform is characteristically asymmetrical and clearly incurved, especially posteriorly. The outer platform is wider than the inner, the greatest width being developed a little behind platform mid-length. Deep adcarinal grooves are present and are deepest anteriorly, where the platform margins are most strongly upturned and the outer platform margin is higher than the inner. There is a slight degree of constriction of the anterior platform, but the rostrum of Po. webbi is never as pronounced as that of, for example, Po. dubius. The ornament of the two specimens is typical of Po. webbi, and consists of numerous, close-spaced but distinct ridges. These are restricted to the platform margins and are arranged at right angles to the carina anteriorly, but become more inclined to it posteriorly. In Uyeno's Canadian example the ornament is developed throughout the length of the platform, whereas in the Torquay individual the anterior margins are rather smooth. In this respect, the latter form approaches Po. alatus HUDDLE, although the nature of the ornament in the middle and posterior parts of the platform is consistent with that of Po. webbi. Po. alatus differs from the last species in having a smooth anterior platform, and a lesser degree of ornamentation posteriorly. Klapper (in Johnson et al. 1980, p. 101) suggested that Po. alatus was probably ancestral to Po. webbi. The Torquay example appears to be transitional between the two taxa.

The two specimens shown on Plate 13, figs. 1-4 are designated Po. aff. webbi. They have the platform outline of the species, and a more or less similar arrangement of the ornament with respect to the carina, but differ in that the ridges themselves are fewer, relatively more robust and less close spaced. Because of the configuration of their ornament, and because the platform margins tend to be slightly serrated, these individuals show tendencies toward Po. sp. A as described by Uyeno (1974, p. 41, pl. 4, figs.

9, 10), which form was distinguished from Po. webbi also by its symmetrical platform and shorter free blade. The free blade is not fully preserved in the Torquay material and, as noted above, the platform outline is consistent with Po. webbi.

In its somewhat robust appearance, the ornament of the last-mentioned of the Torquay examples approaches that of Po. pennatus HINDE, which is characterised by an ornament of rather sharp, clearly separated, strong ridges. However, in comparison both with these, and with rather more typical examples of Po. webbi, the ornament of Po. pennatus is arranged normally to the carina throughout the length of the platform. The latter species may be further differentiated from all representatives of the former by its more or less symmetrical and less incurved platform, which is lanceolate in outline, and is distinctly blunt in appearance at the anterior end. Aborally, the basal cavity of Po. pennatus is located in the anterior half of the platform, and tends to have an elongated and slit-like configuration. In contrast, the basal cavity of Po. webbi, and also of Po. aff. webbi, is situated a little further anteriorward, and is rather more clearly rounded, or sometimes oval, in outline.

Further comparisons concerning Po. webbi are presented under Po. ovatinodosus.

Range and occurrence: Po. webbi is a long ranging species, and spans an interval from the Lower asymmetricus Zone to the velifer Zone (Klapper in Ziegler 1973, p. 394). The form may extend below the lower limit of this range. Uyeno (1974, table 1) recorded Po. webbi in the Firebag Member of the Waterways Formation in the Sp. insitus fauna, below the Lower asymmetricus Zone.

In Torquay, Po. webbi occurs at Babbacombe Cliff (samples BC-11, 33). Po. aff. webbi occurs at Barton Quarry (samples BQ-14, 24).

Form genus Schmidtognathus ZIEGLER

Type species: Schmidtognathus hermanni ZIEGLER 1965b.

Remarks: The schmidtognathids have a short age range, being restricted to within the early Upper Devonian, and are characterised by the morphology of the basal cavity. This feature is moderate to large in size, and is weakly to conspicuously asymmetrical in outline. The rims of the cavity are usually thickened, and stand above the aboral surface of the platform. The basal cavity is largest and most strongly asymmetrical in Sch. hermanni and Sch. pietzneri, and tends to be relatively smaller and less asymmetrical in most of the other species. However, the basal cavity is always sufficiently well developed with respect to both size and asymmetry for members of the group to be distinguished from the more slender of the polygnathids, which they otherwise resemble in their elongated, often lanceolate or triangular platforms.

A large asymmetrical basal cavity is developed in other taxa, such as the broad-platformed Po. asymmetricus subsp. A sensu ORCHARD, and the genus Klapperina. These forms are discussed under Sch. aff. hermanni. The younger genus Pseudopolygnathus also has a large basal cavity, because of which Ziegler (1965b, p. 662, 665) considered there to be a close relationship between this taxon and Schmidtognathus.

The configuration of the aboral surface is an important criterion for taxonomic separation within the schmidtognathids, essentially with regard to the size, outline and position of the basal cavity. The following characters are also used, although usually to a lesser degree: the configuration of the platform, in both plan and lateral view; the nature of the oral surface ornament and carina; the form and extent of development of the adcarinal grooves; the character and relative length of the free blade.

With regard to the evolutionary position of the genus, Ziegler (1965b) considered the ancestry of Schmidtognathus to lie within his Po.

decorosus *s*. *l*. He illustrated specimens from Bicken and Giebringhausen in the Rhenish Slate Mountains, which he assigned to *Sch*. *hermanni*, but described as being transitional from *Po*. *decorosus* *s*. *l*. to this species (Ziegler 1965b, p. 665, pl. 3, figs. 5-8). However, Ziegler and Klapper (in Ziegler *et*. *al*. 1976, p. 120) subsequently referred these individuals, which they thought to be from the Upper *varcus* Subzone, to *Po*. *latifossatus*. They preferred a derivation of *Sch*. *hermanni* from the last species, and recognised specimens which they considered to be intermediate between the two (Ziegler and Klapper *op*. *cit*., p. 120, pl. 3, figs. 19, 25, 26). These examples were from part of the Tully Limestone in New York, and were again of Upper *varcus* Subzone age. According to the authors, they had a platform which was better developed than in *Po*. *latifossatus*, although not as extensively so anteriorly as in *Sch*. *hermanni*. In further comparison with the former, their ornament was more strongly nodose and the basal cavity was more centrally positioned, but the last feature was considerably smaller and less asymmetrical than in the latter.

Schmidtognathus has been incorporated in a multielemental apparatus only by Ziegler (1972, p. 94). He suggested that the genus possessed, in fact, a mono-elemental apparatus, which was composed of an unknown number of paired schmidtognathids, and was devoid of ramiform elements.

Schmidtognathus? *gracilis* KLAPPER

Plate 14, figs. 20, 23-26, 28 (aff.).

*1980 *Schmidtognathus*? *gracilis* n. sp. - KLAPPER in JOHNSON, KLAPPER & TROJAN, p. 103-104, pl. 3, figs. 11, 12, 17-20 (figs. 19, 20 = holotype) (see synonymy).

Diagnosis: See Klapper in Johnson, Klapper and Trojan 1980, p. 103.

Remarks and comparisons: This is a slender species, in which the free blade occupies between one-third and two-fifths of total unit length. The platform margins are typically parallel throughout most of their length, and are either partly or completely nodose, or may bear short transverse ridges. The ornament is separated from the carina by narrow but well developed adcarinal grooves. In (approximately) the anterior two-thirds of the platform, the fixed blade-carina and platform margins are developed at the same height, as a result of which the upper surface of this part of the platform appears characteristically flat and horizontal in lateral view. The platform is arched downwards towards the posterior extremity, and the upper surface curves downwards posteriorly, roughly concentric with the lower border. Again in profile, the posterior tip of the unit appears rather blunt.

As Klapper (loc. cit.) described, the aboral surface of the platform exhibits a range of morphological expression. At one extreme, the basal cavity is rather flat, and is developed throughout much of the length of the platform. A clear depression is present anteriorly, and extends as a narrow groove posteriorly, in which direction the basal cavity gradually narrows (e.g. Klapper op.cit., pl. 3, fig. 19). At the other extreme of variation, the basal cavity is inverted, and surrounds a fairly small, elongated pit anteriorly. The pit may be constricted at its mid-length (e.g. Klapper op.cit., pl. 3, fig. 18). Klapper noted that individuals with the second type of aboral configuration possessed a distinct crimp, and observed forms intermediate between the two variants, in which the basal cavity was only partially inverted posteriorly.

Two specimens from Torquay, illustrated on Plate 14, figs. 20, 25, 26 and figs. 23, 24, 28 approach Sch.? gracilis, but exhibit discrepancies both towards each other, and towards the species. The first individual is consistent with the taxon in its slender, more or less parallel sided platform, and in its oral surface ornamentation. Each margin bears a single row of nodes, separated from the carina by thin, distinct adcarinal grooves. The nodose ornament is restricted to the platform borders also in the second example, but compared with the first specimen and with the type material of Sch.? gracilis, the platform itself is a little broader, and is rather more biconvex in outline. In lateral aspect, the platform appears fairly deep in both of the available individuals, because of the upturned margins, and the upper surface of the anterior platform is characteristically flat and level, sloping downwards posteriorly, concentric with the lower border of the downarched posterior platform. In the first specimen, the oral surface is flat for about one-half of the estimated total platform length, which is rather less than in typical representatives of Sch.? gracilis. In the second example, the anterior two-thirds of the upper surface of the platform are flat, but the posterior tip is rather less blunt than is usual. The posterior extremity of the platform is broken in the former individual. The free blade rises at least moderately steeply before the platform in both forms, and occupies about two-fifths of total unit length.

The aboral features are best preserved in the first of the Torquay specimens, in which the basal cavity is inverted throughout the length of the platform, and surrounds a depression anteriorly. The depression has the form of a moderately large, subcircular and asymmetrical expansion, the asymmetry resulting from the outer border being rather more strongly curved outwards than the inner, and at the same time being directed slightly backwards. The lower surface is somewhat abraded in the second example and, while the basal cavity has a similar anterior expansion to that of the first individual, it does not appear to be inverted. Instead, a rather blunted keel extends behind the basal cavity to the posterior platform tip.

With respect to the aboral configuration, the Torquay material is closest to the second extreme of development evident in the type specimens (described above), but the anterior depression is better developed, relatively larger, less elongated and more nearly circular in outline in the former, compared with the narrow pit of the latter. Because of the various discrepancies between the examples to hand and Sch.? gracilis, they are only tentatively assigned to the species.

Characteristic representatives of Sch.? gracilis are easily distinguished from other members of the genus by their parallel platform margins, the flat nature of the upper surface of the anterior platform in profile, and their aboral morphology. Klapper (op.cit., p. 104) observed that specimens which displayed the first extreme of aboral development resembled some forms of Po. latifossatus. However, as he remarked, all examples of the two species may be readily differentiated from each other by the character of the anterior platform in lateral view. The fixed blade-carina is usually distinctly higher than the platform margins in Po. latifossatus, which contrasts with the typically horizontal profile of Sch.? gracilis. Klapper (loc. cit.) further made the point that the last form could logically be referred to the genus Schmidtognathus only if Po. latifossatus were also included. With regard to this observation, the Torquay specimens designated Sch.? aff. gracilis clearly belong to the genus, in view of the size and asymmetry of the anterior expansion of the basal cavity.

Range and occurrence: In the Antelope Range of Central Nevada, Klapper (op. cit., tables 16, 19) recorded Sch.? gracilis from samples TAV-1320, 1340 and TAVI-160, which he referred to the Lower dengleri Subzone [equivalent to the lower half of the Lowermost asymmetricus Zone (Klapper and Johnson 1980, text-fig.1)].

In Torquay, material designated Sch.? aff. gracilis occurs at Barton Quarry (samples BQ-9, 30).

Schmidtognathus hermanni ZIEGLER

v*1965 Schmidtognathus hermanni n. sp. - ZIEGLER (b), p. 664-665, pl. 3, figs. 9-26 (figs. 23-26 = holotype; non figs. 5-8 = Po. latifossatus WIRTH).

non1970 Schmidtognathus hermanni ZIEGLER - KIRCHGASSER, p. 352, pl. 66, fig. 1.

·1973 Schmidtognathus hermanni ZIEGLER - ZIEGLER, p. 425-426, Schmidtognathus - pl. 1, figs. 3a-3d (originals of ZIEGLER 1965 (b), pl. 3, figs. 23-26 respectively).

·1975 Schmidtognathus hermanni ZIEGLER - BULTYNCK, p. 24, pl. 2, fig. 4.

·1976 Schmidtognathus hermanni ZIEGLER - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pl. 3, figs. 34, 35.

·1980 Schmidtognathus hermanni ZIEGLER - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, figs. 27, 28.

Diagnosis: See Ziegler 1965b, p. 664; 1973, p. 425 (translation of original German).

Remarks and comparisons: See under Sch. aff. hermanni.

Range and occurrence: Sch. hermanni ranges from the base of the Lower hermanni-cristatus Subzone, into the Lowermost asymmetricus Zone (Ziegler 1971, chart 3; 1973, p. 425; in Klapper and Ziegler 1979, text-fig. 5).

Schmidtognathus aff. hermanni ZIEGLER

Plate 15, figs. 1-3, 6, 7, 9, 11-14, 18, 19.

Description (Torquay material): The specimens comprise complete and incomplete platforms, none with the free blade intact. The platform is moderately large, and is approximately twice as long as wide. The outer and inner halves of the platform curve outwards and are more or less similarly developed, although the former exhibits a slightly stronger degree of curvature, and is a little wider, than the latter. The platform is broadest behind its mid-length, tapering posteriorly to the usually pointed tip. Anteriorly, the inner margin meets the free blade slightly behind the outer, and the anterior platform is weakly to more strongly constricted for up to one-third of total platform length, where the platform margins are upturned, and somewhat stretched downwards (in profile). As a result, relatively deep, smooth adcarinal grooves are developed, which continue posteriorward, where they may become sporadically nodose. The oral surface ornament is otherwise largely restricted to the platform margins, and is of fairly fine nodes or granules. These are either discrete, or may coalesce into short, rather weak nodose ridges, which are arranged either normal or rather obliquely to the margins, and are clearest around platform mid-length. The carina comprises about seven or eight nodes, which are at least partly fused and elongated, but are still fairly rounded in outline. The nodes are largest and equisized at platform mid-length where the carina is as high as the slightly thickened and upturned platform margins. The carinal nodes become smaller and lower posteriorly, and the carina dies out in the last quarter of the platform, a little before the posterior tip. The posteriormost part of the carina may be deflected inwards. The platform borders either remain somewhat upturned to the posterior tip and the platform appears gently bowed in cross-section, as in the examples on Plate 15, figs. 1, 2, 6, 9, 11, 12, or the final one-quarter of the platform may be more or less flat, as in the specimen on Plate 15, figs. 13, 14.

In plan view, the length axis is fairly straight, becoming distinctly curved in large specimens. In lateral view the platform is bent downwards posteriorly, but is otherwise fairly flat. The fixed blade rises evenly in height from the carina to the free blade, the character of which is not known.

Aborally, the basal cavity is large and distinctly asymmetrical in outline, and has slightly thickened rims which clearly stand above the platform surface. In the anterior part of the cavity the outer margin displays a strong lateral expansion, which is bluntly rounded to rather more angular in outline, and is accompanied by a distinct infolding of the outer margin in the posterior part of the cavity. The inner margin is more or less arcuate. The basal cavity is developed around platform mid-length, such that the greatest width is located a little before this point. Anteriorly, the cavity fairly abruptly becomes a furrowed keel, but tapers more slowly posteriorward, to a point between one-quarter and two-fifths of total platform length from the posterior extremity. From this position a keel extends to the tip, and may be thinly grooved in its anterior part.

Remarks and comparisons: The material from Torquay approaches Sch. hermanni with regard to the overall platform development, but differs from the species in several respects. As described above, the platforms of the available examples are roughly twice as long as broad, and are widest a little behind their mid-length. In contrast, the platforms of the type specimens (Ziegler 1965b, pl. 3, figs. 9-26) may be nearly three times as long as wide, and their maximum breadth is developed more or less at mid-length. The former resemble the latter in their ornamentation, although the slightly more coarsely nodose ornament of the holotype (Ziegler 1965b, pl. 3, figs. 23-26) is not evident, but are atypical of Sch. hermanni in that the carina does not attain the posterior tip of the platform. Also, the platform margins appear to be more upturned and slightly thicker than is usual in the species, and the platform itself rather more transversely bowed, especially with regard to those forms from Torquay in which the bowing extends into the posterior quarter of the platform.

Aborally, most of the Torquay material is consistent with Sch. hermanni in that the large, strongly asymmetrical basal cavity is developed with its greatest width a little forward of platform mid-length, and narrows posteriorly to a point about two-fifths of total platform length from the posterior tip of the unit. The basal cavity of the individual on Plate 15, figs. 1, 2, 6 is extremely large and, while its maximum breadth is still situated a little anteriorward of platform mid-length, the cavity extends posteriorly almost into the final quarter of the platform. With regard to the configuration of the basal cavity, all the specimens to hand conform with the taxon in that the outer half of the cavity exhibits a strong sideways expansion towards, but not at, its anterior extremity, behind which the margin is clearly infolded. However, the outer anterior lateral expansion tends to be rather more rounded and blunter in outline compared with most representatives of Sch. hermanni in the literature, in which the equivalent expansion is fairly angular and pointed. However, it is interesting to note that Bultynck (1975, pl. 2, fig. 4) illustrated a juvenile example in which the outer anterior lateral expansion is blunt and rounded, and is similar to that of the larger growth stage on Plate 15, figs. 13, 14 herein.

Because of the various discrepancies between the Torquay specimens and Sch. hermanni, they are only tentatively assigned to the species. In contrast with the rest of the material, the specimen on Plate 15, figs. 3, 7 is unusual in several respects. Aborally, the basal cavity is similar in outline to that of the other examples, but it is smaller relative to the overall size of the platform, and seems to be located slightly further anteriorward. Also, the posterior keel does not attain the platform tip. The platform itself is rather broad, flat and somewhat irregular in outline, and the low, weak, nodose ridges of the ornament more nearly cover the entire oral surface. These features may all be gerontic developments, because this particular individual is larger than the others available.

As mentioned in the introductory remarks to the schmidtognathids, a large asymmetrical basal cavity is present in the broad platformed Po. asymmetricus subsp. A sensu ORCHARD, and in the genus Klapperina. With regard to the overall appearance of the unit, these taxa may be distinguished from Sch. hermanni by their shorter free blade, and from both the last species and Torquay material designated Sch. aff. hermanni (in which the length of the free blade is not known) by their wider, rather more subcircular but less symmetrical platform, the outline of which more directly reflects the shape of the basal cavity. The basal cavity itself differs from that of both typical and atypical forms of *Sch*. *hermanni* in that the wide outer lateral expansion is located relatively closer towards, or at, the anterior end of the structure. Also, an infolding of the posterior outer margin tends to be rather less strongly developed in *Po*. *a*. *subsp*. A and in the klapperinids, and the overall outline of the cavity is either triangular in both taxa, or is often L-shaped in the latter. With regard to the position of the basal cavity, it is situated a little further posteriorward in the last forms than in all representatives of *Sch*. *hermanni*, with the greatest width positioned at, or just behind, platform mid-length. The posterior extension of the cavity is usually also developed rather further posteriorward in the former, into the final quarter of the platform, and often to the posterior tip in the klapperinids. Despite the development of the basal cavity being similar in *Sch*. *hermanni* and the genus *Klapperina*, it has been suggested that the latter taxon was derived not from the former, but from *Po*. *cristatus* (*q*.*v*.). The evolutionary position of *Po*. *a*. subsp. A has not yet been assessed.

Occurrence: In Torquay, *Sch*. aff. *hermanni* occurs at Barton Quarry (sample BQ - 18).

Schmidtognathus peracutus (BRYANT)

Plate 15, figs. 4, 5, 8, 10, 15, 16, 22, 23, 27.

*1921 *Polygnathus peracutus* n.sp. - BRYANT, p. 25, pl. 10, fig. 12 (= holotype).

v1965 *Schmidtognathus peracuta* (BRYANT) - ZIEGLER (b), p. 668, pl. 1, figs. 1-10 (see synonymy).

·1968 *Polygnathus normalis* MILLER & YOUNGQUIST - MOUND, p. 509-510, pl. 69, figs. 30, 31 (only).

·1969 *Schmidtognathus peracuta* ZIEGLER [*sic*] - SCHÖNLAUB, pl. 2, figs. 1, 2.

1970 *Polygnathus peracuta* BRYANT - SEDDON (b), p. 61-62, pl. 14, figs. 6-8.

1971 *Schmidtognathus peracutus* (BRYANT) - ORR, p. 56, pl. 6, fig. 9.
•1973 *Schmidtognathus peracutus* (BRYANT) - ZIEGLER, p. 429-430, *Schmidtognathus* - pl. 2, figs. 1a, 1b, 2 (originals of ZIEGLER 1965b, pl. 1, figs. 9, 10 and new photographs of BRYANT 1921, pl. 10, fig. 12 respectively).
non1979 *Schmidtognathus peracutus* (BRYANT) - UYENO, pl. 2, figs. 27-29 (= *Sch. wittekindti*).
•1980 *Schmidtognathus peracutus* (BRYANT) - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, figs. 31, 32.

Diagnosis: A species of *Schmidtognathus* in which the platform is triangular to rather more sagittate in outline, and is relatively flat or slightly transversely bowed (convex upwards) in cross-section. The oral surface bears several longitudinal rows of often low, rounded and usually unfused nodes. The carina is represented by a median row of discrete, rounded nodes, which are either similar in size or only a little larger than those of the rest of the platform ornament, and is often not distinct. The short free blade occupies about one-quarter to one-third of total unit length. Aborally, the weakly asymmetrical basal cavity is not conspicuously large, and is developed in the anterior half of the platform.

Remarks and comparisons: *Sch. peracutus* most closely resembles *Sch. wittekindti*, but is distinguished from the latter by its relatively broader platform and shorter, lower (in profile) free blade. The oral surface of the platform in *Sch. peracutus* typically bears several rows of fairly low nodes and a rather subdued carina, whereas *Sch. wittekindti* characteristically has one row of strong nodes on each platform margin, separated from the prominent carina by deep adcarinal grooves. Adcarinal grooves are not well developed in the former species because the platform margins are less upturned than in the latter, and the platform appears flatter in cross-section, and thinner in lateral view. The two taxa may be differentiated in lateral aspect also by the degree of arching of the entire unit, which is much stronger in *Sch. wittekindti* than in *Sch. peracutus*, and in aboral view by the nature and position of the basal cavity, which is relatively larger and rather more asymmetrical in the former, and is located relatively furtherforward, close to the anterior end of the platform.

These differences being stated, there seems to be considerable morphological gradation between the two species, which is discussed under *Sch. wittekindti*, and is evident also in the specimens from Torquay referred to *Sch. peracutus*. Of these, the fairly large individual on Plate 15, figs. 4, 5, 8 is closest to the last taxon, and is consistent with it in the rather broad, triangular-shaped platform, which bears several rows of rounded, low nodes, aligned more or less parallel to the similarly developed, equally low carina. The nodes display some degree of transverse fusion, which is seen also in a large form illustrated by Ziegler (1965b, pl. 1, figs. 1, 2). The example to hand conforms with *Sch. peracutus* in aboral view because the asymmetrical basal cavity is not large and is located in the anterior half of the platform, and in lateral view in the gentle arching of the platform. The platform is fairly thick in the last aspect, which suggests a tendency towards *Sch. wittekindti*. The free blade is broken, and its character is not known.

The example on Plate 15, figs. 10, 15, 16 resembles *Sch. peracutus* in the morphology of the platform in both plan and lateral views. The free blade is consistent with the species in profile because it is only low and is not arched, but approaches that of *Sch. wittekindti* in occupying almost one-half of total unit length. The basal cavity is also similar to that of the last taxon, because it is fairly large and is developed at the anterior end of the platform. The individual on Plate 15, figs. 22, 23, 27 appears to be a larger form of the previous specimen, which has been laterally compressed and sheared, accentuating the platform arching. The upper surface of the platform tends towards that of *Sch.*? *gracilis* in lateral view, because it is flat anteriorly and slopes downwards posteriorly, but the platform margins are not upturned as in the last species, and the platform is rather flat beneath the ornament. Aborally, the example has the fairly small basal cavity of Sch. peracutus. The cavity shows only a weak asymmetry, and is rather diamond-shaped in outline.

Range and occurrence: Sch. peracutus ranges from within the Upper hermanni-cristatus Subzone, to the top of the Lowermost asymmetricus Zone (Ziegler 1973, p. 429; in Klapper and Ziegler 1979, text-fig. 5).

In Torquay, Sch. peracutus occurs at Barton Quarry (samples BQ - 11, 13, 18, 26).

Schmidtognathus pietzneri ZIEGLER

Plate 16, figs. 1-9.

v*1965 Schmidtognathus pietzneri n. sp. - ZIEGLER (b), p. 666-667, pl. 2, figs. 11-25 (figs. 22, 23 = holotype).

•1969 Schmidtognathus pietzneri ZIEGLER - SCHÖNLAUB, pl. 1, figs. 27, 28.

•1973 Schmidtognathus pietzneri ZIEGLER - ZIEGLER, p. 431, Schmidtognathus - pl. 1, figs. 2a, 2b (originals of ZIEGLER 1965b, pl. 2, figs. 22, 23 respectively).

•1980 Schmidtognathus pietzneri ZIEGLER - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, figs. 29, 30.

Diagnosis: See Ziegler 1965b, p. 667; 1973, p. 431 (translation of original German).

Description (Torquay material): The specimens are all small growth stages. The elongated, slender platform is widest towards, but not always at, the anterior end, while the posterior platform is weakly to more strongly deflected inwards in plan view, and is bent downwards in profile. The posterior tip of the unit is pointed, and the carina often projects slightly beyond the posteriormost part of the platform. The ornament consists of small, usually even-sized nodes, which are restricted to the platform margins, and are separated from the carina by smooth adcarinal grooves. The adcarinal grooves become a little deeper anteriorly, where the anterior platform margins are weakly to strongly stretched downwards, and sometimes display some degree of lateral expansion, stronger on the outer side than on the inner, corresponding to the greatest platform width. The anterior platform margins join the free blade in a combination of usually different, shallow to steep angles, and the inner margin tends to meet the blade slightly behind the outer. The free blade comprises about one-half of total unit length.

Aborally, the large, fairly thick-rimmed basal cavity is subcircular and asymmetrical in outline, and is located in the anterior half of the platform. The outer half of the cavity is wider than the inner, and shows a distinct expansion which is directed outwards and backwards, although an infolding is not developed in the posterior part of the outer margin. The inner margin is arcuate. The anterior part of the cavity fairly abruptly becomes a furrowed keel, the groove extending forwards beneath the free blade. The posterior part of the cavity may equally abruptly become a sharp keel that attains the posterior tip of the unit, or may taper rather more slowly posteriorward, becoming a keel only in the last one-quarter of the platform.

Remarks and comparisons: Both Sch. pietzneri and Sch. hermanni have a large, asymmetrical basal cavity. However, the cavity is located relatively further posteriorward in the latter, and is larger and more strongly asymmetrical than in the former. The outer half of the cavity is expanded more than the inner half in both species, but the outer lateral expansion is more pronounced in Sch. hermanni and the outer margin is infolded posteriorly, which development is not seen in Sch. pietzneri. The taxa may be distinguished also with regard to the overall form of the unit. The greatest platform width is developed close to platform mid-length in *Sch. hermanni*, but is situated relatively further forward in *Sch. pietzneri*, typically at the anterior end of the platform. In the latter species, the free blade occupies about one-third of total unit length, and is thus rather longer than in the former, in which the blade comprises about one-quarter of the unit.

The examples from Torquay are consistent with *Sch. pietzneri* in their aboral morphology, their oral surface configuration, and the inwards and downwards flexure of their posterior platform. However, the anterior platform (described above) tends to be somewhat less well developed than is usual in the species, as a result of which the maximum platform width may be located a little behind the anterior end of the platform. Characteristically the anterior platform margins of *Sch. pietzneri* are rather strongly stretched downwards and both are clearly outwidened, to comprise the greatest platform breadth. Also, the inner anterior platform margin typically meets the free blade in front of the outer margin in *Sch. pietzneri*, whereas the reverse is usually the case in the available specimens, and the free blade itself is relatively longer in the latter. These differences may possibly be attributable to the fact that the material from Torquay includes only juvenile and small growth phases.

The smallest of the specimens to hand (Plate 16, figs. 5, 6, 9) approaches *Po. latifossatus* in aboral view, because the basal cavity tapers only slowly posteriorwards and forms a rather flat development overall, which occupies about one-third of the entire lower surface of the platform. However, the basal cavity in juvenile forms of *Po. latifossatus* may occupy almost all of the lower surface of the platform, and the anterior part of the cavity is not as clearly asymmetrical as in the Torquay specimen. Further, the entire platform is less well developed in the former, compared with that of the latter.

The individual on Plate 16, figs. 3, 4 is rather unusual with regard to the morphology of its platform, which is thicker (in profile) than in the rest of the material available, and the nodes of the ornament tend to be set in from the margins. These features are most apparent in the anterior outer platform, where the nodes are large, and are partly fused into a sculpted, longitudinal ridge-like development. This particular example otherwise conforms both with the other specimens from Torquay, and with the type material of Sch. pietzneri (Ziegler 1965b, pl. 2, figs. 11-25).

Range and occurrence: Sch. pietzneri most commonly occurs in the Upper hermanni - cristatus Subzone, but is known from the base of the Lower hermanni-cristatus Subzone through to the top of the Lowermost asymmetricus Zone (Ziegler 1971, chart 3; 1973, p. 431; in Klapper and Ziegler 1979, text - fig.5).

In Torquay, Sch. pietzneri occurs at Barton Quarry (samples BQ - 11, 18, 26, 28, 29, 30).

Schmidtognathus wittekindti ZIEGLER

Plate 15, figs. 17, 20, 24 (cf.).

v*1965 Schmidtognathus wittekindti n. sp. - ZIEGLER (b), p. 665-666, pl. 1, figs. 11-16, pl. 2, figs. 1-10 (pl. 2, figs. 8-10 = holotype)(see synonymy).

·1970 Schmidtognathus wittekindti ZIEGLER - KIRCHGASSER, p.352-353, pl. 65, figs. 3, 7.

·1973 Schmidtognathus wittekindti ZIEGLER - ZIEGLER, p. 433-434, Schmidtognathus - pl. 1, figs. 1a, 1b (originals of ZIEGLER 1965b, pl. 2, figs. 8, 9 respectively).

·1976 Schmidtognathus wittekindti ZIEGLER - ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON, pl. 3, figs. 36-39.

·1979 Schmidtognathus peracutus (BRYANT) - UYENO, p. 249, pl. 2, figs. 27-29.

Diagnosis: See Ziegler 1965b, p. 666; 1973, p. 433 (translation of original German).

Remarks and comparisons: *Sch*. *wittekindti* characteristically possesses an elongated, very narrow platform, which is triangular in outline, and which bears a single row of nodes on each margin, separated from the carina by well developed adcarinal grooves. In profile, the platform margins are clearly upturned and the platform appears thick, while the entire unit is strongly arched. The free blade occupies up to one-half of total unit length, and the blade denticles are conspicuously high in lateral view, the maximum height being developed more or less at blade mid-length. Aborally, the basal cavity is fairly large, and shows at least some degree of asymmetry. It is often developed close to the anterior end of the platform.

In the literature, specimens have been referred to *Sch*. *wittekindti* which approach *Sch*. *peracutus* in several respects (*e*.*g*. Ziegler 1965b, pl. 1, figs. 11-16, pl. 2, figs. 1, 2 (all cited as "*Sch*. *wittekindti*, tendency to *Sch*. *peracutus*"); Kirchgasser 1970, pl. 65, figs. 3, 7). In these individuals, the platform is flatter (in cross-section) and sometimes broader than is usual in *Sch*. *wittekindti*, and lacks the typically deep adcarinal grooves of this species. The oral surface sculpture resembles that of *Sch*. *peracutus*, because several longitudinal rows of low to rather more prominent nodes are developed on the platform, while a median row of similar nodes represents the carina, which is not distinct. The free blade is consistent with that of the former taxon in being remarkably high, but it may be short, and thus be closer to that of the latter species. For example, the free blade occupies only one-quarter of total unit length in Kirchgasser (1970, pl. 65, fig. 7). Aborally, the basal cavity may be rather small, and again resembles that of the latter species.

A specimen which Uyeno (1979, pl. 2, figs. 27-29) assigned to *Sch*. *peracutus* is thought herein to be intermediate between this species and *Sch*. *wittekindti*, but is considered to lie closer to the latter taxon. The individual approaches *Sch*. *peracutus* with regard to its overall platform morphology, but displays stronger similarities to *Sch*. *wittekindti* in that the free blade comprises almost one-half of total unit length and is very high in lateral view, while the entire unit is strongly arched in the same aspect.

A single form from Torquay is referred to Sch. wittekindti, and is consistent with the species in the length of the free blade, which occupies about one-half of total unit length, and in the pronounced arching of the entire unit in profile. The blade appears to be characteristic of the species also in its height, but this important diagnostic feature cannot be assessed accurately because the upper edge of the blade is broken, and a "cf." designation is therefore preferred for the specimen. The individual is somewhat atypical of Sch. wittekindti in that the platform is relatively broader and its margins are rather less upturned than is usual, and the basal cavity is fairly small. As in the material described above, these characters are all thought to indicate tendencies towards Sch. peracutus.

Sch. wittekindti is discussed further under the last taxon.

Range and occurrence: Sch. wittekindti ranges from within, and possibly from the base of, the Lower hermanni - cristatus Subzone, through into the middle of the Lowermost asymmetricus Zone (Ziegler in Klapper and Ziegler 1979, text-fig. 5). Ziegler (1973, p. 433) stated that specimens at the lower end of the age-range were few, and that the most common occurrence of the species was in the Upper hermanni - cristatus Subzone and the Lowermost asymmetricus Zone. He had previously shown the form to attain, possibly, the Lower asymmetricus Zone (Ziegler 1971, chart 3).

In Torquay, Sch. cf. wittekindti occurs at Barton Quarry (sample BQ - 1).

Schmidtognathus n. sp. A

Plate 15, figs. 21, 25, 26.

Description (Torquay material): The elongated, slender platform is more or less symmetrical and roughly lanceolate in outline, and is widest a little before its mid-length. The anterior platform margins are slightly stretched downwards and frame short adcarinal grooves, of which the outer is a little wider than the inner. The inner anterior platform margin meets the free blade at a shallow angle, whereas the outer anterior platform margin turns inward rather more bluntly and abruptly, to meet the free blade in a right angle, a little behind the inner margin. The ornament is developed throughout the length of the platform, and is more or less restricted to the borders, being separated from the carina by the shallow posterior extensions of the anterior adcarinal troughs. Posteriorly, the ornament consists of a few fine, irregular nodes. Anteriorly, the nodes are slightly coarser, and show a variable degree of transverse elongation, to produce a few rather weak and impersistent ridges, which only rarely extend to the carina. The nodes of the carina-fixed blade (about ten in number) are elongated and fused into a narrow crest, which is elevated above the otherwise rather flat upper surface of the platform (in profile), and which gradually rises in height from the posterior platform, anteriorward to the free blade. The last feature comprises about one-third of the estimated total unit length. The upper edge of the free blade is broken, but the blade does not appear to be deep in lateral view, and its lower border is straight whilst the platform is gently arched. In plan view, the length axis of the entire unit is weakly curved, concave inwards.

Aborally, a large basal cavity is situated in the anterior half of the platform. The cavity is subcircular in outline and is slightly asymmetrical, because the outer half is a little more broadly expanded, and is rather more bluntly rounded, than the inner. The rims are thickened, and stand above the lower surface of the platform. The keel is furrowed anteriorly beneath the free blade. The posterior keel is fairly high, extending from behind the cavity towards the broken posterior platform tip.

Remarks and comparisons: This proposed new species of Schmidtognathus is based on only one specimen, but is distinctive. Aborally, the basal cavity of *Sch*. n. sp. A resembles that of *Sch*. *pietzneri*, but exhibits a lesser degree of asymmetry than in the latter. The two taxa are readily distinguished in oral aspect, because the platform of *Sch*. n. sp. A lacks the distinct anterior lateral expansion, the rather triangular outline, and the incurved posterior tip characteristic of *Sch*. *pietzneri*, and approaches instead the platform morphology of *Sch*. *hermanni*. However, compared both with the last species, and with material to hand designated *Sch*. aff. *hermanni*, *Sch*. n. sp. A has a narrower platform which lacks anterior constrictions, and in which the greatest width is developed relatively further anteriorward. In aboral view, all representatives of *Sch*. *hermanni* are easily differentiated from *Sch*. n. sp. A with regard to the distinctive configuration of their often larger basal cavities, which are also located rather further posteriorward than in the latter.

One of the specimens from Torquay described as *Sch*.? aff. *gracilis*, shown on Plate 14, figs. 23, 24, 28, resembles *Sch*. n. sp. A in its rather biconvex platform outline, although the platform margins of *Sch*.? *gracilis* are usually parallel. However, compared with *Sch*. n. sp. A, both typical and atypical forms of *Sch*.? *gracilis* have more strongly upturned platform margins and better developed adcarinal grooves, while the anterior platform of the former taxon lacks the flat profile characteristic of all representatives of the latter, the carina-free blade instead clearly rising higher than the platform margins. The last-mentioned of the Torquay examples is similar to *Sch*. n. sp. A also in aboral view, but the basal cavity of *Sch*.? *gracilis* is typically a much larger development than that of *Sch*. n. sp. A, occupying a greater proportion of the lower surface of the platform, and sometimes exhibiting inversion.

Occurrence: In Torquay, *Sch*. n. sp. A occurs at Barton Quarry (sample BQ - 30).

Schmidtognathus n. sp. B

Plate 14, figs. 14-16, 19, 22.

Description (Torquay material): The unit is conspicuously thick and robust in all aspects. In plan view the length axis is weakly incurved, most strongly so posteriorly. The platform is about twice as long as broad and the two halves are similarly developed, although the outer half is a little wider than the inner. The platform margins are rather irregular and both exhibit a slight degree of outward curvature, but they are more or less parallel throughout their length. In the posterior part of the platform the margins curve fairly gradually to the rather blunt posterior tip, the curvature being a little more pronounced in the outer platform than in the inner. The anterior platform margins turn inward more abruptly and meet the free blade at steep angles, the outer margin joining a little posteriorward of the inner. Short, triangular (in oral view) anterior adcarinal troughs are developed, behind which the upper surface of the platform tends to be rather flat beneath the ornament. The ornament consists of a few irregular, fairly stout nodes in the specimen on Plate 14, figs. 14, 15, 22. The nodes tend to be set in from the margins, and are smallest, rounded (in outline) and randomly distributed posteriorly, but become transversely enlarged and more prominent anteriorly. In the example on Plate 14, figs. 16, 19 the nodes are more even-sized throughout the platform, and have partially coalesced into a fairly coarse, irregular network over much of its upper surface. A few discrete nodes are apparent posteriorly. In all the material the carina is a distinct, blunt fused ridge, which is higher than the upper surface of the platform in profile, and attains its maximum height a little behind platform mid-length. Thereafter, the carina becomes rapidly lower and slightly narrower, and does not quite reach the posterior platform tip. Just before the termination, one or two carinal nodes become a little more discrete.

In lateral view the entire unit is weakly arched, a little more strongly so in the posterior platform. The free blade is preserved only in the individual on Plate 14, figs. 14, 15, 22 in which it occupies roughly one-third of total unit length. The blade is not deep in profile, and the upper and lower edges appear subparallel, although the former is incomplete.

Aborally, a moderately large, thick rimmed basal cavity is located in the anterior half of the platform. The cavity shows some degree of asymmetry because the outer half is a little wider, and its margin more bluntly rounded, than the inner. In the specimen on Plate 14, figs. 14, 15, 22 a weak infolding is developed in the posterior part of the outer cavity margin. The blunt keel attains the platform tip posteriorly, and is furrowed anteriorly beneath the free blade.

Remarks and comparisons: As in Sch. n. sp. A, representatives of Sch. n. sp. B are rare, but again are distinctive. Their morphology is somewhat variable, but they share a thick, rather broad and irregular but more or less parallel sided platform, the oral surface of which is fairly flat beneath the rather coarse, irregular ornament, and the high, blunt, fused ridge of the carina. These features readily distinguish the proposed new species from other members of the genus, in which the platform is lanceolate, triangular, or narrow and parallel sided in outline, and the ornament is more regular, and is often separated from the carina by well developed adcarinal grooves. Aborally, the moderately large, thick rimmed, slightly asymmetrical basal cavity of Sch. n. sp. B is characteristic of the schmidtognathids. As described above, the outer cavity margin is infolded posteriorly in the example on Plate 14, figs. 14, 15, 22. An infolded posterior outer cavity margin is a diagnostic feature of Sch. hermanni, but, compared with this species, the basal cavity of Sch. n. sp. B is relatively smaller, less well defined and less strongly asymmetrical, and is also located rather further anteriorward.

In its robust nature, and in the outline and oral surface configuration of the platform, Sch. n. sp. B approaches Po. caelatus BRYANT. However, the platform outline is much more irregular and more variable in the latter, the ornament may be more strongly ridge-like, and the free blade is not well differentiated from the platform. Aborally, the basal cavity of *Po. caelatus* is more centrally positioned compared with that of *Sch.* n. sp. B, and is relatively smaller, and symmetrically circular or oval in outline.

Occurrence: In Torquay, *Sch.* n. sp. B occurs at Barton Quarry (sample BQ - 26).

Form genus Spathognathodus BRANSON & MEHL

Type species: Spathodus primus BRANSON & MEHL 1933b.

Remarks: Various forms have been referred to Spathognathodus in the literature, many of which have now been reassigned to other taxa (see Ziegler 1973, 1975, 1977), such as Ozarkodina and Eognathodus. Klapper and Philip (1971, p. 448-449) proposed Type 1 apparatuses for these two (multielemental) genera, which differed essentially only in the nature of the P element. This was spathognathodontan in the former and eognathodontan in the latter, while the O1, N, A1, A2 and A3 elements were ozarkodinan, neoprioniodontan or synprioniodontan, hindeodellan, plectospathodontan and trichonodellan, respectively, in both associations. Klapper and Philip (1972, p. 99) subsequently suggested that Polygnathus was probably derived from Ozarkodina, by way of Eognathodus. Just the P elements of Ozarkodina and Eognathodus are recognised in the Torquay faunas and are described below, the latter taxon being used as a form genus.

Weddige (1977, p. 326) established the form genus Tortodus, which has rare representatives in the collections to hand. As envisaged by him, the taxon receives spathognathodiform elements in which the denticulated bar is weakly to strongly twisted inwards (in plan view) posteriorly, where the denticles are lowest and incline outwards. The central and, sometimes, posterior parts of the bar are thickened beneath the denticles, to produce two ledge-like lateral expansions. The degree of thickening is variable, and the ledges may be only incipient, appearing just as slight lateral swellings of the bar, or they may be better developed and platform-like. Aborally, the basal cavity tends to be at least moderately flared. The multielemental position of Tortodus is not known.

Spathognathodus itself is retained herein in its form generic sense for those specimens which may have the role of an O1 (ozarkodinan) element in a Type 1 apparatus, such as that of the multielemental Polygnathus.

Spathognathodus planus BISCHOFF & ZIEGLER

Plate 18, figs. 9, 11.

v*1957 *Spathognathodus planus* n.sp. - BISCHOFF & ZIEGLER, p. 117, pl. 19, figs. 34, 35 (fig. 35 = holotype).

1970 *Spathognathodus planus* BISCHOFF & ZIEGLER - PEDDER, JACKSON & ELLENOR, pl. 16, figs. 5. 7.

1975 *Spathognathodus planus* BISCHOFF & ZIEGLER - BULTYNCK, p. 25, pl. 25, figs. 8, 9 (see synonymy).

·1978 *Spathognathodus planus* BISCHOFF & ZIEGLER - ORCHARD, p. 951, pl. 111, figs. 9, 13, 17.

·1978 *Polygnathus xylus* STAUFFER - UYENO, p. 17-18, pl. 4, fig. 4 (only: "01 element").

Diagnosis (after Bischoff and Ziegler 1957): A species of *Spathognathodus*, in which the blade is gently arched in lateral view, and bears closely arranged, posteriorly inclined denticles. The denticles are larger in the anterior half of the unit than in the posterior half. The basal cavity is a long, narrow groove.

Remarks and comparisons: Orchard (1978, p. 916, 938) thought that *Sp. planus* could be the 01 element of *Po. varcus s. l.*, while Uyeno (1978, p. 17) suggested that the form was the 01 element of the multielemental *Po. xylus*. *Sp. planus* is not common in the Torquay faunas although, when encountered, it is together with members of the *Po. varcus* group. However, it should be noted that the latter often occur without the former.

Orchard (1978, p. 951) described the range of morphological variation exhibited by representatives of *Sp. planus* in his Plymouth collections. He observed that they varied with regard to the extent of arching and sideways flexing of the unit, and to the regularity of the denticulation. He also noted that the denticle (the cusp) directly above the basal cavity tended to be slightly larger than those adjacent to it. Similar variations are apparent in the Torquay specimens. In profile, the last are consistent with the species in the gentle bowing (convex upwards) of the blade, and in the backwards inclination of the denticles in the posterior half of the unit, which are smaller than the rather more upright denticles of the anterior half.

Sp. planus is close to the older Sp. obliquus in morphology, the two taxa differing only in that the latter bears relatively fewer and less close spaced denticles. Sp. semialternans (WIRTH) resembles Sp. planus in that the anterior denticles tend to be larger than those in the posterior part of the unit, although the denticulation is more or less erect throughout the entire unit in the former. The upper edge of Sp. planus traces an approximate, convex upwards curve in lateral view, whereas the upper border of Sp. semialternans appears more nearly horizontal over the anterior two-thirds of the unit, and curves downwards only posteriorly. The basal cavity of the latter tends to be better developed than that of the former, and is located just a little further posteriorward, roughly at the beginning of the posterior one-third of the unit. The two taxa may be distinguished also with respect to the form of the aboral margin. In Sp. planus, the lower edge is weakly arched (convex upwards) either throughout the entire unit or just under the basal cavity. In contrast, and as Ziegler and Klapper (in Ziegler et al. 1976, p.118) described, the lower border of Sp. semialternans is straight to slightly curved (convex downwards) before the basal cavity, arches upwards under the cavity, and then arches downwards (tracing a convex upwards curve) behind the cavity.

Range and occurrence: Ziegler (1971, chart 2) showed Sp. planus to range from within the lower half of the (then) obliquimarginatus Zone through to the top of, and possibly higher than, the latericrescens horizon in the varcus Zone. In terms of correlations made by Weddige (1977, table 3), this span starts within the *ensensis* Zone. The *latericrescens* horizon was characterised by the joint occurrence of *I. l. latericrescens* and *Ancyrolepis walliseri*, and therefore represents a short interval about the Lower-Middle *varcus* Subzone boundary in Europe (Ziegler 1971, chart 2, p. 258; in Klapper and Ziegler 1979, text-fig. 5). By inference, the age range of *Sp. planus* extends upwards at least into the Middle *varcus* Subzone.

In Torquay, *Sp. planus* occurs at Lummaton Quarry (samples LM-9, 10, 17, 18) and Madrepore Road (sample MR-1).

Form genus *Eognathodus* PHILIP

Type species: *Eognathodus sulcatus* PHILIP 1965.

Eognathodus bipennatus montensis WEDDIGE

Plate 18, figs. 29-32 (cf.).

·1966 *Spathognathodus* cf. *bipennatus* BISCHOFF & ZIEGLER - BULTYNCK, p. B202-B203, pl. 2, figs. 4, 6, 7 (only: pl. 1, fig. 13, pl. 2, fig. 8 = *E. b. bipennatus*).

*·1977 *Eognathodus bipennatus montensis* n. ssp. - WEDDIGE, p. 324, pl. 6, figs. 95, 96 (fig. 95 = holotype)(see synonymy).

·1978 *Eognathodus bipennatus* (BISCHOFF & ZIEGLER) subsp. A. - PICKETT, p. 98-100, pl. 2, figs. 4-10, 11-13 (?), 14 (only).

?1979 *Eognathodus* aff. *E. bipennatus* (BISCHOFF & ZIEGLER) - CHATTERTON, p. 187-188, pl. 5, figs. 4, 5.

Diagnosis (after Weddige 1977): A subspecies of *E. bipennatus* in which, in lateral view, the anterior blade denticles are not conspicuously higher than the upper surface of the middle part of the unit. In the same aspect, the anterior edge of the blade is straight, inclines forward, and meets the aboral margin in a sharp angle of about eighty degrees. The basal cavity is located either at, or a little behind, unit mid-length.

Remarks and comparisons: E. b. montensis may be distinguished from the younger E. b. bipennatus (BISCHOFF & ZIEGLER) in profile. The anterior blade denticles of the latter are distinctly higher than the oral surface of the central part of the unit, are largely fused, and are developed such that the upper edge of the anterior blade describes an approximate, and rather high, semicircle. The anterior border of the unit shows a slight degree of curvature (convex outwards), and meets the aboral margin in a blunt, sometimes rounded, right angle. In contrast, the anterior blade denticles of the former are only a little higher than the oral surface of the middle part of the unit, and the trace of the upper edge of the anterior blade is either somewhat irregular or, when the denticles are developed at a similar height to each other, is fairly flat. The anterior margin of the unit is straight, inclines forward, and meets the lower border at a sharp, acute angle of about eighty degrees. In both taxa the basal cavity may be located at unit mid-length, or may be situated a little anteriorward of this position in the nominate subspecies, and slightly posteriorward in E. b. montensis.

In none of the available specimens is the anterior part of the unit completely preserved, but there is no indication of the high blade denticles characteristic of E. b. bipennatus. The basal cavity appears to be developed a little behind unit mid-length, consistent with E. b. montensis, although a "cf." designation is preferred because the material is broken. The aboral expansion is shallow in lower view, and is broadly flared and subrectangular in outline, most conspicuously so in larger growth stages (e.g. Pl. 18, figs. 30, 32).

The upper surface of the unit in all the Torquay examples tends to be abraded, but bears a few subdued, broad transverse ridges posteriorly, which are replaced anteriorly by a shallow longitudinal furrow. The last feature extends from a point above the posterior border of the basal cavity, to just before the anterior blade denticles, and is flanked by smooth longitudinal ridges. This manner of oral surface configuration is developed in representatives of both *E. b. montensis* and *E. b. bipennatus* in the literature, and also in some examples of the older (Lower Devonian) *E. sulcatus*. The longitudinal groove may sometimes extend close to the posterior extremity of the unit in *E. b. bipennatus* (*e.g.* Bischoff and Ziegler 1957, pl. 21, fig. 31: holotype), and both in this taxon, and in *E. sulcatus*, the ridges peripheral to the groove are commonly denticulated, comprising low but distinct nodes. The last two forms are similar in profile, but the basal cavity is located relatively further posteriorward in the latter, being developed in the posterior half of the unit.

Material from the base of the Funeral Formation in the southern Mackenzie Mountains of Canada, discussed and illustrated by Chatterton (1979, p. 173, 187-188, pl. 5, figs. 4, 5), may be referable to *E. b. montensis*, and is questionably included in synonymy herein. The specimens were designated *E.* aff. *E. bipennatus*, and Chatterton thought that they were intermediate between *E. sulcatus* and *E. bipennatus* [*E. b. bipennatus*] with regard to their morphology, and probably also to their phylogeny.

Range and occurrence: In the Eifelian Hills of Germany, *E. b. montensis* was recorded within the c. costatus Zone (Weddige 1977, tables 2, 5).

In Torquay, *E.* cf. *b. montensis* occurs at Dyer's Quarry (sample DY - 2), Peaked Tor Cove (samples PK - 3, 4) and at Triangle Point (sample TP - 12).

Genus *Ozarkodina* BRANSON & MEHL

Type species: *Ozarkodina typica* BRANSON & MEHL 1933b.

Ozarkodina brevis (BISCHOFF & ZIEGLER)

Plate 18, figs. 2-5, 7, 8, 12, 16, 20.

v*1957 *Spathognathodus brevis* n. sp. - BISCHOFF & ZIEGLER, p.116-117, pl. 19, figs. 24, 27-29 (fig. 28 = holotype).

1977 Ozarkodina brevis (BISCHOFF & ZIEGLER) - KLAPPER in ZIEGLER, p. 263-265, Ozarkodina - pl. 3, figs. 9a, 9b, 11 (figs. 9a, 9b = originals of ZIEGLER & KLAPPER in ZIEGLER, KLAPPER & JOHNSON 1976, pl. 3, figs. 15, 16 respectively; fig. 11 = fig. 9a at increased magnification)(see synonymy).

·1978 Ozarkodina brevis (BISCHOFF & ZIEGLER) - KLAPPER in JOHNSON & KLAPPER, pl. 1, figs. 13, 15 (only).

1978 Spathognathodus brevis BISCHOFF & ZIEGLER - ORCHARD, p. 951, pl. 108, figs. 22-24, 27.

1979 Ozarkodina brevis (BISCHOFF & ZIEGLER) - UYENO, p. 240, pl. 2, fig. 19.

·1979 Ozarkodina brevis (BISCHOFF & ZIEGLER) - SAVAGE & AMUNDSON, pl.1, figs. 3-6 (only).

·1980 Ozarkodina brevis (BISCHOFF & ZIEGLER) - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, fig. 15.

Diagnosis: See Bischoff and Ziegler 1957, p. 117; Klapper in Ziegler 1977, p. 263 (translation of original German).

Remarks and comparisons: The P element of O. brevis is distinctive, and is characterised by the development of a broadly flared basal cavity at the posterior extremity of the short blade. As the Torquay material illustrates, the basal cavity has a variable morphology, but it is always strongly laterally expanded with an asymmetrical and subquadrate or rather more circular outline, and projects a little beyond the posterior end of the blade. The blade itself is short and, in profile, is subrectangular and roughly twice as long as high. There are between nine and twelve blade denticles, of which the posteriormost (the cusp) tends to be the largest. In lateral view, the cusp is either erect (e.g. Pl. 18, fig. 8) or is posteriorly inclined (e.g. Pl. 18, figs. 4, 16).

Specimens referred to O. brevis in the literature exhibit variation with regard to the development of the posterior end of the blade. For example, Seddon (1970a, pl. 16, figs. 11, 12) and Uyeno (1979, pl. 2, fig. 19) figured material, from the Canning Basin of Australia and Powell Creek in Canada respectively, in which the cusp is exceptionally wide and high, and is strongly inclined posteriorly. Uyeno (1974, p. 42, pl. 7, figs. 11-13, pl. 8, figs. 4, 9) had previously designated O. cf. O. brevis (as Sp. cf. Sp. brevis) individuals from the Waterways Formation of Canada, which were unusual in that a small denticle was consistently developed behind the cusp, because of which the basal cavity was sometimes located a little anteriorward of the posterior extremity of the blade.

Seddon (1970a, p. 740) thought that O. brevis resembled Pelekysgnathus planus in profile but, as Klapper (in Ziegler 1977, p. 263) observed, the two taxa may be easily differentiated by the nature of the basal cavity. In the former, the cavity abruptly narrows anteriorward of the broad but rather shallow expansion, to produce a groove which extends to the anterior end of the blade. In the latter, as in all pelekysgnathids, there is a deep aboral excavation, similar to the basal cavity of the icriodids. Also, the individual blade denticles are less distinct in Pel. planus than in O. brevis.

Range and occurrence: Klapper (in Ziegler 1977, p. 264) stated that O. brevis ranged from the Lower varcus Subzone through into the Lowermost asymmetricus Zone, and that the species may have been recorded in younger faunas by Bischoff and Ziegler (1957, p.33-34). Ziegler (in Klapper and Ziegler 1979, text-fig. 5) showed the age range of O. brevis to extend from the upper part of the Lower varcus Subzone into the Middle varcus Subzone, and possibly through to the top of the Upper hermanni - cristatus Subzone. Other records of the species suggest that it may occur below the Lower varcus Subzone. Pedder et al. (1970, p. 263-265) reported the form from the Timor Limestone of

New South Wales, where the associated faunas, which included O. bidentata and E. b. bipennatus (as Sp. bidentatus subspp. and Sp. bipennatus respectively) indicate correlation with the ensensis Zone. In Plymouth, Orchard (1978, p. 914-915, text-fig. 2, table 1) found O. brevis at Gasworks Quarry (samples GQ16, 20) in Fauna 6, which was referred to the (then) obliquimarginatus Zone.

In Torquay, O. brevis occurs at Babbacombe Cliff (samples BC-21, 32), Barton Quarry (samples BQ-11, 12, 29), Lummaton Quarry (samples LM-1, 3, 6, 7, 10, 11, 13, 15, 18) and Parkfield Road (PF-5).

Ozarkodina sannemanni sannemanni (BISCHOFF & ZIEGLER)

Plate 19, figs. 25, 27-32.

v*1957 Spathognathodus sannemanni n. sp. - BISCHOFF & ZIEGLER, p.117-118, pl. 19, figs. 15, 19-23, 25 (figs. 15, 21 = holotype).

1958 Spathognathodus sannemanni sannemanni BISCHOFF & ZIEGLER - ZIEGLER, p. 72, pl. 9, fig. 15.

·1959 Spathognathodus sannemanni sannemanni BISCHOFF & ZIEGLER - KREBS, pl. 1, fig. 10.

·1968 Spathognathodus sannemanni sannemanni BISCHOFF & ZIEGLER - POLLOCK, p. 440, pl. 63, figs. 10, 11.

·1969 Spathognathodus sannemanni sannemanni BISCHOFF & ZIEGLER - SCHÖNLAUB, pl. 1, fig. 26.

·1980 Ozarkodina sannemanni (BISCHOFF & ZIEGLER) - KLAPPER in JOHNSON, KLAPPER & TROJAN, pl. 3, fig. 37.

Diagnosis (after Bischoff and Ziegler 1957): A subspecies of O. sannemanni, in which the entire blade is bowed (convex outwards) in oral aspect, and the posteriormost part may be deflected inwards. The basal cavity is located a little behind unit mid-length, and is broadly expanded to produce two unequal platform-like developments, each of which is semicircular in outline, and bears one to three distinct nodes orally.

Remarks and comparisons: Several subspecies of *O. sannemanni* have been proposed. Ziegler (1958, p. 72-73) erected *O. s. treptus* (as *Sp. s. treptus*), which was slightly younger than the nominate subspecies. The former is characterised by the nature of the posterior part of the unit, where the blade is strongly deflected inwards (in plan view) behind the basal cavity, and at the same time is twisted outwards (in the vertical plane). The expansion of the basal cavity is less in *O. s. treptus* than in *O. s. sannemanni*, and so the platform-like lateral expansions are not as well developed as in the latter.

Pollock (1968, p. 439-440) described four new subspecies of *O. sannemanni* (as *Sp. sannemanni*), which were distinguished from each other, and from the nominate subspecies, essentially in the number (or absence) of denticles on the oral surfaces of the inner and outer lateral expansions. The validity of at least some of Pollock's new forms appears to be doubtful. His "*Sp. s. adventa*" is very small compared with his other new forms and with the nominate subspecies, and could be a juvenile growth phase of one of the last. All of his new taxa occurred in more or less the same faunas, usually together with *O. s. sannemanni*, and it is possible that the former may, in fact, lie within the range of morphological variation of the latter.

The material from Torquay is broken, but comprises several growth stages. In the smallest forms (*e.g.* Pl. 19, fig. 30) two unequal lateral bulges are present on either side of the blade. The lateral expansions become better developed and clearly more semicircular in outline with ontogeny, one node gradually becoming more distinct on the oral surface of each platform-like projection, as in the largest of the Torquay specimens on Plate 19, figs. 25, 27-29, 32. Mature examples of *O. s. sannemanni* consequently approach *A. r. binodosa*, but the nodes are developed rather more from the blade in the former, instead of clearly from the platform as in the latter. This distinction remains valid even with regard to juveniles of A. r. binodosa to hand (e. g. Pl. 16, figs. 17, 18, 22).

Range and occurrence: Ziegler (in Klapper and Ziegler 1979, text-fig. 5) showed O. sannemanni [sic] to range from the base of the Upper varcus Subzone, through into the higher part of the Middle asymmetricus Zone. O. s. treptus seems to be confined to within the Upper asymmetricus Zone (compare Ziegler loc. cit. with Ziegler 1958, table 10), so the former age range is taken to be that of O. s. sannemanni. In Torquay, O. s. sannemanni occurs at Babbacombe Cliff (samples BC-11, 33) and Barton Quarry (samples BQ-18, 23); O. sannemanni subsp. indet. at Petit Tor Beach (samples PB-6, 12).

Form genus Tortodus WEDDIGE

Type species: Tortodus kockelianus (BISCHOFF & ZIEGLER 1957)

Tortodus variabilis (BISCHOFF & ZIEGLER)

Plate 18, figs. 1, 6 (aff.).

v*1957 Polygnathus? variabilis n. sp. - BISCHOFF & ZIEGLER, p. 99-100, pl. 18, figs. 8-17, pl. 19, figs. 10, 11, 16, 17 (pl. 18, fig. 13 = holotype).

•1971 Polygnathus variabilis BISCHOFF & ZIEGLER - ORR, p. 54, pl. 5, figs. 1-3.

•1977 Tortodus variabilis (BISCHOFF & ZIEGLER) - WEDDIGE, p. 330, pl. 3, fig. 57.

•1979 Tortodus variabilis (BISCHOFF & ZIEGLER) - LANE, MÜLLER & ZIEGLER, p. 220, pl. 2, figs. 6, 7.

Remarks and comparisons: A single specimen from Torquay is tentatively referred to this rather variable species. The individual is strongly bowed (concave inwards) in plan view, and the unit is laterally thickened posteriorly to produce two ledge-like projections, of which the outer is a little wider than the inner. The anterior part of the unit is poorly preserved, but is high in profile and appears to be denticulated. The upper edge becomes rapidly lower posteriorward, where the oral surface of the thickened part of the unit bears a rather blunt, fused, ridge-like carina which is lowest towards, and attains, the posterior tip. Narrow transverse ridges are developed on the carina, and curve round its upper surface.

Orchard (1978, p. 950-951, pl. 110, figs. 3, 5, 6, 8, 11, 15, 16, 19, 25) designated Po. aff. variabilis specimens from Plymouth which were characterised by the development of a linguiform tongue. The Torquay example approaches the Plymouth material in the cross-ridged carina, although a true tongue is not developed in the former. Also, the lateral expansions tend to be more pronounced and platform-like in Orchard's individuals, and bear an ornament of nodes and/or short, irregular ridges. In contrast, the oral surfaces of the lateral projections in the available specimen are more or less smooth.

Range and occurrence: In the Eifelian Hills of Germany, T. variabilis ranges from within the upper half of the ensensis Zone, sporadically into the Lower varcus Subzone (Weddige 1977, tables 2, 5). In Plymouth, "Po. aff. variabilis" was recorded from Princerock Quarry (samples PS 3, 4), Cattedown Quarry (sample CQ 10) and Gasworks Quarry (samples GQ 16, 20): all Fauna 6, referred to the (then) obliquimarginatus Zone, and also in Cattedown Quarry, sample CQ 8 (Orchard 1978, p. 914, text-fig. 2, table 1).

In Torquay, T. aff. variabilis occurs at Redgate Beach (sample RB-2).

REFERENCES

ADRICHEM BOOGAERT, H.A. VAN. 1967. Devonian and Lower Carboniferous conodonts of the Cantabrian Mountains (Spain) and their stratigraphic application. Leidse geol. Meded., 39: 129-192.

ANDERSON, W.I. 1966. Upper Devonian conodonts and the Devonian-Mississippian boundary of north-central Iowa. J. Paleont., 40: 395-415.

ARBIZU, M., GARCIA-ALCALDE, J.L., GARCIA-LOPEZ, S., MENDEZ-BEDIA, I., SANCHEZ DE POSADA, L.C., SOTO, F.M., TRUYOLS, M., TRUYOLS., J., ALVAREZ, F., MENDEZ, C. & MENENDEZ, J.R. 1979. Biostratigraphical study of the Moniello Formation (Cantabrian Mountains, Asturias, NW Spain). Geol. et Palaeontol., 13: 103-124.

AUSTEN, R.A.C. 1842. On the geology of the South-east of Devonshire. Trans. geol. Soc. Lond. (Ser. 2), 6: 433-489.

AUSTIN, R.L. 1967. New conodont horizons in S.W. England. Proc. Ussher Soc., 1: 282-283.

BISCHOFF, G. & ZIEGLER, W. 1957. Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons. Abh. hess. Landesamt. Bodenforsch., 22: 1-136.

BLYTH, F.G.H. 1957. The Lustleigh Fault in North-east Dartmoor. Geol. Mag., 94: 291-296.

BOOGAARD, M. VAN DEN. 1972. Conodont faunas from Portugal and southwestern Spain. Part 1. A Middle Devonian fauna from near Montemor-o-Novo. Scripta Geol., 13: 1-11.

BOUCKAERT, J., MOURAVIEFF, A., STREEL, M., THOREZ, J. & ZIEGLER, W. 1972. The Frasnian-Famennian boundary in Belgium. Geol. et Palaeontol., 6: 87-92.

——— & STREEL, M. 1974 (eds). Guidebook to the International Symposium on Belgian Micropaleontological Limits. Namur 1974.

BRAITHWAITE, C.J.R. 1966. The petrology of Middle Devonian limestones in South Devon, England. J. sedim. Petrol., 36: 176-192.

——. 1967. Carbonate environments in the Middle Devonian of South Devon, England. Sediment. Geol., 1:283-320.

BRANSON, E.B. & MEHL, M.G. 1933a. A study of Hinde's types of conodonts preserved in the British Museum. Univ. Mo. Stud., 8: 133-167.

—— & ——. 1933b. Conodonts from the Bainbridge (Silurian) of Missouri. Ibid., 8: 39-52.

—— & ——. 1934. Conodonts from the Grassy Creek Shale of Missouri. Ibid., 8: 171-259.

—— & ——. 1938. The conodont genus Icriodus and its stratigraphic distribution. J. Paleont., 12: 156-166.

BRYANT, W.L. 1921. The Genesee Conodonts. Bull. Buffalo Soc. nat. Sci., 13: 1-59.

BULTYNCK, P. 1965. Contribution à l'étude des corrélations stratigraphiques entre le Massif schisto-rhénan et l'Ardenne. Étude d'une faunule à Conodontes dans un petit bioherme du Couvinien supérieur à Couvin. Annls. Soc. géol. Belg., 88: 61-72.

——. 1966. Répartition stratigraphique de quelques Conodontes dans le Couvinien. Ibid., 89: 189-206.

——. 1970. Révision stratigraphique et paléontologique (Brachiopodes et Conodontes) de la coupe type du Couvinien. Mem. Inst. géol. Univ. Louvain, 26: 152 pp.

——. 1972. Middle Devonian Icriodus assemblages (Conodonta). Geol. et Palaeontol., 6: 71-86.

——. 1975. Conodontes de la Formation de Fromelennes, du Givetien de l'Ardenne Franco-Belge. Bull. Inst. r. Sci. nat. Belg., 50 (Sci. Terre 10): 30 pp.

——. 1976. Le Silurien supérieur et le Devonien inférieur de la Sierra de la Guadarrama (Espagne Centrale). Troisième partie: elements icriodiformes, pelekysgnathiformes et polygnathiformes (1). *Ibid.*, *49* (Sci. Terre 5): 74 pp.

CARLS, P. 1979. Emsian-Eifelian stratigraphy of the Eastern Iberian Chains. *In* GARCIA-ALCALDE, J.L. *et al.* (ed.). *Meeting of the International Subcommission on Devonian stratigraphy*. *Guidebook of the field trip*: 35-39. Oviedo.

——— & GANDL, J. 1969. Stratigraphie und Conodonten des Unter-Devons der Östlichen Iberischen Ketten (N.E. Spanien). *Neues Jb. Geol. Paläont. Abh.*, *132*: 155-218.

CASTLE, C. 1977. Conodonts from Middle/Upper Devonian boundary beds at Barton Quarry, Torquay (Abstract). *Proc. Ussher Soc.*, *4*: 62.

———. 1978. Conodont faunas from Babbacombe Cliff, Torquay. *Ibid.*, *4*: 129-134.

CHALYMBADSCHA, W.G. & TSCHERNYSHEVA, N.G. 1969. The stratigraphic importance of Upper Devonian conodonts in the Volga-Kama region and the possibility of their evaluation for international correlation. *Dokl. Akad. Nauk. SSSR*, *184*: 1170-1173 [in Russian].

——— & ———. 1970. Conodonts of the genus *Ancyrodella* from the Devonian strata of the Volga-Kama region and their stratigraphical significance. *In* Biostratigraphy and palaeontology in the east of the Russian platform and the western Ural range. *Kasan Staatsuniv.*, 1: 81-102 [in Russian].

CHAMPERNOWNE, A. 1874. On a contortion of the limestone of Torquay, and the presence of *Calceola sandalina* at its base. *Rep. Trans. Devon. Ass. Advmt Sci.*, *6*: 548-551.

———. 1878. Notes on the Devonians and Old Red Sandstone of North and South Devon. *Geol. Mag.* (Dec. 2), *5*: 193-199.

———. 1881. The Ashburton Limestone: its age and relations. *Ibid.*, *8*: 410-416.

———. 1884. On some zaphrentoid corals from British Devonian Beds. *Q. Jl geol. Soc. Lond.*, *40*: 497-506.

CHATTERTON, B.D.E. 1974. Middle Devonian conodonts from the Harrogate Formation, southeastern British Columbia. Can. J. Earth Sci., 11: 1461-1484.

——. 1976. Distribution and paleoecology of Eifelian and Early Givetian conodonts from western and northwestern Canada. In BARNES, C.R. (ed.). Conodont Paleoecology. Spec. Pap. geol. Ass. Can., 15: 143-157.

——. 1979. Aspects of late Early and Middle Devonian conodont biostratigraphy of western and northwestern Canada. In STELCK, C.R. & CHATTERTON, B.D.E. (eds). Western and Arctic Canadian biostratigraphy. Spec. Pap. geol. Ass. Can., 18: 161-231.

CLARK, D.L. & ETHINGTON, R.L. 1967. Conodonts and zonation of the Upper Devonian in the Great Basin. Mem. geol. Surv. Am., 103: 94 pp.

COEN, M. & COEN-AUBERT, M. 1971. L'Assise de Fromelennes aux bords sud et est du bassin de Dinant et dans le Massif de la Vesdre. Annls. Soc. géol. Belg., 94: 5-20.

COLLINSON, C. 1963. Collection and preparation of conodonts through mass production techniques. Circ. Ill. St. geol. Surv., 343: 16 pp.

DAVIDSON, T. 1864-1865. Monograph of the British Devonian Brachiopoda. Parts 1 and 2. Palaeontogr. Soc. (Monogr.).

——. 1882-1884. Supplement to the British Devonian Brachiopoda. Palaeontogr. Soc. (Monogr.).

DEARMAN, W.R. 1963. Wrench-faulting in Cornwall and South Devon. Proc. Geol. Ass., 74: 265-287.

DE LA BECHE, H.T. 1829. On the geology of Tor and Babbacombe Bays, Devon. Trans. geol. Soc. Lond. (Ser. 2), 3: 161-170.

——. 1839. Report on the Geology of Cornwall, Devon and West Somerset. London.

DINELEY, D.L. 1961. The Devonian System in South Devonshire. Fld. Stud., 1: 121-140.

——— & RHODES, F.H.T. 1956. Conodont horizons in the west and south-west of England. Geol. Mag., 93: 242-248.

DRUCE, E.C. 1973. Upper Paleozoic and Triassic conodont distribution and the recognition of biofacies. In RHODES, F.H.T. (ed.). Conodont Paleozoology. Spec. Pap. geol. Soc. Am., 141: 191-237.

———. 1974. Australian Devonian and Carboniferous conodont faunas. In BOUCKAERT, J. & STREEL, M. (eds). International Symposium on Belgian Micropaleontological Limits, Namur 1974: Publication 5, 18 pp.

DUFFIELD, S.L. & WARSHAUER, S.M. 1981. Upper Devonian (Frasnian) conodonts and ostracodes from the subsurface of western West Virginia. J. Paleont., 55: 72-85.

EDWARDS, H.M. & HAIME, J. 1853. A Monograph of the British fossil corals: Part IV. Corals from the Devonian formation. Palaeontogr. Soc. (Monogr.).

ELLIOTT, G.F. 1961. A new British Devonian alga, Palaeoporella lummatonensis, and the brachiopod evidence for the age of the Lummaton Shell-Bed. Proc. Geol. Ass., 72: 251-260.

EPSTEIN, A.G., EPSTEIN, J.B. & HARRIS, L.D. 1977. Conodont color alteration - an index to organic metamorphism. Prof. Pap. U.S. geol. Surv., 995: 27 pp.

ERBEN, H.K. 1962. Zur Analyse und Interpretation der Rheinischen und Hercynischen Magnafazies des Devons. Symposium Silur/Devon-Grenze, 1960, 2: 42-61.

———. 1964. Facies developments in the Marine Devonian of the Old World. Proc. Ussher Soc., 1: 92-118.

——— & ZAGORA, K. 1968. Devonian of Germany. In OSWALD, D.H. (ed.). International Symposium on the Devonian System, 1: 53-68.

ETHINGTON, R.L. & FURNISH, W.M. 1962. Silurian and Devonian conodonts from Spanish Sahara. J. Paleont., 36: 1253-1290.

FLAJS, G. 1966. Die Mitteldevon/Oberdevon-Grenze im Paläozoikum von Graz. Neues Jb. Geol. Paläont. Abh., 124: 221-240.

FORDHAM, B.G. 1976. Geology and Lower-Middle Devonian Coral Conodont Biostratigraphy of the Nogoa Anticline, Springsure District, Central Queensland. Proc. R. Soc. Qd., 87: 63-76.

GARCIA-ALCALDE, J.L., ARBIZU, M.A., GARCIA-LOPEZ, S. & MENDEZ-BEDIA, J. 1979. Cantabrian Mountains (NW Spain). In GARCIA-ALCALDE, J.L. et al. (ed.). Meeting of the International Subcommission on Devonian stratigraphy. Guidebook of the field trip: 4-31. Oviedo.

GARCIA-LOPEZ, S. 1976. La Caliza de Candas en la zona de Luanco (Asturias) y su contenido en conodontos. Trab. geol., 8: 173-185.

GLENISTER, B.F. & KLAPPER, G. 1966. Upper Devonian Conodonts from the Canning Basin, Western Australia. J. Paleont., 40: 777-842.

——— ——— & CHAUFF, K.M. 1976. Conodont Pearls? Science, 193: 571-573.

GUPTA, V.J. 1975. Upper Devonian conodonts from Phulchauki, Nepal. Himalayan Geology, 5: 153-168.

HASS, W.H. 1947. Conodont zones in the Upper Devonian and Lower Mississippian formations of Ohio. J. Paleont., 21: 131-141.

———. 1951. Age of the Arkansas novaculite. Bull. Am. Ass. Petrol. Geol., 35: 2526-2541.

———. 1956. Age and correlation of the Chatanooga Shale and the Manry Formation. Prof. Pap. U.S. geol. Surv., 268: 47 pp.

———. 1959. Conodonts from the Chappel Limestone of Texas. Ibid., 294: 365-399.

———. 1962. Conodonts. In MOORE, R.C. (ed.). Treatise on Invertebrate Paleontology. Part W, Miscellanea: W3-W69.

HELMS, J. 1963. Zur "Phylogenese" und Taxionomie von Palmatolepis (Conodontida, Oberdevon). Geologie, 12: 449-485.

——— & ZIEGLER, W. (in press). On Phylogeny of the Genus Palmatolepis. In Treatise on Invertebrate Paleontology. Vol. W, 2nd. edition.

HENDRIKS, E.M.L., HOUSE, M.R. & RHODES, F.H.T. 1971. Evidence bearing on the stratigraphical successions in South Cornwall. Proc. Ussher Soc., 2: 270-274.

HINDE, G.J. 1879. On conodonts from the Chazy and Cincinnati Group of the Cambro-Silurian, and from the Hamilton and Genesee-Shale Divisions of the Devonian, in Canada and the United States. Q. Jl geol. Soc. Lond., 35: 351-369.

HOLL, H.B. 1868. On the older rocks of South Devon and East Cornwall. Ibid., 24: 400-454.

HOUSE, M.R. 1963. Devonian ammonoid successions and facies in Devon and Cornwall. Ibid., 119: 1-27.

——. 1964. A new goniatite locality at Babbacombe and its problems. Proc. Ussher Soc., 1: 125-126.

——. 1968. Devonian ammonoid zonation and correlations between North America and Europe. In OSWALD, D.H. (ed.). International Symposium on the Devonian System, 2: 1061-1068.

——. 1973. Delimitation of the Frasnian. Acta geol. pol., 23: 1-14.

——. 1975. Facies and time in Devonian tropical areas. Proc. Yorks. geol. Soc., 40: 233-288.

——. 1977. Introduction; Subdivision of the marine Devonian; South-west England. In HOUSE et al. A correlation of Devonian rocks of the British Isles. Geol. Soc. Lond., Special Report No. 7: 110 pp.

——. 1979. Biostratigraphy of the early Ammonoidea. In HOUSE, M.R., SCRUTTON, C.T. & BASSETT, M.G. (eds). The Devonian System. Spec. Pap. Palaeontology, 23: 263-280.

—— & BUTCHER, N.E. 1962. Excavations in the Devonian and Carboniferous rocks of the Chudleigh area, South Devon. Proc. Ussher Soc., 1: 28-29.

—— & SELWOOD, E.B. 1964. Palaeozoic palaeontology in Devon and Cornwall. In HOSKING, K.F.G. & SCHRIMPTON, G.J. (eds). Present views of some aspects of the geology of Cornwall and Devon. R. geol. Soc. Corn., Commemm. Vol. for 1964: 45-86.

—— & ZIEGLER, W. 1977. The goniatite and conodont sequences in the early Upper Devonian at Adorf, Germany. Geol. et Palaeontol., 11: 69-108.

HUDDLE, J.W. 1934. Conodonts from the New Albany Shale of Indiana. Bull. Am. Paleont., 21, bulletin 72: 136 pp.

——. 1968. Redescription of Upper Devonian conodont genera and species proposed by Ulrich and Bassler 1926. Prof. Pap. U.S. geol. Surv., 578: 55 pp.

——. 1970. Revised descriptions of some Late Devonian polygnathid conodonts. J. Paleont., 44: 1029-1040.

——. 1972. Historical introduction to the problem of conodont taxonomy. In LINDSTRÖM, M. & ZIEGLER, W. (eds). Symposium on conodont taxonomy. Geol. et Palaeontol., SB 1: 3-16.

JOHNSON, J.G. & KLAPPER, G. 1978. Devonian brachiopods and conodonts from central Oregon. J. Paleont., 52: 295-299.

—— —— & TROJAN, W.R. 1980. Brachiopod and conodont successions in the Devonian of the northern Antelope Range, central Nevada. Geol. et Palaeontol., 14: 77-116.

JUKES-BROWNE, A.J. 1906. The Devonian limestones of Lummaton Hill, near Torquay. Proc. Geol. Ass., 19: 291-302.

——. 1907. The age and origin of the plateaus around Torquay. Q. Jl geol. Soc. Lond., 63: 106-123.

——. 1912. The making of Torbay. Trans. Devon. Ass. Advmt Sci., 44: 718-731.

——. 1913. The Devonian limestones of Dartington, and their equivalents at Torquay. Proc. Geol. Ass., 24: 14-32.

——. 1914. The lost land of Torbay. Trans. Torquay nat. Hist. Soc., 1: 287-296.

—— & NEWTON, R.B. 1914. The fossils found on the site of the Torquay Museum. Geol. Mag., 51: 311-318.

KAYSER, F.H.E. 1889. Ueber das Devon in Devonshire und im Boulonnais. Neues Jb. Miner. Geol. Paläont., 1: 179-191.

KERSHAW, S. & RIDING, R. 1980. Stromatoporoid morphotypes of the Middle Devonian Torbay Reef Complex at Long Quarry Point, Devon. *Proc. Ussher Soc.*, *5*: 13-23.

KIRCHGASSER, W.T. 1970. Conodonts from near the Middle/Upper Devonian boundary in North Cornwall. *Palaeontology*, *13*: 335-354.

KLAPPER, G. 1969. Lower Devonian conodont sequence, Royal Creek, Yukon Territory, and Devon Island, Canada, with a section on Devon Island stratigraphy by A.R. Ormiston. *J. Paleont.*, *43*: 1-27.

———. 1971. Sequence within the conodont genus *Polygnathus* in the New York lower Middle Devonian. *Geol. et Palaeontol.*, *5*: 59-79.

———. 1977. Lower and Middle Devonian conodont sequence in central Nevada. *In* MURPHY, M.A., BERRY, W.B.N. & SANDBERG, C.A. (eds). Western North America: Devonian. *Univ. of California*, *Riverside Campus Museum Contribution*, *4*: 33-54.

———. 1981. Review of New York Devonian conodont biostratigraphy. *In* *Devonian Biostratigraphy of New York*. Subcommission on Devonian Stratigraphy, July 1981: 57-66.

——— & FURNISH, W.M. 1963. Conodont zonation of the early Upper Devonian in eastern Iowa. *Proc. Iowa Acad. Sci.*, *69*: 400-410.

——— & JOHNSON, D.B. 1975. Sequence in conodont genus *Polygnathus* in Lower Devonian at Lone Mountain, Nevada. *Geol. et Palaeontol.*, *9*: 65-83.

——— & JOHNSON, J.G. 1980. Endemism and dispersal of Devonian conodonts. *J. Paleont.*, *54*: 400-455.

——— & PHILIP, G.M. 1971. Devonian conodont apparatuses and their vicarious skeletal elements. *Lethaia*, *4*: 429-452.

——— & ———. 1972. Familial classification of reconstructed Devonian conodont apparatuses. *In* LINDSTRÖM, M. & ZIEGLER, W. (eds). Symposium on conodont taxonomy. *Geol. et Palaeontol.*, *SB 1*:97-105.

——— ——— & JACKSON, J.H. 1970. Revision of the *Polygnathus* *varcus* Group (Conodonta, Middle Devonian). *Neues Jb. Geol. Paläont. Mh.*, *11*: 650-667.

———, SANDBERG, C.A., COLLINSON, C., HUDDLE, J.W., ORR, R.W., RICKARD, L.V., SCHUMACHER, D., SEDDON, G. & UYENO, T.T. 1971. North American Devonian conodont biostratigraphy. *Mem. geol. Soc. Am.*, *127*: 285-316.

——— & ZIEGLER, W. 1977. *Distribution of conodonts in Lower/Middle Devonian boundary beds of the Barrandian.* Submission to I.U.G.S.-Subcommission on Devonian stratigraphy, Prague Field Conference, October 1977: 4 pp.

——— & ———. 1979. Devonian conodont biostratigraphy. *In* HOUSE, M.R., SCRUTTON, C.T. & BASSETT, M.G. (eds). The Devonian System. *Spec. Pap. Palaeontology*, *23*: 199-224.

——— ——— & MASHKOVA, T.V. 1978. Conodonts and correlation of Lower-Middle Devonian boundary beds in the Barrandian area of Czechoslovakia. *Geol. et Palaeontol.*, *12*: 103-116.

KREBS, W. 1959. Zur Grenze Mittel-/Ober Devon und zur Gliederung des obersten Mittel-Devons und der tieferen Adorf-Stufe nach Conodonten. *Senckenberg*. *leth.*, *40*: 367-387.

———. 1969. Early void-filling cementation in Devonian fore-reef limestones (Germany). *Sedimentology*, *12*: 279-299.

———. 1979. Devonian basinal facies. *In* HOUSE, M.R., SCRUTTON, C.T. & BASSETT, M.G. (eds). The Devonian System. *Spec. Pap. Palaeontology*, *23*: 125-139.

——— & ZIEGLER, W. 1965. Uber die Mitteldevon/Oberdevon-Grenze in der Riffazies bei Aachen. *Fortschr. Geol. Rheinld. Westf.*, *9*: 731-754.

KULLMANN, J. & ZIEGLER, W. 1970. Conodonten und Goniatiten von der Grenze Mittel-/Oberdevon aus dem Profil am Martenberg (Ostrand des Rheinischen Schiefergebirges). *Geol. et Palaeontol.*, *4*: 73-85.

LANE, H.R. 1968. Symmetry in conodont element pairs. *J. Paleont.*, *42*: 1258-1263.

———, MÜLLER, K.J. & ZIEGLER, W. 1979. Devonian and Carboniferous conodonts from Perak, Malaysia. *Geol. et Palaeontol.*, *13*: 213-226.

——— & ORMISTON, A.R. 1979. Siluro-Devonian biostratigraphy of the Salmontrout River Area, east-central Alaska. Ibid., 13: 39-96.

LANGE, F.G. 1968. Conodonten-Gruppenfunde aus Kalken des tieferen Oberdevon. Ibid., 2: 37-57.

LINDSTRÖM, M. 1970. A supragenic taxonomy of the conodonts. Lethaia, 3: 427-445.

——— & ZIEGLER, W. 1965. Ein Conodontentaxon aus vier morphologisch verschiedenen Typen. Fortschr. Geol. Rheinld. Westf., 9: 209-218.

LLOYD, W. 1933. The geology of the country around Torquay (2nd. edn.). Mem. geol. Surv. Engld & Wales: x + 169 pp.

LONSDALE, W. 1840. Notes on the age of the limestones of South Devonshire. Trans. geol. Soc. Lond. (Ser. 2), 5: 721-738.

McGREGOR, D.C. & UYENO, T.T. 1972. Devonian spores and conodonts of Melville and Bathurst Islands, District of Franklin. Geol. Surv. Can., Paper 71-13: 37 pp.

McLAREN, D.J. 1970. Time, life and boundaries. J. Paleont., 44: 801-815.

MATTHEWS, S.C. 1962. A Middle Devonian conodont fauna from the Tamar Valley. Proc. Ussher Soc., 1: 27-28.

———. 1970. Conodonts from the Lummaton Shell Bed (Middle Devonian, Torquay). Ibid., 2: 170-172.

———. 1977. The Variscan foldbelt in southwest England. Neues Jb. Geol. Paläont. Abh., 154: 94-127.

MILLER, A.K. & YOUNGQUIST, W. 1947. Conodonts from the type section of the Sweetland Creek shale in Iowa. J. Paleont., 21: 501-517.

MIRAUTA, E. 1971. Étude des conodontes devoniennes de la Dobrogea Septentrionale (Zone de Tulcea). Mem. Inst. géol. Bucarest, 14: 7-34.

MOUND, M.C. 1968. Upper Devonian conodonts from Southern Alberta. J. Paleont., 42: 444-524.

MOURAVIEFF, N.A. 1977. Additional conodonts from near the Middle/Upper Devonian boundary in North Cornwall; a progress report. Proc. Ussher Soc., 4: 63-66.

——— & BOUCKAERT, J. 1973. MAILLIEUX's (1940) Manticoceras intumescens (BEYREICH) in the Belgian Frasnian with respect to the conodont zonation. Geol. et Palaeontol., 7: 93-95.

MÜLLER, K.J. 1956. Zur Kenntnis der Conodonten-Fauna des europäischen Devons. I. Die Gattung Palmatolepis. Abh. senckenb. naturforsch. Ges., 494: 1-70.

——— & CLARK, D.L. 1967. Early Late Devonian conodonts from the Squaw Bay Limestone in Michigan. J. Paleont., 41: 902-912.

——— & MÜLLER, E.M. 1957. Early Upper Devonian (Independence) conodonts from Iowa, part 1. Ibid., 31: 1069-1108.

NICHOLSON, H.A. 1886-1892. A monograph of the British stromatoporoids. Palaeontogr. Soc. (Monogr.).

NORRIS, A.W. & UYENO, T.T. 1971. Stratigraphy and conodont faunas of Devonian outcrop belts, Manitoba. Spec. Pap. geol. Ass. Can., 9: 209-223.

ORCHARD, M.J. 1972. Conodont biostratigraphy of the Plymouth Limestone about the Middle/Upper Devonian boundary. Proc. Ussher Soc., 2: 471-474.

———. 1975a. Conodonts, correlation and stratigraphy of the Plymouth Limestones. Ph.D. Thesis, University of Hull.

———. 1975b. Famennian conodonts and cavity infills in the Plymouth Limestone (S. Devon). Proc. Ussher Soc., 3: 49-54.

———. 1977. Plymouth-Tamar. In HOUSE et al. A correlation of Devonian rocks of the British Isles. Geol. Soc. Lond., Special Report No. 7: 110pp.

———. 1978. The conodont biostratigraphy of the Devonian Plymouth Limestone, South Devon. Palaeontology, 21: 907-955.

———. 1979. On a varcus Zone conodont fauna from the Ilfracombe Slates (Devonian, North Devon). Geol. Mag., 116: 129-134.

ORR, R.W. 1964. Conodonts from the Devonian Lingle and Alto Formations of southern Illinois. Circ. Ill. St. geol. Surv., 361: 28 pp.

———. 1971. Conodonts from the Middle Devonian strata of the Michigan Basin. Bull. Indiana Dep. Conserv. geol. Surv., 45: 110 pp.

——— & KLAPPER, G. 1968. Two new conodont species from Middle-Upper Devonian boundary beds of Indiana and New York. *J. Paleont.*, *42*: 1066-1075.

PEDDER, A.E.H., JACKSON, J.H. & ELLENOR, D.W. 1970. An interim account of the Middle Devonian Timor Limestone of north-eastern New South Wales. *Proc. Linn. Soc. N.S.W.*, *94*: 242-272.

PERRY, D.G., KLAPPER, G. & LENZ, A.C. 1974. Age of the Ogilvie Formation (Devonian), Northern Yukon: Based primarily on the occurrence of brachiopods and conodonts. *Can. J. Earth Sci.*, *11*: 1055-1097.

PHILIP, G.M. 1965. Lower Devonian conodonts from the Tyers area, Gippsland, Victoria. *Proc. R. Soc. Vict.*, *79*: 95-118.

———. 1966. Middle Devonian conodonts from the Moore Creek Limestone, northern New South Wales. *J. Proc. R. Soc. N.S.W.*, *100*: 151-161.

——— & JACKSON, J.H. 1967. Lower Devonian subspecies of the conodont *Polygnathus linguiformis* HINDE from southeastern Australia. *J. Paleont.*, *41*: 1262-1266.

——— & McDONALD, L. 1975. A provisional phylogeny for some reconstructed Late Devonian polygnathid conodont apparatuses. *Alcheringa*, *1*: 97-107.

PHILLIPS, J.. 1841. *Figures and descriptions of the Palaeozoic fossils of Cornwall, Devon and West Somerset.* London.

PICKETT, J. 1978. Conodont faunas from the Mount Frome Limestone (Emsian/Eifelian), New South Wales. *Bull. Aust. Bur. Miner. Resour.*, *192*: 97-107.

POLLOCK, C.A. 1968. Lower Upper Devonian conodonts from Alberta, Canada. *J. Paleont.*, *42*: 415-443.

PÖLSLER, P. 1969. Conodonten aus dem Devon der Karnischen Alpen (Findenigkofel, Österreich). *Jb. geol. Bundesanst.*, *112*: 399-440.

RHODES, F.H.T. & DINELEY, D.L. 1957a. Devonian conodont faunas from southwest England. *J. Paleont.*, *31*: 353-369.

——— & ———. 1957b. Supplementary notes on Devonian conodont faunas from southwest England. *Ibid.*, *31*: 1175.

———, WILLIAMS, J.A. & ROBINSON, J.C. 1973. Micromorphologic studies of platform conodonts. In RHODES, F.H.T. (ed.). Conodont Paleozoology. Spec. Pap. geol. Soc. Am., 141: 117-141.

RICHTER, D. 1965. Observations on vulcanicity and tectonics of the Torquay area. Proc. Ussher Soc., 1: 189-190.

———. 1969. Structures and metamorphism of the Devonian rocks south of Torquay, South-east Devon (England). Geol. Mitt., 9: 109-178.

RIDDOLLS, B.W. 1970. The origin of calcareous nodules in Upper Devonian slate near Newton Abbot. Proc. Ussher Soc., 2: 158-159.

SADLER, P.M. 1973. An interpretation of new stratigraphic evidence from South Cornwall. Ibid., 2: 535-550.

SALTER, J.W. 1864-1865. Monograph of the British Trilobites from the Cambrian, Silurian and Devonian formations. Palaeontogr. Soc. (Monogr.).

SANDBERG, C.A. & ZIEGLER, W. 1973. Refinement of standard Upper Devonian conodont zonation based on sections in Nevada and West Germany. Geol. et Palaeontol., 7: 97-122.

——— & ———. 1979. Taxonomy and biofacies of important conodonts of Late Devonian styriacus-Zone, United States and Germany. Ibid., 13: 173-212.

SANDERSON, D.J. & DEARMAN, W.R. 1973. Structural zones of the Variscan fold belt in S.W. England, their location and development. J. geol. Soc. Lond., 129: 527-536.

SAVAGE, N.M. 1977. Middle Devonian (Eifelian) conodonts of the genus Polygnathus from the Wadleigh Limestone, southeastern Alaska. Can. J. Earth Sci., 14: 1343-1355.

——— & AMUNDSON, C.T. 1979. Middle Devonian (Givetian) conodonts from central Oregon. J. Paleont., 53: 1395-1400.

SCHÖNLAUB, H.P. 1969. Das Paläozoikum zwischen Bischofalm und Hohem Trieb (Zentrale Karnische Alpen). Jb. geol. Bundesanst., 112: 265-320.

SCHRIEL, W. & STOPPEL, D. 1963. Das Alter der Cephalopodenkalke im mitteleren Selketal (Devon; Unterharz). Z. dt. geol. Ges., 115: 77-99.

SCHUMACHER, D. 1971a. Conodonts from the Middle Devonian Lake Church and Milwaukee Formations. In CLARK, D.L. (ed.). Conodonts and biostratigraphy of the Wisconsin Paleozoic. Inf. Circ. Wis. geol. nat. Hist. Surv., 19: 55-67.

——. 1971b. Conodonts and biostratigraphy of the "Kenwood" Shale (Upper Devonian). Ibid: 68-77.

——. 1976. Conodont biofacies and paleoenvironments in Middle Devonian-Upper Devonian boundary beds, central Missouri. In BARNES, C.R. (ed.). Conodont Paleoecology. Spec. Pap. Geol. Ass. Can., 15: 159-169.

SCRUTTON, C.T. 1965. The ages of some coral faunas in the Torquay area. Proc. Ussher Soc., 1: 186-188.

——. 1967. Marisastridae (Rugosa) from south-east Devonshire, England. Palaeontology, 10: 266-279.

——. 1968. Colonial Phillipsastraeidae from the Devonian of south-east Devon, England. Bull. Br. Mus. nat. Hist. (Geol.), 15: 181-281.

——. 1975. Preliminary observations on the distribution of Devonian rugose coral faunas in south-west England. In SOKOLOV, B.S. (ed.). Drevnie Cnidaria, 2: 131-140. Novosibirsk.

——. 1977a. Reef facies in the Devonian of eastern South Devon, England. Mém. Bur. Rech. géol. minier., 89: 125-135.

——. 1977b. Facies variations in the Devonian limestones of eastern South Devon. Geol. Mag., 114: 165-193.

—— (ed.) 1978a. A field guide to selected areas of the Devonian of South-west England. Palaeontological Association, International Symposium on the Devonian System (P.A.D.S. 78), Sept. 1978: 73 pp.

——. 1978b. The stratigraphy and structure of Babbacombe Cliff, Torquay, and its significance. Proc. Ussher Soc., 4: 120-128.

SEDDON, G. 1970a. Frasnian conodonts from the Sadler Ridge-Bugle Gap area, Canning Basin, Western Australia. J. geol. Soc. Aust., 16: 723-753.

———. 1970b. Pre-Chappel conodonts of the Llano region, central Texas. Bull. Univ. Tex. Bur. econ. Geol. Technol., 68: 130 pp.

SEDGWICK, A. & MURCHISON, R.I. 1840. On the physical structure of Devonshire, and on the subdivisions and geological relations of its older stratified deposits, etc. Part 1 (1837, p.633-687) and Part 2 (1839, p.688-704). Trans. geol. Soc. Lond. (Ser. 2), 5: 633-704.

SELWOOD, E.B. 1966. Thysanopeltidae (Trilobita) from the British Devonian. Bull. Br. Mus. nat. Hist. (Geol.), 13: 191-220.

SHACKLETON, R.M., RIES, A.C. & COWARD, M.P. 1982. An interpretation of the Variscan structures in S.W. England. J. geol. Soc. Lond., 139: 533-541.

SHANNON, W.G. 1921. Some additions to the palaeontology of south-east Devon. Rep. Trans. Devon. Ass. Advmt Sci., 53: 246-253.

———. 1924. The petrography and correlation of the igneous rocks of the Torquay promontory. Geol. Mag., 61: 193-203.

———. 1928. The geology of the Torquay district. Proc. Geol. Ass., 39: 103-136.

SMYTHE, D.K. 1973. Structure of the Devonian limestone at Brixham. Proc. Ussher Soc., 2: 617-625.

SPARLING, D.R. 1981. Middle Devonian conodont apparatuses with seven types of elements. J. Paleont., 55: 295-316.

STAUFFER, C.R. 1938. Conodonts of the Olentangy Shale. Ibid., 12: 411-443.

———. 1940. Conodonts from the Devonian and associated clays of Minnesota. Ibid., 14: 417-435.

STEWART, G.A. & SWEET, W.C. 1956. Conodonts from the Middle Devonian bone beds of central and west-central Ohio. Ibid., 30: 261-273.

STEWART, I.J. 1981. Late Devonian and Lower Carboniferous conodonts from north Cornwall and their stratigraphical significance. Proc. Ussher Soc., 5: 179-185.

SZULCZEWSKI, M. 1971. Upper Devonian conodonts, stratigraphy and facial development in the Holy Cross Mts. Acta geol. pol., 21: 129 pp.

TELFORD, P.G. 1975. Lower and Middle Devonian conodonts from the Broken River Embayment, North Queensland, Australia. Spec. Pap. Palaeontology, 15: 96 pp.

TSIEN, H.H. 1974. Paleoecology of Middle Devonian and Frasnian in Belgium. In BOUCKAERT, J. & STREEL, M. (eds). International Symposium on Belgian Micropaleontological Limits, Namur 1974: Publication 12, 53 pp.

TUCKER, M.E. & VAN STRAATEN, P. 1970a. Conodonts and facies on the Chudleigh Schwelle. Proc. Ussher Soc., 2: 160-170.

——— & ———. 1970b. Conodonts from the Upper Devonian of the Saltern Cove-Elberry Cove area (Abstract). Ibid., 2: 159.

ULRICH, E.O. & BASSLER, R.S. 1926. A classification of the tooth-like fossils, conodonts, with a description of American Devonian and Mississippian species. Proc. U.S. Natn. Mus., 68: 1-63.

USSHER, W.A.E. 1884. On the geology of South Devon, with special reference to the long excursion. Proc. Geol. Ass., 8: 442-480.

———. 1890. The Devonian rocks of South Devon. Q. Jl geol. Soc. Lond., 46: 487-517.

———. 1903. The geology of the country around Torquay. Mem. geol. Surv. Engld & Wales: iv + 142 pp.

———. 1913. The geology of the country around Newton Abbot. Mem. geol. Surv. Engld & Wales: vi + 149 pp.

UYENO, T.T. 1967. Conodont zonation, Waterways Formation (Upper Devonian), northeastern and central Alberta. Geol. Surv. Can., Paper 67-30: 20 pp.

———. 1974. Conodonts of the Waterways Formation (Upper Devonian) of northeastern and central Alberta. Bull. geol. Surv. Can., 232: 93 pp.

———. 1978. Some late Middle Devonian (Polygnathus varcus Zone) conodonts from central Mackenzie Valley, District of Mackenzie. Ibid., 267: 13-23.

———. 1979. Devonian conodont biostratigraphy of Powell Creek and adjacent areas, western District of Mackenzie. *In* STELCK, C.R. & CHATTERTON, B.D.E. (eds). Western and Arctic Canadian Biostratigraphy. *Spec. Pap. geol. Ass. Can.*, *18*: 233-257.

VACHELL, E.T. 1963. The structure of the Torbay region - the Marldon Beacon nappe. *Proc. Ussher Soc.*, *1*: 59-60.

VAN STRAATEN, P. & TUCKER, M.E. 1972. The Upper Devonian Saltern Cove Goniatite Bed is an intraformational slump. *Palaeontology*, *15*: 430-438.

WALLISER, O.H. 1957. Conodonten aus dem oberen Gotlandium Deutschlands und der Karnischen Alpen. *Notizbl. hess. Landesamt. Bodenforsch.*, *85*: 28-52.

WANG, C.-Y. & ZIEGLER, W. 1981. Middle Devonian conodonts from Xiguitu Qi, Inner Mongolia Autonomous Region, China. *Senckenberg. leth.*, *62*: 125-139.

WEBBY, B.D. 1966. Middle-Upper Devonian palaeogeography of North Devon and West Somerset, England. *Palaeogeogr. Palaeoclimat. Palaeoecol.*, *2*: 27-46.

WEDDIGE, K. 1977. Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten. *Senckenberg. leth.*, *58*: 271-419.

———, WERNER, R. & ZIEGLER, W. 1979. The Emsian-Eifelian boundary. An attempt at correlation between the Eifel and Ardennes regions. *Newsl. Stratigr.*, *8*: 159-169.

——— & ZIEGLER, W. 1979. Evolutionary patterns in Middle Devonian conodont genera *Polygnathus* and *Icriodus*. *Geol. et Palaeontol.*, *13*: 157-164.

WHIDBORNE, G.F. 1888-1907. A monograph of the Devonian fauna of the South of England. *Palaeontogr. Soc.* (*Monogr.*).

———. 1901. Devonian fossils from Devonshire. *Geol. Mag.*, *8*: 529-540.

WHITELEY, M.J. 1981. The faunas of the Viverdon Down area, south-east Cornwall. *Proc. Ussher Soc.*, *5*: 186-193.

WIRTH, M. 1967. Zur Gliederung des höheren Paläozoikums (Givet-Namur) im Gebiet des Quinto Real (Westpyrenäen) mit Hilfe von Conodonten. Neues Jb. Geol. Paläont. Abh., 127: 179-244.

WITTEKINDT, H. 1965. Zur Conodonten-Chronologie des Mitteldevons. Fortschr. Geol. Rheinld. Westf., 9: 621-646.

WOLSKA, Z. 1967. Górno-dewónskie Konodonty z poludniowo-zachodniego regionu Gór Swietokrzyskich. Acta palaeont. pol., 12: 363-435.

WOODWARD, H.B. 1877. Notes on the Devonian rocks near Newton Abbot and Torquay; with remarks on the subject of their classification. Geol. Mag. (Dec. 2), 4: 447-454.

YOUNGQUIST, W.L. 1947. A new Upper Devonian conodont fauna from Iowa. J. Paleont., 21: 95-112.

——— & PETERSON, R.F. 1947. Conodonts from the Sheffield Formation of north-central Iowa. Ibid., 21: 242-253.

ZIEGLER, W. 1956. Unterdevonische Conodonten, insbesondere aus dem Schönauer und dem Zorgensis-Kalk. Notizbl. hess. Landesamt. Bodenforsch., 84: 93-106.

———. 1958. Conodontenfeinstratigraphische Untersuchungen an der Grenze Mitteldevon/Oberdevon und in der Adorfstufe. Ibid., 87: 7-77.

———. 1962a. Phylogenetische Entwicklung stratigraphisch wichtiger Conodonten-Gattungen in der Manticoceras-Stufe (Oberdevon, Deutschland). Neues Jb. Geol. Paläont. Abh., 114: 142-168.

———. 1962b. Taxonomie und Phylogenie Oberdevonischer Conodonten und ihre stratigraphische Bedeutung. Abh. hess. Landesamt. Bodenforsch., 38: 1-166.

———. 1965a. Zum höchsten Mitteldevon an der Nordflanke des Ebbesattels. Fortschr. Geol. Rheinld. Westf., 9: 519-538.

———. 1965b. Eine Verfeinerung der Conodontengliederung an der Grenze Mittel-/Oberdevon. Ibid., 9: 647-676.

———. 1971. Conodont stratigraphy of the European Devonian. Mem. geol. Soc. Am., 127: 227-284.

———. 1972. Über devonische Conodonten-Apparate. Geol. et Palaeontol., SB 1: 91-96.

——— (ed.) 1973. Catalogue of Conodonts, I: 504 pp. Stuttgart.

——— (ed.) 1975. Catalogue of Conodonts, II: 404 pp. Stuttgart.

——— (ed.) 1977. Catalogue of Conodonts, III: 574 pp. Stuttgart.

———. 1979. Historical subdivisions of the Devonian. In HOUSE, M.R., SCRUTTON, C.T. & BASSETT, M.G. (eds). The Devonian System. Spec. Pap. Palaeontology, 23: 23-47.

———, KLAPPER, G. & JOHNSON, J.G. 1976. Redefinition and subdivision of the varcus Zone (Conodonts, Middle-?Upper Devonian) in Europe and North America. Geol. et Palaeontol., 10: 109-140.

——— ——— & LINDSTRÖM, M. 1964. The validity of the name Polygnathus (Conodonta, Devonian and Lower Carboniferous). J. Paleont., 38: 421-423.

———, WERNER, R., WEDDIGE, K., ALBERTI, G.K.B., STRUVE, W., HASS, W., BIRENHEIDE, R., BECKER, G., GROOS-UFFENORDE, H., WALLISER, O.H., SCHAARSCHMIDT, F., WINTER, J. & CARLS, P. 1980. Proposal of a boundary stratotype for the Lower/Middle Devonian boundary (partitus-boundary). National Subcommission on Devonian Stratigraphy of the Federal Republic of Germany: 64 pp.

APPENDIX

Introduction

Areas and localities in the Torquay region are listed in the same order as in Chapter 5, and the majority of individual samples are identified either in terms of a measured section, or by a ten-figure grid-reference, and by a brief lithological description. Sample numbers are underlined throughout the Appendix (e.g. TP-1, BC-20). Details of each conodont fauna are then given (i.e. total number of each element-type, followed by, in parentheses, that figure expressed as a percentage of the faunal total; total number of elements in fauna; weight of rock processed; yield, to nearest whole number), followed by a listing of the platform-elements and simple cones identified in the fauna, the figure(s) in parentheses being the total number of each identification. Bars are also identified, in terms of the system of symbols proposed by Klapper and Philip (1971: A1, A2, A3 etc.), and conodont preservation is indicated by use of the Colour Alteration Index (CAI) of Epstein *et al*. (1977). Finally, a mention is made of any other microfaunal elements present in the sample; many of these additional forms, especially the foraminifera, were identified by Dr. M.D. Brasier (University of Hull). The "white spheres" recorded in several samples are as described by, for example, Glenister and Klapper (1976).

Abbreviations used are as in the main text, with the addition of broad-plat = broad-platformed, lst = limestone, med = medium, v = very.

Area 1

Daddyhole Cove-Triangle Point (SX927628-928628, Text-fig. 4; Daddyhole Lst) (see Scrutton 1977b, p.169; 1978a, p.32-34 for details of macrofaunas)

Section I (inverted, measured behind Triangle Point platform; beds generally pale weathering)

110" (approx) massive, med-dark grey lst, covered by shale slip at top of section. TP-7 at 40-45" above base of unit, from med grey-pink, med grained crinoidal area

5")
68") med-dark grey, fine grained lsts with crinoidal and shelly debris;
4½") abundant branching tabulate corals in 5" bed
5")
23")

45" med-dark grey, fine grained lst with rich, jumbled fauna of branching and massive tabulates (*e.g.* *Thamnopora*, *Alveolites*), solitary Rugosa and small rounded stromatoporoids (sometimes intergrown with corals), with occasional brachiopods, bryozoa, gastropods and clasts of sediment in crinoidal debris

33" richly fossiliferous lst, as above

7½")
6½") med-dark grey, fine-med grained and sometimes crinoidal lsts,
12") with scattered solitary corals and brachiopods; large
20") gastropods at top of 20" and 6½" beds
12")

5½" thin, dark, fine grained lsts with crinoidal and shelly debris. TP-6 from top 2"

7") med-dark grey, fine-med grained lsts with scattered but sometimes
11") locally abundant fauna of corals, stromatoporoids and brachiopods,
24") and areas of crinoidal debris. TP-5 from top 6" of 30" bed
30")

48" lst with scattered fauna, as above

38" richly fossiliferous lst, as 45" bed above

17" poorly fossiliferous, dark, fine grained lst

37" richly fossiliferous lst, as 45" bed above

24" poor exposure (path)

10") med-dark grey, fine grained lsts with crinoidal and
)
38") shelly debris. TP-4 from 10" bed

36")
)
3") med-dark grey, fine grained lsts with occasional corals (branching
)
25") tabulates, solitary Rugosa) and brachiopods, and areas of shelly
)
16") and crinoidal debris. TP-3 from 6" bed
)
6")

26" thin-bedded, dark, fine grained lsts (individual beds 1-6" thick), with partings and thin beds of dark shale; lsts contain crinoidal and shelly debris

5½") dark grey, fine grained, often shaly lsts with scattered corals,
)
16") small rounded stromatoporoids and areas of crinoidal debris.
)
17") TP-2 from basal 4" of 17" bed
)
10")

(beds correlated across small fault)

80"+ thin-bedded lsts and shales to sea-level, as 26" unit above. TP-1 from 3" shaly lst at 44-47" below top of unit

Section II (inverted, measured across Triangle Point platform; beds generally pale weathering)

29")
)
2") med-dark grey lsts with crinoidal and shelly debris, and scarce
)
19") small rounded stromatoporoids. TP-17 from 2" bed - med grey,
)
7") slightly reddened, med grained lst
)
15")
)
50")

200" (approx) dark, massive lst, as above but features masked by reddened skin; this and higher units form the ridge at the western end of Triangle Point platform

25")
18")
12")
16") med-dark grey, fine grained lsts with areas and bands of
60") crinoidal debris; corals (mainly branching tabulates - Thamnopora)
19") and small rounded stromatoporoids are sometimes locally abundant,
8") as in 25", 16" and 8" beds. TP-16 from basal 6" of 18" bed
9")
24")
22")
17")

47" richly fossiliferous lst, as 45" bed in Section I. TP-15 from top 6"

12")
7½")
15")
55") med-dark grey, fine grained lsts with occasional corals (mainly
5") branching tabulates, sometimes locally abundant as on top surface
2") of 7½" bed), and bands of fine crinoidal and shelly debris; abundant
18") gastropods in 5" bed. TP-14 from top half of 15" bed, TP-13 from
2") 4½" bed
2")
68")
4½")

11") med-dark grey, fine grained lsts with a few small scattered
42") corals, and bands of fine crinoidal and shelly debris; shell
48") fragments and sectioned gastropods on top surfaces of 11" and
17") 42" beds

13") med-dark grey, fine grained lsts with a few small scattered corals,
)
28") and bands of fine crinoidal and shelly debris. TP-12 from basal
)
38") 10" of 26" bed
)
26")

6" dark, rather shaly lst

37" med-dark grey, fine grained lst with small scattered corals and bands of crinoidal and shelly debris. TP-11 from top 10"

36" richly fossiliferous lst, as 45" bed in Section I. TP-9 and TP-10 from basal and top 6" of bed respectively

22" med-dark grey, poorly fossiliferous lst

64" dark grey, fine grained lst; richly fossiliferous in top 40", as 45" bed in Section I; sectioned gastropods on top surface

5") dark, fine grained, sometimes crinoidal lsts with a few corals and
)
2") brachiopods; large gastropods and occassional solitary Rugosa on top
)
6") surface of 6" bed

38" dark, fine grained lst with occasional shaly partings; possible dessication cracks on top surface

6")
)
8") dark grey, fine grained lsts with tabulate and rugose corals, small
)
27") scattered rounded stromatoporoids (sometimes intergrown with corals),
)
24") and brachiopods, in crinoidal and shelly debris; branching tabulates
)
8") are sometimes locally abundant on top surfaces of beds. TP-8 from
)
3") 3" bed.

base of section taken at main bedding plane at eastern end of Triangle Point platform; main bedding plane comprises dark grey lst with corals (tabulate and rugose), small rounded stromatoporoids (sometimes intergrown with corals) and brachiopods in sometimes coarse crinoidal and shelly debris - fauna is often locally abundant

Section III (inverted, measured along seaward edge and up western face of Knoll Quarry)

500" (approx) poorly exposed, grass-covered, massive and thick-bedded lst; med-dark grey and fine grained, with areas of crinoidal debris

51") med-dark grey, fine grained, massive lsts with areas of crinoidal
)
81") and shelly debris, and occasional small rounded stromatoporoids
)
46") and scattered small solitary Rugosa (as in 81" bed). TP-23 from
)
25") 10-20" above base of 51" bed

181" dark grey, fine grained, sometimes crinoidal massive lst

15")
)
20") med-dark grey, fine grained lsts with crinoidal debris and some
)
21") pink, shaly-looking partings. TP-22 from top 4" of shaly 21" bed
)
10")
)
13")
)
16")

45" richly fossiliferous lst, as 45" bed in Section I

23")
)
14")
)
12")
)
77") med-dark grey, fine grained lsts with crinoidal debris, pink
)
11") shaly-looking partings, scattered branching tabulates and small
)
5½") solitary Rugosa. TP-21 from shaly 7½" bed
)
11")
)
25")
)
7½")
)
43")

45" fairly thin-bedded, rubbly-looking, dark, fine grained lsts (individual beds usually 3-6" thick), with crinoidal debris and pink, shaly-looking partings

23") med-dark grey, fine grained lsts with areas of sometimes coarse
7½") crinoidal debris, and pink, shaly-looking partings; lowest beds
2") in western face of quarry. <u>TP-20</u> from top 6" of 60" bed
60")

14") med-dark grey, fine grained lsts with areas of sometimes coarse
81") crinoidal debris, and pink, shaly-looking partings
22") richly fossiliferous lsts,
52") as 45" bed in Section I
19")
33")
68")
18") med-dark grey, fine grained lsts
41") with areas of sometimes coarse
10") crinoidal debris
7")
28")
23")
78")
6" broken, rubbly lst
116" (approx) rubbly, poorly exposed lst to gravel cover

<u>Section IV</u> (inverted, main part of section measured near Daddyhole Road)

39")
22") med-dark grey, fine-med grained lsts with areas of
22") crinoidal debris - 16" bed is coarsely crinoidal;
10") scattered small rounded stromatoporoids at top of
16") 39" bed
34")
90") massive lsts, as above. <u>TP-26</u> from coarsely crinoidal area
88") in top 6" of 90" bed

36")
21")
33") med-dark grey, fine-med grained lsts with areas of crinoidal
12") debris. TP-25 from lower half of 12" bed, from an area with
6") fine crinoidal debris
37")
15")

90" (approx) overgrown lst to base of section at ground level

Exposure above the 39" bed, on The Knoll, is generally poor; TP-27 (SX9279162900) and TP-28 (SX9278462888) are at approx 80" and 330" respectively above the top of the main measured section, both from patches of pale weathering, med grey-pink, massive lsts with a few rounded stromatoporoids and solitary corals in crinoidal debris, cropping-out on the eastern side of The Knoll

Section V (inverted, measured in north-eastern corner of Daddyhole Cove) (section comprises about 20-25 ft of alternating red calcareous shales and thin grey lsts, individual beds showing variation in thickness due to faulting and slipping; the three lst bands in the top c.8 ft of the section are distinctive, lsts in the lower parts being thinner, often impersistent and less well defined; base of section covered by fallen rocks and boulders)

30" red calcareous shale
6-10" med grey lst band
8-14" red calcareous shale
8-14" med grey lst band
24" red calcareous shale
12-15" med grey, med grained lst band - DH-2
12-15' + red calcareous shales with thin (usually 1-2"), often impersistent lst bands. DH-1 from red-grey, crinoidal shale and shaly lst at 80-85" below 12-15" (DH-2) lst band

DH-1.	Conodonts: polygnathids (linguiform)	2 (15)	weight 3.5 kg
	icriodids	11 (85)	yield 4/kg
	Total	13	

Po. l. bultyncki (2); *I. retrodepressus* (7), *I.* sp. indet. (4); CAI 5-6.

Other microfauna: pyritic material, including pyritised gastropods, echinoderm plate, endichnial burrow infillings.

DH-2.	Conodonts: polygnathids (linguiform)	1 (33)	weight 1.5 kg
	icriodids	1 (33)	yield 2/kg
	bars	1 (33)	
	Total	3	

Po. l. subsp. indet. (1); *I. retrodepressus* (1); A1; CAI 6-7.

Other microfauna: pyritic material, including pyritised endichnial burrow infillings.

TP-1. Conodonts: none; weight 0.5 kg.

TP-2. Conodonts: none; weight 0.5 kg.

TP-3. Conodonts: none; weight 1.25 kg.

TP-4. Conodonts: none; weight 1 kg.

TP-5. Conodonts: none; weight 1 kg.

TP-6. Conodonts: none; weight 0.75 kg.

TP-7. Conodonts: icriodids (sp. indet.) 1; weight 1 kg; yield 1/kg

Other microfauna: crinoid ossicles.

TP-8. Conodonts: none; weight 0.75 kg.

TP-9. Conodonts: none; weight 1.25 kg.

TP-10. Conodonts: none; weight 1.25 kg.

TP-11. Conodonts: none; weight 1 kg.

TP-12.	Conodonts: icriodids	10 (2)	weight 1 kg
	spathognathodids	25 (5)	yield 43/kg
	bars	8 (18)	
	Total	43	

I. c. corniger (7), *I. retrodepressus* (1), *I.* sp. indet. (2); *E.* cf. *bipennatus montensis* (25); O1, A1, N; CAI 5-6.

TP-13. Conodonts: none; weight 0.5 kg

Other microfauna: crinoid ossicles.

TP-14. Conodonts: icriodids 1; weight 1 kg; yield 1/kg

I. c. corniger (1); CAI 6-7.

TP-15. Conodonts: icriodids 1; weight 1.5 kg; yield 1/kg

I. retrodepressus (1); CAI 6-7

TP-16. Conodonts: icriodids 4; weight 0.5 kg; yield 8/kg

I. c. corniger (4); CAI 6-7.

TP-17. Conodonts: icriodids 11; weight 1 kg; yield 11/kg

I. c. corniger (6), *I.* aff. *introlevatus* (3), *I.* sp. indet. (2); CAI 6.

TP-20. Conodonts: none; weight 0.5 kg

Other microfauna: foraminifera (*Hemisphaerammina*).

TP-21. Conodonts: none; weight 0.5 kg.

TP-22. Conodonts: icriodids 3; weight 0.5 kg; yield 6/kg

I. c. corniger (3); CAI 6-7

Other microfauna: foraminifera (*Hemisphaerammina*), crinoid ossicles, possible apex of hyolithid.

TP-23. Conodonts: none; weight 0.5 kg.

TP-24 (SX9279662912, not on sections): med-dark grey, fine grained lst with with calcite veining.

Conodonts:	polygnathids (lanceolate, sp. indet.)	1 (50)	weight 1 kg
	icriodids (sp. indet.)	1 (50)	yield 2/kg
	Total	2	

TP-25. Conodonts: none; weight 1 kg.

TP-26. Conodonts: icriodids 7; weight 1 kg; yield 7/kg

I. c. corniger (4), *I. retrodepressus* (1), *I.* sp. indet. (2); CAI 6-7

Other microfauna: possible endichnial burrow infillings.

TP-27. Conodonts: icriodids 2; weight 1.5 kg; yield 1/kg

I. c. corniger (2); CAI 6-7.

TP-28. Conodonts: icriodids 29 (97) weight 2.5 kg

simple cones 1 (3) yield 12/kg

Total 30

I. c. corniger (14), *I. c. corniger*? (3), *I. retrodepressus* (4), *I.* sp. indet. (8); *Acodina* sp. (1); CAI 5-6.

Other microfauna: pyritic material, including pyritised gastropods.

Dyer's Quarry (SX92236277, Text-fig. 5b; Daddyhole Lst)

(see Scrutton 1977b, p.169-170; 1978a, p.35 for details of macrofauna)

Section (back face of quarry, base of section taken at level of quarry floor)

30' (approx) inaccessible, well-bedded, dark lsts to top of section in back face of quarry

9" dark grey, micritic lst

45" dark grey, micritic lst with shell debris and shale partings; 1-1½" shaly band at base of bed

17" dark grey, micritic lst with areas of coarse, sometimes articulated crinoidal debris

18½" dark grey, micritic lst with fine shell debris, laminations and shale partings. DY-4 from basal 8"

15") dark grey, micritic lsts with thin shale partings within and
23") between beds. DY-3 from basal 6" of 48" bed
48")

25" dark grey, micritic lst, with laminations towards base of bed, and a band of shelly and crinoidal debris at 12-17" above base

2" shale band

40" dark grey, micritic lst with thin shale partings

4-6" tuff band; weathers back into face

28" dark grey, micritic lst with *Heliolites* and fine shell debris;
some coarsely crinoidal areas

21") dark grey,
39") micritic lsts

½-1" dark ?tuff band; weathers back into face

15" dark grey, micritic lst with occasional gastropods and corals

½-¾" dark ?tuff band; weathers back into face

10") dark grey, micritic lsts;
26") irregular shale partings in 26" bed

13½" dark grey, micritic lst with shells and shell fragments; v fine
scale laminations towards top of bed

3" soft, possibly tuffaceous, shale band

10")
7½") dark grey, micritic lsts with dark shale partings within and between
6½") beds; occasional corals, usually solitary Rugosa and massive
12") tabulates, with fine shell debris and small gastropods,
6") especially in the highest of these beds. DY-1 from basal 6" of
6") 24" bed (lowest bed in back face of quarry), DY-2 from 7½" bed
15½")
24")

base of section taken at quarry floor - dark, micritic lsts with abundant
corals

DY-1. Conodonts: none; weight 0.5 kg
Other microfauna: pyritised gastropod.

DY-2. Conodonts: spathognathodids 1; weight 1 kg; yield 1/kg
E. cf. *b. montensis* (1); CAI 5-6.
Other microfauna: pyritised ostracods (Beyreichiacian-type).

DY-3. Conodonts: none; weight 1.5 kg
Other microfauna: pyritised ostracods.

DY-4. Conodonts: none; weight 1 kg.

Peaked Tor Cove (SX921628, Text-fig. 5b; Daddyhole Lst)

Section I (base of section at beach level; top at landward end of small cave at SX9214662846, developed in axis of faulted, overturned syncline; beds rightway-up, on lower limb of fold)

13" med-dark grey lst

26" (approx - thickness variable) med-dark grey, med grained lst. PK-2 from 14-20" above base

13" med-dark grey lst

23" rubbly-looking, grey, crinoidal lst, with shaly partings, small branching tabulates, solitary Rugosa, atrypid brachiopods (sometimes articulated) and shell fragments

9") med-dark grey, sometimes coarsely crinoidal lsts, with large
)
4") spirifers and other brachiopods (sometimes articulated), bryozoa
)
5") and large solitary Rugosa

9" med-dark grey, finely crinoidal lst with Alveolites

21" med-dark grey lst with reddened shaly partings, brachiopods (sometimes articulated), bryozoa, large solitary Rugosa and crinoidal debris

20") med-dark grey, sometimes reddened lsts with fine crinoidal debris and
)
8") shell fragments, and occasional Alveolites and solitary Rugosa.

PK-1 from 8" bed

15") med-dark grey lsts with reddened shaly partings, bryozoa,
)
26") Alveolites, solitary Rugosa and occasional brachiopods
)
20") with crinoidal and shelly debris
)
30")

300" (approx) brecciated lst, as above, to base of section (beach level)

Section II (base of section at seaward end of small cave at SX9214662846, developed in axis of faulted, overturned syncline; top at seaward end of eastern face of cove; beds inverted, on upper limb of fold)

150" med-dark grey lsts and reddened shaly lsts, with occasional solitary Rugosa in crinoidal and shelly debris

85" lsts and shaly lsts, as above; some of the reddened shaly areas contain flattened brachiopods. PK-4 from grey lst in top 6" of unit

11" grey-red, shaly lst with large brachiopods and shell fragments

51" lsts and shaly lsts, as 150" unit above

64" red-grey shaly lsts and calcareous shales, with spiriferid and other brachiopods (often articulated and flattened), small solitary Rugosa and crinoidal and shelly debris. PK-3 from shaly lst at 5-10" above base of unit

28") med-dark grey lsts with occasional
)
21") reddened shaly areas

88" poor, mud-covered exposure

26" med-dark grey lst with occasional reddened areas, and with abundant brachiopods (sometimes large), small solitary Rugosa and crinoidal and shelly debris

160" (approx) med-dark grey shaly lsts with brachiopods, solitary Rugosa and crinoidal and shelly debris to base of section

PK-1. Conodonts: icriodids 2; weight 1 kg; yield 2/kg

I. c. corniger (1), *I.* sp. indet. (1); CAI 6-7.

PK-2. Conodonts:

icriodids	4 (67)	weight 1 kg
bars	2 (33)	yield 6/kg
Total	6	

I. c. corniger (2), *I.* sp. indet. (2); O1, A1; CAI 6-7.

PK-3. Conodonts:

icriodids	14 (93)	weight 0.75 kg
spathognathodids	1 (7)	yield 20/kg
Total	15	

I. c. corniger (7), *I.* sp. indet. (7); *E.* cf. *b. montensis* (1); CAI 6-7.

PK-4. Conodonts:

polygnathids (linguiform)	1 (4)	weight 1 kg
icriodids	22 (78)	yield 28/kg
spathognathodids	1 (4)	

bars	4 (14)
	Total 28

Po. *l*. subsp. indet. (1); *I*. *c*. *corniger* (10), *I*. sp. indet. (12); *E*. cf. *b*. *montensis* (1); O1, A1, B1; CAI 5-6.

Rock End Walk (SX92366276, Text-fig. 5b; Daddyhole Lst?)

RE-1-3 from pale weathering, med-dark grey and sometimes reddened, fine-med grained, massive lsts, with a fauna of massive and branching tabulate corals (*e.g.* *Heliolites*, *Alveolites*, *Thamnopora*) and Rugosa (*e.g.* *Cystiphyllum*).

RE-1 (SX9235962753). Conodonts: none; weight 1.5 kg.

RE-2 (SX9236062766). Conodonts: bars (indet.) 1; weight 2.25 kg.

RE-3 (SX9237162769). Conodonts: bars (indet.) 1; weight 1.5 kg.

Vane Hill Road (SX92056330, Text-fig. 5a; Daddyhole Lst)

Section I

fault

45")
7")
7") dark grey, fine grained lsts with areas of
7") crinoidal and shelly debris, and scattered
5") branching tabulates (*e.g.* *Thamnopora*) and
7") solitary Rugosa
40")

5' (approx) no exposure (wall and steps)

13" dark grey, fine grained lst with branching tabulates

76" dark grey, fine grained lst with a rich, jumbled fauna of tabulate and rugose corals, small stromatoporoids, bryozoa, brachiopods, etc. in crinoidal debris - as 45" bed in Triangle Point, Section I

4" dark grey, fine grained lst

16" richly fossiliferous lst, as 76" bed above

6' (approx) no exposure

29" richly fossiliferous lst, as 76" bed above

11")
)
43") dark grey, fine grained lsts with
)
26") scattered corals and areas of
)
5") crinoidal debris
)
5")

34" richly fossiliferous lst, as 76" bed above. VH-1 from top 6"

9") dark grey, fine grained lsts with small scattered corals (mainly
)
16") branching tabulates and solitary Rugosa), and areas of crinoidal debris

8' (approx) poorly exposed, rubbly and brecciated lst

17" dark grey, fine grained lst

34") dark grey, fine grained lsts to ground (pavement) level; contain
)
16") sparse small solitary Rugosa and areas of crinoidal debris, with
branching tabulates (*e.g.* *Thamnopora*) and small rounded stromatoporoids
in 34" bed

Section II

18")
)
34") dark grey, fine grained lsts with areas of crinoidal and
)
15") shelly debris. VH-2 at 18-24" above base of 36" unit
)
36")
)
31")

10' (approx) no exposure (wall and steps)

61" dark grey, fine grained lst with areas of crinoidal and shelly debris

fault

VH-1. Conodonts: none; weight 0.5 kg.

VH-2. Conodonts: none; weight 0.5 kg.

Hope's Nose (SX947635, Text-fig. 5c; Daddyhole Lst)

(see Scrutton 1977b, p.170; 1978a, p.29-32 for details of macrofauna)

HN-1-7 from old quarry on Hope's Nose, all from below disconformity; sample locations are shown on profile of S.S.E. face of quarry, Text-fig. 5c.

HN-1: v dark grey, v fine grained, massive, stromatoporoid lst, with fine calcite veining (unit a. on Text-fig. 5c)

Conodonts: none; weight 1.25 kg.

HN-2: lithology as HN-1.

Conodonts: none; weight 1 kg.

HN-3: lithology as HN-1.

Conodonts: none; weight 1 kg.

HN-4: dark grey, v fine grained, bedded lst (unit b. on Text-fig. 5c).

Conodonts: none; weight 1.25 kg

HN-5: lithology as HN-4.

Conodonts: none; weight 1 kg.

HN-6: dark grey, fine grained, poorly bedded lst (unit c. on Text-fig. 5c).

Conodonts: none; weight 1.75 kg.

HN-7: lithology as HN-6.

Conodonts: none; weight 1 kg.

Section I

10-15' (approx) dark calcareous shale exposed in cliff around SX94836347

3-4" distinctive, med grey, fine grained lst band with much calcite veining: HN-13

4-7" dark calcareous shale: HN-12

3-4" distinctive, contorted lst band

44" dark calcareous shale

4-5" coarse tuff band

20" dark shale with shell debris

115" well-bedded, med-dark grey, fine grained cleaved lsts and shales; lst beds 4-38" thick, shale bands 1-5" thick; fauna includes brachiopods, sometimes locally abundant, with crinoidal and shelly debris. HN-11 from 7" lst bed at 29-36" above base of unit

6-7" tuff band

52" well-bedded, cleaved, dark lsts and shales; as 115" unit above, but lst beds 3-20" thick, shale bands and partings ½-2" thick. HN-10 from 12" thick, fine-med grained crinoidal lst at top of unit

(section continued across small fault)

100" med-dark grey, thin-bedded, cleaved lsts with thin partings and bands of dark shales to beach shingle; lst beds usually 2-4" thick, shales 1-1½" thick; fauna includes brachiopods in crinoidal and shelly debris

HN-10. Conodonts: none; weight 0.5 kg
Other microfauna: foraminifera (Hemisphaerammina); abundant pyritic material, including pyritised gastropods.

HN-11. Conodonts: icriodids (sp. indet., CAI 5-6) 2; weight 1 kg; yield 2/kg

HN-12. Conodonts: none; weight 0.75 kg
Other microfauna: abundant pyritic material.

HN-13. Conodonts: none; weight 0.75 kg
Other microfauna: abundant pyritic material.

Area 2

Redgate Beach (SX935649, Text-fig. 6; Daddyhole Lst, Walls Hill Lst)
(see Scrutton 1977b, p.171; 1978a, p.35-37 for details of macrofaunas)

Section I (northern cliff of Redgate Beach; Daddyhole Lst, Walls Hill Lst)
top of section is in pale, massive, stromatoporoid Walls Hill Lst, as developed in highest parts of northern cliff at Redgate Beach and on Long Quarry Point; RB-7 (SX9350564977) from pale grey-pink crinoidal lst close to the base of this unit

40' (approx) med grey-red, shaly crinoidal lst with laminar stromatoporoids, massive tabulate corals (e.g. Alveolites, Heliolites) and solitary Rugosa. RB-5 from basal 5" of unit, RB-6 at 175-180" above base

25' (approx) pale-med grey-pink, pale weathering, fine-med grained massive lst, with occasional laminar stromatoporoids, branching tabulates and solitary Rugosa in crinoidal and bioclastic debris; basal unit of Walls Hill Lst. RB-3 from basal 10" of unit, RB-4 at 100-106" above base

35' (approx - to sea level) dark grey, bedded, fine-med grained crinoidal lsts with thin partings and bands of v dark, cleaved mudstones and shales; lst bands (sometimes lenticular) 1-16" thick, argillaceous horizons up to 20" thick; fauna of long, thin, laminar stromatoporoids, small massive and branching tabulates (e.g. Thamnopora), solitary Rugosa and shell fragments; top of Daddyhole Lst. RB-1 from 1½" lst band at 300" below top of unit, RB-2 from 4" lst band with shale partings at 200-204" below top of unit

Section II (poorly exposed, grey-red shaly Walls Hill Lst by path behind Redgate Beach, probably with repetition due to faulting)

150" (approx - top of section covered by grass and boulders) med grey-red, shaly crinoidal lst; crinoidal debris sometimes coarse

19" grey crinoidal lst

9" grey crinoidal lst

41" med grey-red, shaly crinoidal lst. RB-12 from top 6" of unit, from coarsely crinoidal area

8" grey lst, with laminar stromatoporoids in a coarsely crinoidal matrix

118" med grey-red, shaly crinoidal lst

135" poor exposure

63" med grey-red, shaly crinoidal lst. RB-11 from basal 10"

100" poor exposure

9" grey lst with fine bioclastic and crinoidal debris

250" med grey-red, shaly crinoidal lst to ground (path) level. *RB-10* from med-coarse crinoidal area at 50-55" above base of section

RB-1. Conodonts: icriodids (sp. indet.) 1; weight 0.5 kg; yield 2/kg.

RB-2. Conodonts:	polygnathids (lanceolate)	2 (12)	weight 2.5 kg
	polygnathids (linguiform)	4 (24)	yield 7/kg
	icriodids	5 (29)	
	simple cones	1 (6)	
	spathognathodids	1 (6)	
	bars	4 (24)	
	Total	17	

Po. *pseudofoliatus* (2), *Po*. *l*. *linguiformis* (3), *Po*. *l*. subsp. indet. (1); *I*. *expansus* group (2), *I*. sp. indet. (3); *Neopanderodus* sp. (1); *T*. aff. *variabilis* (1); 01, A1, A2; CAI 6-7.

RB-3. Conodonts:	polygnathids (lanceolate)	1 (25)	weight 2 kg
	polygnathids (linguiform)	1 (25)	yield 2/kg
	bars	2 (50)	
	Total	4	

Po. *pseudofoliatus* (1), *Po*. *l*. *linguiformis* (1); CAI 6-7.

RB-4. Conodonts:	polygnathids (lanceolate)	8 (42)	weight 1.5 kg
	polygnathids (linguiform)	4 (21)	yield 13/kg
	simple cones	4 (21)	
	bars	3 (16)	
	Total	19	

Po. *pseudofoliatus* (5), *Po*. *l*. *linguiformis* (1), *Po*. *l*. subsp. b (1), *Po*. *l*. subsp. indet. (2), *Po*. sp. indet. (3); *Belodella* sp. (4); CAI 7. Other microfauna: white spheres.

RB-5. Conodonts:	polygnathids (lanceolate)	5 (39)	weight 1.5 kg
	polygnathids (linguiform)	1 (8)	yield 9/kg
	icriodids	2 (15)	
	simple cones	2 (15)	

	bars	3 (23)	
		Total 13	

Po. pseudofoliatus (2), *Po. x. ensensis* (2), *Po. l. linguiformis* (1), *Po.* sp. indet. (1); *I. expansus* group (1); *I.* sp. indet. (1); *Belodella* sp. (2); A1, A2; CAI 7

Other microfauna: fish teeth; white spheres.

RB-6. Conodonts:	polygnathids (lanceolate)	1 (8)	weight 1.5 kg
	polygnathids (linguiform)	2 (17)	yield 8/kg
	icriodids	3 (25)	
	bars	6 (50)	
		Total 12	

Po. l. linguiformis (1), *Po. l.* subsp. indet. (1), *Po.* sp. indet. (1); *I. expansus* group (2), *I.* sp. indet. (1); A1, A2, B1; CAI 6-7.

RB-7. Conodonts: none; weight 0.5 kg.

RB-8 (SX9345565002, not on sections): from med grey-red, shaly crinoidal lst unit of Walls Hill Lst between faults

Conodonts: bars 1; weight 1 kg; yield 1/kg.

RB-9 (SX9338964868, not on sections): pale-med grey-buff, pale weathering, fine grained, massive lst

Conodonts: polygnathids (lanceolate, sp. indet.) 1; wt 0.5 kg; yld 2/kg.

RB-10. Conodonts:	polygnathids (linguiform)	8 (38)	weight 1.5 kg
	icriodids	6 (28)	yield 14/kg
	simple cones	3 (14)	
	bars	4 (19)	
		Total 21	

Po. l. linguiformis (4), *Po. l.* subsp. b (2), *Po. l.* subsp. indet. (2); *I.* aff. *obliquimarginatus* (3), *I.* sp. indet. (3); *Belodella* sp. (3); A1, B1; CAI 5-6.

RB-11. Conodonts:	polygnathids (lanceolate)	1 (25)	weight 0.5 kg
	simple cones	1 (25)	yield 8/kg

	bars	2 (50)	
	Total	4	

Po. pseudofoliatus (1); *Belodella* sp. (1); A1, A2; CAI 6-7.

RB-12.

Conodonts:	polygnathids (lanceolate)	16 (40)	weight 1.5 kg
	polygnathids (linguiform)	4 (10)	yield 27/kg
	icriodids	2 (5)	
	simple cones	2 (5)	
	spathognathodids	1 (2)	
	bars	15 (38)	
	Total	40	

Po. x. ensensis (5), *Po. l. linguiformis* (2), *Po. l.* subsp. a (2), *Po.* sp. indet. (11); *I. expansus* group (1), *I.* cf. *regularicrescens* (1); *Neopanderodus* sp. (2); *Tortodus* sp. (1); O1, A1, O2, B1; CAI 6-7.

RB-13 (SX9346764814): from isolated outcrop of med grey-pink, pale weathering, massive lst with laminar stromatoporoids, tabulate and rugose corals in a bioclastic and crinoidal matrix (Walls Hill Lst)

Conodonts:	polygnathids (lanceolate)	11 (41)	weight 1.5 kg
	polygnathids (linguiform)	8 (30)	yield 18/kg
	simple cones	3 (11)	
	bars	5 (18)	
	Total	27	

Po. pseudofoliatus (3), *Po. x. ensensis* (2), *Po.* cf. *l. alveolus* (1), *Po. l. linguiformis* (4), *Po. l.* subsp. a (1), *Po. l.* subsp. indet. (2), *Po.* sp. indet. (6); *Belodella* sp. (2), *Neopanderodus* sp. (1); O1, A1, A2; CAI 6-7

Other microfauna: white spheres.

RB-14 (SX9347864807): lithology as RB-13

Conodonts:	polygnathids (lanceolate)	4 (24)	weight 1.5 kg
	polygnathids (linguiform)	4 (24)	yield 11/kg
	simple cones	1 (6)	

bars 8 (48)

Total 17

Po. x. ensensis (2), *Po. l. linguiformis* (2), *Po. l.* subsp. a (1), *Po. l.* subsp. indet. (1), *Po.* sp. indet. (2); *Belodella* sp. (1); O1, A1, A2, B1; CAI 6-7.

RB-15, 17-19 from fault block of pale-med grey-pink, pale weathering, often micritic, massive lst at southern end of Redgate Beach; contains fauna of occasional stromatoporoids, branching tabulates and solitary Rugosa (Walls Hill Lst); RB-16 from red, fine grained calcareous infilling in the massive lst

RB-15 (SX9353564731). Conodonts: none; weight 0.5 kg.
RB-16 (SX9354964730). Conodonts: none; weight 1.5 kg.
RB-17 (SX9356564724). Conodonts: none; weight 1 kg.
RB-18 (SX9356464713). Conodonts: none; weight 0.5 kg.
RB-19 (SX9354364715). Conodonts: none; weight 1.5 kg.

Long Quarry Point (SX937650, Text-fig. 6; Walls Hill Lst)

LG-1-13 from pale-med grey, white weathering, massive lst; contains fauna of stromatoporoids (including tabular, laminar, conical, rounded and encrusting forms), with associated tabulate corals, solitary and massive Rugosa, and occasional bryozoa and brachiopods; matrix variably bioclastic, crinoidal or micritic, with some spar-filled cavities; see Scrutton 1977b, p.172, 1978a, p.37 for details of macrofauna and individual subfacies

LG-1 (SX9366265045, Subfacies i *sensu* Scrutton 1978a): pale-med grey-pink, med grained crinoidal lst
Conodonts: none; weight 0.5 kg.

LG-2 (SX9370065021, Subfacies i): med grey-pink, coarsely crinoidal lst with sparry areas

Conodonts: bars (A1) 1; weight 1 kg; yield 1/kg

Other microfauna: crinoid ossicles

LG-3 (SX9373865030, Subfacies i): pale-med grey, med grained lst

Conodonts:	polygnathids (lanceolate)	1 (50)	weight 0.5 kg
	polygnathids (linguiform)	1 (50)	yield 4/kg
		Total 2	

Po. aff. *pseudofoliatus* (1), *Po*. *l*. *alveolus* (1); CAI 7.

LG-4 (SX9374265033, Subfacies i): lithology as LG-1

Conodonts:	polygnathids (lanceolate)	3 (75)	weight 1.5 kg
	simple cones	1 (25)	yield 3/kg
		Total 4	

Po. cf. *c*. *costatus* (1), *Po*. *pseudofoliatus* (1), *Po*. sp. indet. (1); *Belodella* sp. (1); CAI 7-8.

LG-5 (SX9374665044, Subfacies i): med grey, coarsely bioclastic lst with sparry patches

Conodonts:	polygnathids (lanceolate)	6 (46)	weight 2.25 kg
	polygnathids (linguiform)	3 (23)	yield 6/kg
	bars	4 (31)	
		Total 13	

Po. *pseudofoliatus* (2), *Po*. aff. *pseudofoliatus* (2), *Po*. *l*. *linguiformis* (3), *Po*. sp. indet. (2); A1, A2, A3; CAI 7.

LG-6 (SX9381165070, Subfacies i): med grey, finely crinoidal lst

Conodonts:	polygnathids (lanceolate)	3 (50)	weight 1 kg
	polygnathids (linguiform)	1 (17)	yield 6/kg
	icriodids	2 (33)	
		Total 6	

Po. *x*. *ensensis* (2), *Po*. aff. *x*. *xylus* (1), *Po*. *l*. *linguiformis* (1); *I*. *expansus* group (2); CAI 7

Other microfauna: silicified internal casts of ?ostracods.

LG-7 (SX9380765082, Subfacies i): pale grey-pink, mottled lst with fine crinoidal debris and coarse sparry patches

Conodonts:	polygnathids (lanceolate)	1 (25)	weight 1 kg
	simple cones	1 (25)	yield 4/kg
	bars	2 (50)	
	Total	4	

Po. cf. *c. costatus* (1); A1, A2; CAI 6-7

Other microfauna: crinoid ossicles.

LG-8 (SX9378365086, Subfacies ii): v pale grey-pink, fine-med grained, crinoidal lst

Conodonts:	polygnathids (lanceolate)	2 (29)	weight 1.5 kg
	polygnathids (linguiform)	1 (14)	yield 5/kg
	bars	4 (57)	
	Total	7	

Po. pseudofoliatus (2), *Po. l. linguiformis* (1); O1, A1, B1; CAI 7.

LG-9 (SX9375065115, Subfacies ii): lithology as LG-8

Conodonts: none; weight 0.5 kg.

LG-10 (SX9371165130, Subfacies ii): pale grey-pink, coarsely crinoidal lst

Conodonts: none; weight 0.5 kg.

LG-11 (SX9369865149, Subfacies iii): v pale grey, micritic lst

Conodonts: none; weight 1.5 kg

Other microfauna: corals, bryozoa.

LG-12 (SX9365965173, Subfacies iv): pale-med grey, micritic lst

Conodonts: polygnathids (linguiform) 1; weight 0.5 kg; yield 2/kg

Po. l. alveolus (1); CAI 7.

LG-13 (SX9359065179, Subfacies iv): lithology as LG-12

Conodonts: none; weight 1 kg.

Babbacombe Road (SX93196475-93016508, Text-fig. 7a; Wall Hill Lst)

Section I (measured by northbound side of road)

165" grey-red shaly lst

13" red, calcareous, crinoidal shale with occasional thin (c.2") grey lst bands

60" grey-red, shaly, crinoidal lst with occasional small solitary Rugosa

47" calcareous shale with thin lst bands, as 13" unit above

350" med grey, pale weathering, massive lst to ground (pavement) level, becoming poorly bedded between 80" and 160" below top of unit; contains laminar stromatoporoids and solitary Rugosa in crinoidal matrix, with rounded stromatoporoids towards top of unit. BR-1 at 290-300" below top of unit

Section II (measured by southbound side of road)

135" grey-red, shaly crinoidal lst with occasional thin lst bands. BR-4 from shaly lst in basal 3" of unit, BR-5 from thin (1-1½"), grey lst band at 90" above base

72" red, calcareous, locally crinoidal shale with thin, often impersistent lst bands

3-4" grey crinoidal lst with small solitary Rugosa

28" red, calcareous, locally crinoidal shale

95" med grey, pale weathering, often crinoidal, massive lst to fault at ground (pavement) level, showing poor bedding in lower half of unit; contains laminar stromatoporoids and solitary Rugosa, with rounded stromatoporoids towards top of unit. BR-2 at 75-80" below top of unit, BR-3 from top 6"

BR-1. Conodonts:	polygnathids (linguiform)	3 (60)	weight 1 kg
	bars	2 (20)	yield 5/kg
	Total	5	

Po. l. linguiformis (3); A1, B1; CAI 7.

BR-2. Conodonts: bars 1; weight 1 kg; yield 1/kg.

BR-3.

Conodonts:	polygnathids (linguiform)	3 (23)	weight 1 kg
	icriodids	3 (23)	yield 13/kg
	bars	7 (54)	
	Total	13	

Po. *l*. *linguiformis* (3); *I*. *expansus* group (1), *I*. sp. indet. (2); A1, A2, B1, B3; CAI 6-7

Other microfauna: silicified internal casts of ?ostracods

BR-4. Conodonts: none; weight 0.5 kg.

BR-5. Conodonts: none; weight 1 kg.

BR-6-9 from pale grey-pink, white weathering, massive lst in disused quarries on Babbacombe Road; contains fauna of stromatoporoids (laminar and small conical coenostea) and abundant tabulate and rugose corals (*e*.*g*. *Thamnopora*, *Heliolites*, *Alveolites*) in a sometimes coarse crinoidal matrix; Walls Hill Lst, Subfacies ii-iii *sensu* Scrutton 1978a

BR-6 (SX9324864961).

Conodonts:	polygnathids (linguiform)	1 (33)	weight 0.5 kg
	bars	2 (67)	yield 6/kg
	Total	3	

Po. *l*. subsp. indet. (1); A1; CAI 6-7.

BR-7 (SX9325564972).

Conodonts: polygnathids (linguiform) 1; weight 0.5 kg; yield 2/kg

Po. *l*. *linguiformis*? (1)

Other microfauna: corals.

BR-8 (SX9323365061). Conodonts: bars (A1) 1; weight 1 kg; yield 1/kg

Other microfauna: crinoid ossicles.

BR-9 (SX9301065078).

Conodonts:	polygnathids (linguiform)	3 (21)	weight 1.5 kg
	icriodids	1 (7)	yield 9/kg

bars	10 (72)
	Total 14

Po. l. linguiformis (1), *Po. l.* subsp. a (1), *Po. l.* subsp. b (1); *I.* aff. *obliquimarginatus* (1); A1, A2, B1, B3; CAI 6-7.

Other microfauna: white spheres; ostracods.

Withy Point (SX93176548, Text-fig. 7a; Walls Hill Lst)

WP-1 (SX93159654459): pale-med grey, v fine grained, flinty lst

Conodonts: none; weight 0.5 kg.

New Quarry (SX933653, Text-fig. 7a; Walls Hill Lst)

Section I

190" pale-med grey, fine grained, brecciated, massive lst with reddened ?dolomitised patches and skins; fauna of tabulate corals (mainly massive forms, including *Alveolites*) and solitary Rugosa, with *Amphipora* at 25" above base of unit. NQ-3 at 120-130" above base

240" pale-med grey, fine grained, brecciated, massive lst with reddened ?dolomitised patches and skins, to sea level; fauna of massive tabulate and colonial rugose corals (including *Hexagonaria*), becoming most abundant towards top of unit. NQ-1 at 110-120" below top of unit, NQ-2 from top 6" of unit

Section II (measured along fault gully)

66")
20") med grey-red, bioclastic and crinoidal, sometimes shaly
40") lsts. NQ-5 from finely crinoidal and bioclastic area in
71") basal 6" of 71" bed, NQ-6 from coarsely crinoidal area in
20") top 10" of 66" bed

45" med grey-red, bioclastic and crinoidal lst, becoming less shaly than above. NQ-4 from top 10"

32") med grey-red, sometimes coarse,
8½") bioclastic and crinoidal lsts
9½")

80" badly weathered, poorly exposed lsts to ground level, to fault

NQ-1. Conodonts: none; weight 1.5 kg.

NQ-2. Conodonts:polygnathids (lanceolate, sp. indet.) 1; wt 1.5 kg; yld 1/kg.

NQ-3. Conodonts: none; weight 1.5 kg.

NQ-4. Conodonts: bars 1; weight 0.5 kg; yield 2/kg

Other microfauna: crinoid ossicles.

NQ-5. Conodonts:

polygnathids (lanceolate)	1	(6)	weight 1 kg
polygnathids (linguiform)	2	(12)	yield 17/kg
icriodids	1	(6)	
spathognathodids	1	(6)	
bars	12	(72)	
Total	17		

Po. pseudofoliatus (1), Po. l. linguiformis (2); I. aff. obliquimarginatus (1); Tortodus sp. (1); O1, B1; CAI 6-7.

NQ-6. Conodonts: bars (B1) 2; weight 0.5 kg; yield 4/kg.

Bishop's Walk (SX93566454, Text-fig. 6; Walls Hill Lst)

Section

77")
18") pale-med grey, pale weathering, massive, micritic lsts
13") with occasional pink ?dolomitised areas.
19")
20")

84" poor exposure

18") pale-med grey, massive micritic lsts, as above, to ground
43") (path) level. BW-1 from top 6" of 18" bed

BW-1. Conodonts: none; weight 1.5 kg.

Ashton Terrace (SX93346411, Text-fig. 7b; Walls Hill Lst)

Section

45") med grey, pale weathering, massive, micritic
40") lsts - reddened and brecciated

28")
35") med grey, pale weathering, micritic lsts with
42") sparse, thin, laminar stromatoporoids.
17") AT-1 from basal 4" of 32" bed
23")
32")

90" med grey, pale weathering, massive, micritic, rubbly-looking lst to ground (pavement) level

AT-1. Conodonts: none; weight 1.5 kg.

Kent's Cavern (SX93426421, Text-fig. 7b; Walls Hill Lst)

Section (measured in car park)

20' (approx) massive lsts to top of cliff

54" med grey, pale weathering, massive, micritic lst with sparse laminar stromatoporoids

½" shale parting

8" med grey, pale weathering, micritic lst

1" shale parting

73") med grey, pale weathering, massive, micritic lsts to ground
62") level; contain sparse, laminar stromatoporoids. KC-1 from
80") basal 10" of 73" bed, from slightly reddened, ?dolomitised
42") area

KC-1. Conodonts: none; weight 0.5 kg.

Ilsham Marine Drive (SX93746403, Text-fig. 7c; Walls Hill Lst)

Section

10' (approx) med grey-red shaly lst with laminar stromatoporoids

15' (approx) med grey, massive, micritic lst with much brecciation and reddening; contains laminar stromatoporoids, with small solitary Rugosa at top of unit. IM-2 at 12'-12' 6" above base of unit

30' (approx) med grey, pale weathering, massive, micritic lst with small amplitude stylolites and laminar stromatoporoids. IM-1 at 10'-10' 6" above base of section

IM-1. Conodonts: none; weight 1 kg.

IM-2. Conodonts: none; weight 0.5 kg.

Anstey's Cove (SX935646, Text-fig. 6)

AC-1 (SX9354864688): from deep red-grey, fine grained lst horizon in deep red shales with associated tuffs

Conodonts: none; weight 1.5 kg.

Area 3

Parkfield Road-Teignmouth Road (SX909650-910657, Text-fig. 8)

Section I

(developed in shaly lsts with thin lst bands; fauna of thin laminar stromatoporoids and massive and branching tabulate corals (*e.g.* *Alveolites*, *Thamnopora*) in a crinoidal matrix; fauna is most abundant in the lst bands, and tends to be more scattered in the shaly lsts)

20' (approx) inaccessible shaly lsts and lsts, as below, to top of cliff

8" med-dark grey lst

58" med-dark grey-pink shaly lst

8½" med-dark grey lst

41" med-dark grey-pink shaly lst

7½" med-dark grey lst

13" med-dark grey-pink shaly lst

9" med-dark grey lst

79" med-dark grey-pink shaly lst to ground level. PF-1 at 65-70" above base of section, from fine-med grained crinoidal area

Section II

(lithologies and macrofaunas as in Section I)

20' (approx) inaccessible shaly lsts and lsts, as below, to top of cliff

9" med-dark grey lst

18" med-dark grey-pink shaly lst

10" med-dark grey lst: PF-3

30" med-dark grey-pink shaly lst

7" med-dark grey lst

160" med-dark grey-pink shaly lst to ground level. PF-2 from fine-med grained area at 130-135" above base of section

PF-1. Conodonts: none; weight 0.5 kg.

PF-2. Conodonts:

Conodonts:	polygnathids (lanceolate)	1 (33)	weight 0.5 kg
	bars	2 (67)	yield 6/kg
	Total	3	

Po. sp. indet. (1); B1; CAI 5-6.

PF-3. Conodonts: bars (B2) 2; weight 0.5 kg; yield 4/kg.

PF-4 (SX9096165288): med-dark grey-pink, fine grained, crinoidal shaly lst with thin laminar stromatoporoids

Conodonts: none; weight 0.5 kg.

PF-5 (SX9094865331): med-dark grey-red, med grained, massive lst with sparse laminar stromatoporoids and corals

Conodonts:	polygnathids (lanceolate)	5 (50)	weight 1.5 kg
	polygnathids (linguiform)	1 (10)	yield 7/kg
	simple cones	1 (10)	
	bars	3 (30)	
	Total	10	

Po. pseudofoliatus (3), Po. l. linguiformis (1), Po. sp. indet. (2); Neopanderodus (1); B1; CAI 7.

PF-6 (SX9095065338): med grey, coarse grained lst, with some crinoidal debris and a few solitary rugose corals

Conodonts:	polygnathids (lanceolate)	1 (14)	weight 2.5 kg
	simple cones	2 (29)	yield 3/kg
	spathognathodids	1 (14)	
	bars	3 (43)	
	Total	7	

Po. sp. indet. (1); Belodella sp. (2); O. brevis (1); A1, B1; CAI 6

Other microfauna: white spheres.

PF-7 (SX9094665390): med grey-red, med-coarse grained, crinoidal shaly lst

Conodonts: none; weight 0.5 kg.

PF-8 (SX9094565392): med grey-pink, med grained crinoidal shaly lst with sparse solitary rugose corals

Conodonts: none; weight 0.5 kg.

PF-9 (SX9094165406): med-dark grey-red, med grained crinoidal shaly lst with a few laminar stromatoporoids and branching tabulates

Conodonts:	polygnathids (lanceolate)	2 (14)	weight 0.5 kg
	icriodids	5 (36)	yield 28/kg
	simple cones	1 (7)	
	bars	6 (43)	
	Total	14	

Po. pseudofoliatus (2); *I. arkonensis* (3), *I. expansus* group (1), *I.* sp. indet. (1); *Belodella* sp. (1); 01, A1, B1; CAI 6-7.

PF-10 (SX9093665408): pale-med grey, pale weathering, massive lst with broken stromatoporoids and a few solitary rugose corals in a partly crinoidal matrix

Conodonts: none; weight 1 kg.

TR-1 (SX9098065492): med grey-pink, bedded lst with massive and branching tabulate corals (*e.g. Alveolites*, *Thamnopora*) and solitary Rugosa in a crinoidal matrix

Conodonts:	icriodids	1 (25)	weight 1 kg
	bars	3 (75)	yield 4/kg
	Total	4	

I. expansus group (1); 01, A1, B2; CAI 6-7.

TR-2 (SX9110665560): med grey, med grained, crinoidal and bioclastic, shaly lst

Conodonts:	polygnathids (lanceolate)	7 (58)	weight 0.5 kg
	bars	5 (42)	yield 24/kg
	Total	12	

Po. l. linguiformis (7); 01, A2, B1; CAI 6-7.

TR-3 (SX9109565650): pale-med grey, pale weathering, massive, micritic lst

Conodonts: none; weight 0.75 kg

TR-4 (SX9106665687): lithology as TR-3, with sparse broken stromatoporoids and patches of fine crinoidal debris

Conodonts: none; weight 0.75 kg

Other microfauna: crinoid ossicles; pyritised endichnial burrow infillings.

TR-5 (SX9106065778): lithology as TR-3

Conodonts: none; weight 0.5 kg.

St James Road (SX912650, Text-fig. 8a)

Section

Developed in c. 50' med-dark grey-red, med-coarse grained, bioclastic and crinoidal, massive lsts, with frequent localised concentrations of rolled, rounded and bun-shaped stromatoporoids, branching and massive tabulate corals (*e.g. Thamnopora*, *Alveolites*) and solitary Rugosa; less fossiliferous areas appear paler grey in colour. SJ-1 from richly fossiliferous area at 4'-4' 6" above base of section, SJ-2 from coarsely crinoidal but less fossiliferous area at 35'-35' 6" above base of section (base of section at ground level)

SJ-1.	Conodonts:	polygnathids (linguiform)	1 (25)	weight 0.5 kg
		bars	3 (75)	yield 8/kg
		Total	4	

Po. l. subsp. indet. (1); A1, B1, B2; CAI 6-7.

SJ-2.	Conodonts:	polygnathids (lanceolate)	23 (42)	weight 1 kg
		polygnathids (linguiform)	19 (35)	yield 55/kg
		icriodids	1 (2)	
		simple cones	3 (5)	
		bars	9 (16)	
		Total	55	

Po. timorensis (3), *Po. x. ensensis* (5), *Po. x. xylus* (1), *Po.* aff. *x. xylus* (1), *Po. varcus* group sp. indet. juvenile (1), *Po. l. linguiformis* (19), *Po.* sp. indet. (12); *I.* sp. indet. (1); *Belodella* sp. (1), *Neopanderodus* sp. (2); A1, A3, B1, B2, N; CAI 6-7.

Other microfauna: white spheres; bryozoa.

Area 4

Castle Road (SX914642, Text-fig. 9)

Section (measured by the side of Castle Road)
(developed in pale weathering, bedded lsts with a fauna of stromatoporoids (laminar, encrusting and broken forms), branching and massive tabulate corals (*e.g.* *Thamnopora*, *Alveolites*, *Heliolites*), solitary and colonial Rugosa and bryozoa with crinoidal debris; fauna is most abundant in the higher parts of the section (*i.e.* 51" bed upwards), where some horizons are crowded with stick-like corals aligned parallel to bedding, while the lower shaly parts are less fossiliferous)

15' (approx) inaccessible bedded lst to top of section

22" med grey-pink lst

58") med grey and grey-red, massive lsts. CR-4 from top
72") 4" of 58" bed, from area with fine crinoidal debris
49")

13" med grey lst

1" grey-pink shaly parting

12")
24") med grey and grey-pink lsts. CR-3 from basal 6" of
24") 16" bed, from fine-med grained, grey-pink area
14")
16")

40" massive, med grey-red lst with abundant stick-like corals aligned parallel to bedding

22" med grey lst

4½" med grey-red shaly lst

19") med grey-pink lsts with abundant stick-like corals aligned
17") parallel to bedding

3½" med grey-red shaly lst

6" med grey lst

26" med grey, rather fine grained lst. <u>CR-2</u> from lower half of bed

8½" med grey lst, reddened and shaly in lower part

51" massive, med grey lst

5" med grey lst

2" med grey-red shaly lst

4½" med grey lst

6" med grey-red shaly lst

7")
)
10") med grey lsts
)
7")

2½" med grey-red shaly lst

5" med grey, finely laminated lst

6" med grey-red shaly lst

6" med grey-red lst

12" med grey, finely laminated lst

7" med grey-red shaly lst

65" poor exposure

29" med grey-red shaly lst. <u>CR-1</u> from top 4", from area with fine crinoidal debris

6") med grey
)
6") lsts

11" med grey-red shaly lst

6" med grey lst

57" med grey-red shaly lst with thin (1-6") lst bands

9" med grey lst

68" med grey-red shaly lst with thin (1-3") lst bands

9" med grey lst

35" as 68" unit above, to base of section at ground level

CR-1.	Conodonts:	polygnathids (lanceolate)	3 (43)	weight 0.5 kg
		simple cones	3 (43)	yield 14/kg
		bars	1 (14)	
		Total	7	

Po. x. ensensis (1), Po. varcus group sp. indet. juvenile (1), Po. sp. indet. (1); Belodella sp. (1), Coelocerodontus sp. (2); O1; CAI 6-7.

CR-2.	Conodonts:	polygnathids (lanceolate)	3 (27)	weight 1.5 kg
		polygnathids (linguiform)	3 (27)	yield 7/kg
		bars	5 (46)	
		Total	11	

Po. timorensis (2), Po. l. linguiformis (3), Po. sp. indet. (1); A1, B1, B2; CAI 6-7.

CR-3.	Conodonts:	polygnathids (lanceolate)	1 (50)	weight 2 kg
		bars	1 (50)	yield 1/kg
		Total	2	

Po. sp. indet. (1); B1; CAI 6-7

Other microfauna: white spheres; crinoid ossicles.

CR-4.	Conodonts:	polygnathids (lanceolate)	1 (25)	weight 1.5 kg
		polygnathids (linguiform)	1 (25)	yield 3/kg
		bars	2 (50)	
		Total	4	

Po. l. linguiformis (1), Po. sp. indet. (1); A1; CAI 6-7.

Stentiford Hill (SX917641, Text-fig. 9)

Section I (measured in old quarry on south side of Stentiford Hill and along Stentiford Hill Road)

40-50' (approx) inaccessible and overgrown outcrop in old quarry on south side of Stentiford Hill, behind Stentiford Hill Road. SH-3 (SX91758-64089) from med grey-pink, slightly shaly, crinoidal lst close to top of section

600" med grey-red, thin-bedded lsts and shaly lsts (individual beds 2-4" thick), with scattered laminar and broken stromatoporoids, branching and massive tabulate corals (*e.g.* *Thamnopora*, *Heliolites*, *Alveolites*), solitary and colonial Rugosa and crinoidal debris (highest part of section along Stentiford Hill Road). *SH-2* from crinoidal lst at 180" below top of unit

40" no exposure

150" thin-bedded lsts and shaly lsts, as 600" unit above

80" no exposure (steps)

460" thin-bedded lsts and shaly lsts, as 600" unit above, becoming less shaly in lowest 90". *SH-1* from coarsely crinoidal, shaly lst at 300-303" below top of unit

40" no exposure

20" thin-bedded lsts and shaly lsts, as 600" unit above

60" no exposure

80" thin-bedded lsts and shaly lsts, as 600" unit above, to base of section near junction with Alpine Road

Section II (measured in old quarry behind Market Street, on western side of Stentiford Hill)

64" med grey-red, thin-bedded lsts and shaly lsts to top of section at fault; individual beds 1-3" thick, lsts proper sometimes appearing lenticular; fauna as in 600" unit in Section I. *SH-5* from crinoidal lst at 10-12" above base of unit

40" thin-bedded lsts and shaly lsts, as 64" unit above

38") rather more massive grey crinoidal lsts, with laminar
)
50") and broken stromatoporoids

47" thin-bedded lsts and shaly lsts, as 64" unit above

5½" med grey-red, crinoidal lst

6" thin-bedded lsts and shaly lsts, as 64" unit above

20" med grey-red, crinoidal lst

8" thin-bedded lsts and shaly lsts, as 64" unit above

10" med grey-red, crinoidal lst

40" thin-bedded lsts and shaly lsts, as 64" unit above

5" med grey-red, crinoidal lst: SH-4

57" thin-bedded lsts and shaly lsts, as 64" unit above, to base of section at ground level

Section III

8-10' (approx) thin-bedded lsts and shaly lsts to top of cliff (inaccessible)

88" med grey-red, thin-bedded lsts and shaly lsts, as 64" unit in Section II. SH-7 from shaly lst at 28-30" above base of unit

43" thin-bedded lsts and shaly lsts, as above

63" thin-bedded lsts and shaly lsts, as above

42" thin-bedded lsts and shaly lsts, as above. SH-6 from grey crinoidal lst at 2-5" above base of unit

5" grey lst band

97" thin-bedded lsts and shaly lsts, as 88" unit above, to base of section at ground level, at fault

SH-1. Conodonts:	polygnathids (lanceolate)	1 (25)	weight 0.5 kg
	polygnathids (linguiform)	1 (25)	yield 8/kg
	bars	2 (50)	
	Total	4	

Po. l. subsp. indet. (1), *Po.* sp. indet. (1); B1; CAI 6-7.

SH-2. Conodonts: none; weight 0.5 kg

SH-3. Conodonts:	polygnathids (linguiform)	1 (33)	weight 0.5 kg
	bars	2 (67)	yield 6/kg
	Total	3	

Po. l. linguiformis (1); A1; CAI 6-7

Other microfauna: foraminifera (*Psammosphaera*).

SH-4. Conodonts: none; weight 0.5 kg.

SH-5. Conodonts: none; weight 0.5 kg.

SH-6. Conodonts: none; weight 0.5 kg.

SH-7. Conodonts:

simple cones	5 (83)	weight 1 kg
bars	1 (17)	yield 6/kg
Total	6	

Belodella sp. (1), *Coelocerodontus* sp. (3), *Panderodus* (1); CAI 6-7.

Madrepore Road (SX91776394, Text-fig. 9)

Section IV

(short section developed in bedded, bioclastic and sometimes coarsely crinoidal lsts with several horizons crowded with fossils, while alternating beds are relatively less fossiliferous; the fauna in the richly fossiliferous bands includes branching and massive tabulate corals (*e.g.* *Thamnopora*, *Alveolites*, *Heliolites*) and solitary Rugosa, often aligned parallel to bedding, with occasional colonial Rugosa (*e.g.* *Hexagonaria*) and small laminar and encrusting stromatoporoids; the rather less fossiliferous horizons contain scattered branching and massive tabulates, solitary Rugosa and small stromatoporoids)

10" richly fossiliferous, pale grey weathering, med grey and grey-red lst

15" less fossiliferous, pale grey weathering, med grey and grey-red lst

20" richly fossiliferous lst, as 10" bed above

25" less fossiliferous lst, as 15" bed above

4-5" richly fossiliferous lst, as 10" bed above

27" less fossiliferous lst, as 15" bed above

6" richly fossiliferous lst, as 10" bed above; fauna includes a large *Hexagonaria* colony

9" less fossiliferous lst, as 15" bed above. MR-1 from med grey-red, v coarsely crinoidal lower half of unit

10" richly fossiliferous lst, as 10" bed above

14½" less fossiliferous lst, as 15" bed above

9" richly fossiliferous lst, as 10" bed above

7" less fossiliferous lst, as 15" bed above, to base of section

MR-1. Conodonts:	polygnathids (lanceolate)	13 (14)	weight 1.5 kg
	polygnathids (linguiform)	10 (11)	yield 63/kg
	simple cones	35 (37)	
	spathognathodids	2 (2)	
	bars	34 (36)	
	Total	94	

Po. ansatus (4), *Po. timorensis* (5), *Po. x. xylus* (1), *Po. varcus* group sp. indet. juveniles (2), *Po. l. linguiformis* (9), *Po. l. mucronatus* (1), *Po.* sp. indet. (1); *Belodella* spp. (28, including "*B. devonicus*" and "*B. resimus*"), *Coelocerodontus* sp. (2), *Neopanderodus* sp. (5); *Sp. planus* (2); 01, A1, A2, A3, 02, B1, B2; CAI 6-7
Other microfauna: white spheres; pyritised foraminifera (*Nanicella*).

Waldon Hill (SX915637, Text-fig. 9)

WH-1-6 from massive, thick and irregularly bedded, med grey-red and grey-pink, pale grey weathering lsts exposed in a much-faulted section by the side of, and behind, Warren Road (SX91656367-91426393), and in isolated outcrops in Royal Terrace Gardens (around SX915635). The lsts bear an often locally abundant fauna of branching and massive tabulate corals (*e.g. Thamnopora*, *Alveolites*, *Heliolites*), solitary Rugosa and laminar, broken and encrusting stromatoporoids in a variably fine-coarse bioclastic and crinoidal matrix

WH-1 (SX91546635541): med-dark grey-red, med grained bioclastic lst with white calcite veining

Conodonts:	polygnathids (lanceolate)	13 (54)	weight 0.5 kg
	simple cones	1 (4)	yield 48/kg

	bars	10 (42)	
		Total 24	

Po. pseudofoliatus (5), *Po.* aff. *x. ensensis* (3), *Po.* sp. indet. (5); *Belodella* sp. (1); 01, A1, A2, 02, B1; CAI 6-7.

Other microfauna: white spheres.

WH-2 (SX9165463675): med-dark grey-red, coarsely bioclastic lst with calcite veining

Conodonts:	polygnathids (lanceolate)	4 (15)	weight 0.5 kg
	polygnathids (linguiform)	9 (35)	yield 52/kg
	spathognathodids	1 (4)	
	bars	12 (46)	
		Total 26	

Po. varcus group sp. indet. juveniles (4), *Po. l. linguiformis* (4), *Po. l. mucronatus* (3), *Po. l.* subsp. indet. (2); *Tortodus* sp. (1); 01, A1, A2, B1; CAI 6-7

Other microfauna: fish teeth and other possible fish remains (spherical ?denticles).

WH-3 (SX9165063690): med grey-pink, med grained, dolomitised lst with fine crinoidal debris

Conodonts:	polygnathids (lanceolate)	12 (17)	weight 0.5 kg
	polygnathids (linguiform)	29 (41)	yield 142/kg
	icriodids	15 (21)	
	bars	15 (21)	
		Total 71	

Po. aff. *ovatinodosus* (2), *Po. varcus* (2), *Po. x. xylus* (1), *Po. l. linguiformis* (24), *Po. l. linguiformis* epsilon morphotype (1), *Po. l.* subsp. indet. (4), *Po.* sp. indet. (7); *I. expansus* group (3), *I.* aff. *obliquimarginatus* (2), *I.* sp. indet. (10); 01, A1, A2, B1, B2; CAI 6-7

Other microfauna: white spheres.

WH-4 (SX91598637 50): med grey-pink, med grained bioclastic lst
Conodonts: none; weight 0.5 kg.

WH-5 (SX91546638 27): med grey-pink, fine-med grained sugary-looking lst
Conodonts: none; weight 0.5 kg.

WH-6 (SX91461638 92): med-dark grey-pink, med grained crinoidal lst
Conodonts: none; weight 0.5 kg.

Area 5

Lummaton Quarry (SX913665, Text-fig. 10; Walls Hill Lst, Lummaton Shell Bed Member, Barton Lst)

LM-1-9 from massive, pale-med grey, pale weathering, frequently dolomitised Walls Hill Lst; fauna of abundant, often large stromatoporoids with scattered corals (branching and massive tabulates, and Rugosa) in an often crinoidal, sometimes sparry matrix

LM-10-18 from massive, med grey, partly dolomitised, bioclastic and crinoidal Barton Lst, with abundant tabulate and rugose corals, some brachiopods and scattered, small, rounded stromatoporoids. LM-10, 11 from the brachiopod-dominated, richly fossiliferous lenses of the Lummaton Shell Bed Member, at the base of the Barton Lst

(see Scrutton 1977b, p.173, 174; 1978a, p.39-40 for details of macrofaunas)

LM-1 (SX91316664 27): v pale buff-grey, coarsely crinoidal, dolomitised lst

Conodonts:	polygnathids (lanceolate)	1	(20)	weight 1.5 kg
	polygnathids (linguiform)	2	(40)	yield 3/kg
	spathognathodids	1	(20)	
	bars	1	(20)	
	Total	5		

Po. timorensis (1), Po. l. linguiformis (1), Po. l. linguiformis epsilon morphotype (1); O. brevis (1); CAI 7.

LM-2 (SX9129866455): pale buff-grey, med grained, dolomitised lst

Conodonts: none; weight 0.5 kg.

LM-3 (SX9121266508): lithology as LM-2

Conodonts:	polygnathids (lanceolate)	3 (10)	weight 1 kg
	polygnathids (linguiform)	4 (14)	yield 29/kg
	simple cones	9 (31)	
	spathognathodids	1 (3)	
	bars	12 (41)	
	Total	29	

Po. timorensis (3), *Po. l. linguiformis* (4); *Belodella* spp. (9, including "*B. devonicus*" and "*B. triangularis*"); *O. brevis* (1); O1, A1, A2, B1; CAI 7-8.

LM-4 (SX9121066512): pale buff-grey, coarsely crinoidal, dolomitised lst

Conodonts:	polygnathids (lanceolate)	1 (14)	weight 0.75 kg
	polygnathids (linguiform)	1 (14)	yield 9/kg
	simple cones	3 (43)	
	bars	2 (29)	
	Total	7	

Po. timorensis (1), *Po. l. linguiformis* (1); *Belodella* spp. (3, including "*B. triangularis*"); A1, A2; CAI 7-8.

LM-5 (SX9120866517): pale buff-grey-pink, fine-med grained, dolomitised lst

Conodonts:	polygnathids (lanceolate)	1 (25)	weight 0.75 kg
	polygnathids (linguiform)	1 (25)	yield 6/kg
	simple cones	1 (25)	
	bars	1 (25)	
	Total	4	

Po. timorensis (1), *Po. l. linguiformis* (1); "*B. resimus*" (1); B1; CAI 7.

LM-6 (SX9120966521): lithology as LM-5

Conodonts:	simple cones	14 (88)	weight 0.5 kg
	spathognathodids	1 (6)	yield 32/kg

bars	1 (6)
	Total 16

Belodella spp. (13, including "*B. devonicus*" and "*B. triangularis*"), *Coelocerodontus* sp. (1); *O. brevis* (1); A1; CAI 7-8.

LM-7 (SX9121266529): pale buff-grey, med grained, crinoidal, dolomitised lst

Conodonts:	polygnathids (lanceolate)	1 (3)	weight 1 kg
	polygnathids (linguiform)	2 (6)	yield 36/kg
	simple cones	19 (53)	
	spathognathodids	1 (3)	
	bars	13 (36)	
		Total 36	

Po. varcus group sp. indet. juvenile (1), *Po. l. linguiformis* (2); *Belodella* spp. (19, including "*B. devonicus*" and "*B. triangularis*"); *O. brevis* (1); O1, A1, A2, A3, N, B1; CAI 7-8

Other microfauna: white spheres.

LM-8 (SX9127766514): lithology as LM-5

Conodonts:	simple cones	2 (67)	weight 1.5 kg
	bars	1 (33)	yield 2/kg
		Total 3	

Belodella spp. (2, including "*B. resimus*" and "*B. triangularis*"); A1; CAI 7.

LM-9 (SX1921866540): lithology as LM-7

Conodonts:	polygnathids (lanceolate)	2 (11)	weight 1 kg
	polygnathids (linguiform)	4 (22)	yield 18/kg
	simple cones	4 (22)	
	spathognathodids	1 (6)	
	bars	7 (39)	
		Total 18	

Po. timorensis (2), *Po. l. linguiformis* (4); *Belodella* spp. (4, including "*B. resimus*" and "*B. triangularis*"); *Sp. planus* (1); O1, A1, N, B1; CAI 7

Other microfauna: abundant white spheres.

LM-10 (SX9122866556): med grey, coarse grained lst with abundant brachiopods and crinoidal debris

Conodonts:	polygnathids (lanceolate)	3 (9)	weight 1.5 kg
	polygnathids (linguiform)	4 (13)	yield 21/kg
	simple cones	7 (22)	
	spathognathodids	2 (6)	
	bars	16 (50)	
	Total	32	

Po. timorensis (3), *Po. l. linguiformis* (4); *Belodella* spp. (6, including "*B. triangularis*"), *Coelocerodontus* sp. (1); *O. brevis* (1), *Sp. planus* (1); O1, A1, A2, B2; CAI 7

Other microfauna: v abundant white spheres.

LM-11 (SX9120966585): med grey-buff, coarse grained, partly dolomitised lst with abundant small brachiopods

Conodonts:	polygnathids (lanceolate)	8 (29)	weight 1.5 kg
	polygnathids (linguiform)	3 (11)	yield 19/kg
	simple cones	1 (4)	
	spathognathodids	1 (4)	
	bars	15 (53)	
	Total	28	

Po. ansatus (4), *Po. timorensis* (4), *Po. l. linguiformis* (2), *Po. l. mucronatus* (1); "*B. triangularis*" (1); *O. brevis* (1); O1, A1, A2, A3, O2, B1, B2, B3, N; CAI 7.

LM-12 (SX9122066591): med grey, med-coarse grained, crinoidal and bioclastic lst

Conodonts: none; weight 0.5 kg

Other microfauna: white spheres.

LM-13 (SX9129166593): med grey-buff, med grained, partly dolomitised, crinoidal and bioclastic lst

Conodonts:	polygnathids (linguiform)	2 (18)	weight 1.5 kg
	simple cones	3 (27)	yield 7/kg
	spathognathodids	2 (18)	
	bars	4 (36)	
	Total	11	

Po. l. linguiformis (1), *Po.* cf. *l. linguiformis* delta morphotype (1); *Belodella* sp. (1), *Coelocerodontus* sp. (1), *Neopanderodus* sp. (1); *O. brevis* (2); A1, A2, N; CAI 7

Other microfauna: fish tooth.

LM-14 (SX9127066604): med grey-pink, med grained, partly dolomitised lst with a few small brachiopods

Conodonts:	simple cones	3 (60)	weight 1.5 kg
	bars	2 (40)	yield 3/kg
	Total	5	

Belodella spp. (3, including "*B. resimus*"); B1; CAI 7

Other microfauna: white spheres.

LM-15 (SX9122666617): lithology as LM-14

Conodonts:	polygnathids (lanceolate)	7 (15)	weight 0.5 kg
	polygnathids (linguiform)	2 (4)	yield 92/kg
	simple cones	31 (67)	
	spathognathodids	1 (2)	
	bars	5 (11)	
	Total	46	

Po. ansatus (3), *Po. ansatus*? (*Po. varcus* group juveniles, 2), *Po. x. xylus* (2), *Po. l. linguiformis* (2); *Belodella* spp. (29, including "*B. devonicus*", "*B. resimus*", "*B. resimus-triangularis*"), *Coelocerodontus* sp. (2); *O. brevis* (1); O1, A1, A2, B1; CAI (6)-7

Other microfauna: white spheres.

LM-16 (SX9122266634): med grey-buff, v coarse grained, crinoidal and bioclastic lst

Conodonts:	polygnathids (lanceolate)	2 (11)	weight 0.5 kg
	polygnathids (linguiform)	2 (11)	yield 38/kg
	simple cones	5 (26)	
	bars	10 (52)	
	Total	19	

Po. ansatus (1), *Po. varcus* group sp. indet. juvenile (1), *Po. l.* subsp. indet. (2); *Belodella* spp. (2, including "*B. devonicus*"), *Coelocerodontus* sp. (1), *Neopanderodus* sp. (2); O1, A1, A2, B1; CAI 6-7.

LM-17 (SX9122966655): pale-med grey-buff, fine-med grained, partly dolomitised lst

Conodonts:	polygnathids (lanceolate)	4 (13)	weight 2 kg
	polygnathids (linguiform)	9 (30)	yield 15/kg
	simple cones	4 (13)	
	spathognathodids	1 (3)	
	bars	12 (40)	
	Total	30	

Po. aff. *ovatinodosus* (1). *Po. varcus* group sp. indet. juvenile (1), *Po. l. linguiformis* (8), *Po. l. linguiformis* epsilon morphotype (1), *Po.* sp. indet.(2); *Belodella* spp. (4, including "*B. devonicus*"); *Sp. planus* (1); O1, A1, A2, O2, B1, B2, N; CAI 6-7.

LM-18 (SX9129666643): med-dark grey-pink, med-coarse-grained, crinoidal and bioclastic, partly dolomitised lst

Conodonts:	polygnathids (lanceolate)	12 (29)	weight 1 kg
	polygnathids (linguiform)	2 (5)	yield 42/kg
	simple cones	9 (21)	
	spathognathodids	4 (10)	
	bars	15 (36)	
	Total	42	

Po. ansatus (1), *Po. timorensis* (1), *Po. varcus?* (4), *Po. varcus* group sp. indet. juveniles (6), *Po. l. linguiformis* (2); *Belodella* spp. (6, including "B. devonicus" and "B. triangularis"), Coelocerodontus sp. (1), Neopanderodus sp. (2); O. brevis (3), Sp. planus (1); O1, A1, A2, N, B1, B2; CAI 7-8

Other microfauna: white spheres.

Trumlands Quarry (SX91516628, Text-fig. 8c)

Section (measured in disused and largely overgrown quarry)

(section comprises thick-bedded, partly dolomitised, sometimes shaly lsts with a fauna of branching and massive tabulate corals (e.g. Thamnopora, Alveolites, Heliolites), solitary Rugosa and occasional small laminar stromatoporoids; corals may be locally abundant)

10' (approx) poorly exposed, thick-bedded lsts to top of section
35") fairly massive, med grey-red, fossiliferous lsts with abundant
31") stick-like corals aligned parallel to bedding in 37" bed.
37") TL-3 from fine grained, dolomitised, basal 4" of 40" bed
40")

35") med grey-red, fossiliferous lsts; 35" bed
26") becomes shaly towards the base

1" grey-red shale

12") med grey-red, fossiliferous lsts with
20") thin shaly partings

20' (approx) poor, overgrown exposure

18") med grey-red, fossiliferous lsts with thin shaly partings. TL-2
25") from fine grained, partly dolomitised top 6" of 25" bed

30") med grey-red fossiliferous lsts; 45" bed
45") becomes shaly towards the base

30' (approx) poor, overgrown exposure to base of section at ground level.

TL-1 from med grey-red, fine-med grained lst at SX9152366268, close to base of section .

TL-1. Conodonts:	simple cones	1 (17)	weight 0.5 kg
	bars	5 (83)	yield 12/kg
	Total	6	

Neopanderodus sp. (1); A1, B1, B2, N; CAI 7.

TL-2. Conodonts:	polygnathids (lanceolate)	1 (11)	weight 0.75 kg
	polygnathids (linguiform)	3 (33)	yield 12/kg
	simple cones	2 (22)	
	bars	3 (11)	
	Total	9	

Po. timorensis (1), *Po. l. linguiformis* (3); *Coelocerodontus* sp. (2); A1, B1; CAI 7.

TL-3. Conodonts:	polygnathids (lanceolate)	8 (8)	weight 1 kg
	polygnathids (linguiform)	5 (24)	yield 21/kg
	bars	8 (38)	
	Total	21	

Po. timorensis (3), *Po. x. xylus* (1), *Po. l. linguiformis* (5), *Po.* sp. indet. (4); A1, B1, N; CAI 6-7.

Area 6

Barton Quarry (SX912671, Text-fig. 11; Barton Lst)

BQ-1-32, MH-1, 2 from massive, med grey, partly dolomitised, bioclastic and crinoidal Barton Lst; fauna of abundant corals (branching and massive tabulates, solitary and colonial Rugosa), with small scattered stromatoporoids and, only rarely, other fossil groups such as goniatites and brachiopods; see Scrutton 1977b, p.174, 1978a, p.40 for details of macrofauna

BQ-1 (SX9124667078): med grey-pink, coarse grained, bioclastic lst with areas of recrystallised calcite

Conodonts:	polygnathids (lanceolate)	12 (43)	weight 2.5 kg
	polygnathids (broad-plat)	2 (7)	yield 11/kg

schmidtognathids	1 (4)
icriodids	1 (4)
bars	12 (43)
Total	28

Po. cristatus (2), Po. dubius (1), Po. ovatinodosus (2), Po. sp. indet. (9); Sch. wittekindti (1); I. latecarinatus (1); O1, A2, O2, B1, B2; CAI 6-7

Other microfauna: sponge spicules.

BQ-2 (SX9124967083): med-darker grey, mottled, coarse grained bioclastic lst, with bands of recrystallised calcite

Conodonts:	polygnathids (lanceolate)	8 (21)	weight 1.5 kg
	polygnathids (broad-plat)	1 (3)	yield 25/kg
	bars	29 (76)	
	Total	38	

Po. cristatus (1), Po. aff. dubius (4), Po. sp. indet. (4); O1, A1, A2, A3, O2, B1, B2, N; CAI 6-7.

BQ-3 (SX9125267087): from band of deep brick-red, fine grained, compact dolomite

Conodonts: none; weight 0.5 kg.

BQ-4 (SX9125967112): med grey-deep pink, fine-med grained bioclastic lst

Conodonts:	polygnathids (lanceolate)	10 (50)	weight 0.75 kg
	simple cones	1 (5)	yield 27/kg
	bars	9 (45)	
	Total	20	

Po. dubius (1), Po. aff. dubius (3), Po. sp. indet. (6); O1, A1, B1, B2, B3; CAI 6-7.

BQ-5 (SX9125167159): med-pale grey-pink, mottled, med-coarse grained, bioclastic lst

Conodonts:	polygnathids (lanceolate)	15 (72)	weight 0.5 kg
	bars	6 (28)	yield 42/kg
	Total	21	

Po. aff. dubius (7), Po. sp. indet. (8); O1, A1, A2; CAI 6-7.

BQ-6 (SX9124667168): from irregular area of v deep red, fine grained dolomite

Conodonts: none; weight 0.5 kg

BQ-7 (SX9124267174): pale-med grey-pink, coarse grained bioclastic lst

Conodonts:	polygnathids (lanceolate)	7 (70)	weight 1 kg
	schmidtognathids	1 (10)	yield 10/kg
	bars	2 (20)	
	Total	10	

Po. aff. dubius (1), Po. ovatinodosus (1), Po. sp. indet. (5); Sch. sp. indet. (1); A1; CAI 6.

BQ-8 (SX9123767186): med brownish-grey, coarse grained bioclastic lst

Conodonts: icriodids 1; weight 0.5 kg; yield 2/kg

I. expansus group (1); CAI 6.

BQ-9 (SX9123667191): med grey-pink, coarse grained, bioclastic, partly dolomitised lst

Conodonts:	polygnathids (lanceolate)	4 (50)	weight 1 kg
	schmidtognathids	1 (13)	yield 8/kg
	bars	3 (38)	
	Total	8	

Po. aff. dubius (2), Po. sp. indet. (2); Sch.? aff. gracilis (1); A1, B1; CAI 6-7.

BQ-10 (SX9128267179): med-dark brownish-grey, coarse grained, bioclastic lst, with pink dolomitised veins and patches

Conodonts:	polygnathids (lanceolate)	9 (43)	weight 1 kg
	polygnathids (linguiform)	1 (5)	yield 21/kg
	schmidtognathodids	1 (5)	
	simple cones	1 (5)	
	bars	9 (43)	
	Total	21	

Po. aff. *dubius* (1), *Po*. *ovatinodosus* (2), *Po*. *l*. subsp. indet. (1), *Po*. sp. indet. (6); *Sch*. sp. indet. (1); *Belodella* sp. (1); A1, N, B1, B2, B3; CAI 6-7

Other microfauna: white spheres.

BQ-11 (SX9128867178): med grey-buff-pink, coarse grained, bioclastic, partly dolomitised lst

Conodonts:			
	polygnathids (lanceolate)	9 (31)	weight 0.5 kg
	schmidtognathids	2 (7)	yield 58/kg
	spathognathodids	2 (7)	
	bars	16 (55)	
	Total	29	

Po. *ovatinodosus* (1), *Po*. sp. indet. (8); *Sch*. *peracutus* (1), *Sch*. *pietzneri* (1); *O*. *brevis* (2); O1, A1, A2, A3, N; CAI 6

Other microfauna: white spheres.

BQ-12 (SX9128867170): lithology as BQ-11

Conodonts:			
	polygnathids (lanceolate)	5 (50)	weight 0.75 kg
	spathognathodids	1 (10)	yield 13/kg
	bars	4 (40)	
	Total	10	

Po. aff. *dubius* (1), *Po*. *ovatinodosus* (1), *Po*. sp. indet. (3); *O*. *brevis* (1); A1, B1, B2; CAI 6-7.

BQ-13 (SX9129367168): med brownish-grey, coarse grained, bioclastic lst

Conodonts:			
	polygnathids (lanceolate)	12 (35)	weight 2 kg
	schmidtognathids	2 (6)	yield 17/kg
	simple cones	2 (6)	
	bars	18 (53)	
	Total	34	

Po. *dubius* (1), *Po*. *ovatinodosus* (8), *Po*. *x*. *xylus* (1), *Po*. sp. indet. (2); *Sch*. *peracutus* (1), *Sch*. sp. indet. (1); *Belodella* sp. (2); A1, A2, N, O2, B1, B2, B3; CAI 6

Other microfauna: fish tooth; brown phosphatic pellets.

BQ-14 (SX9129467164): med-dark grey, med-coarse grained, bioclastic lst

Conodonts:	polygnathids (lanceolate)	7 (50)	weight 0.5 kg
	bars	7 (50)	yield 28/kg
	Total	14	

Po. *dubius* (1), *Po*. aff. *webbi* (1), *Po*. sp. indet. (5); A1, A2, 02, B1, B2; CAI 6-7.

BQ-15 (SX9129167161): med grey-pink, fine-med grained, partly dolomitised, bioclastic lst

Conodonts:	polygnathids (lanceolate)	4 (36)	weight 1 kg
	bars	7 (64)	yield 11/kg
	Total	11	

Po. aff. *dubius* (1), *Po*. *x*. *xylus* (1), *Po*. sp. indet. (2); A1, A2, N, B1, B3, N; CAI 6-7

Other microfauna: white spheres.

BQ-16 (SX9129467159): lithology as BQ-15

Conodonts:	polygnathids (lanceolate)	14 (52)	weight 0.5 kg
	icriodids	1 (4)	yield 54/kg
	simple cones	1 (4)	
	bars	11 (41)	
	Total	27	

Po. *dubius* (1), *Po*. aff. *dubius* (5), *Po*. sp. indet. (8); *I*. sp. indet. (1); *Belodella* sp. (1); 01, A1, A2, N, B1, B2, B3; CAI 6-7.

BQ-17 (SX9129267151): lithology as BQ-14

Conodonts:	polygnathids (lanceolate)	2 (67)	weight 1 kg
	bars	1 (33)	yield 3/kg
	Total	3	

Po. sp. indet. (2); B1; CAI 6-7.

BQ-18 (SX9129867149): med brownish-grey, fine-med grained, partly dolomitised, bioclastic lst

Conodonts:	polygnathids (lanceolate)	49 (44)	weight 1.5 kg
	polygnathids (broad-plat)	2 (2)	yield 73/kg
	schmidtognathids	9 (8)	
	ancyrodellids	1 (1)	
	icriodids	1 (1)	
	simple cones	3 (3)	
	spathognathodids	1 (1)	
	bars	44 (40)	
	Total	110	

Po. *a*. *ovalis* (1), *Po*. *cristatus* (1), *Po*. aff. *dubius* (11), *Po*. *ovatinodosus* (15), *Po*. sp. indet. (23); *Sch*. aff. *hermanni* (7), *Sch*. *peracutus* (1), *Sch*. *pietzneri* (1); *A*. *r*. *rotundiloba* (1); *I*. *latecarinatus* (1); *O*. *s*. *sannemanni* (1); *Belodella* sp. (3); O1, A1, A2, A3, N, O2, B1, B2, N; CAI 6-7

Other microfauna: foraminifera (*Rheophax*); abundant pyritic material, including pyritised endichnial burrow infillings.

BQ-19 (SX9130267151): med grey-pink, med-coarse grained, partly dolomitised bioclastic lst

Conodonts:	polygnathids (lanceolate)	7 (70)	weight 0.5 kg
	bars	3 (30)	yield 20/kg
	Total	10	

Po. aff. *dubius* (2), *Po*. *ovatinodosus* (3), *Po*. sp. indet. (2); A1, B1, B2; CAI 6-7.

BQ-20 (SX9130467152): lithology as BQ-19

Conodonts:	polygnathids (lanceolate)	11 (55)	weight 1 kg
	icriodids	1 (5)	yield 20/kg
	bars	8 (40)	
	Total	20	

Po. *dubius* (1), *Po*. aff. *dubius* (1), *Po*. *ovatinodosus* (3), *Po*. sp. indet. (6); *I*. *expansus* group (1); A1, A2, B1, B2; CAI 6-7.

BQ-21 (SX9130967154): lithology as BQ-19

Conodonts:	polygnathids (lanceolate)	2 (14)	weight 1.5 kg
	icriodids	2 (14)	yield 9/kg
	nothognathellids	1 (7)	
	bars	9 (65)	
	Total	14	

Po. sp. indet. (2); *I.* sp. indet. (2); 01 (nothognathellid), A1, A3, N; CAI 6.

BQ-22 (SX9130767148): pale-med grey-buff, coarsely crinoidal lst with some dolomitisation

Conodonts:	polygnathids (lanceolate)	20 (71)	weight 1.5 kg
	bars	8 (29)	yield 19/kg
	Total	28	

Po. *dubius* (3), *Po.* aff. *dubius* (3), *Po.* *ovatinodosus* (3), *Po.* *x.* *xylus* (3), *Po.* sp. indet. (8); 01, A1, B1, B3, N; CAI 6-7.

BQ-23 (SX9130767144): pale-med grey-pink, med grained, partly dolomitised bioclastic lst

Conodonts:	polygnathids (lanceolate)	21 (49)	weight 0.5 kg
	schmidtognathids	1 (2)	yield 86/kg
	icriodids	2 (5)	
	spathognathodids	1 (2)	
	bars	18 (42)	
	Total	43	

Po. aff. *dubius* (4), *Po.* *ovatinodosus* (7), *Po.* *x.* *xylus* (2), *Po.* sp. indet. (8); *Sch.* sp. indet. (1); *I.* sp. indet. (2); *O.* *s.* *sannemanni* (1); 01, A1, A2, B1, B2; CAI 6-7

Other microfauna: white spheres

BQ-24 (SX9130467139): lithology as BQ-23

Conodonts:	polygnathids (lanceolate)	2 (18)	weight 0.5 kg
	icriodids	3 (27)	yield 11/kg

	bars	6 (55)	
	Total	11	

Po. aff. *webbi* (1), *Po.* sp. indet. (1); *I. expansus* group (2); *I. latecarinatus* (1); O1, A1, A2, B1; CAI 6-7.

BQ-25 (SX9129867126): med brownish-grey, coarse grained lst

Conodonts: icriodids 1; weight 1 kg; yield 1/kg

I. expansus group (1); CAI 6-7.

BQ-26 (SX9129367116): med-dark grey-pink, med-coarse grained, partly dolomitised, crinoidal and bioclastic lst

Conodonts:	polygnathids (lanceolate)	16 (35)	weight 2.75 kg
	polygnathids (broad-plat)	3 (7)	yield 13/kg
	schmidtognathids	4 (9)	
	bars	22 (49)	
	Total	45	

Po. asymmetricus subsp. indet. (2), *Po. cristatus* (1), *Po. dubius* (4), *Po.* aff. *dubius* (3), *Po. ovatinodosus* (1), *Po.* sp. indet. (8); *Sch. peracutus* (1), *Sch. pietzneri* (1), *Sch.* n. sp. B (2); O1, A1, A2, O2, B1; CAI 6-7

Other microfauna: white spheres.

BQ-27 (SX9129367108): pale-med grey-buff, med grained, partly dolomitised bioclastic lst

Conodonts:	polygnathids (lanceolate)	6 (43)	weight 1.25 kg
	bars	8 (57)	yield 11/kg
	Total	14	

Po. aff. *dubius* (2), *Po. ovatinodosus* (2), *Po.* sp. indet. (2); O1, A1, B1, B2; CAI 6.

BQ-28 (SX9129167097): med grey-pink-buff, coarse grained, bioclastic and crinoidal lst

Conodonts:	polygnathids (lanceolate)	11 (42)	weight 1 kg
	schmidtognathids	1 (4)	yield 26/kg

	bars	14 (54)	
	Total	26	

Po. dubius (2), Po. aff. dubius (2), Po. ovatinodosus (1), Po. varcus group sp. indet. juvenile (1), Po. x. xylus (1), Po. sp. indet. (4); Sch. pietzneri (1); A1, A2, 02, B1, B2, N; CAI 6.

BQ-29 (SX9128567092): lithology as BQ-28

Conodonts:	polygnathids (lanceolate)	10 (47)	weight 1 kg
	schmidtognathids	1 (5)	yield 21/kg
	spathognathodids	1 (5)	
	bars	9 (43)	
	Total	21	

Po. aff. dubius (4), Po. ovatinodosus (1), Po. x. xylus (1), Po. sp. indet. (4); Sch. pietzneri (1); O. brevis (1); O1, A1, B1, B2; CAI 6.

BQ-30 (SX9127867083): med grey-buff, fine-med grained, dolomitised lst

Conodonts:	polygnathids (lanceolate)	15 (37)	weight 1.5 kg
	polygnathids (broad-plat)	1 (3)	yield 27/kg
	schmidtognathids	5 (12)	
	bars	19 (48)	
	Total	40	

Po. cristatus (1), Po. dubius (3), Po. aff. dubius (3), Po. ovatinodosus (2), Po. sp. indet. (7); Sch.? aff. gracilis (1), Sch. pietzneri (2), Sch. n. sp. A (1), Sch. sp. indet. (1); O1, A1, A2, N, B1; CAI 6-7.

BQ-31 (SX9127467060): med grey-pink, med-coarse grained, partly dolomitised, bioclastic lst

Conodonts:	polygnathids (lanceolate)	4 (44)	weight 0.5 kg
	bars	5 (56)	yield 18/kg
	Total	9	

Po. aff. dubius (2), Po. sp. indet. (2); A1, B1; CAI 6-7.

BQ-32 (SX9128867035): med-dark grey-pink-buff, med grained, partly dolomitised, bioclastic lst

Conodonts:	polygnathids (lanceolate)	3 (38)	weight 1.5 kg
	polygnathids (linguiform)	2 (25)	yield 5/kg
	bars	3 (38)	
	Total	8	

Po. timorensis (2), *Po. varcus* group sp. indet. juvenile (1), *Po. l. linguiformis* (2); A1, N, B1; CAI 6-7

Other microfauna: white spheres.

MH-1 (SX9137567050): med grey-pink, coarsely bioclastic, dolomitised lst

Conodonts:	polygnathids (lanceolate)	3 (21)	weight 0.5 kg
	polygnathids (linguiform)	1 (7)	yield 28/kg
	simple cones	3 (21)	
	bars	7 (50)	
	Total	14	

Po. timorensis (1), *Po. varcus* group sp. indet. juveniles (2), *Po. l. linguiformis* (1); *Neopanderodus* sp. (3); A1, A2, B1, B2; CAI 6

Other microfauna: white spheres.

MH-2 (SX9137267019): pale grey-buff, fine grained, sugary-looking lst

Conodonts: bars (A1; CAI 6) 1; weight 1 kg; yield 1/kg

Other microfauna: white spheres.

Clennon Lane (SX911668, Text-fig. 8b; Barton Lst)

CL-1, 2 from massive, coral-small stromatoporoid Barton Lst, developed as at Barton Quarry

CL-1 (SX9120066890): pale grey-buff, fine grained, dolomitised lst, with red, v thin, irregular ?dolomite veins

Conodonts: none; weight 0.5 kg.

CL-2 (SX9106466878): med grey-pink, med grained, dolomitised lst

Conodonts: none; weight 0.5 kg.

Area 7

Babbacombe Cliff (SX926656, Text-figs. 12, 13; Barton Lst, Babbacombe Slates) (see Scrutton 1978a, p.40-43; 1978b for details of macrofaunas)

BC-1-10 from thin, fine grained, v dark grey, impersistent and sometimes lenticular lst bands in black Babbacombe Slates exposed at footbridge near Half Tide Rock (SX92816552); location of samples shown on Text-fig. 13 and Text-fig. 12, Sections I, II

BC-1, 2 from 200" thickness of slates cropping-out below footpath to right-hand side of footbridge; BC-1 from $\frac{1}{2}$-$\frac{3}{4}$" lst band at $182\frac{1}{2}$" below top of exposure, 17" above beach level; BC-2 from 2" lst band at 154" below top of exposure, 44" above beach level

BC-3, 4 from slates cropping-out above footpath to right-hand side of footbridge; BC-3 from 2" lst band at 95-97" above footbridge; BC-4 from $1\frac{1}{2}$" lst band at $26\frac{1}{2}$-28" above BC-3

BC-5 from 107" thickness of slates cropping-out below footpath to left-hand side of footbridge, from $\frac{3}{4}$" lst band at 94" below top of exposure, $12\frac{1}{4}$" above beach level

BC-6-10 from slates cropping-out above footpath to left-hand side of footbridge; BC-6 from 2" lst band at 31-33" above footpath; BC-7 from $\frac{1}{2}$" lst band at $41\frac{1}{2}$-42" above footpath; BC-8 from 1-$1\frac{1}{2}$" lst band at 63-$64\frac{1}{2}$" above footpath; BC-9 from 2" lst band at 74-76" above footpath; BC-10 from $\frac{1}{2}$-1" lst band at 86-87" above footpath

BC-1. Conodonts:	polygnathids (lanceolate)	20 (74)	weight 0.5 kg
	icriodids	2 (7)	yield 54/kg
	bars	5 (19)	
	Total	27	

Po. dubius (2), Po. ovatinodosus (5), Po. sp. indet. (13); I. sp. indet. (2); 01, A1, 02, B2; CAI 6

Other microfauna: pyritic material, including pyritised endichnial burrow infillings.

BC-2. Conodonts:

polygnathids (lanceolate)	23 (47)	weight 1.5 kg
polygnathids (broad-plat)	3 (6)	yield 33/kg
ancyrodellids	1 (2)	
icriodids	2 (4)	
bars	20 (41)	
Total	49	

Po. dengleri (3), *Po. dubius* (3), *Po. ovatinodosus* (10), *Po.* sp. indet. (10); *A. rotundiloba* subsp. indet. (1); *I. expansus* group (1), *I.* sp. indet. (1); 01, A1, A2, A3, 02, B1; CAI 6

Other microfauna: pyritic material.

BC-3. Conodonts: none; weight 0.75 kg.

BC-4. Conodonts: none; weight 1 kg.

BC-5. Conodonts:

polygnathids (lanceolate)	12 (55)	weight 0.75 kg
polygnathids (broad-plat)	2 (9)	yield 29/kg
icriodids	1 (5)	
bars	7 (32)	
Total	22	

Po. dengleri (2), *Po. decorosus* (1), *Po. dubius* (2), *Po. ovatinodosus* (3), *Po. x. xylus* (1), *Po.* sp. indet. (5); *I. expansus* group (1); A1, A2, A3, B1; CAI 6.

BC-6. Conodonts: bars (01, A1; CAI 6) 3; weight 0.75 kg; yield 4/kg

Other microfauna: crinoid ossicles.

BC-7. Conodonts: none; weight 0.5 kg

Other microfauna: pyritic material.

BC-8. Conodonts:

polygnathids (lanceolate)	7 (78)	weight 0.5 kg
bars	2 (22)	yield 18/kg
Total	9	

Po. decorosus (3), *Po. dubius* (1), *Po. ovatinodosus* (1), *Po.* sp. indet. (2); A1?; CAI 6

Other microfauna: pyritic material, including pyritised gastropods.

BC-9. Conodonts:

polygnathids (lanceolate)	27	(41)	weight 1.75 kg
polygnathids (broad-plat)	5	(7)	yield 38/kg
ancyrodellids	1	(2)	
icriodids	3	(5)	
bars	30	(45)	
Total	66		

Po. dengleri (5), Po. dubius (4), Po. ovatinodosus (3), Po. ovatinodosus? (1), Po. sp. indet. (19); A. r. binodosa (1); I. expansus group (2), I. cf. symmetricus (1); O1, A1, O2, B1, B2; CAI 6
Other microfauna: pyritic material, including pyritised gastropods and endichnial burrow infillings.

BC-10. Conodonts: none; weight 0.5 kg.

Section III (inverted Barton Lst)

(section comprises fairly pale weathering, bedded, rather shaly-looking lsts with scattered branching and massive tabulate corals (e.g. Thamnopora, Alveolites), solitary and colonial Rugosa (e.g. Phillipsastrea) and occasional small rounded stromatoporoids in bioclastic and crinoidal debris)

15' (approx) inaccessible bedded lst to top of cliff

21") fairly massive, med grey lsts, often appearing shaly
32") towards top and bottom of beds. BC-14 from rather
30") shaly top 6" of 32" bed
50")

130" no exposure

4" shaly lst

12" med grey lst

72" med-dark grey lst divided into thin (1-2"), irregular, sometimes lenticular units by thin, shaly-weathering partings; occasional bands are thicker (3-5") and less shaly. BC-13 from 4", finely crinoidal, med grey lst band at 29-33" above base of unit

30" med grey lst

15" med grey lst

26" med-dark grey, lenticular-looking lsts (units 2-3" thick) with irregular, shaly-weathering partings

8" med grey lst

7" med grey lst

52" lenticular-looking lsts, as 26" unit above

6")
4") med grey lsts, with shaly partings
7") in 4" bed
8")

42" lenticular-looking lsts, as 26" unit above (base of exposure; section continued in adjacent outcrop)

45" lenticular-looking lsts, as 26" unit above

54") fairly massive, med grey lsts to fault
31") BC-12 from top 10" of 45" bed
45")

Section IV (inverted Barton Lst, measured by steps)

(section comprises bedded, sometimes shaly-looking, bioclastic and crinoidal lsts, with a scattered fauna as in Section III)

8" med grey lst (any higher beds overgrown)

42" med-dark grey, fine-med grained lst divided into 1-4" thick, irregular lenticular-looking units by thin, shaly-weathering partings. BC-23 from dark, fine grained lst at 10-12½" above base of unit

23" fairly massive grey lst

41" lst with shaly-weathering partings, as 42" unit above

5" med grey lst

37" lst with shaly-weathering partings, as 42" unit above

18" poorly exposed, rubbly-looking lst

45" no exposure (grass covered)

12" fairly massive, med grey lst

9½" lst with shaly-weathering partings, as 42" above

7½" med grey lst

42" lst with shaly-weathering partings, as 42" unit above

14" fairly massive, med-dark grey lst

19" lst with shaly-weathering partings, as 42" unit above, to base of section at ground (path) level

Section V (Barton Lst, measured along fault face)

(section comprises bedded, bioclastic and crinoidal lsts with occasional shaly-weathering partings; fauna as in Section III, sometimes locally abundant; beds below the sill are inverted, while those above the sill may be the rightway-up)

57" med-dark grey, sometimes grey-pink, well-bedded lsts (individual beds 2-8" thick), with occasional shaly-weathering partings between, and sometimes within, beds. BC-22 from 2" med grey, fine-med grained lst at 21-23" above base of unit

12" med-dark grey lst

52" well-bedded lsts, as 57" unit above

30")
15") med-dark grey and grey-pink,
10") fairly massive lsts
33")

2" grey-pink, shaly-weathering band

15" med-dark grey lst

2" grey-pink, shaly-weathering band

8" med-dark grey lst

30" med-dark grey and grey-pink lst with occasional v thin shaly-weathering partings

6" med-dark grey lst

6" med-dark grey lst with shaly-weathering partings

100" well-bedded lsts, as 57" unit above; rather brecciated

18" badly weathered grey lst

20" med-dark grey and grey-pink lst divided into rather lenticular-looking, 1-4" thick units by thin, shaly-weathering partings

22" fairly massive med-dark grey-pink lst with an abundant fauna (corals and small stromatoporoids), often aligned parallel to bedding

75" lenticular-looking lsts with thin shaly-weathering partings, as 20" unit above. BC-21 from med-dark grey-pink, fairly coarse grained area at 17-19" below top of unit

7" + massive lst (bed shows much variation in thickness, and locally increases to 21" thick)

22" + bedded lsts (individual beds 1-6" thick) with v thin shaly-weathering partings (entire unit shows much variation in thickness, locally increasing to 45" thick)

20' (approx) igneous rock (sill), showing much variation in thickness

47" bedded lsts (individual beds 1-10" thick) with shaly-weathering bands between beds, to base of section at ground (path) level

Section VI (inverted Barton Lst, measured below igneous rock (sill) exposed in steep, high cliff at SX92626559; section comprises bedded, sometimes shaly-weathering, bioclastic and crinoidal lsts, with a scattered fauna as in Section III)

massive, igneous rock (sill)

110" med-dark grey, bedded lsts (individual beds usually 1-6" thick, occasionally up to 11" thick), with thin shaly-weathering partings; beds closest to contact with igneous rock exhibit green-red banding. BC-20 from med-dark grey, fine-med grained lst at 64-68" below top of unit

50" massive grey lst

12" bedded lsts, as 110" unit above

12") med-dark grey
17") lsts

82" massive, med-dark grey lst to overgrown base of section

Section VII (inverted Barton Lst, measured by Oddicombe Beach Hill) (section comprises dark, bedded lsts with frequent shaly partings; fauna includes Alveolites, branching tabulates and solitary Rugosa in fine crinoidal debris, as recorded above BC-33)

74" fairly thin-bedded, dark grey lsts (individual beds 1-5" thick), with thin shaly partings

14") dark grey lsts with fine
9½") crinoidal debris

12" thin-bedded lsts with shaly partings, as 74" unit above

10" med-dark grey lst

5" dark, rather shaly lst

11" med-dark grey lst

28" thin-bedded lsts with shaly partings, as 74" unit above

17") dark grey lsts with fine
7") crinoidal debris

45" thin-bedded lsts with shaly partings, as 74" unit above

23" fairly massive, med-dark grey lst

39" thin-bedded lsts with shaly partings, as 74" unit above

6" dark grey lst

53" thin-bedded lsts with shaly partings, as 74" unit above. BC-34 from top 4" of unit

7" dark grey lst

4" dark, shaly lst

6") dark grey lsts with Alveolites, branching tabulates (e.g. Thamnopora)
9") and solitary Rugosa in fine crinoidal debris

3½" dark shaly lst

10" dark grey lst

12" thin-bedded lsts with shaly partings, as 74" unit above

5" dark, fine grained lst: BC-33

20" thin-bedded lsts with shaly partings, as 74" unit above, to base of section at ground level

Section VIII (inverted Barton Lst transitional to Babbacombe Slates, measured in roadside exposure at the top of Oddicombe Beach Hill; section comprises black slates with thin lst bands, and v dark lsts with slaty/shaly partings, the slaty/shaly component decreasing in amount in the structurally higher parts of the section, above the 200" no exposure; there is probably repetition towards the structural base of the section due to faulting and folding)

92" v dark grey bioclastic and crinoidal lsts divided into thin ($\frac{1}{2}$-2") units by thin (c.$\frac{1}{2}$") shaly partings, with occasional thicker (5-6") lst bands

10$\frac{1}{2}$" v dark lst with abundant small corals (branching and massive tabulates, solitary Rugosa) in fine crinoidal and bioclastic debris

2$\frac{1}{2}$" v dark shaly lst

8$\frac{1}{2}$" v dark lst

44" v dark, finely bioclastic and crinoidal lsts divided into c.$\frac{1}{2}$-2" units by thin (c.$\frac{1}{2}$"), dark shaly/slaty partings

8" v dark lst

37" v dark lst with shaly/slaty partings, as 44" unit above

7$\frac{1}{2}$" v dark grey, fine grained lst with fine crinoidal debris and small corals: BC-32

33" v dark lsts with shaly/slaty partings, as 44" unit above

9" v dark, fine grained lst

104" v dark, finely bioclastic and crinoidal lsts, divided into c.$\frac{1}{2}$-2" units by thin shaly/slaty partings; occasional lst bands are thicker (c.4-6")

45" well-bedded, v dark, finely bioclastic and crinoidal lsts (individual beds 4-6" thick), with few shaly/slaty partings

200" no exposure (blocked-out by wall)

150" v dark lsts divided into c.2-4" units by c.1-2" shaly/slaty partings

29" black slates with thin (1-2"), v dark lst bands

32" v dark lsts with shaly/slaty partings, as 150" unit above

10" black slates with thin lst bands, as 29" unit above. <u>BC-31</u> from thin (½"), v dark, fine grained lst band at top of unit

5" v dark, fine grained lst

22" black slates with a thin (1½"), v dark, fine grained lst band at 9" above base of unit

4½" v dark, fine grained lst

6" black slates

4-5' (approx) no exposure (blocked-out by wall)

28" poorly exposed black slates

8" poorly exposed v dark lst

8-10' (approx) no exposure (blocked-out by wall)

20" poorly exposed black slates

5-6' (approx) no exposure (blocked-out by wall)

37" black slates with few thin lst bands

16" no exposure

7" black slates

5" v dark, fine grained lst

78" black slates with few, thin (c.1-2") lst bands

5" v dark, fine grained lst

50" no exposure

91" black slates with thin lsts, as 78" unit above

6" v dark, fine grained lst: <u>BC-30</u>

21" black slates with thin lsts, as 78" unit above

4" v dark, fine grained lst

76" black slates with thin lsts, as 78" unit above, to base of section; small solitary Rugosa in thin lst band at 60" above base of section

BC-11 (not on sections): from small, poorly exposed outcrop of Barton Lst at SX9285965460 - sample at 42-44" above ground level, from v dark, v fine grained, shaly-weathering lst

Conodonts:	polygnathids (lanceolate)	49 (61)	weight 1.5 kg
	polygnathids (broad-plat)	2 (2)	yield 54/kg
	icriodids	3 (4)	
	spathognathodids	3 (4)	
	bars	24 (30)	
	Total	81	

Po. dengleri (2), *Po. dubius* (11), *Po.* aff. *dubius* (1), *Po.* aff. *ordinatus* (2), *Po. ovatinodosus* (10), *Po. ovatinodosus*? (1), *Po. webbi* (2), *Po.* sp. indet. (22); *I.* sp. indet. (3); *O. s. sannemanni* (3); 01, A1, A2, N, 02, B1, B2; CAI 6

Other microfauna: pyritic material, including spheres and endichnial burrow infillings.

BC-12. Conodonts: none; weight 0.5 kg.

BC-13.

Conodonts:	polygnathids (lanceolate)	3 (38)	weight 1.5 kg
	icriodids	3 (38)	yield 5/kg
	bars	2 (25)	
	Total	8	

Po. aff. *dubius* (1), *Po.* sp. indet. (2); *I. expansus* group (1), *I.* sp. indet. (2); CAI 6.

BC-14. Conodonts: polygnathids (lanceolate) 1; weight 0.5 kg; yield 2/kg

Po. sp. indet. (1); CAI 6.

BC-20.

Conodonts:	polygnathids (lanceolate)	1 (17)	weight 0.5 kg
	simple cones	2 (33)	yield 12/kg
	bars	3 (50)	
	Total	6	

Po. sp. indet. (1); *Belodella* sp. (1), *Neopanderodus* sp. (1); A1; CAI 5-6.

BC-21. Conodonts:

simple cones	1 (13)	weight 0.5 kg
spathognathodids	1 (13)	yield 16/kg
bars	6 (75)	
Total	8	

Coelocerodontus sp. (1); O. brevis (1); A1, A2; CAI 6-7.

BC-22. Conodonts:

polygnathids (lanceolate)	8 (25)	weight 0.5 kg
polygnathids (linguiform)	12 (38)	yield 64/kg
simple cones	2 (6)	
bars	10 (31)	
Total	32	

Po. ansatus (2), Po. timorensis (3), Po. l. linguiformis (9), Po. l. mucronatus (3), Po. sp. indet. (3); Belodella sp. (1), Coelocerodontus sp. (1); A1, A2, O2, B2; CAI 6-7.

Other microfauna: stick-like bryozoa.

BC-23. Conodonts:

polygnathids (lanceolate)	6 (38)	weight 0.5 kg
polygnathids (linguiform)	4 (25)	yield 32/kg
bars	6 (38)	
Total	16	

Po. timorensis (3), Po. l. linguiformis (4), Po. sp. indet. (3); A1, A2, N; CAI 6-7.

BC-30. Conodonts: none; weight 0.5 kg.

BC-31. Conodonts: bars (A1; CAI 6) 1; weight 0.5 kg; yield 2/kg.

BC-32. Conodonts:

polygnathids (lanceolate)	25 (27)	weight 2 kg
polygnathids (broad-plat)	4 (4)	yield 46/kg
schmidtognathids	1 (1)	
ancyrodellids	1 (1)	
icriodids	3 (3)	
simple cones	1 (1)	
spathognathodids	1 (1)	
bars	56 (61)	

Po. *a*. *asymmetricus* (1), *Po*. cf. *a*. *asymmetricus* (1), *Po*. *a*. subsp. indet. (1), *Po*. *cristatus* (1), *Po*. *dubius* (3), *Po*. *ovatinodosus* (12), *Po*. *x*. *xylus* (1), *Po*. sp. indet. (9); *Sch*. sp. indet. (1); *A*. *binodosa* (1); *I*. *latericrescens* (2), *I*. sp. indet. (1); *Belodella* sp. (1); *Elsonella* *rhenana* (*partim*: ?A1, A2, A3 only); 01, A1, A2, A3, 02, B1, B2; CAI 5-6.

Other microfauna: stick-like bryozoa; pyritic material, including pyritised foraminifera (*Nanicella*, *Saccammina*, *Hyperammina*).

BC-33.	Conodonts: polygnathids (lanceolate)	27	(45)	weight 0.5 kg
	polygnathids (broad-plat)	1	(2)	yield 120/kg
	spathognathodids	2	(3)	
	bars	30	(50)	
	Total	60		

Po. *cristatus* (1), *Po*. aff. *dubius* (4), *Po*. aff. *ordinatus* (1), *Po*. *ovatinodosus* (8), *Po*. *webbi* (1), *Po*. sp. indet. (13); *O*. *s*. *sannemanni* (2); *Elsonella* *rhenana* (*partim*: A2 element only); 01, A1, A2, A3, N, 02, B1, B2, B3; CAI 5-6.

BC-34.	Conodonts: polygnathids (lanceolate)	1	(20)	weight 0.5 kg
	bars	4	(80)	yield 10/kg
	Total	5		

Po. aff. *dubius* (1); A1, N, B2; CAI 5-6

Other microfauna: pyritic material.

Petit Tor Quarry (SX927662, Text-fig. 14; Walls Hill Lst and associated red Upper Devonian sediments)

Section (north face of quarry)

120' (approx) pale grey-pink, white weathering, massive, stromatoporoid Walls Hill Lst; stromatoporoids include laminar, conical, irregular and broken forms, with an associated fauna of branching and massive tabulate corals and solitary Rugosa; matrix is variably, and sometimes coarsely, bioclastic and crinoidal. Large, irregular areas of red sediments are frequently developed as cavity infillings within the massive lsts; the red sediments include slates, slaty lsts and, less often, pale pink flinty lsts (see Scrutton 1977b, p.173; 1978a, p.38-39 for details of macrofaunas)

PQ-1 (SX9272666243): from pale grey-pink, med grained, crinoidal matrix of massive lst at 160-170" above quarry floor (*i.e.* base of section)

Conodonts: none; weight 0.5 kg.

PQ-2 (SX9273966244): from pale grey, med-coarse grained, crinoidal matrix of massive lst at 520-526" above quarry floor

Conodonts: bars (01) 1; weight 1 kg; yield 1/kg.

PQ-3 (SX9274866254): from red, finely crinoidal, calcareous slate infilling at 810-820" above quarry floor

Conodonts:	icriodids	2 (67)	weight 0.5 kg
	bars	1 (33)	yield 6/kg
	Total	3	

I. symmetricus (1), *I.* sp. indet. (1); A1; CAI 6-7.

PQ-4 (SX9271366268): from red-grey, calcareous slate infilling at c.90' above base of section, in small combe behind quarry

Conodonts:	polygnathids (lanceolate)	3 (43)	weight 1 kg
	palmatolepids	2 (28)	yield 7/kg
	icriodids	2 (28)	
	Total	7	

Po. sp. indet. (3); *Pa. subrecta* (2); *I. symmetricus* (2); CAI 6-7.

PQ-5 (SX9271066272): from pale grey-pink, fine grained, micritic and crinoidal matrix of massive lst at c.100' above base of section, in small combe behind quarry

Conodonts: none; weight 1.5 kg

Other microfauna: crinoid ossicles.

Petit Tor Beach (SX926664, Text-fig. 14; Walls Hill Lst and associated red Upper Devonian sediments)

PB-1-7 from red nodular lsts and calcareous mudstones in vertical wall behind lowest ledge at southern end of beach (SX92686637)

PB-1 (SX9269466377): red-grey, med-coarse grained, nodular lst

Conodonts:			
	polygnathids (lanceolate)	5 (14)	weight 2.5 kg
	palmatolepids	6 (17)	yield 14/kg
	ancyrodellids	2 (6)	
	icriodids	5 (14)	
	bars	18 (50)	
	Total	36	

Po. decorosus (3), *Po.* sp. indet. (2); *Pa. hassi* (1), *Pa.* aff. *proversa* (2), *Pa. subrecta* (2), *Pa.* sp. indet. (1); *A.* aff. *gigas* (1), *A. lobata* (1); *I.* aff. *brevis* (1), *I. symmetricus* (1), *I.* sp. indet. (3); O1, A1, A2, B1; CAI 6-7.

PB-2 (SX9269066378): red, med grained, slaty lst

Conodonts:			
	polygnathids (lanceolate)	15 (21)	weight 1.5 kg
	palmatolepids	4 (5)	yield 49/kg
	ancyrodellids	1 (2)	
	icriodids	5 (7)	
	simple cones	19 (26)	
	bars	29 (40)	
	Total	73	

Po. decorosus (3), *Po.* sp. indet. (12); *Pa. hassi* (2), *Pa. subrecta* (1), *Pa.* sp. indet. (1); *A. lobata* (1); *I.* aff. *brevis* (2), *I. expansus* group (1), *I. symmetricus* (2); *Belodella* sp. (17), *Coelocerodontus* sp. (2); O1, A1, A2, A3, N, B3; CAI 7-8.

PB-3 (SX9268666379): red calcareous mudstone, with patches of coarse recrystallised calcite

Conodonts:	polygnathids (lanceolate)	3 (12)	weight 1 kg
	palmatolepids	1 (4)	yield 25/kg
	icriodids	1 (4)	
	simple cones	6 (24)	
	bars	14 (56)	
	Total	25	

Po. *decorosus* (2), *Po*. sp. indet. (1); *Pa*. sp. indet. (1); *I*. aff. *brevis* (1); *Belodella* sp. (5), *Coelocerodontus* sp. (1); A1, A2, A3, N, B2, B3; CAI 7-8.

PB-4 (SX9268066381): lithology as PB-3

Conodonts: none; weight 1.25 kg.

PB-5 (SX9267866383): red-grey, fine grained nodular lst

Conodonts: bars (O1, A1, A2) 4; weight 0.5 kg; yield 8/kg.

PB-6 (SX9267366381): lithology as PB-3

Conodonts:	polygnathids (lanceolate)	1 (6)	weight 1.25 kg
	icriodids	3 (19)	yield 13/kg
	simple cones	4 (25)	
	bars	8 (50)	
	Total	16	

Po. *decorosus* (1); *I*. aff. *brevis* (2), *I*. *symmetricus* (1); *Belodella* sp. (2), *Coelocerodontus* sp. (2); O1, A1, A2, N; CAI 6-7.

PB-7 (SX9267066384): red-grey, med grained, slaty lst

Conodonts:	polygnathids (lanceolate)	3 (11)	weight 1.25 kg
	simple cones	16 (57)	yield 22/kg
	bars	9 (32)	
	Total	28	

Po. sp. indet. (3); *Belodella* sp. (11), *Coelocerodontus* sp. (5); A1, A2, B1, B2, N; CAI 6-7.

PB-8 (SX9266666385): med grey, med grained, thin (c.1") lst band in tightly folded red slates

Conodonts: none; weight 0.5 kg.

PB-9 (SX9268166388): from pale grey-pink, micritic matrix of pale grey, massive, stromatoporoid lst (Walls Hill Lst)

Conodonts: none; weight 1 kg

Other microfauna: tentaculitid.

PB-10 (SX9271866380): lithology as PB-9

Conodonts:	polygnathids (linguiform)	4 (57)	weight 1.5 kg
	bars	3 (43)	yield 5/kg
	Total	7	

Po. *l*. *linguiformis* (2), *Po*. *l*. subsp. indet. (2); A2, N; CAI 6-7.

PB-11 (SX9267466348): from pale grey-pink, micritic and finely crinoidal matrix of massive, stromatoporoid lst (Walls Hill Lst)

Conodonts:	polygnathids (lanceolate)	6 (67)	weight 1.5 kg
	bars	3 (33)	yield 6/kg
	Total	9	

Po. *l*. *linguiformis* (5), *Po* *l*. *linguiformis* delta morphotype (1); A1; CAI 7.

PB-12 (SX9267566348): deep red, fine grained, slaty lst infilling within pale, massive, stromatoporoid lst

Conodonts:	polygnathids (lanceolate)	12 (30)	weight 1 kg
	polygnathids (broad-plat)	3 (7)	yield 41/kg
	palmatolepids	3 (7)	
	icriodids	1 (2)	
	simple cones	12 (29)	
	bars	10 (24)	
	Total	41	

Po. *asymmetricus* subsp. A (3), *Po*. *decorosus* (1), *Po*. sp. indet. (11); *Pa*. *hassi* (1), *Pa*. *subrecta* (1), *Pa*. sp. indet. (1); *I*. aff. *brevis* (1);

Belodella sp. (12); A1, A2, ?A3, O2; CAI 6-7.

Blackler's Quarry/Petit Tor (SX92446637, Text-fig. 14; Walls Hill Lst?)

Section (base taken at steep fault face forming northern wall of combe behind Petit Tor Beach)

114" massive and thick-bedded, pale-med grey and grey-pink, pale weathering lsts with branching and massive tabulate corals (e.g. Thamnopora, Alveolites), solitary Rugosa and laminar stromatoporoids in a fine-med grained, sometimes crinoidal matrix. BL-6 and BL-7 from finely crinoidal areas at 110-114" and 18-22" respectively below top of section

85" no exposure

46" massive lst, as 114" unit above

80" no exposure

360" massive and thick-bedded lsts, as 114" unit above, with several horizons crowded with branching and massive tabulates and solitary Rugosa, often aligned parallel to bedding; Hexagonaria (colonial Rugosa) occurs near BL-5. BL-3, BL-4 and BL-5 from fine-med grained areas at 270-275", 235-240" and 120-125" respectively below top of unit

200" massive and thick-bedded lsts, as 114" unit above. BL-2 from finely crinoidal area at 110-116" below top of unit

50" massive and thick-bedded lsts, as 114" unit above, to base of section at steep, brecciated fault face; several horizons crowded with corals. BL-1 from finely crinoidal area at 25-30" below top of unit

BL-1. Conodonts: none; weight 1.75 kg.

BL-2. Conodonts: none; weight 1.75 kg.

BL-3. Conodonts: none; weight 1 kg

Other microfauna: crinoid ossicles

BL-4. Conodonts: none; weight 1.5 kg.

BL-5. Conodonts: polygnathids (lanceolate) 2; weight 1 kg; yield 2/kg

Po. sp. indet. (2); CAI 6-7.

BL-6. Conodonts: bars 2; weight 1 kg; yield 2/kg

01; CAI 6-7.

BL-7. Conodonts: bars 2; weight 1 kg; yield 2/kg

A1, ?02; CAI 6-7.

PLATE 1

Figs. 1-11,13. Icriodus retrodepressus BULTYNCK

1,7. Oral, lateral views. Daddyhole Cove, DH-2/I3 (x60)(small growth stage).

2,3. Oral, aboral views. Triangle Point, TP-28/I13 (x40).

4. Oral view. Daddyhole Cove, DH-2/I8 (x40).

5. Oral view. Triangle Point, TP-28/I1 (x50).

6,10. Oral, lateral views. Triangle Point, TP-12/I1 (x60).

8,11. Oral, lateral views. Triangle Point, TP-28/I15 (x50).

9. Oral view. Triangle Point, TP-28/I12 (x50).

13. Oral view. Triangle Point, TP-26/I1 (x40).

Figs. 12,14-20. Icriodus corniger corniger WITTEKINDT

12. Oral view. Triangle Point, TP-28/I16 (x50).

14,15,20. Oral, aboral, lateral views. Triangle Point, TP-17/I2 (x40).

16. Oral view. Triangle Point, TP-28/I6 (x60)(small growth stage).

17. Oral view. Triangle Point, TP-17/I6 (x60)(small growth stage).

18. Oral view. Triangle Point, TP-28/I9 (x50).

19. Oral view. Triangle Point, TP-28/I2 (x40).

Figs. 21-29. Icriodus aff. introlevatus BULTYNCK

21,22,24. Oral, aboral, lateral views. Triangle Point, TP-17/I4 (x35).

23,28,29. Oral, aboral, lateral views. Triangle Point, TP-17/I3 (x35).

25,26,27. Oral, aboral, lateral views. Triangle Point, TP-17/I1 (x40).

PLATE 1

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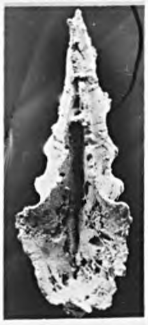

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PLATE 2

Figs. 1,2,6. Icriodus corniger corniger WITTEKINDT (?)
1,6. Oral, lateral views. Triangle Point, TP-28/I17 (x40).
2. Oral view. Triangle Point, TP-28/I5 (x40).

Fig. 8. Icriodus cf. regularicrescens BULTYNCK
8. Oral view. Redgate Beach, RB-12/I2 (x50).

Figs. 3-5,7,11-16. Icriodus aff. obliquimarginatus BISCHOFF & ZIEGLER
3,4. Lateral, oral views. Redgate Beach, RB-10/I1 (x70) (juvenile growth stage).
5,13. Oral, lateral views. Redgate Beach, RB-10/I2 (x70) (juvenile growth stage).
7,11. Lateral, oral views. Waldon Hill/Warren Road, WH-3/I3 (x40).
12,14. Oral, lateral views. Waldon Hill/Warren Road, WH-3/I6 (x40).
15,16. Oral, lateral views. Babbacombe Road, BR-9/I1 (x50).

Figs. 9,10,17-28,33. Icriodus expansus BRANSON & MEHL group
9. Oral view, Redgate Beach, RB-2/I1 (x60).
10. Oral view. Waldon Hill/Warren Road, WH-3/I1 (x50) (small growth stage).
17,20. Oral, lateral views. Waldon Hill/Warren Road, WH-3/I2 (x50).
18. Oral view. Long Quarry Point, LG-6/I2 (x40).
19,22. Lateral, oral view. Parkfield Road, PF-9/I3 (x60).
21. Oral view. Babbacombe Road, BR-3/I1 (x50).
23,24. Oral, lateral views. Redgate Beach, RB-2/I3 (x60)(small growth stage).
25,27. Oral, lateral views. Redgate Beach, RB-5/I1 (x50).
26. Oral view. Teignmouth Road, TR-1/I1 (x50).
28,33. Oral, aboral views. Long Quarry Point, LG-6/I1 (x40).

Figs. 29-32,34. Icriodus arkonensis STAUFFER
29,30,31. Oral, aboral, lateral views. Parkfield Road, PF-9/I1 (x50).
32,34. Oral, lateral views. Parkfield Road, PF-9/I2 (x60).

PLATE 2

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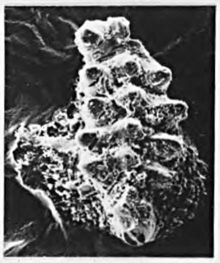

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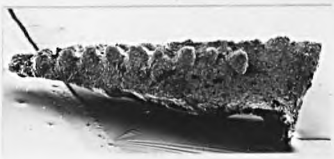

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PLATE 3

Figs. 1-9,13,18-20. *Icriodus latecarinatus* BULTYNCK

1,2,3. Oral, aboral, lateral views. Barton Quarry, BQ-24/I1 (x30).

4,5,6. Oral, aboral, lateral views. Barton Quarry, BQ-18/I1 (x60).

7,8,9. Oral, aboral, lateral views. Barton Quarry, BQ-1/I1 (x45).

13,18. Oral, lateral views. Babbacombe Cliff, BC-32/I2 (x35).

19,20. Oral, lateral views. Babbacombe Cliff, BC-32/I1 (x45).

Figs. 10-12,14-16,21,25,30. *Icriodus expansus* BRANSON & MEHL group

10,11,12. Oral, aboral, lateral views. Barton Quarry, BQ-24/I3 (x50).

14,15,16. Lateral, oral, aboral views. Babbacombe Cliff, BC-5/I1 (x50).

21,25. Oral, lateral views. Barton Quarry, BQ-24/I2 (x50).

30. Oral view. Petit Tor Beach, PB-2/I2 (x70) (juvenile growth stage).

Figs. 17,22,23. *Icriodus symmetricus* BRANSON & MEHL

17. Oral view. Petit Tor Beach, PB-1/I1 (x60) (juvenile growth stage).

22,23. Lateral, oral views. Petit Tor Quarry, PQ-4/I1 (x50).

Figs. 24,26-29,31. *Icriodus* aff. *brevis* STAUFFER

24,26,27. Lateral, oral, aboral views. Petit Tor Beach, PB-3/I1 (x80) (juvenile growth stage).

28,29. Oral, lateral views. Petit Tor Beach, PB-2/I1 (x80) (juvenile growth stage).

31. Oral view. Petit Tor Beach, PB-12/I1 (x80) (juvenile growth stage).

PLATE 3

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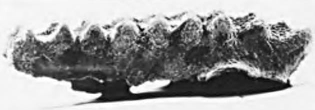

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PLATE 4

Figs. 9,13,14,20-24; 1-8 (aff.). Polygnathus pseudofoliatus WITTEKINDT

9,13,14. Lateral, oral, aboral views. Long Quarry Point, LG-4/Po3 (x40) (small growth stage).

20,21,22,23. Lateral, oral, oblique oral, aboral views. Redgate Beach, RB-2/Po6 (x50).

24. Oral view. Redgate Beach, RB-2/Po4 (x40).

1,2,3. Oral, lateral, aboral views. Long Quarry Point, LG-3/Po1 (x50).

4,5,6. Oral, lateral, aboral views. Long Quarry Point, LG-5/Po1 (x40).

7,8. Oral, lateral views. Long Quarry Point, LG-5/Po2 (x60).

Figs. 10-12,15-17. Polygnathus cf. costatus costatus KLAPPER

10,11,12. Oral, aboral, lateral views. Long Quarry Point, LG-7/Po1 (x40) (tectonically flattened specimen).

15,16,17. Oral, aboral, lateral views. Long Quarry Point, LG-4/Po2 (x50) (tectonically flattened specimen).

Figs. 18,19. Polygnathus xylus ensensis ZIEGLER & KLAPPER

18. Oral view. Redgate Beach, RB-12/Po2 (x50).

19. Oral view. Redgate Beach, RB-13/Po2 (x40).

Figs. 25-27. Polygnathus aff. xylus xylus STAUFFER

25,26,27. Oral, aboral, lateral views. Long Quarry Point, LG-6/Po1 (x60) (juvenile growth stage).

PLATE 4

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PLATE 5

Figs. 7,11,12; 19,20 (aff.). Polygnathus xylus xylus STAUFFER

7,11. Oral, aboral views. Lummaton Quarry, LM-15/Po8 (x60) (small growth stage).

12. Oral view. St. James Road, SJ-2/Po6 (x70) (small growth stage).

19,20. Oral, aboral views. St. James Road, SJ-2/Po2 (juvenile growth stage).

Figs. 8,9; 1-6 (aff.). Polygnathus xylus ensensis ZIEGLER & KLAPPER

8. Oral view. St. James Road, SJ-2/Po7 (x65).

9. Oral view. St. James Road, SJ-2/Po10 (x65).

1,2,3. Oral, aboral, lateral views. Waldon Hill, WH-1/Po2 (x35).

4,5,6. Oral, aboral, lateral views. Waldon Hill, WH-1/Po1 (x35).

Figs. 10,15-17. Polygnathus aff. ovatinodosus ZIEGLER & KLAPPER

10. Oral view. Waldon Hill/Warren Road, WH-3/Po1 (x35).

15. Oral view. Waldon Hill/Warren Road, WH-3/Po2 (x30).

16,17. Oral, aboral views. Lummaton Quarry, LM-17/Po2 (x35).

Figs. 13,14,18,23. Polygnathus pseudofoliatus WITTEKINDT

13. Oral view. Parkfield Road, PF-5/Po1 (x40).

14. Oral view. Parkfield Road, PF-5/Po2 (x40).

18,23. Oral, lateral views. Waldon Hill, WH-1/Po3 (x40).

Figs. 21,22,24-32. Polygnathus varcus STAUFFER group (very small growth stages, sp. indet.)

21,24. Oral, lateral views. Lummaton Quarry, LM-16/Po2 (x80).

22,28,29. Aboral, lateral, oral views. Barton Quarry, MH-1/Po1 (x60).

25,26,31. Oral, lateral, aboral views. Lummaton Quarry, LM-15/Po5 (x80).

27,30,32. Oral, lateral, oblique aboral views. Lummaton Quarry, LM-7/Po1 (x70).

PLATE 5

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PLATE 6

Figs. 1-23,31. Polygnathus timorensis KLAPPER, PHILIP & JACKSON

1,2,3. Oral, aboral, lateral views. Lummaton Quarry, LM-9/Po4 (x35).

4,5,6. Oral, aboral, lateral views. Lummaton Quarry, LM-1/Po1 (x35).

7,9. Lateral, oral views. Lummaton Quarry, LM-4/Po3 (x70) (specimen with rounded posterior platform, short carina, and strong denticles at inner geniculation point).

8. Oral view. Madrepore Road, MR-1/Po3 (x60).

10. Oral view. Lummaton Quarry, LM-9/Po5 (x60).

11,12. Oral, lateral views. Lummaton Quarry, LM-10/Po1 (x60).

13,14. Oral, lateral views. Trumlands Quarry, TL-3 (x35) (dolomitised specimen).

15. Oral view. Trumlands Quarry, TL-2 (x60).

16,17. Oral, lateral views. Lummaton Quarry, LM-11/Po2 (x60).

18,19. Oral, aboral views. Babbacombe Cliff, BC-20/Po4 (x35).

20,21. Oral, lateral views. Lummaton Quarry, LM-18/Po9 (x35).

22. Oral view. Trumlands Quarry, TL-3 (x70) (small growth stage).

23. Oral view. Barton Quarry, BQ-32/Po1 (x70) (small growth stage).

31. Oral view. Lummaton Quarry, LM-3/Po2 (x70) (small growth stage).

Figs. 28;24-27,29-30(?). Polygnathus varcus STAUFFER

28. Oral view. Waldon Hill/Warren Road, WH-3/Po6 (x50).

24. Oral view. Lummaton Quarry, LM-18/Po4 (x50) (very small growth stage).

25. Oral view. Lummaton Quarry, LM-18/Po5 (x80) (very small growth stage).

26,27,29. Oral, aboral, lateral views. Lummaton Quarry, LM-18/Po2 (x50) (very small growth stage).

30. Oral view. Lummaton Quarry, LM-18/Po6 (x80) (very small growth stage).

PLATE 6

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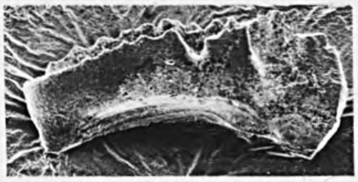

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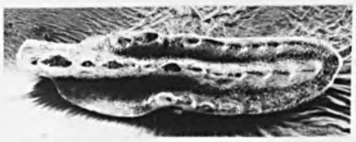

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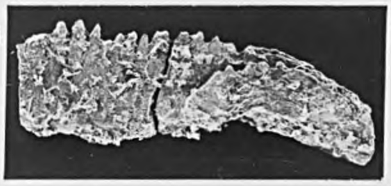

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PLATE 7

Figs. 1-16,19,21,23;17,18,20,22,24(?). Polygnathus ansatus ZIEGLER & KLAPPER

1,2,3. Oral, lateral, aboral views. Madrepore Road, MR-1/Po2 (x40).

4,5,6. Oral, lateral, aboral views. Lummaton Quarry, LM-11/Po4 (x60).

7,8,9. Oral, aboral, lateral views. Lummaton Quarry, LM-18/Po3 (x60).

10,11,12. Oral, aboral, lateral views. Lummaton Quarry, LM-16/Po1 (x40) (juvenile growth stage).

13,14,15. Oral, aboral, lateral views. Lummaton Quarry, LM-15/Po3 (x40).

16,19. Oblique oral, lateral views. Lummaton Quarry, LM-11/Po3 (x40).

21,23. Oral, lateral views. Madrepore Road, MR-1/Po1 (x40).

17,18. Oral, aboral views. Lummaton Quarry, LM-15/Po7 (x70) (juvenile growth stage).

20,22,24. Oral, aboral, lateral views. Lummaton Quarry, LM-15/Po4 (x80) (juvenile growth stage).

PLATE 7

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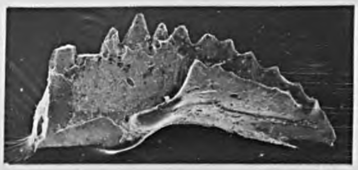

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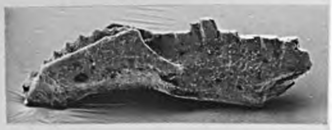

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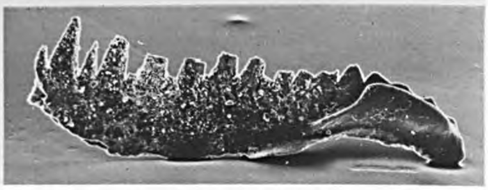

PLATE 8

Fig. 1. *Polygnathus linguiformis* subsp. a *sensu* WEDDIGE 1977

1. Oral view. Redgate Beach, RB-12/Po1 (x30).

Figs. 3,4,8;2(cf.). *Polygnathus linguiformis alveolus* WEDDIGE

3,4,8. Oral, aboral, lateral views. Long Quarry Point, LG-3/Po1 (x60) (small growth stage).

2. Oral view. Redgate Beach, RB-13/Po1 (x30).

Fig.6. *Polygnathus linguiformis bultyncki* WEDDIGE

6. Oral view. Daddyhole Cove, DH-2/Po1 (x40).

Figs.7,13. *Polygnathus linguiformis* subsp. b *sensu* WEDDIGE 1977

7. Oblique oral view. Redgate Beach, RB-10/Po1 (x60).

13. Oblique oral view. Babbacombe Road, BR-9/Po1 (x60).

Figs. 9,10,12;5(cf.). *Polygnathus linguiformis linguiformis* HINDE, delta morphotype ZIEGLER & KLAPPER

9,10,12. Oral, aboral, lateral views. Petit Tor Beach, PB-11/Po1 (x30).

5. Oral view. Lummaton Quarry, LM-13/Po1 (x60) (juvenile growth stage).

Figs. 11,14-18,20. *Polygnathus linguiformis linguiformis* HINDE, epsilon morphotype ZIEGLER & KLAPPER

11,16. Oral, aboral views. Waldon Hill/Warren Road, WH-3/Po3 (x30).

14,15,18. Oral, aboral, lateral views. Lummaton Quarry, LM-1/Po1 (x40).

17,20. Oblique oral, aboral views. Lummaton Quarry, LM-17/Po1 (x40).

Figs.19,21-30. *Polygnathus linguiformis mucronatus* WITTEKINDT

19,22,23. Lateral, oral, aboral views. Babbacombe Cliff, BC-22/Po1 (x30).

21,26. Lateral, oral views. Waldon Hill/Warren Road, WH-2/Po5 (x30).

24,29,30. Oblique oral, aboral, lateral views. Lummaton Quarry, LM-11/Po1 (x40).

25. Oral view. Waldon Hill/Warren Road, WH-2/Po3 (x30).

27,28. Oral, aboral views. Madrepore Road, MR-1/Po5 (x60) (juvenile growth stage).

PLATE 8

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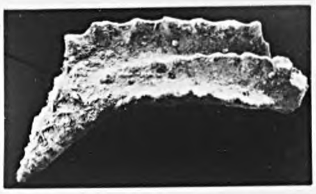
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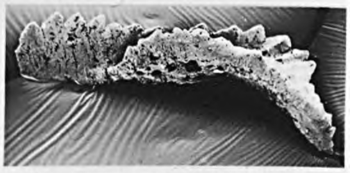
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PLATE 9

Figs.1-20,23-25;21,22(?). Polygnathus linguiformis linguiformis HINDE

1. Oral view. Waldon Hill/Warren Road, WH-3/Po11 (x30).
2. Oblique oral view. Waldon Hill/Warren Road, WH-3/Po12 (x30) (specimen with strong serrations in the outer margin, at the point of flexure to the tongue).
3. Oblique oral view. Waldon Hill/Warren Road, WH-3/Po10 (x35).
4. Oblique oral view. Waldon Hill/Warren Road, WH-3/Po14 (x35).
5. Oblique oral view. Waldon Hill/Warren Road, WH-3/Po9 (x35).
6. Oral view. Waldon Hill/Warren Road, WH-3/Po13 (x35) (specimen with constricted tongue).
7. Oblique oral view. St.James Road, SJ-1/Po14 (x40).

8,9. Oblique oral, aboral views. Waldon Hill/Warren Road, WH-2/Po4 (x35).

10,13. Oral, aboral views. Trumlands Quarry, TL-3 (x35) (dolomitised specimen).

11. Oblique oral view. Teignmouth Road, TR-2/Po1 (x40).

12,15. Oblique oral, aboral views. Babbacombe Cliff, BC-22/Po3 (x35).

14. Oblique oral view. Babbacombe Cliff, BC-20/Po1 (x70) (juvenile growth stage).
16. Oral view. Babbacombe Road, BR-1/Po2 (x35).
17. Oral view. Redgate Beach, RB-2/Po5 (x35).
18. Oral view. Redgate Beach, RB-2/Po2 (x35).
19. Oblique oral view. Barton Quarry, BQ-33/Po1 (x60) (juvenile growth stage).
20. Oblique oral view. St.James Road, SJ-1/Po13 (x40).

21,22. Aboral, oblique oral views. Babbacombe Road, BR-7/Po1 (x30).

23. Oblique oral view. St.James Road, SJ-1/Po11 (x40).
24. Oral view. Long Quarry Point, LG-6/Po4 (x30).
25. Oral view. Redgate Beach, RB-2/Po11 (x30).

PLATE 9

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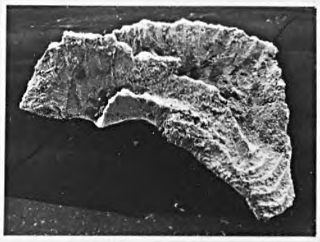

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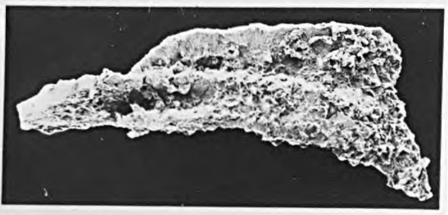

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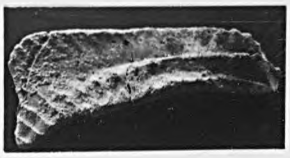

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Plate 10

Figs. 1-22. Polygnathus linguiformis linguiformis HINDE

1,5. Oblique oral, aboral views. Lummaton Quarry, LM-17/Po3 (x30).

2,3,4. Oblique oral, lateral, aboral views. Lummaton Quarry, LM-15/Po1 (x30).

6,10,13. Oblique oral, aboral, lateral views. Lummaton Quarry, LM-9/Po3 (x30).

7,8,9. Lateral, oblique oral, aboral views. Lummaton Quarry, LM-15/Po2 (x40).

11,14. Oblique oral, lateral views. Lummaton Quarry, LM-10/Po3 (x30).

12,16,17. Oblique oral, lateral, aboral views. Lummaton Quarry, LM-16/Po3 (x40).

15,19. Lateral, oblique oral views. Lummaton Quarry, LM-7/Po2 (x40) (small growth stage).

18. Oblique oral view. Lummaton Quarry, LM-5/Po1 (x70) (juvenile growth stage).

20. Oblique oral view. Lummaton Quarry, LM-4/Po1 (x40).

21,22. Aboral, oblique oral views. Lummaton Quarry, LM-10/Po4 (x70) (juvenile growth stage).

PLATE 10

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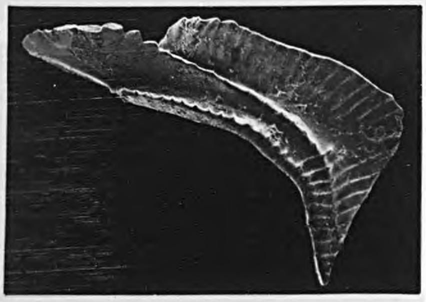

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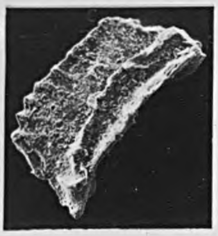

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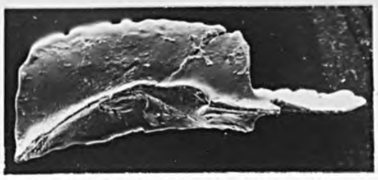

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PLATE 11

Figs. 3-6,8-27,29-33;1,2,7,28(?). Polygnathus ovatinodosus ZIEGLER & KLAPPER

3,4,5,6. Oral, oblique oral, oblique aboral, lateral views. Barton Quarry, BQ-23/Po3 (x35).

8,9,12. Oblique oral, oblique aboral, lateral views. Barton Quarry, BQ-23/Po5 (x50).

10,11. Oral, aboral views. Barton Quarry, BQ-28/Po5 (x35).

13. Oral view. Barton Quarry, BQ-20/Po3 (x40).

14. Oral view. Barton Quarry, BQ-19/Po3 (x30).

15,16. Oral, aboral views. Barton Quarry, BQ-29/Po2 (x30).

17,18,24. Oral, aboral, lateral views. Babbacombe Cliff, BC-32/Po1 (x40)(small growth stage).

19,25,26. Oral, aboral, lateral views. Barton Quarry, BQ-18/Po7 (x35)(small growth stage).

20,27. Oral, aboral views. Barton Quarry, BQ-22/Po10 (x30)(small growth stage).

21. Oral view. Babbacombe Cliff, BC-9/Po2 (x30).

22. Oral view. Babbacombe Cliff, BC-33/Po2 (x50).

23. Oral view. Barton Quarry, BQ-23/Po1 (x30).

29,30,32. Oral, aboral, lateral views. Babbacombe Cliff, BC-32/Po20 (x35).

31,33. Oral, lateral views. Babbacombe Cliff, BC-32/Po17 (x50).

1,2,7. Oral, aboral, lateral views. Babbacombe Cliff, BC-11/Po23 (x40).

28. Oral view. Babbacombe Cliff, BC-9/Po13 (x35).

PLATE 11

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PLATE 12

Figs. 1-16;17-27 (aff.). Polygnathus dubius HINDE

1,2,3. Oral, aboral, lateral views. Barton Quarry, BQ-1/Po2 (x30).

4,5,6. Oral, aboral, lateral views. Barton Quarry, BQ-20/Po1 (x35).

7. Oral view. Babbacombe Cliff, BC-32/Po13 (x30).

8,9. Oral, aboral views. Babbacombe Cliff, BC-11/Po1 (x50)(small growth stage).

10,11. Oral, aboral views. Barton Quarry, BQ-4/Po5 (x40).

12,13. Oral, aboral views. Barton Quarry, BQ-26/Po7 (x30).

14,15,16. Oblique oral, aboral, lateral views. Barton Quarry, BQ-22/Po9 (x40)(small growth stage).

17,18,21. Oblique oral, aboral, oral views. Barton Quarry, BQ-20/Po2 (x35).

19,20. Oral, aboral views. Barton Quarry, BQ-26/Po15 (x40)(small growth stage).

22,23. Oral, aboral views. Barton Quarry, BQ-19/Po2 (x30).

24,25. Oral, aboral views. Barton Quarry, BQ-5/Po1 (x30).

26,27. Oblique oral, aboral views. Barton Quarry, BQ-5/Po2 (x30).

Figs. 28-33. Polygnathus xylus xylus STAUFFER

28. Oral view. Barton Quarry, BQ-28/Po4 (x60)(small growth stage).

29,30,31. Oblique oral, oral, aboral views. Barton Quarry, BQ-15/Po3 (x50).

32. Oral view. Barton Quarry, BQ-23/Po6 (x50).

33. Oral view. Barton Quarry, BQ-22/Po11 (x60).

PLATE 12

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PLATE 13

Figs. 8,14;1-4 (aff.). Polygnathus webbi STAUFFER

8,14. Oblique oral, oral views. Babbacombe Cliff, BC-11/Po14 (x40).

1,2. Oral, aboral views. Barton Quarry, BQ-14/Po1 (x40).

3,4. Oral, aboral views. Barton Quarry, BQ-24/Po1 (x40).

Figs. 5-7,9-13,15,16. Polygnathus decorosus STAUFFER

5. Oral view. Petit Tor Beach, PB-1/Po1 (x50).

6. Oral view. Petit Tor Beach, PB-3/Po3 (x60).

7,12. Oral, lateral views. Petit Tor Beach, PB-3/Po1 (x60).

11. Oral view. Petit Tor Beach, PB-2/Po2 (x60).

9,10,15. Oblique oral, aboral, oral views. Babbacombe Cliff, BC-8/Po1 (x50).

13,16. Oral, lateral views. Petit Tor Beach, PB-3/Po2 (x60).

Figs. 17-22,25-27. Polygnathus cristatus HINDE

17,22,25. Oral, aboral, lateral views. Barton Quarry, BQ-1/Po4 (x60).

18. Oral view. Babbacombe Cliff, BC-33/Po4 (x70).

19,20. Oral, aboral views. Barton Quarry, BQ-30/Po1 (x30) (dolomitised specimen).

21. Oral view. Barton Quarry, BQ-1 (x40).

26,27. Oral, aboral views. Babbacombe Cliff, BC-32/Po9 (x60)(juvenile growth stage).

Figs. 23,24,28,29. Polygnathus asymmetricus subsp. A sensu ORCHARD 1978

23,24. Oral, aboral views. Petit Tor Beach, PB-12/Po1 (x60).

28,29. Aboral, oral views. Petit Tor Beach, PB-12/Po2 (x60) (juvenile growth stage).

PLATE 13

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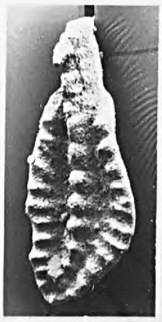
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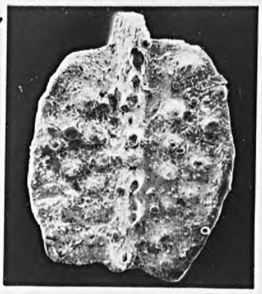
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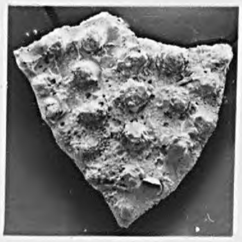
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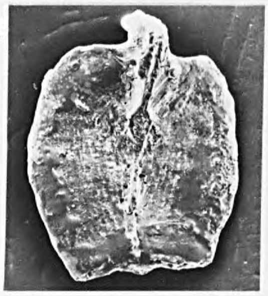
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PLATE 14

Figs. 1,2;3 (cf.). *Polygnathus asymmetricus asymmetricus* BISCHOFF & ZIEGLER

1,2. Oral, aboral views. Babbacombe Cliff, BC-32/Po8 (x30).

3. Oral view. Babbacombe Cliff, BC-32/Po10 (x40).

Figs. 6,7,10. *Polygnathus asymmetricus ovalis* ZIEGLER & KLAPPER

6,7,10. Oral, aboral, lateral views. Barton Quarry, BQ-18/Po4 (x40).

Fig. 9. *Polygnathus asymmetricus* BISCHOFF & ZIEGLER, subsp. indet.

9. Oral view. Babbacombe Cliff, BC-32/Po15 (x70).

Figs. 4,5,8,11,13,17. *Polygnathus dengleri* BISCHOFF & ZIEGLER

4,5,8. Oblique oral, aboral, oral views. Babbacombe Cliff, BC-5/Po3 (x60).

11,13. Oral, lateral views. Babbacombe Cliff, BC-9/Po9 (x60).

17. Oral view. Babbacombe Cliff, BC-9/Po10 (x40).

Figs. 12,18,21,27. *Polygnathus* aff. *ordinatus* BRYANT

12,18. Oral, aboral views. Babbacombe Cliff, BC-11/Po18 (x60).

21,27. Oral, aboral views. Babbacombe Cliff, BC-11/Po14 (x50).

Figs. 14-16,19,22. *Schmidtognathus* n.sp. B

14,15,22. Oral, aboral, lateral views. Barton Quarry, BQ-26/Sch3 (x30).

16,19. Oblique oral, aboral views. Barton Quarry, BQ-26/Sch4 (x30).

Figs. 20,23-26,28. *Schmidtognathus*? aff. *gracilis* KLAPPER

20,25,26. Oral, lateral, aboral views. Barton Quarry, BQ-9/Sch1 (x40).

23,24,28. Oral, aboral, lateral views. Barton Quarry, BQ-30/Sch5 (x35).

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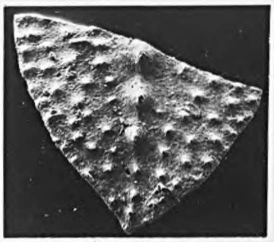
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PLATE 15

Figs. 1-3,6,7,9,11-14,18,19. Schmidtognathus aff. hermanni ZIEGLER

1,2,6. Oral, aboral, lateral views. Barton Quarry, BQ-18/S1 (x40).

3,7. Oral, aboral views. Barton Quarry, BQ-18/S8 (x30) (?gerontic growth stage).

9,11,12. Lateral, oblique oral, aboral views. Barton Quarry, BQ-18/S4 (x30).

13,14. Oblique oral, aboral views. Barton Quarry, BQ-18/S9 (x35).

18,19. Oral, aboral views. Barton Quarry, BQ-18/S5 (x30).

Figs. 4,5,8,10,15,16,22,23,27. Schmidtognathus peracutus (BRYANT)

4,5,8. Oral, aboral, lateral views. Barton Quarry, BQ-26/S1 (x40).

10,15,16. Lateral, oral, aboral views. Barton Quarry, BQ-11/S1 (x40).

22,23,27. Aboral, oral, lateral views. Barton Quarry, BQ-18/S2 (x35).

Figs. 17,20,24. Schmidtognathus cf. wittekindti ZIEGLER

17,20,24. Oral, lateral, aboral views. Barton Quarry, BQ-1/S2 (x30).

Figs. 21,25,26. Schmidtognathus n. sp. A

21,25,26. Lateral, oral, oblique aboral views. Barton Quarry, BQ-30/S1 (x35).

PLATE 15

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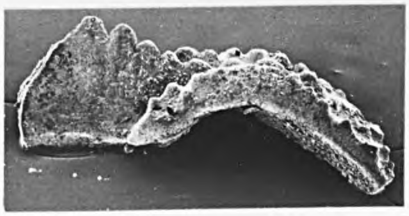

PLATE 16

Figs. 1-9. Schmidtognathus pietzneri ZIEGLER (small growth stages)

1,2. Oral, aboral views. Barton Quarry, BQ-28/S1 (x50).

3,4. Oral, aboral views. Barton Quarry, BQ-26/S2 (x50).

5,6,9. Oral, aboral, lateral views. Barton Quarry, BQ-30/S3 (x50).

7,8. Oral, aboral views. Barton Quarry, BQ-29/S1 (x50).

Figs. 10,11,13-15. Ancyrodella lobata BRANSON & MEHL

10,11,15. Oral, lateral, aboral views. Petit Tor Beach, PB-1/A2 (x30).

13,14. Oral, aboral views. Petit Tor Beach, PB-2/A1 (x30).

Figs. 12,16. Ancyrodella aff. gigas sensu ORCHARD 1978

12,16. Oral, aboral views. Petit Tor Beach, PB-1/A1 (x60).

Figs. 17,18,20-22,24. Ancyrodella rotundiloba binodosa UYENO

17,18,22. Oral, aboral, lateral views. Babbacombe Cliff, BC-32/A1 (x120) (very small growth stage).

20,21,24. Oral, aboral, lateral views. Babbacombe Cliff, BC-9/A1 (x60).

Figs. 19,23. Ancyrodella rotundiloba rotundiloba (BRYANT)

19,23. Oral, aboral views. Barton Quarry, BQ-18/A1 (x70) (small growth stage).

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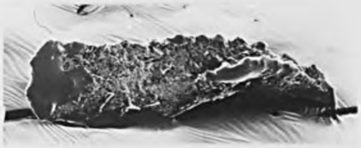

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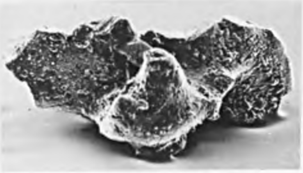

PLATE 17

Figs. 1-6,8. Palmatolepis subrecta MILLER & YOUNGQUIST

1,2,3. Oral, lateral, aboral views. Petit Tor Beach, PB-12/Pa1 (x50).

4,5,6. Lateral, oral views. Petit Tor Quarry, PQ-4/Pa1 (x50).

5,8. Oral, aboral views. Petit Tor Beach, PB-1/Pa1 (x50).

Figs. 7,9-12. Palmatolepis hassi MÜLLER & MÜLLER

7,10. Oral, aboral views. Petit Tor Beach, PB-12/Pa2 (x40).

9. Oral view. Petit Tor Beach, PB-2/Pa3 (x60).

11. Oral view. Petit Tor Beach, PB-2/Pa1 (x60).

12. Oral view. Petit Tor Beach, PB-1/Pa3 (x60).

Fig. 13. Palmatolepis aff. proversa ZIEGLER

13. Oral view. Petit Tor Beach, PB-1/Pa2 (x30).

Figs. 14,15. Palmatolepis sp. indet.

14,15. Oral, oblique oral views. Petit Tor Beach, PB-2/Pa2 (x120) (juvenile growth stage: note strongly developed central node).

PLATE 17

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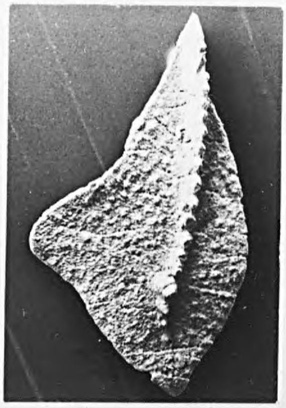

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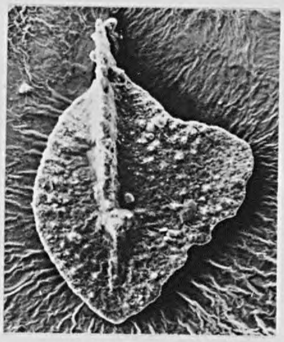

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PLATE 18

Figs. 1,6. *Tortodus* aff. *variabilis* (BISCHOFF & ZIEGLER)

1,6. Oral, lateral views. Redgate Beach, RB-2/T1 (x40).

Figs. 2-5,7,8,12,16,20. *Ozarkodina brevis* (BISCHOFF & ZIEGLER) (P element only).

2,4,7. Oral, lateral, aboral views. Lummaton Quarry, LM-13/Sp1 (x70).

3. Oral view. Lummaton Quarry, LM-6/Sp1 (x140).

5,8. Oral, lateral views. Lummaton Quarry, LM-10/Sp1 (x105).

12,16,20. Oral, lateral, aboral views. Lummaton Quarry, LM-15/Sp1 (x70).

Figs. 9,11. *Spathognathodus planus* BISCHOFF & ZIEGLER

9. Lateral view. Lummaton Quarry, LM-10/Sp3 (x40).

11. Lateral view. Madrepore Road, MR-1/Sp1 (x40).

Figs. 10,13,23-28. Type 1 elements (*sensu* Klapper and Philip 1971) from Lummaton Quarry.

10,13. Lateral, aboral views of A2 element, from possible Type 1 multielemental association (*partim*) (LM-17/bar 1, x40).

23. Lateral view of A3 element, from possible Type 1 multielemental association (*partim*) (LM-11/bar 1, x40).

24. Lateral view of N element, x30) from possible Type 1
27. Lateral view of A1 element, x30) multielemental association
28. Lateral view of A2 element, x80) (*partim*) (LM-18/bars 1-3).

25. Lateral view of A1 element, x20) from possible Type 1 multielemental
26. Lateral view of A2 element, x40) association (*partim*) (LM-16/bars 1,2).

Figs. 15,18,19,21. Type 2 elements from Lummaton Quarry.

15. Lateral view of B2 element, x40) from possible Type 2
18. Lateral view of B3 element, x40) multielemental association
19. Lateral view of N element, x40) (*partim*) (LM-11/bars 2-4).

21. Lateral view of B1 element, from possible Type 2 multielemental association (*partim*) (LM-15/bar 1, x30).

PLATE 18

(continued)

Figs. 11,14,17. Type 1 elements from Madrepore Road.

11. Lateral view of O1 element, x40) from ?two possible Type 1
14. Lateral view of O1 element, x30) multielemental associations
17. Lateral view of A1 element, x50) (partim) (MR-1/Sp1, bars 1,2).

Fig. 22. Type 1 element from Long Quarry Point.

22. Lateral view of A1 element, from possible Type 1 multielemental association (partim) (LG-7/bar 1, x40).

Figs. 29-32. Eognathodus cf. bipennatus montensis WEDDIGE

29,31. Oral, lateral views. Triangle Point, TP-12/E1 (x50).

30,32. Oral, lateral views. Triangle Point, TP-12/E2 (x50).

PLATE 18

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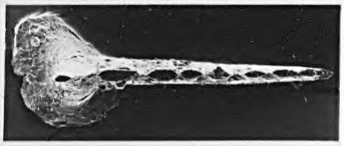

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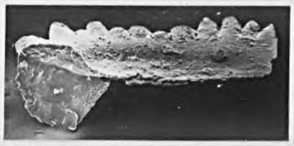

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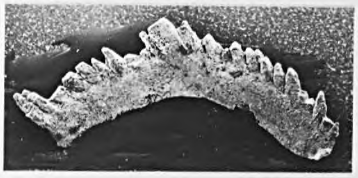

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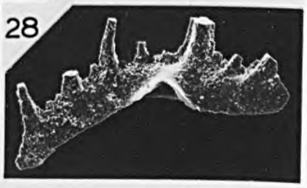

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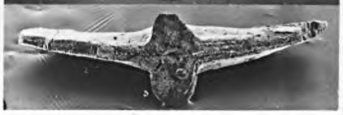

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PLATE 19

Figs. 1-6,8,9. Type 1 elements (*sensu* Klapper and Philip 1971) from Barton Quarry.

1,2,5. Oblique oral, lateral, aboral views)
of 01 (nothognathellan) element, x80) from ?two possible Type 1
3. Lateral view of A3 element, x60) multielemental associations
4. Oral view of ?A3 element, x60) (*partim*) (BQ-21/bars 1-5).
6. Lateral view of A1 element, x60)
9. Lateral view of N element, x50)

8. Lateral view of N element, from possible Type 1 multielemental association (*partim*) (BQ-15/bar 1, x60).

Figs. 7,10-12, 14-16. Type 2 elements from Barton Quarry.

7. Lateral view of N element, from possible Type 2 multielemental association (*partim*) (BQ-15/bar 2, x30).

10. Lateral view of B2 element, x20) from possible Type 2
14, 15. Oral, lateral views of 02) multielemental association
element, x30) (*partim*) (BQ-1/bars 1,2).

11. Lateral view of B2 element, x40) from ?two possible Type 2
12. Lateral view of B3 element, x40) multielemental associations
16. Lateral view of B2 element, x40) (*partim*) (BQ-16/bars 1-3).

Figs. 13,19,21,22,24. Type 1 elements from Babbacombe Cliff.

13. Lateral view of A3 element, from possible Type 1 multielemental association (*partim*) (BC-5/bar 1, x50).

19. Lateral view of 01 element, x60) from ?two possible Type 1
21. Lateral view of A2 element, x40) multielemental associations
22. Lateral view of A3 element, x80) (*partim*) (BC-32/bars 1-4).
24. Lateral view of 01 element, x40)

PLATE 19

(continued)

Figs. 17,18,20,23,26. Type 2 elements from Babbacombe Cliff.

17. Lateral view of O2 element, x20) from possible Type 2 multielemental
)
20. Lateral view of B2 element, x30) association (*partim*) (BC-32/bars 5,6).

18. Oblique lateral view of B2 element, x30) from possible Type 2
)
23,26. Oral, lateral views of O2 element,) multielemental association
)
x20) (*partim*) (BC-22/bars 1,2).

Figs. 25,27-32. *Ozarkodina sannemanni sannemanni* (BISCHOFF & ZIEGLER) (P element only)

25,27,28. Oral,outer lateral, inner lateral views. Barton Quarry, BQ-18/Sp1 (x70).

29,32. Oral, oblique oral views. Babbacombe Cliff, BC-11/Sp1 (x70).

30. Oral view. Babbacombe Cliff, BC-11/Sp2 (x80).

31. Oral view. Barton Quarry, BQ-23/Sp1 (x80).

PLATE 19

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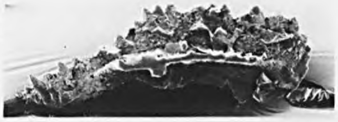
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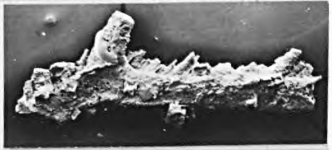
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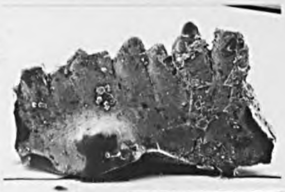
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PLATE 20

Figs. 1,2,6. *Elsonella rhenana* LINDSTRÖM & ZIEGLER (*partim*) from Babbacombe Cliff, BC-32/bars 7-9.

1. Lateral view of roundyan (A3) element, x25.
2. Lateral view of falcodontan (O1) element, x80.
6. Lateral view of ?oulodontan (N) element, x80.

Figs. 3,7-9,13. Type 1 elements (*sensu* Klapper and Philip 1971) from Petit Tor Beach, from possible Type 1 multielemental associations (*partim*).

3. Oblique lateral view of A3 element, PB-3/bar 1 (x80).

7,9. Oblique oral, aboral views of ?A3 element, PB-12/bar 1 (x80).

8. Lateral view of A2 element, PB-10/bar 1 (x30).

13. Lateral view of A2 element, PB-1/bar 1 (x40).

Figs. 4,10,14. Type 2 elements from Petit Tor Beach, from possible Type 2 multielemental association (*partim*).

4. Lateral view of N element, PB-10/bar 2 (x60).

10,14. Oral, aboral views of O2 element, PB-12/bar 2 (x60).

Figs. 5,11,12,15-21,23-26,41. *Belodella* spp.

5,11. Lateral,basal views. Lummaton Quarry,LM-15/C1 (x40,x90 respectively).

12,16. Lateral,basal views. Lummaton Quarry,LM-15/C2 (x35,x70 respectively).

15,20. Basal,lateral views. Lummaton Quarry,LM-15/C3 (x70,x35 respectively).

17,23. Lateral,basal views. Lummaton Quarry,LM-15/C4 (x50,x110 respectively).

18,24. Basal,lateral views. Lummaton Quarry,LM-15/C5 (x70,x35 respectively).

19,25. Lateral,basal views. Lummaton Quarry,LM-15/C6 (x50,x110 respectively).

21,26. Lateral,basal views. Lummaton Quarry,LM-15/C7 (x35,x100 respectively).

41. Lateral view. Petit Tor Beach, PB-2/C1 (x35).

(5,11. = "*B. devonicus*"; 21,26. = "*B. resimus*"; 17,19,23,25. = "*B. triangularis*"; 12,15,16,18,20,24. = "*B. resimus*" transitional to "*B.triangularis*"; 41. = B. sp. indet.).

PLATE 20

(continued)

Figs. 22,27-29,31,32,35-37,39,40. Neopanderodus spp.

22,32. Lateral,basal views. Lummaton Quarry,LM-18/C1 (x50,x90 respectively).

27,35. Lateral,basal views. Lummaton Quarry,LM-16/C1 (x50,x70 respectively).

28. Lateral view. Redgate Beach, RB-2/C1 (x50).

29,36. Lateral,basal views. Lummaton Quarry,LM-18/C2 (x40,x60 respectively).

31,37. Lateral,basal views. Madrepore Road, MR-1/C1 (x40,x80 respectively).

39. Lateral view. Barton Quarry, MH-1/C1 (x40).

40. Lateral view. Barton Quarry, MH-1/C2 (x50).

Fig. 30. Panderodus sp.

30. Lateral view. Stentiford Hill, SH-7/C1 (x35).

Figs. 33,34,38,42,43. Coelocerodontus spp.

33,38. Lateral,basal views. Lummaton Quarry,LM-18/C3 (x40,x50 respectively).

34,43. Lateral,basal views. Lummaton Quarry,LM-15/C8 (x50,x60 respectively) (strongly recurved specimen).

42. Lateral view. Petit Tor Beach, PB-2/C2 (x40).

PLATE 20

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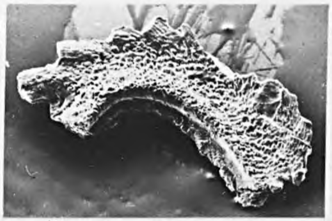

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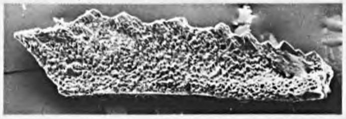

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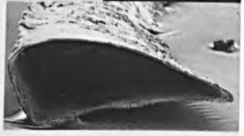

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