

PALAEOZOIC PALAEONTOLOGY IN DEVON AND CORNWALL

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I. INTRODUCTION

In attempting to review the principal fossil faunas and published work relating to them, it is necessary at the outset to stress the tremendous amount of work remaining to be done. No major monographic treatment of any fossil group of the area has been published in the last sixty years. Recent work has concentrated on small faunas or restricted groups, and revisionary work in almost all groups is urgently needed. In view of this, any summary given at this stage is intended as a review of an existing knowledge which is admittedly incomplete and inadequate. The following account has been divided into sections and one of us (M.R.H.) is responsible for the sections on the Historical Survey, Lower Palaeozoic and Devonian of South Devon and Cornwall whilst the other author (E.B.S.) has prepared the sections on the Devonian and Carboniferous of Central and North Devon. Others have been helpful in various ways: J. M. Edmonds, M. Mitchell, H. P. Powell and F. S. Wallis have helped in the provision of specimens illustrated on the plates: J. Saunders has helped with some photography. C. T. Scrutton has commented upon the text and often revised the coral records and N. E. Butcher, Scott Simpson, H. G. Reading, J. M. Thomas and R. G. Walker have commented upon the correlation charts, although the published version expresses the opinion of the authors. Localities mentioned are positioned by the National Grid Reference and grid lines are shown on the accompanying map (Fig. 1).

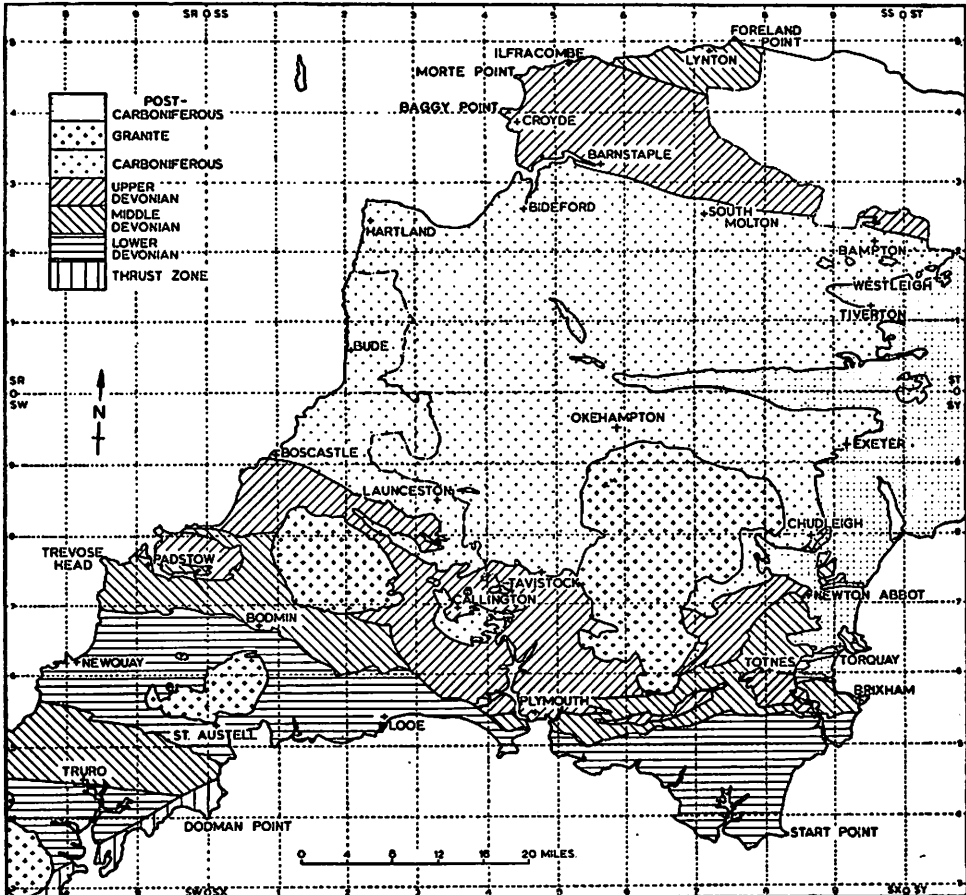


Fig. 1. Sketch map illustrating the geology of Devon and Cornwall. Lines taken mostly from maps of the Geological Survey. The National Grid is also shown.

II. HISTORICAL SURVEY

John Phillips published his *Palaeozoic Fossils of Cornwall, Devon and West Somerset* in 1841 as the palaeontological sequel to the *Report* of de la Beche (1839). Phillips' work remains the sole attempt to give a general survey of south-western Palaeozoic fossils. Earlier work was listed by de la Beche (1839 p. xxiii-xxviii) of which some is of historic interest, such as Playfair's records of fossils at Plymouth, or Lonsdale's work on corals which was responsible for persuading Sedgwick and Murchison to establish the Devonian System in 1839. Other work, such as Sowerby's descriptions (in Sedgwick and Murchison 1840) or that of Ansted (1838) on Cornish clymenids are descriptive works which are still of value.

Subsequent to 1841 the last century saw the publication of several monographs of British fossil groups which include descriptions of Devonian, and to a lesser

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extent, Carboniferous fossils from the south-west. Among these are H. Woodward (1884) and J. W. Salter's work on trilobites (1864, 5), that on brachiopods by Thomas Davidson (1864-65), on stromatoporoids by H. A. Nicholson (1886-1892), H. M. Edwards and J. Haime on corals (1835) and A. H. Foord and G. C. Crick (1888-1897) on cephalopods. An important work of wider scope is G. F. Whidborne's sumptuous *Monograph of the Devonian Fauna of the South of England* (1888-1907), the first two volumes of which are concerned with the fauna of the Middle Devonian limestones of Lummaton, Wolborough, Chircombe Bridge and Chudleigh, and the third with the Upper Devonian fauna of the Marwood and Pilton Beds of North Devon and Somerset. There are several faunal lists of the last century especially which are important for reference. These include Sedgwick and M'Coy's *British Palaeozoic Fossils* (1855), *The Fauna and Flora of the Devonian and Carboniferous Periods* by J. H. Bigsby (1878). Collins' *Working List* (1893) and its *Addenda* (1910) are valuable sources for Cornish Fossils. Etheridge (1867) gives a comprehensive account of the geology of north Devon. Full lists of references up to the date of publication are given in appendices of the Survey Memoirs.

Contributions of the present century will be more fully listed in the text, but papers dealing with specific groups which are valuable sources of reference include: on corals, Lang and Smith (1935), Taylor (1950), Middleton (1959); on ostracods, Jones (1890); on brachiopods, Reed (1921), Goldring (1955B); on ammonoids, for the Devonian Selwood (1960) and House (1963) and for the Carboniferous, Butcher and Hodson (1960); for trilobites there is a recent review by Stubblefield (1960); for fish, A. S. Woodward (1899-1901), White (1956); for conodonts, Dinely and Rhodes (1959), and for Carboniferous plants of the region, Arber (1904) and Crookall (1930). A general statement on Devonian problems was given by Simpson (1951) and further comments are in the *Lexique Stratigraphique* (Simpson 1959).

Any brief review of this sort would be incomplete without reference to those who have made substantial contributions by locating new fossil localities. Of these W. A. E. Ussher of the Geological Survey together with the Cornish amateurs C. W. Peach (1842-1926) and Howard Fox (1836-1922) stand supreme. In Devon there is a galaxy of names including W. Pengelly, A. Champenowne, Inkerman Rogers, Jukes-Browne and many others. Of recent times particularly remarkable are the discoveries by Dr. E. M. L. Hendriks in the structurally complex terrain of South Cornwall and southernmost Devon.

III. LOWER PALAEOZOIC

Apart from derived fossils within the Trias of Budleigh Salterton, the only evidence for Lower Palaeozoic rocks is in Cornwall along the disturbed zone between St. Austell to beyond the Helford River which is thought by Dr. E. M. L. Hendriks to be part of a major thrust belt. Before the publication of Hendriks' results, the whole of the south-western tip of Cornwall was marked on Geological Survey maps as Lower Palaeozoic. On current maps all killas except certain thrust blocks is marked as Devonian.

1. **Ordovician.**

The white and grey massive quartzite at Perhaver, Gorran Haven and at Carne, Veryan, first reported by Peach (1841), provides the oldest known fossils of Cornwall. The trilobites from Perhaver were described by Salter (1864, 1865) and lists were given by Watts (in Evans and Stubblefield 1929, p. 79) and by Stubblefield (1939, 1960). *Synhomalonotus*, phacopids, cheirurids and asaphids are known and from Carne a trinucleid pygidium. From Carne comes a fine ribbed orthid which has been referred to "*Orthis altera*" Barrande (Hendriks 1937, p. 332) and from Perhaver the types of *Corineorthis decipiens* Stubblefield (*supra cit.*). Locality details are given by Reid (1907, p. 15, 22). The precise age of the faunas is uncertain but some are thought to be Llandeilian.

Supposed Ordovician fossils near Mudgeon in N. Meneage (Flett and Hill 1912, p. 175) have now been referred to the Devonian genera *Plicochonetes* and *Douvillina* (Stubblefield *supra cit.*).

2. **Silurian.**

Fossils in limestone lenticles along the Veryan section of the Crush Zone (in Sheet 353) have been referred to the Silurian, especially those from around Portloe Cove and Malmanare Point. Blue, black and grey limestones here yielded to Hendriks (*op. cit.* p. 333, 334), *Slava interrupta* J. de C. Sowerby, *S. cf. persignata* (Barrande) and various nautiloids thought to be of Ludlovian age. Also Bather (1907) has determined a *Scyphocrinus* from Catasuent Cove (Reid 1907, p. 21) which has been taken to indicate Wenlockian. At Porthluney (Reid 1907) nautiloids were determined by Crick as Ludlovian but this has since been questioned by Spath (Hendriks 1937, p. 333): various fenestellids, brachiopods and bivalves also occur (Green and Sherborn 1904, 1906). Examination of these limestones for conodonts is clearly desirable (see recent comment by House 1965).

In the Meneage area (Sheet 359), however, Stubblefield (*op. cit.*) considered that the evidence there for Silurian in the Crush Zone was inconclusive and rested on records of *Serpulites longissimus* from Fletchings Cove alone.

IV. UPPER PALAEZOIC : CORNWALL AND SOUTH DEVON.

Devonian rocks occur throughout southern Devon and over most of Cornwall except for the areas of the granite moors: these outcrops are separated from the Devonian rocks of North Devon by the wide tract of Carboniferous Culm rocks found throughout central Devon. Because of facies changes in parts of the Devonian, a geographic treatment of the fossil occurrences is preferred. The accompanying chart (Fig. 2) shows current views on the correlation of the Devonian facies.

1. **Lower Devonian.**

No convincing evidence for the Gedinnian has yet come to light in Devon and Cornwall. Siegenian and Emsian faunas are rich, however, and the distinction between Dartmouth Slates below, and Staddon Grit and Meadfoot Beds above has been recognised in a lithological sense in both counties, but detailed faunal correlations are still lacking.

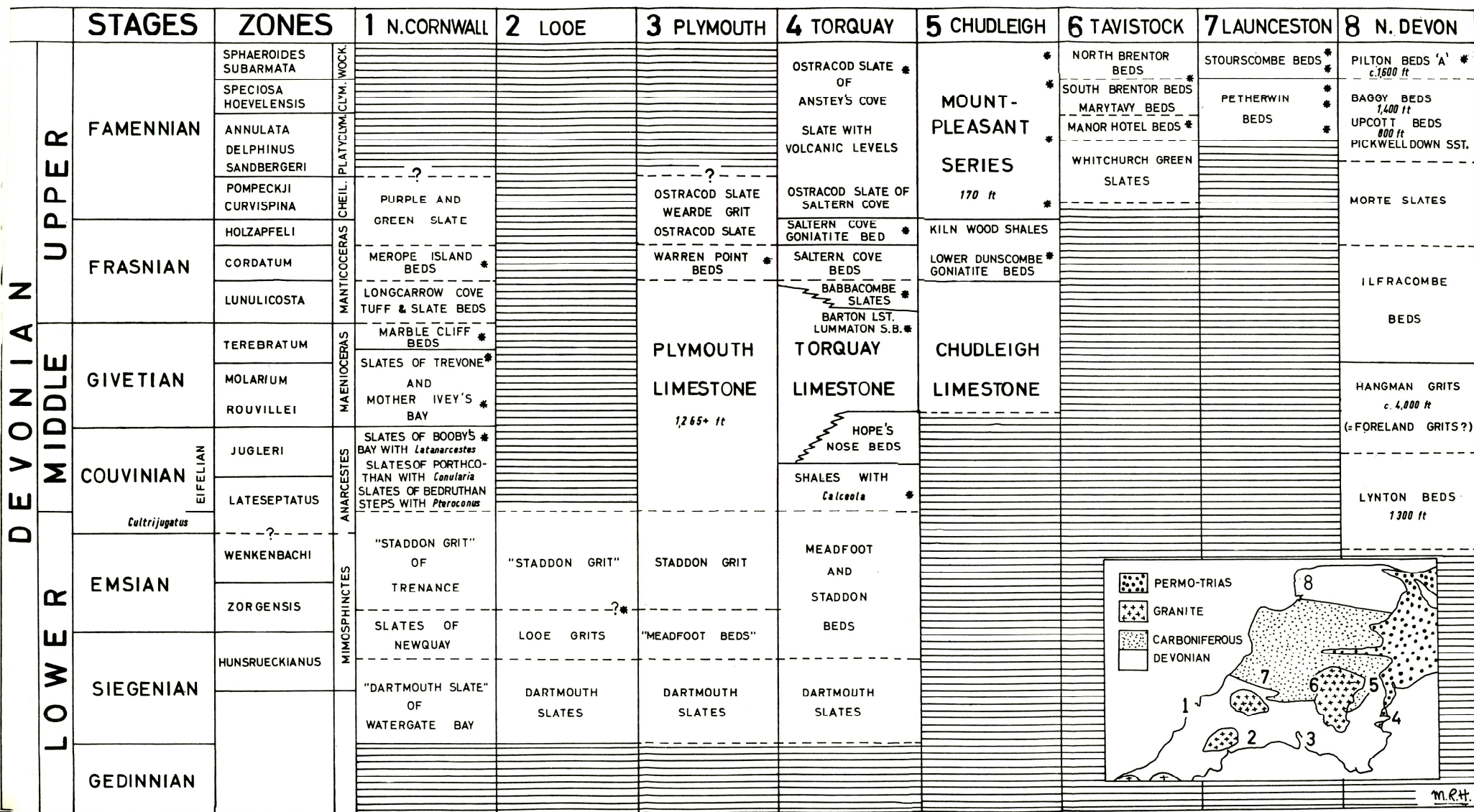


Fig. 2. Correlation chart of the Devonian rocks of Devon and Cornwall. For sources and references see text.

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Dartmouth Slates

Purple and greenish fish-bearing slates are known from north Cornwall to south Devon. Detailed correlation of these beds using their pteraspids has only recently been attempted (White 1956) and representatives of the lower and middle Siegenian have been recognised.

North Cornwall. A faulted anticline passing east-west through Watergate Bay exposes sandy micaceous shales or reddish purple and pale green slates (Reid and Scrivenor 1906, p. 5, *et seq.*). Fish remains were first recorded from here by R. Valletín and H. Fox (1899) and the fish were described by A. S. Woodward (1899, 1900, 1901). The northern half of the bay as far as Stem Point yields fish, and the same levels reappear in the southern half of the bay south of Zacry's Island. Locality details are given in the *Memoir* (*op. cit.*) where Traquair records pteraspids, acanthodians and possibly a coccostean, a *Phlyctaenaspis* is identified by Woodward (in Fox 1900, p. 148). White (1956) has shown that "*Pteraspis cornubicus*" from the slates here and from Looe Bay represents *Protaspis*, *Rhinopteraspis leachi* and *R. dunensis*. It is on this evidence that lower and middle Siegenian are thought to be represented.

South Cornwall. "*Pteraspis cornubicus*" is known from Lantiver Bay (Woodward 1899) and the Dartmouth Slates at various places along the coast between Polperro and Cawsand similarly yield fish for which White's redeterminations also apply. They were first figured by Peach in 1868. In addition to pteraspids and cephalaspids (Woodward 1901) bellerephontids are not uncommon, usually recorded as "*Bellerephon trilobatus*" (= *Bucanella trilobata*). The various localities are given in the *Memoir* (Ussher 1907, p. 21-27). The known Cornish records up to 1908 were given by Collins (1910, p. 421-424) in his *Addenda to the Working List*.

South Devon. Pteraspid localities here are recorded in the *Memoirs* for Ivybridge (Sheet 349, Ussher 1912, p. 20-26), Kingsbridge and Salcombe (Sheets 355 and 356; Ussher 1904, p. 13-15) and Torquay (Sheet 350, Ussher, 1903, p. 20-23; Lloyd 1933, p. 29-32) although in the latter area no determinable fish remains are known. North of the Start near Cockridge Point, Hendriks (1951, p. 263) records *Drepanaspis* from near the Dartmouth Slates/Meadfoot Beds' junction and she records pteraspids at several places.

Staddon Grit and Meadfoot Beds.

The distinction between an upper Staddon Grit, and a lower more argillaceous series, the Meadfoot Beds, is clearly demonstrable near Plymouth (Hendriks 1951) but to the east, at Torquay, Lloyd (1933) claimed the divisions could not be separated. To the west, near Looe and on the north Cornish coast, the Survey maps do mark the distinction. Brachiopods, trilobites and lamellibranchs are common at many places, and these serve to give correlations with the upper Siegenian and Emsian. In south Devon the Couvinian has also been claimed in the Staddon Grit, but the significance of the evidence for this will be questioned later.

North Cornwall. Southwards from the Dartmouth Slates of Watergate Bay, grey calcareous slates are exposed past Newquay to Perran Bay (Reid and Scrivenor 1906, p. 12-29). Commonest fossils are simple and tabulate corals (Collins 1893). Phacopids and nautiloids have been noted, but no recent determinations are available. From Criggars, Newquay, come gastropods and corals and Oakley (1951) has identified a probable *titusvillid* sponge.

North from the Dartmouth Slates, between Stem Cove and Mawgan Porth poorly preserved tabulate corals, simple corals and gastropods are recorded (Fox 1902, p. 538; Reid and Scrivenor 1906, p. 18) in beds regarded as Meadfoots Beds, but between Mawgan Porth and Bedruthan Steps, in beds regarded by the Survey as Staddon Grits only a *Homalonotus* is recorded (Reid, Barrow and Dewey 1910, p. 6).

East Cornwall. The Gramscatho Beds of Meneage and Roseland will, for convenience, be considered under the Lower Devonian. The principal outcrops discussed here are those around St. Austell Bay and Fowey, and those of the Looe district. Fowey is a famous locality for upper Lower Devonian fossils, especially the now lost locality of Punch's Cross. Lists are given in the memoir of sheet 347 (Ussher, Barrow and MacAlister 1909, p. 17-25). From here early workers recorded much (Peach 1841, 1842) and the corals have been the subject of special treatment (Collins 1893, p. 553, 1895) but are in need of revision. The recorded brachiopods appear to include the following genera: *Acrospirifer*, *Spinocyrtia*, *Hysterolites*, *Tropidoleptus* together with stropheodontids and leptaenids. From Punch's Cross Collins (1896) figured various crinoid remains. From Polruan, Green (1899) described "*Nereitopsis cornubicus*" (= *Pteronotus mirus*) and Davidson (1865 p. 83) described *Stropheodonta gigas* (M'Coy).

These rocks reappear east of the Golant-Polperro belt of Dartmoor Slates at Looe, another famous locality (Green 1904, 1906; Peach 1841, etc.). A long faunal list is given in the *Memoir* (Ussher 1907, p. 40) based on Collins' and Davidson's published accounts and this was farther revised by Asselberghs (1921, p. 165) who compared the fauna with Lower Devonian faunas of the Ardennes. Asselberghs gives a list revising Davidson's figures (1864-1871) and his determinations (without fresh revisions) include: *Athyris avirostris*, *Spirifer primaevus*, *S. excavatus*, *Rhynchonella papilis*, *Stropheodonta gigas* (this is M'Coy's source), *St. sedgwicki*, *Orthotetes ingens*, *Proschizophoria personata*, *Leptostrophia explanata*, *Rhenorenselaria strigiceps* and *Spirifer hystericus*. Ussher recorded also *Pleurodictyum problematicum*, favositids, phacopids and crinoids. On the basis of this fauna, Asselberghs referred the Meadfoot Beds of Looe to the Siegenian, and Simpson (1959, p. 70) supports this. On the basis of a very poorly preserved *Mimosphinctes*, House (1963, p. 14) suggests that Lower Emsian may also be represented. Although the overlying Staddon Grits are mostly unfossiliferous, they doubtless are mostly of Emsian age.

East of the Portwrinkle Fault the same fossiliferous horizons reappear and, as Ussher has pointed out, elucidation of the faunal succession may be possible there, and the section deserves further attention.

It is necessary now to turn to the area in Roseland and Meneage so well

described by Hendriks (1937, 1949) where the flysch-like deposits called the Gramscatho Series are known. This name is used for strata formerly called Falmouth, Portscatho, Veryan, Grampound and Manaccan Beds which crop out south-westward from St. Austell Bay. The rocks are mostly clay-slate with sandy and calcareous beds and grits. At the top is thought to lie the Gidley Wells Conglomerate. (Hendriks 1937, p. 329) in which was found a pebble containing *Machaeracanthus* and below which *Theca swindernana* is recorded. At certain levels in the Gramscatho Series *Pachypora* is recorded. The plant *Dadoxylon hendriksi* Lang (1929) came from Pendower (Hendriks 1937, p. 342) and forms are known the tracheids of which comparable to *Asteroxylon mackiei*. Westoll (1964) has suggested that the Rhynie Chert source for the type of *A. mackiei* is of Lower O.R.S. age. The plant remains cannot with certainty be referred to as other than probably Devonian (*Dadoxylon* also occurs in the Carboniferous). The *Machaeracanthus* may be Lower or Middle Devonian. Much has still to be learnt on the age relations of the Gramscatho Series.

Plymouth to Dartmouth. The type section of the Staddon Grit is on the east side of Plymouth Sound and is described in the *Memoir* (Ussher 1907, p. 40). Few fossils apart from impressions of brachiopods are known. In slates of Meadfoot type immediately south of Staddon Heights, between Andurn Point and Bovisand Bay, Hendriks (1951, p. 273) records *Styliolina*, *Metriophyllum* or *Syringaxon* (see Smith 1951), ? *Hysterolites hystericus* and *Pteraspis*. In Sandy Cove she notes *Pleurodictyum rhenanum* (Smith 1951, p. 303), *Thamnopora cervicornis*, *Phacops*, *Batostomella*, *Encrinites turgidus* and others, including a possible *Sphaerospongia*. This fauna suggests Upper Siegenian or Lower Emsian. Fossiliferous levels were also noted here by Ussher (1912, p. 28).

The Meadfoot Beds and Staddon Grit crop out in a belt which passes east from the coast sections of Plymouth Sound to beyond Dartmouth to the cliffs between Sharkham Point and Scabbacombe Head (Ussher 1903, p. 23-26), but apart from the western records already mentioned, few fossils are recorded apart from *Homalonotus*, spiriferids (Lloyd 1933, p. 34) and a *Pteraspis* (*op. cit.* p. 33).

Bigbury Bay to Start Bay. For this region the *Memoir* accounts (Ussher 1912, p. 26-40) give some fossil records, but the most modern summary is by Hendriks (1951, p. 263-269). The best localities here are at Warren Point where are recorded *Spinocyrtia subcuspidatus* var. *lateincisus*, and *Spirifer* cf. *speciosus* var. *intermedia*, the former Upper Emsian, the latter possibly lower Couvinian, and the only evidence suggesting a reversion to Meadfoot Beds lithology within or above the Staddon Grit (Dineley 1961, p. 12, 13). Beds on the north side of Woolman Point yielded *Syringaxon*, *Metriophyllum* and *Amphipora* (Smith 1951). From the north side of Ayrmer Cove, *Pleurodictyum rhenanum*, *Thamnopora cervicornis*, *Actinostroma* (Smith 1951) and titusvillid sponges (Oakley 1951) are described.

Paignton area. The railway cutting at Saltern Cove is historically of importance since it was the identification of Lower Devonian fossils here by Davidson (1882, p. 4, 5) among specimens collected by Whidborne that refuted Holl's (1868) theory that they were Carboniferous, and essentially gave the key to the establishment of

the Devonian stratigraphy of South Devon. Records are given by Ussher (1903, p. 26-28) and Lloyd (1933, p. 35, 36). At the south end of Goodrington Sands *Acrospirifer arduennensis*, *Pleurodictyum problematicum* and others are recorded, and from a quarry on Windmill Hill Clump comes a rich fauna including *Camaro-toechia* cf. *daleidensis*, *Chonetes sarcinulata*, *Pleurodictyum problematicum*, *Digonus gigas* and *Tropidoleptus rhenanus*. *Acrospirifer paradoxus* is noted from a lane section near Marldon (Lloyd 1933, Pl. 2, Figs. 11, 12). These records appear to include both Emsian and Siegenian representatives.

Torquay district. In this district Lloyd was unable to separate the Meadfoot Beds (the type of locality of which is here) from the Staddon Grit. The two editions of the *Memoir* (Ussher 1903, p. 28-38; Lloyd 1933, p. 36-41) give detailed accounts of the localities and faunas, Lloyd giving illustrations which include *Spinocyrtia subcuspidatus*, *Spirifer speciosus*, *Acrospirifer pellico* (= *Spirifer hercyniae*), *Spirifer alatifomis*, *Tropidoleptus rhenanus*, *Stropheodonta munchisoni*, *Schizophoria provulvaria* and others from the Meadfoot Beds of the Torquay area. Reed has given revisions of the mollusca (1922), brachiopods (1921) and trilobites (1920); among the latter Stubblefield (1960) notes the following described species: *Burmeisterella elongata*, *B. champernownei*, *B. bifurcata*, *Digonus goniopygaeus*, *D. gigas* and *Asteropyge*. Lloyd (1933, p. 24) has noted the prevalence of Emsian species in the Meadfoot Beds, and the rarity of Siegenian species. This does support Dineley's view, referred to above, that the Meadfoot Beds here may be in part the lateral equivalents of beds referred to the Staddon Grits in Cornwall.

2. Middle Devonian.

In Cornwall the Middle Devonian is represented by slates except for the upper Givetian limestone-shale alternations which comprise the Marble Cliff Beds (Fox 1895, p. 688). Passing eastward these slates, rich in *Styliolina*, form a broad belt to the Tamar and include beds wrongly referred to the Upper Devonian on Geological Survey maps. Beyond the Tamar, however, thick limestone series predominate at Plymouth, Ashburton, Chudleigh and Torquay, and these have long been celebrated for the wealth of their fossils. In most areas the detailed stratigraphy has still to be elucidated, but it should be possible to do this in the future.

North Cornwall. Along the coast, much complicated Middle Devonian slates crop out between Bedruthan Steps (SW 849695) and Trevone (SW 892760) and they reappear farther north around Portquin and Port Isaac (SW 996808). Fossils were first collected here in detail by Howard Fox (1895A, p. 653, 1902, p. 535) and his records, together with some others, are listed in the *Memoir* (Reid, Barrow and Dewey 1910, p. 8-16). Recent work shows that in the northern part of the outcrop, around Trevoze Head and Trevone, undoubted Givetian is recognisable. The Eifelian age of more southerly outcrops is probable.

Bedruthan Steps, at Samartin and Pendarves Islands, are the source of abundant *Pteroconus mirus* Hinde (in Fox 1900 Pl. 7). For this region a long faunal list is given in the *Memoir* including zaphrentids, *Pleurodictyum*, crinoids and bryozoans together with rare phacopids, spiriferids and gastropods. Woodward deter-

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mined *Pteraspis* and *Scaphaspis* from here. Unfortunately the fauna has not been satisfactorily dated. At Lower Butter Cove (SW 844714), *Pteronotus*, *Conularia* and corals are noted by Fox. At Trescore (SW 849720) simple corals, *Pleurodictyum*, *Conularia*, orthocones and phacopids are recorded and a similar, but richer fauna occurs at Porthcothan Beach (SW 853723), especially at Boathouse Cove.

The next rich Middle Devonian horizon is in Booby's Bay, at a point 750 yards south of Trevoze Lighthouse (SW 853757) where *Buchiola*, *Tentaculites*, *Styliolina*, *Conularia* and corals are recorded (Fox 1895) together with the goniatites *Latanarcestes noeggerathi*, *Sobolewia* and anarcestids which appear to be Upper Eifelian (House 1963). Dinas Head (SW 849762) has yielded *Aulacopleura* (Stubblefield 1960, p. 105; Agrell 1939 Pl. 9, Fig. 12) and *Phillipsastraea* is recorded in the *Memoir*. These rocks are thought to be altered Marble Cliff Beds; and Polventon or Mother Ivey's Bay provided the type of "*Homalonotus*" *barratti* Woodward (1903), probably a phacopid. Goniatites occur quite commonly on the east side of Trevoze peninsula. *Agoniatites* occurs below Mother Ivey's Cottage and *Wedekindella brilonense* 320 yards north-east of Trevoze (SW 863758) and near Merope Rocks (SW 860766). The finest goniatite collecting is at Pentonwarra Point, at the south-west end of Trevone Bay (SW 890760): the fossils are mostly small and pyritised. From here come, *Agoniatites costulatus*, *Wedekindella brilonense*, *Maenioceras terebratum*, *Cabrieroceras*, *Werneroceras*, *Sobolewia*, *Protornoceras*, *Tornoceras*, *Aulatornoceras* and others. (House 1956, 1963, p. 12). Various corals, trilobites and orthocones also occur here and *Styliolina* is abundant at some levels.

From the Marble Cliff Beds at Marble Cliff (SW 891765) the limestones have yielded Upper Givetian conodonts after acid etching, but this work by F. H. T. Rhodes has still to be published. Also from these beds is an *Echinasterella sladeni* determined by Bather and recorded in the *Memoir* (p. 21).

Records of Middle Devonian fossils occur in the eastern part of the estuary (Fox 1906, p. 36-49; Reid, Barrow and Dewey 1910, p. 22-24) where the strata are erroneously referred to the Upper Devonian. Particularly rich localities are: half a mile south of Padstow on the southern side of the estuary where simple corals, *Pleurodictyum* and *Conularia* are recorded: north of Tregonce the cliffs (SW 928742) yield corals and brachiopods. *Styliolina* is not uncommon in the slates hereabouts. On the north side of the estuary at Dinham Creek (SW 973746) '*Phacops granulatus*' is recorded, but the best locality is near Cant Cove (SW 953746) where various simple and tabulate corals abound, phacopids are common (Woodward 1906, Pl. 1) and various brachiopods including "*Spirifer* aff. *cultrijugatus*" and "*S. cf. speciosus*" are recorded. An *Agoniatites* also occurs here (Crick 1906, p. 68, Fig. 2). Restudy of this fauna is long overdue, but is probably Eifelian.

The most northerly outcrop of Middle Devonian in Cornwall is around Port Isaac and Portquin (SW 971806) where the same goniatite fauna as at Trevone occurs as small pyritised moulds in the slate ledges on the north and south sides of the middle part of the inlet. *Agoniatites*, *Wedekindella*, *Maenioceras*, and others

occur. This is the source of *Phacops* (*Phacops*) *pentops* (Thomas 1909; Stubblefield 1960, p. 107). An account is in the *Memoir* (Reid, Barrow and Dewey 1910, p. 26): the supposed *Cheiloceras* from here (Dewey 1914, p. 157) are misidentifications (House 1956).

East Cornwall. The Middle Devonian grey slate outcrop is marked on the Geological Survey Maps (sheets 335, 336, 337, 347, 348) as passing to the east in a broad belt until severed by the Portwrinkle wrench fault in the neighbourhood of Liskeard. Middle Devonian is also included in the widest outcrops of slate along the Tamar marked on the Geological Survey maps as Upper Devonian. At Neal (Nail) Point (SX 437614) where Ussher (1907, p. 80) recorded *Styliola*, Matthews (1962, p. 27) records the conodonts *Polygnathus eiflia*, *P. linguiformis*, *P. webbi* and *P. xylus* which are Middle Devonian.

Around Liskeard, near Trussel Bridge, trilobites, corals, spiriferids and *Receptaculites* are recorded (Giles 1851, p. 169) and at Roseland Quarry (SX 278632) on the east side of the Scaton Valley a similar fauna occurs, together with similar records from other scattered localities which are listed in the *Memoir* (Ussher 1907).

No Middle Devonian is marked on maps of the southern Cornish coast, although some evidence for its existence in Roseland has been given. In the St. Austell district (Ussher, Barrow and MacAllister 1909, p. 234) it is possible that the fauna of the *Conularia* rich levels of the north coast is represented.

South Devon, Plymouth and Totnes areas. Passing eastwards across the Tamar, there is a sharp change of facies in the Middle Devonian from shale to limestone, possibly emphasised by wrench faulting. The fauna of the Plymouth Limestone has long been celebrated. Phillips (1841) and Sowerby (in Sedgwick and Murchison 1840) gave some of the earliest illustrations. Faunal lists were given by Worth (1878) and these were mostly copied in the *Memoir* (Ussher 1907, p. 51-54). Davidson figured many brachiopods from here, as did Edwards and Haime for corals, and Nicholson for stromatoporoids. The latest work on corals is by Taylor (1950) who named many new forms and gave a map of the limestone outcrop. At present the best collecting localities are at Richmond Walk (SX 460543) and especially Cattedown (SX 495537).

The brachiopods have not been revised since Davidson's *Monograph*, but include *Stringocephalus burtini*, *Merista*, *Retzia*, *Cyrtina*, atrypids, spiriferids, strophomenids and pentamerids. Phillips' *Spirifer simplex* from here is the type of *Pyramidalia* Nalivkin. These brachiopods are seriously in need of revision. From Cattedown Quarry Worth records stromatoporoids, *Amphipora*, "*Acervularia*", cystiphyllids, favositids, *Heliolites*, *Pleurodictyum* and bryozoans. Mr. C. T. Scrutton has revised Taylor's genera in the light of later work, mostly by Birenheide. The Plymouth list includes: *Acanthophyllum* (A.) (= *Ptenophyllum*), *A. (Grypophyllum)* (= *Leptoinophyllum*, *Hoeiphylum*), *Domophyllum* (= ? *Trematophyllum*), *Stringophyllum* (S.), *S. (Neospongophyllum)* (= *Vollbrechtophyllum*), *Hexagonaria* (= *Prismatophyllum*), *Macgeea* (M.) (= *Pexiphyllum*), *M. (Thamnophyllum)* (= *Disphyllum* (*Phacellophyllum*), *Cylindrophyllum* (= ? *Spinophyllum*),

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Phillipsastraea (= *Pachyphyllum*), *Mesophyllum* (M.) (= *Archophyllum*, *Enteleio-phyllum*, *Dialytophyllum*) and *M.* (*Cystiphyloides*) (= *Cystiplasma*, *Nardophyllum*). Taylor claimed to recognise faunas from the Eifelian to the lowest Frasnian in the Plymouth Limestone.

Towards the east the limestone outcrops give way to slates, and this is in part at least a facies change. Around Yealmpton (SX 580515) and Brixton (SX 580515) limestones reappear and various stromatoporoids and corals are recorded in the *Memoir* (Ussher 1912, p. 59-61) in part a quotation from Worth. Evidence of the Middle Devonian age of the slates hereabouts is forthcoming in the lists given in the *Memoir*. The principal localities are: one quarter mile north of Staddiscombe (SX 513513), at Elburton (SX 534530) by a roadside north of the Inn and in a road cutting 600 yards to the south-east. Englebourne has yielded an *Anarcestes* (A.) cf. *lateseptatus* (House 1963, p. 4).

Much farther east, limestones around Dartington, Berry Pomeroy and Staverton have yielded rich faunas for which the best details are given by Jukes-Browne (1913) together with a map. This account is supplemented by Lloyd (1933, p. 64-68). Details will not be repeated here, but the finest section is at Shinner's Bridge (SX 791621) where some hundred feet of beds are exposed rich in stromatoporoids, *Heliolites* and many others. Champernowne (1879) records Couvinian types hereabouts. A limestone quarry at Pit Park (SX 789625), unfortunately now being filled in, has provided a varied fauna (Champernowne 1879, p. 67, 1884, Davidson 1864) including *Stringocephalus burtini* and *Uncites gryphus* and Nicholas records *Clathrodictyum confertum*, *Stromatoporella socialis* and *S. curiosa*. (Lloyd 1933, p. 78). At a quarry near Staverton (SX 806637) the upper well-bedded limestones have yielded the lower Frasnian goniatites *Koenenites* and *Probeloceras* (Middleton 1960, House 1963, p. 7).

Torquay. A complete review of fossil localities and faunas of the Torquay Limestone would be outside the scope of this contribution and this amount is limited to essentials. The bulk of the massive limestone is Givetian, and is rich in stromatoporoids and corals and, locally, in brachiopods, pelecypods and trilobites (Lummaton Shell Bed). Below this are bedded limestones, as at Dyer's Quarry (SX 924627) and Triangle Point (SX 928627) which are rich in corals, and at Hope's Nose (SX 948636): these beds are at least in part Eifelian. The lowest Eifelian beds known are slates which were encountered when the foundations of the Pengelly Lecture Theatre of the Torquay Natural History Society were dug (Jukes-Browne and Newton 1914) when *Anarcestes lateseptatus* was identified. Possible relations between part of the Torquay massive limestones and the bedded off-reef facies are illustrated here (Fig. 3) by a hypothetical section prepared by Dineley (1961). The best accounts of this region are those of the *Memoirs* (Ussher 1903; Lloyd 1933), and Shannon (1928).

The Lecture Theatre fauna is similar to that known at Mudstone or Queen's Sands, Brixham (SX 932552) where a richer cephalopod fauna occurs (Whidborne 1890, p. 95) and various phacopids, brachiopods and corals are known (Jukes-Browne and Newton *op. cit.*, Champernowne 1884) and Pengelly (1868 p. 423)

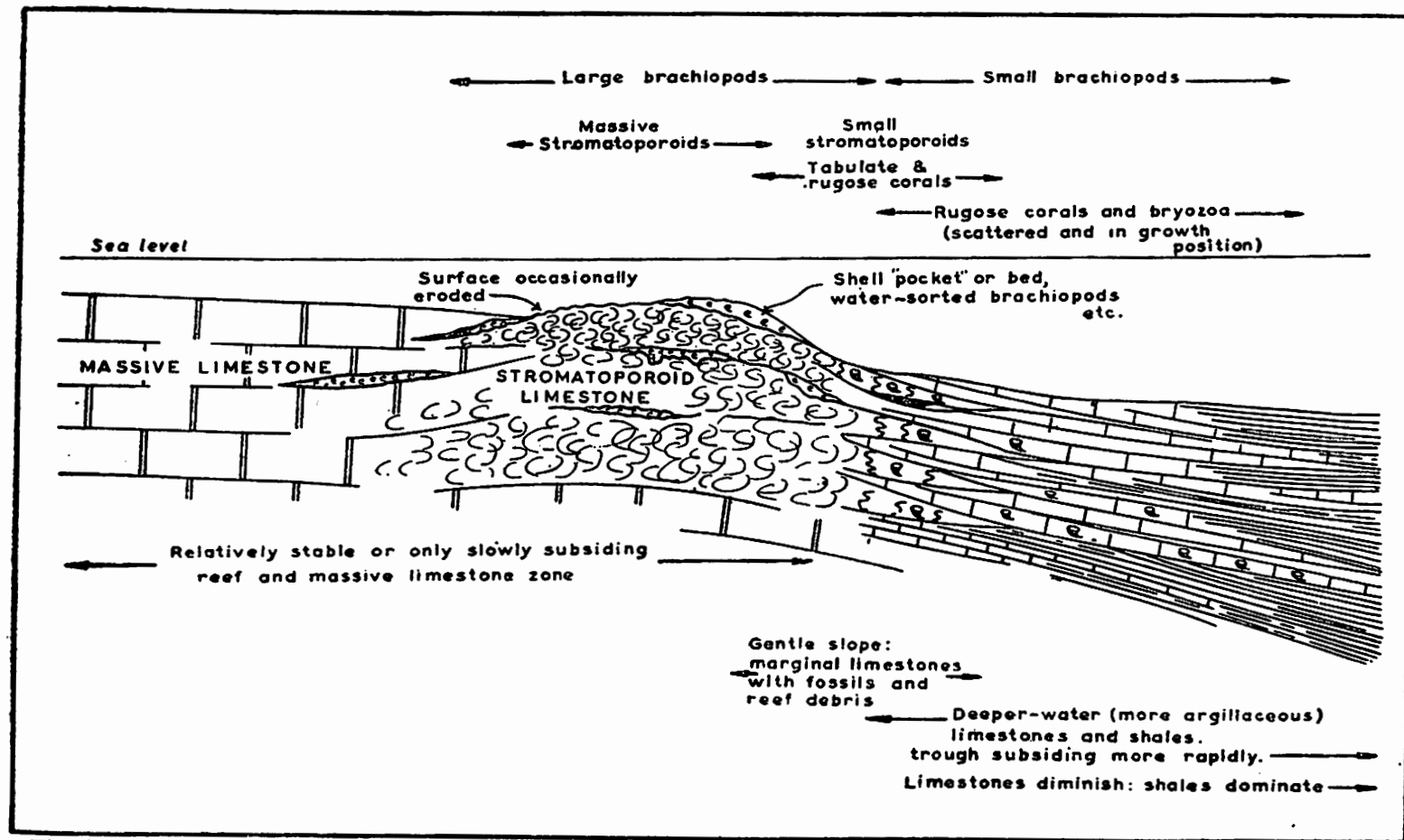


Fig. 3. A diagram illustrating possible ecological and depositional facies around the Middle Devonian limestone reefs of Torbay. From Dineley 1961 reproduced by permission of *Field Studies*.

recorded a *Pteraspis*, possibly from a lower horizon. These shales are also seen at Triangle Point where they are faulted against the bedded limestones. Both here and at Daddy Hole Cove (SX 927627) *Calceola sandalina*, spiriferids, atrypids and others are recorded.

The higher bedded limestones are rich in solitary corals, especially *Mesophyllum* (M.) spp. *Thamnophyllum trigeminum* (formerly called here *Phacelophyllum caespitosum*) and stringophyllids at Dyer's Quarry and *Acanthophyllum* (*Grypophyllum*), *Thamnopora* and many others at Triangle Point. From Daddy Hole Knoll Quarry, Jones (in Whidborne 1888, p. 293 named the ostracod *Kyamodes whidbornei*. Hope's Nose Quarry is particularly rich and several species were described from here by Phillips including the types of *Kayseria lens*. This probably comes from the platy limestones at the south end of the promontory where fenestellids, athyrids, atrypids, spiriferids, *Productella* and others occur (*Memoir* p. 57). The thicker bedded limestones, formerly quarried, which underlie the platy limestones have a rich stromatoporoid and coral fauna.

The bulk of the Torquay Limestone consists of a thick series of massive, principally stromatoporoid, limestones, commonly dolomitised. The Walls Hill limestones (SX 936650) and probably part of the Babbacombe Cliff limestones (SX 928655) belong here, but the principal localities which may be unambiguously dated are the limestones of the quarries of Lummaton (SX 913666) and Barton (SX 913671) where uppermost Givetian fossils occur, the recognition of which is relatively recent. Formerly misidentifications obscured their relations. The Shell Bed at Lummaton (Jukes-Brown 1906), or possible Shell Beds, provided an enormously rich fauna which was described by Whidborne: he named new species of crinoids, bryozoa, productellids, pentamerids, spiriferids and many lamellibranchs from here. The chief forms of interest which occur are *Stringocephalus burtini* and *Hypothyridina procuboides* (see Elliott 1961 where an alga from here is described). The goniatites include the uppermost Givetian zone fossil *Maenioceras terebratum* and tornoceratids (House 1963). Barton provided the types of *Phillipsastraea hennahi*, *Douvillina interstitialis* and several others described by early workers. The upper Givetian goniatite *Wedekindella brilonense* is known from here.

Newton Abbot. The limestone quarries in this region fall conveniently into three groups: those at Wolborough (SX 850706), those around East Oggwell and Ramsleigh (SX 844702) and those in Bradley Wood near Chircombe Bridge (SX 834711). Details of these and others are given in the *Memoir* (Ussher 1913, p. 19-24) and more recent descriptions of the corals have been given by Middleton (1959).

The Chircombe Bridge Quarry formerly yielded *Calceola sandalina* and Middleton has confirmed that these limestones are at least in part Eifelian; but Whidborne also records *Stringocephalus*, *Uncites* and others hereabouts which are probably Givetian.

Wolborough was the richest locality of this region, and several forms were described by Phillips (1841) from here under the locality Newton Bushel. Goniatites include *Agoniatites transitorius*, *A. obliquus*, *Maenioceras molarium*, *M. aff. decheni*, *Sobolewia nuciformis*, *Wedekindella psittacina* and others, the whole being

a middle Givetian assemblage (House 1963, p. 5). Whidborne described five new species of *Hexacrinus* from here and new species also of the genera *Leioptera*, *Actinoptera*, *Pterinea*, *Myalina*, *Parallelodon*, *Goniophora*, *Isocardia* and *Cypricardinia* amongst others. This is the source of *Hexacrinites interscapularis* Phillips (the genotype). The list also includes many of the forms known also at Lummaton, including *Phillipsastraea* of which this is the earliest well-dated record.

The Ramsleigh Quarry (*Memoir* p. 20, 21) has many corals and brachiopods, including *Hypothyridina* and evidence that it is at least partly Frasnian in age is forthcoming from the conodonts recorded by Dineley and Rhodes (1956, p. 244). Both *Agoniatites* and *Manticoceras* are recorded from here and the former suggests that Givetian is also present (House 1963, p. 6).

Other exposures, more distant from Newton Abbot may now be considered. At Kingsteignton large quarries now in work (SX 884736) show well bedded limestones with *Amphipora* and other corals. The numerous small quarries here are listed in the *Memoir* (p. 29, 30). Rhodes and Dineley (1956) have given an account of conodonts from a borehole at Bishopsteignton between Floor Lane and Church Road (SX 910733): these authors suggest that part of the succession is inverted, but an alternative hypothesis involving thrusting has been suggested by Vachell (1963, p. 105-107).

Ashburton — *Buckfastleigh*. This belt of limestone yields the famous Ashburton Marble in which *Ihamnopora* and *Amphipora* are especially common with many others. Some details are given in the *Memoirs* (Ussher 1913, p. 27, 1912, p. 62). This area is very much in need of reinvestigation.

Chudleigh. The *Memoir* (Ussher 1913, p. 28, 29) gives faunal lists for the Chudleigh Limestone in which gastropods predominate, most probably from Upcott Quarry (SX 986804). Details of the outcrops and some new records are given by Anniss (1933). At Palace Wood Quarry (SX 867787) *Amphipora ramosa* and stromatoporoids are not uncommon, and the overlying beds are richer in rugose corals. *Stringocephalus* occurs at Holman's Wood Quarry (SX 883812). The fauna at the top of the massive limestone at Lower Dunscombe Quarry (SX 886791), listed in the *Memoir*, includes spiriferids and *Hypothyridina* (Roemer 1880, Kayser 1889) and is probably lowest Frasnian in age, but will be discussed later.

3. Upper Devonian.

In general in the Upper Devonian it is possible to separate several facies regions. In a southern area passing from Padstow, past Plymouth to Torquay argillaceous or ostracod slate facies predominates with local volcanism. A more northerly belt, from Tintagel to Launceston shows later Upper Devonian brachiopod/lamelli-branch slates within the latter area and at Tavistock and Chudleigh levels rich in clymenids and goniatites (for the horizons involved and their correlation see the accompanying chart). It will be noted that in the Torquay and Plymouth areas the Middle Devonian massive limestones continue up into the Lower Frasnian. In north Devon, above the Ilfracombe Beds and Morte Slates the sequence is mainly of sandstones and siltstones.

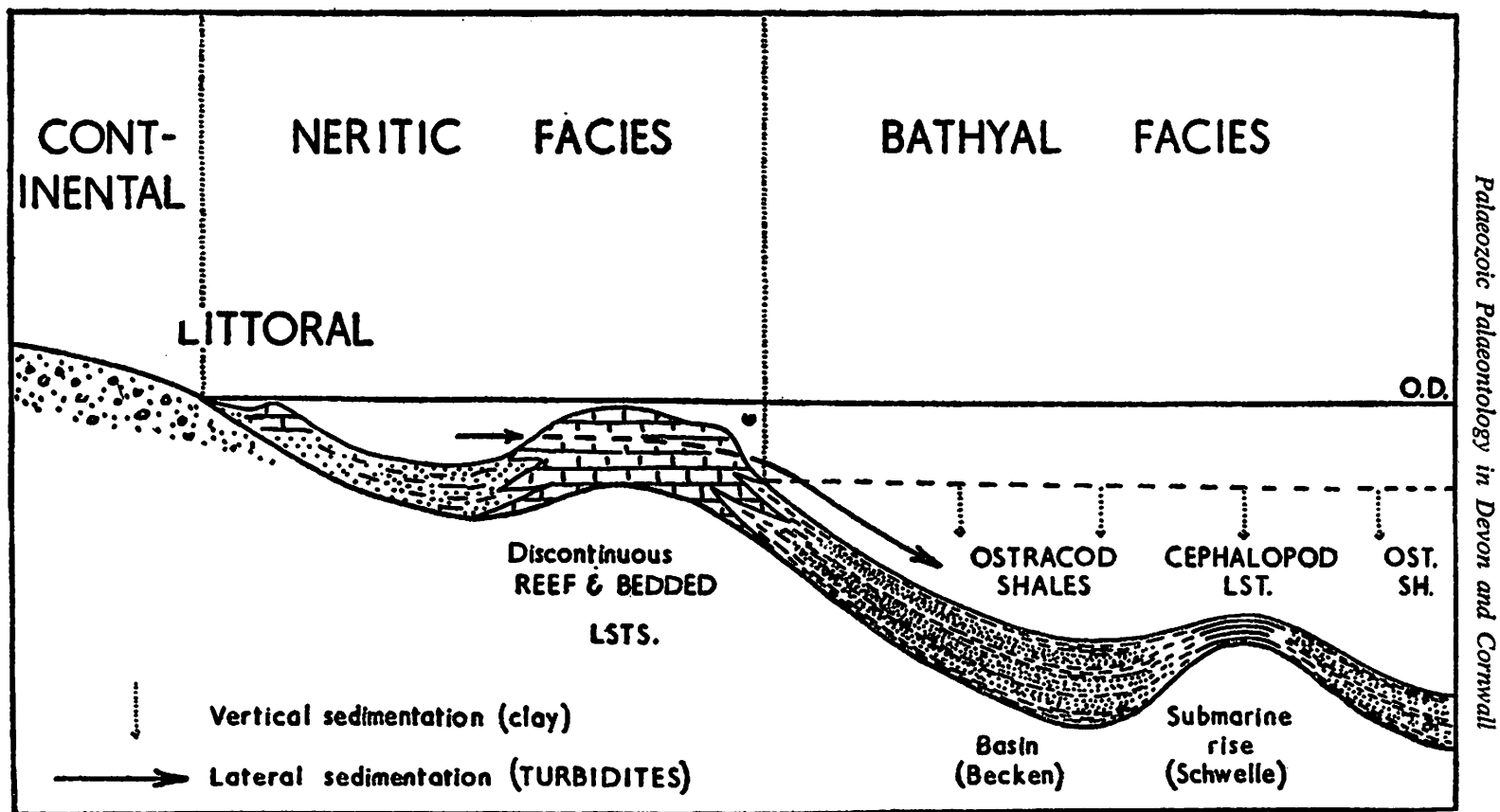


Fig. 4. A composite diagram to show the relationship of the bathyal to shallower water deposits in the Upper Devonian. Based on Rabien from Goldring 1962 reproduced by permission of the University of Exeter.

In Devon the facies distribution appears to be directly comparable to that known in Germany (Fig. 4). The north Devon succession is mainly a near shore clastic sequence and in South Devon both thick ostracod slate sequences occur (as between Torquay and Plymouth) representing the basin deposit, and also condensed sequences (as at Chudleigh) of submarine-ridge type, rich in cephalopods. Intercalations such as the Wearde-Efford Grits may represent turbidite intercalations in the basin facies.

North Cornish Coast. In the Padstow region the dateable Upper Devonian consists of a lower group of goniatite-rich slates of Frasnian age called the Lower Merope Island Beds and an upper group of Purple and Green Slates with upper Frasnian goniatites at their base. The accounts of Fox (1903, 1905) and the *Memoir* (Reid, Barrow and Dewey 1910) give some account of localities, but reference should also be made to the stratigraphical revisions of House (1956, 1963). The Lower Merope Island Beds at their type locality (SW 895770) yield at the south end of the islands small pyritised goniatites in bands of dark slate including the Frasnian. *Manticoceras*, *Ponticeras*, *Archoceras*, *Tornoceras* and *Aulatornoceras*. Most of these occur on the south side of Butter Cove (SW 907779), on the north side of Harbour Cove (SW 911771) and *Manticoceras* itself is abundant in a bed on the north side of Daymer Bay (SW 875776) near where *Phacopidella ductifrons* was found by Pringle (Thomas 1909, Pl. 7, Fig. 1; Stubblefield 1960, p. 107). The type locality of *Ponticeras pedderi* is at the south-eastern corner of St. George's Cove (SW 920765).

From the Purple and Green Slate Howard Fox (1906) obtained ostracods and *Posidonia* at several localities among which are Tristram Cove (SW 931789), Shilla Mill (SW 940785), Trevanger Hill (SW 959773) and at Rooke Mill Quarry (SW 947783); 1200 yards north of Chapel Amble he records *Posidonia venusta*, *Entomis serratostrata*, *E. gyrata* (?) and *Barychilina* (?) *semen*: revision of these is needed. Near Pentire Haven (SW 884797) the Gravel Caverns Conglomerate (Fox 1905, Reid, Barrow and Dewey 1910, p. 25) has yielded *Buchiola*, *Manticoceras* aff. *calculiforme*, *Tornoceras* cf. *uniangulare*, *T.* aff. *crassum* and *Aulatornoceras*, apparently a middle Frasnian fauna (House 1963, p. 13). From Epphaven (SW 961799) comes an ophiurid *Symsteura minveri* Bather 1905, p. 83) from rocks of uncertain age.

Farther north, at Bounds Cliff (SX 022813), Purple and Green Beds occur with limestone bands rich in spiriferids and bryozoa, but the next principal locality is around Tintagel where the Delabole Slates (SX 075840) have a fauna including forms usually referred to *Cyrtospirifer verneuili*.

Plymouth Region. Upper Devonian slates crop out eastward from Padstow in a broad belt towards the Tamar where are the only fossil localities of note (Ussher 1907, p. 78-82, the descriptions including Middle Devonian horizons). There are several localities along the Tamar. At 110 yards south of Warren Point (SX 444604), *Manticoceras* occurs in purple and green banded slate (House 1963, p. 16) and between Earth and Ince Brake, about 770 yards from Ince Castle (SX 389566), Ussher thought he recognised this fauna also. Various entomids named "*E.*

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serratostrata" and "*E. gyrata*" were identified by Jones (1890) from Thancke's Lake near Torpoint (SX 432555) and there are similar traces north of Carkeel (SX 412608), SSE of Markwell (SX 378579), and in Antony Park (SX 421560). These ostracod localities are very much in need of reinvestigation following recent German work. There are also records of spiriferids hereabouts. Attention has already been drawn to the fact that the Plymouth limestone probably includes lower Frasnian strata at the summit. Plymouth provided Sowerby's type of *Hypothyridina cuboides*, frequently used as a Frasnian guide fossil.

Between Plymouth and the Torquay region Upper Devonian slates are known with entomids and posidoniids (Ussher 1912, p. 64-66). Within the slates are tuff horizons. The Asprington Volcanic Group, in the lower part of the succession becomes progressively important towards Stoke Gabriel. Nearer Plymouth the Wearde-Efford Grit occurs within the slate series. As has already been noted, at Staverton Lower Frasnian goniatites occur above the massive Middle Devonian limestones in shales interbedded with tuffs and thin limestones.

Torquay District. It has long been held that the Torquay limestone passes up into the Upper Devonian, but this was mainly through a misunderstanding of the age of the Lummaton fauna. All that possibly remains is the Petit Tor (SX 926665) limestone which has thrust against it slates with *Beloceras* and *Manticoceras* (Ussher 1890, p. 405, 1903, p. 103; House 1963, p. 8). Lower Frasnian slates with *Proboloceras forcipiferum* and *Tornoceras* are known from Babbacombe (SX 927650) (House 1964).

Further south Frasnian faunas are also known. From the promontory between Saltern Cove and Saltern Small Cove (SX 896587) a rich upper Frasnian goniatite fauna occurs including *Archoceras angulatum*, *A. varicosum*, *A. ussheri*, *Manticoceras cordatum*, *Crickites holzapfeli*, *Tornoceras*, *Aulatornoceras* and others (Lee 1877; Annis 1927; Donovan 1943; House 1963, p.8). Farther south, at Galmpton Point (SX 902573) and a little to the east at Elberry Cove and Ivy Cove *Manticoceras* occurs with *Buchiola* in red slates interbedded with thin limestones.

The Famennian of this region appears to consist almost wholly of ostracod slate with volcanic seams. The principal dated level of the upper Famennian is at the southern end of Anstey's Cove (SX 935646) (House *loc. cit.*) where the ostracods *Richterina (Maternella) hemispherica*, *R. (M.) cf. dichotoma* and *R. (R.) striatula* occur.

Newton Abbot. Dineley and Rhodes (1956) have shown that the limestones of Ramsleigh Quarry (SX 844702) yield Frasnian palmatolepids and a *Manticoceras* from here was figured by Shannon (1921). General lists are given in the *Memoir* (Ussher 1913, p. 20, 21). As at Torquay higher horizons are represented by ostracod bearing slates with volcanic horizons. Knowles Hill (SX 858718) is such a locality which has yielded abundant *Trimeroccephalus mastophthalmus* (see Stubblefield 1960, p. 106) and Thomas (1909) described *T. trinucleus* from here. Specimens of these trilobites frequently show a distinctive moulting arrangement of the parts (Pl. 3, Fig. 11).

From the region around Liverton, west of the Bovey Valley, come Famennian entomids, clymenids, *Posidomya* and *Cladochonus* in slates at several localities (Ussher 1913, p. 38, p. 38-40; Bristow 1963). Farther south localities around Highweek (SX 841719) have provided *E. serratostrata*, *E. gyrata*, *Posidonia* and *Trimeroccephalus* (Jones 1890, Ussher *op. cit.*, p. 32-34).

Similar faunas in slates are known at several places bordering the Teign Estuary especially in a railway cutting at Hackney, south-east of Kingsteignton. Hereabouts also calcareous nodules occur in the slates heralding the type found at Chudleigh. These nodules, when weathered, have provided *Buchiola* and other fossils especially opposite Coombe Cellars (SX 900728). Farther north at Olchard (SX 877770) an inlier of Devonian rocks shows slates and nodular limestones, the former with entomids and *Tentaculites*, the latter with clymenids (Ussher *op. cit.*, p. 3)7. At Whiteway Barton (SX 884751) Frasnian goniatites are also recorded.

Chudleigh. What is presumed to be the top of the massive Chudleigh Limestone at Lower Dunscombe Quarry (SX 886791) has yielded to Dineley and Rhodes (1956) Frasnian conodonts. The goniatite bed above this contains *Manticoceras*, *Beloceras* and *Tornoceras* together with phacopids and a *Coccosteus* plate (Roemer 1880; Ussher 1913, p. 36; Annis 1933; House 1963, p. 9). A little farther south, at Mountpleasant, (House *loc. cit.*) pits have proved the presence of a complete but reduced Famennian succession with faunas of the *Cheiloceras*, *Platyclymenia*, *Clymenia* and *Wocklumeria* Zones. The latter has the ammonoids *Parawocklumeria*, *Kalloclymenia*, *Cyrtoclymenia* and *Cymaclymenia* and the ostracods *Richterina* (*Maternella*) and *R. (R.)*. These fossils occur within calcareous nodules set in dark slates. The Famennian sequence is about 170 feet thick and has been named the Mountpleasant Series. These beds are exposed again near Winstow Cottages (SX 863780) (House and Butcher 1962, p. 28) and a similar fauna has been obtained.

North-west Dartmoor. There are several Upper Devonian localities between Tavistock and Okehampton (Dearman and Butcher 1959; Reid and others 1912, p. 6-8). Faunas occur in slates and include various brachiopods, especially *Ambo-coelia urei*, spiriferids, *Sanguinolaria* and crinoids. The main localities which may be dated are: a stream bed near Lydford Station (SX 50208324) with *Imitoceras* cf. *sulcatum* and *Platyclymenia* (? *Pleuroclymenia*) sp: from the bank of a stream north of Marytavy Church (SX 50487919), *I. sulcatum*: from a disused quarry 400 yards north of South Brentor Farm (SX 47978058), *Cymaclymenia*, *Sporadoceras*, *Phacops* (*Cryphops*?) *wocklumeriae*, and a suite of lamellibranchs including *Myalina*, *Paracyclus* and *Posidonia* (Dearman and Butcher 1959, p. 57; House 1960). These localities belong to the Manor House Beds, the Marytavy Beds and South Brentor Beds respectively.

Between this region and the next fossiliferous region at and around Launceston are several small localities listed in the *Memoir* (Reid and others 1911).

Launceston. The localities around South Petherwin have been known since Ansted (1838), Sowerby (1840) and Phillips (1841) listed their fauna with large numbers of new types described. Only the trilobites and ammonoids have recently

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been revised, (Selwood 1960) and the spiriferids, lamellibranchs, and other elements are in need of study. A full faunal list is given in the *Memoir* (Reid *et al.* 1911, pp. 19, 20).

From the Lower Petherwin Beds of the Gatepost Quarry (SX 326821) Selwood records *Gonioclymenia*, *Clymenia*, *Kosmoclymenia*, *Cymaclymenia*, *Imitoceras*, *Phacops* (P.) *granulatus* and P. (P.) *accipitrinus accipitrinus*. A similar but sparser fauna comes from Oldwit Farm (SX 319819) in a road section. Most museums have a fauna from the Landlake Quarry (SX 328823), now filled with refuse: the localities already mentioned belong to the Hoevelensis Zone, Landlake has a fauna of the Annulata Zone, including: *Costaclymenia*, *Gonioclymenia*, *Platyclymenia*, *Clymenia*, *Kosmoclymenia*, *Cyrtoclymenia*, *Imitoceras*, *Sporadoceras*, *Phacops* (P.) *granulatus* and *Cyrtosymbole* (? *Waribole*) *dunhevedensis*. Ammonoids and trilobites are rare in the Upper Petherwin Beds, but Selwood records *Kosmoclymenia* and *Cyrtosymbole* (*Waribole*) from the Lower Landlake Quarry (SX 328824).

An incredibly rich fauna is known from the Stourscombe Beds of the type locality (SX 344839): this represents the Wocklumeria Stufe of German. Selwood records the following: *Gonioclymenia*, *Kalloclymenia*, *Wocklumeria*, *Epiwocklumeria*, *Postglatziella*, *Kosmoclymenia*, *Cyrtoclymenia*, *Cymaclymenia*, *Parawocklumeria*, *Kensyoceras*, *Imitoceras*, *Sporadoceras*, *Discoclymenia*, *Phacops* (P.) *Phacops* (*Cryphops*?), P. (*Dianops*) and *Chaunoproetus*. Some of these also occur at Overwood Farm (SX 303873) and there are trilobite-bearing slates exposed at Heale Farm (SX 362862), Smallacombe Farm (SX 375860) and Coombe Farm (SX 386858).

V. UPPER PALAEOZOIC: CENTRAL AND NORTH DEVON

1. Devonian.

North Devon. The distribution of Devonian strata in North Devon is much more regular than in South Devon and Cornwall. An ascending sequence of beds can be traced along the coast from Lynton to the Carboniferous/Devonian boundary included in the Pilton Beds at Fremmington near Barnstaple. Broadly, the stratigraphic units may be traced from the coast in an east south easterly direction into Somerset, where they are lost beneath the New Red Sandstone. Locally, the very regular strike of the beds is deflected by folding. No Geological Survey map is available which shows the distribution of the beds, but other maps are available. These are reviewed by Goldring (1952). The latest and best known map is that of Hamling (Hamling and Rogers, 1910): this map is particularly interesting for it sets out to show all of the fossiliferous localities known in North Devon at the time of publication. So far no important changes in facies have been recorded along the strike.

Foreland Grits

The Foreland Grits, well exposed at the type locality of The Foreland (SS 754512) near Lynton, are of Old Red Sandstone facies and are composed of grey and green massive quartzitic sandstones with some thinner bedded purplish slates and sandstones.

There is some dispute as to whether the Foreland Grits underlie the Lynton Beds (Williams 1837; Champernowne and Ussher 1879) or are identical to the Hangman Grits (Sedgwick and Murchison 1840). Simpson (1964) supports the latter view, contending that the Foreland Grits are the Hangman Grits repeated on the north limb of an anticline that runs from Lynmouth to Oar.

With the exception of fossil wood (Williams, 1837), the beds are unfossiliferous, so that little palaeontological contribution can be made to the dispute. *Psilophyton* has been recorded from Horner Wood (SS 897450) near Porlock in Somerset (Evans 1914, p. 100).

Lynton Beds (Late Emsian — early Couvinian)

The Lynton Beds probably represent the oldest strata present in North Devon. They are made up of 1,300 feet of laminated sandstones and slates but the lamination in the sandstones is not at first apparent due to bioturbation and cleavage (Simpson 1964).

Shelly fossils are locally abundant, but the fauna is impoverished and very poorly preserved. Fossils have been recorded from a number of localities, principally Woody Bay (Woodabay), the east side of Lee Bay (list includes *Acrospirifer paradoxus*, see Whidborne 1901), Heddon Mouth, Watersmeet, Lynton (Barhick Mill), and the Valley of Rocks near Lynton. Faunal lists and locality details are presented in a number of papers (Whidborne 1901; Etheridge 1867; Hicks 1896B; Evans 1919). As the fauna is at present being reinvestigated by Professor S. Simpson details are not included, but in a preliminary note he (Simpson 1964) refers the beds to the late Emsian or early Eifelian and records that "pelecypods such as *Modiomorpha*, *Perinea*, *Limoptera* and *Actinodesma* predominate. *Platyorthis circularis* is a common brachiopod and species of the *Spirifer subcuspidatus* group are frequent. In the slates fenestellid bryozoans are important". *Chondrites* (Simpson 1957) is common throughout the Lynton Beds.

Hamling and Rogers (1910) record obscure fish remains, possibly *Pteraspis*, and Arber and Goode (1916) unidentifiable plant fragments.

Hangman Grits (Middle Devonian)

The Hangman Grits are made up of 4,000 feet of reddish and greenish quartzitic sandstones and slates of Old Red Sandstone facies, which extend from the coastal section between Combe Martin and Martinhoe, inland to the Brendon Hills.

Fossils are rare except for a few plant remains and other fossils near the top of the sequence. Evans (1922A) records *Stringocephalus cf. burtini* from the base of Little Hangman Cliff, and *Coccosteus* with plant remains in the Rawn's Beds. Thus a Middle Devonian age is indicated. The Little Hangman Grits (Evans 1922B) have yielded *Naticopsis* and *Myalina* from Sherry Combe (SS 608480) and *Cucullaea* and *Spirifer*.

Ilfracombe Beds (Frasnian and Givetian)

The Ilfracombe Beds are characteristically exposed on the coast between Combe Martin and Ilfracombe and can be traced east south east to the Croydon

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Hills. Lithologically the rocks are made up of massive bands of limestone contained within a dominantly slaty sequence. Extensive faunal lists are included in papers by Etheridge (1867 p. 640), Hicks (1896B, p. 364), and Evans (1919, p. 109), but apart from the corals the fauna remains unrevised. A number of brachiopods is noted, including *Cyrtospirifer verneuili* and *Rhynchonella (Hypothyridina) cuboides*; Evans notes (1919) that these occur at quite a low level within the Ilfracombe Beds and concludes that the greater part of the beds is of Upper Devonian age.

The lower part of the sequence beneath the limestones is sparingly fossiliferous but *Tentaculites* and fucoids (*Chondrites*) are recorded from the Lester Series east of Combe Martin (Evans 1922A).

Holwill (1961, 1962) has been able to prove palaeontologically that there are only two main limestones within the Ilfracombe Beds: the upper, named the David's Stone Limestone, and the lower, the Jenny Start Limestone; each is about 30 feet thick. A third limestone, the Combe Martin Beach Limestone, is 3 feet to 4 feet thick and is intercalated in the slates which separate the main limestones.

It is from the limestones that the well known coral fauna has been obtained. The Jenny Start limestone, which is most fully developed at Jenny Start (SS 567475), thins around Oakstor Bay and has yielded a fauna which places it in the Givetian. Three corals are recognised by Evans (1929) from this section: *Endophyllum (Spongophyllum) bowerbanki*, *Phacellophyllum caespitosum* and *Thamnopora (Pachypora) cervicornis*. Holwill (1962) also records massive rugose corals belonging to the Disphyllidae.

The Combe Martin Beach Limestone has yielded a fauna of Bohemian aspect (Holwill 1962) including *Barrandeophyllum*, *Syringaxon*, *Metriophyllum*, *Alveolites* and *Thamnopora* together with poorly preserved brachiopods and gastropods; these indicate an horizon low in the Frasnian. This limestone is well exposed on the west side of Combe Martin Beach (SS 576473) and can be traced westwards as far as the Parlour (SS 573474), where it is faulted out to sea. It can be picked up again at Hagginton Beach and Beacon Point some two miles to the west, where it again yields the characteristic fauna.

The David's Stone Limestone is also referred by Holwill (1962) to the Frasnian. Many fossils have been obtained from David's Stone (SS 571474) west of Combe Martin, including solitary corals of the family Laccophyllidae (*Syringaxon* and *Barrandeophyllum*) and the tabulate coral *Thamnopora*. *Syringaxon* and *Barrandeophyllum* also occur in the Red Limestone (Evans 1922A) 120 yards south of Jenny Start.

The limestones are succeeded by a series of slates with occasional grit bands which extends from Ilfracombe westwards towards Lee. These beds have yielded *Cyrtospirifer verneuili* at Goosewell Quarry (SS 553472) south of Watermouth Castle, and at West Hagginton Bay (Evans 1922A). Fucoids (*Chondrites*) occur at a number of localities within these slates.

Phacopid trilobites probably referable to *Phacops (Trimerocephalus) masto-phthalmus* are noted by Etheridge (1867 p. 640) from Widmouth and Combe Martin.

Morte Slates (Upper Devonian)

The Morte Slates form a group of dark slates which can be traced from Morte Point to Wiveliscombe in Somerset. The slates overlie the Ilfracombe Beds and are distinguished from them by the virtual absence of calcareous material and fossils. For long thought to be unfossiliferous, the slates have yielded fossils both from the coast (Hicks 1896A) and from the Wiveliscombe area to the east (Hicks 1897).

Three important fossil localities are mentioned from the Devon outcrop; Morte Point (SS 443455), Mullacott (SS 517455) about one and a half miles south of Ilfracombe, and Barricane Beach (SS 454441) south of Mortehoe. From these localities, Hicks (1896A) records the following (unrevised) fauna: *Lingula mortonsis*, *Crania*, *Stricklandinia lirata* *Rhynchonella lewisii*, *R. stricklandi*, *Spirifera hamlingii*, *Orthis rustica*, *Modiolopsis barricanensis*, *Pterinaea mortonsis*, *Cardiola interrupta*, *Avicula* sp. The determination of the Morte Slate fauna led Hicks to the conclusion that the beds were of Silurian and Lower Devonian age. This was strongly disputed at the time and is no longer accepted. Further collecting by Evans and Pocock (1912) at Barricane Beach revealed better preserved spiriferids which could be referred to *Cyrtospirifer verneuili*, a characteristic Upper Devonian form. *C. verneuili* has also been discovered (Ussher 1908) from localities referred to by Hicks (1897) in Somerset. A revision of the remaining part of the fauna has yet to be completed.

Pickwell Down Sandstone (Upper Devonian)

The Pickwell Down Sandstone attains a thickness approaching 4,000 feet in Morte Bay and can be traced as a continuous outcrop eastwards into Somerset. Lithologically the beds are of old Red Sandstone facies and are made up of a series of red, purple and green sandstones and grey slates. Fossil wood occurs occasionally in the lower horizons (Evans 1922A, p. 216) but otherwise the beds are generally unfossiliferous. Fish remains have however been obtained from the Bittadon "Felsite", a tuff band that marks the base of the unit. The locality at Mill Rock, Woolacombe Bay (SS 455431) has been described by Rogers (1919) and the fauna by A. S. Woodward (1919). This fauna is characteristic of the Upper Devonian and includes *Holonena* cf. *ornatum*, *Bothriolepis*, *Holoptychius*, *Polyplocodus* and *Coccosteus*.

Upcott Beds (Upper Devonian)

The Upcott beds total 800 feet of yellowish and greenish cleaved sandstones and slates and can be traced inland as a clearly defined unit between the Pickwell Down Sandstone and the Baggy Beds. First recognised by Hull (1880), the beds have failed to yield recognisable fossils, but fragmentary material suggests marine organisms (Simpson, 1959). The beds are thus linked, environmentally at least, to the overlying Baggy Beds.

Baggy Beds (Fammenian, ?*Clymenia* Zone)

The Baggy Beds are made up of some 1,400 feet of massive cross-bedded sandstones and thinner bedded sandstones and silts associated with intraformational

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conglomerates, slumped masses and occasional thin crinoidal and gastropodal limestones. The lithologies have been described by Goldring (1960), who compares them to the sediments at present accumulating on the tidal flats of the Wadden Sea; this conclusion is supported by the littoral nature of the fauna.

The beds can be traced from the coast at Baggy Point (SS 418406) east south east through Marwood for 20 miles; near Highbray (SS 690342) the outcrop is deflected to the south by folding but then resumes the original strike direction and can be traced towards North Molton, where according to Ussher's (1906) map they thin or are faulted out.

Fossil records are centred principally on three sections, Baggy Point, Marwood (SS 543376) and Sloley Quarry (SS 567372). The faunas have been investigated by Phillips (1841), Salter (1863) and Whidborne (1896-1907). Revised determinations of the shelly faunas are not available, but it is known that no fossils are present which allow direct correlation with the ammonoid sequence in the Upper Devonian. Goldring (1962B) indicated that from the structural position of the beds they must be in part of *Clymenia* Zone age.

The lower part of the sequence is characterised by thick shelled lamellibranchs including several species of *Dolabra* (*Cucullaea*), gastropods, *Lingula* and plant remains; whilst the upper part is characterised by the gradual incoming of the overlying Pilton Bed fauna.

The flora of the Baggy Beds, which was largely obtained from Marwood and the Sloley Quarry, was first described by Sedgwick and Murchison (1840) and the floral list enlarged by Salter (1863), Hall (1867), and Whidborne (1896). The latest revision is by Arber and Goode (1916), who record *Sphenopteridium rigidum*, *Sphenopteris*, *Xenotheca devonica*, *Telangium*, *Knorria* and *Cordaites*. In this paper a new locality, Croyde Hoe, Baggy Point, is noted.

Trace fossils from the coastal section have been investigated by Goldring (1962B), who recognises the following forms: *Teichichnus* cf. *rectus*, *Monocraterion* cf. *tentaculatum*, *Arenicolites curvata* and *Diplocraterion yoyo*. The latter shows both protrusive and retrusive forms which Goldring interprets as responses to repeated phases of sedimentation and erosion.

Pilton Beds

The outcrop of the Pilton Beds extends from the coast west of Barnstaple to Wiveliscombe. The lower part consists of thin bedded calcareous slates and sandstones, whilst the upper part is less arenaceous and characterised by thin bands and nodules of cherty material. There is a gradual passage from the underlying Baggy Beds into the Pilton Beds, which is marked both in the lithologies and in the faunas. The arbitrary base (Goldring 1962B) is taken at the top of a group of massive sandstones seen on the coast south of Baggy Point (SS 424401). Thus the well known locality of Laticosta Cave (a few yards to the south) which yields many specimens of *Nudirosta laticosta* is included within the Lower Pilton Beds.

The fauna of the Pilton Beds is large and varied and has attracted the attention of collectors for many years. The first important work on the palaeontology of the

area was completed by Phillips (1841), who included within his Pilton Group the underlying Baggy Beds. Many faunal lists were later to be published—Salter (1863), Hall (1867), Etheridge (1867), Whidborne (1896). These lists were superseded by an exhaustive monographic study by Whidborne (1896-1907), who demonstrated the enormous diversity of the fauna. To a very large extent, this work represents the most modern treatment available dealing with the whole assemblage and, as such, stands in urgent need of revision. Certain faunal groups however have been the subject of special study: in particular, the brachiopods (Reed 1943; Goldring 1957, 1955B), and the trilobites (Reed 1944; Goldring 1955A).

Some dispute existed as to the age of the beds, but Paul (1937) pointed out the close similarity of the fauna to the Etroeungt Beds. This was later fully confirmed by Goldring (1955A), who was able to demonstrate the presence of the Carboniferous/Devonian boundary within the Pilton Beds. The lower part of the Pilton Beds (Pilton A) has an Etroeungt fauna, and the upper part (Pilton B, C, D) is of Tournaisian age.

The Pilton Beds are remarkably fossiliferous throughout their outcrop and many localities have been observed, particularly on the coastal section. A large number of localities with grid references is indicated by Goldring (1957 p. 211; 1955A, and others by Hamling (map in Hamling and Rogers 1910).

Lower Pilton Beds (*Wocklumeria* Zone)

Goldring referred the Pilton Beds of Devonian age to Pilton A; these beds are characterised by the presence of the trilobite *Phacops* (*Phacops*) *accipitrinus accipitrinus*, a Phillips species fully described by R. & E. Richter (1933). Later Goldring (1957) subdivided Pilton A on the basis of the productellids into lower (A1), middle (A2), and upper (A3) horizons.

The A1 horizon is characterised by *Productella* (*Hamlingella*) *goergesi* and *P.* (*Whidbornella*) *pauli*, but only a few specimens of *P.* (*Whidbornella*) *caperata*. A2 is characterised by *P.* (*Whidbornella*) *caperata* and *P.* (*Hamlingella*) *goergesi* but no *P.* (*Whidbornella*) *pauli*. A3 is characterised by *P.* (*Whidbornella*) *caperata* and usually *P.* (*Hamlingella*) *piltonensis* but without *P.* (*Hamlingella*) *goergesi*. *P.* (*Steinhagella*) *steinhagei* has also been recorded from this horizon.

Reed's (1943) revision of the brachiopod fauna of the Pilton Beds includes, besides the productellids, the following Devonian forms: *Athyris concentrica*, *Crurithyris unguiculus*, *Yunnanella partridgeae*, *Reticularia whidbornei*, *R.* (*Reticulariopsis*?) *microgemma* var. *tenuistriata*, *Spirifer* (*Cyrtia*) *disjunctus*, *Spirifer verneuili* var. *guttata*, *Spirifer* (*Gurichella*) *bouchardi* var. *belliloci*, *S.* (*Gurichella*) *obliteratus* var. *brushfordensis*, and *Chonetes* (*Pliochonetes*) *plebia sauntounensis*.

Dineley and Rhodes (1956) recorded conodonts, a new element in the fauna, from Sauntoun (SS 445388). Some 15 conodont genera were identified: large polygnathids were most conspicuous, *Gnathodus* and *Spathognathodus* common, and *Lonchodus* and *Ozarkodina* rare. Fish scales and teeth also occurred abundantly.

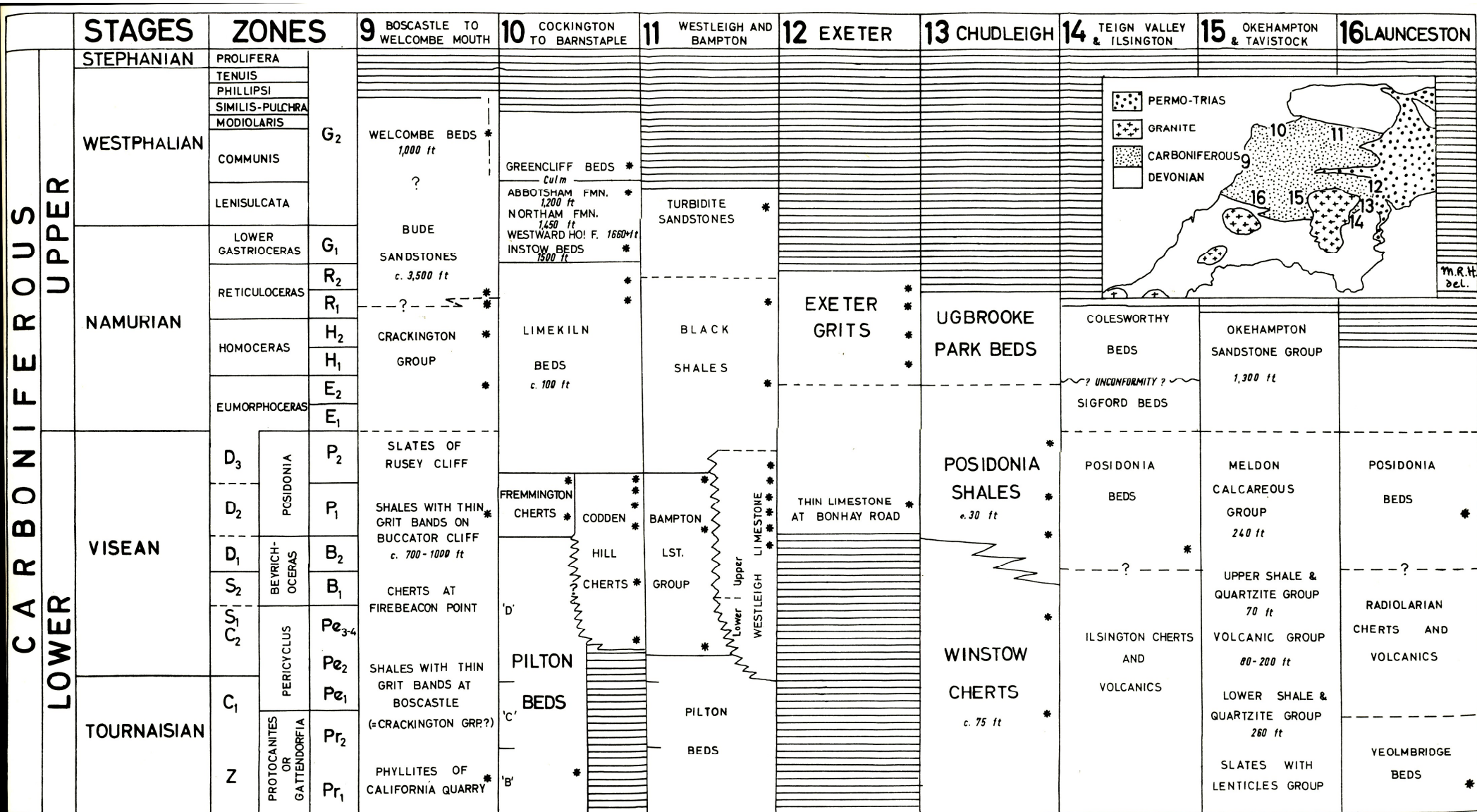


Fig. 5. Correlation chart of the Carboniferous rocks of Devon and Cornwall.

2. Carboniferous.

Carboniferous rocks crop out extensively in Devon and Cornwall in the great synclinorium of South West England. The Lower Carboniferous rocks are present only on the northern and southern margin of the major structure, with the Upper Carboniferous rocks accounting for the remaining area. These rocks are of Culm facies.

The classification of the Culm was formulated by Ussher in a series of papers at the close of the last century and a summary of his views was published in 1901. In this paper, he clearly distinguishes between the argillaceous Lower Culm and the arenaceous Middle and Upper Culm. The former corresponds broadly to the Lower Carboniferous, whilst the Middle and Upper Culm are of Upper Carboniferous age. In recent years, authors have generally preferred to drop the term 'Middle Culm', though it has lately been revived by Prentice (1960A). General correlations are indicated on Fig. 5.

LOWER CARBONIFEROUS

With the exception of a central tract between South Molton and Brushford, where they have been faulted out, the Lower Culm beds in North Devon can be traced from Barnstaple in the west to Burlescombe in the east. To the south, the outcrop is much disrupted tectonically, but the principal outcrop can be followed in a narrow band from the coast near Boscastle, north of Bodmin Moor, to the northern part of Dartmoor. Numerous outliers also occur to the south of this.

Lithologically, the Lower Culm is made up of an ascending sequence of dark slates, radiolarian cherts and limestones, with important volcanics developed in the upper part of the sequence in the southern outcrop. The limestones are very impersistent and appear to be interbedded with, and replaced by, cherts and siliceous shales. Important changes of facies are recorded within the cherts and limestones of the northern outcrop, but generally over the whole of the South West the beds show remarkable lithological uniformity and evidently accumulated in a period of relatively slow sedimentation named the 'Bathyal Lull' by Goldring (1962A). The faunas, in which planktonic and vagile benthos are characteristic, are meagre but uniform over the whole area.

The stratigraphical units recognised within the Lower Culm of South West England include the Yeolmbridge Beds, Radiolarian Cherts and *Posidonia* Beds from the southern outcrop, and the Upper Pilton Beds, Chert Beds, Westleigh Limestone and Bampton Limestone from the northern outcrop.

Yeolmbridge Beds (*Gattendorfia* Zone)

Grey and buff slates with occasional lenticular limestones crop out in isolated localities in the Launceston district. At Penfoot (SX 302833) the upper horizons have yielded *Gattendorfia subinvoluta*, *G. crassa*, *G. tenuis* and *G. occlusa* together with the trilobites *Cyrtosymbole* (*Macrobole*) *drewerensis*, and *C. (Macrobole) duodecimata*. *Gattendorfia* sp. *C. (Macrobole) drewerensis*, *C. (Macrobole) duodecimae*, and *C. (Macrobole) aff. blax* have also been recorded from the Yeolmbridge

Slate Quarry (SX 322875) (Selwood 1960). There is some evidence that the lower horizons of these beds are of Devonian age.

A comparable trilobite fauna has also been recorded (Selwood, 1961) from Black phyllites in the California Quarry, Boscastle (SX 092910).

The lithologies identified with the Yeolmbridge Beds occur within the *Transition series* described by Dearman and Butcher (1959) north west of Dartmoor, but in this area the lowest Carboniferous horizons have yet to be recorded palaeontologically.

Radiolarian Cherts (*Pericyclus* Zone)

The radiolarian cherts form the most mappable horizon in the Lower Culm Measures of the southern outcrop and are clearly indicated on the Geological Survey Sheets 337 and 338. These beds have yielded few fossils; radiolaria, although locally abundant, are by no means uniformly distributed through the rocks. The radiolarian fauna has been described by Hinde and Fox (1895, 1896, 1897) but relatively few localities have yielded determinable material. Important localities include Carzantic (SX 363833) and Tregear Down (SX 248865) in Cornwall, and Ramshorn Down (SX 793739) near Bovey Tracey in Devon. Horizons within the cherts that can be dated with precision are extremely rare, but recently a rich conodont fauna including *Scaliognathus anchoralis*, *Hindeodella segaformis* and *Doliognathus latus*, the indices of the *Anchoralis* Zone (IIp) have been recorded from Viverton Down, 1½ miles south of Callington (SX 376676) (Matthews 1961). Zone II[∞] is also indicated by conodonts at Chudleigh (House and Butcher 1962); *Pronorites* and goniatitids in siliceous shales at the same locality suggest the horizon of B₂/P₁.

Posidonia Beds (*Goniatites* Zone)

The limestones within the Lower Culm Measures rarely crop out and are available for study only in a series of flooded quarries recognised in that part of the Lower Culm outcrop east of Launceston. These limestones are, for the most part, unfossiliferous but Bristow (1963) has noted conodonts of III[∞] age from Woodah Quarry near Doddiscombsleigh (SX 855865) in the Teign valley. In a neighbouring locality Ussher (1902) records *Posidonia becheri*. Phillips (1841) recorded *Goniatites crenistria* from the Cannapark Quarry, Launceston (SX 305855), which indicates a low Visean age (P_{1a}). P₁ goniatites are also noted from Gull Rock (SX 117933), north of Boscastle (Selwood 1961).

The calcareous and siliceous slates that appear to overlie the worked limestones are more fossiliferous and a large number of localities has been recorded. Ussher (1913, p. 45-48) notes a number of localities yielding goniatites and posidonids in the Teign valley; the more important zonal occurrences have been described by Butcher and Hodson (1960). The best known locality in the area is at Wadden Barton (SX 885796), which has yielded a rich fauna (H. Woodward 1884 A,B). Woodward's list includes four new species of '*Phillipsia*', *Posidonia becheri*, *P. corrugatus* and a number of species of goniatites. This list is reproduced, with additions, by Ussher (1913, p. 47), who also notes the presence of a similar fauna at Hestow Farm (SX 889761) near Ideford (1913, p. 48). Ussher (1907) also records the *Posidonia*

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Beds in the Plymouth Memoir; here he notes the occurrence of beds similar to those at Wadden Barton on Herod Down (p. 104) which have yielded *Posidonia* and *Glyptoceras spirale*. *Posidonia becheri* is also recorded in the same area (p. 106) at Halton Quay (SX 415657). The shaley and lenticular limestones at this locality have also yielded foraminifera including *Endothyra*, *Trochammina* and *Nodosinella* (Fox 1896) which have been compared with foraminifera obtained from Westleigh, North East Devon. The cherts associated with these limestones are radiolarian. Foraminifera are also noted (Fox 1896) from Eastcottedown (SX 468848), and Alder (SX 473872) north east of Dartmoor.

The highest goniatite horizon recorded by Butcher and Hodson (1960) is that of P_{2c} with the occurrence of *Paragoniatites newsomi* south of Ugbrooke Park, Chudleigh. Beds of P_2 age are also indicated at Spira Bridge, Ashton Station, where *Sudetoceras* aff. *ordinatum* occurs. Perhaps the most ubiquitous horizon recognised is that of *Neoglyptoceras spirale*, which as in many localities in North Devon occurs together with *Goniatites* aff. *granosus* and *Posidonia becheri* at Wadden Barton (Butcher and Hodson 1960). Prentice (1960A, p. 276) suggests that this association indicates a low P_{2a} age. *G. granosus* has not been specifically mentioned at other localities where the *spirale* band occurs; thus a P_{1d} age is indicated. A number of these localities is recorded in the Launceston Memoir (Reid *et al.* 1911, p. 25) and in the Newton Abbot Memoir (Ussher 1912, p. 41-48), and in all the goniatites are associated with *Posidonia becheri*. This fossil, which is generally taken to be of P_1 age, has also been recorded from localities to the north and west of Dartmoor (Dearman and Butcher 1959). P_{1c} limestones are indicated in the Bonhay Road section, Exeter, by the occurrence of *Goniatites sphaericostatus* (Butcher and Hodson 1960).

Lower zonal records are very sparse, but Butcher and Hodson note a goniatite referable to the *Bollandoceras micronotum* group (B_a) from Doddyscombsleigh (SX 855865) and *Entogoniatites grimmeri* (B_2) from Canonteign (SX 835829).

Upper Pilton Beds (*Gattendorfia* Zone. ?*Periclytus* Zone)

North West Devon. In North West Devon Goldring (1955A) recognises Pilton B of lowest Carboniferous age characterised by the trilobite subgenera *Cyrtosymbole* (*Macrobole*), *C. (Waribole)* and *Brachymetopus* (*Brachymetopina*), and Pilton C characterised by the trilobites *Piltonia* and *B. (Brachymetopina)*. Prentice (1960A) has suggested a further division, Pilton D, for a series of unfossiliferous silty shales which separates the fossiliferous Pilton Beds from the overlying chert beds.

The trilobite fauna has been described in detail by Goldring (1955A) and the following forms recognised from the Upper Pilton Beds: *Cyrtosymbole hicksi*, *C. (Macrobole) hercules* (I), *C. (Macrobole) duodecimae* (I), *C. (Macrobole) mulesi*, *C. (Waribole) porteri* (I), *Brachymetopus (Brachymetopina) woodwardi* (I) ?(II). *Piltonia salteri* ?(I) ?(II). Goniatites are rare but some diagnostic forms are recorded. Goldring (1955A) notes *Gattendorfia crassa* and *Imitoceras* sp., and

Prentice and Thomas (1960) recognise *Protocanites* cf. *lyoni*. Precise details of trilobite and goniatite localities are given by Goldring (1955A).

Other faunal groups are, as yet, unrevised but the occurrence of *Productina fremmingtonensis* has been noted by Goldring (1957).

North East Devon. The faunas of the Pilton Beds of this area have yet to be investigated. A series of hard black slates lying between the Pilton Beds and the overlying cherts and limestones is probably equivalent to Pilton D of Prentice. These slates have yielded no fossils.

The Chert Beds

North West Devon. With the exception of the lowest levels, the Lower Culm in North West Devon is represented by the Chert Beds (Prentice 1960A). Two principal facies have been recognised: the Northern or Fremmington facies, and the Central or Coddan Hill facies (Prentice 1958), which have been brought into juxtaposition by overthrusting.

The deposits of the Northern facies show little signs of disturbance during their deposition. They contain abundant radiolaria (Hinde and Fox 1895), but very few other fossils; there is a striking absence of inhabitants of the littoral benthos. The most abundant macrofossil is *Posidonia*. *P. becheri* occurs throughout the sequence except at the top of the beds, where it is replaced by *P. membranacea* and *P. corrugatus*. Rare goniatites also occur together with *Chonetes* cf. *hardrensis*. Amongst the goniatites which were collected by Hall towards the end of the last century, Prentice (1960A) has identified *Goniatites* aff. *falcatus* (P_{1b}) and *Girtyoceras* aff. *brueningianum* (P_1 - P_2 junction). Butcher and Hodson interpret the Hall goniatites differently and record *Girtyoceras burhennei* and *Goniatites sphaericostratus*. These would indicate a P_{1c} age.

The cherts of the Central facies are predominantly detrital with few radiolaria but the fauna (Prentice 1958) is more varied than in the Northern facies and includes prolecanitids, pericyclids, orthocones, byrozoa, button corals, reptant tabulate corals, and trilobites. *Posidonia* occurs only at the top of the series.

The macrofauna was noted by Phillips (1841) and his faunal list was considerably enlarged by Hinde and Fox (1895). In this paper, Woodward (p. 647-9) described the trilobites, Bather the brachiopods (p. 649-51), and Crick the cephalopods (p. 652-3). Two localities feature prominently in this account: Hannaford Quarry near Barnstaple (SS 603298) and Coddan Hill Quarry (SS 567296). Additional trilobite descriptions were made by Woodward (1902) and further contributions to trilobite studies by R. & E. Richter (1939, 1951). Vaughan (1904) described the corals and brachiopods from Coddan Hill and came to the conclusion that the beds could be compared with the *Zaphrentis* Zone of the Carboniferous Limestone of the Bristol district and that a break was present in the Lower Culm. This was strongly contested by Hind (1904A, B) and has not been confirmed subsequently. Vaughan's list includes: *Chonetes hardrensis*, *Leptaena analoga*, *Rhipidomella michelina*, *Cleiothyris glabistria*, *Orbiculoidea* sp. and *Zaphrentis* aff. *phillipsi*.

The occurrence of *Ammonellipsites kayseri* and *A. kochi* at Tawstock suggests the presence of the *Pericyclus* Zone (Prentice 1960A) and *Merocanites* aff. *applanatus* suggests the presence of B₁ in the Codden Hill Quarry (Butcher and Hodson, 1960). The trilobite faunas of the Central facies generally confirm the ages determined on the basis of the goniatites, but Prentice (1960A) notes a mixture of Zone II goniatites with Zone II and IIIa trilobites in the Park Gate Quarry, Tawstock (SS 555297), where the following trilobites have been recorded: *Carbonocoryphe* aff. *bindenianni*, *Cyrtosymbole* (*Waribole*) cf. *aequalis* (IIIa), *Phillibole* (*Liobole*) *glabra glabra* (II), *Phillibole* ?*cystispina spatulata* (II/III). From the Templeton Quarry, Tawstock (SS 543297), Prentice (1960A) notes ?*Phillibole culmica*, *Phillibole* (*Phillibole*) *coddonensis*. Other evidence of IIIa in these beds is the association of *Prolecanites discoides* with *Beyrichoceras* and members of the *G. hudsoni-antiquatus* group at unspecified localities (Prentice and Thomas 1960).

The top of the Chert Beds is marked by the 'spirale' band in both the Northern and Central facies in North West Devon. Prentice (1960A) records a number of localities where the horizon is to be found and notes particularly the occurrence in the Fremmington Pill section (SS 513330). The band yields *Posidonia corrugata*, *P. membranacea*, *Neoglyphioceras spirale*, cf. *N. spirale* and *Mesoglyphioceras granosum*. The presence of goniatites with *granosum* ornament suggests (Prentice, 1960A, p. 276) that an horizon is represented low in P_{2a}.

North East Devon. Two distinct facies have been recognised at this horizon (Thomas 1963A; the Bampton Limestone Group and the Westleigh Limestones. The former is made up of a thick group of cherts with interbedded limestones which were possibly introduced into the area by turbidity currents, whilst the latter is a calcarenite-turbidite facies in which thick bedded, coarse calcarenite is interbedded with fine shales.

(i) Bampton Limestone Group (Chert Formation of Swarbrick, 1962)
(*Goniatites* Zone and *Pericyclus* Zone)

The Bampton Limestone Group has been divided by Thomas (1962A), on the relative abundance of interbedded limestones into three units—an unfossiliferous Lower Bampton Limestone, Middle Bampton Cherts, and Upper Bampton Limestone. The Middle Bampton Cherts are frequently highly radiolarian black slates and have yielded in addition to the radiolaria (Hinde and Fox 1896) *Merocanites* cf. *similis* (Zone II) from Kersdown (SS 962222). The Upper Bampton Limestones contain the thickest Limestone units and range up to the P_{1d}/P_{2a} junction. The locality in the Upper Bampton Limestones which yielded the original material upon which Phillips (1841) based his description of '*Goniatites*' *spirale*, has not been located subsequently, but from other localities *Goniatites spirale* has been found associated with *Goniatites* cf. *granosum*, *Dimorphoceras kathleeni* and *Sudeticeras splendens* (Prentice and Thomas 1960) an horizon indicating P_{2a} (Prentice 1960A, p. 276). The presence of P_{1d} is also indicated at Bampton by the occurrence of *Goniatites* cf. *bisati* (Butcher and Hodson 1960). *Neoglyphioceras spirale* has recently been redescribed by Bisat (1955).

(ii) The Westleigh Limestones

Near Westleigh (ST 062174) the thick bedded upper Westleigh Limestones overlie the fine grained Lower Westleigh Limestones, but to the north the latter are absent and appear to be the stratigraphic equivalent of the basal Culm Measures (Thomas 1963A). The shales in the Westleigh Limestones are burrowed by worms and yield a large fauna of pelagic fossils (goniatites, orthocones and *Posidonia*) and a sparse fauna of productids, chonetids and trilobites. The calcarenites which are interbedded with the shales contain much crinoid debris, rolled coral colonies and abraded brachiopods. Thomas (1963B) has suggested that these were introduced into the area by turbidity currents.

Faunal lists from the Westleigh Limestones are recorded by Downes (1878, 1879) and Owen (1939, 1950). The later list by Owen, principally from Rocknell Quarry (ST. 052169) includes *Zaphrentis* aff. *postume*, *Koninckophyllum*, sp., *Michelinia* aff. *egertoni*, *Productus* sp., *Chonetes hardrensis*, spiriferids, rhynchonellids, lingulids, *Posidonia becheri*, *Aviculopecten* sp., 'Orthoceras' and *Phillipsia aequalis*. Radiolaria, sponge spicules and foraminifera have been recorded from the Canonsleigh Quarry near Burlescombe Station (Hinde and Fox 1895, p. 619).

The goniatites of the Westleigh Limestone have been revised and a fairly complete succession of goniatite subzones has been recognised.

- P_{2a} *Goniatites granosus*, *Sudeticeras splendens* (Prentice and Thomas 1960; Butcher and Hodson 1960).
P_{1d} *Neoglyphioceras spirale*, *Sudeticeras splendens* (Prentice and Thomas 1960).
P_{1c} *Hibernicoceras carraunse*, *Sudeticeras crenistriatus* and a doubtful *Goniatites sphaericostriatus* (Prentice and Thomas 1960).
P_{1b} *Goniatites falcatus* (Prentice and Thomas 1960).
P_{1a} *Goniatites crenistria* (Prentice and Thomas 1960).
B₂ *Bollandites* cf. *castletonense* Group, *Merocanites henslowi* (Butcher and Hodson 1960); *Prolecanites discoides* and *Goniatites hudsoni-antiquatus* Group (Prentice and Thomas 1960).

NAMURIAN

A greywacke turbidite facies is characteristic of the Namurian of South West England; the greywackes appear during H times in the south but not until R_{2c} times in the north. The fauna is sparse, but rare goniatite finds have enabled a fairly complete chronology to be established. It appears from the evidence gathered by Butcher and Hodson (1960) and Prentice and Thomas (1960) that the gaps represent incomplete collecting rather than breaks in sedimentation. With the exception of comminuted plant remains, occasional orthocones and species of *Dunbarella* (Prentice 1960A), little is associated with the goniatites.

Northern Outcrop. The lowest horizon so far recognised is from the black shales that underlie the greywacke series at Bampton where *Cravenoceratoides* cf.

lirifer indicates E₂ (Thomas 1962B). These shales also yield occasional flattened spiriferids. The succeeding *Homoceras* Zone has not been identified positively in North Devon.

Reticuloceras superbilingue has been obtained from the greywacke series south of Bampton (Prentice and Thomas 1960; Butcher and Hodson 1960). This is the highest Namurian horizon (R_{2c}) so far recorded.

Moore (1929) has recorded *Reticuloceras reticulatum* (R_{1c}) and *Reticuloceras gracile* (R_{2a}) from the Limekiln Beds (Prentice 1960) at Fremmington (SS 513332), a series of pale grey siliceous siltstone between the Chert Beds and the Instow Fish Bed. The R_{1b} subzone also appears to be present in shales east of Bampton which have yielded doubtful *Homoceras beyrichianum* and *Reticuloceras pulchellum* (Prentice and Thomas 1960).

Southern Outcrop. Numerous records of Namurian goniatites have been made in the Exeter district. The earliest discovery was that of Phillips (1841) who described *Goniatites inconstans* (R_{1a}) from Exeter; from this Bisat (1924) deduced the presence of the *Reticuloceras* Zone in the area. Later discoveries were made by F. G. Collins (1911) and Vicary in the same district. Butcher and Hodson (1960) have reinvestigated this fauna and have produced evidence for the existence of H_{1b} (*Homoceras beyrichianum*) from Idestone Hill (SX 878885); H_{2b} (*Homoceras undulatum*) from Bonhay Road, Exeter, R_{1b} (*Reticuloceras regularum*, *R. moorei* and *R. nodosum*) from Stoke Road, Exeter, and also from Pinhoe Brick Pit (*R. nodosum*) (SX 955944); R_{1c} (*Homoceras striolatum*) from Pinhoe Brick Pit; R_{2a} (*Reticuloceras* aff. *gracile*) from Pinhoe Brick Pit; and R_{2b} (*Reticuloceras bilingue*) from Perridge Tunnel, Exeter (SX 862903).

Namurian rocks also crop out extensively on the North Cornish coast; these have yielded goniatites from which Owen (1950) has recognised the presence of the *Homoceras* and *Reticuloceras* Zones near Crackington Haven. This area is at present being reinvestigated by the Geological Survey. In *Summary of Progress, 1963 Cravenoceratoides* cf. *edalensis* (E₂) is recorded from Widemouth (p. 28) and twelve further goniatite localities are indicated (p. 62). See also Mackintosh (1964).

LOWER WESTPHALIAN

Lower Westphalian rocks have been recognised in North Devon only. The stratigraphical units used here are those described by Prentice (1960A, B) but these have recently been revised (de Raaf, Reading and Walker 1965). The Northam Beds of Prentice are divided into a lower Westward Ho! Formation, and an upper Northam Formation which is succeeded by the Abbotsham Formation. The latter is combined with the Northam Formation as the Bideford Group (Walker, 1964).

Instow Beds (*Gastrioceras* Zone)

The Instow Beds (Prentice 1960A) form a greywacke-shale sequence overlying the Limekiln Beds in North West Devon. A fish bed at the top of the beds has yielded a varied fauna. Collections originally made by Hall (1876) and Rogers

(1910) have been revised by Prentice (1960A) whose faunal list includes *Gastrioceras carbonarium*, *Anthracoceras arcuatilobum*, orthocones, *Dunbarella papyracea* and the fish *Rhabdoderma elegans* and *Elonichthys aitkeni*. *Gastrioceras listeri* has also been recorded (Prentice and Thomas 1960). A number of other localities yielding a comparable G₂ fauna has been recorded by Rogers (1910) between Westward Ho! and Hartland Point, and a further locality has been noted by Butcher and Hodson (1960) at Welcombe, north of Bude.

The same horizon occurs in the shale-greywacke sequence in North East Devon in the area south east of Bampton (Prentice and Thomas 1960; Thomas 1963A). Prentice and Thomas have also noted *Gastrioceras langenbrahmi* in North East Devon; this fossil marks the base of the Westphalian in Britain (see Ramsbottom and Calver 1962).

Northam Beds

The Northam Beds (Prentice 1960B) are not clearly defined and no fossils are known from this horizon with the exception of the trace fossil *Teichichnus* and other burrows (de Raaf, Reading and Walker 1965).

Abbotsham Beds

The Abbotsham Beds of North Devon (Prentice 1960B) contain the youngest Carboniferous assemblage so far recognised in South West England. These beds, of a paralic cyclic facies, have yielded numerous fish remains, a recognisable flora and important horizons of non-marine lamellibranchs (Rogers 1909, 1910). Arber (1904, 1907), who described the flora, referred the beds to the Middle Coal Measures, but Crookall (1930) reidentified the material and ascribed the beds to the Lower Coal Measures. This view was fully confirmed by B. Simpson (1933), who recognised from the non-marine lamellibranch fauna the zones of *Anthracomya lenisulcata* from Abbotsham Cliff (SS 408276) and *Carbonicola ovata (communis)* from Robert's Quarry, Bideford, (SS 468264).

Poorly preserved Lower Coal Measure plants (Crookall 1930) and fish horizons (Owen 1950) have also been observed in the Bude Sandstones. Owen (1950) and Prentice (1962) have suggested an equation of these rocks with the Abbotsham Beds, but Reading (1963) has pointed out significant facies differences and noted that though the two successions are roughly the same age there is no palaeontological evidence that they are exactly synchronous.

A list of the flora from the Abbotsham and Bude Beds is given by Dewey (1948) and includes *Neuropteris schehani*, *Alethopteris lonchitica*, *Mariopteris ?muricata*, *Sphenopteris striata?*, *S. hoeninghausi*, *Lepidophloios acerosus*, *Calamites suckowi* and *Calamocladus equisetiformis*.

Cockington Beds

The Cockington Beds (Prentice 1960B), which overlie the Abbotsham Beds, are of a greywacke-shale facies and have yielded a gastrioceratid fauna. Prentice and Thomas (1960) record *Gastrioceras subcrenatum* (Wright non C. Schmidt). The nomenclature of the Lower Westphalian gastrioceratids, and particularly G.

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subcrenatum, is confused and not yet fully resolved (Ramsbottom and Calver 1962), but it seems unlikely that the name *subcrenatum* can be retained for these fossils since Prentice and Thomas clearly do not intend the species to be confused with the *subcrenatum* recorded from the *listeri* horizon.

Prentice (1960B) also records younger gastrioceratids. The identifications are as yet unpublished, though Prentice has indicated that they represent a level probably still within the Lower Coal Measures. (Discussion to Prentice 1960B).

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PLATE 1. Lower Devonian Fossils.

Figs. 1, 2. *Pteroconus mirus* (Hinde) (= *Nereitopsis cornubicus* Green). 1, from Polyne Quarry, near Looe, South Cornwall, B.M. A 999. 2, from Bedruthan Steps, North Cornwall, G.S.M. FB 22. Both X2.

Fig. 3. *Spirifer alatifformis* Drevermann. Meadfoot Beds, from foundations of a house on Marine Drive, 500 yards east of Kilmore, Torquay. G.S.M. 49685, X 1.

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- Fig. 4. *Tropidoleptus rhenanus* (Frech). Meadfoot Beds, Meadfoot Sands, Torquay. G.S.M. 6862 (fig'd Davidson 1865, Pl. 17, Figs. 1-3), X 1.
 Fig. 5. *Mucrospirifer* sp. Lynton Beds, Hamling Coll., T.N.H.M., X 1.
 Fig. 6. Spiriferids of *bischofi* and *subcuspidatus* groups. Lynton Beds, Hamling Coll., T.N.H.M., X 1.
 Fig. 7. *Douvillina elegans* Drevermann. From a pit $\frac{1}{4}$ mile south of Mudgeon, south Cornwall. G.S.M. Dr i2236, X 1.3.
 Fig. 8. '*Naticopsis*' sp. Hangman Grits, Hamling Coll. T.N.H.M., X 1.
 Fig. 9. *Platyorthis circularis* (Sowerby). Pedicle valve. Lynton Beds, Hamling Coll., T.N.H.M. 1835, X 1.
 Fig. 10. *Schellwienella umbraculum* (Schlotheim) Lynton Beds, Hamling Coll., T.N.H.M. 1163, X 1.
 Fig. 11. *Pleurodictyum* sp. 'Meadfoot Beds', Looe, Cornwall. G.S.M. 1054, X 1.
 Fig. 12. *Platyorthis circularis* (Sowerby). Brachial valve. Lynton Beds, Hamling Coll., T.N.H.M. 1838, X 1.

PLATE 2. Middle Devonian Fossils

- Fig. 1. '*Murchisonia*' *bilineata* (d'Arch. and de Vern.), Middle Devonian, Chudleigh. G.S.M. 51063.
 Figs. 2-4. *Cyrtina heteroclita* (Defrance). Lummaton Shell Bed, Lummaton. O.U.M. D265, X 2.
 Figs. 5, 6. *Uncites gryphus* (Schlotheim). Orchard Quarry. Dartington. G.S.M. 50942, X 1.
 Fig. 7. *Kayseria lens* (Phillips). Hope's Nose Beds, Hope's Nose, Torquay. G.S.M. 50872, X 2.
 Figs. 8, 9. *Pyramidalia simplex* (Phillips). Probably from the Plymouth Limestone (fig'd Phillips 1841, Pl. 60, Fig. 124), G.S.M. 6915, X 1.
 Figs. 10, 11. *Thamnophyllum trigeminum* (Quenstedt). Dyer's Quarry, Torquay. O.U.M. D271, 2, X 2.
 Fig. 12. *Mesophyllum* (M.) sp. Dyer's Quarry, Torquay. O.U.M. D273, X 0.66.
 Fig. 13. *Thamnopora cervicornis* (Blainville). Middle Devonian Torquay. G.S.M. 6202 (fig'd Edwards and Haime 1853, Pl. 48, Fig. 2), X $\frac{1}{2}$.
 Fig. 14. *Acanthophyllum* (*Acanthophyllum*) *heterophyllum* (Edwards & Haime). Triangle Point, Torquay. O.U.M. D274, X 1.
 Fig. 15. *Phillipsastraea hennahi* (Lonsdale). Lummaton Quarry, Torquay. T.N.H.M., Jukes-Browne Coll. no. 62, X 1.5.
 Figs. 16, 17. *Dechenella* (*Dechenella*) *setosa* Whidborne. Chircombe Bridge Quarry, Newton Abbot. B.M. I. 5039, I. 5056, X 2.
 Figs. 18, 19. *Hypothyridina procuboides* (Kayser). Lummaton Shell Bed, Lummaton, Torquay. E.U.C., X 1.
 Fig. 20. *Scutellum pardalios* (Whidborne). Wolborough, Newton Abbot. Croker Coll., E.C.M. 7194, X 1.

PLATE 3. Upper Devonian Fossils.

- Fig. 1. *Manticoceras cordatum* (G. and F. Sandberger). Lower Dunscombe Quarry, Chudleigh. M.R. House Coll. D.107, X 1.
 Fig. 2. *Archoceras varicosum* (Drevermann). Saltern Cove Goniatite Bed, Saltern Small Cove, Paignton. M.R.H. Coll. D.208, X 3.
 Fig. 3. *Platyclymenia* (*Platyclymenia*) sp. Mount Pleasant, Chudleigh. M.R.H. Coll. D.1311, X 2.
 Fig. 4. *Cymaclymenia striata* (Münster). Mount Pleasant, Chudleigh. M.R.H. Coll., X 1.

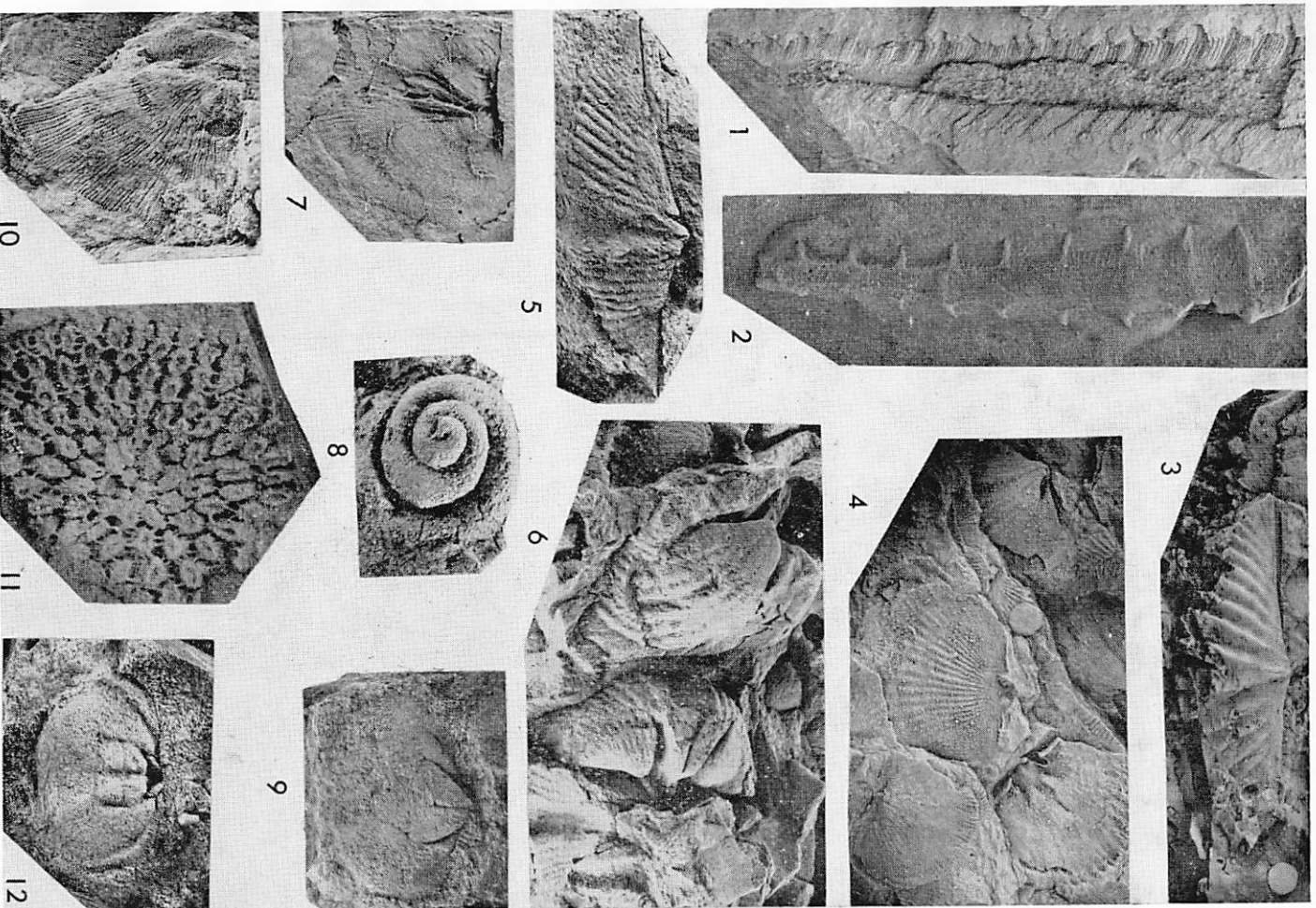
M. R. House and E. B. Selwood

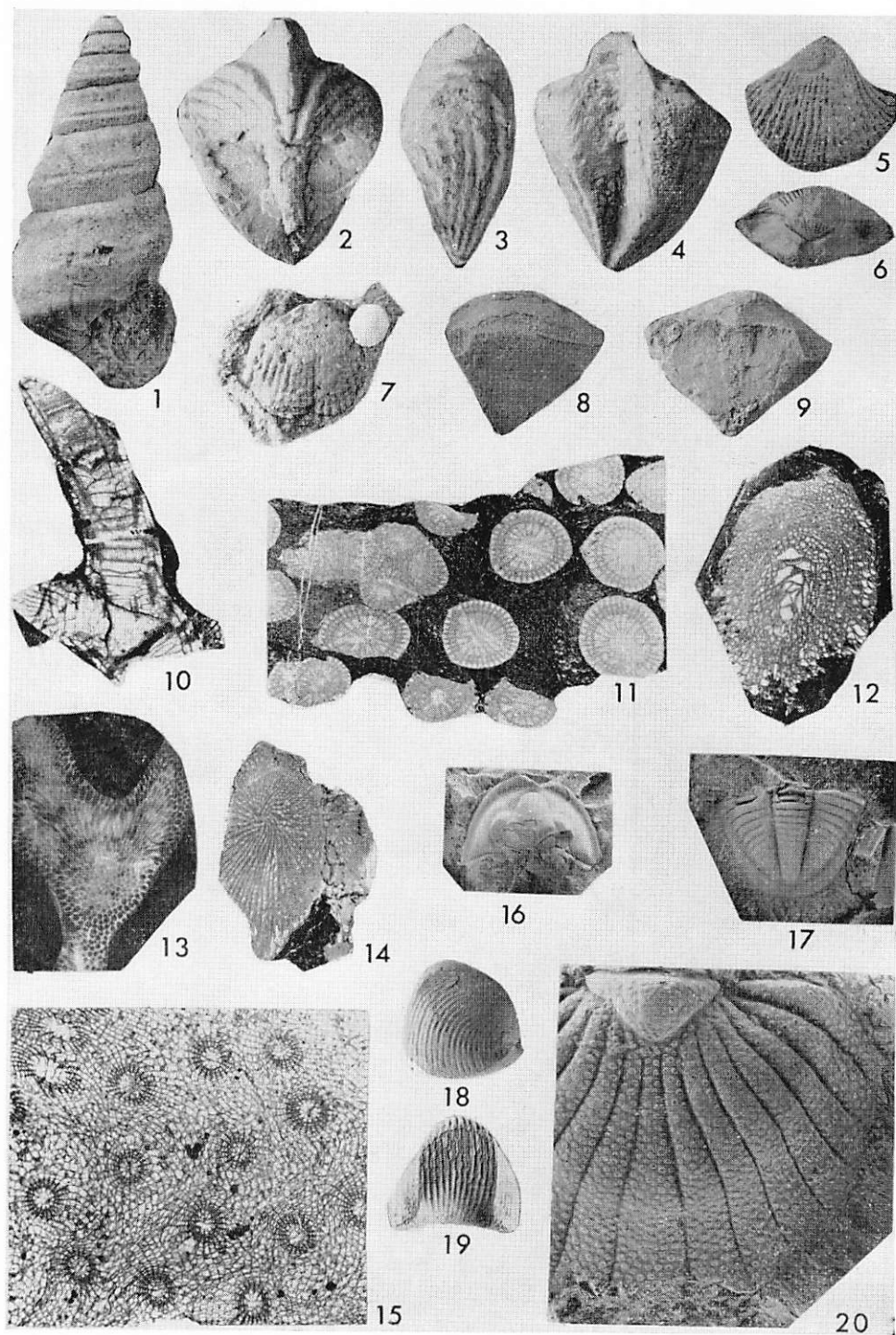
- Fig. 5. *Productella (Whidbornella) caperata* (Sowerby). Pilton Beds, Braunton, N. Devon. G.S.M. 33469, X 1.
Fig. 6. *Phacops (Phacops) accipitrinus accipitrinus* Phillips. Lectotype from the Upper Pilton Beds, New Road Quarry, Pilton. (fig'd Phillips 1841, Pl. 56, Fig. 249b). G.S.M. 7055, X 1.
Fig. 7. *Parawocklumeria laevigata* Selwood. Stourscombe Beds, Launceston (SX 344839). E.U.C., X 2.
Fig. 8. "*Ambocoelia*" *urei* (Fleming). Pilton Beds, Pilton. O.U.M. D263, X 2.
Fig. 9. *Phillipsastraea bowerbanki* (Edwards and Haime). Ramsleigh Quarry, East Oggwell. T.N.H.M. Jukes-Browne Coll. 294a, X 2.
Fig. 10. *Phillipsastraea goldfussi* (de Verneuil and Haime). Ramsleigh Quarry, East Oggwell, T.N.H.M. Jukes-Browne Coll. 311, X 2.
Fig. 11. *Trimerocephalus mastophthalmus* (R. Richter). Knowle's Hill Quarry, Newton Abbot. Lower Famennian. O.U.M. D262, X 1.
Fig. 12. *Coccosteus* sp. Lower Dunscombe Quarry, Chudleigh. B.M. P 5282 (fig'd Roemer, 1880), X 1.

PLATE 4. Upper Devonian and Carboniferous Fossils

- Fig. 1. *Goniatites falcatus* Roemer. Hele Quarries, $\frac{3}{4}$ mile south of Dulverton Station. G.S.M. US963, X 2.
Fig. 2. *Cyrtospirifer verneuli* (Murchison) (The Delabole Butterfly). Delabole Slates, Upper Devonian, Delabole, North Cornwall. E.U.C., X 1.
Fig. 3. *Goniatites sphaericostriatus* Bisat. Bonhay Road, Exeter, P_{1c}. B.M. C9111, X 3.
Fig. 4. *Gastrioceras circumnodosum* Foord. North of Shag Rock, near Knap Head, North Cornwall. G₂ S.M. E 14609, X 3.
Fig. 5. *Bollondites castletonensis* (Bisat) group. Westleigh Limestones, near Burlescombe. B₂. B.M. C9113, X 2.
Fig. 6. *Reticuloceras nodosum* Bisat and Hudson. Pinhoe, Exeter. R₁. B.M. C9123, X 4.
Fig. 7. *Paragoniatites newsomi* (Smith) group. $\frac{3}{4}$ mile south of Ugbrooke House, near Chudleigh. P_{2c} G.S.M. US436, X 5.
Fig. 8. *Reticuloceras bilingue* Bisat. Namurian ballast from Perridge Tunnel, $3\frac{1}{2}$ miles W.S.W. of Exeter. G.S.M. US 1822a, X 2.
Fig. 9. *Posidonia becheri* (Bronn). Upper Westleigh Limestone, Whipcott Quarry, Holcombe Rogus. J.M. Thomas Coll., X 1.
Fig. 10. *Homoceras undulatum* (Brown). Bonhay Road, Exeter. H_{2b}. B.M. C9109, X 3.

Explanation of abbreviations: B.M. = British Museum (N.H.) London. E.C.M. = Exeter City Museum. E.U.C. = Exeter University Collection. G.S.M. = Geological Survey and Museum, London. O.U.M. = Oxford University Museum. S.M. = Sedgwick Museum, Cambridge. T.N.H.M. = Torquay Natural History Museum. Specimens in private collections are so indicated.





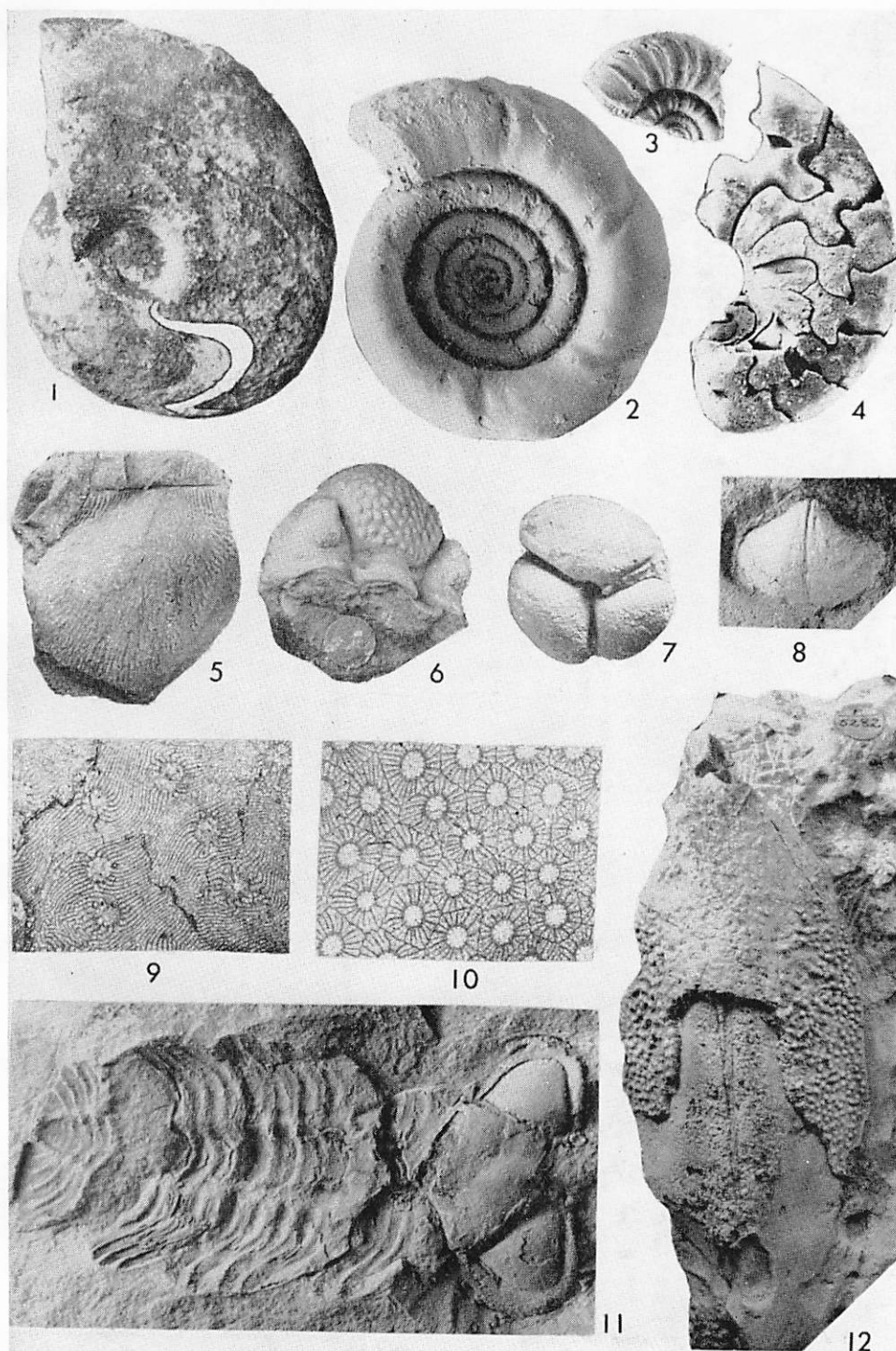


PLATE 4

