Trearne Quarry, North Ayrshire

[NS 373 533]

Introduction

Trearne Quarry [NS 373 533] is situated 2.2 km ESE of Beith and 24 km south-west of Glasgow. Until recently, it was an active quarry exploiting the Dockra Limestone (Lower Limestone Formation, Brigantian). The currently exposed sequence reveals reef limestones and associated beds in which there are considerable facies variations. Parts of the sequence are also highly fossiliferous (Figure 2.35). These features make the site of immense interest and value to stratigraphers, palaeontologists and sedimentologists alike. Useful guides to the quarry have been provided by Lawson (in Bluck, 1973) and Burton and Todd (in Lawson and Weedon, 1992), and valuable geological information, based on the uncompleted studies of K.A.G. Shiells, is given in Shiells and Penn (1971). Richey *et al.* (1925, 1930) published good background information about the geology of the general area as well as summaries of previous work, though they present little direct information about the site itself. Aspects of the geology, palaeontology and mineralogy of the site are also reported by Richey (1946), Shiells (1966, 1968, 1969), McIntosh (1974), Browne (1975), Todd (1988) and Monro (1999).

Description

Trearne Quarry has been worked in several bays so there are extensive quarry faces revealing sections which are almost exclusively within the 7–8 m-thick Dockra Limestone. At the north-east end of the quarry and at the south end, in a largely water-filled area of the workings, NW–SE-trending dolerite dykes cut the limestone. A fire-clay, coal and dark shale, which underlie the Dockra Limestone, can be seen in a trench north of the quarry entrance. The fireclay (1 m) is light coloured and contains calcareous nodules. It is overlain by the coal, which is up to 12 cm thick and very variable in character with shale and limestone layers within it. Plant stems (*Lepidodendron*) and roots (*Stigmaria*) have been recorded from it as well as nodules of iron sulphides and calcite veins (Burton and Todd in Lawson and Weedon, 1992). The shale shows upward changes in fossil content. At the base (0.24 m) it contains plant remains and scattered fish debris. The central portion of the shale (0.54 m) contains siderite nodules and *Lingula* spp.. Interestingly, both *Lingula squamiformis* and *Lingula mytilloides* are present: the former is more common towards the base and is sometimes preserved in life position, whereas the latter becomes locally more dominant higher in the shale. The top unit within the shale (1 m) contains a marine fauna with *Pleuropugnoides* abundant at the base. The fauna is dominated by brachiopods (*Antiquatonia insculpta, Eomarginifera praecursor, Martinothyris, Spirifer, Composita*, '*Dielasma*'*, Crania, Orbiculoidea*) and bivalves (*Pterinopecten, Edmondia, Phestia, Sanguinolites*) but gastropods (*Straparollus, Glabrocingulum*), bryozoans (*Rhabdomeson*), crinoids (*Ureocrinus*) and rare goniatites may also be found. This part of the shale contains pyrite nodules and some of the brachiopod shells are pyritized.

Immediately above the shale, but within the quarry, the Dockra Limestone shows lateral and vertical facies variations (Figure 2.36). To the north, the limestone is made up of more-or-less equal proportions of dark-grey argillaceous limestones and calcareous mudstones in beds up to 0.5 m thick. As the section is followed south the proportion of shale decreases rapidly and limestone beds of a mottled but generally lighter colour make up an increasing proportion of the section. Farther to the south, these pass into more massive but lenticular limestones with, apart from one thicker unit of thin interbedded limestone and shale near the base, a few thin, largely stylolitic, shale partings.

The northern limestones and shales of the Dockra Limestone have a variable bioclast content and distinctive faunas (Burton in Lawson and Weedon, 1992). The many limestone beds frequently contain large specimens of the flat davidsoniacean brachiopod *Brochocarina trearnensis,* and in addition there are some large gigantoproductids. A range of small productoids, of which *Antiquatonia insculpta is* most common, also occur together with the solitary rugose coral *Aulophyllum.* Crinoid debris is fairly common. In the mudrocks, small solitary corals (zaphrentids, *Fasckulophyllum* and *Allotropiophyllum*) and brachiopods (*Antiquatonia insculpta* and other productoids, *Spirifer, Composita*)are common, but large solitary corals (*Caninia*)are also present. Rare but well-preserved specimens of the goniatite *Beyrichoceratoides truncatum* can be found as well as bivalves and trilobites. In some mudrock horizons *Lingula* may be present. Elsewhere there are a few complete crinoids and scattered *Archaeocidaris* plates. To the south, stick and fenestellid bryozoans and long coralla of *Heterophyllia* are present and the brachiopods that become more diverse, Include *Kochiproductus* and *Martinothyris.* In the upper parts of the limestone–mudrock sequence, at the northern end of the quarry, an unusual and different fauna with large bivalves (*Pinna* and *Sedgwickia gigantia*) and abundant cephalopods (orthoceratids, nautiloids and goniatites) is developed (Burton in Lawson and Weedon, 1992).

The mottled limestones show a complex internal structure (Shiells and Penn, 1971). They are grain-supported and show complex histories, with microbial mats, early diagenetic cementation and penecontemporaneous erosion producing a complex irregular microrelief on the sea floor (Burton in Lawson and Weedon, 1992). Concentrations of crinoid debris occur in pockets and as wider patches of long stem lengths. Brachiopod diversity is highest in these beds and forms present include the productoids *Avonia, Promarginifera, Eomargingera, Pugilis, Krotovia, Kochiproductus* and *Buxtonia* as well as *Rugosochonetes, Martinothyris* and *Dielasma*'. Among other fossils are specimens of the bivalve *Pinna* in life position and the phosphatic pyramidal shells of the cnidarian *Paraconularia.* The fossils in the limestone are well preserved and because of the early cementation these are uncrushed. In contrast, the associated mudrocks do not show early cementation and have compacted with extensive crushing and deformation of their fossil content (Burton in Lawson and Weedon, 1992).

At the southern end of the quarry, the unit of thin limestone and shale alternations (1 m) is distinguished by an assemblage of partially disarticulated crinoids (*Rhabdocrinus scotocarbonarius, Ureocrinus bockschii*)together with bryozoans (*Rhabdomeson*), brachiopods (*Eomarginifera praecursor*) and small zaphrentid corals (Burton in Lawson and Weedon, 1992). The more massive limestones at this end of the quarry contain, especially towards the base, in-situ growths of the colonial rugose coral *Siphonodendron*, which are up to 1 m high and 3 m across. The limestones between the coral colonies contain abundant elongate sponge spicules from the attachment ropes of *Hyalostelia smithi* and show textural evidence of algal precipitates and binding of the sediment (Burton in Lawson and Weedon, 1992). In these limestones there are also bryozoan colonies (*Septopora* and fenestellids), crinoid debris and a reduced variety of brachiopods (*Eomarginifera longispina, Krotovia spinulosa, Echinoconchus punctatus, Brachythyris*). The brachiopod shells often contain geopetal infills, which are out of alignment with the bedding and suggest some post-depositional disturbance of the shells. The *Siphonodendron* colonies become smaller and scarcer upwards, while solitary corals such as *Dibunophyllum, Caninia* and *Aulophyllum* become more common and may occur in clusters, which have been washed together. At up to five levels within these limestones there are irregular lenses (up to 7 cm thick) made up of coral and brachiopod debris. Locally, at one part of the face, flat chaetetid sponge bases can be seen growing on the irregular and hummocky surface of a bed of bioclastic debris. Broken and stacked gigantoproductid valves are also present.

Another band of overturned and disarticulated gigantoproductid valves is present below the thick bed of crinoidal grainstones that caps this part of the sequence. The crinoidal limestones contain not only long lengths of randomly orientated crinoid stem but also spines of the brachiopod *Eomarginifera,* fish teeth (*Petalodus*) and fan-shaped colonies of fenestellid bryozoans (Burton in Lawson and Weedon, 1992). The uppermost surface of this bed is marked by yellow-coloured crinoidal limestones with stigmarian roots (Lawson in Bluck, 1973; Burton in Lawson and Weedon, 1992). A further, and possibly separate, surface of emergence (palaeokarst) lies about 0.3 m lower in the sequence.

In addition to the intrusion of the dykes at the northern and southern ends of the quarry, which was accompanied by localized decalcification and baking of the country rock, there is extensive veining of the limestone. These veins have a complex mineralized infill and the following minerals are recorded: calcite, quartz, dolomite, barite, strontianite, fluorite, pyrite, chalcopyrite, millerite (Todd in Lawson and Weedon, 1992). Many of these minerals can be found as secondary mineralizations in the cavities within brachiopod shells. Chert bands are developed in the northern part of the quarry and locally there is some silicification of fossils (Richey *et al.,* 1930; Lawson in Bluck, 1973; Burton in Lawson and Weedon, 1992).

Interpretation

Trearne Quarry lies close to the north-eastern margin of the North Ayrshire Basin (Richey *et al.,* 1925, 1930; Whyte, 1981). During Brigantian times, the lavas of the Clyde Plateau Volcanic Formation made an upland or island area to the east ((Figure 2.3)c) against which the sedimentary successions of the Lawmuir Formation and the Lower Limestone Formation thinned (Richey, 1925; Richey *et al.,* 1925, 1930; Whyte, 1981). At Trearne, the Dockra Limestone is 7–8 m thick, but to the east it thins to zero within 8 km. A shallow strait probably also existed to the north between the North Ayrshire Basin and Central Coalfield Basin (Richey, 1925; Richey *et al.,* 1930;*Whyte,* 1981).

The varied assemblage of carbonate and palaeontological facies developed at Trearne reflects and provides vital detail of this palaeogeography. The basal shales provide valuable evidence of the marine trangression, with a progression from a peaty soil and swamp facies through a brackish-water facies containing *Lingula* to a more fully marine facies with diverse faunal assemblages. The association of the two *Lingula* species is interesting and their distribution suggests that *Lingula squamiformis,* which appears earlier in the bed, may have been more tolerant of reduced salinity than *Lingula mytilloides.*

The thin shales and limestones at the base of the Dockra Limestone at the southern end of the quarry have been interpreted as a tiered community of crinoids, bryozoans and brachiopods living in water depths of about 10 m (Burton in Lawson and Weedon, 1992).

The massive limestones and the mottled limestones correspond respectively to the Reef Limestones and the Multicomponent Mudstones of Shiells and Penn (1971), and collectively to the Trearne Facies of Richey (1946; Richey *et al.,* 1930). The Reef Limestones are reef-mound limestones with small local reliefs and with corals, bryozoans, sponges and algae contributing to the buildup. The Multicomponent Mudstones represent the flank beds of these buildups. The associated fauna in these beds is largely preserved at the site at which it lived and some of it is in life position (Shiells and Penn, 1971; Burton in Lawson and Weedon, 1992). However, in both the Reef Limestones and Multicomponent Mudstones, there is evidence of shell disturbance, and localized debris beds indicate at least occasional higher energy events. Water depths may have been shallower than those of the underlying tiered crinoid community, and the upward replacement of colonial corals by solitary corals in the massive limestones may indicate a shallowing trend (Burton in Lawson and Weedon, 1992). The crinoidal grainstones at the top of the succession also indicate shallower and more turbulent conditions.

The dark limestones and shales of the northern part of Trearne Quarry correspond to the Lugton Fades of Richey (1946; Richey *et al.,* 1930) and to the Bedded Limestone and Shale of Shiells and Penn (1971). The presence of some complete crinoids and clumps of *Archaeocidaris* plates, which represent the undispersed remains of individual echinoderms, indicate quiet depositional conditions, as does the preservation of bivalves in life position or with valves splayed but still associated. The infaunal bivalves, corals with radicular structure (*Allotropiophyllum*) and the flat thin platy valves of *Bochocarina trearnensis,* for which this is the type locality (McIntosh, 1974), indicate a very soft bottom substrate. The shales and limestones were deposited on the shoreward side of the reef mounds in a protected lagoonal environment. The scattered occurrences of *Lingula* indicate more brackish conditions and oscillations of the Dockra Limestone shoreline.

Shiells (Shiells, 1966, 1968, 1969; Shiells and Penn, 1971) made a special study of the diverse productoid fauna, noting its distribution and preservation within the limestones and shales. Geopetal fills and unbroken long spines indicated that many of the productoids were still in life position even though hinge lines might be inclined (Shiells and Penn, 1971). Two species, *Promarginifera trearnensis* and *Kochiproductus coronus,* and their functional morphologies were described in detail, based on type material from Trearne (Shiells, 1966, 1968, 1969).

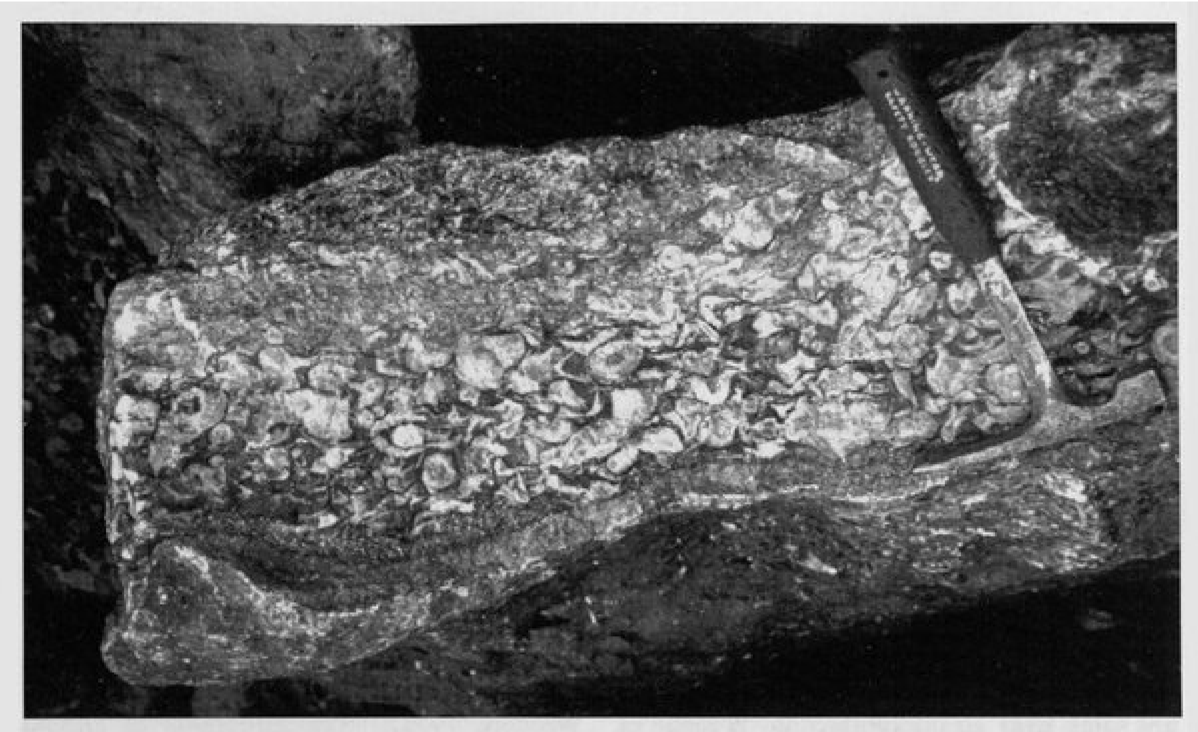
The crucial palaeontological importance of Trearne Quarry has been underlined by the unique soft-bodied fauna that has recently been discovered at the site. This highly significant and extremely exciting discovery is currently being worked on by C.J. Burton and N. Clark (Glasgow University), who are also describing new sponges from the locality (C. Burton, pers. comm., 2000).

The well-defined palaeosol development at the top of the Dockra Limestone at Trearne is a common though not ubiquitous feature of this horizon in North Ayrshire (Richey, 1946; Richey *et al.,* 1930; Whyte, 1981). Macnair (1915), influenced by this feature, suggested that the Dockra Limestone was equivalent to the Blackbyre Limestone of the Central Coalfield, which has also frequently been modified by an overlying palaeosol. However, Carruthers and Richey (1915; Richey 1925; Richey *et al.,* 1930), using other criteria, developed a correlation in which the Dockra Limestone was equated with the Hurlet Limestone of the Paisley district. This latter correlation was widely accepted until recently when Wilson (1979), using new fossil evidence, suggested an alternative correlation in which the Dockra Limestone was equated with the higher Blackhall Limestone. Although accepting parts of this correlation, Whyte (1981) has argued that the fossil evidence is not unequivocal and that the Dockra and Hurlet limestones are equivalents (Figure 2.4). The absence of an equivalent of the Blackhall Limestone in North Ayrshire is considered by Whyte (1981) to be related to the prolonged overstep of the disconformity surface above the Dockra Limestone. Wilson (1989) and Whyte (1981) present palaeogeographical maps based on their differing views of the correlation of the Dockra Limestone.

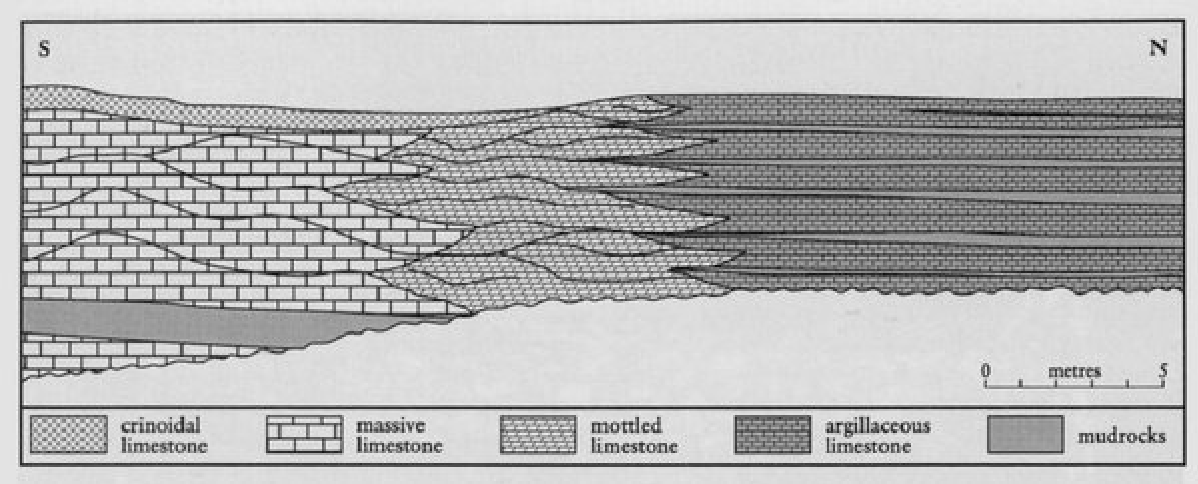
Conclusions

Trearne Quarry provides a unique section through a highly fossiliferous Brigantian reef complex that developed in the Dockra Limestone towards the north-eastern margin of the North Ayrshire Basin during late Dinantian times. The complex variations in sedimentary facies and rich faunas at Trearne make this one of the most valuable combined interest sites in the Midland Valley and one of particular significance to the stratigrapher, sedimentologist and palaeoecologist. It is the type locality for several invertebrate taxa and, as recent exciting discoveries have amply demonstrated, a site of great palaeontological potential. It also provides vital information for the correlation of Brigantian successions between the North Ayrshire Basin and Central Coalfield Basin.

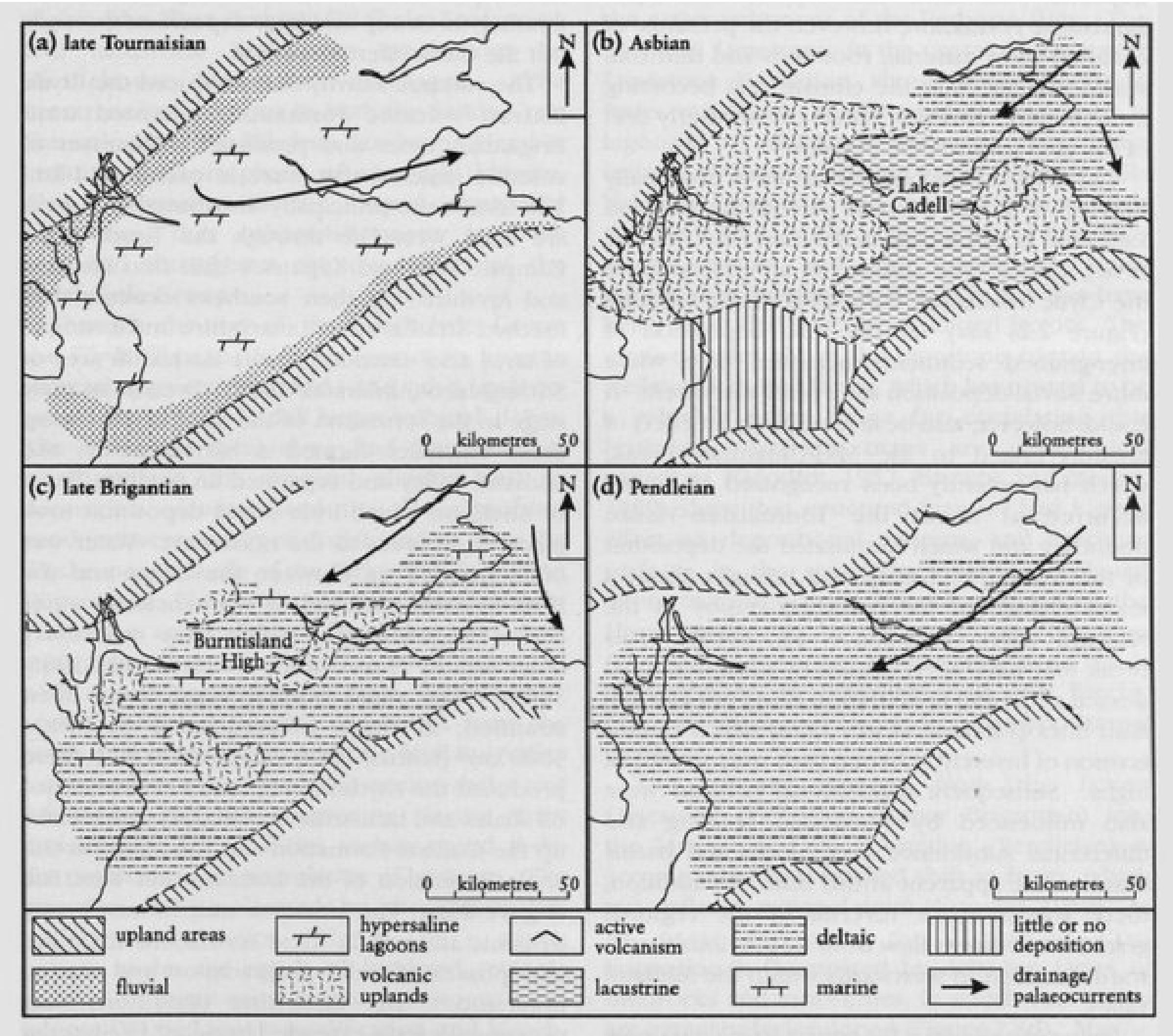
References



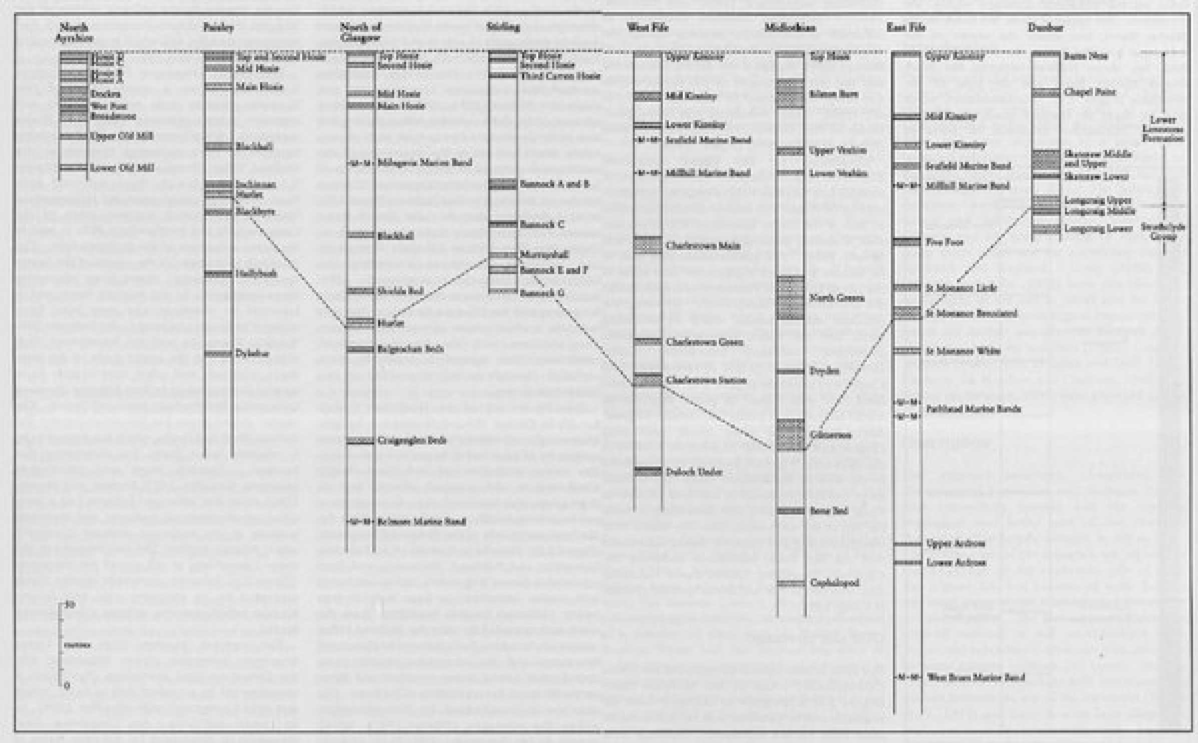
(Figure 2.35) Solitary corals in the Dockra Limestone (Lower Limestone Formation, Brigantian) from the Trearne Quarry GCR site. (Photo: C. MacFadyen.)



(Figure 2.36) Schematic south–north cross-section showing facies distributions in the Dockra Limestone (Lower Limestone Formation, Brigantian) at the Trearne Quarry GCR site, Bathgate. After information principally from Shiells and Penn (1971).



(Figure 2.3) Lower Carboniferous palaeogeographical reconstructions of the Midland Valley area: (a) late Tournaisian (Ballagan Formation, Inverclyde Group); (b) Asbian (Sandy Craig Formation, Strathclyde Group); (c) late Brigantian (Lower Limestone Formation, Clackmannan Group); (d) Pendleian (Limestone Coal Formation, Clackmannan Group). Based on various sources and including information from Craig (1991) and Whyte (1994).



(Figure 2.4) Correlation of the principal marine horizons in the Brigantian Lower Limestone Formation and uppermost part of the Strathclyde Group in the Midland Valley from North Ayrshire to Dunbar. Note that most of the named units figured here are, unless otherwise stated, limestones (names abbreviated). Based on various sources and including information from George et al. (1976), Cameron and Stephenson (1985), Wilson (1989) and Francis (1991).