Petershill, West Lothian

[NS 985 695] and [NS 987 707]

Introduction

High in the hills 1 km to the north-east of Bathgate a staggered line of old quarries highlight the outcrop of a thick sedimentary intercalation within the Bathgate Hills Volcanic Formation (Bathgate Group). The largely volcanic sequence of the Bathgate Hills Volcanic Formation makes up the elevated topography of the Bathgate Hills and dips westwards beneath younger rocks of the Central Coalfield Basin on whose eastern margin it lies. The Petershill GCR site embraces two of these quarries, the Petershill Reservoir Quarry [NS 985 695] and the Rifle Range Quarries [NS 987 707], within which there are exposures of the Petershill Limestone (upper Brigantian) and some associated clastics. The limestone, which has long been famous for its sedimentary and palaeontological features, has been painstakingly described by Jameson (1980), who has also provided a thorough review of previous work. Bassett (1958) and Stephenson and Monro (in McAdam and Clarkson, 1986) have written excursion guides to the locality. Other publications with relevant information are Peach *et al.* (1910), Macgregor and Anderson (1923), Hill (1938–1941), Robertson *et al.* (1949), Parks (1954), Muir and Hardie (1956), Mitchell and Mykura (1962), Jameson (1987) and Cameron *et al.* (1998).

Description

A schematic cross-section showing the facies relations in the Petershill Limestone at this site is illustrated in (Figure 2.23). On the east bank and margin of Petershill Reservoir Quarry (the reservoir is now drained) the Petershill Limestone comprises bedded limestones and slightly argillaceous limestones (4 m) containing *Thalassinoides* burrows, patches of *Siphonodendron funceum,* abundant solitary corals, spiny productoids and echinoids. The solitary rugose corals occur in aggregations of several species, including *Aulophyllum pachyendothecum* and *Koninckophyllum,* mostly in life position. Endothyrid foraminifera, ostracodes and filamentous and dasycladacean algae have also been recorded from these beds (Jameson, 1987). At the northern end of the quarry, a small fault downthrowing to the south reveals a small section of the underlying bioturbated argillaceous limestones and shales that contain gigantoproductids, *Eomarginifera, Hyalostelia* sponge spicules and the phosphatic tubes of *Sphenothallus.*

Exposed at the southern end of the quarry are more massive limestones (9 m), the principal facies of a 'biohermal buildup' first recognized by Jameson (1987). These overlie the bedded limestones and are separated from them by an erosion surface (see (Figure 2.23)). At the base, cream-coloured lime mudstones and wackestones contain a relatively low-diversity assemblage of small productoids and sponges (*Hyalostelia*)and show stromatactoid cavities and brecciation. Fenestellid bryozoans are also present. This passes up into a high-diversity productoid-sponge-rostroconch assemblage. In places, either *Hyalostelia* sponge spicules or fenestellid bryozoan fronds have formed mats protecting and stabilizing the sediment surface. Small shelter cavities occur under some of the bryozoan fronds. Myodocopid ostracodes (*Entomoconchus*)are common in this facies, and productoids (namely *Echinoconchus elegans* and *Antiquatonia hindi*), spiriferoids, orthotetoids, fistuliporoid bryozoans, *Hexaphyllia, Amplexus coralloides,* ostracodes, encrusting foraminifera, worm tubes, *Pinna* and *Conocardium* are also present. Above this, there are beds of poorly sorted crinoidal packstone. Massive beds seen on the west side of the quarry are separated from the overlying moderately well-sorted crinoidal packstones (1.2 m) by an erosion surface. These are overlain in turn by dark, sandy micaceous siltstones.

The Rifle Range Quarries run for about a kilometre along the strike of the beds, and in these the lower parts of the Petershill Limestone consist of heterogeneous packstones (Figure 2.23), which show marked variations in grain size, sorting and composition. The lowest 3–4 m of this facies comprise cross-bedded crinoidal packstones with bands containinglarge corals (*Actinocyathus floriformis, Lithostrotion vorticale, Palastraea regia, Thysanophyllum, Syringopora, Siphonodendron*) and the demosponge *Chaetetes.* Although much of the fauna is in *situ,* some of the coral colonies appear to have been overturned and have sometimes re-grown. Bands, typically 15–20 cm thick and crowded with gigantoproductids, also occur and show disarticulated and stacked valves. In addition to small-scale planar and trough cross-bedding, some beds show lenticular bedding. In the centre of the sequence a slightly more argillaceous, less well-sorted and finer-grained unit with *Zoophycos* and solitary corals dies out southwards along the quarry face. In general, beds also get finer to the south. A thin clay way-board occurs within the upper part of these beds and at its top an erosion surface cuts 3 m down into the underlying limestone. Above this there are impersistent sandstones and tuffs and laterally extensive crinoidal packstones and grainstones, which also have an eroded upper surface. This erosion surface is covered by a thin veneer of sandstone and by black shales, though at the northern end of the quarries a basalt lava rests directly on the limestones. Both of these erosion surfaces have associated fissure systems, which contain an infill of tuff, plant-bearing sandstone and limestone intraclasts.

Interpretation

The Petershill Limestone is part of a major sedimentary intercalation within the volcanic sequence of the Bathgate Hills Volcanic Formation. The location of this volcanic activity may be linked to the major structural feature of the Burntisland High (Jameson, 1987; and see (Figure 2.3)c). The Petershill Limestone is correlated with the Main Hosie Limestone and Mid Hosie Limestone of the Central Coalfield Basin (Cameron *et al.,* 1998; see also Macnair, 1917). On the eastern margin of the Central Coalfield Basin and to the south of Bathgate, where the volcanics are not present, these two limestones are relatively thin, with a combined thickness of less than 4 m (Macgregor and Anderson, 1923; Cameron *et al.,* 1998). However, close to Bathgate, where the volcanics are present, the limestone thickens rapidly and then more gradually thins northwards. This unusual and thicker development of the Petershill Limestone accumulated in the shallower water around a submarine high formed by the volcanics.

The Petershill Limestone formed during a relatively quiescent phase in the volcanic activity. The lavas, which underlie this marine limestone, are overlain by a sequence of tuffs and sandstones with plant rcmains. Thcsc indicatc a prolonged period of subaerial weathering prior to the marine transgression. Marine deposition commenced with the formation of a thin dark shale that passed up into the calcareous mudstones and argillaceous limestones of the basal parts of the Petershill Limestone. These appear to have formed in a shallow lagoonal environment (Jameson, 1987). As the transgression continued, purer limestones were deposited in the southern part of the outcrop (Jameson, 1987). Representatives of both the argillaceous limestones and the purer limestones are seen on the eastern bank of the Petershill Reservoir Quarry.

Following a subsequent regressive episode, during which the erosion surface at Rifle Range Quarries was formed, a more varied suite of carbonates were deposited. In particular, the heterogeneous packstones of the Rifle Range Quarries were deposited in a shallow-water nearshore area, which was subject to relatively high-energy conditions. The turbulence caused movement of crinoid debris, overturning of corals and the disarticulation and stacking of gigantoproductid valves. These carbonate shoals protected a landward lagoon in which argillaceous limestones and calcareous mudstones, similar to those at the base of the Petershill Limestone, continued to form (Jameson, 1987). At the same time, but on the seaward side of the shoals and in slightly deeper water, the growth of sponges, bryozoans and algae contributed to the development of the massive limestones that formed the core of the biohermal buildup at Petershill Reservoir Quarry (Jameson, 1987). Jameson (1987) has found evidence from geopetal structures to indicate that the buildup had a relief of 1.5–2 m above the local sea floor and that the flanks sloped at about 10° to 12°. The sequence of assemblages within the bioherm indicates an initial pioneer community colonizing an area of algally stabilized sediment and building up a low mound. The increased abundance and diversity of the fauna led to rapid in-situ accumulation and stabilization of the mound. Continued upward growth, however, exposed the mound to increased current activity and led to the formation of the crinoidal beds, which cover the mound. These show that the mound was not able to withstand significant current activity.

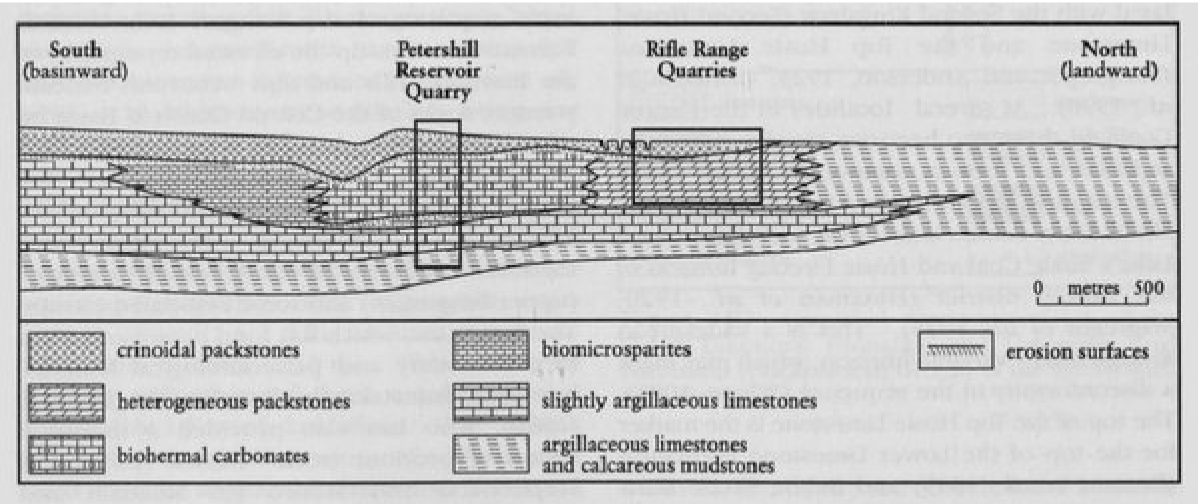
The erosion surfaces at the top of the Petershill Limestone indicate regressive phases of erosion and subaerial exposure separated by a minor transgression during which crinoidal grainstones formed (Jameson, 1987). The fissures preserve in their infill sedimentary material, which is not preserved elsewhere, and which indicates the prolonged nature of these two events. The presence of tuffaceous material in the fissures indicates some volcanic activity. Intermittent volcanic activity also took place during the deposition of the limestone since the impersistent clay wayboards are bentonite horizons resulting from the alteration of ash-fall deposits (Stephenson and Monro in McAdam and Clarkson, 1986; Jameson, 1987).

The faunas of the Petershill Limestone are not only of great palaeoecological importance but are also of immense taxonomic significance. This is the source horizon for the type material of a number of important and well-known corals including *Actinocyathus floriformis, Aulophyllum pachyendothecum, Koninckophyllum ecbinatum* and *Caninia juddi* (Hill, 1938–1941), and Parks (1954) based his study of morphological variation in *Aulophyllum pachyendothecum* on material from Petershill Reservoir Quarry. Hinde (1887–1912) used material from Petershill in his description of the sponge *Hyalostelia,* and Davidson (1851–1886, 1860) also used material from this area in brachiopod descriptions. Clark (1960) described conodonts from the Petershill Limestone, and Latham (1932) lists ostracode species from quarries in the limestone. Fleming's (1825) description of *Dentalium indistincta* (= *Sphenothallus indistincta*) is most probably based on Petershill material (the first scientific description of a sphenothallid tube) and, in addition, spirorbid worm tubes have been recorded from the Petershill Limestone by Etheridge (1880). The foraminiferal assemblage indicates a late Viséan age for this unit (Jameson, 1980).

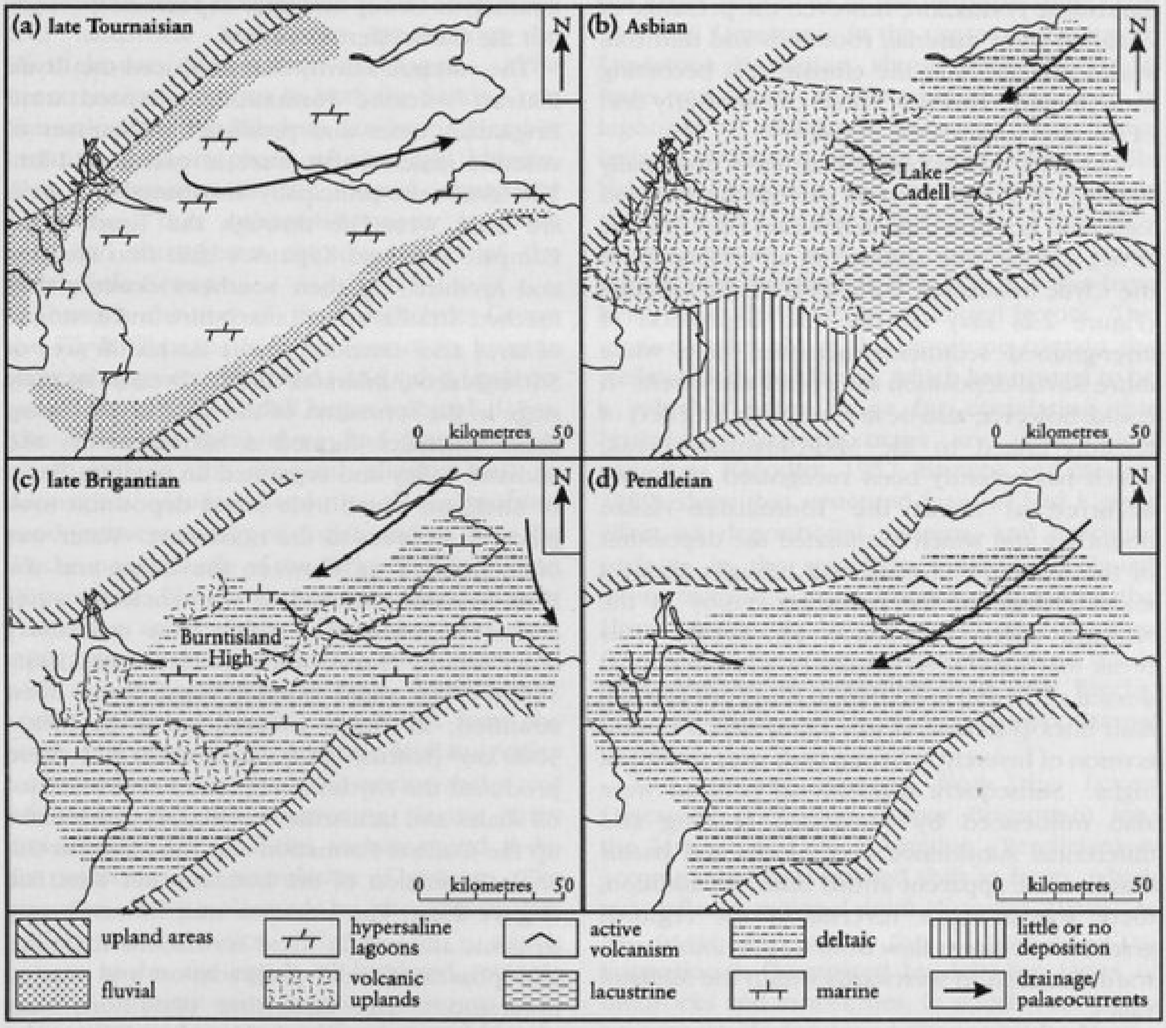
Conclusions

The Petershill GCR site is a classic and important site famous for its Lower Carboniferous fossils and its carbonates. The Petershill Limestone (upper Brigantian) lies within the predominantly volcanic sequence of the Bathgate Hills Volcanic Formation and shows clearly the effect of volcanism on local sedimentation. The lateral and vertical facies variations within the Petershill Limestone are of immense interest to carbonate sedimentologists and palaeontologists. The limestone comprises a unique biohermal buildup with a diverse, abundant and well-preserved fauna, and a laterally equivalent facies of coarsely bedded limestones with corals and gigantoproductids that were deposited on an adjacent shoal area. The faunas of the Petershill Limestone remain of great palaeoecological, stratigraphical and taxonomic significance.

References



(Figure 2.23) Schematic north-south cross-section showing facies distributions in the Petershill Limestone (upper Brigantian) at the Petershill GCR site, Bathgate. After Jameson (1987).



(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).