Marloes

[SM 7780 0772]–[SM 7882 0715]

Introduction

The region of Pembrokeshire to the south of Haverfordwest is divided into five structural areas by broadly east–west trending faults (see e.g. Sanzen-Baker, 1972). The Silurian rocks exposed at Marloes Sands are representative of the succession in the Marloes structural block, delimited in the north by the Musselwick Fault and to the south by the Ritec Fault (Figure 3.18), (Figure 4.23). The Silurian age of these strata was recognized by Murchison (1839, pp. 391–3) and the sections were logged by De la Beche (1846, pp. 25–8), who coined the term 'Coralliferous Series' for the conspicuous grey unit within the sequence that contains abundant shelly fossils, including corals.

The first full accounts of the local succession, together with a review of earlier literature, were provided by Cantrill *et al.* (1916) in the Milford Memoir of the Geological Survey. These authors allocated the strata in Marloes Bay and immediately inland to four units: the 'Skomer Volcanic Series', which they regarded to be of early Ordovician age; the 'Conglomerate Series' of late Llandovery age; the 'Coralliferous Series' of 'Wenlock and Woolhope' age; and the 'Sandstone Series', which they considered to be chiefly Ludlow in age. Ziegler *et al.* (1969) later demonstrated that the Skomer Volcanic Series graded upwards and laterally into the Conglomerate Series and combined the two in the Skomer Volcanic Group. Ostracods found within the lower part of the group on Midland Island [SM 7463 0901] suggest a Silurian age (Ziegler *et al.,* 1969), and Llandovery fossils are common in the upper beds. The entire group, or most of it, is therefore probably of Llandovery age.

The Coralliferous Series was renamed the Coralliferous Group by Walmsley and Bassett (1976) to accord with modern stratigraphical terminology. The unit can be seen to lie unconformably on the Skomer Volcanic Group on the south-east side of Renney Slip [SM 7600 0865] and at Marloes Sands [SM 7870 0725], but the contact is complicated by a small fault at the latter locality (Cantrill *et al,* 1916; Ziegler *et al.,* 1969). The lower part of the Coralliferous Group contains Llandovery macrofossils (Cantrill *et al.,* 1916), and conodont microfaunas indicate that the group spans the Llandovery–Wenlock boundary (Mabillard and Aldridge, 1983).

The exposures in Marloes Sands are transected by several faults (Figure 3.19), but an almost unbroken sequence of excellent and accessible cliff exposures is available from within the upper part of the Skomer Volcanic Group to the top of the Coralliferous Group from [SM 7849 0741] to [SM 7882 0715]. Additional fault-bounded exposures of the Coralliferous Group occur at the western end of the bay [SM 7780 0772]–[SM 7811 0765] and at Mathew's Slade [SM 7837 0748]. Together these exposures provide the most complete accessible section through the Llandovery and early Wenlock strata of Pembrokeshire. Fossils date the upper beds of the Skomer Volcanic Group as Aeronian in age; the Coralliferous Group begins in the upper part of the Telychian and extends into the lower Wenlock (see (Figure 4.24)).

This is a site of major national importance, showing the development of sedimentary and volcanic facies on the southern margin of the Welsh Basin. Fossils occur throughout the succession, but are more abundant and diverse in the Coralliferous Group. The unconformity between the Skomer Volcanic Group and the Coralliferous Group is of regional tectonic significance, and is related temporally to a period of southerly-sourced turbidite deposition in the Welsh Basin to the north.

Description

Only the upper part of the Skomer Volcanic Group is exposed at Marloes Sands; lower units crop out in the cliffs around Woolsack Point at the western end of the Marloes Peninsula [SM 755 094] and on Skomer and Midland islands west of the peninsula. The total thickness of the group is approximately 1000 m (Ziegler *et al.,* 1969). The oldest beds in Marloes Bay are at the eastern side of Mathew's Slade [SM 7845 0742], where about 6 m of arkosic sandstones overlain by a basalt flow can be seen in a heavily faulted outcrop (Ziegler *et al.,* 1969). Immediately to the east the more completely

exposed and nearly vertically inclined succession begins with a grey sandstone followed by two basalt flows, the Lower and Upper Marloes basalts (Figure 3.20). The lower basalt is 23 m thick (Ziegler *et al.,* 1969) with a vesicular base and a reddened top; the upper flow is 19 m thick and also displays a vesicular base (Ziegler *et al.,* 1969). Above the basalts are up to 3 m of thin- to medium-bedded sandstones and siltstones, largely faulted out, followed by a 9 m thick conglomerate containing quartz and rhyolite pebbles. The remainder of the Skomer Volcanic Group, some 150 m in thickness, comprises sandstones, silty mudstones and conglomerates with numerous tuffaceous bands; a measured section was provided by Ziegler *et al.* (1969, pp. 432, 434). Several of the siltstone and sandstone beds show scoured bases, rippled tops and bioturbation. Some 70 m above the basalts is a prominent 6 m band of brecciated tuff with a rippled upper portion (Ziegler *et al.,* 1969; Siveter *et al.,* 1989). Fifteen metres above the tuff and 57 m below the top of the Skomer Volcanic Group, three prominent sandstone beds, almost vertical and separated by dark siltstones, form a landmark known as the Three Chimneys [SM 7860 0732]; (Figure 3.21).

Fossils occur in some of the mudstones and siltstones and in rare calcareous beds; there is a general increase in the number and diversity of organisms towards the top of the Skomer Volcanic Group. The most characteristic fossil is the brachiopod *Lingula,* and some horizons yield little else; these were referred to a restricted *Lingula* benthic community by Ziegler *et al.* (1969). The more diverse fauna, referred to as a diverse *Lingula* community, also contains strophomenid and rhynchonellid brachiopods, favositid corals, tentaculitids, crinoid columnals, bivalves and gastropods (Ziegler *et al.,* 1969; Siveter *et al.,* 1989). Conodont elements have been recovered from limestone ribs and lenses near the top of the group, with *Pranognathus tenuis* characteristic (Aldridge, 1985). The fossil evidence all indicates an early Aeronian age for the upper beds of the Skomer Volcanic Group.

The unconformity at the base of the Coralliferous Group is accompanied by an angular discordance of 5–10°, similar to that recognized at the better-exposed section in Renney Slip, 3 km to the WNW Above the unconformity the lowest 10 m of the Coralliferous Group comprises sandstones and conglomerates with large asymmetric ripples, which pass upwards into hard blue-grey silty cleaved mudstones with shelly limestone lenses and thin sandstones (Siveter *et al.,* 1989). Occasional metamorphosed bentonite bands and tuffaceous horizons also occur. The entire group is about 100 m thick (Cocks *et al.,* 1992).

The conglomeratic basal beds contain only rare fossils (Sanzen-Baker, 1972), but the rest of the Coralliferous Group is richly fossiliferous. Lists of macrofossils have been provided by Cantrill *et al.* (1916, pp. 66–7) and by Walmsley and Bassett (1976, p. 201). The fauna is dominated by diverse brachiopods and corals, but also includes trilobites, crinoids, bryozoans, orthocones, bivalves, gastropods, tentaculitids and cornulitids. In the lower beds, *Eocoelia sulcata* and the solitary rugose coral *Palaeocyclus porpita* occur, with *Costistricklandia lirata lirata* abundant a little higher; this fossil assemblage indicates a late Telychian age. *Costistricklandia* decreases in abundance above 30 m and is absent from the upper half of the Coralliferous Group. Hurst *et al.* (1978) reported *E.* cf. *sulcata* and *P. porpita* 2 m below the top of the group, indicating that the entire unit is close to the Llandovery–Wenlock boundary. This age is supported by the abundant conodont elements reported from limestone lenses through the lower 70 m of the group by Mabillard and Aldridge (1983); these include *Pterospathodus amorphognathoides, Kockelella ranuliformis, Distomodus staurognathoides, Apsidognathus ruginosus,* and *Icriodella? sandersi.* The Coralliferous Group at Marloes Sands is the type locality for the conodont species *Apsidognathus ruginosus* Mabillard and Aldridge, 1983, and *Icriodella? sandersi* Mabillard and Aldridge, 1983, and for the stratigraphically important brachiopod *Costistricklandia lirata lirata* (J. de C. Sowerby, 1839). Siltstone samples from the section have also yielded small numbers of blackened, poorly preserved acritarchs, with *Domasia trispinosa, Micrhystridium stellatum* and *Veryhachium trispinosum* identified in the lower half; blackened, fractured remains of scolecodonts and possibly of chitinozoans also occur in palynological preparations (Mabillard and Aldridge, 1983).

Interpretation

Murchison (1839, pp. 392–3) originally regarded the Marloes basalts as intrusive, but subsequent workers (e.g. Cantrill *et al.,* 1916; Ziegler *et al.,* 1969) have recognized their extrusive features, including the reddened upper surfaces of the individual flows. The basalts flowed into a transgressive sea, with the flows gradually submerged by a sequence of transgressive sediments (Bridges, 1976). Bridges (1976) intepreted the beds immediately above the Marloes basalts as

representing a lagoon to barrier island to offshore marine sedimentary sequence (Figure 3.22), and identified other comparable sequences within the Marloes Sands succession; these environmental sequences can be correlated westwards into other successions at Anvil Bay [SM 7565 0884] and Renney Slip [SM 7604 0876]. The lagoonal deposits are dominantly muddy with some silts and sands; burrowed horizons with small phosphatic nodules compare with the intense bioturbation in modern lagoons, where phosphatization is known to occur in semi-arid hypersaline conditions (Phleger and Ewing, 1962, cited in Bridges, 1976). Restricted marine conditions are also indicated by the very low diversity shelly fauna, dominated by the euryhaline *Lingula.* The barrier island conglomerates and sandstones range in thickness from 0.15 m to 9.0 m, with granules and pebbles concentrated into lenticles; large symmetrical ripples are suggestive of wave reworking close to the shoreline. Fossils are rare in these coarser sediments, and specimens are broken and abraded. The open marine sediments comprise fossiliferous sandstones and mudstones, and dominate the upper part of the Skomer Volcanic Group section in Marloes Sands. A richer fauna is present than evident in the lagoonal facies, and includes brachiopods, corals, crinoids and conodonts.

The evidence from macrofossils and from conodonts is that the unconformity at the base of the Coralliferous Group cuts out all or most of the upper Aeronian and much of the Telychian. The top of the Skomer Volcanic Group is an erosion surface; reddening of the uppermost 50 cm suggests that erosion was subaerial, at least in the latest stages (Sanzen-Baker, 1972). The presence of this intra-Llandovery unconformity attests to an interval of local uplift; this has been ascribed to the initial phases of Avalonian and Laurentian plate collision by Soper and Woodcock (1990).

The basal conglomerates of the Coralliferous Group suggest origin on a shoreline, with rapid transgression above shown by the development of a *Costistricklandia* benthic community (Ziegler *et al.,* 1969). Many of the fossils are concentrated in shelly lenses, suggesting transport during storm conditions. Shallowing in the upper part of the group is indicated by the incoming of coarser sediments and a change in brachiopod faunas (Siveter *et al.,* 1989); shallow water may also be indicated by the development of a prominent bed of algal oncolites in the upper part of the unit.

Structural features throughout the section give evidence of the tectonic history of the Pembrokeshire area, and particularly of the Marloes block. Small faults, en echelon tension gashes and other features give evidence of Variscan S–N compression, and there is a pervasive cleavage. At the Three Chimneys, an anomalous bedding/cleavage relationship occurs, which suggests younging to the north-west in beds that can be observed to young to the southeast. This has been explained by the tectonic tilting of the Skomer Volcanic Group prior to deposition of the Coralliferous Group and the subsequent development of the Variscan cleavage (Graham *et al.,* 1977).

Altogether, the Marloes Sands sections provide excellent evidence of the volcanic, sedimentological, palaeoenvironmental and tectonic history of this area of South Wales. The sequence contrasts with that of the Haverfordwest area to the north of the Variscan deformation front in Pembrokeshire (see site description for Gasworks Lane), where a quieter, more offshore, depositional environment obtained, and where there is little evidence of volcanicity. Basalts and tuffs in the Skomer Volcanic Group of Marloes Sands and other nearby exposures give direct evidence, along with the Telychian site at Cullimore's Quarry and the Wenlock site at Moons Hill Quarry, of the extent of early Silurian volcanicity in the southern part of the Welsh Basin. The unconformity between the Skomer Volcanic Group and the Coralliferous Group coincides with the initiation and development of southerly sourced turbidite flows into the Welsh Basin, as seen at Aberarth and Aberystwyth; these features may all be related to uplift resulting from plate collision.

The succession at Marloes Sands extends into younger Silurian units, the Gray Sandstone Group and the Red Cliff Formation, which are described and discussed in later chapters of this volume (see site report for the Wenlock strata of Marloes in Chapter 4).

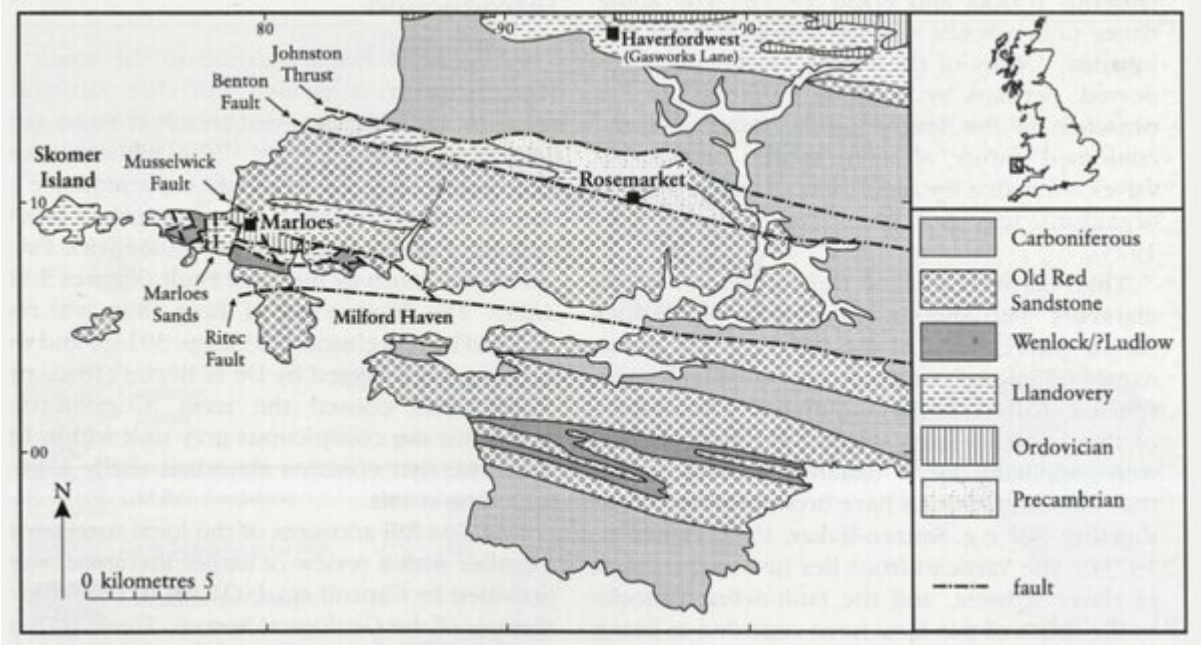
Conclusions

This site provides continuously exposed, excellent representative sections through the upper part of the Skomer Volcanic Group and the entire Coralliferous Group, and exemplifies the unconformable relationship between the two units. There is a long history of study of these classic exposures, beginning with Murchison (1839). The sedimentary successions enable interpretation of the environmental conditions along the southern margin of the Welsh Basin, and there is a rich

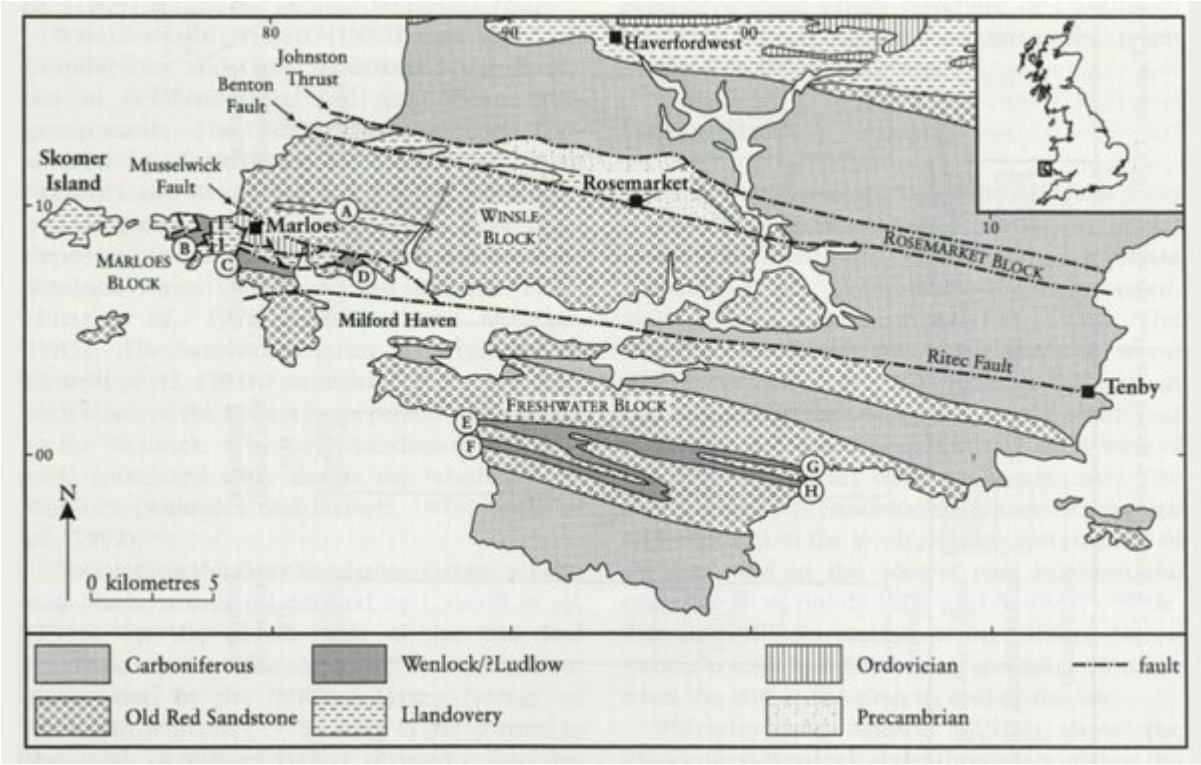
and diverse macrofauna and microbiota. The Skomer Volcanic Group records the development of early Silurian volcanic islands in this area and, with other sites on the southern margin of the Welsh Basin, gives evidence of the extent of Silurian volcanism in this region. The Coralliferous Group records somewhat deeper environments of deposition, lacking volcanic activity except for occasional ash-falls, and hosting a varied fossil fauna dominated by corals, brachiopods and conodonts. In addition, structural features provide evidence of the local and regional effects of late Carboniferous (Variscan) folding and faulting.

These natural exposures provide a very valuable national teaching and research resource, and are also frequently visited by overseas specialists.

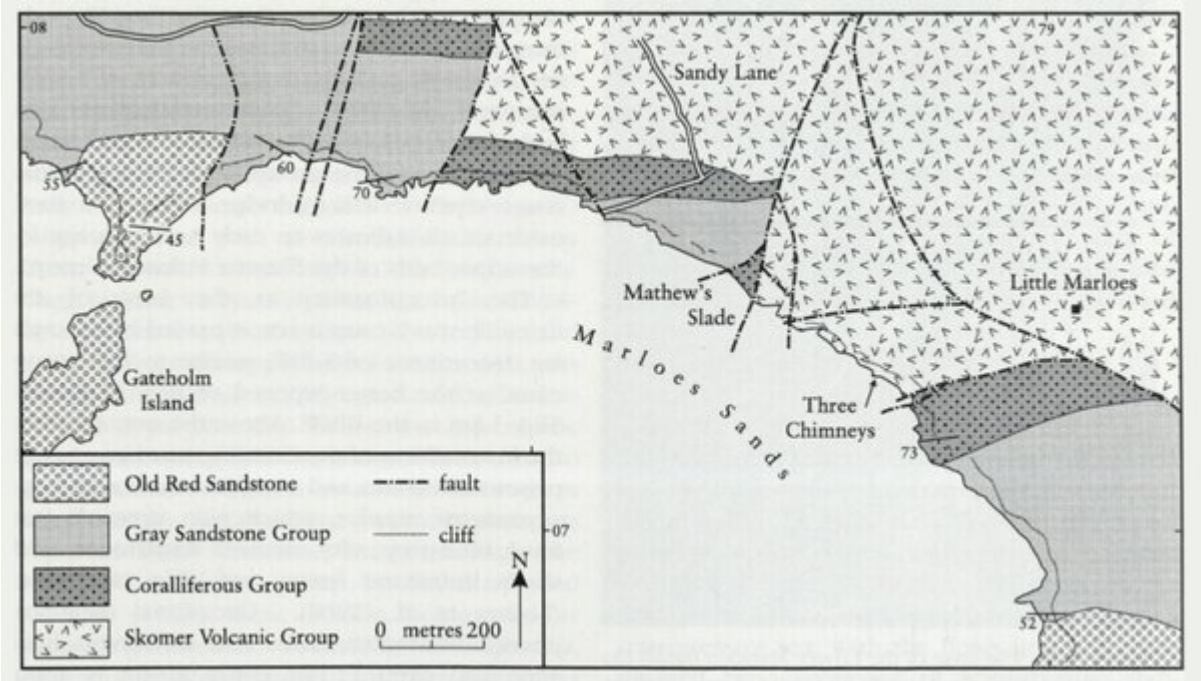
References



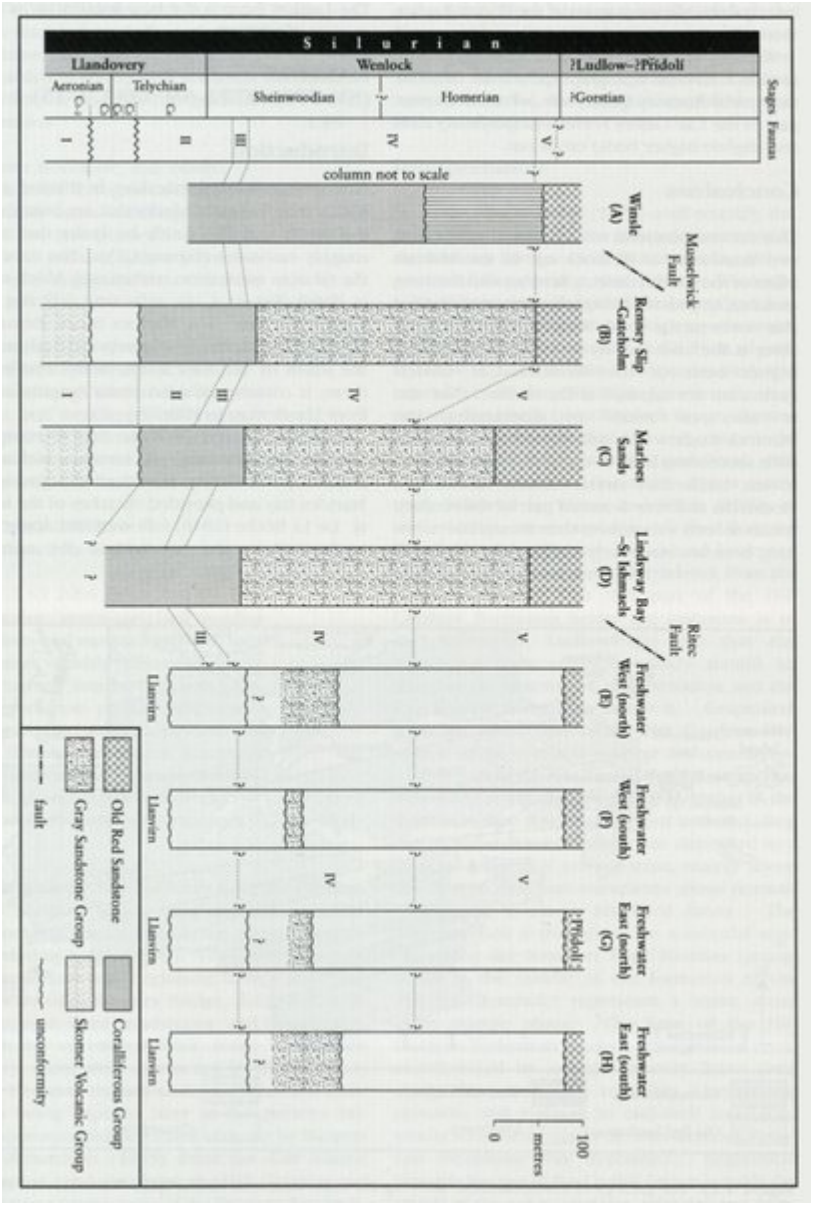
(Figure 3.18) The geology of southern Pembrokeshire, showing the major structural blocks, the important faults, and the network localities at Gasworks Lane (Haverfordwest) and Marloes Sands; modified after Sanzen-Baker (1972).



(Figure 4.23) The geology of Pembrokeshire, showing the main structural blocks (after Walmsley and Bassett, 1976). The letters A-H refer to the successions in Figure 4.24.



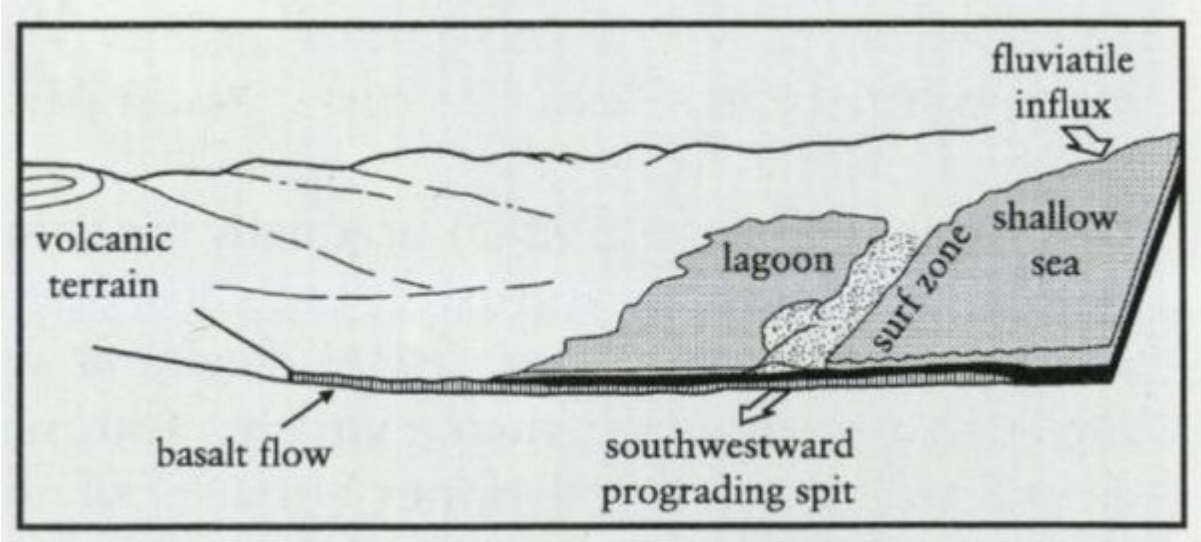
(Figure 3.19) Geological map of Marloes Sands (after Walmsley and Bassett, 1976).



(Figure 4.24) Correlation of Silurian sections in Pembrokeshire (after Walmsley and Bassett, 1976). Sections A–H are located on Figure 4.23.

(Figure 3.20) The base of the Lower Marloes Basalt (to the right), within the Skomer Vocanic Group, Marloes Sands. (Photo: R. J. Aldridge.)

(Figure 3.21) Marloes Sands, with the Skomer Volcanic Group, including the Three Chimneys, to the left and the Coralliferous Group, dipping at a lower angle, to the right. (Photo: R. J. Aldridge.)



(Figure 3.22) Reconstruction of the depositional environment of interbedded sediments and volcanic rocks in the lower part of the Skomer Volcanic Group, Marloes (after Bridges, 1976).