St Non's Bay and Caerfai Bay

[SM 752 242]–[SM 763 241]

Introduction

The cliffs between St Non's Bay and Caerfai Bay provide a nationally important section through the lower parts of the classic Cambrian sequence in South Wales, ranging from the basal Cambrian unconformity, through the Caerfai Group (Comley Series, Lower Cambrian) and Solva Group into the base of the Menevian Group (St David's Series, Middle Cambrian). Because of the good exposure, the St David's area lends itself to demonstration of stratigraphical and sedimentological features. Excursion guides and geological accounts have been published by Green (1911a), Cox *et al.* (1930a, b), T. R. Owen *et al.* (1971), Stead and Williams (1971) and Williams and Stead (1982). In 1973 the British Geological Survey published a geological map, and Rushton (1974) summarized stratigraphical information on the area.

Description

The cliff sections from St Non's Bay to Caerfai Bay expose most of the divisions of the Lower to Middle Cambrian succession (Figure 4.2), (Figure 4.3), (Figure 4.4). Towards the west end of the section, tuffs of the Pebidian Volcanic Group can be seen dipping vertically or overturned slightly to the north. They consist of green and white colour-banded rhyolites and halleflintas. Similar deposits can be seen seawards across the foreshore, although there the tuffs are red or purple. The basal Cambrian conglomerate is in contact with the tuffs at an E–W trending ridge on the foreshore below St Non's Chapel and can be seen to the east on several sea stacks. The base is sharp and slightly overturned to the north, though angular discordance across the contact is difficult to observe. The cliff section at the natural arch in St Non's Bay shows vertically banded Pebidian volcanic tuffs thrust over the Cambrian conglomerate in the lower part of the cliff face, which is in turn thrust over the stratigraphically overlying green sandstones of the St Non's Bay Sandstone. This graphic section has been described and illustrated several times (e.g. Geikie, 1883; Hicks, 1884; Green, 1911a). The conglomerate is massively bedded and clast-sup-ported, with well-rounded clasts, often haematite coated, that include quartz pebbles up to 10 cm in diameter at the base and occasional pebbles of vein quartz and acid igneous rocks. Towards the top of the conglomerate, which is variable in thickness, pebbly beds with a grain size of about 1 cm are followed by finer units that often show large-scale cross-stratification.

All the higher divisions of the Caerfai Group can be seen in the cliffs around St Non's Bay but are more accessible in Caerfai Bay. The St Non's Bay Sandstone, exposed at the northern end of Caerfai Bay, consists of soft, green, medium- to coarse-grained feldspathic sandstones containing epidote and chlorite, and include subsidiary siltstones. The strata dip south at 70° to 80°. Beds are generally less than 1 m thick and are massive and unfossiliferous; most are structureless, but large-scale tabular cross-stratification can be seen in some sandstones, while some siltstones show climbing ripple cross-lamination. One bed on the east side of the bay has an irregular base with a channel cutting down into the sandstone below. The channel-fill consists of cross-laminated sandstone and the rest of the bed is homogenized. Trace fossils include *Skolithos,* U-shaped burrows filled with coarse sediment, and escape burrows showing backfill structures.

The uppermost part of the St Non's Sandstone consists of purple siltstones, some units of which are bioturbated, show *Skolithos* burrows, and are cemented by calcite (Turner 1979). These appear to pass up rapidly into the Caerfai Bay Shales, which are about 15 to 25 m thick (Turner 1979; Landing *et al.* 1998), and consist of cleaved mudstones of a distinctive brick-red colour that show little internal structure because they are homogenized by ubiquitous bioturbation. Williams and Stead (1982) recorded the feeding burrow *Teichichnus.* There are several interbeds of water-laid crystal tuffs up to 8 cm thick. Internally these show cross-lamination and convolute lamination, and commonly have sharp erosive bases, sometimes with load casts or a coarse basal lag (Turner 1979; Williams and Stead 1982). The tops may show an irregular bioturbated top with parallel laminated sand and mud above. The tuff beds, which are the first indication of contemporaneous volcanic activity in the Cambrian of South Wales, have yielded a radiometric age of 519 ± 1 Ma (Landing *et al.* 1998).

The Caerfai Bay Shale is the lowest horizon in Pembrokeshire from which fossils have been obtained, although from localities other than Caerfai Bay. Hicks (in Harkness and Hicks, 1871, p. 396) recorded brachiopods (*Lingulella primaeva* Hicks) and an ostracod ('*Leperditia?*'*cambrensis* Hicks). Siveter and Williams (1995) made further collections, discussed below.

The red shales pass gradually up into the purple Caerbwdy Sandstone. The transition has thin (1–2 cm) purple sandstone beds that become commoner and thicker upwards. When fully developed, the Caerbwdy Sandstone consists of unfossiliferous fine- to medium-grained, thickly bedded (up to 1 m), massive sandstones. They have been quarried locally for building-stone. The sandstones are usually poorly sorted and are micaceous, feldspathic and somewhat argillaceous. Cross-bedding and graded bedding occur very occasionally, and some beds show ripple cross-laminated and parallel-laminated intervals with muddy drapes. Bioturbation is common, with *Skolithos* and bedding-parallel burrows present. Near the junction with the overlying Solva Group some beds become pebbly, with rounded quartz grains and igneous fragments.

The junction of the Solva Group and Caerbwdy Sandstone is exposed on the east side of Caerfai Bay [SM 7617 2420]. It was here that Jones (1940) cited evidence for an unconformity between the Solva and Caerfai groups. He interpreted an offset in the base of the Solva Group as an erosional contact on the uneven surface of Caerbwdy Sandstone, with a considerable break in deposition. However, Stead and Williams (1971) suggested that this contact is faulted, and reported a more gradual transition from purple to green beds higher in the cliff-face that can be verified also on the west side of the bay [SM 7578 2411], where the transition is not complicated by faulting. This is in agreement with the boundary seen at Trwyncynddeiriog (see site report, below).

Towards Pen y Cyfrwy, the western headland of Caerfai Bay, beds of the lower Solva Group are gently folded and faulted against the Caerbwdy Sandstone. The lower beds consist of green, medium-bedded, coarse to pebbly sandstones, intercalated with finer sandstones and thin mudstones. The thicker sandstones often show truncated tabular cross-stratification on a large scale, while finer units may show ripple cross-lamination. The pebbly units disappear up sequence, giving way to thinly bedded sandstones, siltstones and mudstones. Fossils occur at about this level at Trwyncynddeiriog.

The stratigraphy of the remainder of the Solva Group around Caerfai Bay is affected by strike-faulting. On the east side (Figure 4.4) the cliffs are made up of steeply dipping, fine- to medium-grained green sandstones in thick, massive beds that generally lack sedimentary structures. Thickly bedded green and purple sandstones representing part of the middle Solva Group extend south to a major strike fault that runs across the headland, south of which the Menevian Group is exposed dipping south at about 40°. The latter consists of dark- and light-grey mudstones typical of the group (see Porth-y-rhaw) and is overlain by a felsite sill. Towards the sill, where the beds are thermally spotted and bleached, are localities that yielded *Onymagnostus barrandei* (Hicks) and good material of *Plutonides hicksii* (Salter) to Salter and Hicks (1869, pl. 3).

Interpretation

This site provides the best stratigraphical section through the lower parts of the Cambrian sequence in South Wales, from the basal Cambrian unconformity upwards. The unconformable nature of the contact of the basal conglomerate of the Caerfai Group on the Precambrian Pebidian Volcanic rocks is difficult to ascertain in natural exposures, and in many places the contact is clearly faulted. However, Green (1908), by detailed mapping of subdivisions of the Pebidian Volcanic Group, was able to demonstrate regional unconformity; he also made a trench that exposed an unconformable contact between the Cambrian conglomerate and the underlying Dimetian granophyre, which intrudes the Pebidian Group. The coarse nature of the basal conglomerate and large-scale cross-stratification in the finer beds indicate that it was deposited in shallow-water, posibly intertidal, environments (Crimes, 1970a). 'Orientation of the tabular cross-bedding suggests transport from the NNE. Many clasts in the conglomerate are derived from the Pebidian volcanics, but pebbles of Dimetian granophyre are practically unknown.

The St Non's Bay Sandstone was deposited in shallow water. The presence of cross-bedding limited to channel-fillings and the escape burrows indicate rapid deposition of individual beds. Most of the sandstones were presumably intensely

bioturbated in well-oxygenated environments. Although all earlier workers reported a gradational contact between the St Non's Sandstone and the Caerfai Bay Shales, Landing *et al.* (1998) interpreted the top bed of the St Non's Sandstone as a caliche horizon (presumably indicative of subaerial erosion in a hot arid climate) and interpreted the contact with the overlying Caerfai Bay Shales as an unconformity which they compared with the unconformity at the base of the Branchian in south-eastern Newfoundland. However, published maps of the St David's peninsula (British Geological Survey 1973) offer no evidence to suggest an unconformity between the two formations across their entire outcrop, and Landing *et al.*'s suggestion remains to be documented.

Compared with the St Non's Sandstone, the finer grain-size of the Caerfai Bay Shales implies less energetic environments of deposition, though the sedimentary structures in the tuff beds indicate origins from waning flow events, such as storms. The red colour of the mudstones was shown by Turner (1979) to be caused by diagenetic alteration of iron silicates in oxidizing conditions; he surmised that reducing conditions were not developed because organic productivity was low or because the organic matter present was oxidized before burial of the sediment.

Features of the Caerbwdy Sandstone again indicate rapid deposition in high-energy environments. Crimes (1970a, fig. 27) suggested that deposition took place below wave-base, and that the whole Caerfai Group therefore appears to show a transgressive sequence with deposition in a gradually deepening sea. However, the presence of *Skolithos* burrows in the Caerbwdy Sandstone suggests shallow-water deposition, comparable to that in the overlying Solva Group.

The identification of the bradoriid arthropod *Indiana lentiformis* (Cobbold) in the Caerfai Bay Shales has for the first time provided a correlation with the Callavia Sandstone (Ac2) of the Comley succession in Shropshire (Siveter and Williams, 1995) and allows correlation of the Caerfai Bay Shales with the Branchian Series. The underlying divisions of the Caerfai Group, are, by inference, also referred to the Lower Cambrian. However, the correlation of the Caerbwdy Sandstone in relation to the Comley–St David's series boundary remains conjectural. Locally the lower beds of the Solva Group yield the oldest trilobite faunas known from South Wales, which represent the *oelandicus* Zone (see Trwyncynddeiriog site report) and allow reference of the whole Solva Group succession to the St David's Series.

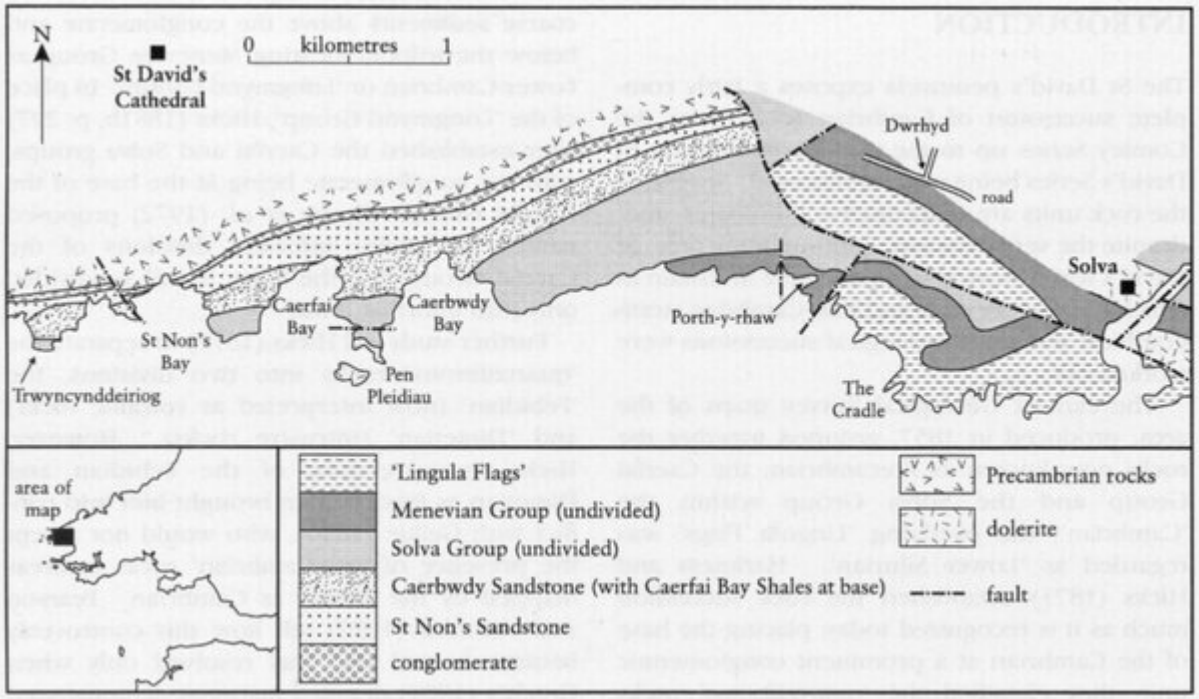
Although there has been discussion over the nature of the boundary between the Caerbwdy Sandstone and the lower Solva Group, most evidence indicates that sedimentation was continuous, though development of pebbly beds may indicate shallowing. However, the succession higher in the Solva Group at this site is much affected by strike-faulting, and the transition upwards into the Menevian Group is faulted out. Sedimentary structures and *Skolithos* burrows in the sandstones of the lower Solva Group suggest energetic deposition above wave-base (Crimes, 1970a). Features in the middle Solva Group suggest similarly rapid deposition of the sandstones, with quieter environments for deposition of the finer sediments. Crimes (1970a) identified a source of sediments to the south-east.

The Menevian Group is represented only by the lower part of the group, referable to the *fissus* Zone. The Menevian is considered further in the Porth-y-rhaw site report (see below).

Conclusions

The extensive coastal exposures from St Non's Bay to Caerfai Bay provide the best and most instructive section through the lower parts of the Cambrian sequence in South Wales. The lowest beds, deposited in shallow water after erosion of the underlying Precambrian volcanic rocks, are the representatives of the Lower Cambrian marine transgression. The general upward succession of the Caerfai Group, the conglomerate, green sandstones and red shales, appear to represent deposition in shallow, though progressively deeper, water. The red shales contain the only fossils that demonstrate the presence of Lower Cambrian rocks in South Wales and also contain volcanic ash that has been dated as 519 million years old. After an episode of shallowing around the boundary between the Caerfai and Solva groups, the overlying succession, which contains Middle Cambrian fossils, suggests a second cycle of gradual deepening.

References



(Figure 4.2) Sketch of the Cambrian geology between St David's and Solva, south-west Wales, after the British Geological Survey (1973), with locations of the GCR sites.

(Figure 4.3) St Non's Bay, a classic section in the St David's area, looking east. To the left of the sea-cave (centre) are Pebidian rocks (Precambrian). To its right is the basal conglomerate of the Caerfai Group, overlain by the St Non's Sandstone, both slightly overturned to the south. The outcrop of the red Caerfai Bay Shale is below where the stone wall descends to the cliff-top, and the dark cliffs to the extreme right are made up of Caerbwdy Sandstone. (Photo: British Geological Survey photographic collection, A6083.)

(Figure 4.4) Caerfai Bay, looking east. Thickly bedded Caerbwdy Sandstone dips steeply to the South, overlain by more thinly bedded units of the Solva Group, a considerable part of which is faulted out. At the extreme right is a dolerite intrusion associated with part of the Menevian Group. (Photo: British Geological Survey photographic collection, A6088.)