
Porth-y-rhaw

[SM 783 243]–[SM 786 241]

Introduction

Porth-y-rhaw is a classic geological locality of international importance. It exposes a fairly continuous sequence of strata from beds of the upper Solva Group up through the Menevian Group (St David's Series, Middle Cambrian). These rocks have yielded trilobite faunas ranging from an approximate equivalent of the *gibbus* Zone up to the *punctuosus* Zone and comprise one of the most complete zonal sequences for the Middle Cambrian known in Britain. The trilobite faunas enable correlation with strata both in Britain and elsewhere, and the site is the type area for several species of trilobites and other groups.

Salter discovered the locality of Porth-y-rhaw by accident in 1862, when he was mistakenly taken there by boat instead of to Solva Harbour. His discovery of the giant trilobite *Paradoxides davidis* and a prolific associated fauna (Salter, 1863, 1864b) enabled him to distinguish the beds from the 'Lingula Flags', and the name 'Menevian' was introduced for them by Hicks and Salter in 1866. Hicks subdivided the Menevian Beds into three divisions:

3. sandstones and shales with *Orthis hicksii*,
2. black flags and shales with *P. davidis*, and
1. grey flags with *P. hicksii*.

All three can be seen at Porth-y-rhaw. These divisions remain only as informal units, referred to as 'lower', 'middle' and 'upper' Menevian.

The locality is mentioned in accounts of the St David's area, notably by Cox *et al.* (1930a), who described the succession in detail, and in guides to the area (Cox *et al.*, 1930b; Owen *et al.*, 1971; Stead and Williams, 1971; Williams and Stead, 1982). Numerous fossils have been collected, and many museums house material from Porth-y-rhaw, but most valuable are the stratigraphically systematic collections of Lewis (unpublished; Jefferies *et al.*, 1987, p. 438) in the National Museum of Wales.

Description

Porth-y-rhaw is a small coastal inlet, on the eastern side of which the type section of the Menevian Group is exposed (Figure 4.6). The cliffs to the west expose the upper part of the Solva Group, which passes gradually upwards into beds of the lower Menevian Group (which they closely resemble), the boundary being poorly defined by Hicks (1881b, p. 298). To the east of the inlet (Figure 4.7) a normal fault throws the upper Menevian Group against the 'Lingula Flags'.

At the inland end of Porth-y-rhaw are grey flaggy sandstones and mudstones of the upper Solva Group overlain by the lower Menevian Group. The rocks are generally vertical or dip south at 80°. Though affected by minor faults, the succession is relatively complete. Green-grey sandstones and siltstones predominate and are medium- to coarse-grained, massive and thickly (10–50 cm) bedded. They often contain large horizontal and vertical burrows filled with dark-grey mudstone, some of which show back-fill structures. Dark-grey mudstones a few centimetres thick are intercalated between sandstones. The mudstones are commonly associated with thin, fine-grained sandstones, with sharp boundaries, that pinch and swell laterally and show ripple cross-lamination. Fossils are rare, but *Bailliaspis dalmani* (Angelin) and *Plutonides aurora* (Salter) are recorded from the upper Solva and suggest the presence of the *gibbus* Zone, whilst the base of the Menevian has yielded *Plutonides hicksii* (Salter) and *Tomagnostus fissus* (Linnarsson) and is referred to the base of the *fissus* Zone.

Up-section the grey sandstones become thinner and fewer. Thinly bedded, grey, flaggy siltstones alternate with dark-grey mudstones on a scale of a few millimetres to several centimetres, giving the rocks a striped appearance. Thin lenticular sandstones with ripple cross-lamination persist into these finer beds. The layers are planar but show much microfaulting. Internally, the dark-grey mudstones show little disruption, whereas lighter-grey silty mudstones contain abundant dark-grey mudstone lenses and dark flecks of organic matter and in places appear mottled, probably because of bioturbation. Certain beds contain the trilobites *Eodiscus punctatus* (Salter) *sensu lato*, *Peronopsis scutalis* (Hicks), *Plutonides hicksii* (Salter) and *Tomagnostus fissus*, with the brachiopod *Linnarssonina sagittalis* (Davidson), and are referable to the *fissus* Zone. The whole lower Menevian succession is about 100 m thick.

The lower Menevian Beds pass gradually upwards into cleaved mudstones of the middle Menevian Group, also approximately 100 m thick. They consist of well-laminated dark-grey mudstones and light-grey silty mudstones with sharp boundaries, alternating on a scale of several millimetres. Some disruption occurs in the lighter-grey layers, probably due to bioturbation. Thin black organic-rich layers, 2–3 mm thick, are occasionally intercalated. Thin lenticular sandstone interbeds show ripple cross-lamination and loaded and bioturbated bases. The beds are pyritous, and contain layers with numerous phosphate nodules (Hicks, 1875b). Thin, pale beds of metabentonite resemble those in equivalent strata in North Wales and St Tudwal's Peninsula (Roberts and Merriman, 1990).

The lower part of the middle Menevian Group yields trilobites including *Cotalagnostus lens* (Gronwall), *Eodiscus punctatus sensu lato* (Figure 4.8)b, *Onymagnostus davidis* (Hicks) (Figure 4.8)a, *Peronopsis scutalis* and '*Solenopleura*' *applanata* (Hicks), and the brachiopod *Linnarssonina sagittalis*. These are representative of the *parvifrons* Zone, and Lewis collected richer faunas from corresponding beds on the western side of the inlet. The higher beds are referable to the *punctuosus* Zone and are the type strata for several of the trilobites found, which include *Anopolenus henrici* Salter, *Eodiscus punctatus sensu stricto*, *Holocephalina primordialialis* Salter, *Meneviella venulosa* (Hicks), *Ptychagnostus punctuosus* (Angelin) *sensu stricto* and *Solenopleuropsis variolaris* (Salter), but the locality is most famous for *Paradoxides davidis* Salter, '*Paradoxides* one and a half feet or more in length ...' (from Salter, 1864a, p. 234). These spectacular fossils are difficult to collect but have nevertheless attracted collectors who have damaged the locality and many specimens through faulty practice. The fossiliferous mudstones are intruded by two vertical dolerite sills, each about 4 m wide. The middle Menevian Group is the source of the sponges *Protospongia fenestrata* Salter and *P hicksii* Hinde and of controversial echinoderm-like animals, the cornute *Protocystites menevensis* Hicks (revised by Jefferies *et al.*, 1987), and the cinctan *Elliptocinctus vizcainoi* Friedrich (1995).

The middle Menevian Group is succeeded abruptly but conformably by sandstones and intercalated mudstones of the upper Menevian Group, said to be about 30 m thick. The sandstones are massive, forming beds 10 cm to 1 m in thickness, consisting of coarse sandstones with quartz and feldspathic pebbles, and finer sandstones with muddy partings. Grey mudstones resembling those in the rest of the Menevian occur between sandstones. The sandstones yield *Billingsella? hicksii* (Davidson) (Cocks, 1978, p. 34). Hicks reported collecting *Paradoxides* and '*Conocoryphe*', but the specimens remain undescribed and the finds have never been repeated. On their basis, however, Hicks referred these beds to the Menevian, although lithologically they resemble the 'Lingula Flags', which are present to the east of Porth-y-rhaw. The 'Lingula Flags' consist of alternations of pale-grey, fine-grained siliceous sandstones with grey mudstones. The sandstones are thinly bedded with sharp planar boundaries and are generally a few centimetres to 20 cm thick. Dr M. Lewis (in ms) reported the presence of *Agnostus pisiformis* (Wahlenberg), the only record of this species in Wales, and indicative of the basal Merioneth Series or possibly uppermost St David's.

Interpretation

The succession at Porth-y-rhaw, supplemented by evidence from other sites close by (Dwrhyd Pit, Caerfai Bay and Solva Harbour), provides the most complete zonal sequence for the St David's Series, ranging from the base of the *fissus* Zone up to the *punctuosus* Zone, exposed in Britain. It is the type locality for several trilobite and other species and is famous for yielding *Paradoxides davidis*. The faunas enable correlation of the Menevian Group with equivalent rocks in North Wales (see site reports for Afon Llafar and Porth Ceiriad), the Midlands, southeast Newfoundland and the zones of the *Paradoxides paradoxissimus* zonal group in Scandinavia. The lower and middle Menevian Group may be correlated with the Abbey Shale Formation of the Nuneaton district (see site report for Hling's Trenches), where the faunal succession is

very similar but the Menevian Group is thicker and much more completely exposed. The assignment of the sandstone beds at the top of the sequence to the upper Menevian rather than to the 'Lingula Flags' is based only on Hicks' unverified record of *Paradoxides*; if this correlation is accepted they may partly correspond to the homotaxial strata of the *Paradoxides forchhammeri* Zone of the Scandinavian sequence. Lithologically, however, the sandstones mark the beginning of the 'Lingula Flags' cycle of deposition, and, in this respect, the sequence corresponds with that in the Harlech Dome (see site report for Afon Llafar).

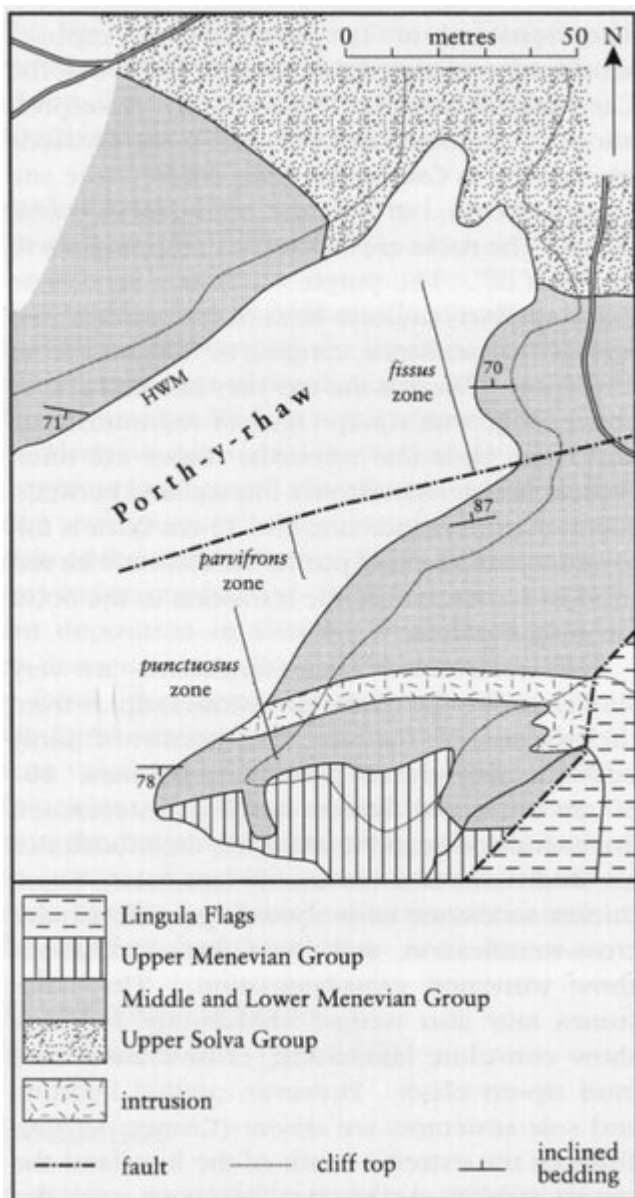
There is little published on the environmental interpretation of the beds exposed at Porth-y-rhaw. The burrows with backfill structures in the sandier beds near the base of the sequence indicate rapid deposition from strong currents, while the fine-grained sandstones were deposited from waning-flow events. However, unlike the strata of the underlying Solva Group, deposition was probably below wave base. The absence of graded bedding and sole marks makes an origin from turbidity flows also unlikely, so the environmental setting is unclear. The sandstones become less significant upwards, presumably as the source of coarse clastic sediment either became exhausted or was drowned. The strongly laminated appearance of the typical Menevian Beds suggests that accumulation occurred under quiet conditions in restricted environments with low but fluctuating levels of oxygenation. Light-grey mudstones and siltstones are bioturbated and represent better oxygenated environments; they may be the result of low-concentration turbidity-type flows. Darker layers, preserving more organic matter, represent periods of low oxygenation in which burrowing organisms were excluded. The thin sandstones with cross-lamination and loaded bases were probably deposited from low-concentration waning-flow events, which may have introduced better oxygenated water into the basin. The increase in darker-coloured mudstones upwards implies that low oxygen levels became predominant in the middle Menevian. However, the abundant phosphate nodules indicate that at least some thickness of sediment must have been oxygenated to allow their precipitation, according to the mechanisms currently proposed for their formation (see site report for Ogof Ddû and references therein).

The sudden appearance of sandstones at the top of the Menevian sequence marks the initiation of current-agitated conditions, with deposition of sandstones from event episodes such as turbidite or storm events. This continued into 'Lingula Flags' times, and Crimes (1970a) reported sedimentary structures, such as convoluted and cross-bedding, ripple-marked beds and coarse conglomeratic sandstones, in higher parts of the 'Lingula Flags' sequence. These beds are inferred to have been deposited in shallow water, from currents flowing from the south or south-west. The presence of shallow-water sandstones in both the underlying upper Solva and the overlying upper Menevian groups suggests that although the typical dark Menevian mudstones were deposited in quiet, restricted environments, water depths were probably not great.

Conclusions

The inlet of Porth-y-rhaw is a classic geological locality of international value and provides a standard sequence of Middle Cambrian fossils used for correlation in Britain and abroad. It is the type locality for many species and is the only place in South Wales to show fossils at the transition between the Middle and Upper Cambrian. Lack of responsible fossil collecting practice in the past highlights the need for its preservation in the future.

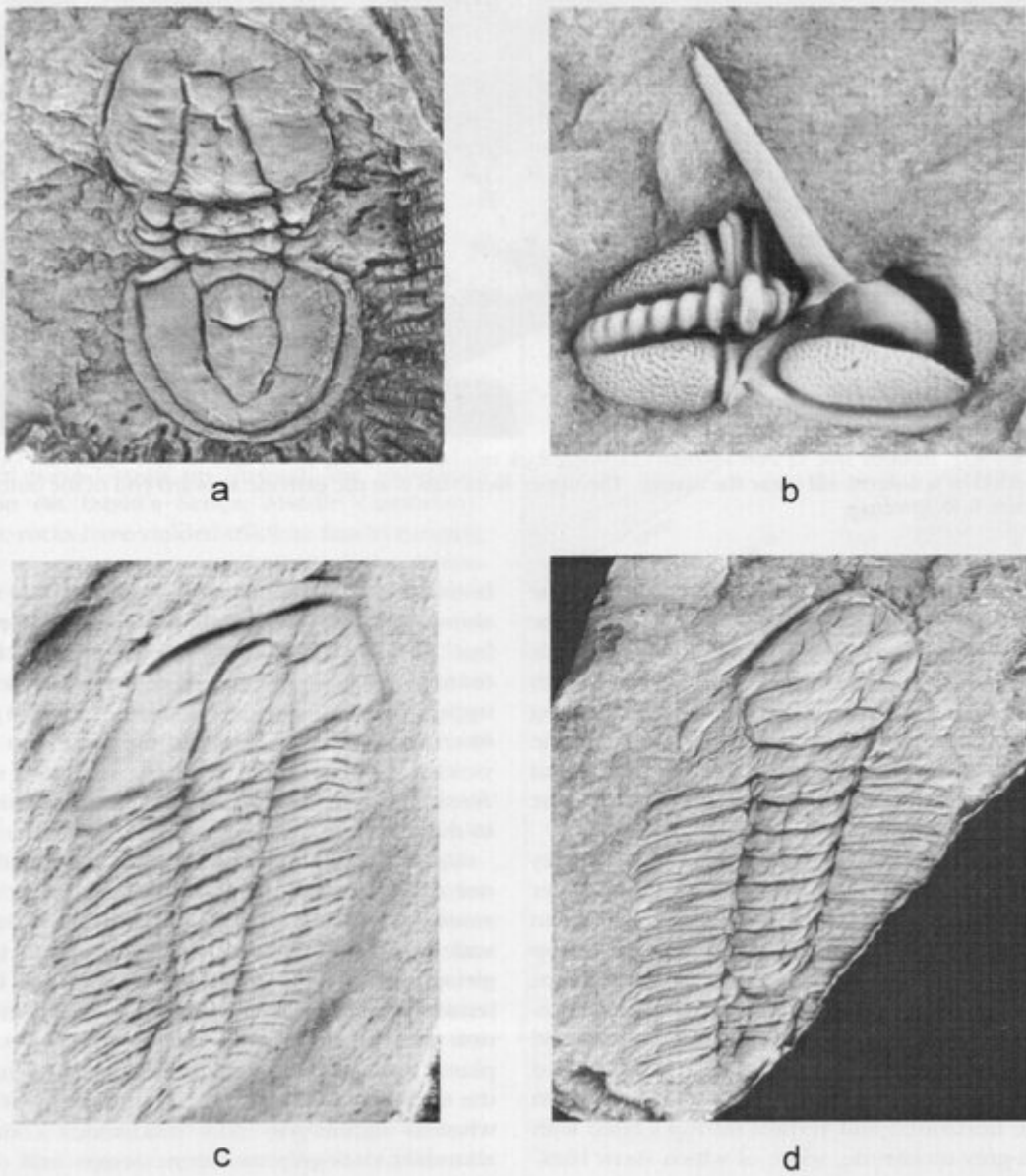
[References](#)



(Figure 4.6) Geological map of Porth-y-rhaw, after Jefferies et al. (1987).



(Figure 4.7) Eastern side of Porth-y-rhaw, showing dark mudstones of the lower and middle Menevian Group intruded by a dolerite sill (near the caves). The upper Menevian is at the extreme seaward end of the outcrop. (Photo: R.M. Owens.)



(Figure 4.8) Middle Cambrian Trilobites from South Wales. (a) *Onymagnostus davidis* (Hicks), x4, from Solva Harbour. (b) *Eodiscus punctatus* (Salter), x8, from Porth-y-rhaw. (c) *Bailiella lyelli* (Hicks), x3, from Trwyncynddeiriog. (d) *Plutonides hicksii* (Hicks), x2.5, from Dwrhyd. (Photos: M. Lewis.)