

St Tudwal's peninsula

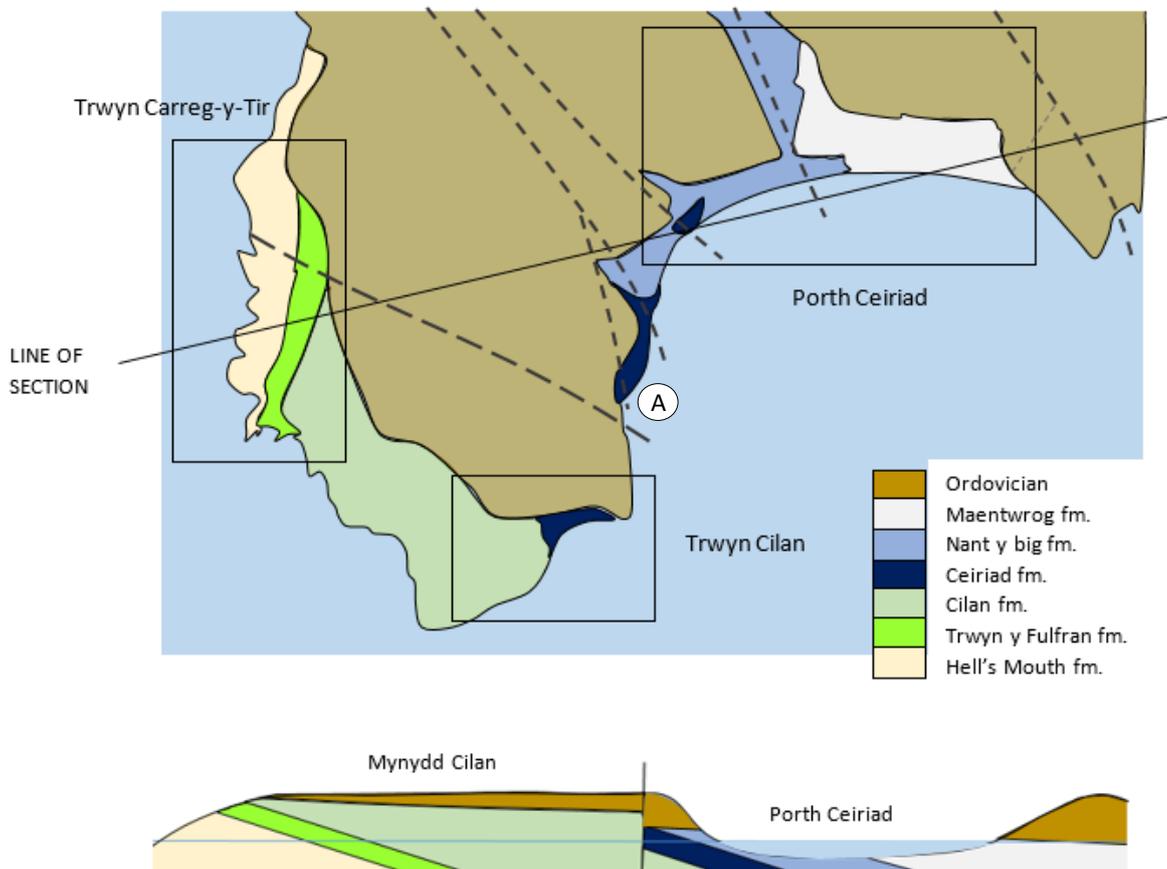


Figure 164:
Field excursions

St Tudwal's peninsula on the south west coast of Llyn provides an additional small outcrop of Cambrian sediments formed in the same marine basin as the Harlech Dome sedimentary sequence. Many similarities exist between the two areas, with coarse proximal turbidite grits in the lower part of the succession, and finer grained sandstone, siltstones and mudstones in the upper part.

The sequence of strata at St Tudwal's peninsula appears to be considerably thinner than the corresponding formations in the Harlech Dome. The exact thickness of the lower group of coarse grits is not known precisely, as the base of the Hell's Mouth Grits is not exposed. In the Harlech Dome, the equivalent Rhinog Grits are underlain conformably by Llanbedr slates and Dolwen Grit which are not seen at St Tudwal's.

The upper part of the succession, correlated with the Mawddach Group of the Harlech Dome, consists mainly of mudstones with thin interbedded sandstones. The Maentwrog and

Ffestiniog formations have been identified in both areas on fossil evidence, although there are some lithological differences between the Harlech Dome and St Tudwal's peninsula strata.

The Cambrian sediments of St Tudwal's are overlain by Ordovician strata which will be examined in more detail during the field excursions in chapter 13. At St Tudwal's peninsula there is an angular unconformity between the Cambrian and Ordovician sequences, indicating uplift and erosion in late Cambrian times. We also find numerous faults associated with the Menai fracture zone. The structural complexity is well illustrated by cliff outcrops just south of Porth Ceiriad (locality A in fig.164). Although inaccessible to examine directly, the fault and fold structures can be viewed from the cliffs across the bay.

Beds of shale and thin sandstone are folded within the fault zone. No appreciable difference in elevation of the Ordovician strata is observed across the fault zone, so most of the fault

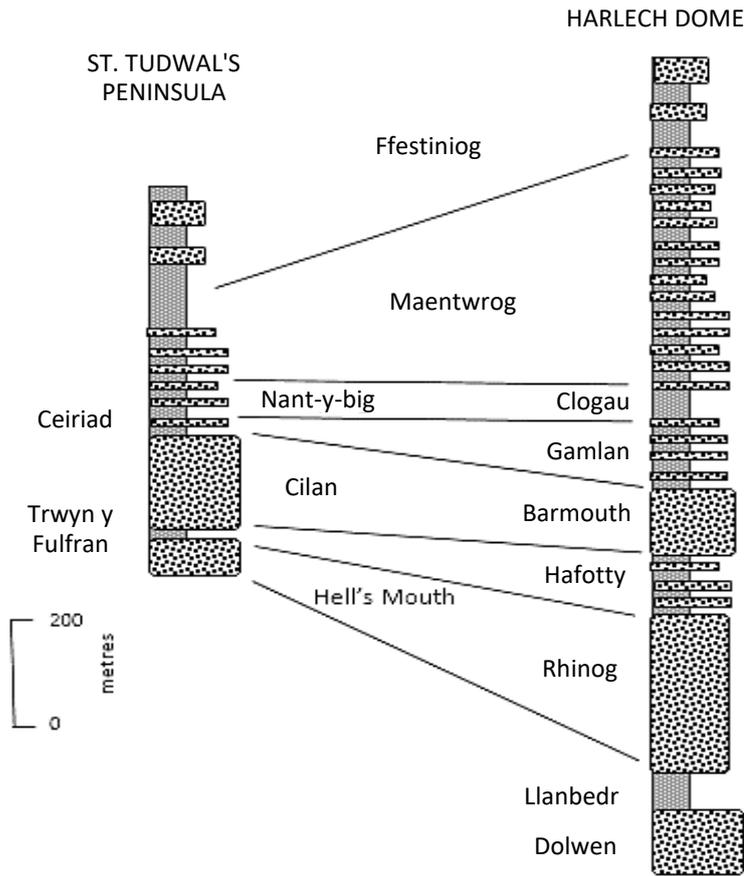
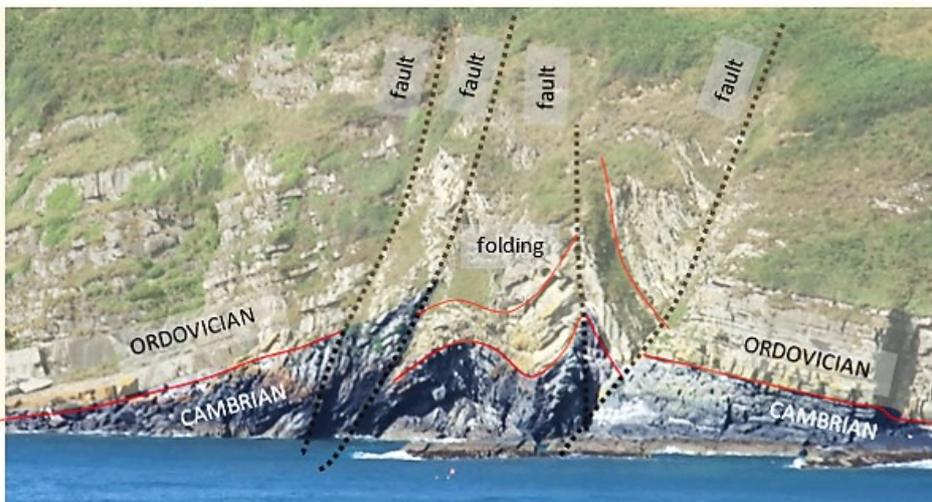


Figure 165: Comparison of Cambrian successions



Figure 166: Fault zone at Porth Ceiriad

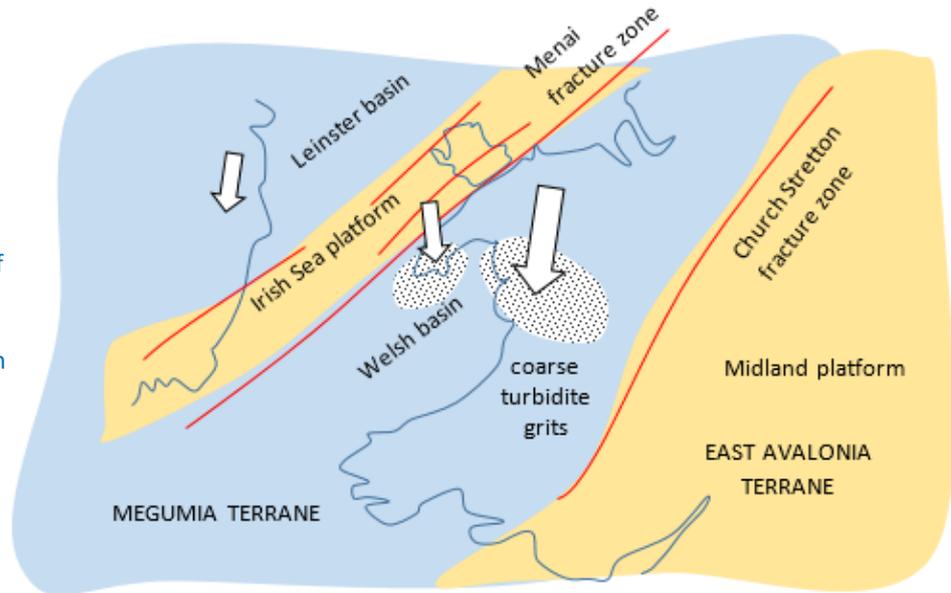


movements may have occurred horizontally. This is consistent with the model for horizontal displacement of terrane fragments as Avalonia separated from the continent of Gondwana during late Cambrian to early Ordovician times.

The Cambrian strata at St Tudwal's peninsula show characteristics of deposition in shallower water

than the equivalent Harlech Dome strata and are thinner, suggesting that the St Tudwal's area was a shallow coastal shelf at this time. A plausible theory is that uplift occurred within the Menai fracture zone, producing a long narrow landmass in the northern Irish Sea area during much of the Cambrian period.

Figure 167: Lower Cambrian palaeogeography, during deposition of the Rhinog Grits in the Harlech Dome and the Hell's Mouth Grits at St Tudwal's peninsula.



In this chapter we visit several spectacular sections of coast where Cambrian strata are displayed in wave cut platforms and cliffs. The lower parts of the succession, dominated by coarse turbidite grits, are seen at Trwyn Carreg-y-tir and Trwyn Cilan. The overlying thinner sandstones and mudstones are examined at Porth Ceiriad.



Visitors are warned that much of the coastal plateau is bordered by grass slopes which become increasingly steep downwards towards the sea and can end in vertical rock cliffs. Great care should be taken if planning a descent towards sea level anywhere away from a recognised beach access path.



Trwyn Carreg-y-tir



2 miles: approximately 1 hour

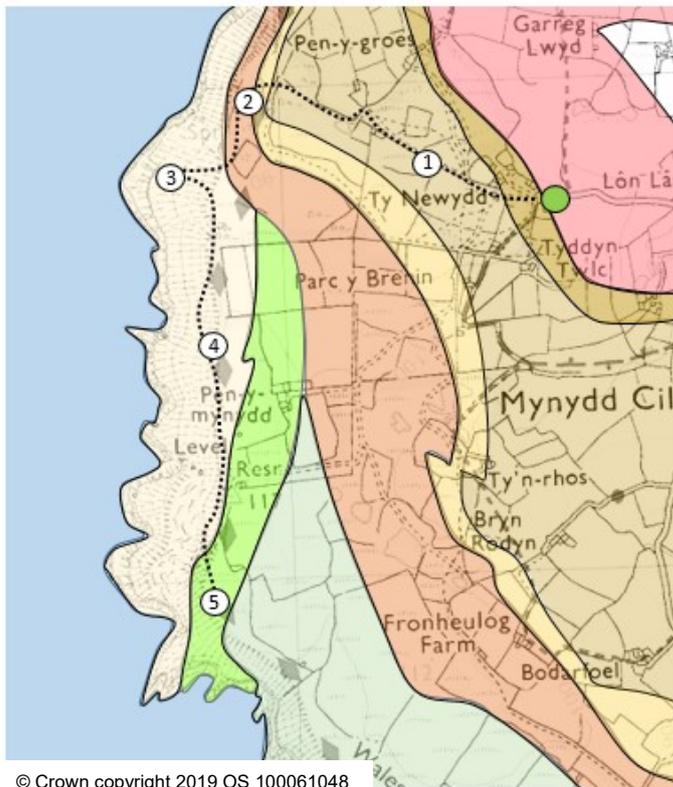


Figure 168: Field excursion.

Start: From Abersoch, take the minor road south to Bwlch Tocyn. Turn right at a T-junction just beyond the old chapel and continue to the parking area at the entrance to the National Trust moorland at Mynydd Cilan [SH295248].

1: Follow the path which skirts around the western edge of the Mynydd Cilan moorland to reach the coast at the Ordnance Survey trig point.

2: Join the coastal footpath. After 100m, take a diagonally descending path to reach old manganese workings near the top of the cliff slope.

The manganese ore occurs within the Trwyn y Fulfran Formation, which is a north- westerly continuation of the Hafotty formation of the Harlech Dome. We have reached one of a series of small mine workings cut along the outcrop of the dark manganese shales near the base of the formation. In the upper part of the formation, shales are interbedded with thin greywacke sandstones formed by occasional turbidite flows into the marine basin where manganese-rich muds were accumulating.



Figure 169: Trwyn y Fulfran Formation. Manganese shales with gently dipping bedding and vertical cleavage.

3: Descend diagonally northwards across the grassy slope to reach a level bench in the upper cliff. At this point, beds of the Hell's Mouth Grits are exposed, and can be viewed running northwards across the cliff face towards the headland of Trwyn y Fosle.

Figure 170:

Outcrops of Hell's Mouth Grit in the cliff face at Trwyn y Fosle.

In the right foreground is a waste tip from manganese workings in the overlying Trwyn y Fulfran Formation.



The Hell's Mouth Grits have a coarse greywacke composition, made up from quartz grains and tiny fragments of igneous and metamorphic rock in a muddy matrix. The grits may be up to 4 m thick, but a bed thickness of 1 m is more common.

The Hell's Mouth Grits exhibit typical features of proximal turbidites. Graded bedding can be found in the thick Bouma A units, and amalgamated A units are found where multiple turbidity flows occurred in rapid succession. These grits are usually overlain by parallel laminated sandstone B units, and occasionally the depositional sequence is completed by a cross-bedded sandstone C unit formed by the migration of sand ripples at the sediment interface in the wake of the turbidite flow.



Figure 171: Turbidite graded grit A unit, overlain by parallel laminated sandstone B unit.

Siltstones are found in the intervals between turbidite flows, and would have formed by the redistribution of finer sediment by bottom currents.

Structures on the bases of grit beds in the Hell's Mouth formation include groove marks, cut by coarser pebbles being dragged along by the turbidity flow. These marks suggest that the sediments were deposited by southwards-directed currents.

Deposition was in a relatively shallow shelf sea, as trace fossils of *Planolites* worm burrows and *Cruziana* trilobite tracks occur on the bases of grit beds.

4: Return to the coastal footpath at the head of the cliff.

5: Continue southwards along the cliff path to view the headland of Trwyn y Fulfran, composed of a thick sequence of proximal turbidites of the Hell's Mouth Grit formation.



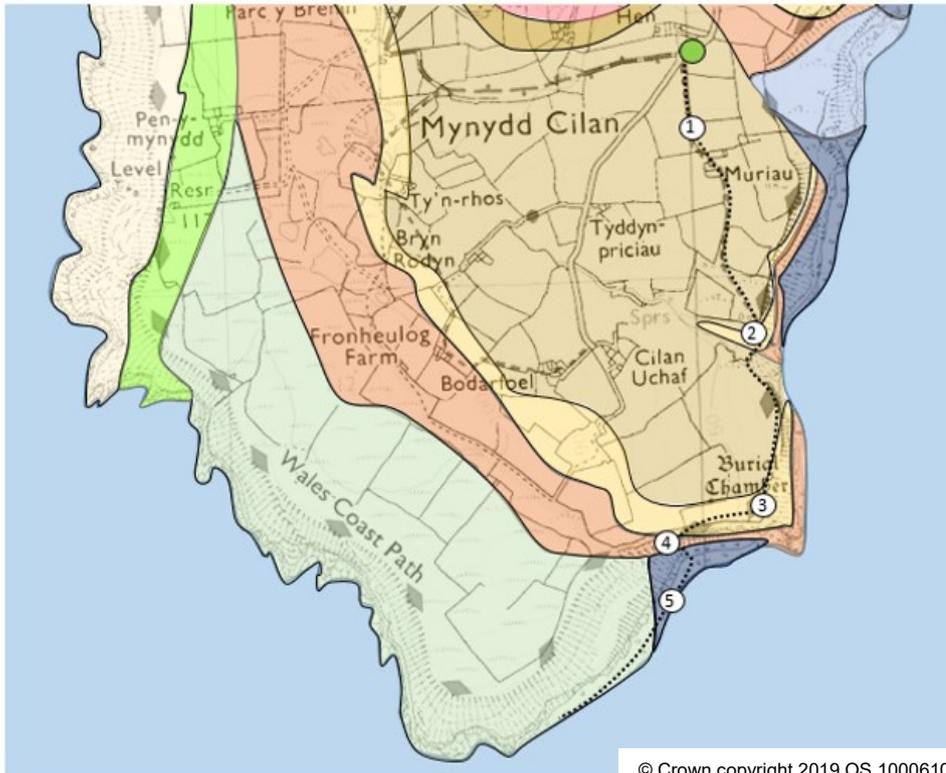
Figure 172: Trwyn y Fulfran, with cliffs cut in proximal turbidites of the Hell's Mouth Grit formation.

From this point, return along the cliff path then across Mynydd Cilan to the parking area. Alternatively, continue southwards along the cliff path to join the Trwyn Cilan field excursion route described below.

Trwyn Cilan



1 mile: approximately 2 hours



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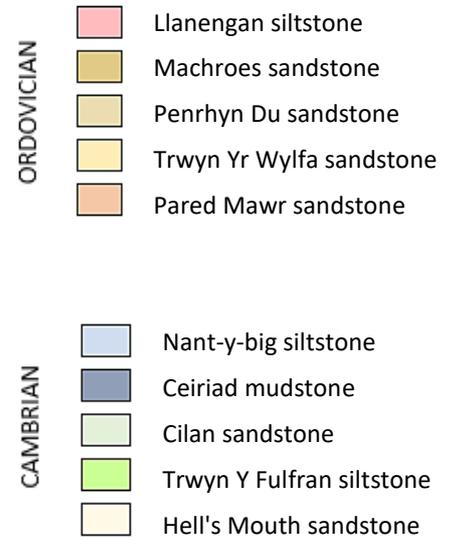


Figure 173: Field excursion.

In the next excursion, we examine rocks of the Cilan Grits and Caered Mudstone formations which overlie the Trwyn y Fulfran manganese shales. The Cilan Grits are proximal turbidites of equivalent age to the Barmouth Grits of the Harlech Dome, and with similar sedimentary features. The Ordovician unconformity above the Caered Mudstones is spectacularly displayed in the cliff outcrops.

Start: Take the minor road south from Abersoch through Bwlch Tocyn. If possible, park on the roadside near Ysgubor Hen [SH300245]. Space is very limited, so it may be necessary instead to use the National Trust car park at Mynydd Cilan [SH295248] and walk to Ysgubor Hen.

- 1:** Follow the footpath to Muriau.
- 2:** After reaching the coastal footpath, walk southwards along the cliff top to Trwyn Llech-y-doll to view the bay below.
- 3:** Continue to the point where a footpath descends the cliff along the outcrop of a massive Ordovician bed. The first part of the descent closely follows the line of the Ordovician unconformity.



Figure 174: Trwyn Llech-y-doll. This photograph is taken from the point where the path, descending along the Ordovician unconformity, makes a sharp turn to the right down the hillslope to reach the shore.

4: Continue downwards with care, reaching the beach where Cilan Grit is exposed.

The final part of the descent is across slabs of Cilan Grit. Before examining the Cilan grits in detail, we will follow the shoreline northwards to the point where Ordovician strata reach sea level.

The first section of low cliff is formed from Caered Mudstones which overlie the turbidite grits. The generally blue-grey mudstones contain a thin white band which appears to be derived from rhyolitic ash. This is an early precursor of the volcanic activity which would accompany the breaking away of Avalonia from Gondwana in late Cambrian times. The mudstones themselves show cross-bedding, with ripple marks on some bedding

surfaces, indicative of deposition in relatively shallow water under the effects of bottom currents.

The Ordovician strata are seen to lie with angular unconformity on the Caered mudstones, indicating uplift and erosion. The lowest Ordovician strata are conglomerates of the Arenig formation, containing pebbles of a variety of rock types typical of the Monian of Lleyn and Anglesey including quartzite and jasper. This deposit may represent the first beach deposits as the area became submerged again after uplift. Sandstones overlie the conglomerate, and show evidence of bioturbation by burrowing organisms, suggesting a shallow shelf sea environment.



Figure 175: Cilan, with thick beds of Ordovician sandstone lying unconformably on Caered mudstones of Cambrian age.

5: Return along the shore to examine the turbidite grits of the Cilan formation.

The Cilan Grits are proximal turbidites dominated by Bouma A unit graded grits, often with quartz granule conglomerate at the base. Relatively few beds are overlain by parallel laminated sandstone B units. The Cilan Grits have a generally coarser grain size than the Hell's Mouth formation, in a similar way to the Barmouth Grits in the Harlech Dome being coarser than the Rhinog Grits.

An interesting feature of some grit beds is the presence of large clasts of mudstone and siltstone, apparently ripped from the walls of submarine channels by the force of turbidite flows. This suggests deposition within the steep channelled upper portion of the turbidite fan. Further evidence comes from finer silt and mud units

between the coarse grits where slump structures are common, suggesting a steep depositional slope.

Markings on bases of coarse grit units include groove casts. The upper surfaces of grits often show ripples, creating cross-bedding. The orientations of these sedimentary structures suggest a turbidity current flow direction towards the south or south-east. Taking all evidence together, it is likely that the Cilan Grits were deposited close to the shore of an upfaulted Irish Sea landmass, within or at the base of a submarine slope. The relatively infrequent finer sediment layers, along with the presence of scoured channels in graded grit units, suggest that multiple turbidite flows were being discharged in rapid succession.

Figure 176: Cilan Grit formation. Coarse turbidite grit containing mudstone clasts.



Towards the top of the Cilan Grit formation, a change in lithology occurs with the appearance of finer sediments. Layers of red and green mudstones and siltstones were deposited. Colour variations suggest varying levels of oxygenation of

the waters which altered the oxidation state of iron minerals present in the clays. Trace fossils of *Planolites* worm burrows and *Cruziana* trilobite tracks have been found, indicating a relatively shallow sea bed close to the shore.

Figure 177: Cilan Grit. Upper beds consisting of red and green siltstones and mudstones.

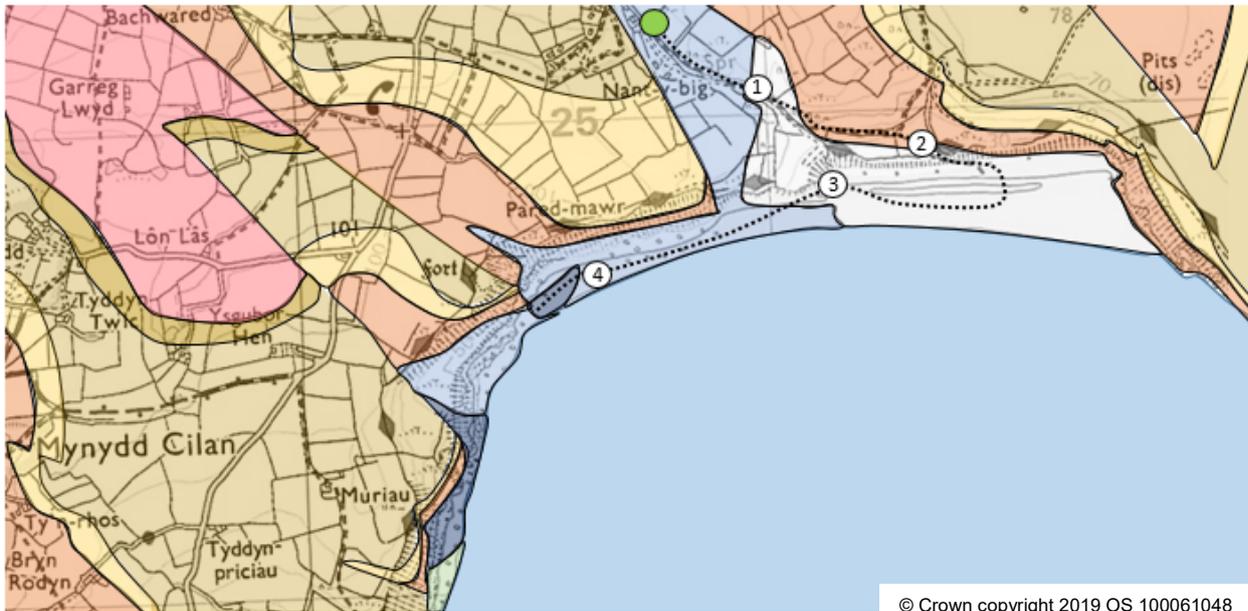


Return up the steep path across Caered Mudstones to the base of the Ordovician outcrop, then follow the line of the unconformity upwards to re-join the coastal path.

Porth Ceiriad



1 mile: approximately 1 hour



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ORDOVICIAN		Llanengan siltstone	CAMBRIAN		Maentwrog siltstone
		Machroes sandstone			Nant-y-big siltstone
		Penrhyn Du sandstone			Ceiriad mudstone
		Trwyn Yr Wylfa sandstone			Cilan sandstone
		Pared Mawr sandstone			

Figure 178:
Field excursion.

The section along the beach at Porth Ceiriad displays a sequence of Upper Cambrian sediments: Caered mudstones, Nant-y-big mudstones and Maentwrog Beds.

Start: Approach along the farm track which leaves the Abersoch-Mynydd Cilan road at Bryncelyn. Access is through Nant-y-big Farm and a charge is made [SH311249].

1: Follow the road to the coast, reaching a car park on the cliffs immediately above the beach.

2: Take the path to the beach, descending the steps across glacial deposits.

3: Walk along the beach to the cliffs cut in the Maentwrog formation.

The middle and upper parts of the Maentwrog succession show characteristics of turbidites, but with the thicker graded grit A units absent. Sedimentary structures suggest a flow direction of turbidity currents from the south along the axis of the Welsh basin from a more distal source, perhaps in the East Avalonian microcontinent.

The highest Maentwrog beds consist of thin shales and sandstones. The sandstone beds increase in thickness as we follow the succession downwards. Major ripples are seen on some bedding surfaces. Sandstones may exhibit convolute bedding suggesting tectonic disturbance of the sediment before it became fully lithified, perhaps through earthquake activity.



Figure 179: Rippled bed surface in Maentwrog strata, Porth Ceiriad.

The lower beds of the Maentwrog formation have the characteristics of finer grained turbidites. Groove casts are found on the bases of the thin sandstones, indicating the turbidite flow direction.

Concretions of iron carbonate are found in some strata, formed by chemical precipitation whilst the sediments were undergoing lithification.



Figure 180: Lower Maentwrog strata, Porth Ceiriad. (above) Sequence illustrating calcareous sandstone [A], current bedded sandstone [B], and conglomerate with rhyolite fragments [C]. (top right) Iron carbonate concretions (bottom right) Lower junction with Nant-y-big mudstone.

Near the base of the Maentwrog succession is conglomerate made up from fragments including rhyolitic volcanic rocks, which may have been derived from nearby Monian outcrops in Lleyn and Anglesey. Several sandstone beds have a high calcium carbonate content, as indicated by the characteristic pitted weathering pattern of limestone. Cross-bedding can also be seen in some sandstones.

4: Continue around the point to the cove backed by high cliffs of Nant-y-big mudstones.

The Nant-y-big mudstones are dark blue and black, pyritous mudstones and siltstones. Thin white-weathering bands consist of rhyolitic volcanic ash. Agnostid trilobites have been found in this location.

The section ends in a series of faults, with folding of the mudstones between the fault planes.