Monian of the Lleyn peninsula

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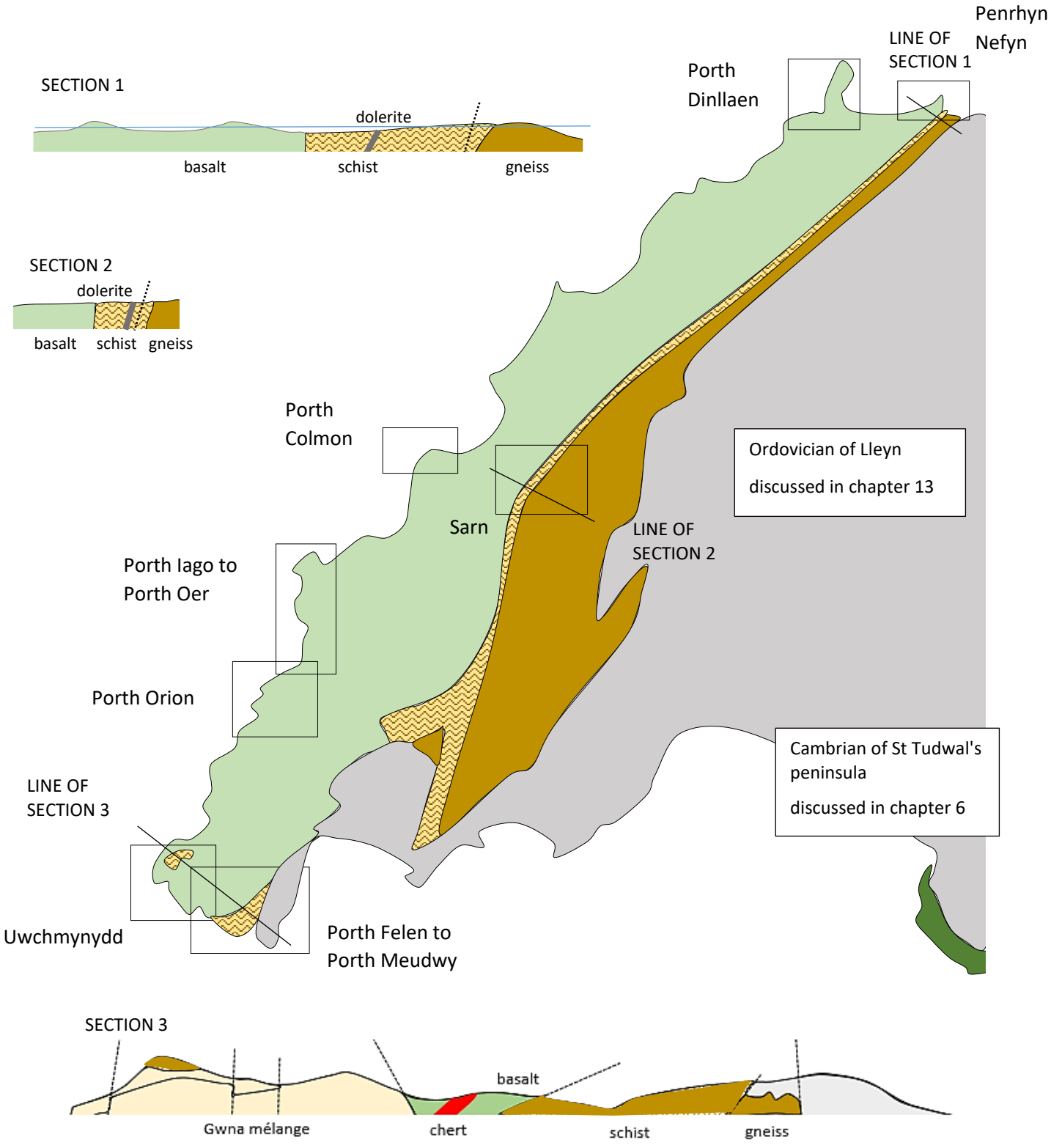


Figure 64: Field study locations

Introduction

The objective of the field excursions in this chapter is to determine the geological history of the Monian terrane of the Lleyn peninsula. Within a small geographical area of north-west Lleyn, a remarkable variety of rock types are exposed. These can be divided into three major groups according to their grade of metamorphism: gneiss, schist, and rocks which are relatively unaffected by metamorphism.

The gneisses show metamorphism at high temperatures and pressures. They occur as a band stretching inland across the peninsula, and are in fault-contact or **unconformably** overlain by Ordovician rocks to the east. The gneisses are collectively known as the ***Sarn Complex***, and were produced by the metamorphism of a variety of igneous and sedimentary rocks. It is thought that they formed originally within an island arc, creating the microcontinent of Avalonia which docked with the African and Amazonian regions of Gondwana in late Precambrian times.

The gneisses are poorly exposed due to glacial deposits covering much of the inland area of peninsula. They can be examined on the coast at Penrhyn Nefyn, and in the Sarn area of central Lleyn.

To the west of the gneiss, we find a zone of schists extending along the peninsula from Nefyn in the north to Uwchmynydd in the south. The schists can be distinguished by a strong foliation extending through the rock, often emphasised by the orientations of mica and other platy minerals. This apparently simple group of rocks does, however, represent the products of two very different geological processes:

> The majority of the schists were produced during plate subduction, either as the Avalonian microcontinent docked with Gondwana in the late Precambrian, or as the microcontinent began to break away and move out into the Iapetus ocean during Cambrian times. Evidence comes from the very high pressure but relatively low temperature mineral assemblages of some of the rocks, known as **blueschists**. It is likely that these rocks were carried down to mantle depths by subduction, metamorphosed under high pressure, then the rock slab returned to the surface due to buoyancy effects.
>
> A second, narrower, band of schists shows rather different characteristics. These rocks have developed a schistose foliation due to mechanical shearing. Their origin appears to be the transverse faulting which occurred during Cambrian times as terrane blocks were moved sideways past one another during the break away of Avalonia from Gondwana. A series of faults cross the region, making up the Menai Straight fracture zone (fig.65).

Both types of schist are exposed at ***Penrhyn Nefyn***. Subduction-related schists are seen at a number of locations along the north-west coast of Lleyn including ***Porthdinllaen*** and ***Uwchmynydd***. Schist produced by movement along the Menai Straight fracture zone is again seen at ***Aberdaron*** (chapter 13).

The final sequence of rocks, of relatively low metamorphic grade, form the ***Gwna Group***. This is a very diverse collection of different rock types from basalt lavas to bedded sediments. The group includes a spectacular large-scale breccia containing huge blocks of sandstone and limestone, known as the Gwna mélange.

The Gwna Group represents the mixture of rocks which accumulated in trench zones on the margin of the Avalonian microcontinent during subduction. Basalt lavas, often showing pillow structures, originally formed at a mid-ocean spreading centre and were transported to the subduction zone on an oceanic plate. Whilst most of the oceanic plate descended into the subduction zone, some surface layers of basalt could be scraped off at the continental margin and preserved. Sediments such as thinly bedded muds and cherts represent deep ocean floor deposits which were similarly scraped off at the continental margin as the plate descended into the subduction zone. The Gwna mélange formed as a slump deposit of continental shelf sediments which were discharged downslope into the trench zone, perhaps as a result of earthquake activity associated with subduction.

For some years, there has been a debate amongst geologists as to the age of the Gwna Group rocks in Anglesey and the Lleyn peninsula. The recrystallised nature of some of the rocks suggests that they are very old, belonging to the late Precambrian period. However, fossils has been found to suggest that some of the strata are early Cambrian in age. More recent evidence from radiometric dating indicates that both theories may be correct (fig.66). Two groups of ages are found:

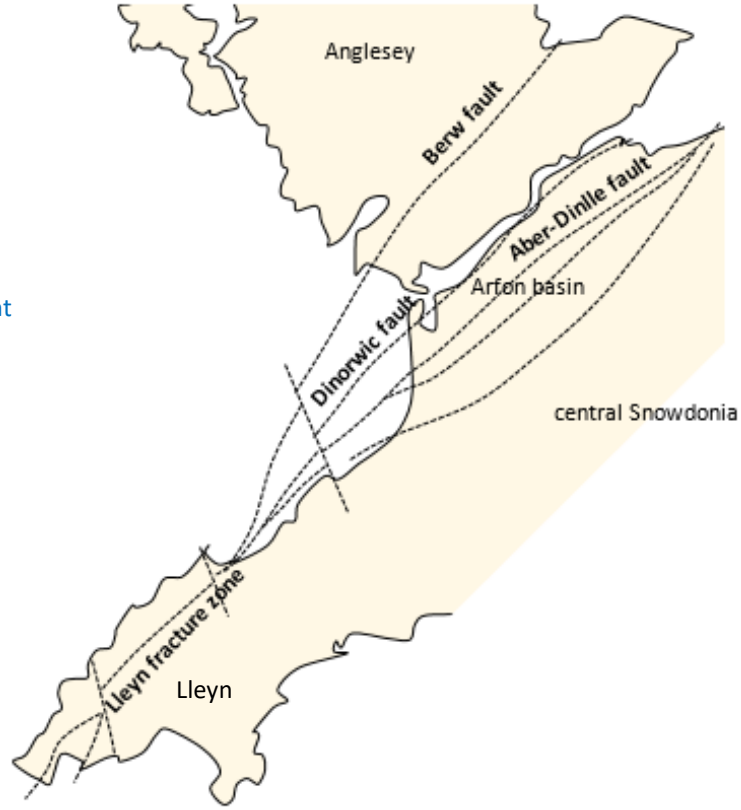


Figure 65: Menai Straight fracture zone

An older group of Gwna rocks, seen at ***Porth Iago*** and ***Mynydd Carreg***, are of late Precambrian **Proterozoic** age (Asanuma et al., 2015). These may have been produced in a subduction zone as Avalonia originally docked with Gondwana.

A younger group of Gwna rocks, of similar composition but a lower grade of metamorphism, straddle the boundary from the end of the Precambrian into the beginning of the Cambrian period. The younger Gwna group may represent subduction trench deposits formed as Avalonia began to break away from Gondwana in early Cambrian times. These rocks may be examined at ***Porth Oer***, ***Porth Orion***, and at ***Uwchmynydd***.

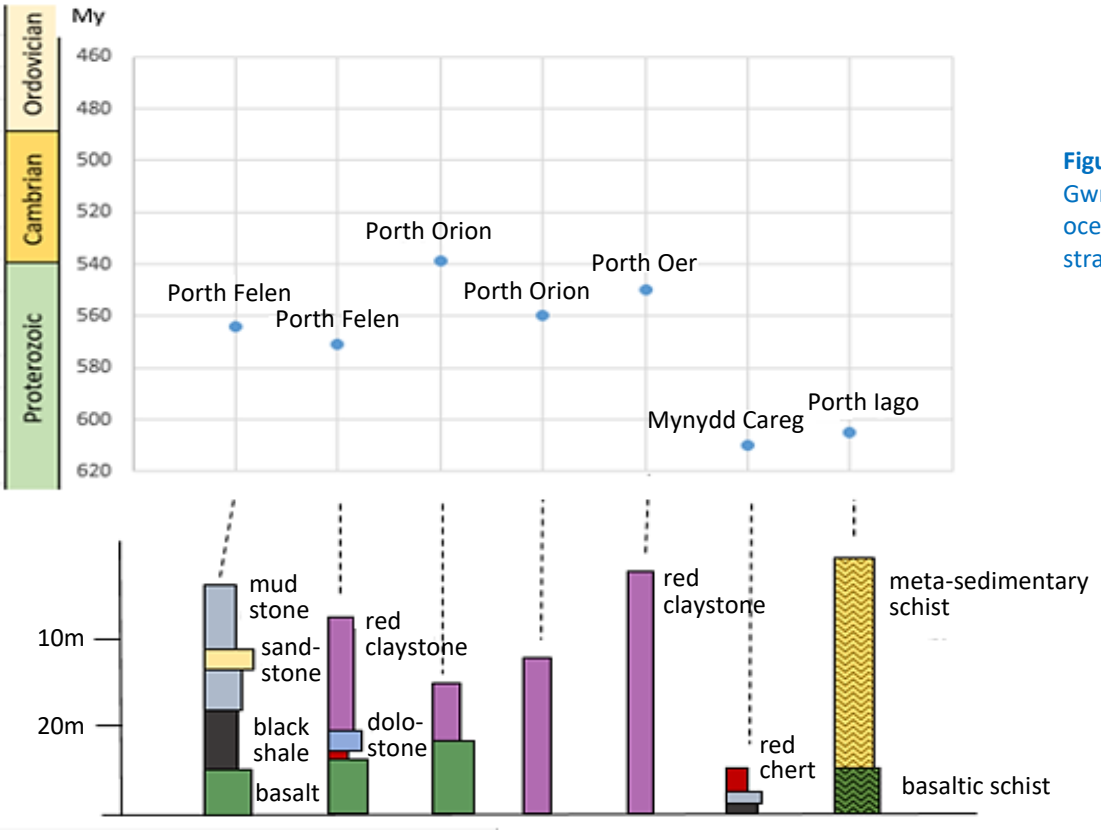


Figure 66: Gwna Group ocean plate stratigraphy.

Penrhyn Nefyn

4 miles: approximately 2 hours

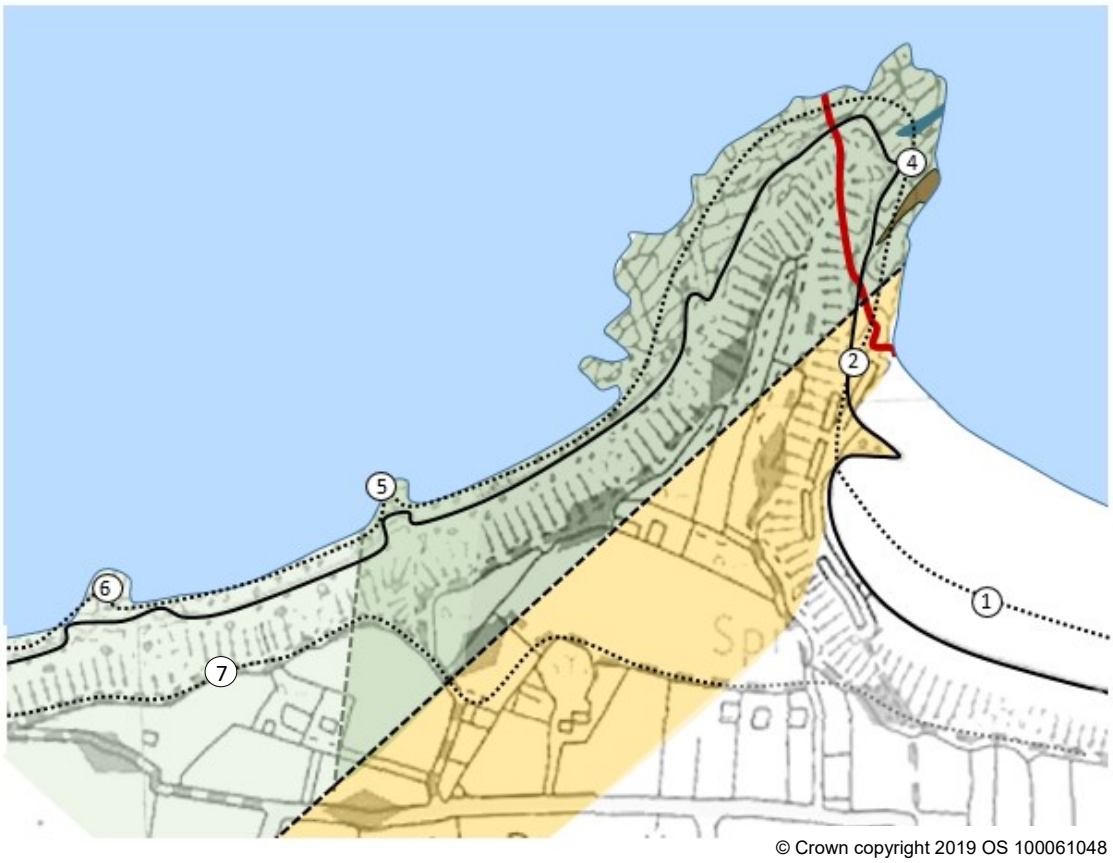


Figure 67: Field excursion.

Penrhyn Nefyn illustrates the relationships between the gneiss, schists of both subduction and fault origin, and basalt of the Gwna group.

Start: Low tide is needed for access to the wave-cut platform at Penrhyn Nefyn headland during this excursion.

Vehicles can be parked near the centre of Nefyn, on the B4417 Morfa Nefyn road near to the war memorial [SH305406].

1: Take the small lane Lôn y Traeth down to the beach, then walk west along the sands to the harbour. Pass the store sheds at the base of the cliff, then descend to the rock platform.

2: Bands of gneiss are seen, dipping at a steep angle between 70° and vertical.

The gneisses are thought to have originated as igneous rocks in an island arc which formed the Avalonian microcontinent during late Precambrian times. The original composition of the rocks can be deduced from their silica content:

Felsic gneisses, derived from diorite or granite. We see large scale banding up a metre in width, with large feldspar and quartz crystals visible. The coarser bands have been broken up into separate pods along shear planes, showing that the outcrop lies within the Lleyn fracture zone.

Mafic gneisses, derived from gabbro. These are termed **amphibolites** due to a dominance of

amphibole minerals. Quartz and feldspar veining is present, metamorphism was very high, with the rock reaching the limits of melting to form a **migmatite**.

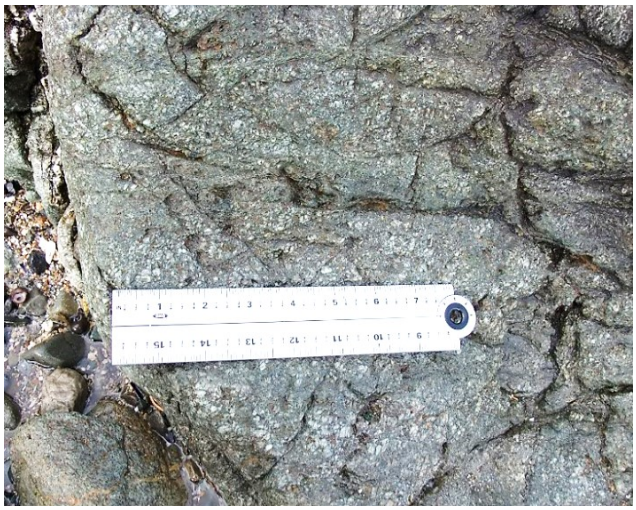


Figure 68: Gneiss, Penrhyn Nefyn: (above) felsic gneiss, showing light coloured crystals of feldspar. The rock is heavily sheared, with coarse bands broken up into separate pods. (below) mafic gneiss, cut by quartz veining.

3: A few metres further along the shore platform, the gneisses pass into schists. The contact is complicated a series of fracture lines between which are seen remnants of gneiss within the schist, heavily broken up in the Lleyn fracture zone. Quartz and feldspar pods show 'S' shaped structures. These minerals would have been close to melting temperature and mechanically soft at the time of the fault movement, so have preserved an indication of the relative movement directions on either side of the fault plane (fig.69).

Figure 69: Schist containing pods of gneiss with sigmoidal 'fish' structures, Penrhyn Nefyn.

A vertical dyke about 10cm wide occurs at this point. It is one of many thin dykes found in Lleyn, all exhibiting a north-west to south-east orientation. The rock is a fresh, unmetamorphosed dolerite, and is of Tertiary age. This intrusion is related to volcanic activity centred on the western isles of Scotland during the opening of the Atlantic in relatively recent geological times.

Figure 70: Tertiary dyke, Penrhyn Nefyn.

4: Continuing along the coastal platform beyond the Lleyn fracture zone, the schists show more uniform banding with less evidence of mechanical deformation (fig.71).

These rocks have a small scale compositional banding, with alternating layers of light quartz and feldspar, and darker layers of chlorite. They are derived from bedded volcanic ashes.

Moving towards the headland, we see outcrops of **green schists** derived from basalt lavas. Remnants of basalt pillow structures can be found.

An unusual band is found within the schists, with evidence of much greater deformation and mineral alteration. This is **blueschist**, formed at exceptionally high pressures at the depth of the earth's mantle. It is thought that this material represents a slab of basalt pillow lavas carried downwards within the subduction zone and subjected to high pressure metamorphism, then breaking away and returning to the surface due to the buoyancy of the hot slab. The rock is now a fine grained mica schist with strongly deformed pods of quartz and red chert.

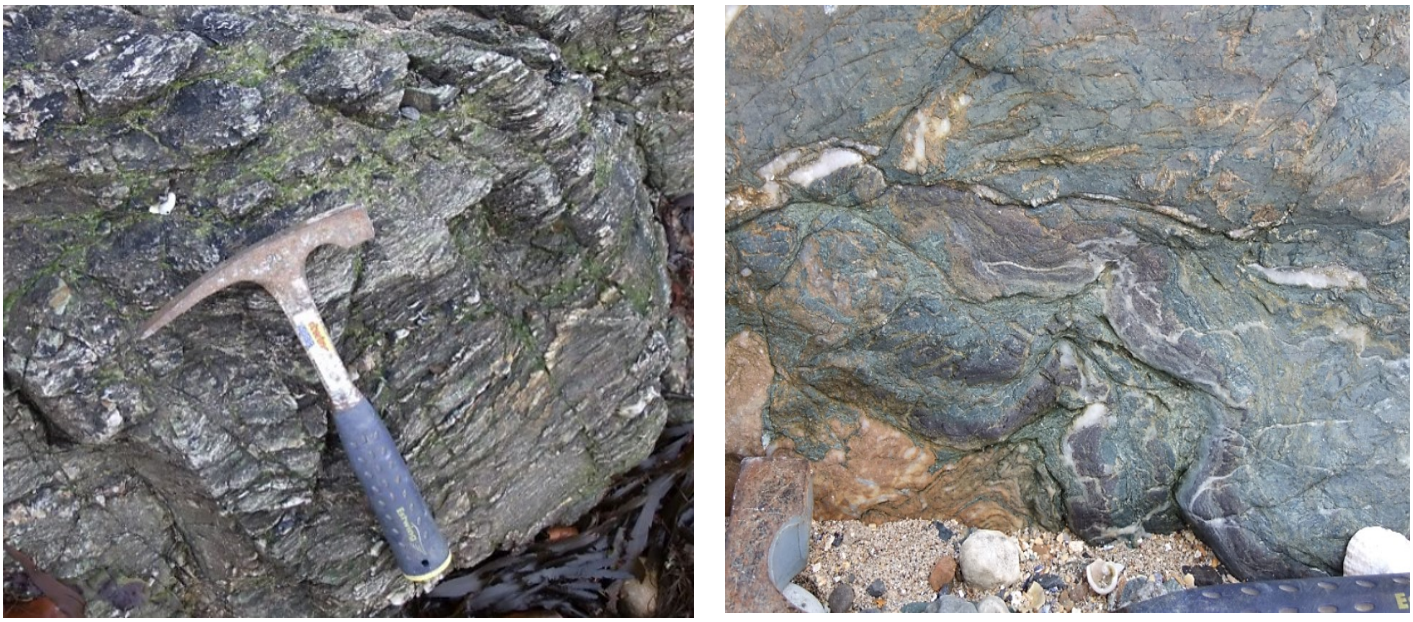


Figure 71: (left) Schist derived from bedded tuff with quartz and carbonate bands, Penrhyn Nefyn. (right) Blueschist, Penrhyn Nefyn.

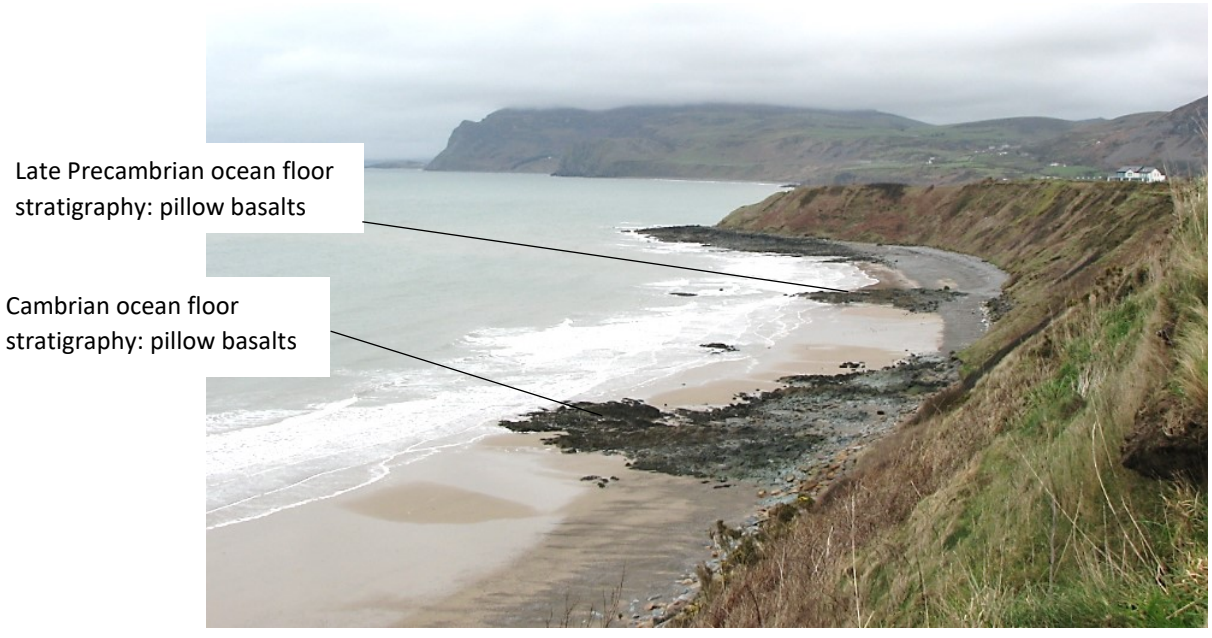


Figure 72: Gwna basalt outcrops, west of Penrhyn Nefyn.

5: Continue around the headland and into the next bay. Examine basalt lavas exposed along the rock platform, and at the first outcrop protruding above the shingle beach (fig.72). The rocks show evidence of metamorphism to greenschist grade, and belong to the older Gwna Group formed during subduction in late Precambrian times as the Avalonia microcontinent docked with Gondwana.

Beyond the prominent gulley in the cliffs is a faulted junction, with Gwna Group rocks further west of younger age. These represent the products of renewed subduction as Avalonia broke away from Gondwana and began to move into the Iapetus Ocean as a microcontinent at the start of Cambrian times.

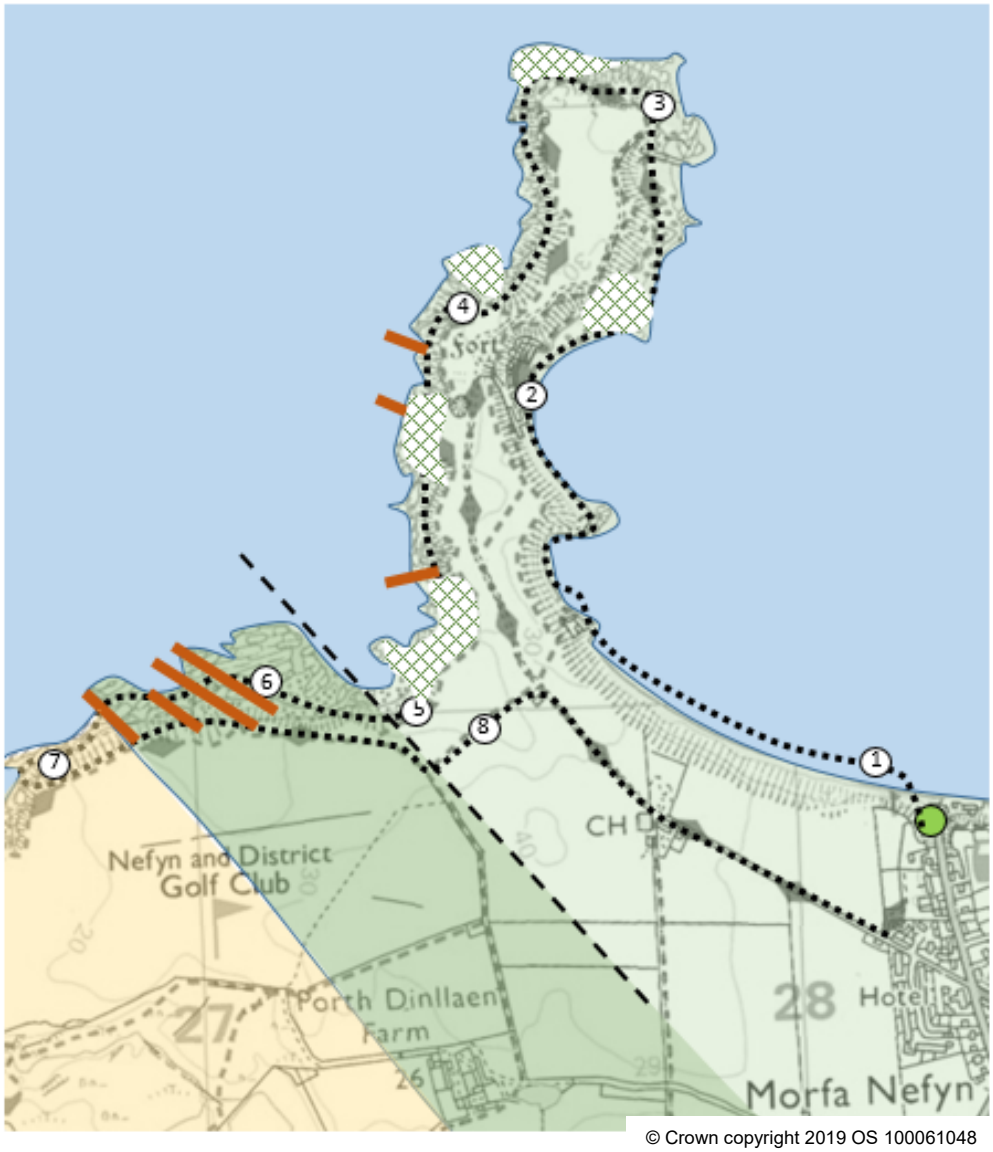
Examine the second, larger outcrop area which breaks through the beach gravel. This is a complex example of ocean plate stratigraphy, made up of a mixture of rock types (fig.73). Thick basalt lavas lie closest to the cliff, followed by foliated schist derived from volcanic ash, and finally a volcanic breccia with containing angular basalt fragments in a finer grained matrix (Cattermole & Romano, 1981).

Figure 73: Gwna basalt outcrops, west of Penrhyn Nefyn

7: Continue along the beach to reach a hotel where a minor road runs down to the beach. Near the start of the road, take steps on the left which ascend to the coastal footpath along the cliff top. Return along the path to Nefyn.

Porth Dinllaen

3 miles: approximately 2 hours



Tertiary dyke

Cambrian ocean floor stratigraphy: pillow basalts

Late Precambrian ocean floor stratigraphy: pillow basalts

Late Precambrian sandstone

Figure 74: Field excursion

Basalt with pillow structures is spectacularly displayed at Porth Dinllaen headland.

Start: From Morfa Nefyn take the road towards the Nefyn golf club. A National Trust car park is situated just before the golf club entrance, with a footpath to the beach [SH281407].

1: Continue along the path at the base of the cliffs around the headland.

Pillow lavas of the Gwna Group are exposed in the cliffs and wave cut platforms. The lavas show the characteristic features of basalts erupted from a sea floor vent or fissure. Pillows may have a vesicular struture due to the escape of gasses, and show dense crusts where rapid crystallisation has occurred in contact with the cold sea water. Individual pillows can sometimes be traced as a string of linked spheroid bodies, suggesting that an early formed skin fractured to allow remaining molten magma to ooze outwards and create a

further pillow structure. Pillows often exhibit flattened bases and domed uppper surfaces, allowing the upwards-facing direction of the lavas to be confirmed.

As superheated steam is released from the interior of the pillows, it can dissolve silica, carbonate and iron. The fluids then escape into the cavities between pillows where quartz, calcite and jasper may be deposited. In some cases the iron content of the fluids was so high that crystals of the iron oxide **haematite** were deposited.

Figure 75: Pillow lavas, Porth Dinllaen.

3: Continue to the lifeboat station at the point of the headland.

Pillow lavas are well exposed, and show all the characteristics of sea floor eruption mentioned earlier. Pyroclastic ash bands are also present, indicating periods of explosive eruption from sea floor vents.

We see that the succession is disrupted by many low-angle thrust faults. This suggests that multiple slices of ocean floor basalt were scraped off the descending oceanic plate during subduction at the continental margin in a process known as **obduction**.

Figure 76: Thrust faulting in the sequence of pillow lavas, Porth Dinllaen.

4: Continue along the coast path around the headland towards Borth Wen. At times when golf is in progress, it is safest to follow the road along the centre of the peninsua, then rejoin the coast path beyond the golf clubhouse.

5: Descend to Borth Wen. A fault runs down the valley at Borth Wen, producing a boundary between the pillow lavas of the Porthdinllaen headland and Gwna mélange outcrops in the bay.

Examine the basalt outcrops to the east of the fault. Amongst the lavas are found **dolostones**. These unusual rocks were formed by the eruption of basalt lava into lime mud on the sea bed, producing a limestone and basalt breccia. The lime mud may have been precipitated from carbonate rich hydrothermal fluids emitted from the volcanic vents.

We now move westwards across the fault to reach the Gwna mélange. This contains masses of quartzite and limestone in a muddy matrix, along with undisturbed beds of mudstone and sandstone grit.

6: Continue westwards along the beach platform. We reach the outcrop of a mafic schist (fig.78). This appears to be a metamorphosed sequence of basalt lavas, basaltic ashes, mudstone and other types of ocean plate stratigraphy. These rocks are of probable Precambrian age, and are related to subduction during the initial convergence of the Avalonian microcontinent with the coast of Gondwana.

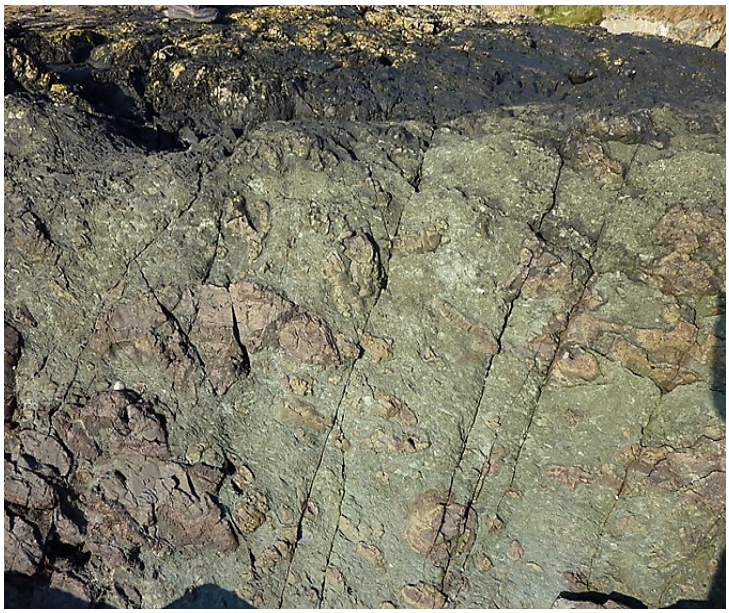


Figure 77: Dolostone blocks in a matrix of claystone.

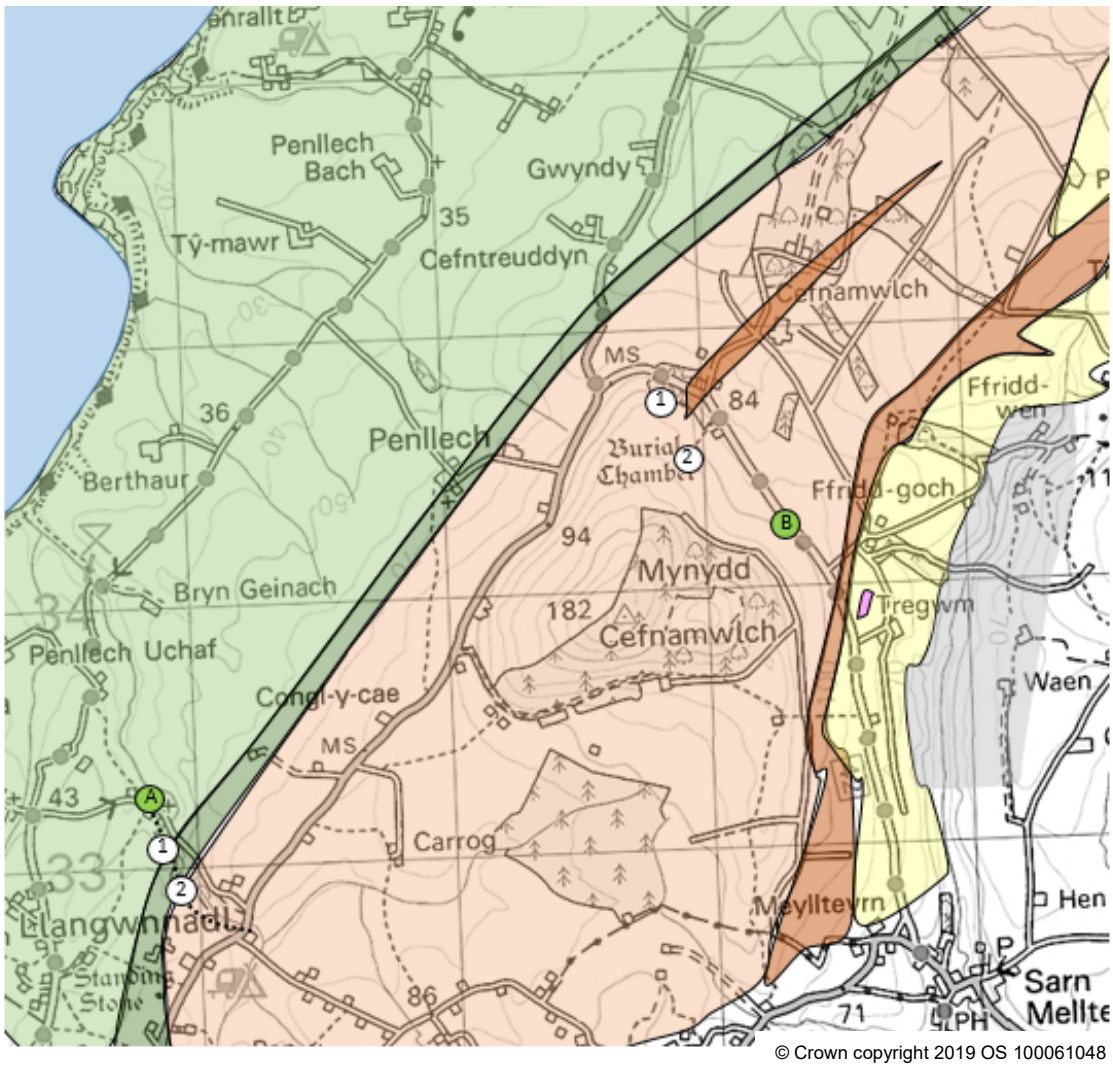
7: Continue along the coast path. The outcrop of mafic schist gives way to a sequence of well-bedded mudstones and sandstones. These rocks exhibit small scale folding.

8: Return along the cliff path to the golf course, than back to the car park.

Figure 78: Schist produced by metamorphism of ocean plate basalts and sediments, Borth Wen

Sarn

1 mile: approximately 1 hour



- Schist
- Gwna mélange with pillow basalts
- Sarn granite
- Bryncroes sandstone
- Trygarn sandstone
- Nant Ffrancon mudstone

Figure 79: Field excursion.

Monian rocks are generally poorly exposed inland of the coast in Lleyn due to thick glacial deposits covering much of the peninsula. In this excursion we visit two outcrop areas around the village of Llangwnadl in central Lleyn. Both are quite overgrown and not easy to access, but are important scientifically for the information they provided to geologists about the sequence of events in late Precambrian times.

Excursion A carries out a transect along a small river gorge, passing from Gwna Group basalt, through the Lleyn shear zone and into gneiss of the Sarn Complex. The sequence is similar to the outcrops better displayed at Penrhyn Nefyn.

Excursion B examines gneisses in old quarries, and demonstrates an unconformity where gneiss is overlain by Ordovician sedimentary rocks.

Start A: park by the church in Llangwnadl [SH209332]. Cross the road and climb over a small wall to reach the path alongside the river.

1: Examine outcrops of schist in the river banks. A few metres upstream from the church, the traverse begins in low-grade schists derived from basalt.

Figure 80: Outcrops of the Gwna Group in river exposures at Llangwnadl.

2: Follow the path alongside the river, skirt around the edge of a field, then return to the river at a small weir. Just below the weir, bands of schist are exposed in the far bank.

Figure 81: Outcrops of the shear zone and Sarn complex

Upstream from the weir, a more massive mafic rock represents a metamorphosed pillow lava. Continuing upstream, more schists are seen, including segregations of quartz and feldspar in a dark matrix, and may have been derived from volcanic ashes in an island arc. These rocks show the characteristic shearing of the Lleyn fracture zone.

The stream curves around a bend. At this point is seen a solid black igneous band which is a Tertiary dolerite dyke.

Beyond the river bend, basic gneisses with large crystals of **hornblende** are seen. Some contain quartz and feldspar segregations. The outcrops of these rocks continue as far as a small waterfall. They represent metamorphosed diorites emplaced within the original Avalonian microcontinent, and their foliated structure may have been developed during transverse movement in the Lleyn fracture zone as terrane blocks moved to their present positions during Cambrian times.

Start B: Park in a layby near the entrance to Mountain Quarry [SH231346].

Climb over the roadside wall to enter the largely overgrown quarry. The best exposures are in a small subsidiary quarry in the north-western part at the top of the main quarry.

2: Examine gneisses in the quarry.

Cleaved Arenig shales, siltstones and fine-grained sandstones overlie a 10 cm thick basal conglomerate which, in turn, rests unconformably upon 'granite'. The surface on which the Arenig sediments rest is uneven and cut by a few small reversed faults, each with a throw of a few centimetres.

Figure 82: Sarn quarry: unconformity, with Ordovician sediments lying on a irregular surface of granitic gneiss.

Figure 83: Sarn quarry: unconformity, with Ordovician sediments lying on a irregular surface of granitic gneiss.

The granite is of a particular variety called monzonite, which has about equal amounts of plagioclase and orthoclase feldspars, with relatively little quartz present. It is light in colour, and cut by closely spaced joints.

Start C: Cefnamlwch

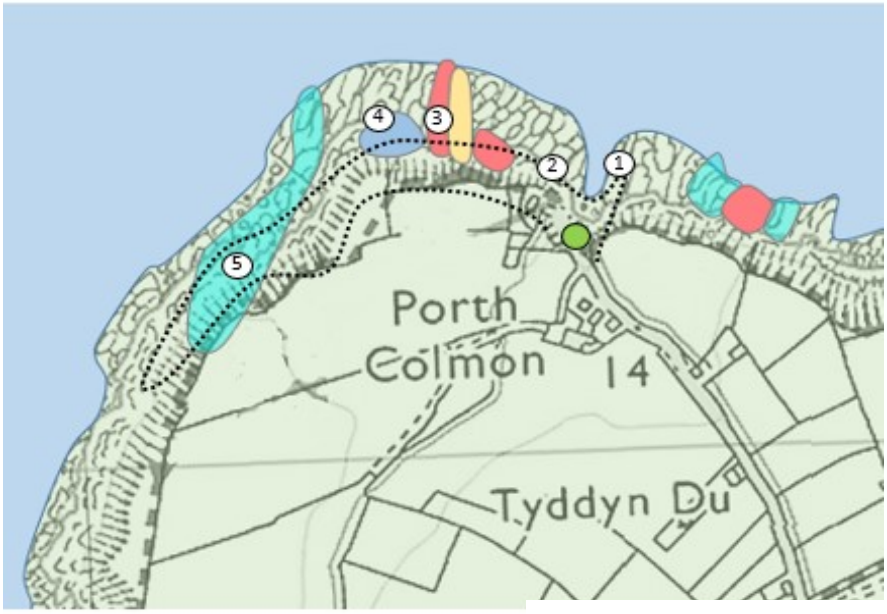
Whist at the old granite quarries, it is well worth visiting the nearby Neolithic monument. Take the track on the southern edge of the wood in which the quarries lie, and the monument is visible in the first field up the hill.

The monument itself has been constructed from a large slab of grey dioritic gneiss, supported on three pillars of the same rock type. Beneath the roof lies a further large slab, this time of white monzonite granite.

Figure 84: Igneous rocks of the Sarn complex forming the Cefnamlwch neolithic monument.

Porth Colmon

1 mile: approximately 1 hour



Tertiary dyke

Cambrian Gwna Group:

mainly pillow basalts

limestone

sandstone

quartzite

Figure 85: Field excursion.

We now move away from the Lleyn shear zone and Sarn Complex, to examine the Gwna Group sedimentary rocks of low metamorphic grade which are exposed along the coast of north-west Lleyn. The principal rock type seen is mélange, consisting of a breccia containing massive clasts of sandstone, quartzite and limestone. This formed as shelf sediments slumped into a subduction trench on the margin of the Avalonian microcontinent in late Precambrian times.

Start: Park at the end of the minor road leading to Porth Colmon [SH194343].

1: Go to the wave-cut platform to the east of the inlet, to see Gwna melange with quartzite sandstone clasts.

Figure 86: Gwna mélange, Porth Colmon.

2: Return to the inlet and follow the wave-cut platform to the west, examining the Gwna mélange.

This rock unit is widespread along the west coast of the peninsula, and may have been the main deposit in an extensive subduction trench extending along the margin of Avalonia. It is characterised by a completely chaotic appearance, with jumbled clasts of various rock types in a grey-green slatey mudstone and siltstone matrix. The clasts include various types of sandstone, locally mixed with less common lithologies such as limestone, white quartzite, basaltic lava and red mudstone. The rock has a steep cleavage, and some minor folds in the ghost stratigraphy can be seen.

3: Examine a Tertiary dolerite dyke which outcrops in a prominent channel in the wave cut platform. This thin intrusion has a chilled margin, inside which is a prominent vertical band rich in calcite vesicles.

4: Examine the enormous white quartzite and pink dolomitic limestone clasts in the mélange, which rise from the wave cut platform as prominent rounded masses.

Figure 87:
(left) Tertiary dyke, Porth Colmon
(right) Margin of the dyke, showing calcite infilling gas vesicles.

Figure 88: Huge clasts in Gwna mélange, Porth Colmon

5: Cross the small bay to examine a further large sandstone clast in the melange, then return along the wave cut platform to the parking area.

Porth Iago to Porth Oer

5 miles: approximately 2 hours

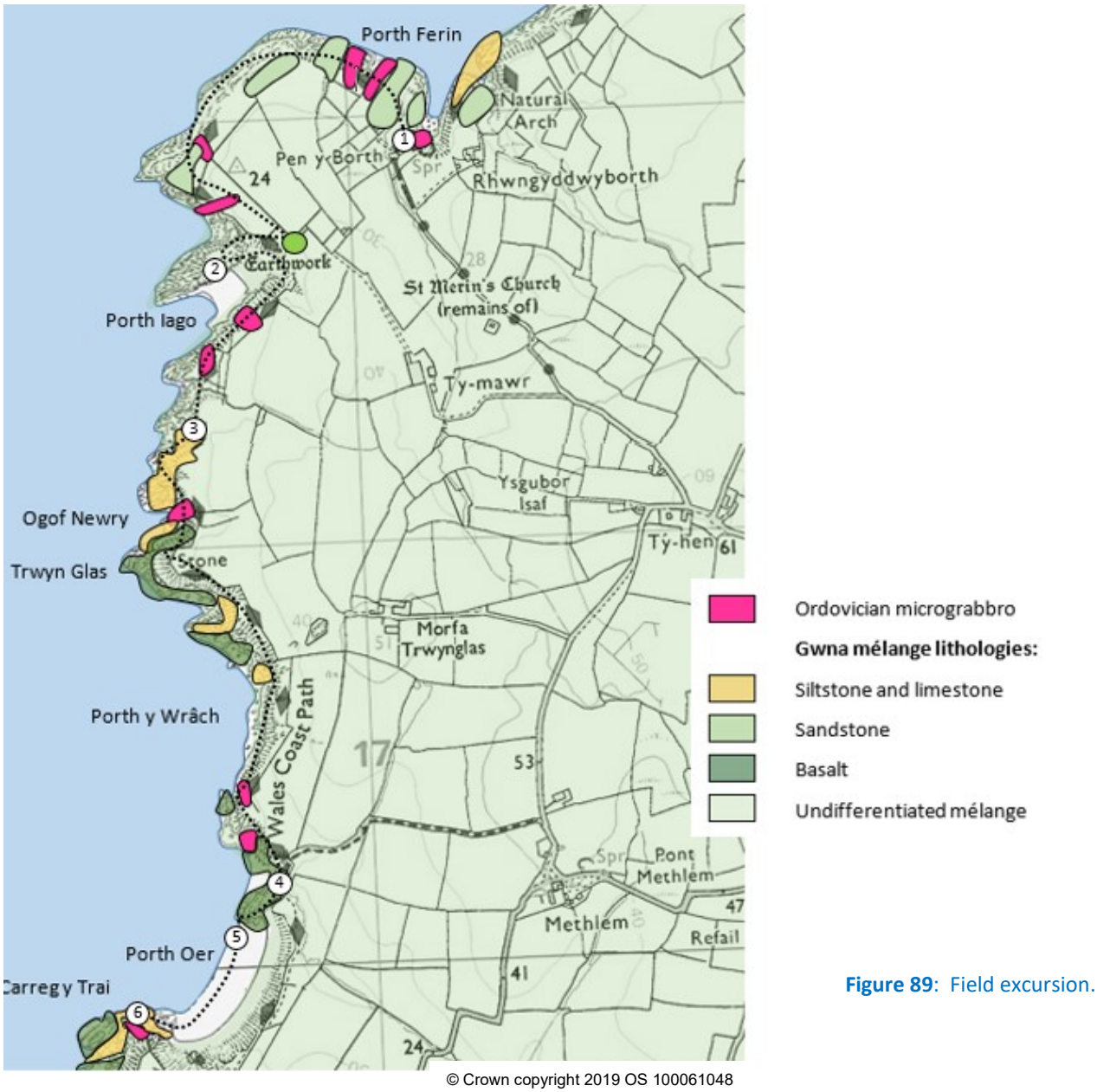


Figure 89: Field excursion.

Start: Parking is available above the cliffs at Porth Iago. Follow the minor road and farm track from Tŷ-hen [SH168317]. A parking fee is payable at the farm.

1: Optionally, follow the cliff path to Porth Ferin. Descend the grassy slope to the beach to view the Gwna mélange. Return around the cliff path to Porth Iago.

2: Descend the path to the beach at Porth Iago. Gwna mélange exposed in the cliffs is similar to the Porth Colmon deposits, consisting of a mud matrix containing a chaotic collection of clasts of sandstone, quartzite and limestone. A ghost stratigraphy can be identified. This deposit is of late Precambrian age, and appears to represent the ocean trench deposits which accumulated during the convergence of the Avalonian microcontinent with Gondwana.

3: Follow the coast path south along the cliffs to Porth Oer.

Gwna mélange is seen in the cliffs and along the coast path. Moving southwards, the amounts of basalt lava and deep water claystone increases. These materials represent ocean plate stratigraphy, scraped from the descending oceanic plate and incorporated into a subduction complex.

Figure 90: Gwna mélange, Porth Iago

Outcrops of dolerite are seen, with a greater degree of alteration than the Tertiary dykes of Penryn Nefyn and Porth Colmon. These intrusions are associated with volcanic activity which affected the Lleyn peninsula in Ordovician times.

4: Skirt around a bay with steep cliffs then descend to the beach at Porth Oer.

5: Examine pillow lavas in the cliff and in outcrops on the beach.

The pillow lava outcrops show a mixture of red and green colouration, representing differing levels of oxygenation during burial on the Precambrian ocean floor. Jasper, composed of hematite stained quartz, has been deposited in the cavities between pillows as silica and iron escaped from the solidifying basalts as hydrothermal fluids.

Figure 91: Pillow lava, Gwna Group, Porth Oer

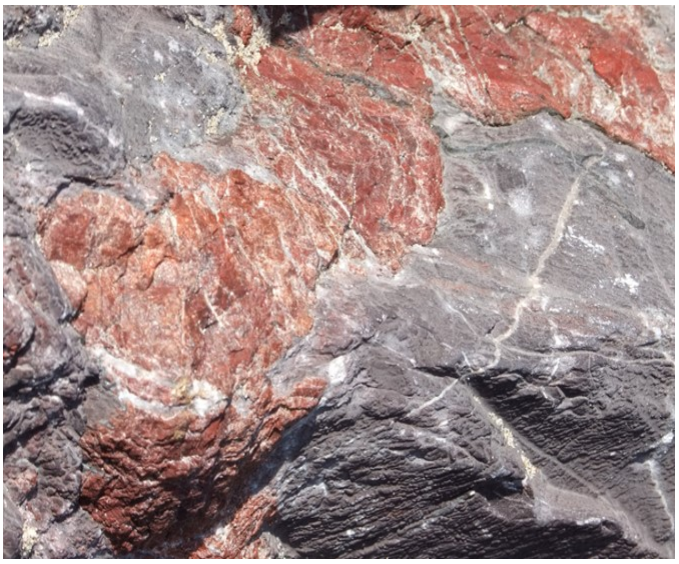


Figure 92: Jasper between lava pillows, Porth Oer.

6: Walk to the south end of the beach and ascend the stone steps to view banded claystone strata outcropping on the wave-cut platform . These rocks, known as 'Gwyddel Beds' represent sediments laid down in deep water on an oceanic plate. Banding may be seasonal, with silica layers produced during periods of peak productivity by marine plankton.

Figure 93: Red banded claystone with minor folds.

On reaching the subducting trench, the ocean floor sediments would still be in a semi-lithified condition, so were subject to soft sediment deformation and folding as they were added to the accretionary prism.

Porth Orion

3 miles: approximately 2 hours

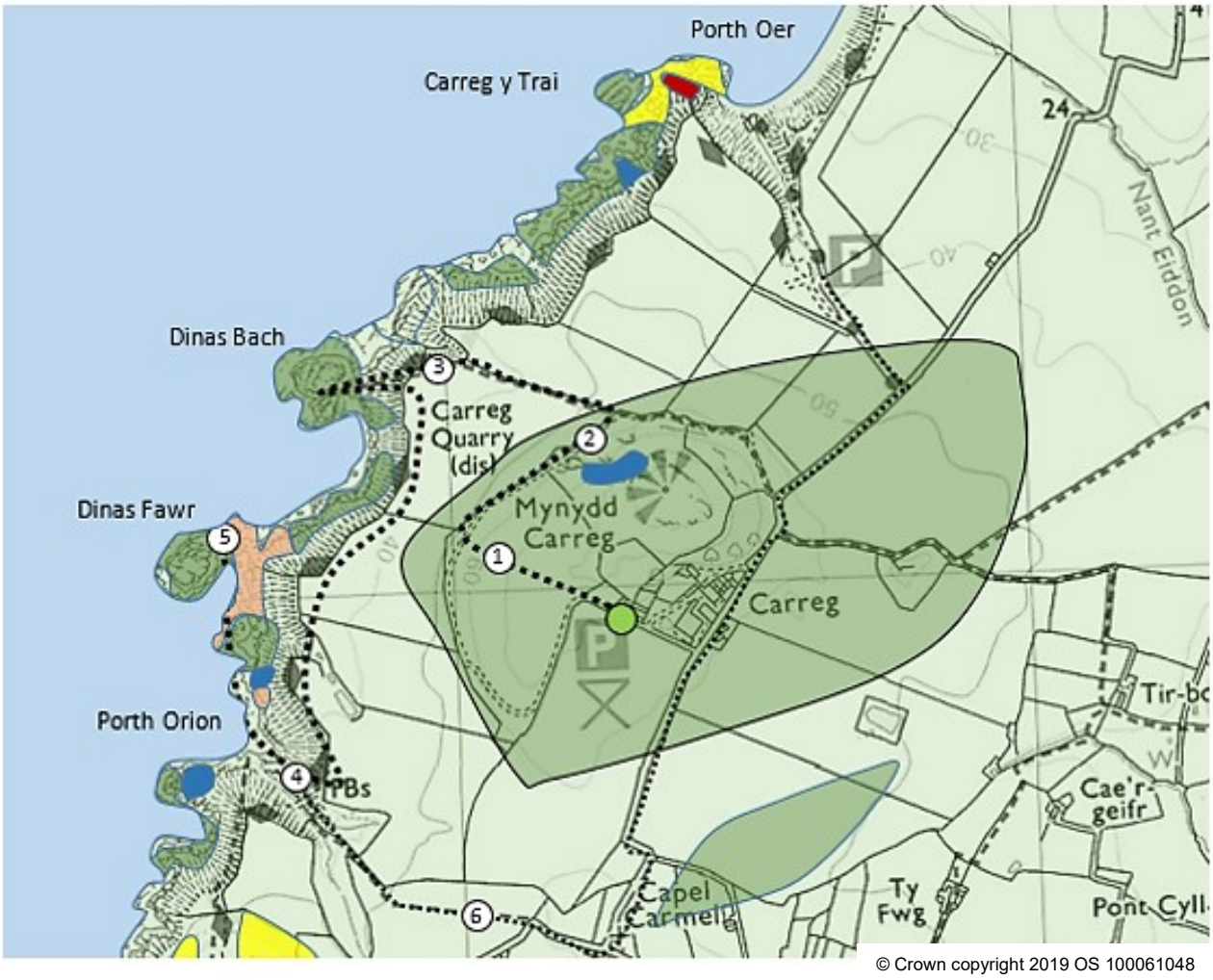


Figure 94: Field excursion.

In this excursion, we continue southwards along the coast of Lleyn to examine jasper quarries at Carreg, and outcrops of basalt lavas and other ocean plate stratigraphy at Dinas Fach island and Porth Orion.

Start: Park at the small National Trust car park at Carreg [SH163290].

1: Descend across the field to a farm track, then follow this to the old jasper quarries below Mynydd Carreg.

2: The quarries, opened in 1904, worked two bands of massive jasper. This semi-precious stone, consisting of hematite stained quartz, was at one time popular for decorative purposes in public buildings, and for making jewellery items.

The jasper is interbedded with other ocean plate stratigraphy, including mudstone, grey chert and dolomitic limestone. Outcrops of these materials are found in the quarries and above on the hillside of Mynydd Carreg.

3: From the quarries, follow a footpath alongside a field boundary to reach the coastal footpath. Walk a short distance southwards along the footpath until a grassy slope comes into view, leading down to inlet between the mainland and

Figure 95: Carrog jasper quarry

Dinas Bach island. At low tide, it is possible to descend and cross to the island to examine spectacular outcrops of pillow lavas (fig.96). Flattening on the bases of individual pillows indicates that the succession has not been overturned at this locality. Basaltic breccia is present between horizons of lava.

Figure 96: Pillow basalt outcrops at Dinas Bach

6: Continue to Porth Orion, then take the path inland across fields to Capel Carmel. The minor road then leads back to Carreg car park.

Uwchmynydd

2 miles: approximately 2 hours

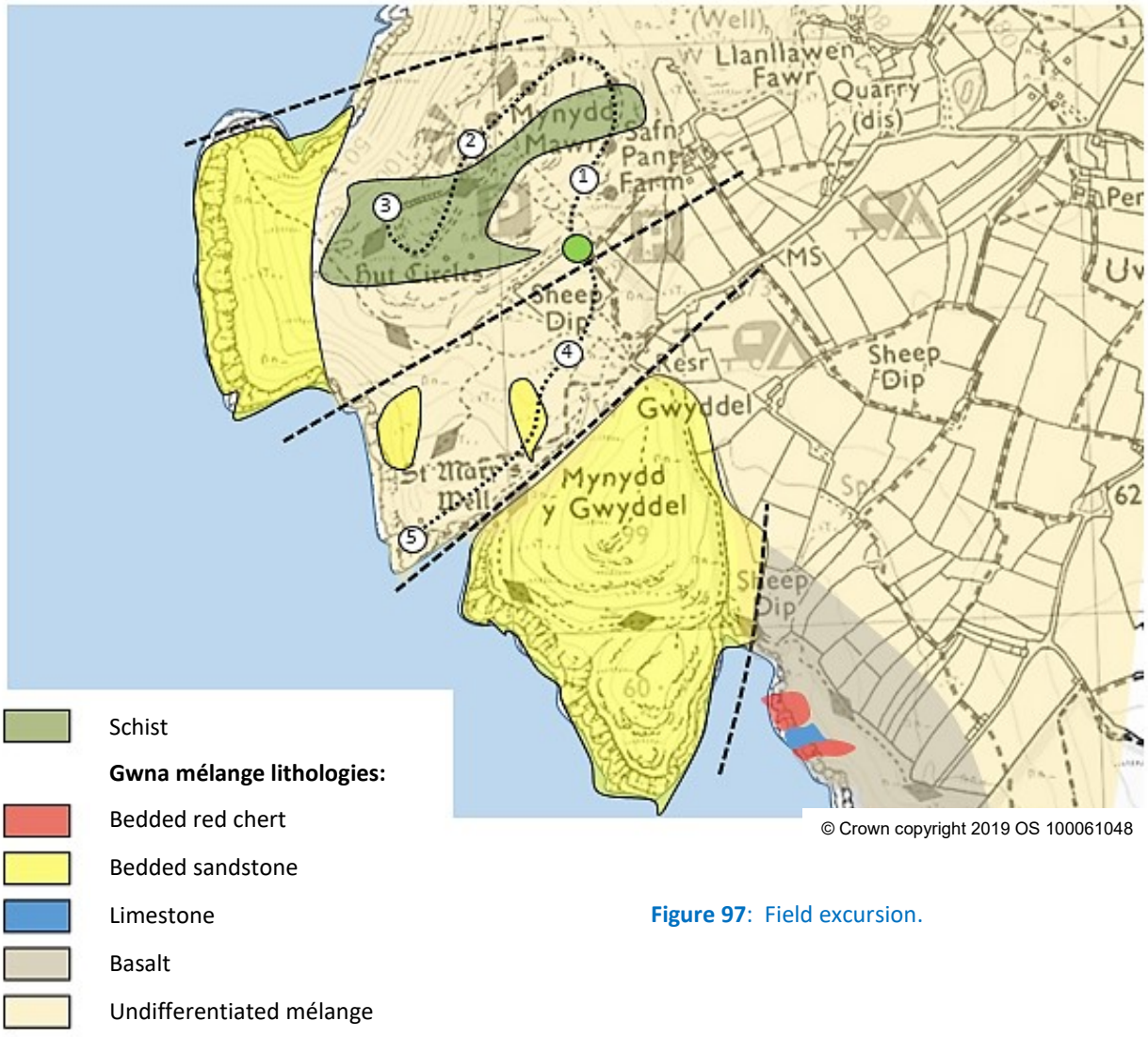


Figure 97: Field excursion.

Start: From Aberdaron, take the minor road through Llanllawen to Uwchmynydd, then park in the grass parking area just within the National Trust headland [SH142256].

1: Walk up the road to the coastguard lookout at the top of Mynydd Mawr.

2: Examine outcrops of schist below the coast guard station (fig.98).

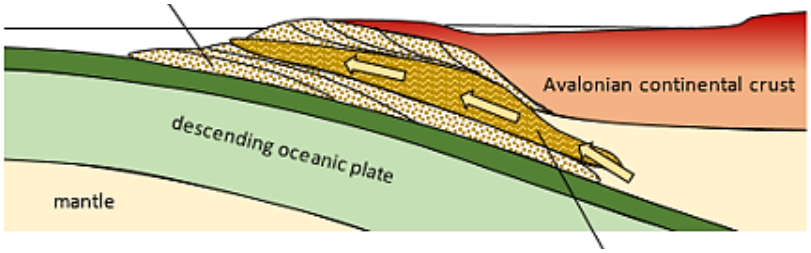
The rocks are similar to the blueschists found at Penrhyn Nefyn, and are thought to represent part of a slab of rocks which was metamorphosed under high pressure in a subduction zone, then returned to the surface due to buoyancy.

Figure 98: Schist at Uwchmynydd

The schists at Mynydd Mawr are flat-lying, in contrast to the steeply dipping outcrop at Penrhyn Nefyn. It is thought that the slab of schist was folded into a sub-horizontal position as it emerged above the subduction zone. The schist unit has been inserted into the accretionary complex between rocks of lower metamorphic grade, above deposits of Gwna melange and below Gwna pillow lavas.

FORMATION OF THE SCHIST UNIT

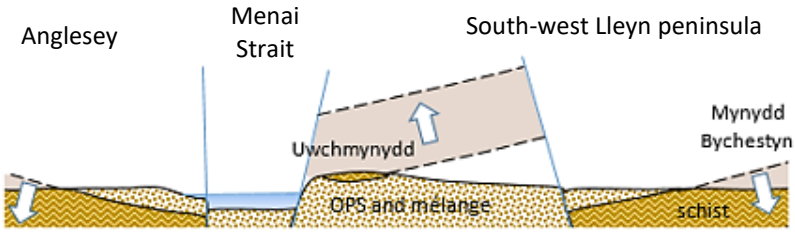
Underthrust complex of ocean plate stratigraphy and slumped mélange of shelf sediments carried downwards with the descending plate



Scists produced by high pressure metamorphism of subducted trench deposits. After breaking away from the descending plate, the hot buoyant schist unit returns towards the surface.

Figure 99: Schist unit in south-west Lleyn.

PRESENT DAY DISTRIBUTION OF THE SCHIST UNIT



upfaulted block

3: Continue eastwards from the coastguard station to a quarry at the head of the cliff.

The quarry has actually extracted a single large block of limestone from the Gwna mélange. Remnants of limestone are visible in the quarry faces.

4: Return past the coast guard lookout and down the road to the to the parking area. Continue down the grassy slope towards Trwyn Maen Melyn.

5: A path around the west of the inlet leads to a rock headland where the Gwna mélange is spectacularly exposed (fig.101).

Figure 100: Quarry in Gwna melange, Uwchmynydd.

Large quartzite boulders are present in a muddy matrix, and show thrust faulting and folding. A wedge of rusty-weathering pillow lavas overlies the mélange, cut by a fault along the axis of the small inlet.

Figure 101: Gwna mélange, Uwchmynydd:

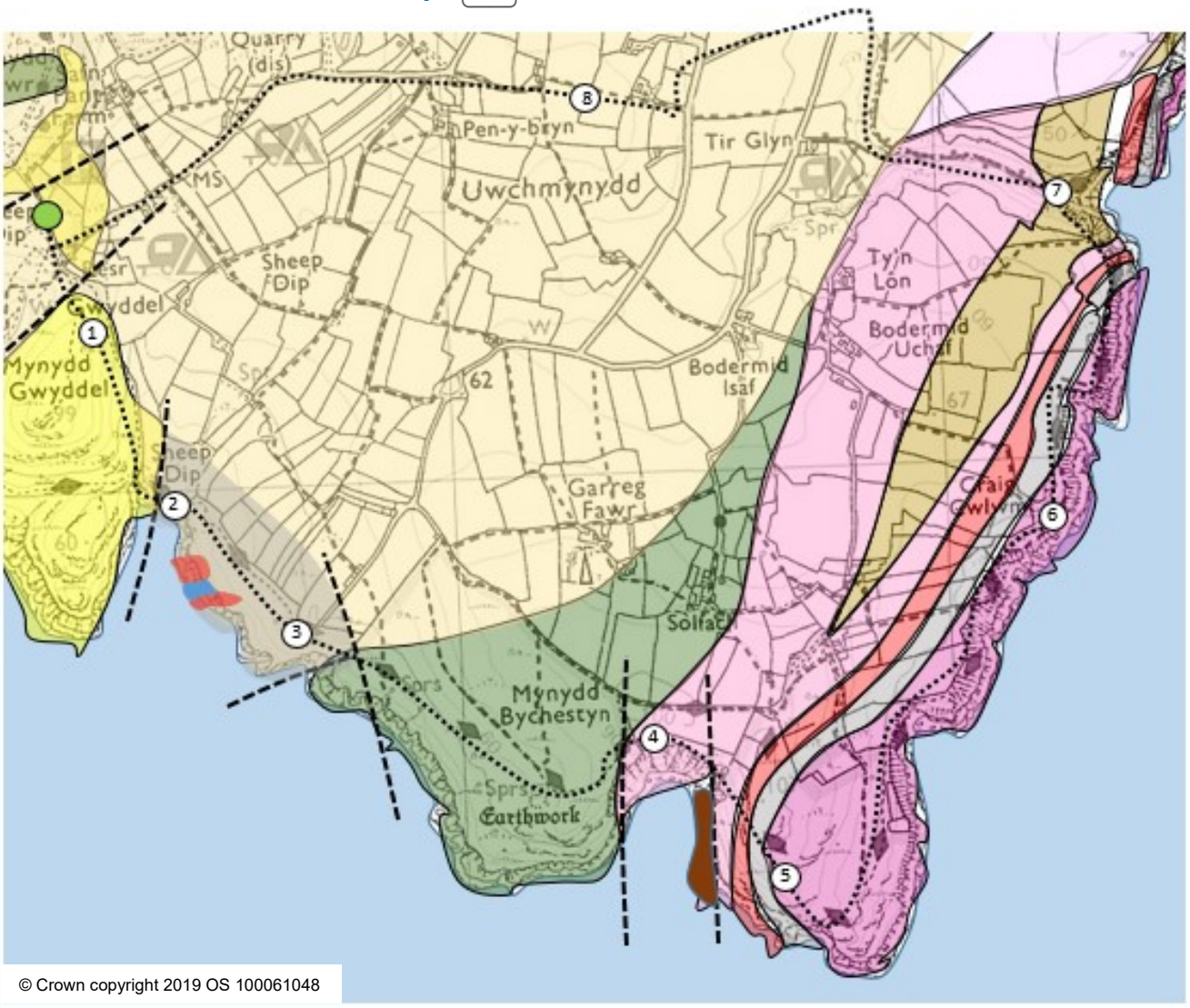
(above) Line of fault in the cliff, with a large block of quartzite in muddy mélange, overlain by rusty weathering pillow lavas.

(below) Mélange, with slump structures disrupting the original bedding.

Return up the grassy slope to the parking area.

Porth Felen to Porth Meudwy

5 miles: approximately 3 hours



- Ordovician microgabbro
- Wig Bach mudstone
- Trwyn Cam sandstone, siltstone
- Porth Meudwy sandstone
- Nant Fffancon mudstone
- Parwyd gneiss
- Schist

Gwna mélange lithologies:

- Red chert
- Limestone
- Sandstone
- Pillow basalt
- Undifferentiated mélange

Figure 102: Field excursion.

The objective of this excursion is to carry out a traverse from the Gwna Group, through schists of the Lleyn fracture zone, to the Ordovician boundary. We then examine sediments and a large dolerite intrusion within the Ordovician succession.

Start: Follow the minor road from Aberdaron to Uwchmynydd, the park in the National Trust parking area [SH142256].

1: Follow the inland path around Mynydd Gwyddel to Porth Felen.

2: At the head of Porth Felen, the Gwyddel Group is faulted against Gwna lavas and greenschists. The fault dips steeply and strikes almost north-south. Descend the fault gulley to observe the slices of basalt ocean plate stratigraphy which were underthrust in the accretionary complex during subduction below the Avalonian microcontinent (Maruyama, Kawai, & Windley, 2010).

Figure 103: Basalt lavas, Porth Felin.

3: Return to the cliff path and continue eastwards.

Pillow lavas, together with limestone form the cliffs in this section and the beds become more disturbed and overfolded towards the south-east. Thrusting affects both the Mona Complex and a Palaeozoic dyke, strongly suggesting a Caledonian age for the faulting.

The remaining coastal exposures between here and Parwyd are of highly crumpled green phyllites which become increasingly schistose as Parwyd is approached. In the cliffs of Trwyn Bychestyn may also be seen a belt of mélange shattered and distorted within the Lleyn fracture zone.

4: Continue to the inlet of Parwyd. Skirt around the Parwyd cliffs, viewing the rock outcrops in the cliff faces.

At Parwyd, the schists are cut by steeply inclined faults, and the Arenig sandstones are apparently thrust against them in the vertical wall of the cliff. Well-bedded Arenig shales and sandstones form the eastern headland (Gibbons & McCarroll, 1993).

The eastern face of the inlet is formed by the Parwyd gneiss. This is not accessible from the cliff top, but has been examined by landing in the inlet by boat. The rock is a coarse, foliated amphibolite gneiss which seems to have been derived by metamorphism of a diorite. It is assumed that the Parwyd gneiss belongs to the Sarn Complex.

Figure 104: Parwyd.

5: Continue along the foot path to Pen y Cil headland.

The first rocks encountered are coarse, well bedded Arenig sandstones but these are cut by a thick, quite coarsely crystallised microgabbro sill. The microgabbro intrusion extends along the coast towards Aberdaron.

6: View the cliff quarries in the microgabbro at Trwyn Dwmi. It was opened in 1907. Ladders had to be used by quarrymen to descend to the quarry face. The quarry produced road setts and kerbstones. A quay was constructed to allow ships to load. Working conditions were very difficult, and the quarry closed in 1938.

7: Continue along the coast path to Porth Meudwy, then follow the road up from Porth Meudwy harbour.