

NEWBOROUGH & LLANFAIR FIELD EXCURSION GUIDE

10/09/2019



Meeting point: Newborough Nature Reserve beach car park outside toilets @ 09:45

Accessible island time: 09:30 – 17:00

Low 01:26 @ 1.70 m

High 07:14 @ 4.10 m

Low 13:46 @ 1.80 m

High 19:23 @ 4.40 m

Risk assessment: completed (MW)

Schedule:

- 10:00 – Introductory talk
- 10:15 – Walk to first Coed trail locality
- 10:45 – Coed trail tour
- 12:00 – Walk to causeway for lunch
- 13:00 – Ynys trail tour
- 14:30 – Return to car park
- 15:00 – Drive to Marquess of Anglesey Column car park
- 15:30 – Meet in car park for tour of blueschist locality

Purpose: To study the ancient sea floor material of the Gwna Complex and the Precambrian blueschists of the Penmynydd Terrane.

Terrain: The tour will involve around 6.5 km walking at Newborough Nature Reserve along largely flat terrain consisting of paved paths, dirt paths and sand. Some localities are situated off pathways (< 50 m) and are on fair terrain. The tour at Llanfair will involve < 1 km walking in a wooded area.

Directions and parking

Newborough Nature Reserve is accessible from two points. The recommended option is the Newborough Nature Reserve car park, which is the starting point for this trail (SH406634). Between 9am – 5pm there is an entry fee of £5 to access the car park for the full day. To reach the car park, head towards Newborough along the A4080 and turn south at the village centre, following the signposts. Beyond the toll there are several parking options. Head to the end of the road (around 2.5 km) to the main car park next to the beach. Another alternative is the Llyn Parc Marw car park (SH413670) on the A4080- heading from Newborough towards Malltraeth – which gives access to Newborough Nature Reserve from the north of the forest but involves a significantly longer walk to the trail. Parking is free, but parking spaces are much more limited.

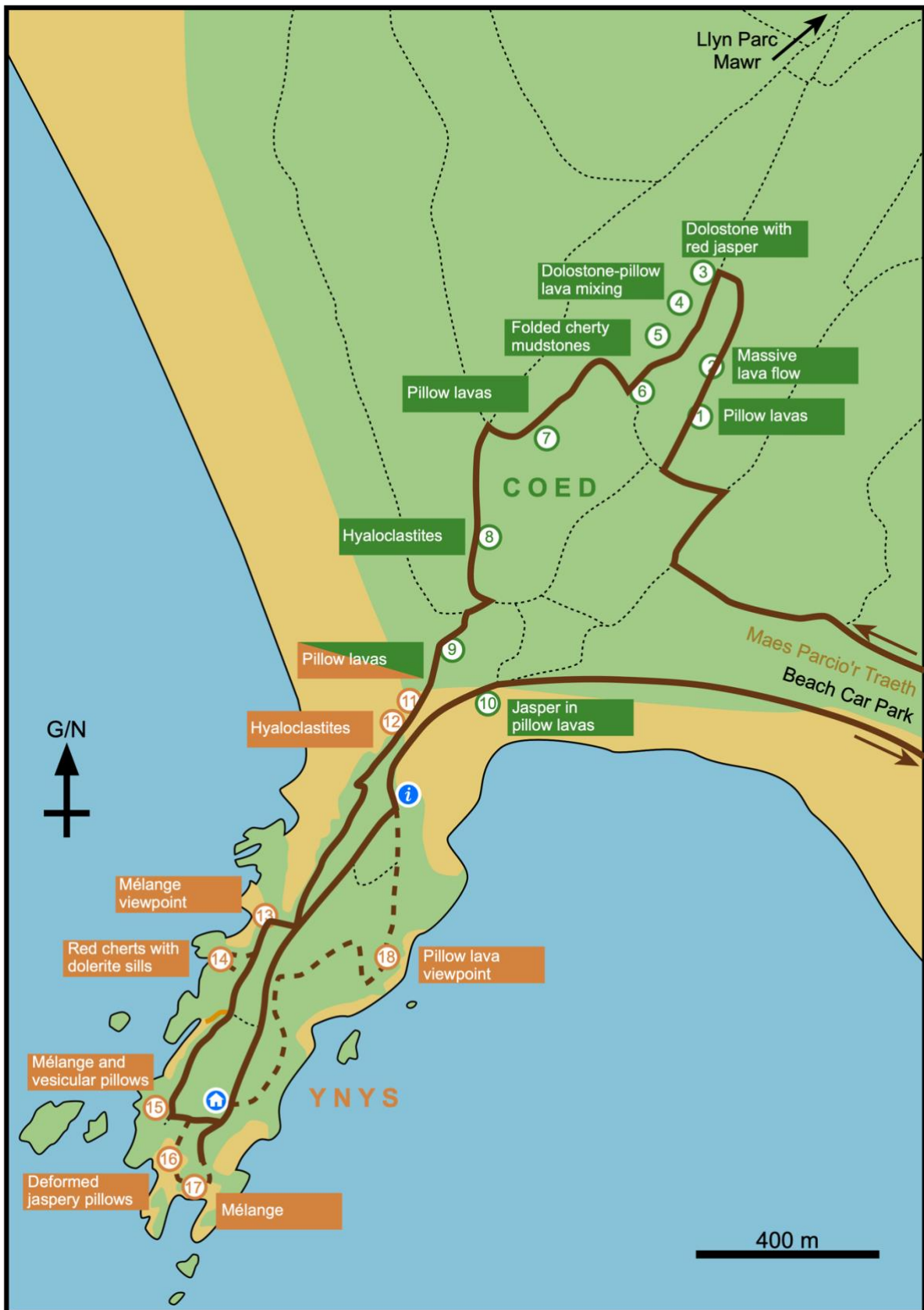
The Marquess of Anglesey Column is accessible from a small, discrete car park (SH533715) on the northern side of the A5, just outside of the town of Llanfair. If arriving from Newborough, the take a right from the A4080 onto the A5 and the car park is on the left after only 100 m. Parking is free and an information board for the site can be found in the car park.

General information

When visiting Llanddwyn Island, please check tide times in advance. During high tide the island may become inaccessible for several hours. If doing the full geotrail, schedule your day by doing the Coed tour at high tide and Ynys tour at low tide. When spending time of Llanddwyn Island, make sure to keep the tides in mind to avoid being cut off.

Llanddwyn Island and Newborough Forest are protected sites so hammering and rock collecting is forbidden. Llanddwyn Island is an important nesting site for a variety of birds so please respect restrictions of access that are put in place. These are most likely to be encountered around Spring and Summer months. Access for dogs is also restricted from Llanddwyn Island and the beach between May and September, although they are free to access the forest.

The full Newborough geotrail involves around 6.5 km walking (starting and ending at the beach car park) along largely flat terrain consisting of paved paths, dirt paths and sand. Some localities are situated off pathways (< 50 m) and are on fair terrain. There is little access to shelter and facilities away from the car park, so bring appropriate supplies. At the Marquess of Anglesey Column, the locality is only a short distance (< 50 m) from the car park in a small, wooded area.



Geological Background

'Where land and sea collided' – the Gwna Complex that makes up Newborough Nature Reserve shows the spectacular remnants of an ancient ocean floor – the Iapetus Ocean – that has long since disappeared. Exposed across Llanddwyn Island and continuing northwards up through Newborough Forest, the Gwna Complex comprises an amalgamation of submarine volcanic rocks and sedimentary rocks that accumulated along the entire lifespan of the ancient ocean. Around 550 million years ago, the Iapetus Ocean began to subduct below the supercontinent of Gondwana. At the centre of this collision, fragments of the downgoing ocean plate were scraped away against the continent under great forces, accumulating into what is now the Gwna Complex.

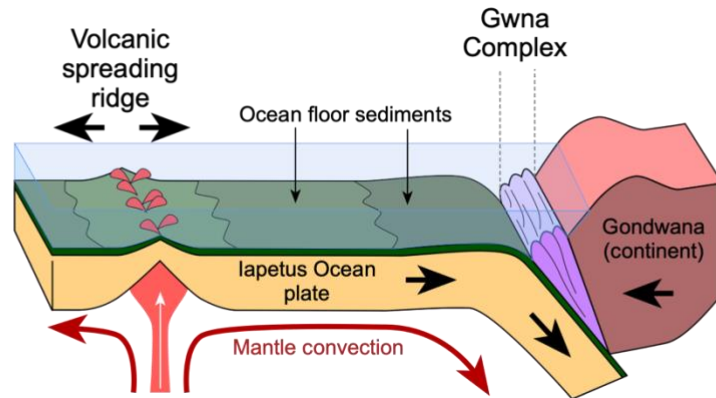
In the afternoon, we will visit the world-famous Precambrian blueschists of Llanfair, some of the oldest known blueschists in the world. Despite their very different – and in the right light, quite striking – appearance, they probably originated from the same basalts seen at Newborough, and some remnant deformed pillow outlines can still be found. The blueschists are the product of high pressure metamorphism at around 25 km depth before being brought back towards the surface.

The lifecycle of an ocean

To fully understand the story of the Gwna Complex, one should know the fundamentals of plate tectonics. Continents and oceans are constantly moving and changing the Earth's surface – albeit very slowly. Oceans form along mid-ocean or axial ridges, which are extensive submarine volcanic systems from which ocean floor material is produced. As ocean floors expand, volcanic material is erupted along these ridges, leading to the slow but steady growth of an ocean.

The Mid-Atlantic ridge, which scars the Atlantic Ocean from Greenland to the Southern Ocean, is a perfect modern-day example. The Atlantic Ocean has slowly been expanding for around 65 million years, pushing apart Europe and Africa from the Americas. It continues to grow to this day.

Eventually, an ocean will effectively run out of room, as other continents begin to push back against it. This leads to the subduction of the ocean, where it is pushed below a neighbouring continent. The subducted ocean will eventually disappear, pushed into the Earth's interior where the material is melted and recycled. This is happening today to the Pacific Ocean, which is subducting below East Asia and the Americas, and is responsible for much of the volcanic activity and earthquakes in those areas. This lifecycle is recorded in the Gwna Complex for the Iapetus Ocean.



Coed – Locality 1 (SH397641)

The first stop is a short introduction to the pillow lavas, which will be seen more extensively later in the tour. Here, a small outcrop of pillow lavas shows the curved features of the pillows, with occurrences of bright red jasper filling spaces between them. At the southern end of the outcrop, a light grey dolerite dyke can be seen cutting across the pillows in an E-W trend, perpendicular to the path.

Coed – Locality 2 (SH397642)

Continuing down the path, the next outcrop shows the unusual occurrence of a massive lava flow, comprised of the same basalt material as the pillow lavas. At the southern end of the locality, curious autobrecciation textures can be seen, made of small spheres of basalt packed tightly together. The outcrop is dark grey with persistent red streaks of jasper and iron-rich material running through, caused by alteration along the joint planes that would have formed during as the lava cooled.

Coed – Locality 3 (SH397643)

At the path junction, see the imposing outcrop of white/yellow dolostone opposite. The dolostones formed from carbonate mud deposited early in the ocean lifecycle around the mid-ocean ridge, directly above the pillow lava base. Towards the bottom of the cliff, see enormous deposits of striking red jasper formed from hydrothermal activity, from the circulation of hot fluids between the different rock types in Newborough. Sporadically, exploded reddened pillow basalts are scattered throughout, having been largely replaced by the surrounding carbonate material.

Towards the top of the cliff, observe a hole within the dolostone. This is the entrance to a Neolithic cave that was supposedly inhabited by early settlers of Anglesey.

Coed – Locality 4 (SH396643)

Further around the corner, the mixing between volcanic pillow basalts and sedimentary dolostone is best exposed. Unlike the pillow lavas at Locality 1, the pillow lavas here are red/purple due to the oxidising effects of interacting with carbonate dolostones. Carbonate mud was deposited on along the mid-ocean ridge while volcanic activity was still going on, leading to a mixing of pillow lavas within the dolostones. At the back of the exposure, reddened basalt is dominant, but following the outcrop around back towards Locality 3, the white/yellow dolostone becomes more common. The mixing has led to fractures in the pillow lavas, causing a cracked texture across their surfaces. In the centre of the outcrop, another light grey dolerite dyke, several metres wide, cuts straight through the rocks, and can be traced back down towards the path. Stretched vesicles can be seen around the centre, left behind from gas bubbles that escaped the rock.

Coed – Locality 5 (SH396642)

A continuation of Locality 4, some excellent exposures of the basalt-dolostone mixing can be seen. Large pillow lavas have had their cores largely replaced by carbonate material as a result of the mixing, leaving the hardened pillow crusts remaining. Back towards the path, two other sedimentary rocks can be found. First is a coarse brown sandstone unit. Beyond that are the striking colours of the silty mudstones. These rocks stratigraphically overlie the dolostones and formed later in the ocean lifecycle.

Coed – Locality 6 (SH395642)

At the base of the path, the spectacular multicoloured silty mudstones is exposed to the left. It displays a series of SE-verging folds with intricate soft-sediment deformation styles. The different layers can be closely observed, with light coloured cherts, purple silty layers which show some graded bedding, and purple to green mudstones. The rocks formed in the deep ocean, where cherts and mudstone accumulate in calm waters, and silts were periodically added from the distant continent.

Coed – Locality 7 (SH394641; optional)

Turning right from Locality 6, the path follows around towards the back of the prominent ridge, which is mostly a continuation of the pillow lavas. The outcrop was photographed during Edward Greenly's extensive geological mapping of Anglesey in the early 1900's. The photograph predates the planting of Newborough Forest in 1947, back

when the area was nothing but sand dunes. Greenly's meticulous fieldwork and mapping of the entire island was revolutionary at the time, and much of his observations and findings still stand today.



Coed – Locality 8 (SH392639; optional)

Turning onto the main pathway and heading south towards the coast, a prominent outcrop to the left of the path exposes another volcanic rock type – hyaloclastites. Also composed of basalts at the mid-ocean ridge, the hyaloclastite formed from more explosive volcanism, where the basalts have fractured into small fragments within a matrix of volcanic glass. The volcanic glass would have been quickly altered, and now appears green due to its high chlorite contents.

Coed – Locality 9 / Ynys – Locality 11 (SH391635)

At the bottom of the path, enter the causeway via the sand dunes. Here, the exquisite shapes of the pillow lavas can be seen in all their glory. Pillow lavas form like

piles of water balloons. As lava is ejected into the cold ocean water, the outer layer immediately cools and solidifies into a thin crust that can still be seen today. The crust insulates the lava inside, which cools slowly after the ‘pillows’ have settled, solidifying the shapes. Pillows have convex bases where they have settled upon the uneven surfaces of other pillows. By looking at the shape of the pillows, one should be able to see that the pillows have since been tilted onto their sides, facing towards the southeast (the direction of the mountains of Snowdonia and Llŷn Peninsula in the distance).

Ynys – Locality 12 (SH390634)

Directly across the causeway, at the base of the steps, the hyaloclastites of Locality 8 reappear. The surrounding beach has some excellent fresh surface examples of the rocks, showing the intricate textures of the rounded basaltic clasts encapsulated in the chaotic, weaving matrix. They are best observed wet, so wash the rocks in seawater to see them best.

Ynys – Locality 13 (SH387629)

After passing through the gate, head west around the cove. At the headland here, look down the rocky crag to see the extent of shearing and deformation that characterised the areas between these protected units visited in Newborough Forest.

Ynys – Locality 14 (SH386629)

Around 100 m further down the path, move to the coastal outcrops to see the impressive layered red cherts. The cherts dip vertically with some evidence of folding. Along with the red cherts, units of mudstones and coarse doleritic sills can be found along the coast here. When exploring, take care on the potentially slippery surfaces. Cherts form in deep ocean environments, much like those at Locality 6. The dolerite sills, different from the dykes seen throughout the area, are a sign of intraplate magmatic activity related to the formation of seamounts.

Looking towards the centre of the island, see the ruins of St. Dwynwen’s Church, built in the Dark Ages in honour of the St. Dwynwen, the patron saint of Welsh lovers.

Ynys – Locality 15 (SH384625)

At the base of Twr Mawr Lighthouse, enter the shallow headland to the right. A dyke cuts along a gulley towards the backwall. To the right of the lighthouse is an excellent outcrop of *mélange*-bearing mudstone, which can be observed in three

dimensions. It contains orientated clasts of mostly basalt, jasper and sandstone, with other rare lithologies. Towards the back of the headland is a rare exposure of vesicular pillow lavas, producing a radial pattern throughout the pillows. The base of the lighthouse is constructed upon sheared dolostone and basalt-dolostone.

Ynys – Locality 16 (SH385625)

Head to the south of the island past the lighthouse and enter the beach at Porth Twr Mawr. In the centre of the beach is a striking outcrop of deformed pillow basalts. The outcrop is split down the centre, juxtaposing pillow lavas mixed with white/grey carbonates on one side and red jasper on the other. The dark grey/purple pillows are speckled with small green spots, marking altered feldspar crystals, and chaotic networks

Ynys – Locality 17 (SH385624)

Following through to the other side of the bay of Porth Twr Bach, the magnificent, chaotic assortment of rocks that comprise the *mélange* of Llanddwyn Island is exposed. The deformed rocks seen at Locality 14 can be seen up close with clean colourful surfaces. The rocks are a product of intense deformation from the continent-ocean collision, and the units have been heavily deformed, displaced and spliced against one another. The rocks seen include green and purple mudstones, pink/white dolomites and dolomite breccias, green hyaloclastites with purple basalt clasts and deformed pillow basalts. The units are cut by a prominent dolerite dyke that extends across the beach parallel to the coast. Contrasted against the bright colours of the surrounding *mélange*, the dark grey dykes have intricate, reddened chilled margins and show multiple episodes of magmatism, with large altered plagioclase crystals several cm in length dispersed throughout the centre.

Ynys – Locality 18 (SH389628)

Returning back across the island past the pilot's cottages, follow the eastern coastal path which runs back through the undeformed pillow lavas towards the north of the island. The pathway benefits from picturesque views of Snowdonia overlooking several raised beaches formed during the Holocene when sea levels were higher.

Coed – Locality 10 (SH392635)

When returning towards the car park along the beach, pass a relatively small but informative pillow lava outcrop past the causeway. See excellent examples of red jasper between the pillows, along with a powdery green mineral – epidote.

Llanfair (SH534715)

The famous Penmynydd blueschists are exposed throughout a small, wooded area surrounding the base of the Marquess of Anglesey Column. The column itself is currently inaccessible. The blueschist is highly deformed, metamorphosed basalt that was subducted to depths of around 25 km, before being exhumed towards the surface and emplaced within the Gwna Complex. At such depths, high-pressure metamorphism led to the formation of glaucophane, a blue amphibole mineral that gives the rock its distinctive colour, best seen in direct sunlight. In the backwall, examples of deformed pillow shapes can be seen by a keen eye, possibly suggesting that the rocks were once pillow lavas like those in Newborough, before being largely destroyed during subduction.

