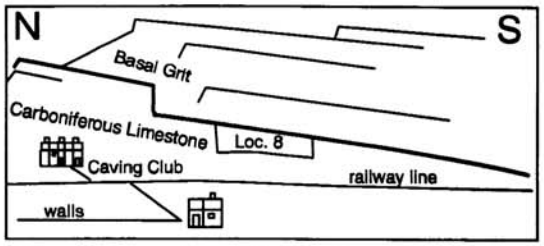
the mouths of vigorous rivers draining the land to the north. The quartz-rich rocks of the Basal Grit are virtually pure **silica** and were quarried as a refractory material for lining furnaces.

The Basal Grit is a tough rock which forms high ground. Beyond the cottages of the South Wales Caving Club ridges on the skyline slope gently to the right (south), following the bedding, with steep **scarp** slopes facing north. The contrast between Basal Grit country (right) and Carboniferous Limestone country (left) is striking. Notice the disused quarry behind and to the right of the caving club - this is Locality 8.



Follow the stone wall towards the caving club, passing a row of limekilns with their loading platform. Cross the line of the old railway to reach the caving club buildings. Turn right and enter the quarry seen from Locality 7.

Locality 8. This quarry exposes the uppermost beds of the Carboniferous Limestone. Fossils are common at the end nearest the caving club, where a cave opening has been exposed in the quarry wall - **do not enter this without proper equipment and experience.** Round black lumps of hard material (try scratching them and the limestone with a penknife blade) are **chert**. This is similar to quartz in composition but differs in structure. It formed by chemical processes after the limestone had been deposited, when silica-rich fluids percolated from the Basal Grit. The contact between the limestone and the Basal Grit is clearly visible along the top of the quarry and blocks of conglomerate lie on the ground.

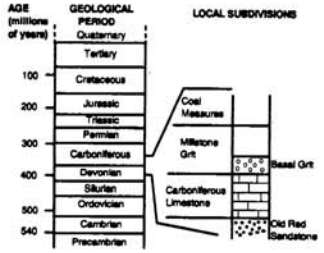
From here you can examine other quarries to the south, which worked the Basal Grit. The rocks include conglomerate, quartz-rich sandstone and beds of friable, fine-grained mudstone or **shale**, some of which yield fossil plants. These easily-eroded beds of shale cause the Basal Grit to form the scarps seen from Locality 7.

Return to the caving club cottages and follow the gravel track towards the working quarry. A sign-board on the right shows paths across the Ogof Ffynnon Ddu National Nature Reserve. The track is bordered by limestone blocks, some with fossils. Before the quarry entrance is the railway station built for the opera singer Adelina Patti who lived at Craig-y-nos. Turn left across a cattle grid onto the surfaced road and immediately turn right along a lane. Pass a row of derelict cottages on your right and aim for a disused limestone quarry 100 m ahead. Skirt the rim of the quarry to crags above its west side for a panoramic view.

Locality 9. The limestone here has been etched by chemical weathering to form **limestone pavement**. The grassy land just beyond the wall is underlain by the **Lower Limestone Shale**, the oldest part of the Carboniferous Limestone. Beyond that area are limestone crags with bedding which dips to the north. The Lower Limestone Shale is in the core of an **anticline**, the crest of which has been eroded away. This is a continuation of the fold seen on Craig y Rhiwarth.

The high ground of the Brecon Beacons to the north (right) is underlain by the **Old Red Sandstone** - river deposits which are older than and underlie the Carboniferous Limestone. Across the valley is the long ridge of Fan Hir. During a short-lived cold spell about 11,000 years ago (which may have lasted only 500 years) after the end of the last major Ice Age, a small glacier built up beneath this ridge. Mounds at the foot of the slope are **moraine** - material eroded from the slope and transported a short distance by the ice.

Descend to the wall and turn left to reach a path. Turn rightover a stile and follow the path across the grassy area, past the crags seen from Locality 9 and down to Pwllcoediog Farm, crossing several stiles. Cross the farmyard and turn left on the bridleway which leads in 1 km to the stepping stones at the entrance to the Country Park (Locality 1).



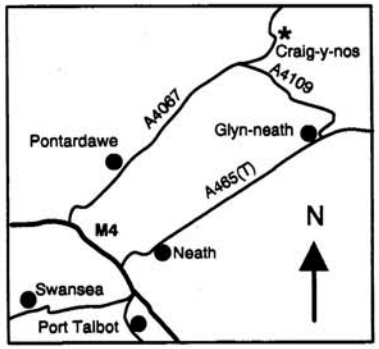
Produced by the Geologists' Association South Wales Group.
If you want to know more about rocks, fossils and the geology of South Wales contact the **Geologists' Association South Wales Group** (Cymdeithas y Daearegwyr - Grŵp De Cymru) at National Museum of Wales, Cathays Park, Cardiff.

Geraint Owen, University of Wales Swansea, March 1996.

Geological Walks in Wales

Craig-y-nos and Penwyllt

This short walk climbs from Craig-y-nos Country Park in the Tawe (Swansea) Valley to Penwyllt, 150 m above the valley floor, to examine the rocks, fossils and landscape of the upper Tawe Valley. The circular route is about 5 km long and should take half a day, but can be extended at Penwyllt.



Location. Craig-y-nos Country Park is off the A4067, 40 km NE of Swansea. The car park is at grid reference SN 8400 1554.

Maps. Ordnance Survey 1:50,000 Landranger sheet 160 (Brecon Beacons); Ordnance Survey 1:25,000 Outdoor Leisure sheet 12 (Brecon Beacons west); British Geological Survey 1:50,000 sheet 231 (Merthyr Tydfil).

Paths are clear and easy to follow in fine weather. In mist or low cloud take extra care: take a map and compass and know how to use them. There is one moderately steep stretch. Penwyllt is exposed and often experiences a cold wind. Do not enter caves or the working quarry. Keep away from cliff faces.

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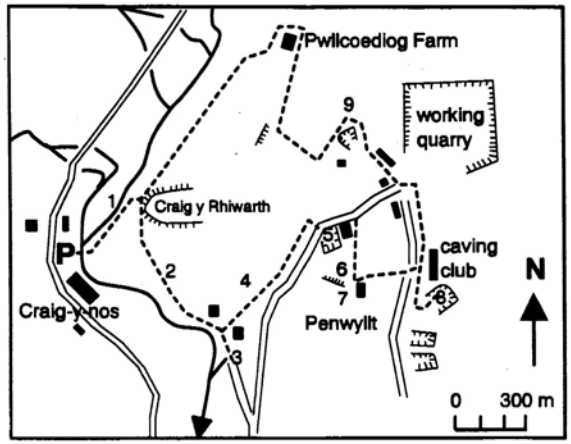


Leave the car park at its bottom end. Cross the bridge, where the river which emerges from the Dan yr Ogof cave system (on the left) joins the River Tawe. Turn left and follow the river upstream to the gates at the edge of the Country Park.

Locality 1. If the river is low enough, examine the stepping stones. They are made of blue-grey **limestone** crowded with **fossils**, mainly crescent-shaped **brachiopods** (shellfish with 2 curved shells) and stick-like, branching **corals**. They show that the rock formed as sediment on the floor of a shallow sea in warm tropical latitudes, like the Bahamas today. Shell debris accumulated layer by layer on the sea bed and hardened into rock. This sea covered southern Britain 350 million years ago in the early **Carboniferous Period** of geological time. These rocks are called the **Carboniferous Limestone**.

The crag of Craig y Rhiwarth dominates this side of the valley. On the skyline vertical layers (**beds**) of limestone can be seen. They have been tilted steeply since they were formed.

The path is littered with pieces of limestone, many with fossils. Look very closely at the surfaces of these stones (a hand lens is useful). Some are made of small, circular shapes, each 1 mm or less across. These are **ooids**, forming **oolitic limestone**. Ooids form today in shallow seas around tropical islands, where lime (**calcium carbonate**) is precipitated from sea-water in layers around a sand grain or shell fragment. Ooids are not fossils - they were never alive.

At the wooden barriers turn right and pass through a gate. In a few metres turn right on the path along the foot of Craig y Rhiwarth.

Locality 2. After 400 m there is a clear view across the valley to the craggy ridge of **Cribarth**, also made of Carboniferous Limestone. On its left (east) flank the beds are tilted (**dip**) to your left (east). Turn around and look to the top of Craig y Rhiwarth. These beds dip west, but others to their right seem flat-lying: in fact they dip gently away from you, in the same direction as those on Cribarth. The rocks of Craig y Rhiwarth have been deformed (**folded**) into an arch or **anticline**: this is the Cribarth Anticline. It is a part of a line of deformed rocks trending NE-SW called the **Swansea Valley Disturbance**. The folding occurred 300 million years ago, and since then erosion has removed the rocks which once covered the limestone. The River Tawe continues this process and has cut a gorge between Cribarth and Craig y Rhiwarth. Downstream, it flows in a deep, straight valley cut along the Swansea Valley Disturbance. Some 18,000 years ago, at the height of the last **Ice Age**, this valley was occupied by a **glacier** which steepened the valley sides. Melting of the ice has resulted in many landslips.

Continue past some houses to a surfaced lane. After a bungalow on the left, notice a wooden gate leading to a path which climbs the hill. Continue past this for a further 100 m.

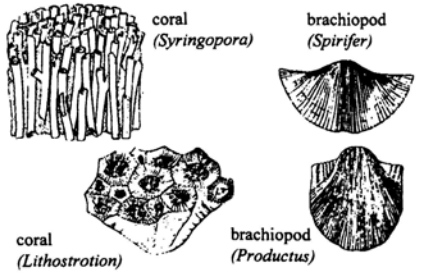
Locality 3. Look down to the right to see a small river which joins the Tawe. This does not flow under the lane, but emerges from a **cave** - Ffynnon Ddu ("black spring"). Limestone dissolves in weak acids, and acids in rainwater and from decaying plant matter in soil dissolve the rock along cracks. Eventually, whole rivers can flow underground in cave systems. The **Ogof** (= cave) **Ffynnon Ddu** system underlies Penwyllt and is one of the longest in Britain, with over 40 km of cave passages. This stream is the **resurgence**, where the water leaves the cave system. It enters the ground at Pwll Byfre, 3 km NE of here.

*Return to the wooden gate and follow the path up the hill. It is floored with slabs and blocks, mainly of limestone. The rocks are cut by cracks (**joints**), which can become enlarged to form caves.*

Locality 4. Just before a stone wall begins on the left, a limestone crag on the right is covered with brown, knobbly material which seems to have been poured over the rock. This is **tufa**. It forms when **calcium carbonate** (lime) which was dissolved in water is precipitated over a rock surface. Similar processes form stalactites and stalagmites in caves.

*Turn left where the path meets the road and cross to a disused quarry. **KEEP AWAY FROM THE QUARRY FACES** - there is plenty of loose material on the ground.*

Locality 5. The bedding dips gently to the south, typical of the rocks away from the Swansea Valley Disturbance. Look for fossils, and for white crystals of **calcite**, a crystalline form of calcium carbonate. The crystals occur in **veins** - sheets of crystals filling joints - which formed from percolating solutions while the rocks were buried. There are also some blocks of brown **sandstone**, made of sand grains cemented together. The sand grains are made of the tough, hard, insoluble mineral **quartz**.



Return to the road and walk uphill. Past a house on the right, follow the signposted footpath through a gate on the right. Continue straight ahead, across a broken stone wall, to examine the line of crags.

Locality 6. Near the top of the crags, a conspicuous bed of limestone is crammed with fossil brachiopods, like small overturned saucers. Above this is the brown sandstone seen at Locality 4. Its base is not flat, but fills deep hollows in the limestone surface. The sand was washed here by rivers, and the hollows are infilled potholes. The limestone was raised above sea-level and eroded, then covered by river-borne sand before being submerged again to allow more limestone to accumulate. These changes in sea-level occurred many times during the accumulation of the Carboniferous Limestone. Land lay not far to the north of Penwyllt, so this area was particularly sensitive to sea-level changes.

Notice the deep hollows in the ground here. These are **shake holes** - depressions formed by collapse above caves.

Continue along the line of the footpath to the partly derelict building.

Locality 7. The pale grey boulders above (west of) the building have fallen from the low hill. They are **conglomerate** - rounded pebbles of **quartz** cemented in a sandy background. This is the **Basal Grit** of the **Millstone Grit**, the rock unit above the Carboniferous Limestone. After the limestone was deposited, pebbles were washed here by strong currents near