The Dolgellau gold belt

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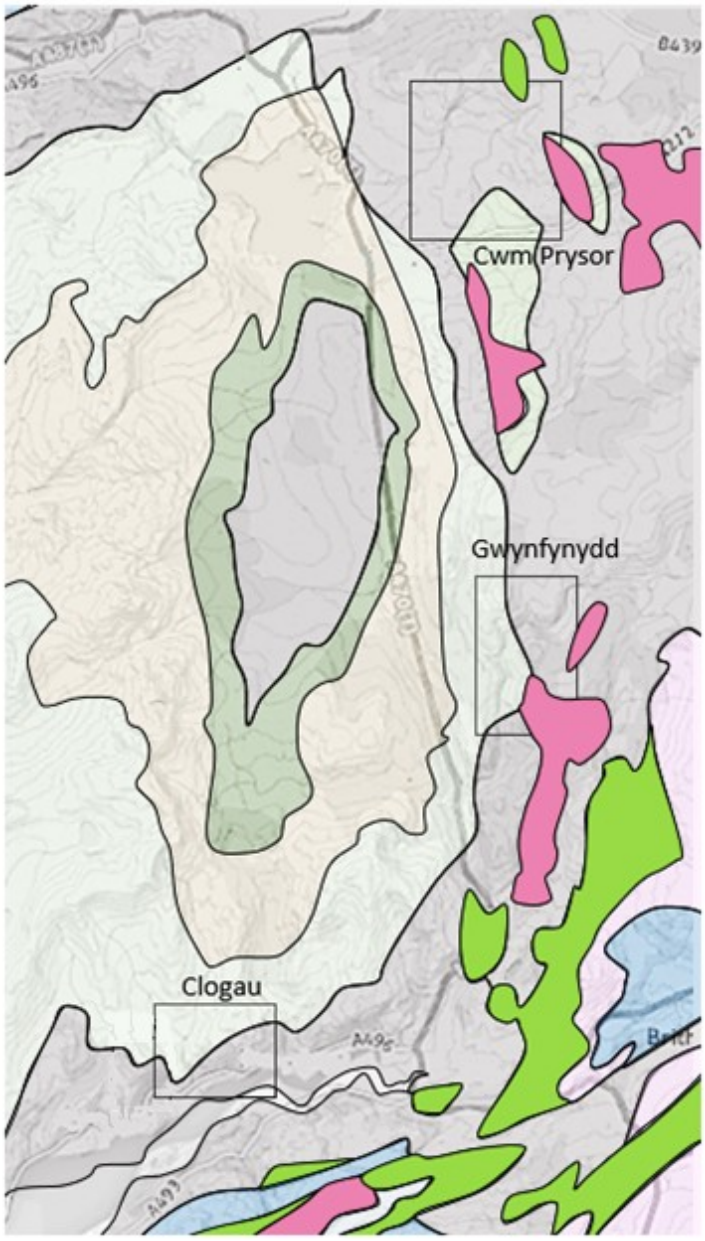


Aran Volcanic Group mafic intrusions, lavas, ashes

Felsic intrusions

Llanvirn sedimentary rocks

Rhobell Volcanic Group

Upper Cambrian mudstones, siltstones, sandstones

Middle Cambrian mudstones, siltstones, sandstones

Rhinog sandstones, mudstones

Llanbedr mudstones, siltstones

Dolwen sandstones, siltstones

Figure 632:
Field excursions.

Gold was discovered at Cwmheisian mine in 1844. There followed a period of intense exploration and mining activity in the Dolgellau area, but only a small number of mines produced significant quantities of gold. These were located in two areas, marked as Zone A and Zone B in fig.633. Zone A was centred on the large mine of Clogau-St David's, whilst Zone B was centred on Gwynfynydd. One significant mine well to the north of the main cluster is Prince Edward.

Several important geological factors have influenced the distribution of the gold lodes. Firstly we can see from the geological map that the major mines all lie on or very close to the outcrop of Clogau Shales. We also observe that the mines lie above major deep crustal fracture zones: Zone A is within the northeast-southwest oriented Bala-Mawddach fracture zone, whilst Zone B mines lie within the north-south Corris-Rhobell fracture zone.

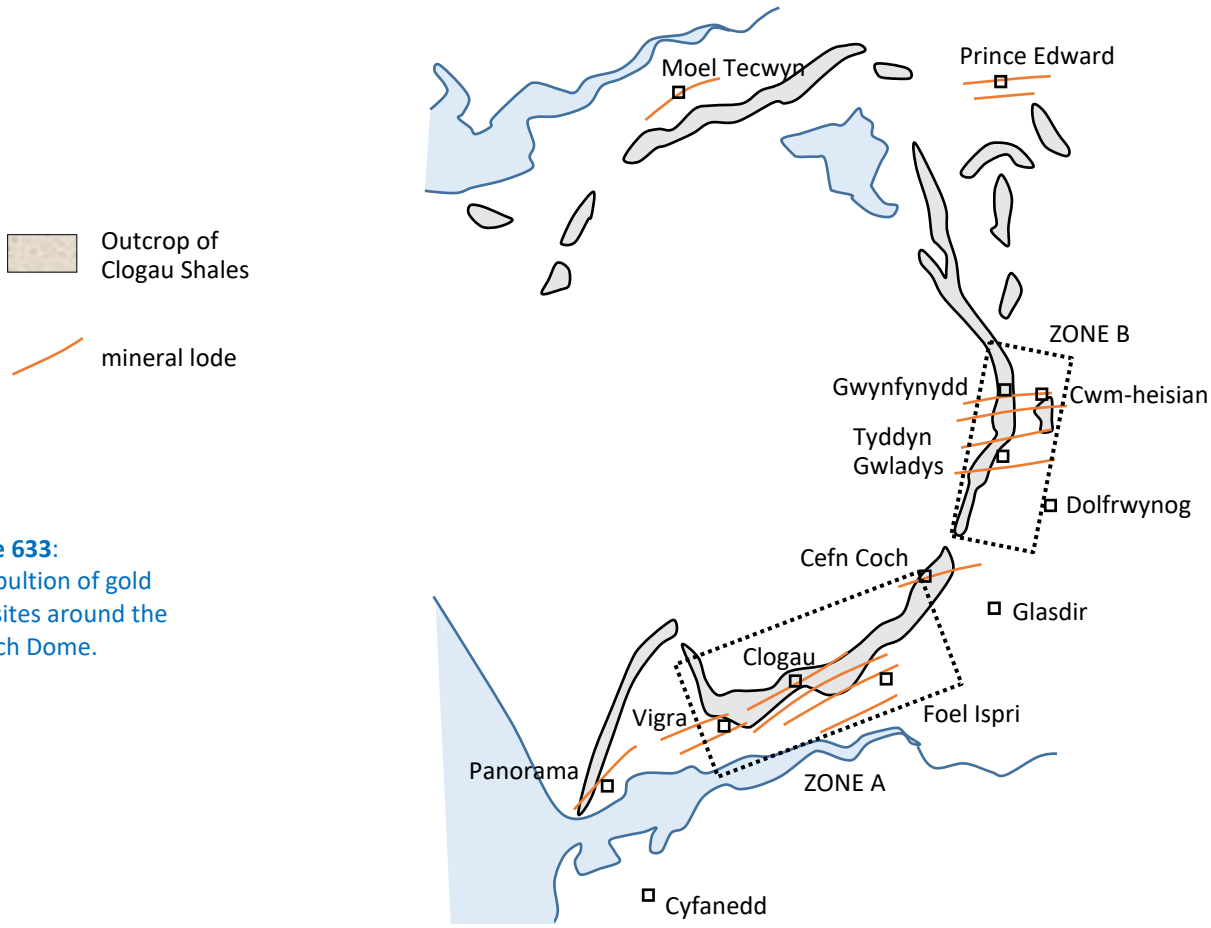


Figure 633: Distribultion of gold deposites around the Harlech Dome.

The gold lodes are found within faults which are oriented approximately east-north-east to west-south-west, in a similar way to the Mid-Wales lead mining area.

The source of the gold is probably regional metamorphism during the Acadian orogeny in early Devonian times, which affected rocks down to a depth of 5km and generated hydrothermal fluids during dehydration reactions.

The Precambrian basement below the Harlech Dome contains igneous rocks similar to the Monian basalt lavas of the Lleyn peninsula, emplaced during convergence of Avalonia with Gondwana. These basement rocks were uplifted at the end of the Cambrian period during the initial formation of the Harlech Dome. By the time of the Acadian orogeny, they lay within the zone of metamorphism and could provide a source of heavy metals including gold.

East-north-east faults formed before or during the Acadian orogeny due to tensional normal faulting at times of crustal relaxation. Mineralising fluids were channelled upwards through the deep fracture zones bordering the Harlech Dome, with mineral veins emplaced in the overlying faults where they cross or run parallel to the deep structures.

Gold is an unusual ore mineral. Unlike the lead and zinc deposits in Mid-Wales and the copper deposits in central Snowdonia, gold was not precipitated by simply lowering the temperature and pressure of the hydrothermal fluid.

Heavy metals normally go into solution by forming positive ions, as in fig. 634).

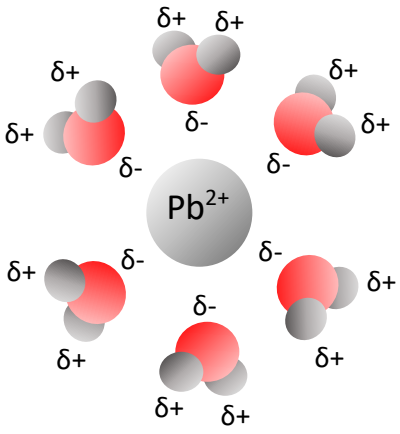


Figure 634: Positively charged lead ion in solution, surrounded by water molecules.

Solution occurs because the positive charge on the metal ion attracts the slightly negatively charged sides of water molecules.

On cooling or reduction in pressure, the metals come out of solution to form electronically neutral crystal structures with non-metals, such as the cubic crystals of the lead sulphide mineral **galena**:

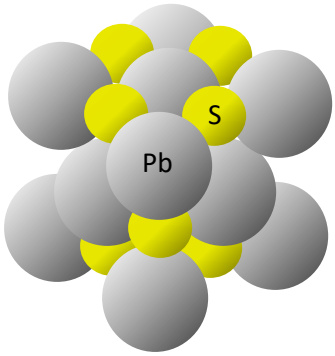


Figure 635: Cubic crystal structure of galena.

Gold atoms, however, are exceptionally stable and do not readily form ions. To enter solution, gold atoms must link to other charged ions to form a gold complex. The two most common complexes which can transport gold in hydrothermal solutions are auric-chloride $AuCl_2^-$ and auric-sulphide $Au(HS)_2^-$.

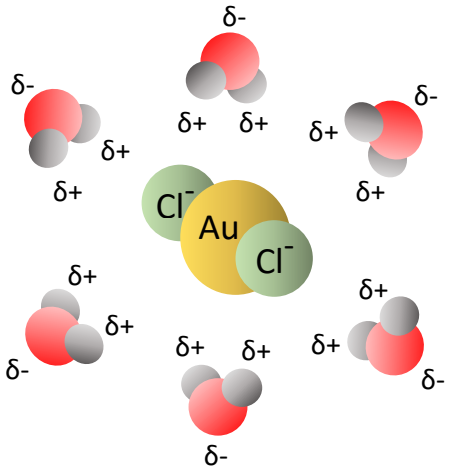


Figure 636: Gold complex in solution.

If the hydrothermal fluid passes through a mudstone containing iron pyrite or carbon, the transport complex can be broken down chemically and the gold is precipitated as a simple metal. For example, the auric-sulphide complex $Au(HS)_2^-$ can react with carbon to form methane. Chemical reactivity can explain why the gold deposits around Dolgellau are closely associated with the Clogau shales and adjacent mudstones in the Gamlan and Maentwrog formations. These rocks were originally formed under reducing conditions on a deep sea bed, and contain finely disseminated pyrite and carbon.

The gold lodes often have a complex structure, containing multiple veins of quartz or multiple sheets of quartz within a single vein. One band of mineralisation may cut across other bands, as in fig. 637.

Figure 637: Mineral lode at Prince Edward mine.

This indicates that mineralising fluids were released into the faults more than once. Refracturing occurred along a slightly different line each time. The chemical composition of the hydrothermal fluids was different on each occasion, leading to the deposition of different mineral assemblages.

Gilbey (1969), and Mason, Bevins & Alderton (2002) identified a mineralisation sequence:

- early deposition of iron pyrite, arsenopyrite and cobaltite.
- main deposition of gold, silver and other rare metals.
- deposition of copper pyrite.
- late stage deposition of lead and zinc sulphides.

Not all of these mineralisation stages are found at every mine. Gilbey noted that arsenopyrite and cobaltite occurs mainly in the Clogau area (fig. 633 zone A) whilst lead and zinc occurs mainly around Gwynfynydd (zone B). An explanation is that the north-south and northeast-southwest deep fractures were under tension at different times,

with mineralisation beginning earlier in zone A and ending later in zone B.

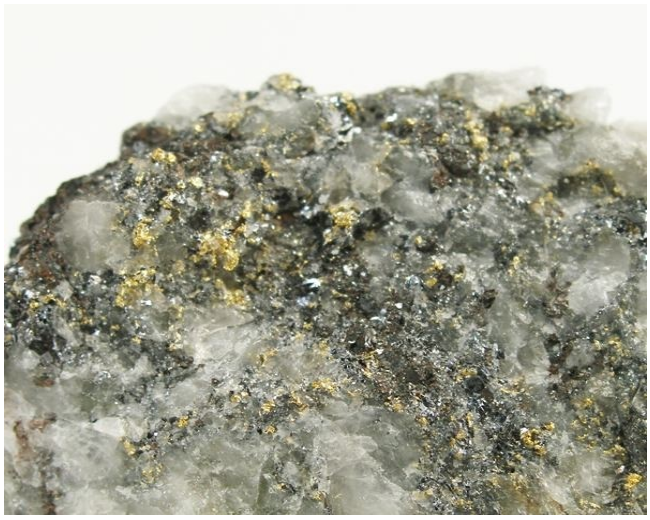


Figure 638: Museum specimen of gold-bearing ore from Gwynfynydd mine.

The unpredictable occurrence of rich gold deposits within quartz veins has been a major problem in the Dolgellau gold belt. Lead, zinc and copper deposits are fairly uniformly distributed, so mines such as Cwmystwyth and Frongoch were able to extract large quantities of ore of fairly constant metal content. Gold is much more randomly dispersed. There are stories of mines in the Dolgellau area going bankrupt and closing, only to reopen a few years later and yield huge gold nuggets after extending the workings by only a few feet.

Gold is most likely to be deposited where faulting has produced a cavity filled by fragments of mudstone containing disseminated pyrite or carbon. This increases the contact surface on which the breakdown of gold complexes can occur. Suitable conditions occur where a fault has been refracted through a much harder rock such as a sill intrusion or massive grit bed. Movement on the fault brings mudstone into contact with the harder rock across the fault. Miners often commented that gold was found where the country rock on one side of the vein was 'greenstone' and the other side was shale.

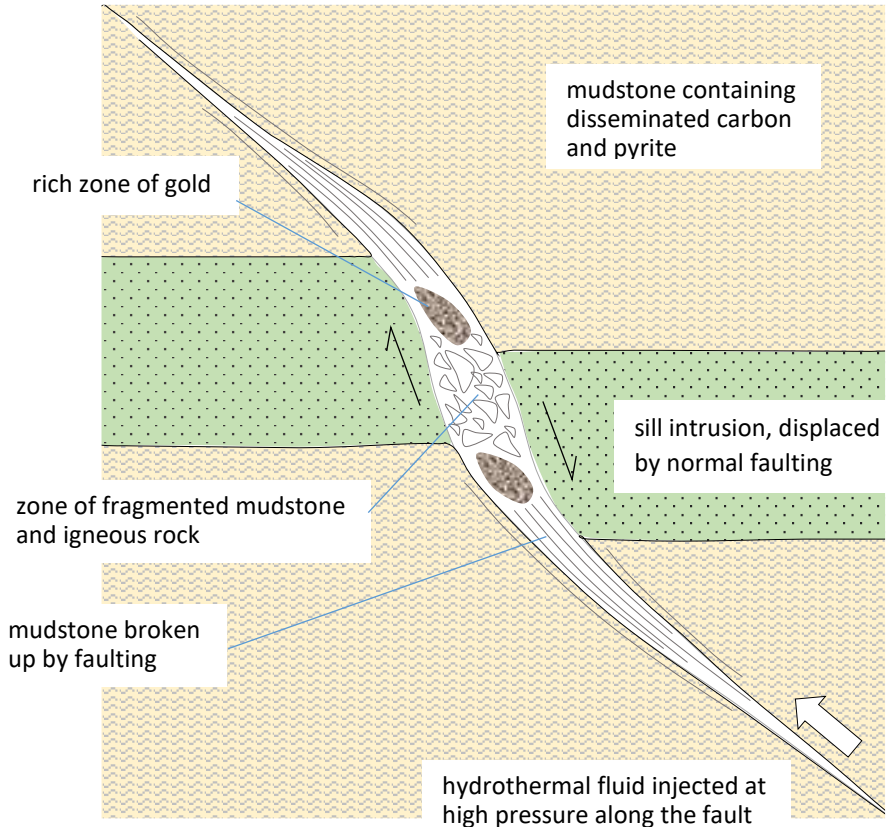


Figure 639: Sites of likely gold deposition in a refracted fault.

It is likely that the gold distribution is linked to the progressive filling of the open cavities by crystals of quartz and other minerals. The randomly connected pore spaces which continued to provide pathways for the hydrothermal fluid provided the most likely points for gold deposition.

Gwynfynydd

5 miles: approximately 2 hours

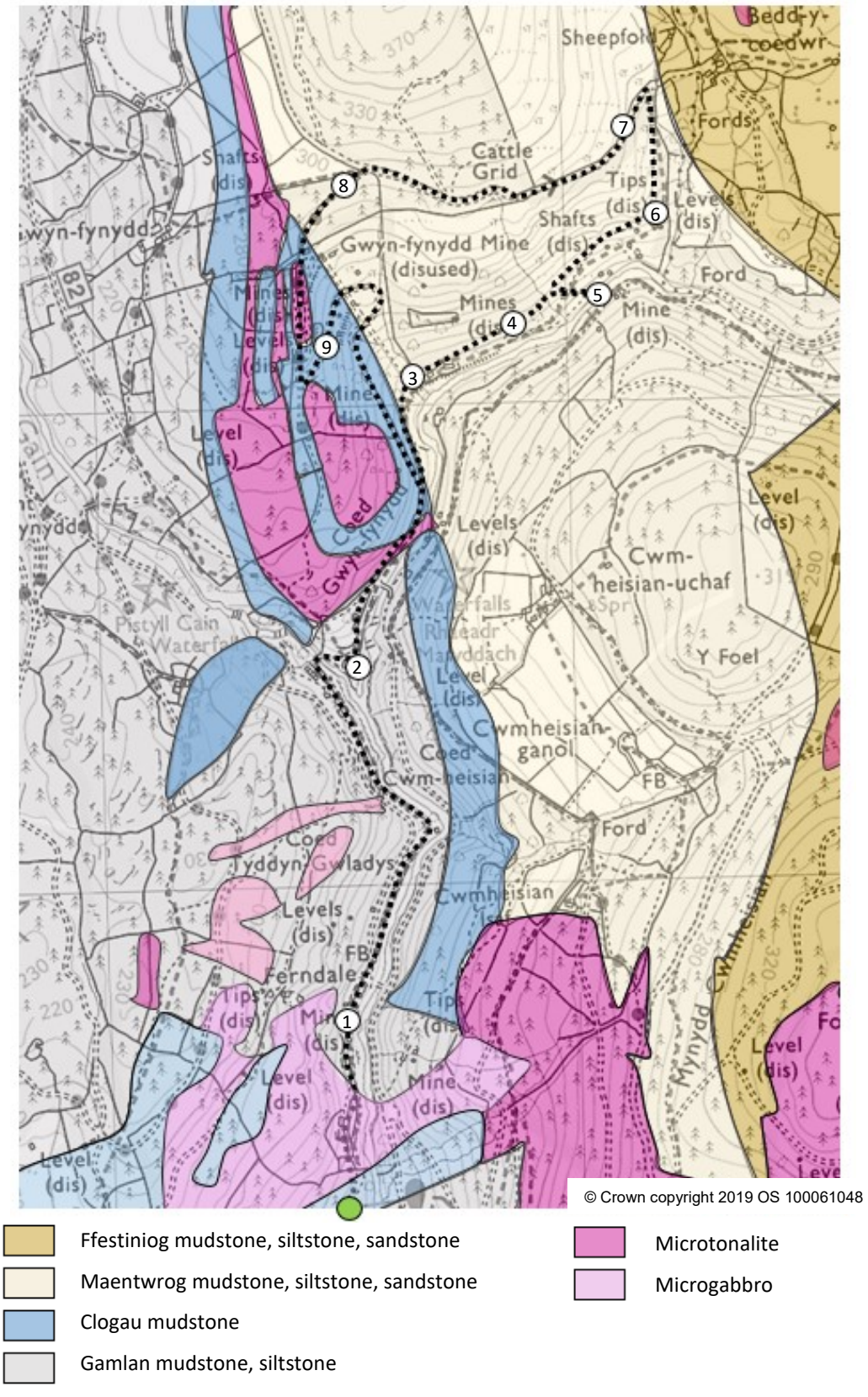


Figure 640: Field excursion.

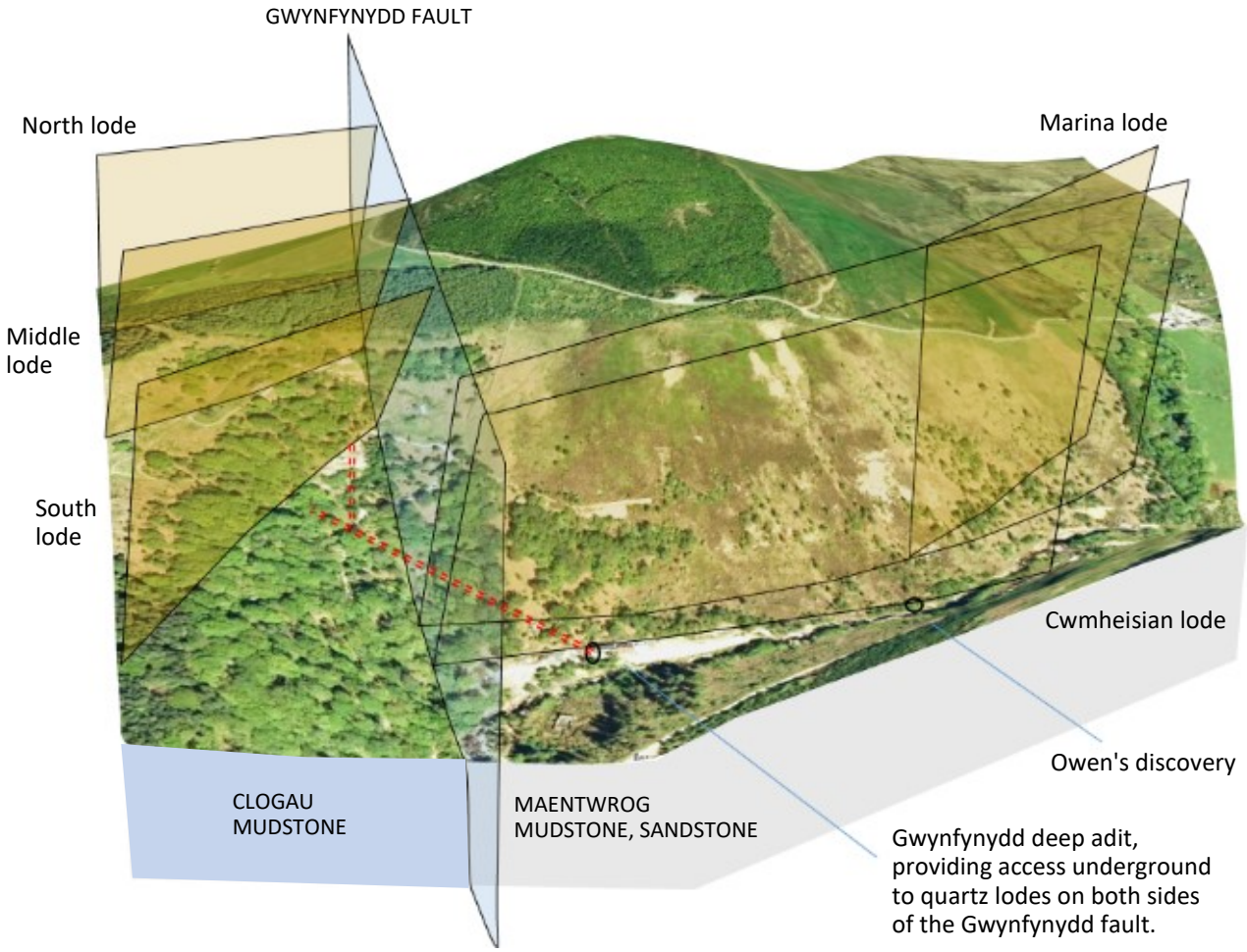


Figure 641: Mineral lodes at Gwynfynydd mine.

In this excursion we explore the area around Gwynfynydd, historically one of the two largest gold mines in the Dolgellau area. The other large mine, Clogau, will be visited in the next excursion.

The Gwynfynydd mine is separated into two production areas by the Gwynfynydd fault. To the west the gold lodes are hosted by Clogau mudstones, whilst to the east the lodes pass through Maentwrog mudstones and interbedded sandstones. Microtonalite sill intrusions are also present, particularly in the Clogau formation. The combination of mudstones containing finely disseminated carbon and iron sulphide, along with massive interbedded igneous intrusions or sandstones, provides suitable geological conditions for gold deposition.

The mineralisation in the Gwynfynydd area occurred before movement on the Gwynfynydd fault, so the pattern of lodes is different on the two sides of the fault. To the west, three gold-bearing quartz lodes have been worked: the north, middle or Chidlaw lode, and south or Collett lode. To the east, several gold-bearing lodes pass through Gwynfynydd and continue up the Mawddach valley where they have been worked at Bedd Coedwr and East Cwmheisian mines. The dominant sulphide minerals in all the veins at Gwynfynydd are pyrite, sphalerite and galena.

Veins on the west of the Trawsfynydd Fault were first mined in the 1860's, with peak production reached in 1888. Work on the east side of the fault began in 1892 with the driving of the deep adit. This tunnel was extended to access lodes on both sides of the fault, and provided the main route by which ore was taken out of the mine.

Start: A car park is provided in the forest at the head of the road from Ganllwyd [SH735263].

Leave the car park and continue up the valley along the unsurfaced track.

1: Next to the track near the entrance to Ferndale bungalow is one of the adits of Tyddyn Gwladys mine.

Figure 642: Gwynfynydd ore processing mill at the time of peak production in the late 19th century.

A mineral lode crosses the valley at this point, and has also been worked by adits higher up the hillside. The mine was initially worked for lead in the early 19th century, but a small amount of gold and silver was also produced in the 1880's.

2: Continue along the track, crossing the bridge below the spectacular waterfall of Pistyll Cain. Immediately to the right is the site of the Gwynfynydd ore-processing mill. Only concrete foundations remain, and a small hydroelectric plant has recently been constructed on the site.

The immense size of the mill can be seen from the photograph in fig. 642, taken at the time of peak production at the end of the 19th century. Ore was carried from the mine on a tramway along the route of the current track. Ore entered the mill at a high level, where it passed through crushers. The powdered ore was fed by gravity to water sedimentation tables, where heavy metal particles were separated from waste quartz. The mill appears to have had a chute for discharging the waste quartz directly into the river. The final stage of processing was the extraction of gold from other heavy metals. This was carried out with mercury in Britten pans, although an electrolytic method was also tested.

3: Follow the track up the valley to Gwynfynydd mine. The buildings around the deep adit entrance date from mining operations since the 1980's.

During the recent period of mining, considerable efforts were made to avoid the dumping of mine waste and the pollution of the river by heavy metal effluent from the mine. Initial processing of ore was carried out in a chamber underground, with only the heavy metal concentrates brought to the surface and taken away by road for final processing. Waste quartz sand was deposited in worked-out sections of the mine. Drainage water leaving the mine was channelled into separating tanks, where it was chemically treated to remove heavy metals from solution.

In periods when the mine has been disused, exploration of the old workings has been possible. Fig. 643 shows a production area, where ore was mined in stopes and dropped down into loading chutes. From here, the ore was carried by tram to a shaft, where it was tipped down to the deep adit level. Finally, the ore was carried out of the mine by tram and down the valley to the mill for processing.

Figure 643:

Gwynfynydd mine.

(right) Buildings along the river bank. The entrance to the deep adit is just beyond the first green shed. Settling tanks for mine effluent are on the right of the track.

(below left) Ore chutes below stopes on the middle lode.

(below right) Ore pass for dropping ore down to the no. 6 level, where it would be trammed out of the mine for processing. Alongside is the ladder way used by miners.

Access to the mine buildings is now restricted. Continue along the footpath which has been re-routed behind the mine buildings to re-join the river bank beyond the mine.

4: Follow the footpath through woodland above the river bank until an open tunnel is reached, spanned by a wooden footbridge. This is the location of Roberts' level, which was an early working for lead on the lodes to the east of the Gwynfynydd fault. These workings were eventually connected underground with the No.6 deep level.

Figure 644: Collapsed entrance to Roberts' level.

5: Continue along the footpath through the woodland. At a clearing, the river becomes visible and a large mass of white rock can be seen. This is a location known as Owen's discovery, where the East Cwmheisian lode crosses the river. Descend to the river bank to examine the outcrop. Veins and larger masses of quartz form a mosaic with blocks of Maentwrog mudstones and siltstones. Lead and zinc sulphide minerals, along with the iron pyrite, can be found within the veins.

Figure 645: Owen's discovery. (left) The quartz lode exposed as it crosses the Afon Mawddach. (right) Quartz veining with sulphide mineralisation, cutting through the Maentwrog sediments.

6: Return to the footpath and continue up the valley. The route passes an adit entrance to the Bedd Coedwr mine, then after a further few hundred yards crosses the hillside above the fenced-off opencast workings of the mine. Bedd Coedwr mine lies on branches of the Marina lode, an eastwards extension of the quartz lode worked at Gwynfynydd.

Follow the footpath as it turns to the left and climbs to the higher ground above the Mawddach valley. This section of the path follows a tributary valley cut along the Bedd Coedwr fault. The quartz lodes terminate at this fault, forming the eastern limit of gold mining in the Gwynfynydd area.

Rock outcrops along the footpath and alongside the road above the Mawddach valley illustrate the different lithologies of the Maentwrog formation (fig.646). These vary from distal turbidite sandstones, siltstones and mudstones, to black carbonaceous deep water muds deposited between turbidite events.

Figure 646: Outcrops of the Maentwrog formation. (left) Thinly bedded distal turbidite siltstones and mudstones. (right) Mudstone containing carbon, along with disseminated iron pyrite which causes rusty weathering.

7: The footpath reaches a road above the Mawddach valley. Turn to the left and follow the road for half a mile, crossing a cattle grid and passing through a forestry plantation.

8: Turn left at the road junction to reach Ty Mawr, a former mine manager's house. Next to the house is the No. 1 adit; the earliest working on the middle lode on the west of the Gwynfynydd fault. Opencast working can be seen along the vein.

9: Descend the track in front of Ty Mawr, passing an adit and opencast workings on the south lode. The track curves around the head of a gravity worked incline, now largely lost in the woodland, which lowered trucks of ore from the upper workings for processing in the mill. At this level is the No.9 adit, which was connected by ladder ways to the deep adit by the river bank.

Continue down the track to the river, then back to the car park at Tyddyn Gwladys.

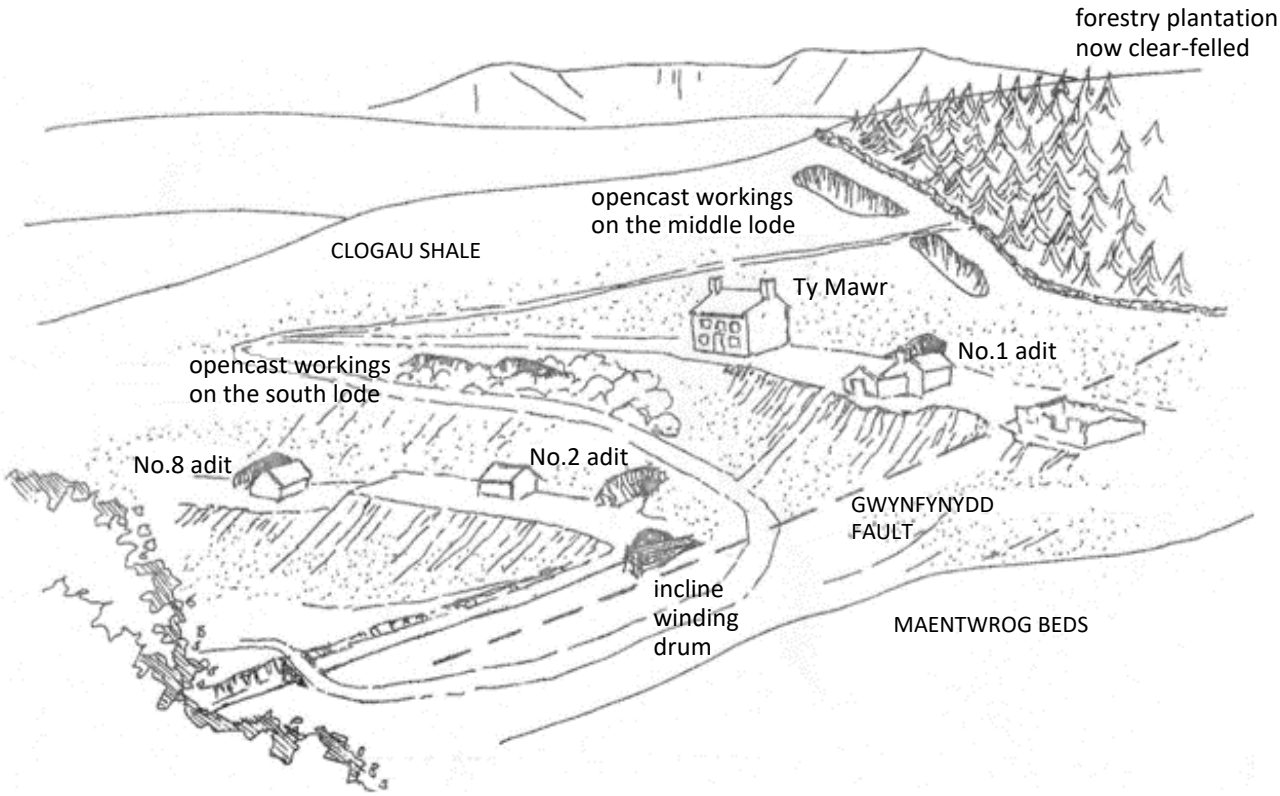


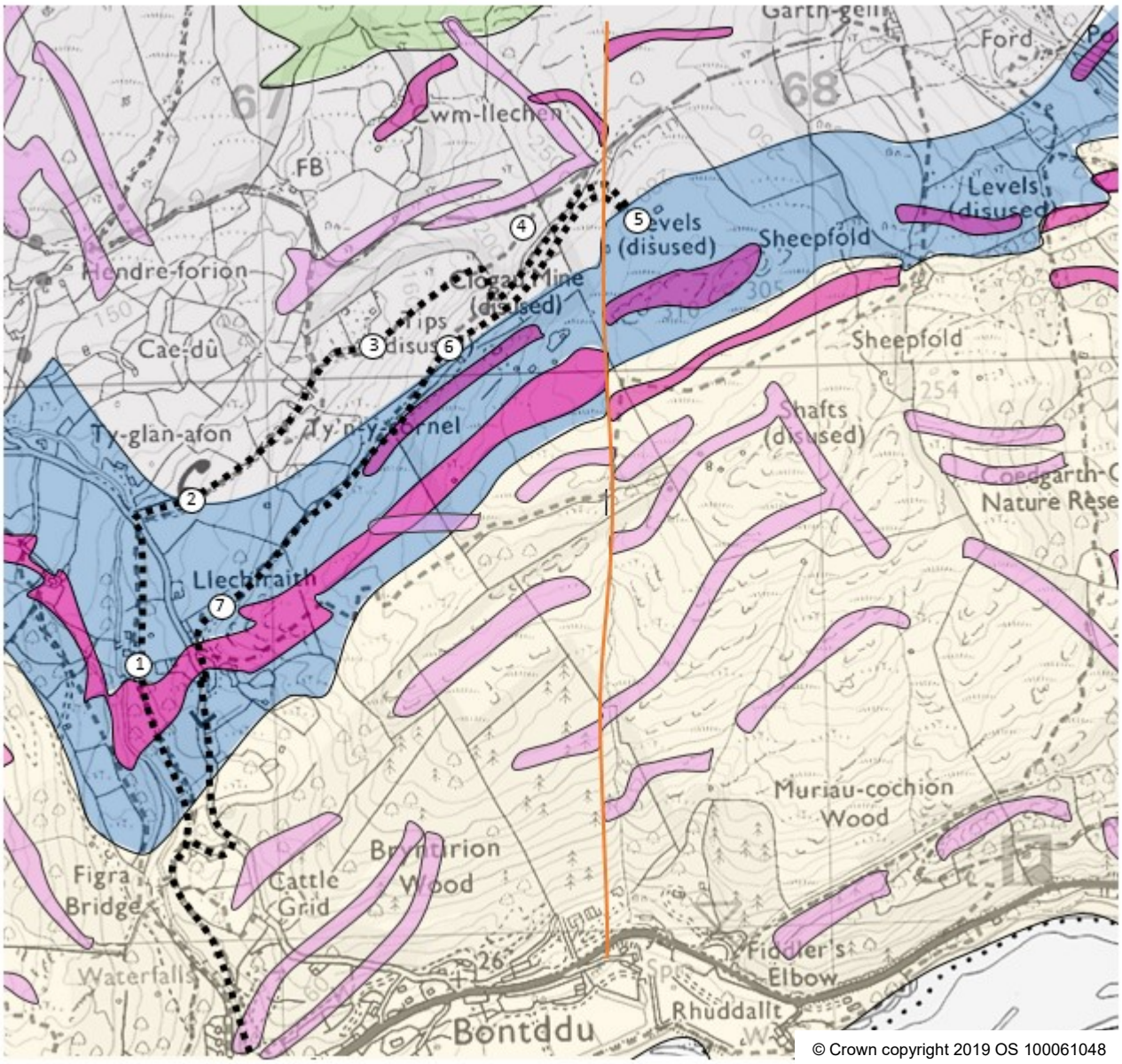
Figure 647:

Field sketch drawn some years ago of the upper workings at Gwynfynydd mine. Many of the features are now concealed by the growth of woodland.

(inset) Old photograph showing the tip outside the No.2 adit and the incline winding drum.

Clogau

4 miles: approximately 2 hours



Maentwrog mudstone, siltstone, sandstone

Clogau mudstone

Gamlan mudstone, siltstone

Barmouth sandstone, mudstone

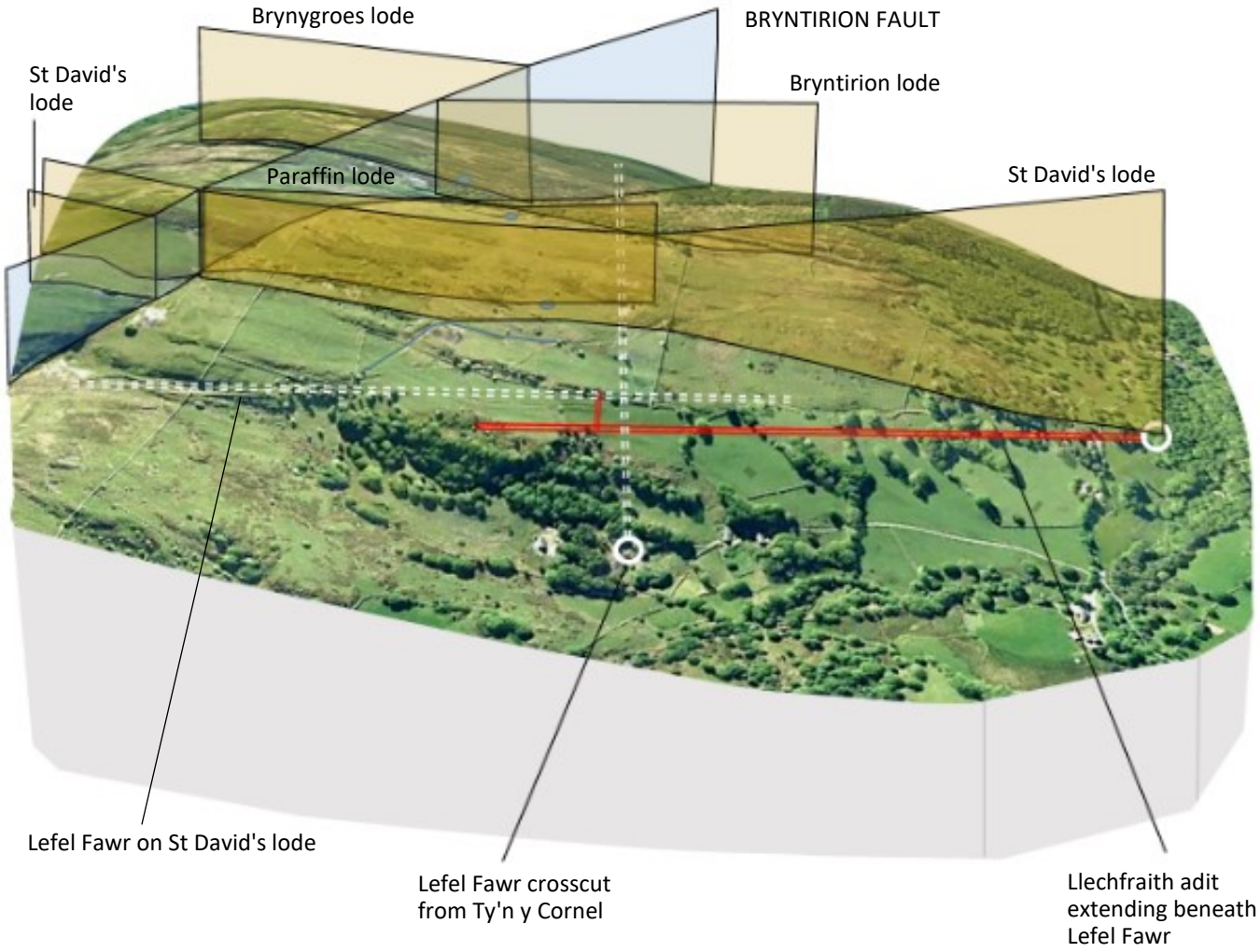
Quartz-microdiorite

Microgabbro

Figure 648: Field excursion.

In this excursion, we visit the Clogau St David's gold mines on the hillsides above the village of Bontddu. This was the most productive of the mining areas in the Dolgellau gold belt, and was worked continuously from the mid-1800's until the First World War, then intermittently since. The mineral assemblages at Clogau suggest deposition from higher temperature hydrothermal fluids than at Gwynfynydd, with arsenopyrite, copper pyrite and cobaltite present, but galena and zinc blende rarely found.

The layout of the mines is illustrated in fig. 649. Several mineral lodes cross the hillside, with the most important being the Clogau St David's lode.



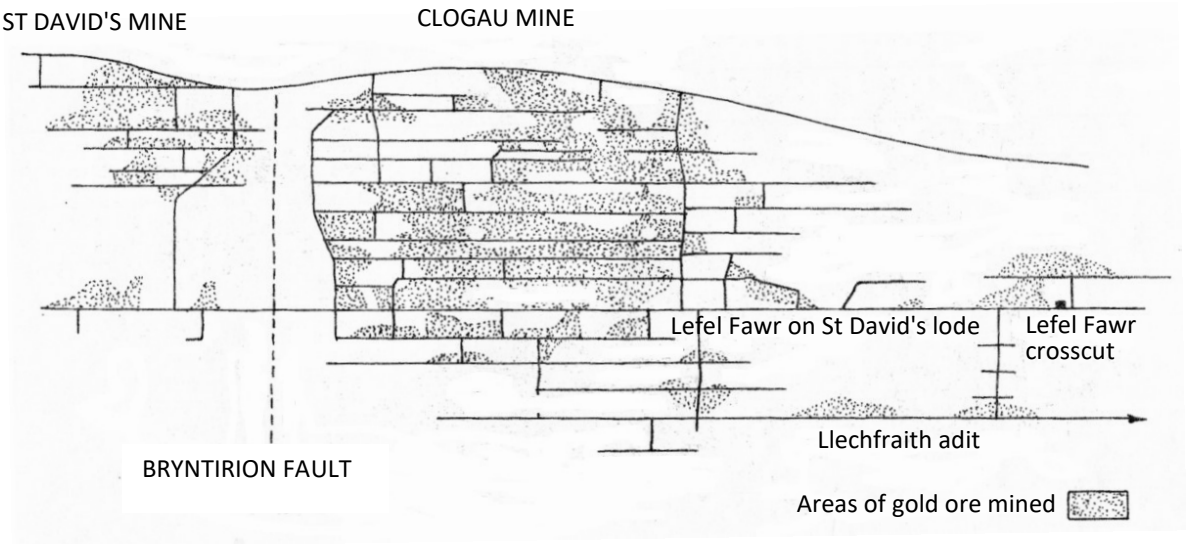


Figure 649: The Clogau St David's gold mining area. (above) Block diagram showing the gold-bearing quartz lodes which have been worked on the hill above the village of Bontddu. (below) Cross-section of the mine workings on the St David's lode.

Lines of early opencast workings can be found along each of the lodes. The Bryntirion fault, formed at a late stage of the Acadian orogeny, displaces the mineral lodes. Initially, the gold lodes were worked as two separate mines: Clogau to the west of the fault, and St David's to the east. Gold was mainly found within the Clogau mudstones, with some mineralisation in the overlying Maentwrog and underlying Gamlan formations. Rich pockets of ore were often associated with the sills of microdiorite and microgabbro which commonly occur within the sequence of sediments.

In the early years of operation of the mines, ore was carried by tramway around the hillside, then lowered down an incline to a processing mill in the deep river valley at Vigra bridge. Mining companies who worked Clogau in the later years of the 19th century constructed deep adits at Llechfraith and Ty'n y Cornel. The Ty'n y Cornel adit became known as the Lefel Fawr. This reached the St David's lode, where a side branch extended along the St David's lode and passed through the Bryntirion fault, connecting the Clogau and St David's mines. The Lefel Fawr crosscut was extended below the workings on the Bryntirion and Brynygroes lodes. The adits provided drainage, allowing deeper sections of the gold lodes to be worked, and formed a convenient underground transport route for ore on its way to the mill.

Start: Park in Bontddu village [SH670187].

1: Take the minor road which ascends alongside the Afon Hirgwm. At the end of the surfaced road, continue along the track which runs through woodland above the river gorge. After a few hundred yards, the site of the ore processing mill is reached at Vigra bridge.

Figure 650: Remains of the mill at Vigra bridge.

In the mid-19th century, the mill processed ore from both the Clogau St David's mines to the east, and also the Vigra mine which was working the St David's lode on the hillside to the west of the river. Ore from both mines was lowered down inclines to this central location. The mill was powered by a large waterwheel.

Cross the bridge and continue along the track above the river until a group of buildings are reached at the mouth of the Llechfraith adit.

Figure 651: Tramway bridge at the mouth of the Llechfraith adit.

The adit provides drainage for the deeper workings along the St David's lode. The tramway emerging from the adit crosses a bridge to reach the site of the now-demolished processing mill from the last period of operation in 1990.

2: Continue along the track to reach the road at Ty-glan-afon. Cross the road and take the track which crosses fields to reach the Ty'n y Cornel adit (fig. 652).

3: The adit, connected to the Lefel Fawr workings on the St David's lode, was the main route for carrying ore out of the mine in the late 1800's. A processing mill was constructed nearby, and large waste tips can be seen around the mouth of the adit.

4: Follow the track, passing to the left of a house, and continue up the valley alongside a dry stone wall.

Figure 652: Ty'n y Cornel adit, giving access to the Lefel Fawr.

At the head of the valley, follow the dry stone wall as it turns to the right. Ascend the path through the steep wooded hillside to reach open grassland on the gentler slopes above.

Walk up the slope to reach an old tramway, constructed to carry ore from the St David's mine to the incline down to the mill at Vigra bridge. Join the tramway and follow it eastwards. Outcrops of thinly bedded distal turbidite siltstones and mudstones can be seen in the rock cuttings alongside the track. Continue until the track ends at waste tips around the No.1 adit of St David's mine.

Figure 653: (left) Bed of the old tramway from St David's mine. (right) Outcrops of Maentwrog distal turbidites in cuttings alongside the tramway.

5: Examine the waste tip which contains large blocks of vein quartz. It is possible to find specimens exhibiting multiple veins of differing thickness, from thin sheets to massive deposits. The multiple nature of the ore lodes is due to the repeated injection of hydrothermal fluids along the fractures. After emplacement, the quartz veins would become harder and more impenetrable than the surrounding mudstones, so refracturing would occur alongside. The presence of rafts of country rock between veins explains the great width of some opencast workings.

Figure 654: Example of multiple quartz veins of varying thickness.

Figure 655: (left) Waste tip outside the No.1 adit at St David's mine. (right) Adit tunnel.

Examine the entrance to the St David's mine, then take the path which ascends diagonally across the hillside to the right of the adit. This leads around a waste tip to reach the opencast workings on the St David's lode. Nearby are the remains of the mine office and workshop.

Figure 656: (left) Opencast workings at St David's mine. (right) Ruins of the mine office and workshop.

6: Return to the mine entrance. The slight valley which you followed from the No.1 adit to the opencast workings lies along the line of the Bryntirion fault.

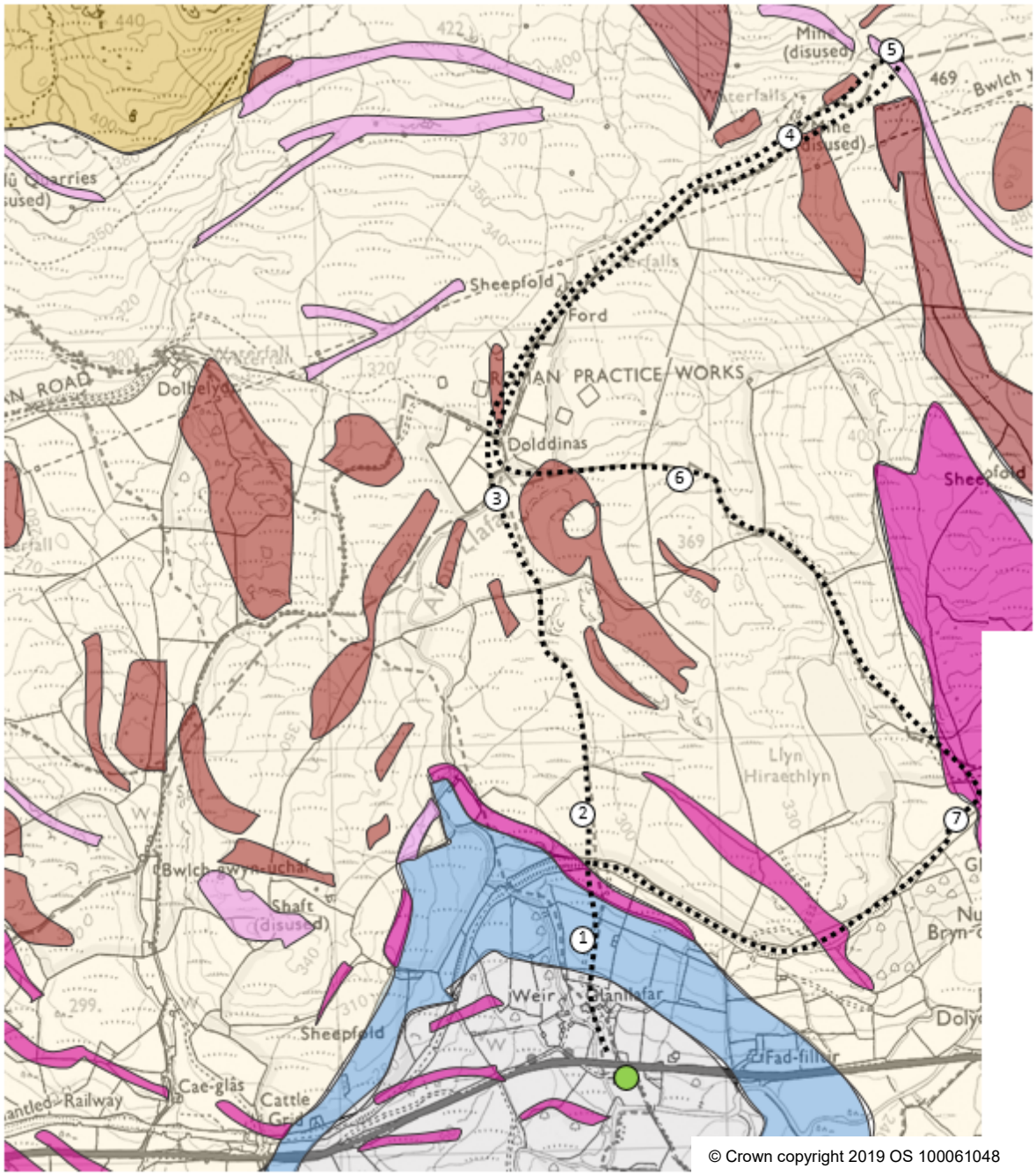
Retrace your route along the tramway until an adit entrance is reached on the left of the track. This is one of a number of adits and opencast workings on the St David's lode within the Clogau mine. A shaft, now protected by fencing, can be seen on the hillside above.

7: Descend diagonally across the grassland to reach a gate at the downslope end of a dry stone wall. This leads to a footpath which skirts around the hillside to reach the Hirgwm valley.

Joni a minor road, and continue for a short distance down hill towards Bontddu. Turn right past a group of houses to reach the river at Vigra bridge, then return along the footpath to the parking place.

Cwm Prysor

5 miles: approximately 2½ hours



- Ffestiniog mudstone, siltstone, sandstone
- Maentwrog mudstone, siltstone, sandstone
- Clogau mudstone
- Gamlan mudstone, siltstone
- Diorite, gabbro
- Microtonalite
- Microgabbro

Figure 657: Field excursion.

In this excursion we visit another important gold mine, this time on the edge of the mining area to the north of Coed y Brenin. Prince Edward mine lies in a remote location and was never developed to the same extent as Gwynfynydd and Clogau, although it was one of the last mines to cease production in the early 1900's.

Start: Park by the chapel at Glanllafar on the main Trawsfynydd to Bala road [SH736362].

1: Cross the main road and follow the track past Glanllafar farm. Continue across several fields to reach the disused railway line. This line once carried much of the slate produced in the quarries of Blaenau Ffestiniog.

2: Cross the old railway and follow the footpath northwards across the moorland to Dolddinas. Along the path you will see outcrops of thinly bedded Maentwrog turbidite siltstones and mudstones, which form the host rocks for the gold lode at Prince Edward mine.

3: At Dolddinas, continue past the ruined farmhouse to join the track to the mine. The track passes underneath a large electricity transmission line, which once carried the output from the now-disused Trawsfynydd nuclear power station.

4: Follow the mine track which ends at the derelict office and workshop buildings of the Prince Edward mine. The mine worked three gold-bearing quartz veins associated with a northeast-southwest fault. The river approximately follows the fault line at this point.

On the river bank can be seen the remains of the mill area, including the concrete foundations of the crusher and gravity separating tables, powered by a water turbine. Unfortunately, it was found that the ore was difficult to process due to the presence of large amounts of fine grained iron pyrite. In the late 1800's the mine was purchased by the Gwynfynydd company. After initial separation at the mine, the ore concentrate was transported to the Gwynfynydd mill (see fig.642 above) for final processing.

Figure 658: Foundations of the processing mill. Thinly bedded Maentwrog turbidites can be seen in outcrops along the river bank.

Above the mill site on the opposite bank of the river is the main adit of the mine. A tramway bridge once connected this to the mill. The adit provided access to working areas within the three mineral lodes. As at Clogau and Gwynfynydd, the lodes were displaced by a late north-south fault. The adit approximately follows this fault, so that the mineral lodes are offset on either side of the tunnel. Within the mine are shafts to deeper levels, once kept dry by pumping but now flooded.

Figure 659: Adit entrance to Prince Edward mine.

5: Continue up the valley to reach an opencast mining area on the mineral lode. An open stope extends downwards to the level of the main adit.

Figure 660: (left) Opencast workings at Prince Edward mine. (right) Underground stope working on the mineral lode, which dips at 70^0 at this point.

6: Return down the mine track to Dolddinas, then take a footpath which skirts around Llyn Hiraethlyn to reach the disused railway.

7: Examine the outcrops of Maentwrog siltstones and mudstones, cut by a more resistant microtonalite sill where the line passes through a cutting.

Leave the old railway at Llanllafar farm and return to the parking area.

Figure 661:
Cutting on the disused railway through Cwm Prysor.