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BRITTANIA or SNOWDON MINE

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ABSTRACT

The six accessible levels of the Brittania Mine, just below the summit of Snowdon, North Wales, are described. The mine worked a vein deposit located within a steeply dipping normal fault system which interects and displaces the junction of the Ordovician Lower Rhyolitic Tuff (LRTF) and the overlying Bedded Pyroclastic Formation (BPF). Two types of mineralization are described: a quartz-sulphide assemblage and a calcite-sulphide assemblage, the latter probably representing a later cooler phase of mineralisation. Preliminary lithogeochemical results indicate strong and pervasive hydrothermal alteration in the mine area, with the influx of iron and potassium and the removal of copper. It is suggested that the deposit is volcanogenic in origin, associated with the 'LRTF Caldera', metals being mobilised from the tuffs by hot circulating fluids and deposited in the fault system at and above the LRTF/BPF contact.

INTRODUCTION

The Brittania Mine [SH 616547] lies on the south-facing slopes below Snowdon summit in North Wales, above the waters of Glaslyn and within the Snowdon Horseshoe (Fig.1). Discovered late in the 18th century, the steeply dipping vein system was worked intermittently throughout the 19th century and into the early years of this century, finally ceasing work in 1916. The history of the mine, and a plan of the surface remains were given by Bick (1982). The vein occurs in rocks of the Ordovician Snowdon Volcanic Group which hosts similar mineralisation elsewhere in the area. The mineralisation consists of quartz-sulphide and calcite-sulphide phases with pyrite and chalcopyrite being the dominant sulphide minerals. The vein was mineralised in stages and shows episodes of brecciation, stockwork formation and development of finely banded structure. The deposit is considered to be a volcanogenic vein related to the development of the Snowdon Caldera.

The purpose of this article is to describe the underground workings and to discuss the geological setting of the deposit. The fieldwork was undertaken between August 1984 and January 1985, as part of an investigation into the metallogenesis of the Snowdon Massif by one of us (T.B.C.) for the British Geological Survey.

GEOLOGICAL SETTING

The mine lies entirely within the Snowdon Volcanic Group (SVG) of Ordovician (Caradocian) age which is composed mainly of acid and basic pyroclastic units with numerous synchronous intrusions and extrusions of dolerite and rhyolite. The SVG comprises three formations:

Upper Rhyolitic Tuff Formation	URTF	>100m
Bedded Pyroclastic Formation	BPF	400m
Lower Rhyolitic Tuff Formation	LRTF	500m

The LRTF in the mine area consists of massive ash flow tuffs and rhyolites in an unbroken homogeneous sequence deposited during a caldera-forming eruption. The BPF in the same area consists of basalt lavas, tuffs and volcaniclastic sediments. A further description of the SVG and associated volcanotectonic structures can be found in Reedman and others (1985).

The Brittania deposit occurs near the top of the LRTF and extends into the overlying BPF - a feature common to many of the deposits in the SVG where the LRTF/BPF contact appears to exert a control on the mineralisation. Furthermore the majority of the stoping has taken place on Nos.4 and 5 levels (Fig.2) just

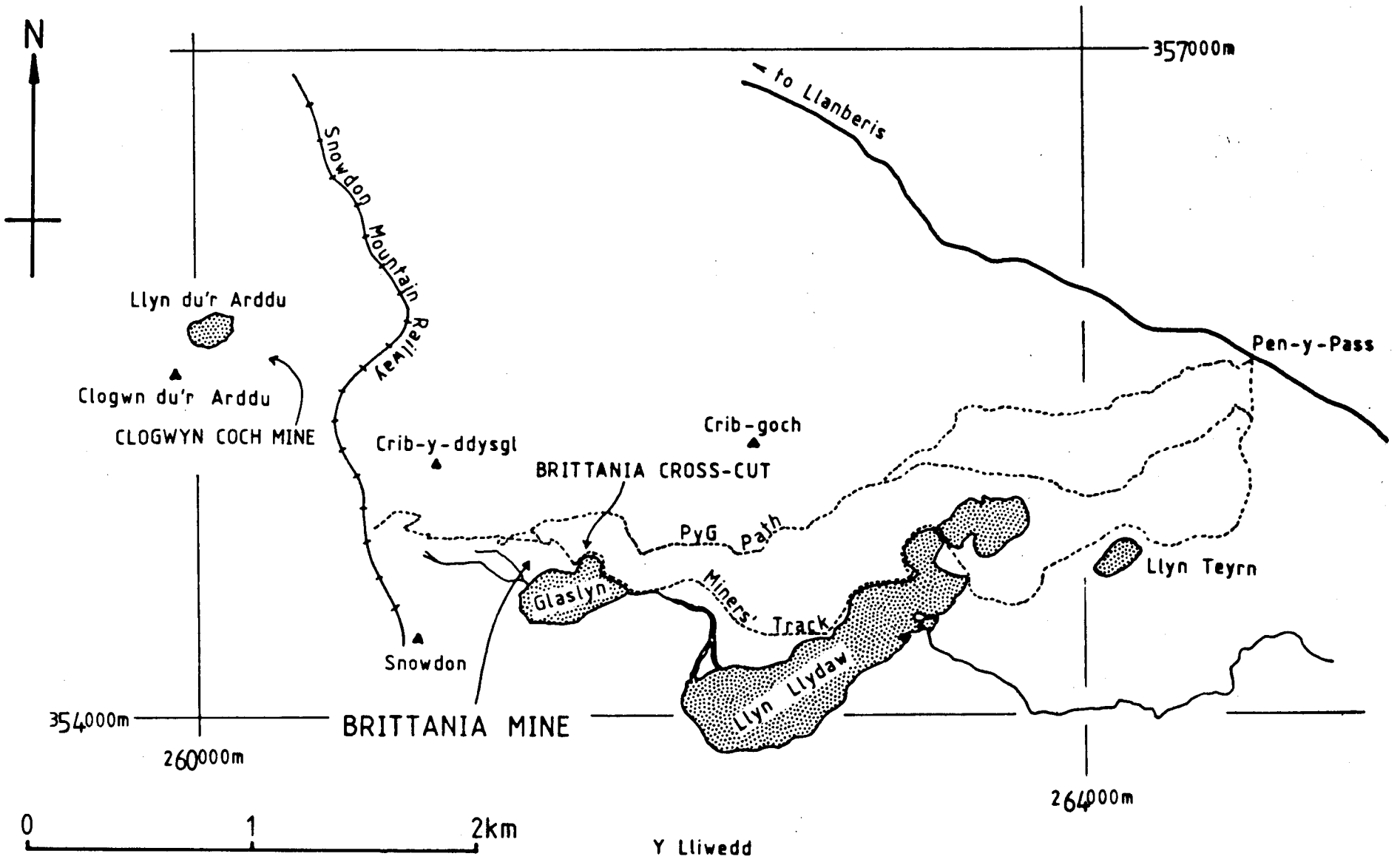


Fig.1. Localities referred to in the text.

above the contact which dips west at a shallow angle - less than 20 degrees. Underground the details of the geology are generally obscured by surface dirt, so mapping was augmented by a ratemeter (which measures radioactivity), and a kappameter (which measures magnetic susceptibility). Typical values for the kappameter are 0.1 to 0.25×10^{-3} SI units within the LRTF, and 0.3 to 1.0×10^{-3} within the BPF. For the ratemeter the total count within the LRTF is in excess of 100 cps (mainly from thorium), and less than 50 cps within the BPF.

DESCRIPTION OF WORKINGS

The mine may be reached by either taking the PyG (Pen-y-Gwryd) Track or the Miners' Track from Pen-y-Pass (Fig.1). This latter was constructed early in the 19th century to afford easier access to the mine and is the more interesting as it passes numerous relics from the various phases of the mine's history.

NEW NO.1 LEVEL

The lowest level, New No.1 level, of the mine lies a short distance above the end of the Miners' Track on the northern side of Glaslyn, partially obscured by the remains of the ropeway terminus. The level was probably driven in the early years of this century and crosscuts for over 100m through barren ground into the line of Sneyd's Lode. The level is of somewhat larger dimensions than the others in the mine, although it reduces to normal dimensions on entering the vein. At the junction of the crosscut and the vein there is an ore box which marks the lower end of Rowland's Winze. (This and all other names are taken from Abandoned Mine Plan R306, which probably dates from around 1850. Although the match between this plan and the mine as surveyed is quite good there are discrepancies, and so there must remain an element of doubt in the names we use.) Shortly after entering the vein there is a small stope, through which water drains, and is ponded behind rubble which has collapsed out of it. The drive then follows a thin calcite vein for a further 80m.

NO.1 LEVEL / SNEYD'S LEVEL

The next level, approximately 50m upslope, is No.1 or Sneyd's Level. This leads into an area of extensive stoping both above and below the level which is recessed into the footwall. A substantial timber ore pass crosses the level which has been completely stoped out beyond. Further access is over planks laid on stemples which span the stope. The dimensions of the stope increase rapidly from this point, and ground has been removed up to the No.2 Level. Along the northern side of this section of the level there are the remains of iron railings which served as protection at the top of the underhand stopes which are now flooded to a few metres below the floor of the drive. The large stope ends abruptly with a duck under a waterfall and the continuation is partially flooded. A short distance on the passage passes under a timber working platform, and by means of a short ladder it is possible to climb up through the stopes to emerge high above the floor of No.1 Level and just short of No.2 Level. No.1 Level ends a short distance after the platform. Joints in the tuffs in the area of this platform and the big stopes described above display small dendrites of native copper.

NO.2 LEVEL / ROWLAND'S LEVEL

It is technically possible to climb into No.2 or Rowland's Level from the stopes above No.1 Level, but it is far easier and safer to abseil down into the level through the stope just inside the entrance to No.3 Level. The entrance to No.2 Level has been blocked by scree on the slopes above Glaslyn. The No.2 Level is by far the longest of those accessible and was probably a main haulage level. Despite its length the only stoping of any consequence is close to the entrance. From the alighting point, the first item of interest along the level is a box at the bottom of an orepass. This orepass extends up to the No.5 Level, and the box contains the remains of a flap system which controlled the discharge of the broken rock. A short distance after the box, the passage turns through a right angle and shortly beyond there is a very substantial flooded

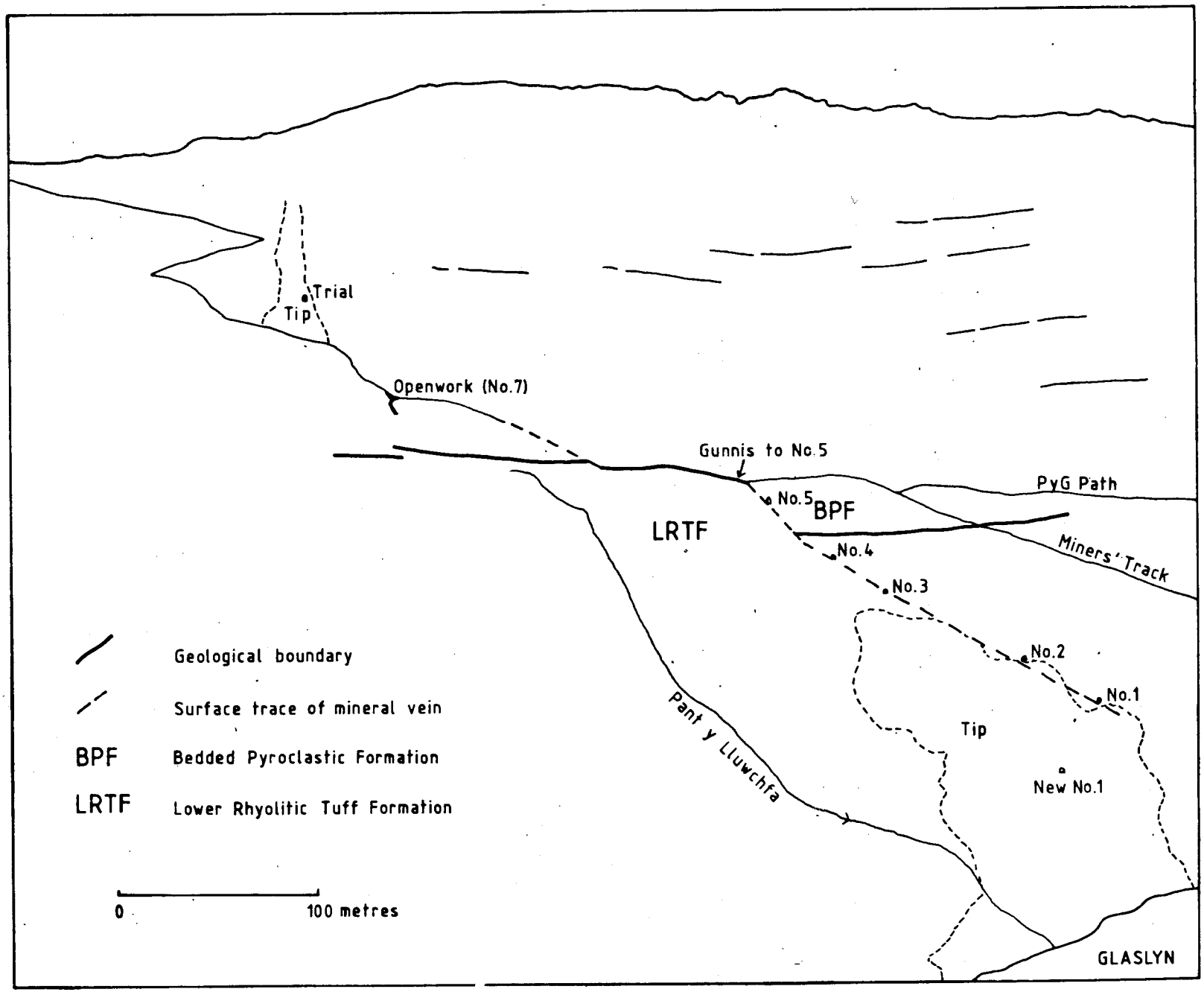
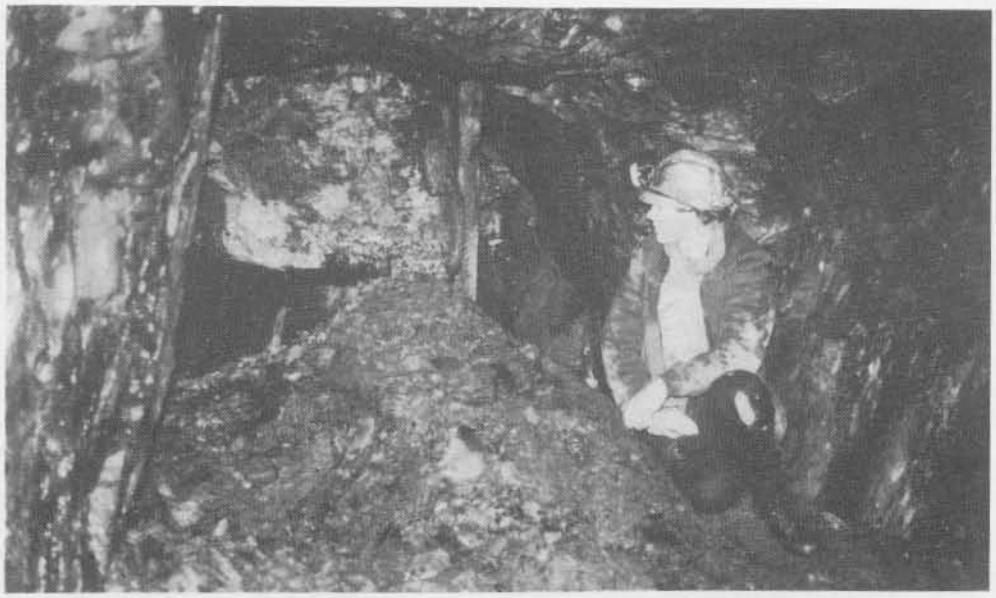

Trial
Tip
Openwork (No.7)
Gunnis to No.5
No.5
BPF
LRTF
PyG Path
Miners' Track
No.4
No.3
No.2
No.1
Tip
New No.1
Pant y Lluwchfa
GLASLYN
Geological boundary
Surface trace of mineral vein
BPF Bedded Pyroclastic Formation
LRTF Lower Rhyolitic Tuff Formation
0
100 metres

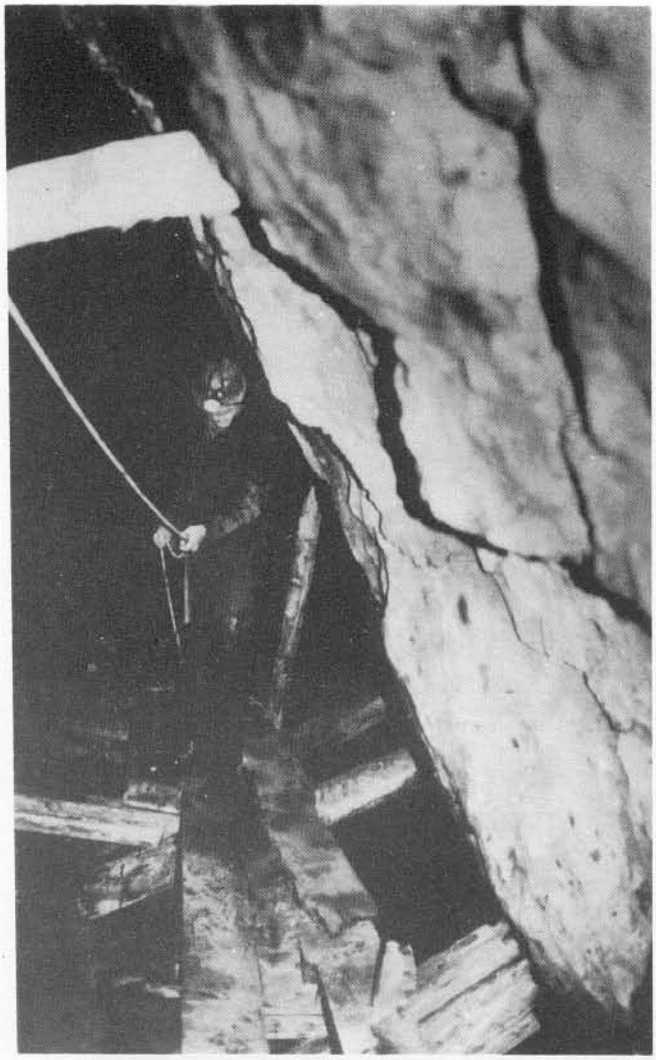
Plate 1. General view of the Brittania Mine area, Snowdon.

2. Entrance to New No. 1 Level.



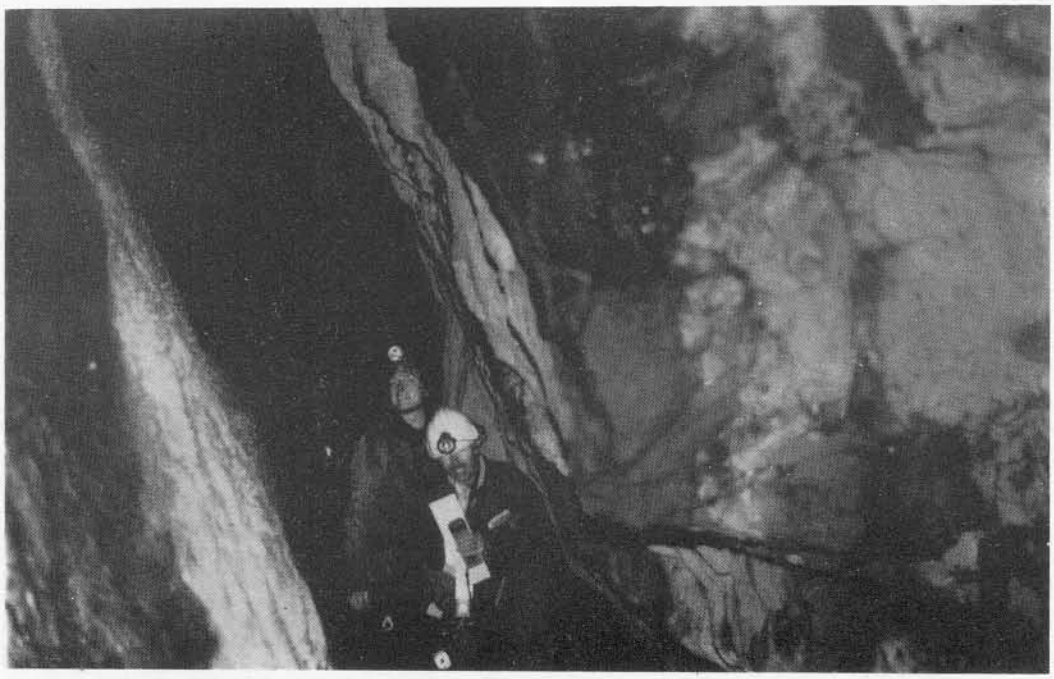
3. Ore chute in New No.1 Level.

4. Waterfall at the end of stoping in New No.1 Level.

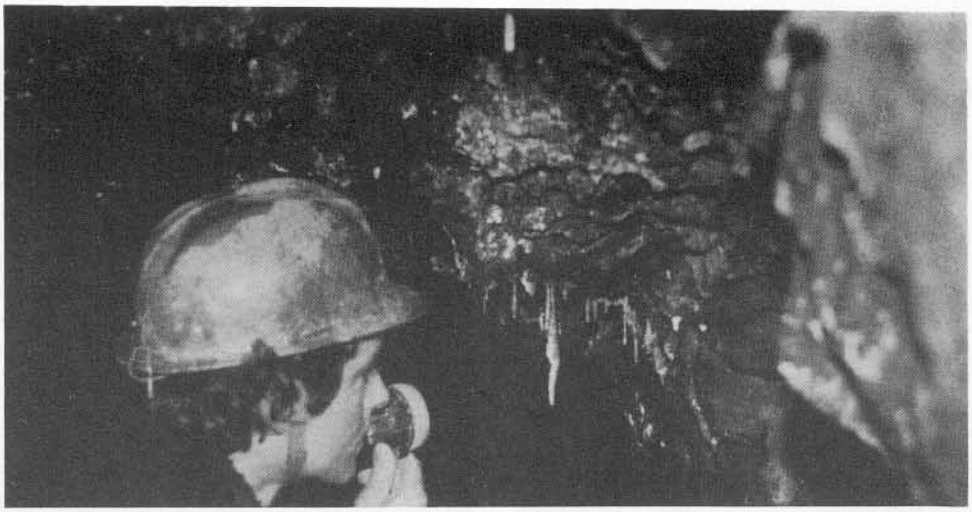


5. Timbering over underhand stopes, No. 1 Level.

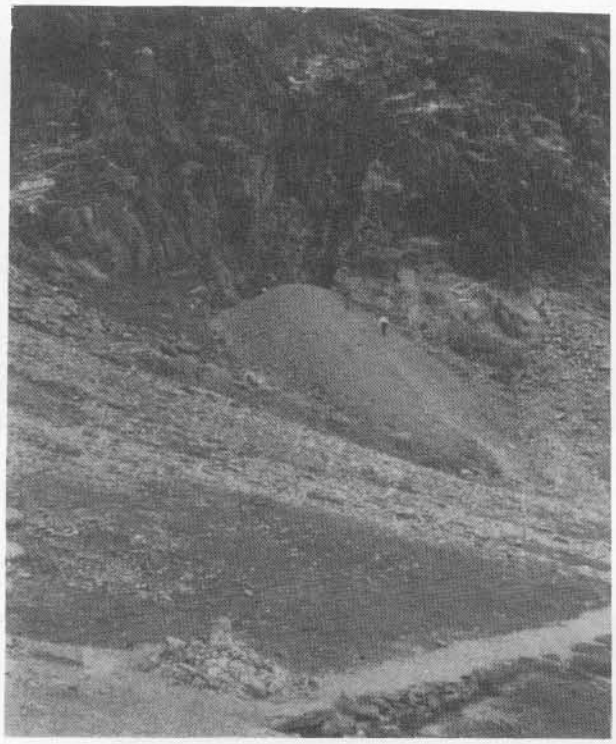
6. Ladderway through stopes above No. 1 Level.



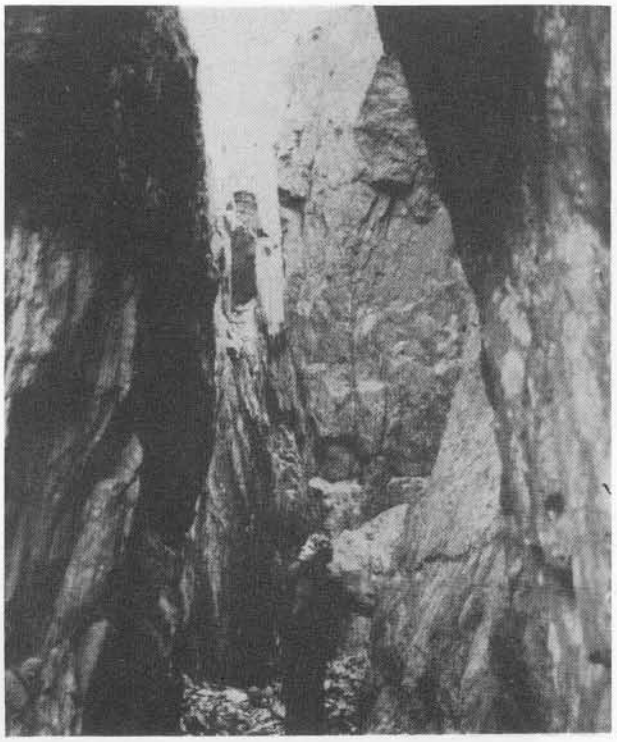
7. Stopes in No.2 Level. Staining on walls is bright blue. Man in foreground is holding the kappameter.



8. Green cupriferous stalactites in a trial in Caunter Lode, No.5 Level.



9. The barren trial on Brittania cross-course.



10. Openworks at the site of No.7 Level.

11. Section of vein showing calcite and sphalerite banding parallel and adjacent to the wall (left) with calcite and sulphide supported wall-rock breccia in the centre of the vein. Specimen is 14 cms wide.

winze to the right, partially covered and fenced off by railings of tubular steel. On the floor at the bend itself there is a wooden box containing an assortment of iron spikes for anchoring pipes and air hoses. Passing under a small stope in an area of brecciated and cavernous vein, another winze is reached down which water drains from No.3 Level. The remains of a climbing chain lie on the floor beneath it. No.2 Level ends in a small chamber with well-exposed brecciated quartz-sulphide and cross-cutting calcite-sulphide mineralisation in the roof.

Returning to the alighting point, within a few metres towards the entrance the large stope from No,1 Level rises past and above this level on the northern side. The remains of chains and iron bars indicate the former existence of a protective rail. At this point it is possible to appreciate an aspect of structural control on the mineralisation. Here the smooth roof of the stope dips steeply to the north and intersects the plane of the main structure at an acute angle. The mineralisation, in part at least, is localised in the footwalls of a conjugate fault or joint system which dips to the north.

The passage to the entrance begins in thick mud, then crosses piles of rubble where the vein above has been stoped out, and finally ends in deep water where the entrance has run in. In wet weather this final section floods to the roof. The top of Rowland's Winze is one of the more interesting features of Snowdon Mine. Here the miners erected an ingenious wooden structure across the footwall of the stope. This allowed them to drop ore directly from the stope to be channeled into the ore pass down to New No.1 Level and thence trammed to surface.

This level, and all those above curve gently to the north at their farthest ends. This marks the transition from Sneyd's Lode into the Caunter Lode. With the exception of No.5 Level no obvious change can be seen underground, although the stopes in the Caunter Lode do not dip as steeply as those in Sneyd's Lode.

NO.3 LEVEL / PASCOE'S LEVEL

The entrance to No.3 Level has been partially obscured by scree, and access is by a flat-out crawl. However the drive soon opens up, and it is the only level which is relatively dry throughout its length. Just inside the entrance a manway down into stopes to the north provides access to No.2 Level.

Very little stoping has taken place in this level, most of it being in the vicinity of the orepass. In the walls of the stopes sulphides infill cavities in brecciated wall-rock. Where the orepass goes through there are the remains of a ventilation gate and brackets for compressor pipes. The level ends in an irregular chamber, partially filled with debris, into which water flows from a hole some ten metres above. This water sinks a short way back down the level and emerges in a raise above No.2 Level, of which there is no trace in No.3 Level.

NO.4 LEVEL / PRICE'S LEVEL

This Level is entered through a stoped-out rift in the rock face. By-passing a pool of water to the left, a flat-out crawl leads into a large chamber partially filled with rubble. This is presumably the Old Water Shaft, and water flows into it from the surface. A slope down the far side of the rubble fill passes under the remains of a ventilation gate into waist-deep water. The quartz-sulphide vein can be seen *in situ* above the ventilation gate. A short wade leads into a substantial stope with a flooded winze in its centre (Owen's Winze) over which is a curved section of railing - one of the few remaining in the mine. The continuation of the entrance passage has been backfilled with deads. One of the chief features of this level is the number of short trial crosscuts that branch off at an acute angle along joints, which lends support to the hypothesis that Sneyd's Lode is developed in a conjugate fracture or joint system. In several places the floor of the level is strewn with partially decayed Nobel's explosives boxes labelled "*Purveyors of Explosives to the Colonies*". Short lengths of fuse are common.

The stopes in the Caunter Lode at the end of No.4 Level are very large (up to 15m high, 10m long and 2 to 3m wide) and noticeably curved. In the final

SNOWDON or BRITTANIA MINE (N.G.R. SH616547) Workings on Sneyd's and Caunter Lodes

PLAN

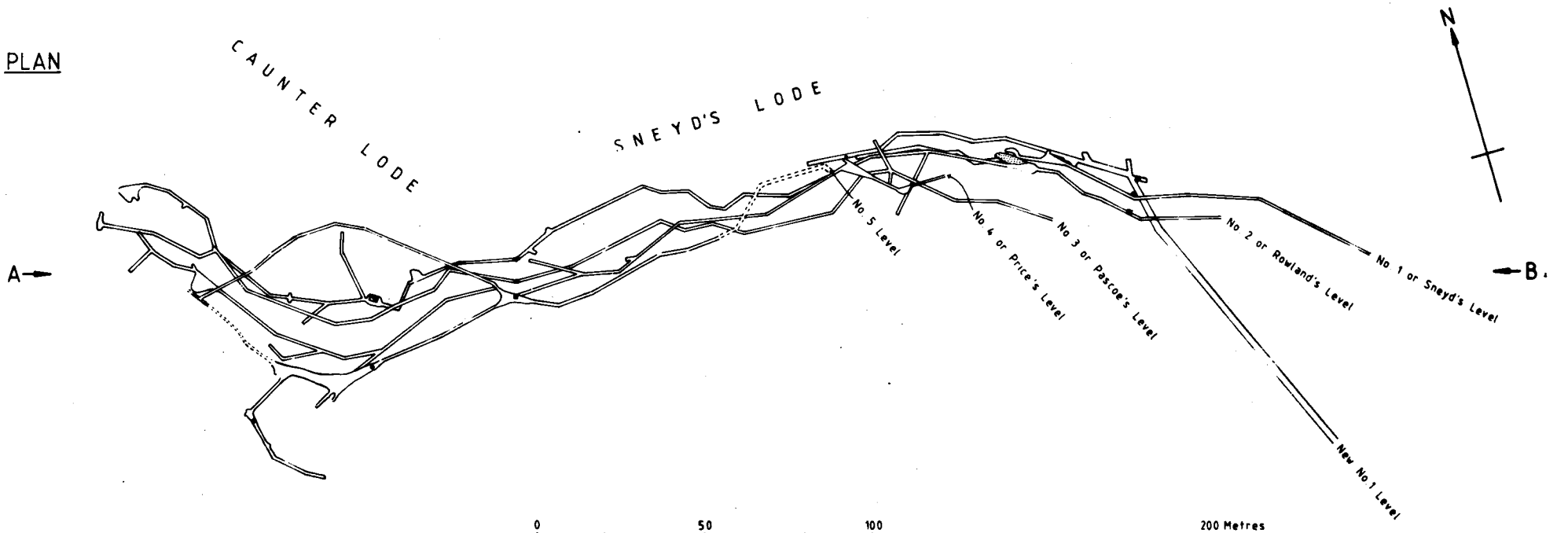


Figure 2a.

1) Surveyed by T. B. Colman, N. d'A. Laffoley and A. J. Rex, August 1984 - January 1985.

2) Surveyed with fibron tape (± 5cm.), and Silva compass (±0·5°).

3) Drawn by N. d'A. Laffoley, January 1985.

4) All names taken from Abandoned Mine Plan No. R306. (?ca. 1850)

KEY

- Winze
- The Ground Stoped
- Crosscut
- Ventilation Gate

Pecked lines denote uncertainty

SECTION A-B

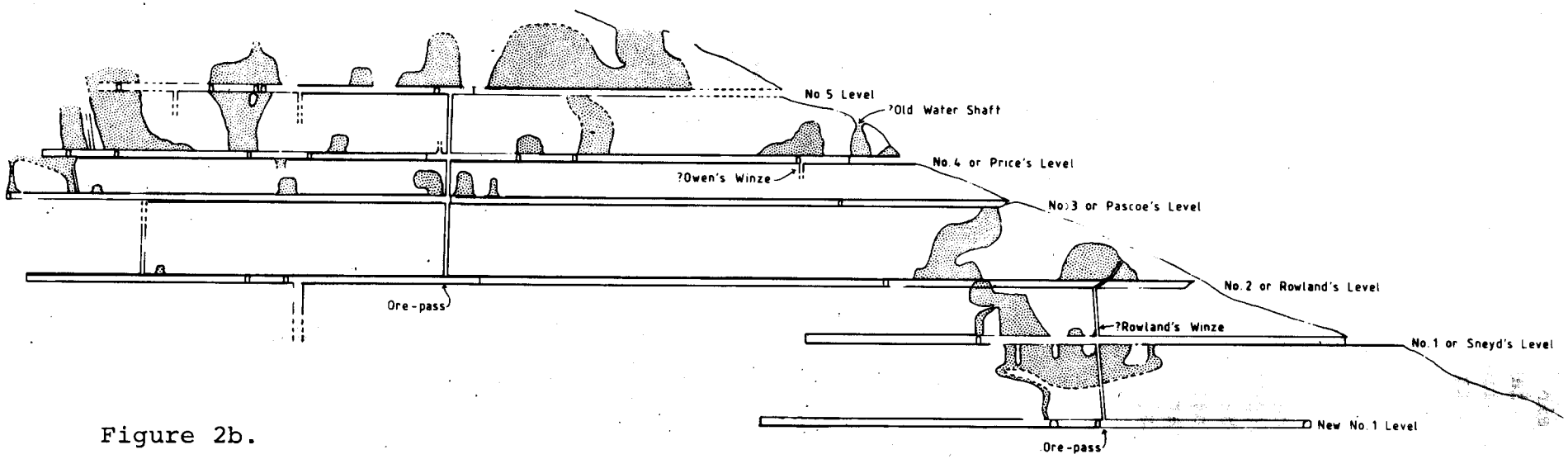
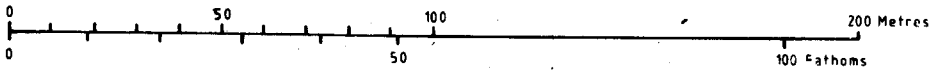


Figure 2b.



part of the level the vein has been stoped out both above and below floor level, and access is by a plank and stemple walkway. The level ends where it has been backfilled to the ceiling, and the condition of the supporting timbers is not good. It is not apparent whether the level continues, but the volume of stoping in the area suggests it does.

NO.5 LEVEL

In terms of industrial archaeology and geology the highest accessible level is the most interesting. Bick (1982) referred to it as "*Level between 4 & 5?*", but it was undoubtedly no minor working, and we refer to it as No.5 Level.

Since the entrance is flooded nearly to roof level, the easiest access is to abseil down through the prominent gunnis (stope which opens to surface) which lies to the south side of the PyG track. Unlike the lower levels which are almost entirely in the LRTF, No.5 Level is mainly in the BPF. It seems likely that the locus of mineralisation lies on the junction between these two formations; certainly the largest stopes in the mine occur on this level. Into the hill away from the gunnis, the vein has been stoped out to a height of many metres above the level, and in places the roof cannot be seen. In contrast to No.1 Level, the ladders here have disintegrated as this area of the level is quite dry. Where the stoping ends the level draughts out very strongly. The ventilation throughout the mine was achieved by judicious placement of ventilation gates without machinery. At the top of the orepass, which leads down to No.2 Level, the passage forks and there is a kibble lying on the floor at the junction.

The passage which leads off to the north crosscuts out of the line of Sneyd's Lode along a small joint. The first few metres are in bleached hydrothermally-altered bedded basic tuffs, after which the tuffs are unaltered. This change is also reflected in a decrease in ratemeter readings which is presumably due to potassium enrichment in the altered rocks of the vein. The purpose of this crosscut is unknown: it ends in the hanging wall of a stope. Running water can be heard.

Returning to the main level, after passing under two stopes, an area of extensive stoping is reached, where several metres of vein have been removed. There is a covered winze in the floor. Along this section of the drive sulphides associated with chlorite are in evidence. Chlorite is not seen in the lower levels, possibly because of the differing chemistry of the LRTF.

The start of the large stope marks the transition between Sneyd's Lode and the Caunter Lode. Ahead two short trials end blind in the footwall of the Caunter Lode, and there is no evidence for any continuation of Sneyd's Lode. Here the Caunter Lode is located within a normal fault, with bedded basic tuffs in the hanging wall and acid tuffs in the footwall. Access along the stopes is on a ledge cut in the footwall of the lode. This ledge is separated from the underhand stoping by tubular steel railings which have survived intact. Both above and below the level the vein closes up and exhibits the classic features of pinch and swell, the drive being within the swell.

About 20m along the stope a small level heads west into the footwall of the Caunter Lode. In it the rails are still in position, and within a few metres there is a small end-tipping ore truck. Around a sharp corner the rails end at a flooded winze in the floor which has the upright supports for a windlass in position. The rails and truck have presumably survived because of the difficulty of getting them past the stope. This level ends after approximately 50m. It was no doubt a trial for extensions to Sneyd's Lode. Returning to the start of the trial heading, the main passage continues across the end of the stope. It was not surveyed, but water can be heard faintly, and presumably it connects with the stope at which the crosscut, described above, ends.

OTHER WORKINGS

Bick (1982) recorded four levels above No.5 Level, but the entrances are all run in or obscured. The site of No.7 Level (No.6 on Bick's plan) is marked by extensive openworks, and the whole of the mountainside around the mine is dotted with small trials. A large waste dump above the Miners' Track, just

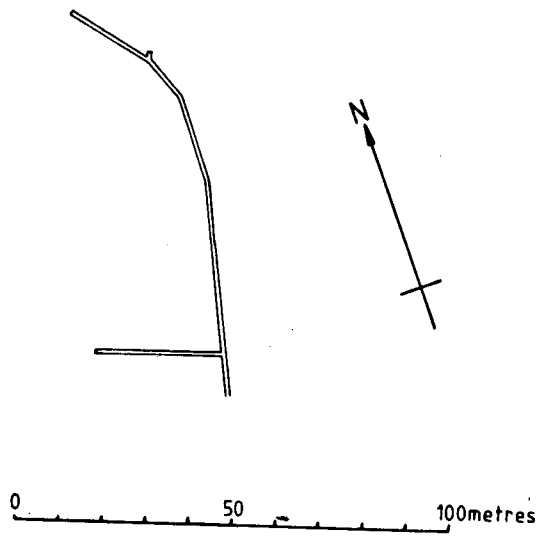


Fig.3. Barren trial on cross-course.

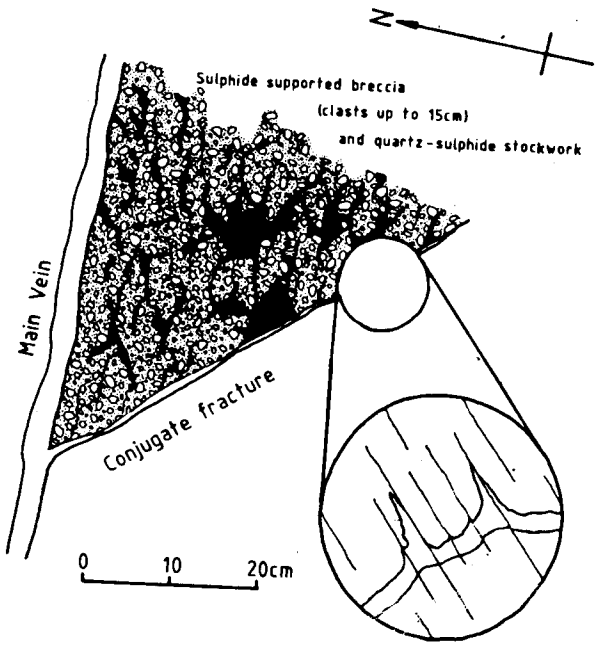


Fig.4. Schematic diagram of formation of economic sulphide breccia and quartz-sulphide stockworks where the main vein develops a conjugate fracture Inset: deformation of vein by cleavage.

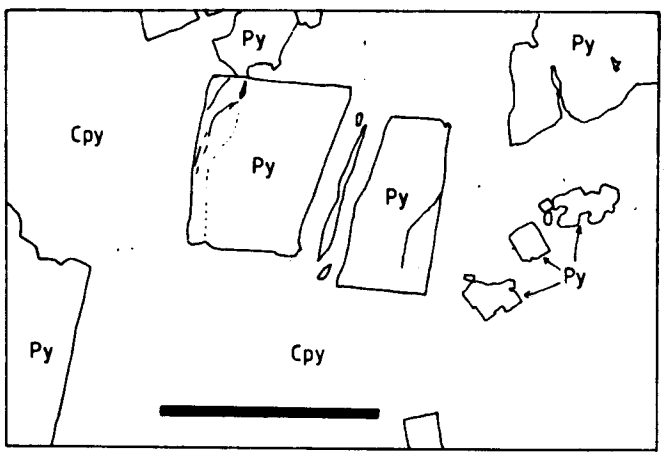


Fig.5. BGS specimen KB1055. Euhedral pyrite (Py) fractured and infilled by later chalcopyrite (Cpy). Plane polarized reflected light. Scale bar 1mm.

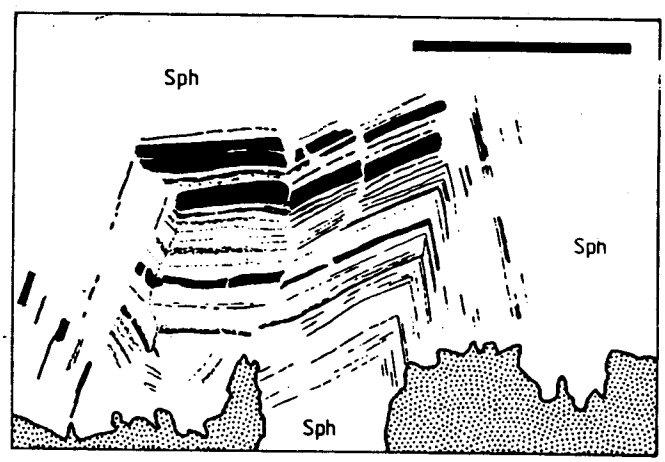


Fig.6. BGS specimen KB1054, Finely banded sphalerite (Sph). Plane polarized transmitted light. Stippled areas are marcasite. Scale bar 1mm.

before the mine is reached, marks the entrance to a rather more extensive trial (fig.3). Driven for over 100m in sheared LRTF, it contains no visible sulphide mineralisation. It followed one of the cross courses marked on the mine prospectus from 1873 (Bick, 1982, p.82).

It is rumoured that Brittania and Clogwyn Coch Mine [SH 603556], close to Llyn du'r Arddu, connected underground. Although this has yet to be definitely disproved, the scale of workings in Snowdon Mine, and preliminary survey work by the authors in Clogwyn Coch, suggest that such a connection would be highly unlikely. Bick (1982) gave the 'copper ore' production as 3160 tons in the period 1804 - 1913. In view of the volume of stoping, particularly on No.4 and No.5 Level, this figure is conservative indeed. Much of the ore production cannot have found its way into the records

MINERALISATION

There are two mineral assemblages:
a)quartz-pyrite-chalcopyrite-sphalerite±galena
b)calcite-marcasite-sphalerite±galena.

The quartz-sulphide phase forms thin veins and wider (up to 1m seen) stockworks which are well displayed at the end of No.2 level and in No.3 level, especially in the stope 150m from the entrance. Here a 1cm vein on 090° develops a conjugate fracture on 140° with quartz sulphide stockworks and breccias between the two veins. The breccia consists of sulphide-supported clasts of wallrock. The vein on 140° is deformed by cleavage in places (Fig.4).

Pyrite forms generally euhedral grains up to 1mm which are sometimes fractured and infilled by later chalcopyrite (Fig.5). It may be euhedral due to metamorphism and recrystallisation. A few early pitted irregular pyrite grains can be seen surrounded by later clear recrystallised pyrite. A carious texture can be developed at the contact. Galena has only been seen in a thin vein at the entrance to New No.1 Level.

The calcite-sulphide phase forms banded veins, generally on the footwall of the vein, but also occurs cutting the quartz-sulphide stockworks at the end of No.2 Level. It is usually banded parallel to the host rock for up to 5cm

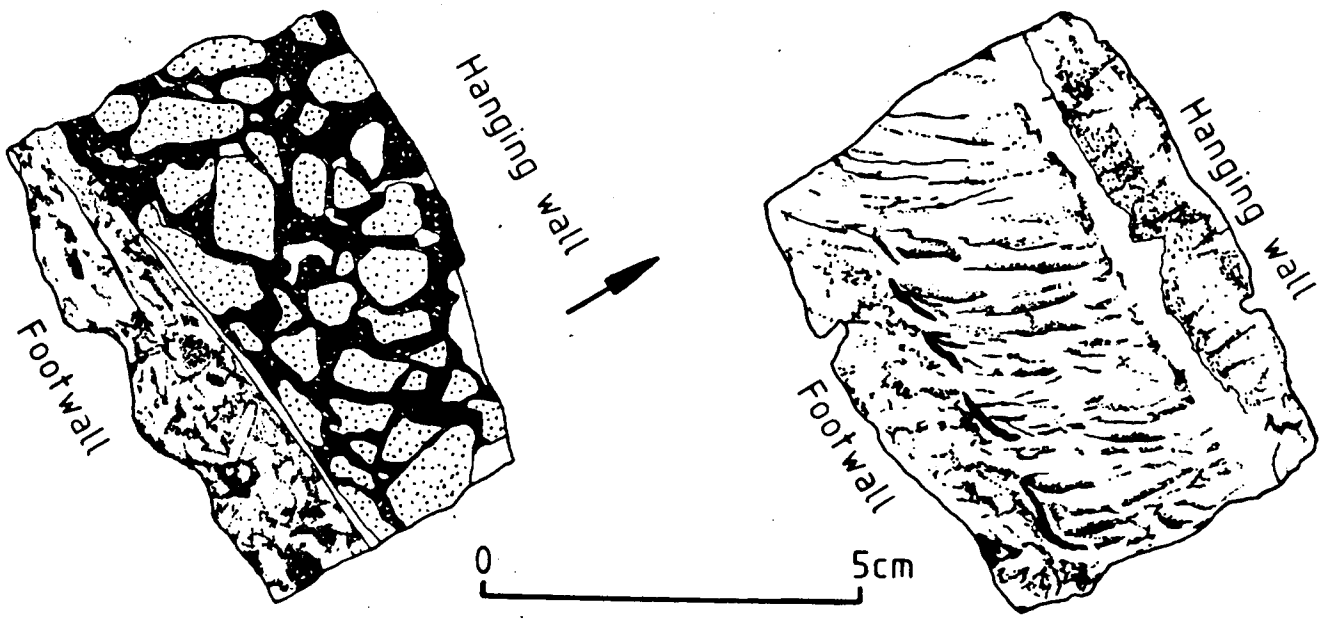


Fig.7. BGS specimen KB 1067 (left). Calcite and sulphide supported wallrock breccia in vein, with indistinctly banded calcite-sulphide assemblage adjacent to footwall. BGS specimen KB 1060 (right) Calcite and marcasite banding in vein, No.2 Level.

away form it and then develops a calcite and sulphide supported breccia with clasts of wallrock (BGS specimen KB1067 Fig.7). It is also common on the waste tips in blocks up to 30cm in size and appears to have been discarded without treatment. The mineral assemblage consists of calcite, crystals up to 2mm, with occasional bladed marcasite grains up to 1cm long growing through the calcite bands. Marcasite also occurs as bands up to 3mm wide interlayered with sphalerite bands. In No.2 Level marcasite occurs as a thin band parallel to the footwall which has been broken into a series of en echelon lenses, and thin maracasite bands have been deposited at an 80° angle to the vein over 3cm before parallel deposition has recommenced (BGS specimen KB1060, Fig.6). This texture may indicate deposition of alternating calcite and marcasite within a cavity in the vein under relatively quiescent conditions. The sphalerite bands are pale to dark brown and exhibit delicate internal banding. In transmitted light, many bands 15-45μm wide can be seen consisting of alternating darker and lighter bands with very sharp V-shaped kinks (Fig.6). The bands are cut by new generations of sphalerite without disruption to the overall parallel banding, although small scale movement can be seen. The banded sphalerite contains very few oriented patches of chalcopyrite - so-called 'chalcopyrite disease', often erroneously attributed to exsolution. Galena has been seen in one sample from dumps and in a marcasite band as small grains parallel to the marcasite/sphalerite banding.

The calcite assemblage can be seen *in situ* in all six levels, over a vertical distance of about 100m. Both assemblages are seen in contact in the large openwork that marks the site of No.7 Level. Tension gashes in the BPF are infilled with a quartz-calcite-sulphide assemblage.

In the lower levels of the mine the tuffs are stained blue and green by secondary copper minerals precipitated by water seeping through the rock. These secondary minerals have been investigated by Bevins (1985). Examining material from No.1 Level they found the new mineral lanthanite-(Ce) ($(Ce,La,Nd)_2(CO_3)_3$) associated with brochantite, posnjakite and rarely chalcoaluminite, the whole assemblage sometimes being coated with a glaze of ferric oxyhydroxides. They propose that these minerals were formed by water percolating down through the mine workings, and that the rare earths may have been leached from allanite which occurs in the BPF and which has also recently been found to be present in the LRTF. In No.5 Level the colouration from secondary minerals is far less developed, and is only well-developed in the short trial in the footwall of the Caunter Lode. The source of copper in this instance is probably the BPF, which contains 30-200ppm copper (unmineralised and mineralised values). The LRTF contains only 4-16ppm (unmineralised and mineralised values). Supergene enrichment may also have imposed a pattern on the deposit. The presence of native copper, along with the other secondary minerals in the lower levels suggests that they correspond to a redox interface. This may be a further reason for the predominance of the secondary minerals lower down. It is also possible that lowering of the water table due to dewatering by the lower levels could be a significant factor.

Gold has been recorded from the mine in the 19th Century. Two samples of sulphide "ore" (unconcentrated) have been analysed for gold using MIBK extraction and atomic absorption spectrophotometry (AAS) and gave contents of less than 100ppb, as have several other sulphide samples from other volcanogenic deposits in the Snowdon Volcanic Group. The mineralogy of the deposit is such that rich gold concentrations would not be expected to occur.

STRUCTURE

The vein has been worked over a length in excess of 300m. It occurs mainly as a normal fault trending 090° and dipping 80°N with a downthrow to the north of 20m, and the western end trending about 130°. The dip also decreases slightly to the west, which marks the transition from Sneyd's Lode into the Caunter lode. The vein exhibits a pinch and swell structure, with most of it

Table 1 BPF AND LRTF CHEMISTRY

	BPF			LRTF	
	Cwm Idwal Reference SPIBPF	Brittania A	Brittania B	Cwm Glas Reference SPILRTF	Brittania
SiO_2	46.42	52.66	47.00	77.64	76.13
Al_2O_3	14.92	10.27	13.54	11.11	9.77
TiO_2	1.93	2.36	2.34	0.23	0.18
Fe_2O_3	12.0	22.68	11.48	1.66	6.64
MgO	8.88	4.98	5.30	0.49	1.06
CaO	6.88	0.43	6.35	1.46	0.11
Na_2O	4.31	0.06	1.56	2.83	0.82
K_2O	0.48	0.20	3.39	2.14	3.04
MnO	0.19	1.05	0.71	0.05	0.2
P_2O_5	0.24	0.34	0.36	0.03	0.00
As	7	73	20	52	13
Ba	95	18	785	271	505
Ce	35	34	36	98	101
Co	46	52	36	0	14
Cr	176	108	186	5	7
Cu	33	220	26	4	13
Ga	19	22	16	19	19
La	11	18	14	44	45
Ni	74	49	70	35	2
Nb	13	14	15	24	28
Pb	8	129	32	24	12
Rb	22	15	86	124	130
S	na	494	na	2570	3239
Sn	0	bd	na	7	6
Sr	385	9	117	93	19
Th	bd	5	bd	22	20
U	bd	bd	bd	4	3
V	271	281	285	11	8
W	4	12	2	1	13
Y	30	41	31	73	78
Zn	87	*186	*134	77	56
Zr	166	177	185	291	238
F	377	718	na	383	na
No. of samples	7	3	3	3	5

Brittania A - Adjacent to vein
Brittania B - 5m from vein
LRTF Brittania - Adjacent to vein

na = not available
bd = below detection
major elements as percentages, trace elements in ppm. All values are means.
* = 2 samples only

occurring as a thin stringer which occasionally widens out, using a conjugate fracture as previously described on No.3 Level, to give mineable mineralisation (now removed). Such swells are exemplified by the stope between No.1 and No.2 Level where the roof is bounded by one of these conjugate fractures, and the section of No.5 level in the Caunter Lode, which is driven entirely within such a mined-out area. In plan, some of the stopes are curved or triangular, especially in No.4 Level, implying some lateral movement, though slickensiding has only been observed at the entrance to New No.1 Level, where a 1cm pyrite-sphalerite-galena vein has horizontal slickensides.

LITHOGEOCHEMISTRY

Wallrock samples of LRTF and BPF have been taken at distances of up to 20m from the main vein and analysed by XRF at Nottingham University for ten major (fused borax bead) and 22 minor (pressed pellet) elements (written communication, B. Atkin and P. Harvey). A total of six LRTF and seven BPF samples were taken from levels 1 to 4 underground and on the surface around and above No.5 Level.

The results for the BPF together with those from a number of other mineralised areas within the Snowdon Caldera have been compared with samples of unmineralised BPF from the Cwm Idwal area, 3km north of Snowdon and outside the caldera (Table 1). This work is still in progress and will be described more fully elsewhere.

At Brittania Mine the BPF is generally enriched in Fe_2O_3, MnO, P_2O_5, As, Cu, Pb, W and Zn and depleted in MgO, CaO, Na_2O, K_2O, Ba and Sr in wallrocks adjacent to mineralisation (Brittania A, Table 1). However, at distances of 3 to 5m from mineralisation (Brittania B, Table 1) there is no iron enrichment, CaO is at Cwm Idwal levels and Na_2O is much less depleted while K_2O is strongly enriched. Enrichment also occurs in Ba and Rb, while Cu and Sr are depleted, with other minor elements remaining similar to Cwm Idwal. See Figs. 8 and 9 for comparison of selected elements adjacent to, and 5m away from mineralization with a Cwm Idwal 'standard' ('SPIBPF') and Table 1 for mean values of the elements analysed.

The results for the LRTF are broadly similar though the "unmineralised" LRTF taken for comparison at Cwm Glas is on the margin of the caldera and may not be entirely outside the influence of hydrothermal activity. Here enrichment in Fe_2O_3, MgO, K_2O, MnO, Ba, Co, Cu, and W can be seen, with depletion in CaO, Na_2O, Ni, Pb, Sr, and Zn. The results are shown in Table 1 and Fig. 10 shows comparison of selected elements against the Cwm Glas 'standard' ('SPILRTF').

A rapid XRF scan of several samples of mineralised rock showed low As and Ba with traces of Te, Tl and W - results which again are similar to those in other areas of the orefield. Analyses of some wallrocks for fluorine has shown elevated levels (628-1475ppm F)(Written communication, R. Fuge and M. Andrews). When compared with the Cwm Idwal and Cwm Glas "reference" areas, these results are similar to those associated with other mineralised areas in the Snowdon district.

The lithogeochemical results show the strong and pervasive hydrothermal alteration which has affected all the mineralised areas in the Snowdon Caldera. Apart from the influx of iron and potassium and removal of copper and sodium, silicification is common in some areas.

DISCUSSION

A possible model for the ore deposit is as follows: initially the main structures of Sneyd's Lode and the Caunter Lode were formed. Sneyd's Lode appears to be controlled by a series of conjugate fractures and tensional features with brecciation in parts. The Caunter Lode may postdate Sneyd's Lode since it appears to truncate it. It dips to the north-east at a shallower angle than Sneyd's Lode, and is predominantly a normal fault, although there is also some evidence for a strike-slip component. Hot circulating fluids then

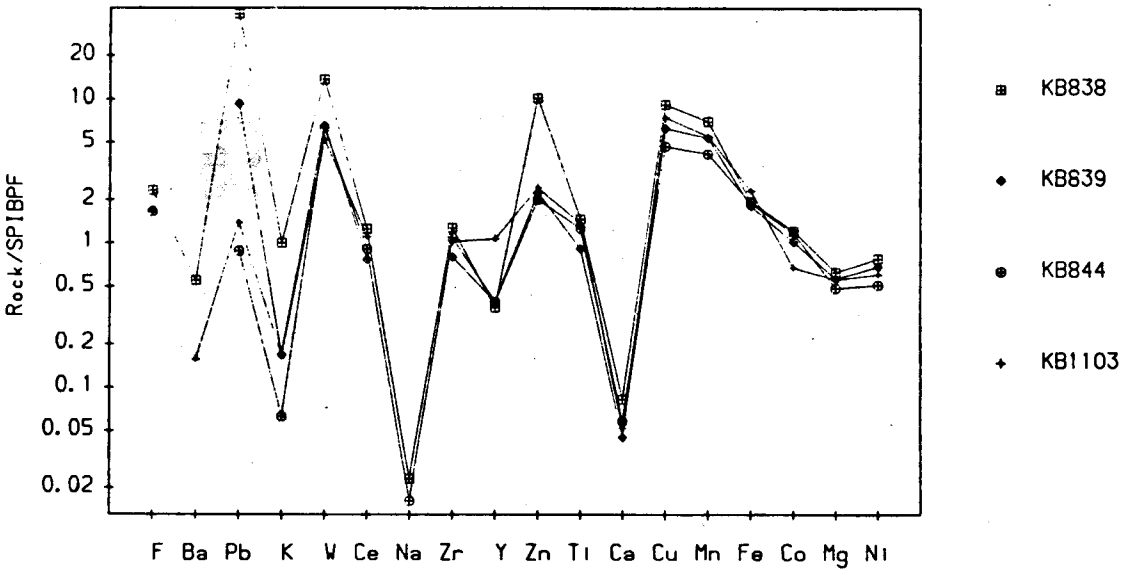


Fig. 8. Comparison of BPF samples adjacent to vein (BRITTANIA A) in Brittania Mine with an un-mineralized "standard" from Cwm Idwal (SPIBPF).

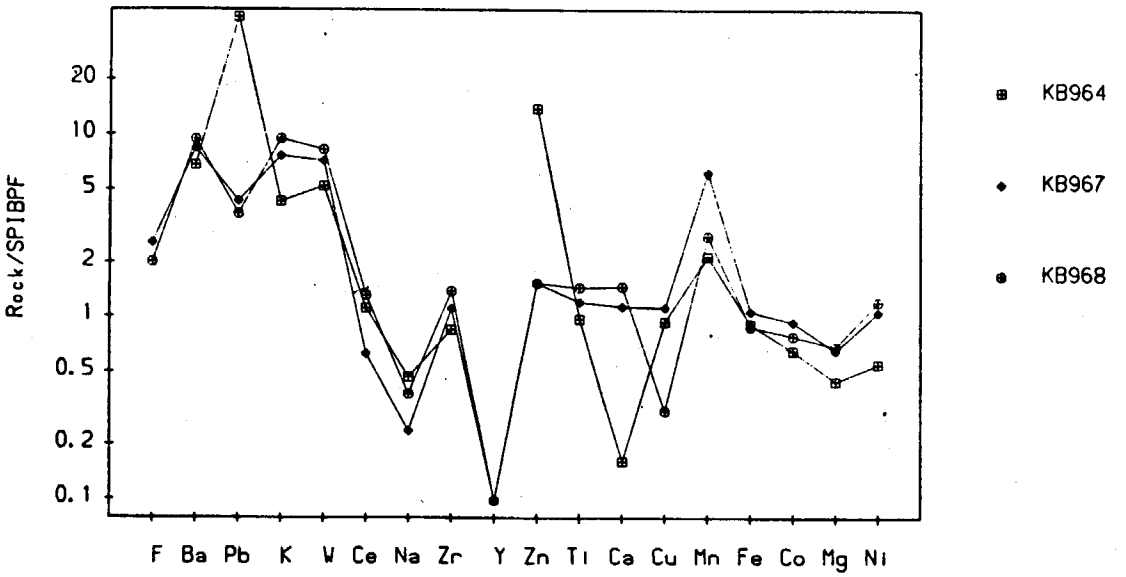


Fig. 9. Comparison pf BPF samples 5 m from vein (BRITTANIA B) in Brittania Mine with an un-mineralized standard from Cwm Idwal (SPIBPF).

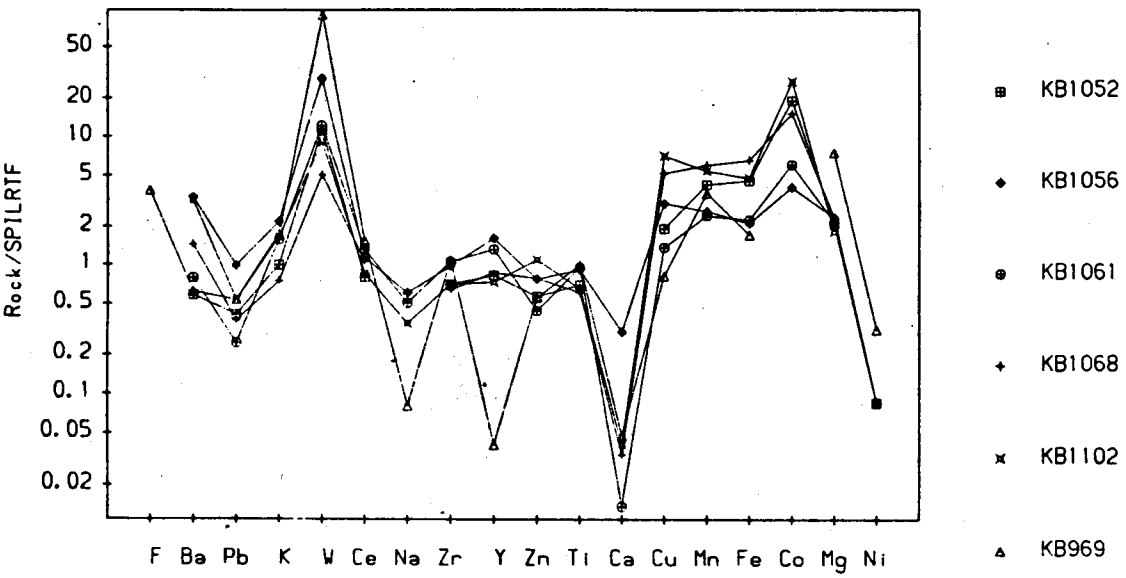


Fig.10. Comparison of LRTF samples from Brittania Mine with an un-mineralized "standard" from CWM Glas (SPIRTF).

mobilised metals in the tuffs and circulated through these structures, and the bulk of the sulphide deposition occurred at the boundary between the tuffs and the overlying BPF. This may be presumed to be due to a shift in the thermodynamic parameters of the hydrothermal system and is possibly related to the chloritization of the basic tuffs. In the lower parts of the deposit quartz-sulphide and calcite-sulphide assemblages are found, and in the BPF chlorite is found in addition. At the large openwork marking the site of No.7 Level, tension gashes in the bedded pyroclastics are filled with a quartz-calcite-sulphide assemblage. Horizontal quartz-chalcopyrite tension gashes also occur at Clogwyn Coch.

The Brittania Mine is one of a number of deposits occurring around and within the "LRTF caldera" (Reedman and others, 1985). It is situated around the LRTF/BPF contact and although exploration has been carried out up to 100m below the contact, very little mineralisation has been found, with the exception of No.1 Level where stopes occur in very fine-grained LRTF which acted as a suitable depositional environment for the ore.

The sulphides are regarded by Reedman and others (1985) as volcanogenic in origin because of their spatial association with the volcanogenic lithologies, synvolcanic faulting, and the high Co:Ni ratios in pyrite at Brittania and elsewhere in the area.

The calcite-sulphide unit is unique to the Brittania Mine in the Snowdon area and may represent a later period of lower temperature mineralisation under conditions of lower pressure and tensional stress. The fairly consistent occurrence and width of this phase is also noteworthy.

Further exploration or development of the Britannia deposit should be concentrated at No.4 and No.5 Levels and follow the E-W fault along the LRTF/BPF contact which does exert a strong influence on the mineral deposition either chemically, structurally or spatially. The first two appear most likely with the abrupt change from acid tuffs to basic tuffs and basalts. However, the small scale erratic nature of the mineralisation, its apparent low grade (though the true overall grade of the mine is not known), and its isolated position in a major tourist centre in a National Park are likely to cause it to remain abandoned, but hopefully still accessible with care.

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REFERENCES

BEVINS,R.E., ROWBOTHAM,G., STEPHENS,F.S., TURGOOSE,S., and WILLIAMS,P.A. 1985. Lanthanite-(Ce),$(Ce,La,Nd)_2(CO_3)_3.8H_2O$, a new mineral from Wales, U.K. *American Mineralogist*, Vol. 70, pp. 411-413, 1985.

BICK,D.,1982. The old copper mines of Snowdonia. 129pp. The Pound House, Newent, Glos.

REEDMAN,A.J., COLMAN,T.B., CAMPBELL,S.D.G., and HOWELLS,M.F. 1985. Volcanogenic mineralization related to the Snowdon Volcanic Group (Ordovician), Gwynedd, North Wales. *J. Geol. Soc. London*, Vol. 142, pp. 875-888, 9 figs, 1 table.