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SEDIMENT - HOSTED, BASE-METAL, VEIN MINERALISATION AT DRWS Y COED AND CWM PENNANT, SNOWDONIA, NORTH WALES.

T.B. Colman

SYNOPSIS

Base-metal vein mineralisation occurs near Drws y *Coed and Cwm Pennant, west of Snowdon, in North Wales. The veins are hosted in Cambrian quartzites and siltstones. The mineralisation consists of pyrite, chalcopyrite and sphalerite with locally abundant galena, magnetite, pyrrhotite, fluorite, calcite and siderite. The mineralisation is similar to that in the nearby Ordovician Snowdon Volcanic Group caldera, but direct comparisons cannot be drawn without additional chemical, isotopic and fluid inclusion data.*

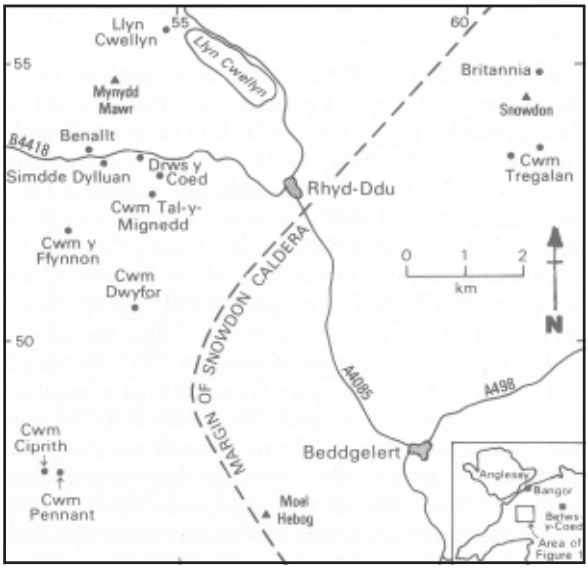


Figure 1. Location map.

Base metal (cu pb zn) mineralisation, hosted in Cambrian quartzites and silts tones, has been worked in a number of small mines and trials east and south-east of Nantlle, North Wales. The largest mines are those in the Drws y Coed valley, south of Mynydd Mawr. This paper describes some investigations of the old workings at the west end of the Drws y Coed valley and in Cwn Pennant to the south. The work was carried out as part of the British Geological Survey (BGS) Multidisciplinary Regional Geological Survey in Snowdonia. The main locations are shown on Figure 1.

Geology

The Cwm Pennant area was mapped by Shackleton (1959) and the Drws y Coed area by Cattermole and Jones (1970). These maps were incorporated into the 1:25000 Central Snowdonia Special Sheet (IGS, 1972). The British Geological Survey has recently completed a resurvey of the area as part of the R.egional Geological Survey programme. The oldest rocks are Upper Cambrian Ffestiniog Flags Formation which contain a series of quartzite beds up to 7m thick near the contact with the overlying Ordovician (Llanvirn) Maesgwm Slates. Most of the mineralisation is within, or close to, the quartzites. The Drws y Coed mining area is mainly on the north limb of an E-W elongated pericline; Cwm Pennant and Cwm Ciprith mines are on the western limb of a N-S anticline. A roughly circular microgranite intrusions of Caledonian age, with a diameter of about 2km, forms the mountain Mynydd Mawr to the north of Drws y Coed. Smaller intrusions of tonalite form the host or wall rock to some of the mineralisation in Cwm y Ffynnon.

Mining Activity

A large number of trails, adits, pits, shafts and more extensive underground workings occur in the Drws y Coed and Cwm Pennant area. An account of the mining history of the area is given by Bick (1982) which is an indispensable guide to the Snowdonia mines. In the early 1970s Kappa Exploration investigated the Drws y Coed mineralisation. Work included mapping, soil geochemistry, EM survey and six diamond drill holes for a total length of 675m, including one to 300m below the main workings at Drws y Coed. The drill targets were EM anomalies and down-dip extensions of the Drws y Coed lodes. No additional mineralisation was found. The geological report (Anon a, 1973) gives some historical details of the mineralisation and also includes a report on exploration for Geolex Development and Mining in 1957-58 which describes some additional trial mining. Grab samples from dumps contained up to 150 g/t Ag in high grade (50% Pb+Zn) samples. Noranda-Kerr, as part of an investigation throughout Snowdonia, carried out a small geochemical programme in parts of Cwm Pennant at around the same time, but ceased work at an early stage (Anon band c, 1973). One of the objectives of the work described below was to compare the Cambrian sediment-hosted mineralisation with similar base-metal sulphide mineralisation to the east, within the caldera of the Ordovician Snowdon Volcanic Group (Reedman and others 1985; Howells and others, in prep).

Benallt

This mine comprises a number of adits and trials in the hill at the west end of the Drws y Coed valley to the north of the road *(B4418)* from Nantlle to Rhyd Ddu. The workings mainly date from 1870 -1874 the deep (bottom) adit was driven in 1874. Three levels are accessible and are driven to a quartzite horizon which hosts the mineralisation. A compass and tape plan of the workings is shown in Figure 2. All the levels are in good condition with free ventilati,on and can be easily waded.

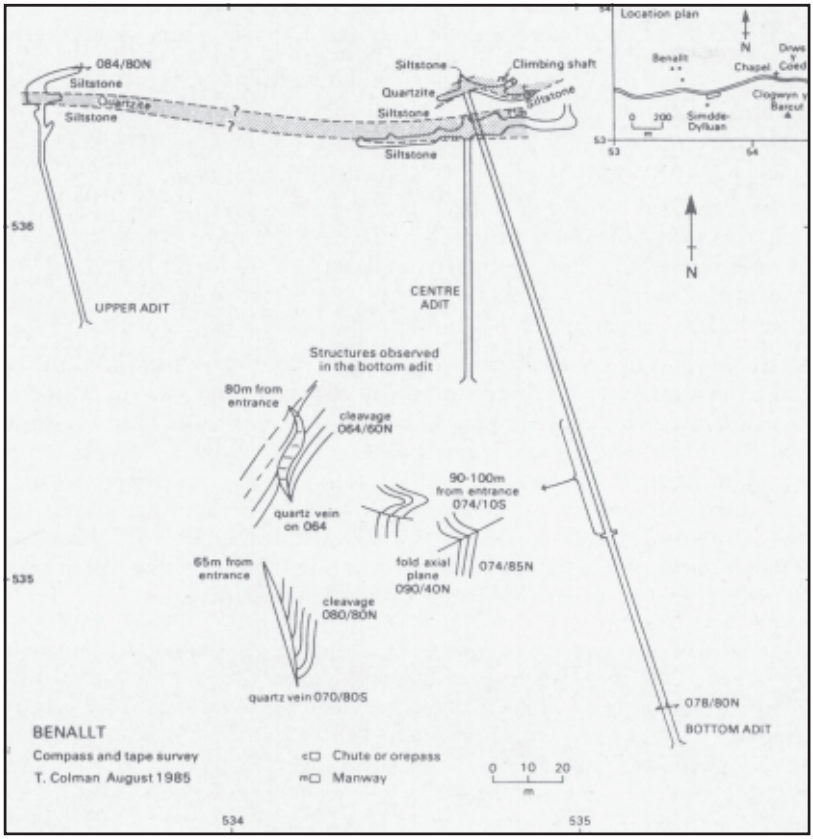


Figure 2. *Benallt mine plan.*

The bottom adit in cleaved silts tone is driven straight for 200m on 345° true from [SH 5353 5345]. The cleavage is faulted and folded at 90 – 100m from the adit entrance and the cleavage is refracted by quartz veins. No stoping has been carried out in the end chamber which shows the quartzite/ siltstone contact on 064/80N. A 2m diameter winze is inclined upwards at 800N for at least 5m and tapers to a 1m hole. R Boyd, in the Geolex Development and Mining report (above), states that during the last working in 1925 “a rise from the bottom level holed into a long abandoned winze exposing arsenical copper sulphides with galena and blende in a quartzose matrix”. The drive beyond the shaft is blocked to the roof by deads with water flowing through. The chamber continues past the drive to an ore pass down from the north and then bends round to the north and stops at a face which exposes quartz tension gashes dipping gently east at 10°. The ore pass is jammed with waste. The magnetic susceptibility of the siltstone is 0.1-0.2 SI units and that of the quartzite is 0.8-1.2 SI units.

The centre adit, also in cleaved siltstone, is driven straight on 356° for 71.5m from [SH 5348 5355]. There are clasts of hard, pyritic silty quartzite in the silts tone 40m from the entrance. The adit ends in a large stope ill quartzite about 15m long, up to 30m high and 3m wide which is spectacularly phosphorescent. The magnetic susceptibility of the quartzite is 0.01-0.1 SI units. To the east the stope constricts to a drive which has a winze descending to the bottom chamber. Beyond the winze the drive enters another stope (in the floor) about 8m across and at least 15m deep and presumably connects with the ore pass in the bottom chamber. To the west the stope constricts to a drive which follows the siltstone/quartzite contact. A 4cm layer of black, unconsolidated sand occurs on the north side of the stope opposite the adit entrance. It dips east at about 40° and appears to be a fault gouge.

Several samples of the wall rocks adjacent to the mineralisation in the centre adit have been analysed. The results show that the siltstone 1m south of the quartzite/siltstone contact (Sample 1112 on Figure 3) has lost SiO_2, Na_2O, K_2O, Ba, Ce, Rb, Sr, Y and Zr and gained Fe_2O_3, MgO, MnO, As, Ni, Pb and S compared to similar samples 5 and 10m south of the south contact and 1m north of the north contact and from the Simdde-Dylluan mine. This is similar to the elements gained and lost by the wall rocks to the volcanogenic mineralisation (Colman, in press). However the data set is too small to allow exact comparisons to be made. Table 1 gives the full analyses.

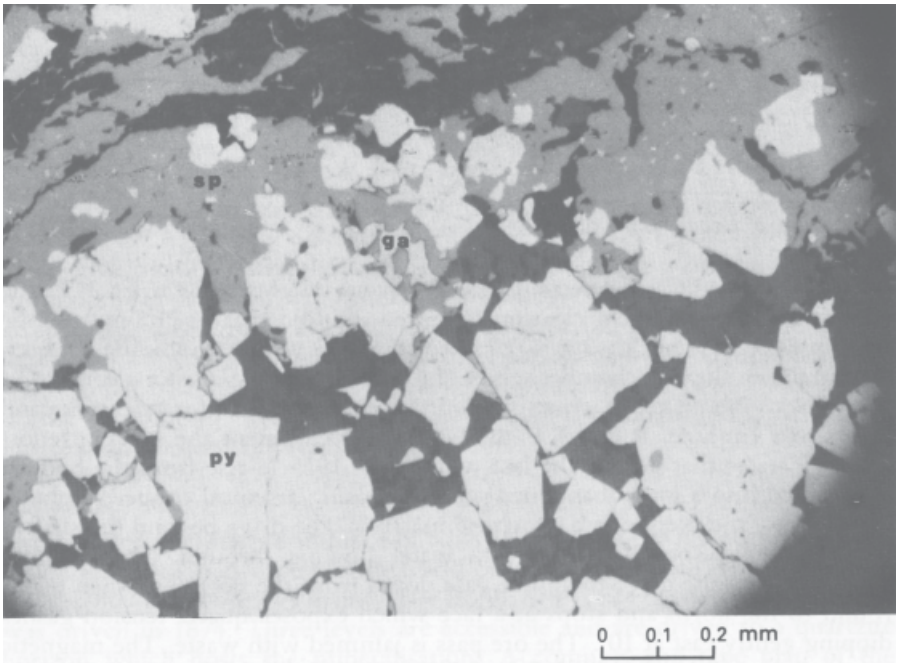


PLATE I. Sample KB 1095 Porpyroblastic pyrite (py) with sphalerite (sp) and galena (ga). Benallt top adit.

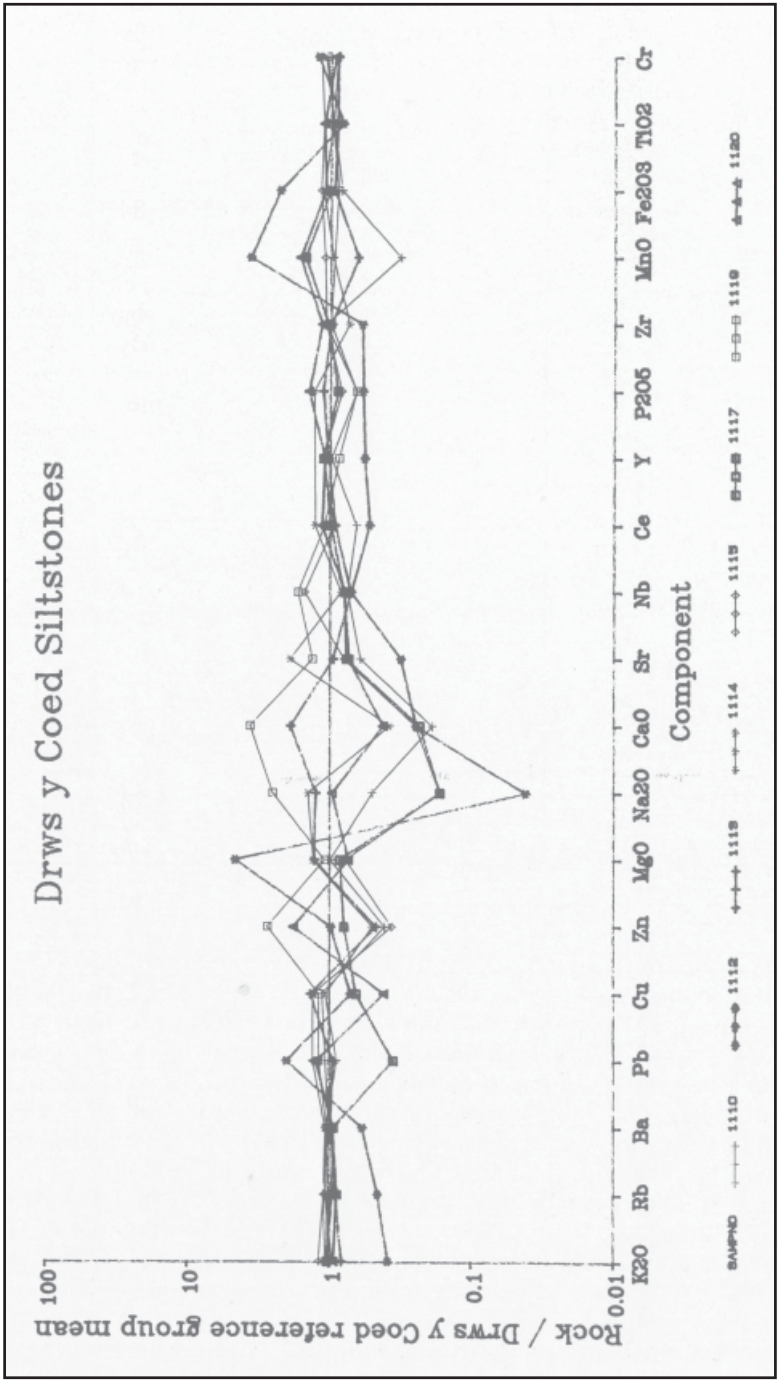


Figure 3. Spidergram of Benallt and Simdde-Dylluan siltstones normalised against their mean values.

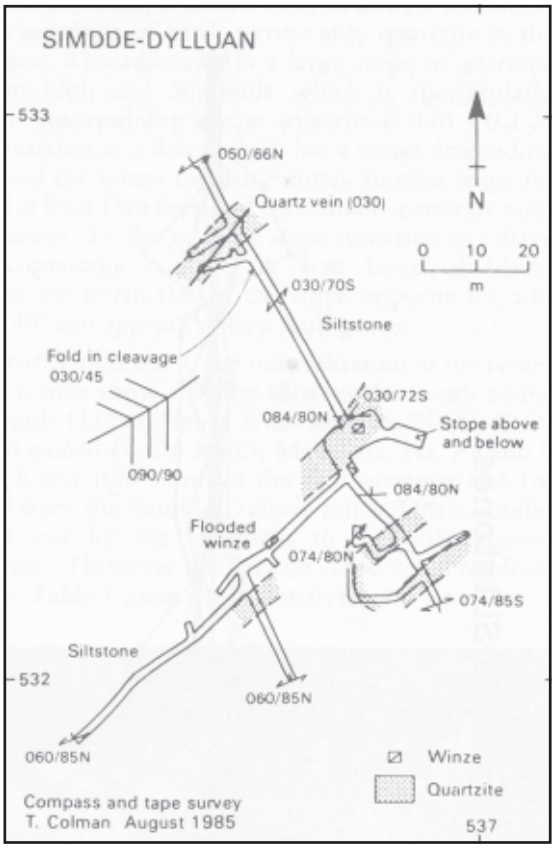


Figure 4.
Simdde-Dylluan mine plan.

The upper ad it lies 100m to the west of the other two adits at [SH 5337 5356] and does not connect with them, but it does intersect the same quartzite bed. It ends in a chamber which is stoped 5m into the roof and has two short drives from it. One is driven east in quartzite for 4m, the other in light grey, cleaved silts tone for 12m on 074˚. A lens of massive sulphide from the west side of the stope is composed mainly of porphyroblastic pyrite with some recystallised euhedral grains. Sphalerite and galena also occur (Plate 1). There are chalcopyrite inclusions in the sphalerite and also a few larger emulsoid bodies.

The topmost adit in the Benallt area (not on Figure 2) at [SH 5336 5365] starts on 015˚ for 4m and then curves to the east. There is a shaft in the entrance which prevents easy access but the level beyond is dry and appears to be in good condition. The size of the dump implies an extensive adit. Several small sulphide veins are exposed in the entrance. The largest, which is up to 30cm wide, is on 040˚ and transacts the cleavage on 080˚. Other smaller veins are parallel-to the cleavage.

Simdde - Dylluan.
This was the last of the Drws y Coed mines to be worked (in conjunction with Benallt) and a good description can be found in Bick (1982). There are several adits south of the layby on the south side of the B4418 at [SH 537 533], but some are flooded as at [SH 5378 5339] with a 1.5m high dam at the entrance. The adit is driven into massive quartzite on 156° and appears to continue for at least 40m. Another adit 20m to the east has a very dangerous entrance under loose slabs and is driven on 156° in silts tones for 5m before reaching quartzite. This level ends with a narrow slot down to the east leading to a lower level which continues but was not investigated. Numerous shafts are recorded by Bick (1982) one of which reached 222m depth (if vertical). However, there are very few surface remains apart from the adits.

The main accessible adit [SH 5365 5329] is about 25m south of the layby (Figure 4). It is driven south on 152° in fissile dark grey cleaved silts tone with thin quartzite bands. There are two cross-cuts following quartz veins up to 1m wide on 030°. The cleavage is folded at 30m from the entrance, just beyond the cross-cuts, with the axial plane dipping south at 20° and plunging west at 10-20°. The cleavage changes from 060/80N to 030/70S. At 52m the bedding is shown by thin dark bands on 084/80N in light grey siltstone which is cleaved at 030/70S. The main part of the mine, east of the shaft 55m from the entrance, is inaccessible without a proper team. The plan shows the accessible workings to the south and west. Very little stoping has been done in this area and the ramifying nature of the workings shows the problems faced by the miners in understanding the nature of the mineralisation. The workings often cut or follow the siltstone/quartzite contacts but only minor amounts of sulphides are visible. Some quartzites appear to cut out, or lens out, between parallel drives which have attempted to crosscut them.

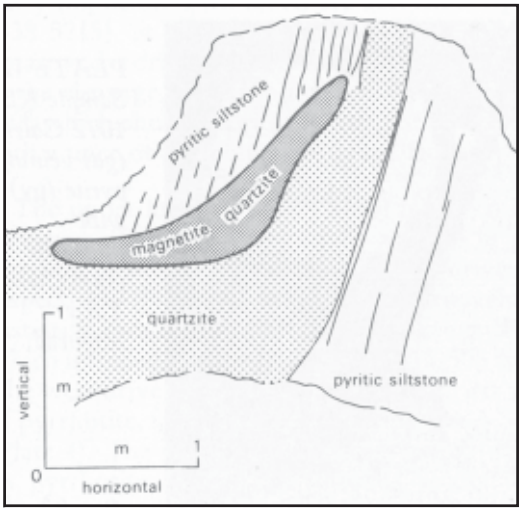


Figure 5.
Trial in magnetite quartzite
Cwm Tal y Mignedd.

Cwm Tal y Mignedd

Several small trials have been worked in the area south-west and south-east of Clogwyn y Barcut, south of Drws y Coed. A 2m long trial at [SH 5467 5296], adjacent to the wall running south east from the hill, is driven on 160° in pyritic quartzite and cleaved silts tone with lenses of pyrite, sphalerite, chalcopyrite and galena developed along the cleavage. The pyrite occurs in rounded to sub-euhedral grains and is sometimes cracked and veined by galena (Plate 2). Some of the quartzite is very magnetic (150 - 275 SI units) with magnetite, coarse pyrite and a trace of chalcopyrite. The form of the magnetic unit is difficult to assess, but it appears to be a thin vein or bed about 1m long (Figure 5) and 40cm across and with a strike on 025°. It may be an exposure of a placer magnetite band as seen higher up the succession in the Ordovician Cwm Eigiau Formation around Snowdon (Evans and Greenwood, 1988). However, the magnetite grains are rather different from those in the magnetic sandstones. They are rounded to elongate, rather than euhedral and are often shattered into a series of sub rectangular grains (Plate 3). They are occasionally surrounded or cut by later pyrite. The mineralisation does not resemble the quartz - magnetite - pyrite veins found in Cwm Tregalan (Reedman and others, 1985).

Two workings 300m to the south-west lie in cleaved (066/70N) quartz pebble conglomerates. The upper working, on 106° at [SH 5447 5282], is open with pyritic quartzite with base-metal mineralisation along the cleavage and ends at a basalt dyke. The lower working, at [SH 5443 5284], is a hole about 15m long on 066°, 10m wide and up to 10m high. Pyrrhotite, chalcopyrite and pyrite occur on the dump together with siderite coated with a secondary pink colbalt bloom in places. The magnetic susceptibility of some samples ranged from 10-50 SI units.

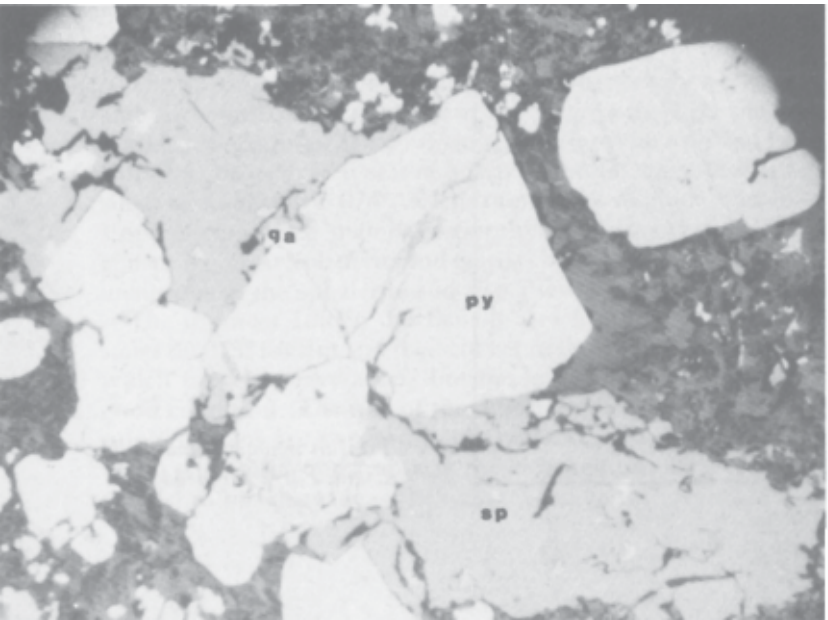


PLATE II. Sample KB 1072 Galena (ga) veining pyrite (py) with sphalerite (sp). Cwm Tal y Mignedd

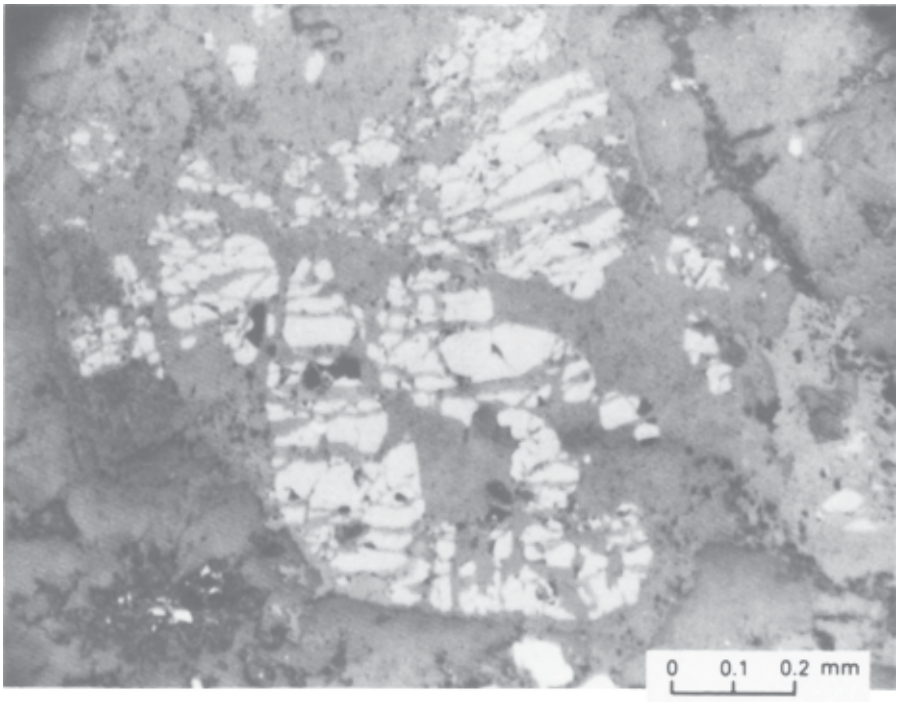


PLATE III. Sample KB 1073 Magnetite grain from Cwm Tal y Mignedd.

Cwm y Ffynnon

These trials are on the west side of Cwm y Ffynnon on the slopes of Mynydd Tal y mignedd. Two levels are accessible by wading. The bottom level [SH 5338 5215], at 325m elevation, appears relatively modern, being about 2m square and is driven in sheared tonalite for 40m on 230˚ which is roughly parallel to the cleavage. It shows no signs of mineralisation apart from thin joints on 140˚ which show traces of weathered pyrite. There are two 2cm quartz veins with a trace of pyrite on 230˚ at the face.

The upper level [SH 5314 5196] is driven in slate for 35m on 174˚ at 380m elevation. Two-foot gauge rails are still in place and an ore truck chassis is standing at the end. The level is then driven east and west on 104 and 250˚ respectively (Figure 6) following a quartz vein at the slate/tonalite contact. The east drive ends in a face of massive broken quartz which displays a vague layering which is folded into a fault trending 115/50S and is strongly sheared on 012/80E. The west drive ends in massive white quartz with stringers and disseminations of pyrrhotite, sphalerite and chalcopyrite. A 5cm sphalerite vein trends 120/60S (Plate 4). The vein has a magentic susceptibility of 15 SI units which reflects its pyrrhotite content. A polished section of the vein shows an emulsoid intergrowth of sphalerite, pyrrhotite and galena (Plate 5). There is a small stope

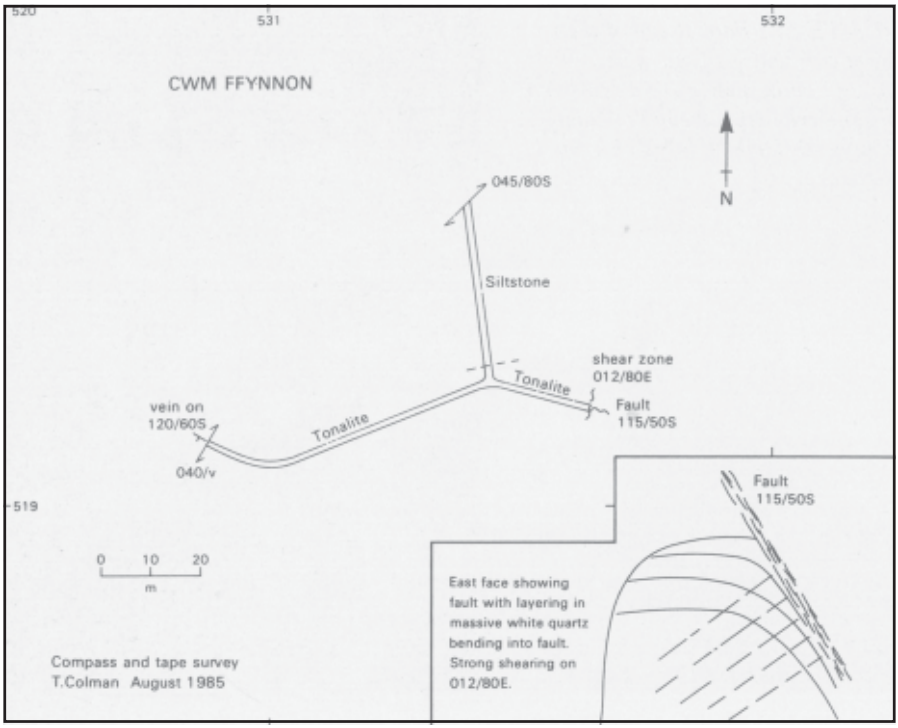


Figure 6. *Cwm* y *Ffynnon mine plan.*

3x3x5m near the end of the adit with slate on the north wall. A sample from a 10cm wide sulphide band near the adit/quartz vein junction assayed at 0.11 % Cu, 1.46% Zn and 0.15% Pb (Anon. a, 1973).

An adit 15m above and 20m east of this level is totally blocked. A small working 10m above this adit is driven in tonalite adjacent to slate. There are two tips. The upper tip shows fine grained spahlerite, galena and a little chalcopyrite, with quartz and some coarse grained galena. The lower one has the same minerals but with much slate and tonalite debris.

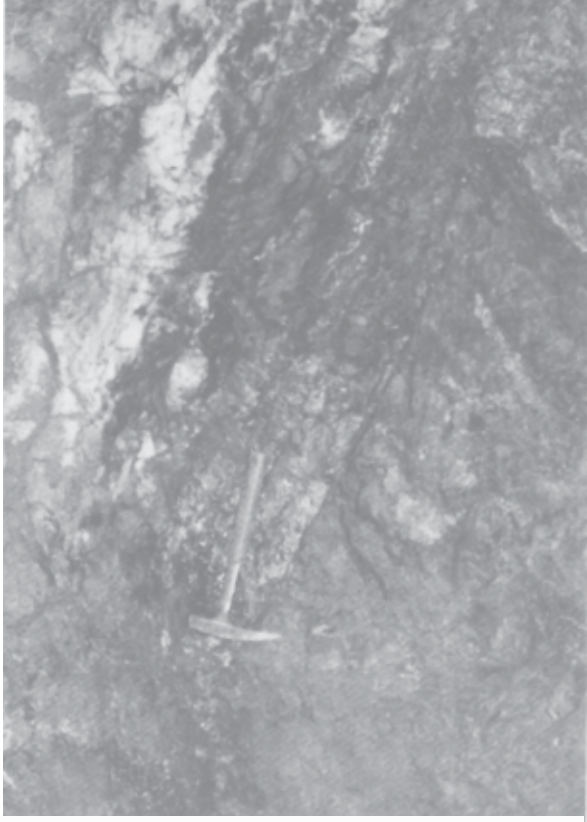
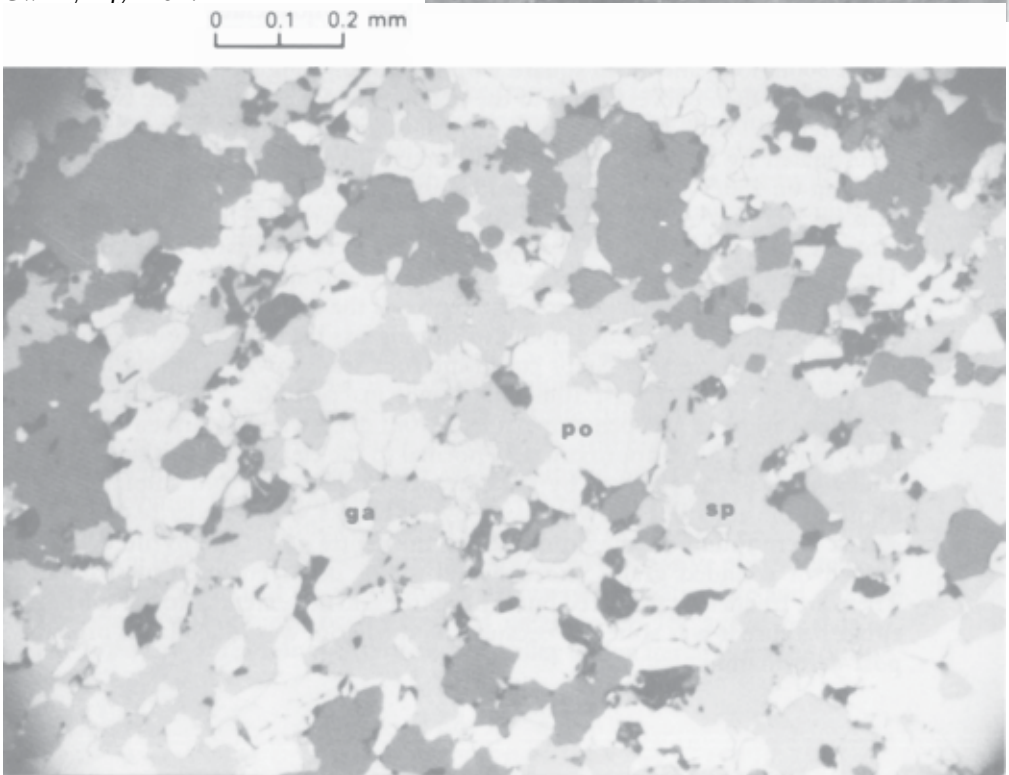


PLATE IV. Face at end of west drive at Cwm y Ffynnon showing massive white quartz and a 5 cm band of sphalerite (sp) above the hammer. The north (right side) wall is in tonalite.

PLATE V. Sample KB 1076 Emulsoid intergrowth of sphalerite (sp), pyrrhotite (po) and galena (ga). Cwm y Ffynnon.



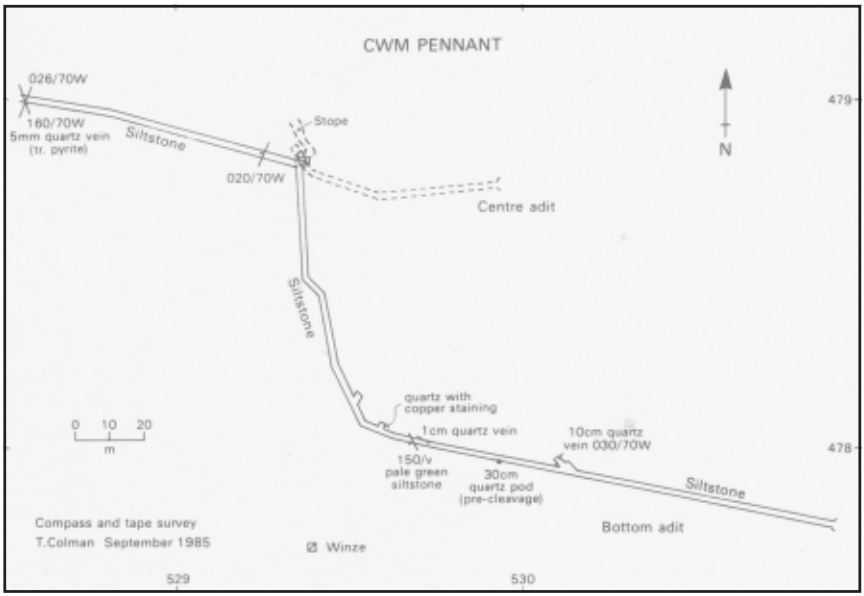


Figure 7. Cwm Pennant mine plan.

Cwm Pennant

Three levels are accessible from the hillside on the west side of Cwm Pennant. his mine is also known as Gilfach by Bick (1982) who includes a sketch section. The bottom level, at 150m elevation, is driven from [SH 5309 4777] and is about 300m long and 1.5m square with no stoping (Figure 7). It is driven first on 282° and then curves round to the north to make a connection, by a winze and orepass, with the centre adit. A few minor quartz veins have been investigated by short crosscuts. A distinctive 2cm pale green silts tone occurs at 126m on 150/90S. The level then continues beyond the winze for a further 82m on 285° but with little evidence of mineralisation. The orepass from the centre level is jammed with deads and appears to be in a dangerous condition. The centre adit, at 190m elevation, is crooked but is again driven generally due west to the winze which is across the centre of the adit and connects to the top and bottom levels. A small amount of stoping has been carried out beyond the winze in the centre adit. Steps cut in the rock lead down round the winze to the stope which is at least 10m long but is inaccessible. The upper level, at 225m elevation, is an open stope at least 10m deep which is driven on a small fault trending 120/90 approximately normal to the cleavage. Fault breccia with sandstone clasts is exposed by the entrance to the stope. No sulphides were found in the adits but a few massive pyrite blocks with sphalerite and a little galena were found on the dump below the centre adit. The pyrite occurs as ragged or rounded grains and euhedral grains occur enclosed in spahlerite. These are frequently fractured but the fractures do not extend into the sphalerite either because it was softer or because the sphalerite was much later, probably post-deformation.

PLATE VI.
Waterwheel Cwm Ciprith looking east across Cwm Pennant to Moel yr Ogof

Cwm Ciprith
The most visible remains at this locality, which is above the Cwm Pennant mine at [SH 526 478] at 250m elevation, are a water wheel and angle bob (Plate 6). The workings are mainly under water but one small adit by the waterwheel is accessible. The adit is driven for about 25m in cleaved silts tone on 270° following a fault on 285/40N which can be traced for a few metres in the south wall covered in calcite flowstone. Near the entrance there is a flooded winze in the floor of a cross cut to the south. Samples from the dumps by the waterwheel show massive pyrite with sphalerite and galena in creamy baryte. A pyritic slate sample contained pyrite cubes to l mm with quartz veins normal to the cleavage and the pyrite crystals overprint the cleavage.

Cwm Dwyfor
This mining area lies at the north end of Cwm Pennant. Many of the adits and shafts are flooded but most of the material mined is still on the waste dumps as little ore was actually transported from the site (Bick, 1982). The remains of a tramway and stone built incline (Figure 8) are still preserved (Plate 8). The flooded opencut follows a one metre wide shattered quartz vein on 090/80N at 400m elevation high up on the east side of the cwm at [SH 5423 5102] above a run-in adit which probably connected to a flooded shaft in the open cut. The bedding is at 000/l0E and the cleavage at 045/75-85N. Massive pyrrhotite with chalcopyrite is abundant on the dump, together with pyritic slate and quartz/calcite veins. Pyrrhotite also occurs streaked out along the cleavage of the slate.

The main mine area is in the centre of the valley and material from the dumps

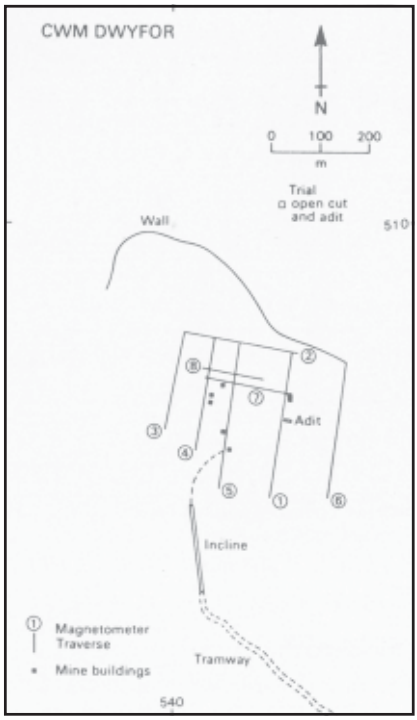


Figure 8. *Cwm Dwyfor location map.*

show a number of parageneses. The most common are a. massive pyrrhotite and b. pyrrhotite with euhedral pyrite and quartz. The magnetic susceptibility of selected samples ranged up to 130 SI units. Magnetite has not been detected in the small number of polished sections prepared from this area so the magnetism is presumably due to pyrrhotite. Other parageneses include c. pyrrhotite with coarse grained galena, d. quartz with calcite and e. white sugary quartz with chalcopyrite. This last type was only seen in situ in a flooded adit on 090°. Blocks of quartz commonly show quartz growing into calcite vugs. The pink-fluorescing calcite is generally not associated with sulphides except for a trace of pyrite. However, one sample contained galena.

The presence of pyrrhotite is unusual in Snowdonia. It occurs in the group of mines on the west side of Nantgwynant from Lliwedd to Hafod y Porth (Reed man and others, 1985), at Cwm y Ffynnon and is also mentioned by Bick (1982) in Nant Ffrancon. It is generally considered to be a higher temperature sulphide mineral but can form at lower temperatures or during the selective alteration of pyrite. At Cwm Dwyfor a series of magneto meter traverses show distinct, sharp anomalies which are probably due to pyrrhotite mineralisation (Figure 9). The traverses cover the main mineralised area and show that pyrrhotite mineralisation may continue to the west. The anomalous trend is at 110°, the same trend as the adit on the east side of the area. No anomaly was found on Line 6 so the mineralisation does not apparently extend to the east

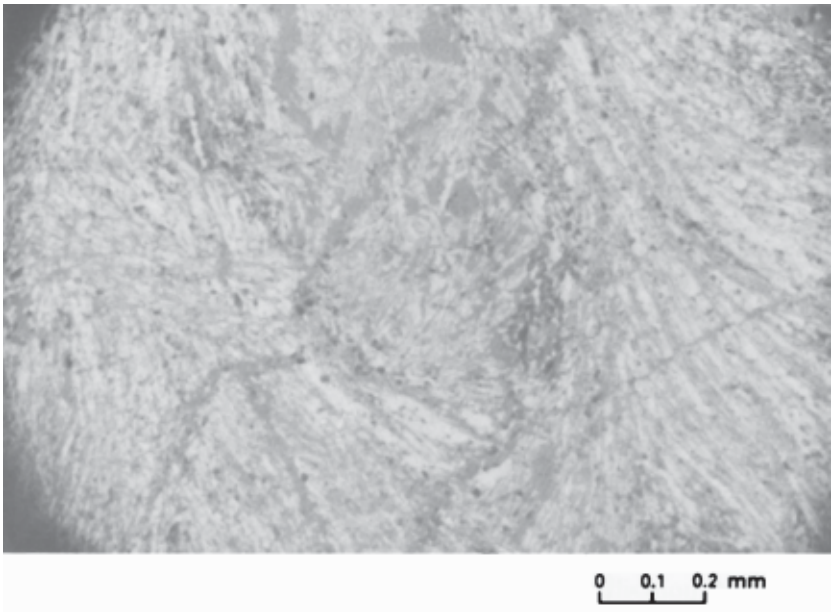


PLATE VII. Sample KB 1126 Swirling aggregates of magnetite from old trial on pyrite-magnetite-fluorite vein. South-west side of Llyn Cwellyn.

PLATE VIII. Cwm Dwyfor and Cwm Pennant. Looking south down Cwm Pennant from the adit above the main mining area which can be seen on the lower centre of the plate. The adit on Figure 8 is at the lift centre, south of the ruined building. The tramway curves away to the south from the mine area.

much beyond the adit. A second anomaly only occurs on Line 5. A curious trackway in one of the dumps consists of a tunnel about 45cm square and 5m long with a roof of slate slabs. The trackway is curved and goes under a waste dump with the remains of wooden rails or wood bases for iron rails. A post on the watershed east of Mynedd Tal-y-mignedd is part of a capstan and has the maker's name *Francis Morton's Patent Liverpool*. It is presumably from the mines.

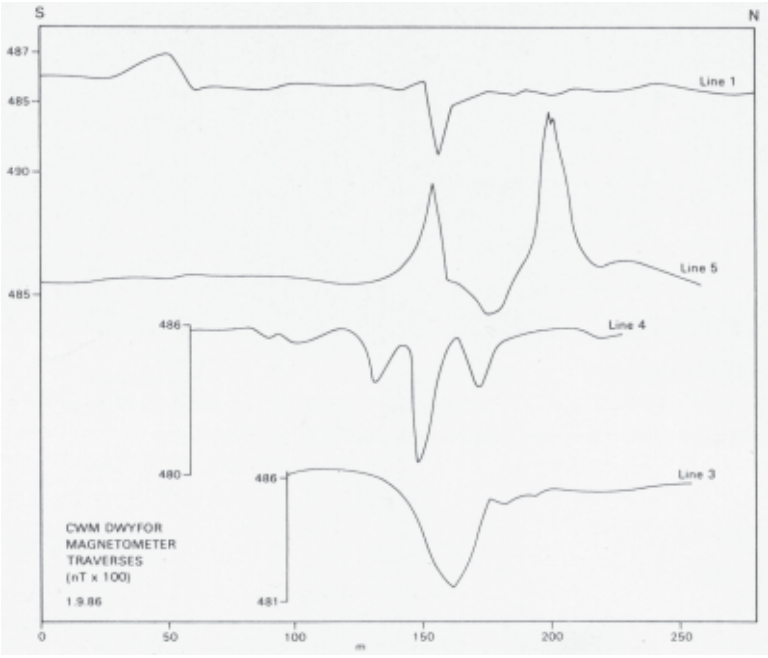


Figure 9. *Magnetometer traverses Cwm Dwyfor.*

Llyn Cwellyn

A small flooded trial on 170/80E occurs 200m north-west of the north end of Uyn Cwellyn at SH 5486 5569. The tip contains blocks, up to 15cm, of fluorite, pyrite, quartz, chalcopyrite and magnetite. The fluorite occurs in massive green and banded white, purple fluorescing varieties. Some blocks of pyrite and quartz are highly magnetic (up to 100 SI units). Magnetite occurs as fine grained, swirling aggregates (Plate 7); a style unlike the magnetite in Cwm Tregalan (Colman and Appleby, in press) or Cwm Tal-y-Mignedd. The rare earth element (REE) content of one sample of fluorite (Colman, in press) shows a flat profile, with a high content of REE, which is typical of magmatic associated profiles. The origin of this mineralisation is uncertain. The vein is adjacent to the Caledonian Mynydd Mawr microgranite. Volcano genic mineralisation in the Snowdon caldera has enhanced levels of fluorine associated with the wall rock alteration (Colman, in press) but only a few fluorite grains have been seen in thin section.

CONTROLS OF THE MINERALISATION

The mineralisation at Drws y Coed and Cwm Pennant occurs in quartz veins either within quartzite horizons or at the contacts of silts tones with intrusive tonalite. It is considered that the competent quartzite and tonalite fractured and allowed the deposition of sulphides in open spaces. Many quartz veins appear to predate the cleavage which refracts across the veins (Figure 2) and rotation and boudinage of veins within the cleavage also occur. Some quartz veins, as at Cwm Dwyfor, appear to follow joints and others have parallel laminations normal to the vein. Old records (Anon a, 1973) show that the mineralisation at Drws y Coed was always located in 'grit', with enrichments at the intersections of cross faults. The mineralisation occurs as a series of steeply dipping, easterly plunging oreshoots up to 7m wide and l00 m long containing up to 10% chalcopyrite.

PARAGENESIS

Pyrite is the earliest sulphide mineral to form, followed by sphalerite, chalcopyrite and galena. Some deposition may have occurred simultaneously to form the emulsoid intergrowths seen at Cwm y Ffynnon. The Caledonian deformation caused extensive deformation and recrystallisation. No colloform or framboidal pyrite has been observed in the Drws y Coed and Cwm Pennant areas though it is common in the Snowdon mineralisation. This may be due to the higher metamorphic grade in these areas compared to the Snowdon area (Roberts and Merriman, 1985).

COMPARISON WITH VOLCANOGENIC MINERALISATION

The gross mineralogy of the veins is similar to that of the Snowdon area. The host rocks are older in the Drws y Coed area and the lithologies very different. The controls of the volcanogenic mineralisation in the Snowdon area are largely chemical or spatial with mineralisation concentrated at the contact of acid and basic tuffs along syn-volcanic faults. Parageneses which have not been seen in the Drws y Coed area include quartz-magnetite-hematite mineralisation seen at Cwm Tregalan (Colman and Appleby, in press), massive galena-sphalerite mineralisation seen at Lliwedd Mine (Reed man and others, 1985) and late-stage calcite-marcasite-sphalerite mineralisation seen at Britannia Mine (Colman and Laffoley, 1986). The fluorite-pyrite-magnetite paragenesis of the Llyn Cwellyn veins does not occur in the Snowdon area.

The relationship of the Drws y Coed mineralisation to that of the Snowdon area cannot be resolved without data on the mineral chemistry. This would include fluid inclusion and stable isotope data and the trace element geochemistry of the sulphides. The Snowdon minerals show a volcanogenic association on the basis of a high Co : Ni ratio in pyrite and the presence of high levels of tin and tungsten in the Cwm Tregalan magnetite veins. No such mineral chemistry is available for the Drws y Coed area and there is no fluid inclusion or stable isotope data for either area. The relationship, if any, is therefore based entirely on the gross mineral species present.

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Drws y Coed Siltstones

OBS	SAMPNO	GROUP	SIO2	AL2O3	TIO2	FE2O3	MGO	CAO	NA2O	
1	1110	1	62.94	18.49	1.00	6.48		1.68	0.13	0.120
2	1112	3	45.08	17.84	0.86	17.70		7.85	0.17	0.001
3	1113	1	60.69	17.53	0.94	7.32		2.18	1.30	0.300
4	1114	1	55.10	12.89	1.01	8.73		2.22	0.26	0.340
5	1115	1	55.94	22.03	1.17	9.11		1.31	0.17	0.040
6	1117	2	61.08	19.82	1.05	7.85		1.45	0.16	0.040
7	1119	2	55.88	20.60	1.02	6.88		1.84	2.49	0.600
8	1120	2	60.56	18.94	1.17	8.52		1.26	0.29	0.230

OBS	K2O	MNO	P2O5	LOI	AS	BA	CE	CO	CR	CU	GA	LA	NB	NI	PB
1	4.80	0.07	0.11	3.94	42	860	48	13	93	19	24	25	18	32	18
2	1.75	0.80	0.10	7.89	75	501	39	14	127	12	23	24	17	62	34
3	3.70	0.14	0.19	4.34	20	835	68	18	92	23	21	38	17	34	16
4	4.31	0.21	0.22	4.37	30	906	94	9	113	18	28	42	20	47	15
5	5.33	0.24	0.14	4.13	39	906	69	17	122	22	29	40	36	14	22
6	4.70	0.33	0.15	3.54	46	797	73	17	104	11	24	41	19	32	6
7	4.62	0.22	0.11	5.18	10	890	80	20	110	20	20	30	40	10	20
8	4.22	0.36	0.24	3.42	18	809	84	18	96	7	24	34	19	29	21

OBS	RB	S	SN	SR	TH	U	V	Y	W	ZN	ZR
1	182	4757	2	23	11	3	123	34	4	84	195
2	76	15258	9	12	13	5	163	20	6	202	109
3	151	9965	2	36	12	1	117	36	3	97	179
4	178	149	5	72	16	2	140	35	6	103	134
5	181	2693	4	30	14	3	140	39	5	75	195
6	158	589	9	29	12	4	114	39	10	163	188
7	170	1180	5	50	10	5	110	30	5	560	180
8	147	785	3	28	12	3	115	38	7	371	209

Table 1 *XRF analyses of siltstones from the Benallt centre adit (Group 1*) *and the Simdde-Dylluan workings (Group 2)*

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