The Underground Geology of part of the Carrock Tungsten Mine, Caldbeck Fells

Minerals and Waste Programme

Open Report OR/15/033

BRITISH GEOLOGICAL SURVEY

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Foreword

This report summarises underground geological mapping undertaken in the disused Carrock Tungsten Mine in May 2013 and the subsequent analysis of water and tungsten vein samples that were collected during the mapping. The mapping, focussed on workings that post-date a previous report on the geology published while the mine was still active, confirms the underground geology previously reported.

Analysis of both surface stream and underground water samples collected during the mapping show that arsenic levels exceed WHO guidelines for drinking water in all samples collected. No other elements exceed the WHO guidelines.

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1 Introduction

Carrock Mine is situated about 20 km west of Penrith and 10 km northeast of Keswick at NGR 332300;532940 (site of last mill) in the Caldbeck Fells of Cumbria. It is the only mine outside southwest England to have commercially mined tungsten ores in the British Isles. This was during several phases of working in the twentieth century, with first commercial mining of tungsten commencing around 1900 (Shaw; 1975, Tyler; 2003). The last phase of working ended in 1981 and the site was 'restored' by 1988 (Cooper; 1990). An account of the working of the mine is given by Tyler (2003). The main ores of tungsten present at the Carrock Mine are scheelite and wolframite, the former has not been worked commercially elsewhere in the UK. The area of the mine is shown in the aerial photograph (Figure 1).

Figure 1: Aerial photograph of the Carrock Mine site. Note the long line of surface workings on Harding Vein (west of centre) with two smaller surface workings further west on Smith Vein and those on Emerson Vein in the centre, east of Brandy Gill Beck. The mill was in the centre of the image (NE of the confluence of Brandy Gill Beck with Grainsgill Beck and tailings of various vintages can be seen at the mill site and to the east both south of Graingill Beck (white) and north of the mine access road (red-brown). Width of image approximately 825m. Aerial photography ©UKP/Getmapping Licence No. UKP2006/01.

When the mine's mill and dressing floor site was cleared and restored in 1988 the entrances to the main mine levels were blocked, though access for mine explorers was still possible. Because of concerns about contamination of Grainsgill Beck, which flows past the mine, by mine drainage waters, the entrance to the main haulage level (No 1 Level) was cleared and restored to its pre-1988 condition by Cumbria Amenity Trust Mining History Society (CATMHS) with financial support for materials from the Lake District National Park and Natural England. All levels are gated for safety.

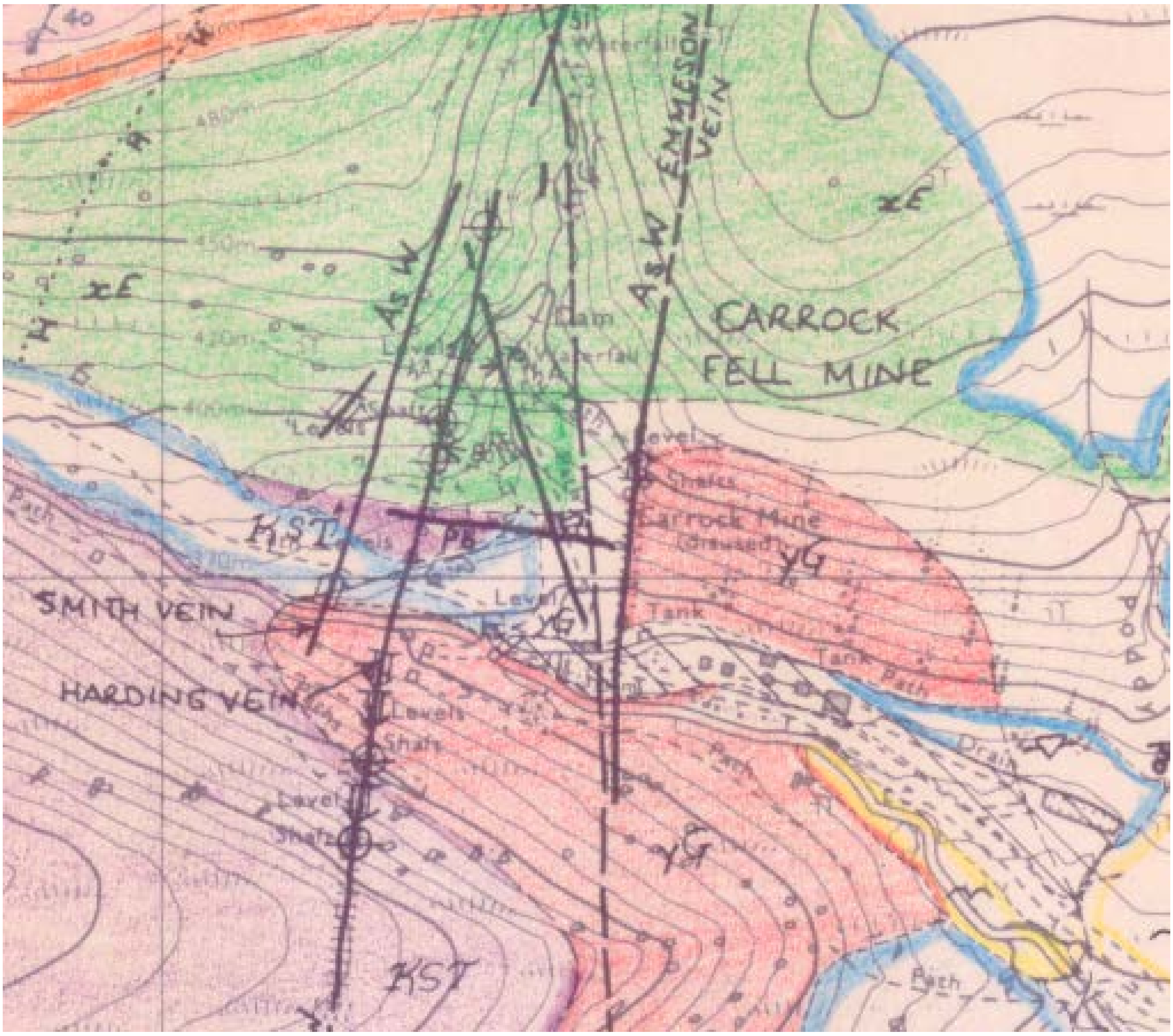

Figure 2: Extract from BGS 1:10,000 scale geological standard of the Carrock Mine area (re-mapped in 1990) showing similar area to Figure 1. (Purple KST = Kirk Stile Formation (Skiddaw Group) mainly hornfelsed; Green xE = Gabbro and Hornfelsed contact gabbro (Mosedale Division); Red yG = greisenised granite (Skiddaw Intrusion); areas outlined in blue = till and areas outlined in yellow = alluvium).

It is beyond the scope of this report to describe the local geology in detail. For a summary see Appleton and Wadge (1976) and Figure 2. The tungsten mineralisation is hosted in a series of strong north-south quartz veins. The mineralisation is associated with a greisenised intrusion, which is part of the Skiddaw Granite (ca 380 ma). In the locality of the mine this granite was intruded into Ordovician Skiddaw Slates which had been previously contact metamorphosed to hornfels by the Carrock Fell Complex gabbro intrusion (ca 470 ma). The veins worked in the mine are hosted by the granite in the south, gabbro to the north and a narrow zone of hornfelsed Skiddaw Slate in between. The tungsten bearing veins are cut by a suite of later, narrow 'lead' veins, not exploited by the mine. These lead veins were exploited in the 19th century, and perhaps earlier as a separate venture (Tyler; 2003).

The underground geology of the workings, up until about 1977 (4 years prior to closure), was published by Moore (1977) and the work reported here focuses on the mine workings that postdate his paper. Field work and limited laboratory analysis was supported by the Lake District National Park Authority and Natural England.

An MSc project, examining water chemistry and tungsten vein mineralisation, was undertaken by a Loughborough University chemistry student in 2013 using water samples and some of the mineral samples collected at the time of the underground survey (Tarip; 2013).

2 History of Working

The mining of Carrock Fell has been reported elsewhere (e.g. Eastwood; 1959, Shaw; 1975, Moore; 1977, Cooper; 1990 and Tyler; 2003) and the summary here is based on these sources and mine reports dating to the final phase of mining held by Cumbria Amenities Trust Mining History Society (CATMHS).

Prior to tungsten mining small amounts of lead were mined in the 19th century and earlier from the east-west trending Brandy Gill lead vein.

The veins at Carrock are not particularly rich and have only been economic to work when the price of tungsten is high, particularly in times of war or heightened military tension.

Between 1870 and 1880 small amounts of tungsten were worked from the mine by small-scale mining methods and hand sorting but no records of production remain. Two of the veins (Emerson and Harding – see below) were worked intermittently between 1901 and 1919 within the greisen in the southern part of the mine, largely to the south of Grainsgill Beck. Between 1913 and 1919 about 14,000 tons of ore were mined, of which about 10,000 tons were processed which produced approximately 75 tons of tungsten. This represents a grade of about 0.75% WO_3. During the Second World War, between 1942 and 1943, the mine was developed, particularly by the driving of what is now known as the No 1 Level, using Canadian Military Engineers on behalf of the Ministry of Supply by Non-Ferrous Minerals Development Ltd. No production resulted because when development and ore reserve assessment were completed tungsten availability had improved and there were higher priorities for the labour resources required to work the mine.

Initiated by World Wide Energy (UK) Ltd in 1971 the final phase of working, including construction of an ore processing mill, commenced at Carrock but was put on care and maintenance the following year following a drop in metal price. The mine was taken over by Carrock Fell Mining Co (a subsidiary of Amalgamated Industries Ltd) in 1976 who worked the mine until 1981 when again the mine was put on care and maintenance. In 1982 Minworth, a Peak District based mining company, acquired the mine but did not re-start production and dismantled the mill and stripped the mine of useful equipment in 1985 prior to site ‘restoration’ in 1988. This last phase of mining worked the Emerson, Waterfall, Harding and Smith Veins to the north of the mine, largely within the gabbro. Mill tailings were deposited into dammed World War One vintage workings on the Harding Vein.

3 Geological Summary

3.1 PREVIOUS WORK

The tungsten veins at the mine are associated with a cupola of the Skiddaw Granite. The granite here was emplaced into folded Skiddaw Slates, comprising mudstones and greywackes of Ordovician age. These rocks had already been intruded by the gabbro and granophyre of the Carrock Fell Complex, intrusion of which caused extensive contact metamorphism of the slates to hornfels (Cooper et al; 2004).

Shepherd et al (1976) suggest that the tungsten mineralisation is associated with late stage cooling of the granite. Fluid inclusion studies of the mineralisation suggests that the tungsten mineralisation was deposited at temperatures between about 350^0C and 170^0 while the later 'lead' veins were deposited at temperatures of less than 150^0C (Ball et al; 1985).

3.2 NEW UNDERGROUND GEOLOGICAL MAPPING

Because the majority of the workings have previously been geologically mapped (Moore; 1977) the aim of the work reported here was to map those parts of the mine that were developed at a late stage in the working of the deposit which have not previously been geologically mapped. Only the last phase of workings was examined in detail. These were the workings on Smith's Vein North, Smith's Vein South and Smith's Vein East. As noted above the host rocks consist of Skiddaw Granite, which is usually intensely greisenised adjacent to the tungsten veins, emplaced into Skiddaw Slate which had previously been contact metamorphosed to hornfels by the intrusion of the Carrock Fell Complex Gabbro. This mapping completed the basic geological mapping of the accessible mine workings and is presented in Figure 3 which also includes the previous work by Moore (1977).

Where seen in the workings, the contact between the granite and the hornfels is intrusive with an irregular surface and frequent xenotiths of hornfels occur within the granite close to the contact. In places slickensides are present at the contact, suggesting post-emplacement minor faulting.

3.2.1 Tungsten Veins

The tungsten bearing veins in the mine are near vertical (with hades varying between about 75^0 east and 75^0 west), have an approximate north-south strike and are hosted by all three of the country rocks noted above. When hosted in the granite the veins are well defined, but narrow (up to ca 30cm wide), structures comprising predominantly quartz sometimes carrying quantities of wolframite and muscovite mica. The granite wall rocks are intensively greissenised.

When hosted in the hornfelsed slate the veins tend to reduce rapidly in size away from the granite and become somewhat less well defined and of variable width while the lack of stoping suggests that they have low tungsten values comprising mainly of vein quartz with minor wolframite and arsenopyrite**.**

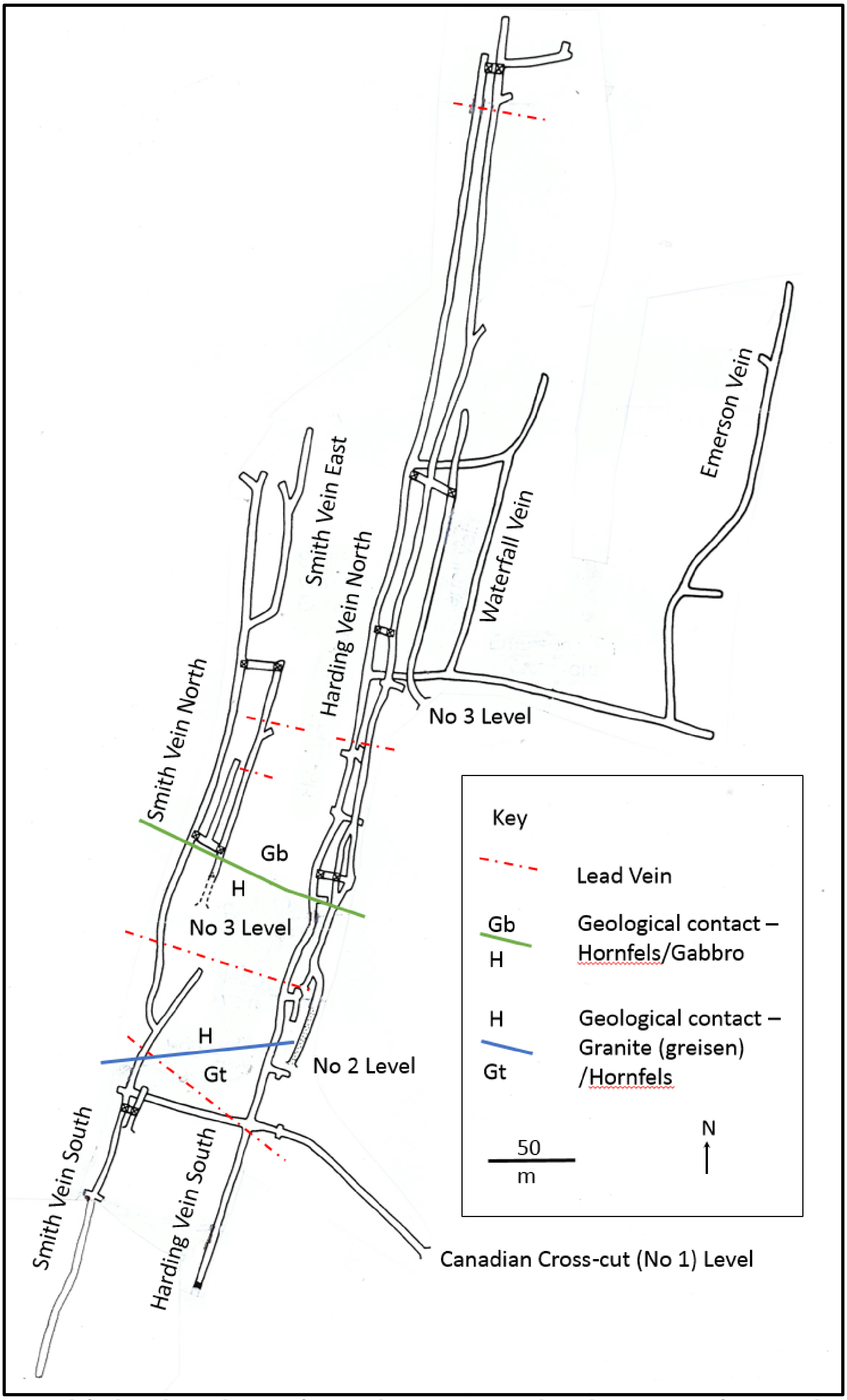

Figure 3: Simplified geological map of Carrock Mine (Survey based on a copy of a Carrock Fell Mining Company plan dated 1982 held by CATMHS; geology based on Moore; 1977 and new field work by the author).

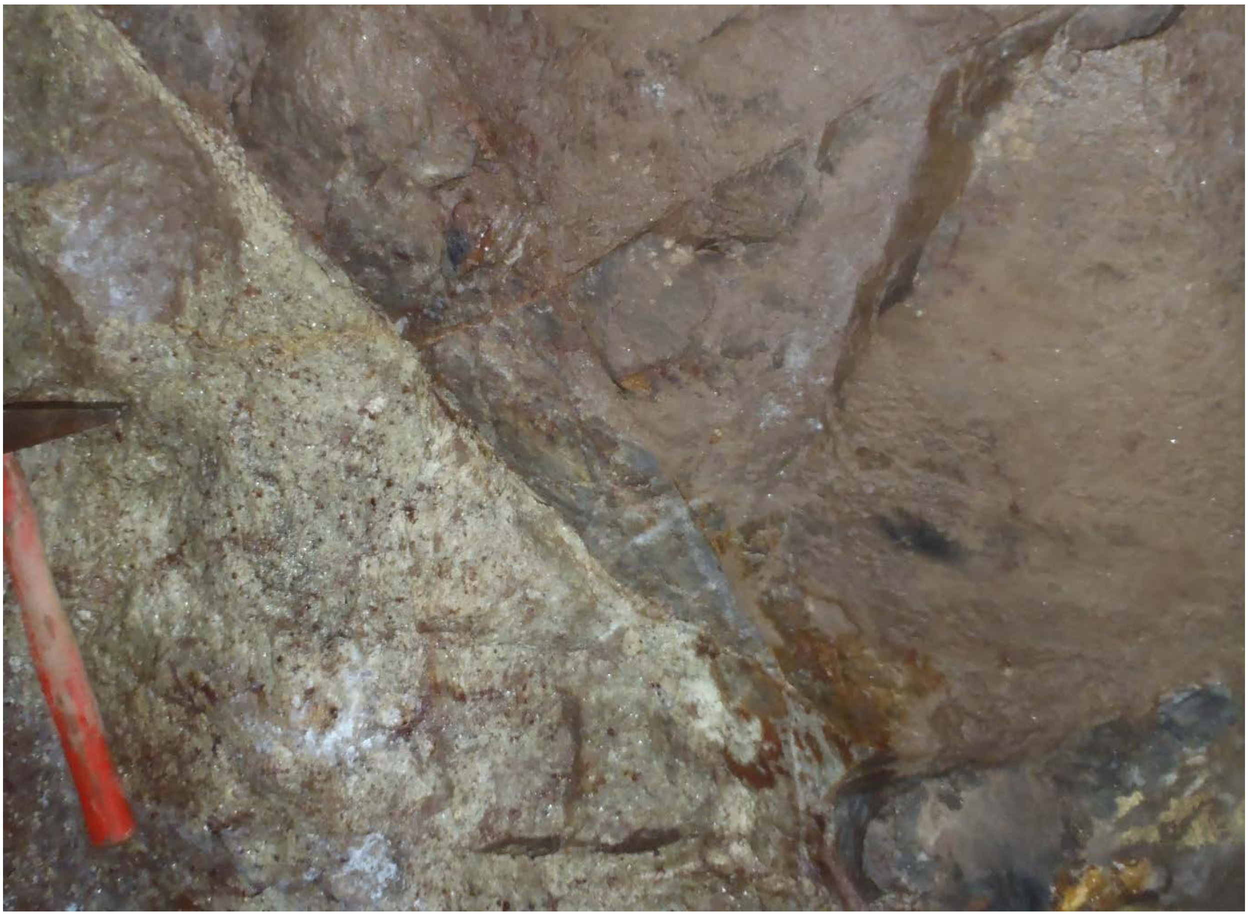

Figure 4: Contact of greisenised granite and hornfelsed Skiddaw Slate, Harding Vein North workings.

In the gabbro the veins are less well defined, largely consisting of zones, up to ca 3m wide, of extensive quartz veining (Figure 5, Figure 6 and Figure 7) that includes individual quartz veins (up to 30 cm wide) in an en-echelon arrangement, as one structure fades an adjacent one expands. Varying quantities of quartz, calcite (Figure 9), wolframite (Figure 8) and scheelite (Figure 9) occur with minor fluorite, arsenopyrite, pyrite, pyrrhotite, sphalerite, apatite, dolomite, ankerite, galena, molybdenite, bismuth, bismuthite, columbite, cuprodamite, malachite, chalcopyrite, wurtzite, chrysocolla and gypsum. The gypsum is the product of the weathering of the sulphide minerals and the reaction of the resulting sulphuric acid with the carbonate minerals present in the veins. The distribution of stoping shows that ore grade tungsten mineralisation is variable with zones of higher grade, workable ore interspersed with barren stretches of the vein structures. The veins are complex structures of multiple, quartz dominated, veins with cross cutting relationships demonstrating multiple phases of mineralisation. The larger veins in these structures usually being a late or the last phase of the tungsten mineralisation. All these veins have visible scheelite and wolframite. Large vugs, mainly lined with quartz crystals, are frequent in the larger vein structures. The carbonate mineralisation in the tungsten vein structures appears to be a late phase of this episode of mineralisation and is much more abundant in and close to the gabbro than elsewhere in the mine workings, suggesting that the gabbro was a likely source of the calcium.

Figure 5: Harding Vein in forefield, Harding Vein North workings.

Figure 6: One of the branches of Smith Vein, forefield.

Figure 7: Smith No 3 level wolfram vein.

Figure 8: Wolframite (bladed black crystals) in Harding Vein North.

Figure 9: Smith Vein showing scheelite (brown) and calcite (pink).

3.2.2 Lead Veins

The tungsten bearing veins are cut by a number of later so called lead veins (Figure 10, Figure 11, Figure 12, Figure 13 and Figure 14). They were referred to by the miners as lead veins because they are genetically related to the veins further north in the Caldbeck Fells that have been extensively worked for lead ores (Cooper and Stanley; 1990). These trend approximately east-west and comprise multiphase crustiform banded mineralisation consisting of varying proportions of baryte and calcite with minor galena, sphalerite and other sulphides. The veins are near vertical, up to 1.5 m wide and can be traced between tungsten veins and between levels in the mine. The amount of lead in these veins was clearly not considered worth working and the veins have not been exploited anywhere in the mine workings. The veins show evidence of multiple phases of mineralisation and several phases of brecciation. The breccia show in Figure 12 is suggestive of collapse of broken wall rock into a fracture cavity prior to or at an early stage of mineralisation.

Figure 10: Lead vein, east wall of Harding Vein North workings.

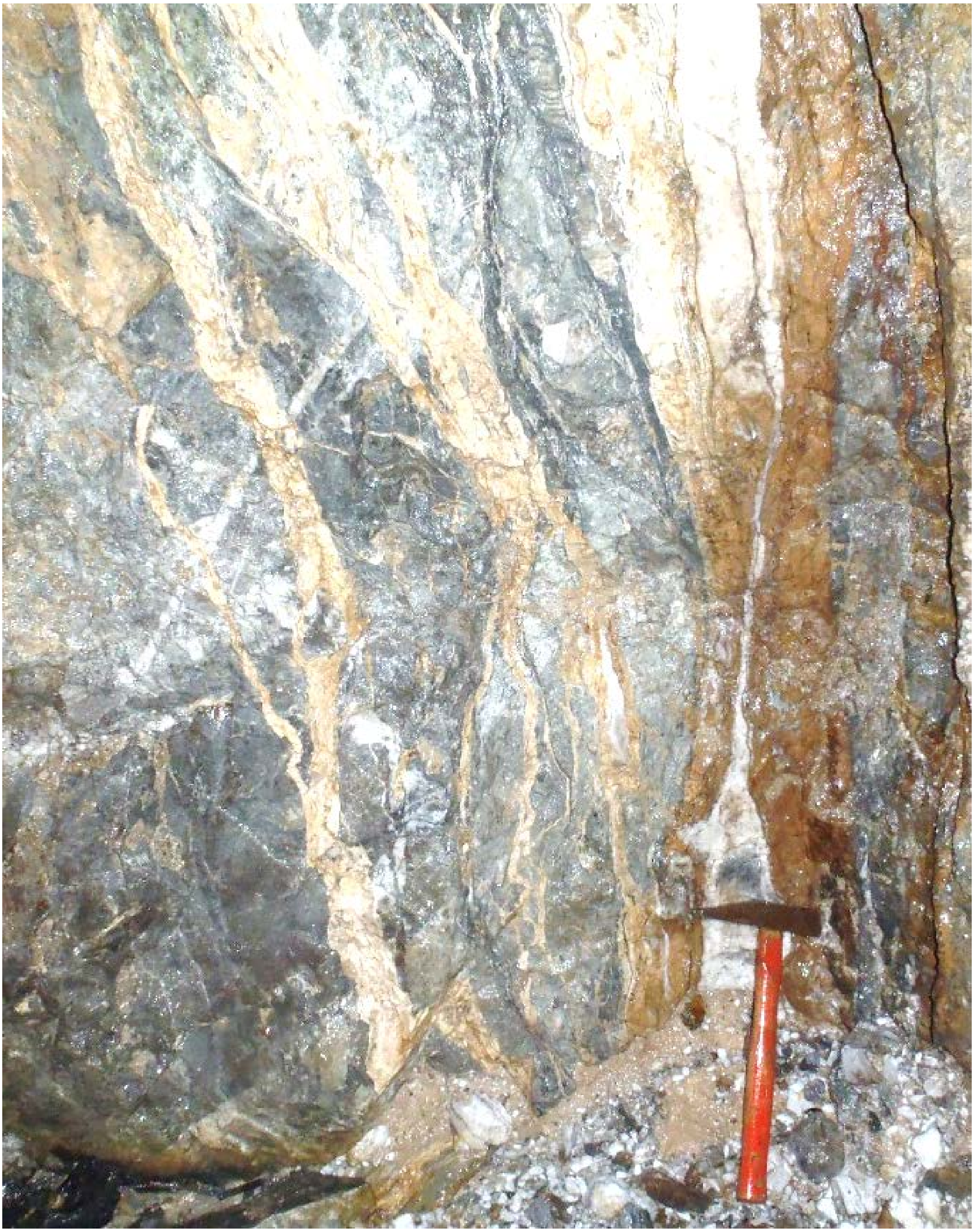

Figure 11: Lead vein, west wall of Harding Vein North workings. Note multiple veins with blocks of wall rocks between.

Figure 12: Smith No 3 level 2nd lead vein.

Figure 13: Smith No 3 level 2nd lead vein.

Figure 14: Lead vein cutting Harding Vein in roof of Harding Vein North workings.

4 Sampling

The mine is situated in an SSSI and approval for sampling was sought from Natural England. Sampling was restricted to collection of representative loose material. Several suites of samples were collected comprising:

- A limited number of representative host rock samples;
- Tungsten vein samples;
- Lead vein samples;
- Tailings samples; and
- Water samples (x10).

The tailings and water samples were collected at both underground and surface locations and the vein and wall rock samples from loose material, considered to be close to its' source, from underground locations only. Details of all samples collected are summarised in Appendix 1.

4.1 ROCK SAMPLES

The wall rock samples collected during fieldwork have not yet been studied in detail. They have principally been used to confirm observations/identification of host rocks made during the underground mapping. They are held at the British Geological Survey and are available for future study.

4.2 VEIN SAMPLES

Two sets of vein samples were collected, one representative of the tungsten mineralisation and the other of the ‘lead’ veins. The tungsten vein samples, mainly from the Smith Vein structures, were examined in detail by Tarip (2013) as part of her chemistry MSc dissertation project. This dissertation contains detailed information on the minerals present and their habit based on SEM/BSEM examination of sub-samples.

4.3 WATER SAMPLES

Ten water samples were collected, six from underground locations and four from surface stream courses. The latter were collected from the Grainsgill and Brandy Gill Becks above, below and close to the mine site. The underground samples were collected before any other disturbance of the water to be representative of the main inflows into the mine including that through the tailings stowed into the worked out stopes of the Harding Vein South. Sample locations are shown on Figure 15. The samples were analysed by Tarip (2013) as a part of her MSc project and the results are summarised in Table 1.

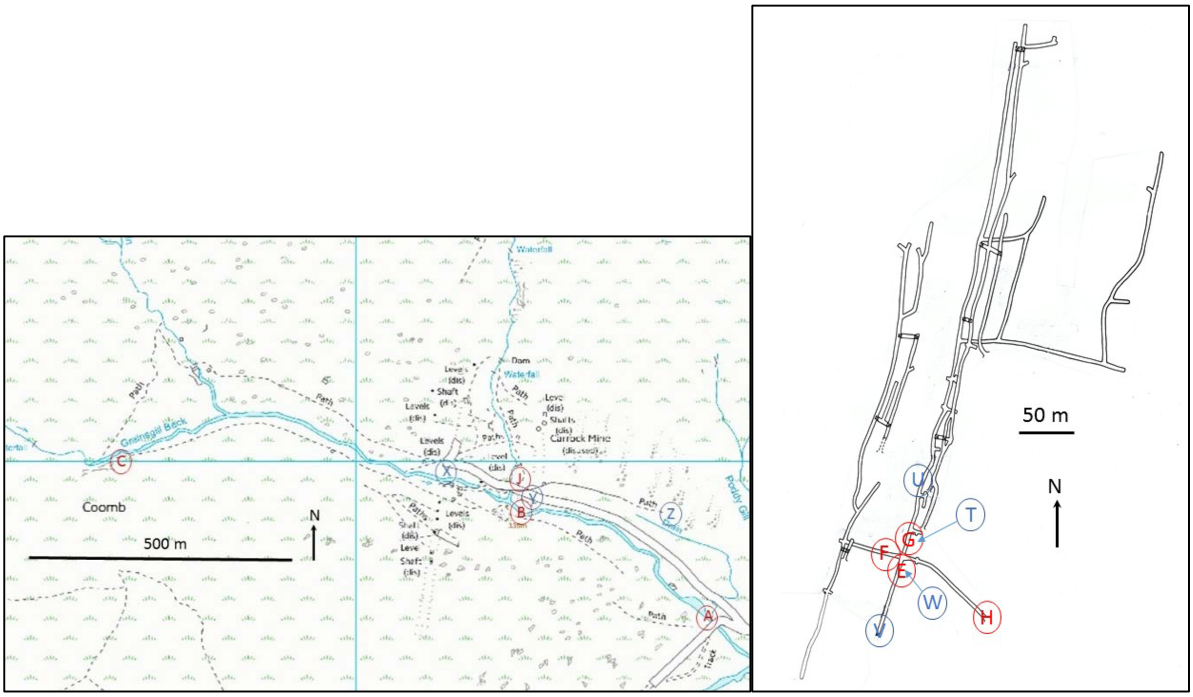

Figure 15: Plans of the surface (left) and mine workings (right) showing the approximate locations of water and tailings samples collected in May 2013. Red circles and sample letters are water samples and blue circles and letters are tailings samples. OS base map Ordnance Survey Licence No. 100021290 EUL. Mine plan based on Figure 23 in Cooper and Stanley (1990) with additions surveyed in May 2013 by Warren Allison and the author.

The analytical data show that the levels of arsenic in all of the water samples, including sample C collected from Grainsgill Beck upstream from the mine, site exceed WHO safety limits (10 µg l^{-1}) (WHO; 2011) significantly (up to 2339.13 µg kg^{-1}). No other elements exceed the WHO limits.

Method	Determinand	Site / Units	Surface stream waters A	B	C	J	Mine waters D	E	F	G	H	I	LoD
Field parameters	T	^{0}C	6.20	5.76	6.14	5.60	6.40	5.10	5.10	6.50	6.10	7.69	-
	pH		7.15	7.16	7.39	7.35	7.6	7.06	7.55	7.69	8.07	7.27	-
	EC	$\mu S\ cm^{-1}$	62.30	60.30	105.69	57.80	120.10	101.10	156.50	152.00	145.70	159.30	-
	TDS	$\mu g\ l^{-1}$	31.20	30.10	52.78	28.90	59.60	50.60	78.10	76.10	72.70	79.60	-
IC	F^-	$\mu g\ kg^{-1}$	<LoD	<LoD	0.06	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	0.45
	Cl^-	$\mu g\ kg^{-1}$	5.69	8.20	5.87	5.93	5.55	5.63	5.52	5.53	4.99	5.87	0.95
	NO_3^-	$\mu g\ kg^{-1}$	<LoD	2.47	0.70	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	1.79
	SO_4^-	$\mu g\ kg^{-1}$	5.17	2.99	10.19	3.92	11.98	22.12	22.36	10.39	9.43	10.28	2.44
ICP-OES	Ca	$\mu g\ kg^{-1}$	4.77	4.24	11.49	3.57	16.56	11.92	18.57	17.53	17.89	17.80	0.12
	Fe	$\mu g\ kg^{-1}$	0.31	0.33	0.78	0.28	0.66	4.10	0.41	0.38	0.38	0.64	0.21
	K	$\mu g\ kg^{-1}$	27.12	27.07	27.12	27.20	27.15	27.15	26.89	27.05	26.97	27.41	0.49
	Li	$\mu g\ kg^{-1}$	1.33	1.33	1.32	1.32	1.32	1.31	1.31	1.31	1.32	1.30	0.15
	Mg	$\mu g\ kg^{-1}$	1.87	1.73	3.19	1.47	4.51	2.49	3.73	4.94	4.23	5.60	0.14
	Na	$\mu g\ kg^{-1}$	260.27	259.37	257.05	254.88	257.97	255.73	256.01	256.18	254.62	256.98	4.86
UV-Vis	Fe^{2+}	$\mu g\ kg^{-1}$	0.60	0.61	0.80	0.59	2.37	0.59	0.61	0.60	0.63	0.75	0.09

ICP-MS	Ag	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	4.56
	As	µg kg^{-1}	309.54	316.71	21.41	409.31	1862.25	2252.27	1598.54	1963.98	1556.90	2339.13	5.93
	Ba	µg kg^{-1}	48.71	41.80	58.09	19.14	38.27	97.71	74.01	34.76	31.57	40.21	6.17
	Bi	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	6.99
	Cd	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	5.56
	Co	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	3.79
	Cr	µg kg^{-1}	5.69	5.41	5.02	5.14	4.74	5.07	4.76	5.41	5.42	4.31	4.11
	Cu	µg kg^{-1}	8.03	5.99	4.22	12.47	6.07	5.99	11.27	7.50	9.77	6.51	3.73
	Hg	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	4.16
	Mo	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	8.34	<LoD	23.26	8.52	<LoD	8.76	4.23
	Ni	µg kg^{-1}	7.10	8.66	5.44	5.04	9.56	15.61	11.32	10.00	9.06	12.18	4.58
	Pb	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	6.31
	Sb	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	6.29	<LoD	<LoD	<LoD	5.06
	Se	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	12.44
	Sn	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	4.43
	Sr	µg kg^{-1}	83.34	73.16	57.46	76.29	151.50	69.33	159.45	165.37	174.05	163.33	5.02
	Th	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	1.50
	Ti	µg kg^{-1}	<LoD	<LoD	<LoD	4.68	3.99	<LoD	4.60	5.85	7.37	7.42	3.80
	U	µg kg^{-1}	<LoD	<LoD	<LoD	<LoD	<LoD	<LoD	3.36	<LoD	<LoD	<LoD	2.78
	W	µg kg^{-1}	8.12	7.31	<LoD	18.43	29.68	78.34	103.28	28.56	69.84	47.15	3.92
	Zn	µg kg^{-1}	56.15	49.39	23.64	57.22	275.93	309.52	153.52	276.59	298.35	288.97	13.26

Table 1: Physical parameters, anionic, cationic and trace element concentrations in surface water and mine drainage samples. See Figure 15 for sample locations. LoD = limit of detection (from Tarip; 2013).

4.4 TAILINGS SAMPLES

There are several surface dumps of tailings arising from the dressing of tungsten during the different phases of mine operation at the site resulting from the extraction of tungsten minerals from the mined ores. These include early stopes that were backfilled during the last phase of mining for disctete disposal within the national park. A suite of seven tailings samples were collected, three of these were from surface tips and the remainder from the floor of the Harding Vein workings where they have accumulated as a result of water flows through the stowed waste in the old stopes on this vein. These samples have not been analysed and are held at the British Geological Survey where they are available for future study.

5 Survey

The geological mapping was based on existing mine plans, however these did not include part of the Smith Vein South workings. These workings were surveyed using a 30m Fibron tape and Suunto compass and clinometers read to 0.5^0. The resulting plan of the surveyed level (Smith Vein South) has been added to the mine plan used in this report.

6 M.Sc. Project Dissertation

As noted above Nursyahidah H H Tarip undertook the determination of the chemistry of the water samples and a study of tungsten mineralisation samples as part of her chemistry master's degree at Loughborough University and prepared a project report on the results of these studies (Tarip; 2013). Other samples collected during the field work undertaken in May 2013 remain available for detailed study (host rocks, lead vein samples and tailings samples). The results of this study have been summarised in the relevant sections above.

7 Summary

The underground geological mapping undertaken in Carrock Mine have confirmed the results of previous work published by Moore (1977) and extended the coverage into the levels that were driven after this work was published. The analysis of the samples collected during this study has highlighted that all the waters sampled have arsenic levels above WHO guideline values.

Samples of host rocks, the later lead veins and the tailings collected during the field work are stored at the British Geological Survey and remain available for detailed study.

8 Acknowledgements

The Lake District National Park Authority and Natural England are thanked for providing support for the field work and limited laboratory study. Warren Allison of Cumbria Amenity Trust Mining History Society is thanked for his support during the underground field work at Carrock Mine. Nursyahidah H H Tarip undertook the water analysis and the SEM study of the tungsten vein minerals for her dissertation as part of her M.Sc. in Chemistry at Loughborough University with the support of Lorraine Field and Jeremy Rushton of the British Geological Survey, all of whom are thanked for their contribution to this report.

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Appendix 1: Carrock Mine samples collected May 2013

WATER SAMPLES

pH meter calibration

Air temperature 10.00^{0}C
Buffer pH = 6.95

A – Grainsgill Beck downstream of mine levels and tips just upstream of road bridge:
Temperature = 6.2^{0}C
pH = 7.15

B - Grainsgill Beck just below mine levels and tip:
Temperature = 5.7^{0}C
pH = 7.16

C - Grainsgill Beck upstream of all workings adjacent to old mine water pipe intake:
Temperature = 6.9^{0}C
pH = 7.03

J – Brandy Gill – at bottom just upstream of mine road bridge:
Temperature = 5.6^{0}C
pH = 7.27

All underground water samples were collected before water was otherwise disturbed.

D – No 1 level entrance by gate:
Temperature = 6.4^{0}C
pH = 7.60

E – Harding Vein South (level here ‘smells’ (chemicals in tailings? 30 years after emplacement in old stopes):
Temperature = 5.1^{0}C
pH = 7.06

F – Cross cut to Smith Vein:
Temperature = 5.1^{0}C
pH = 7.55

G – Harding Vein North:
Temperature = 6.5^{0}C
pH = 7.69

Note that dipiridol largely leaked prior to sampling

H – Harding Vein North – beyond Emmerson Vein junction (water deep with slow velocity):
Temperature = 6.1^{0}C
pH = 8.07

I – Emmerson Vein Junction:
Temperature = 7.69^{0}C
pH = 7.27

TAILINGS MATERIAL SAMPLES

Z – “Brown” tailings from 1970s/80s mill tip on north bank of gill.
Y – “White” 1914/18 vintage tailings on south side of gill.
X – Tailings by mine site of probable 1970s/80s vintage but could be older and may incorporate 19th century lead mine tailings.
W – Harding Vein South from level floor near cross cut level junction.
V - Harding Vein South from level floor adjacent to dam blocking stope which contains tailings disposed of into old stopes in 1970s/80s.
U – Grab sample of ore material from ore chute on Harding Vein North.
T – Ore material from level floor Harding Vein North.

WALL ROCK SAMPLES

Smith Vein workings

1 – Greisenised granite, south forefield.
2 – Granite adjacent to contact.
3 – Hornfels adjacent to granite contact
4 – Hornfels 5 m into ‘new’ crosscut.
5 – Hornfels near 1st lead vein.
6 - ?Hornfels at gabbro contact.
7 – Gabbro at gabbro/hornfels contact.
8 – Veins at gabbro/hornfels contact.
9 – Gabbro at 1st blind rise.
10 – Gabbro at 2nd blind rise.
11 – Gabbro Smith Vein North approaching Smith Vein East.
12 – Loose core sample in same area
13 – Smith Vein North forefield – very sulphide rich.
14 – Smith Vein East forefield - very sulphide rich.
15 – Hornfels – 1m from ‘big’ lead vein.

Harding Vein Workings

16 – Gabbro from forefield.

Waterfall Vein Workings

17 – Altered gabbro.

VEIN MATERIAL SAMPLES

No 1 Level

TUNGSTEN VEINS

Smith Vein

V1 – Near south forefield.
V2 - Near south forefield.
V3 – Blue secondary coating near forefield.
V4 – Wolframite ca 50m into Smith Vein South.
V5 – Smith Vein North forefield – fluorite.
V6 - Smith Vein North forefield – orange fluorescing mineral (calcite?).
V7 - Smith Vein East forefield.

V8 - Smith Vein East forefield - scheelite.

Harding Vein

V9 – Vein north of Emmerson Cross Cut.
V10 – Vein in last boxhole south of Emmerson Cross Cut.

Waterfall Vein

V11 – Forefield north end.
V12 – South of Harding North Cross Cut.

LEAD VEINS

V13 – (2 bags) ‘Large’ lead vein east wall Smith Vein North.
V14 – ‘Small’ lead vein Smith Vein North.
V15 – ‘Small’ lead vein in main cross cut between Smith and Harding Veins.
V16 – ‘Large’ lead vein west wall Harding Vein North.

No 3 Level

TUNGSTEN VEINS

Smith Vein

V17 – Sulphide rich tungsten ore, east wall.
V18 – Sheelite ore, east wall.

LEAD VEINS

V19 – ‘out-bye’ lead vein.