1983/1. Final report on exploratory drilling at the All Nations mine, Moina.

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Abstract

Quartz veins carrying wolframite and trending 105°M and dipping 75°-80°S (the All Nations lode) have been dislocated by a low angle reverse fault trending 080°-090°M and dipping 20°-25°N. A four-hole diamond drilling exploration programme intersected a 0.2-0.5 m thick quartz lode carrying wolframite, molybdenite, bismuth/bismuthinite, and minor cassiterite occurring within Cambrian volcanic rocks which underly Ordovician sediments hosting the All Nations lode. The vein system below the fault strikes 100°M and dips 80°-85°S, and is almost directly beneath, and is probably the depth extension of, the All Nations lode, having been offset 5-15 m to the north. An estimated 40 000-45 000 t of mineralised lode occurs below the reverse fault.

The Cambrian porphyry also contains an east-west trending, vertical(?) stockwork zone, sub-parallel to the wolframite+molybdenite quartz lode, with numerous narrow wolframite+molybdenite+scheelite veins in altered porphyry. Although the grade is low (about 0.04% WO_3+MoS_2) further exploration of this zone at depth is warranted.

INTRODUCTION

A four hole exploratory diamond drilling programme has been completed at the All Nations mine, located near Moina in northern Tasmania (fig. 1). The drilling was undertaken by the Department of Mines under Aid to Mining assistance, at the request of the lessees of Mineral Lease 24M/60 (4.047 ha) and the surrounding Mineral Lease 66M/78 (32.00 ha) (see Collins, 1981*a*).

The All Nations mine [DQ243060] is situated at the head of Narrawa Creek, approximately 2 km east of Moina, and is readily accessible by a vehicle track which leaves the Cradle Mountain Road at a point 1.8 km south of the Cethana Road intersection (figs. 1, 2).

The first three holes (AN1, AN2, and AN3) intersected a thick quartz vein carrying wolframite, molybdenite, and bismuth, and numerous other narrow quartz and quartz-topaz veins also carrying wolframite and molybdenite. A fourth hole (AN4) was initially terminated in the target zone of the quartz lode, but a later extension of this hole also intersected a major quartz vein carrying wolframite and minor molybdenite.

This report synthesises the geological data obtained from the drilling, and the mineralogical and analytical data on vein mineralisation intersected in the drill holes. Results of the early drilling are detailed in previous reports (Collins, 1981*a*, *b*, *c*), and details of the extension to AN4 are appended to this report. An assessment of the mineral resource at the All Nations mine has also been undertaken.

GEOLOGICAL SETTING

The oldest rock in the Moina area is a massive, light to dark green, quartz-phyric and quartz-feldspar-phyric tuff with minor agglomerate, chert, and greywacke of the Bull Creek Formation of Middle-Upper Cambrian

age (fig. 1, Table 1). The Bull Creek Formation is unconformably overlain by up to 30 m of Ordovician Roland Conglomerate. The unconformity is exposed in a road cutting on the old Dolcoath Road (at DQ25280605), though the boundary here is a fault surface dipping 50° to the north.

Table 1. STRATIGRAPHIC SUCCESSION IN THE MOINA AREA (after Jennings, 1963; 1979).

Age	Thickness (m)	Unit	Lithology
Quaternary	?		Alluvial sand and gravel.
Tertiary	0-250	Basalt	Olivine basalt.
	0-20	Greybilly	Quartz conglomerate and grit.
	0-100		Sand, clay and gravel.
Ordovician	0-600	Gordon Limestone	Limestone (including skarn).
	245	Moina Sandstone	Quartzite and sandstone with minor siltstone, grit and conglomerate.
	0-275	Roland Conglomerate	Siliceous conglomerate with minor quartzite and siltstone.
Cambrian	>445	Bull Creek Formation	Quartz-feldspar porphyry, agglomerate, chert, greywacke.

The Roland Conglomerate consists of a terrestrial sequence of pink and white siliceous pebble-boulder conglomerate and interbedded quartz sandstone. In the All Nations area, it crops out along a ridge to the south of the mine (fig. 2). The Roland Conglomerate is conformably overlain by the Moina Sandstone, which consists of a sequence of interbedded quartz sandstone and siltstone with minor siliceous grit and fine pebble conglomerate in excess of 100 m in thickness. Bedding in the Roland Conglomerate and Moina Sandstone dips generally 20°-35° to the north. At Lake Gairdner (fig. 1), the Moina Sandstone is conformably overlain by 180+ m of Gordon Limestone, also of Ordovician age. The Palaeozoic rocks are blanketed by an extensive cover of Tertiary basalt and sediment and Quaternary alluvium (fig. 1).

The Cambrian and Ordovician formations in the All Nations area occur on the southern limb of a broad, open, east-west trending syncline (see Jennings *et al.*, 1959; Jennings, 1979), and have been intruded by a stock-like body of Late Devonian biotite granite (the Dolcoath Granite) which crops out on Dolcoath Hill [DQ259064], 1.5 km east of the All Nations mine. Despite its stock-like appearance at the surface, the Dolcoath Granite plunges gradually westward from Dolcoath Hill to extend beneath Moina (Gee, 1966; McKibben, 1971; Collins, 1975), and therefore probably occurs at a relatively shallow depth beneath the All Nations mine (fig. 1).

Mineralisation in the Moina area is genetically associated with emplacement of the Dolcoath Granite. Numerous quartz-wolframite-cassiterite-molybdenite vein deposits occur within granite and in Cambrian and Ordovician rocks, and skarn occurs in the basal Gordon Limestone at Moina (Jennings, 1965; Collins, 1979).

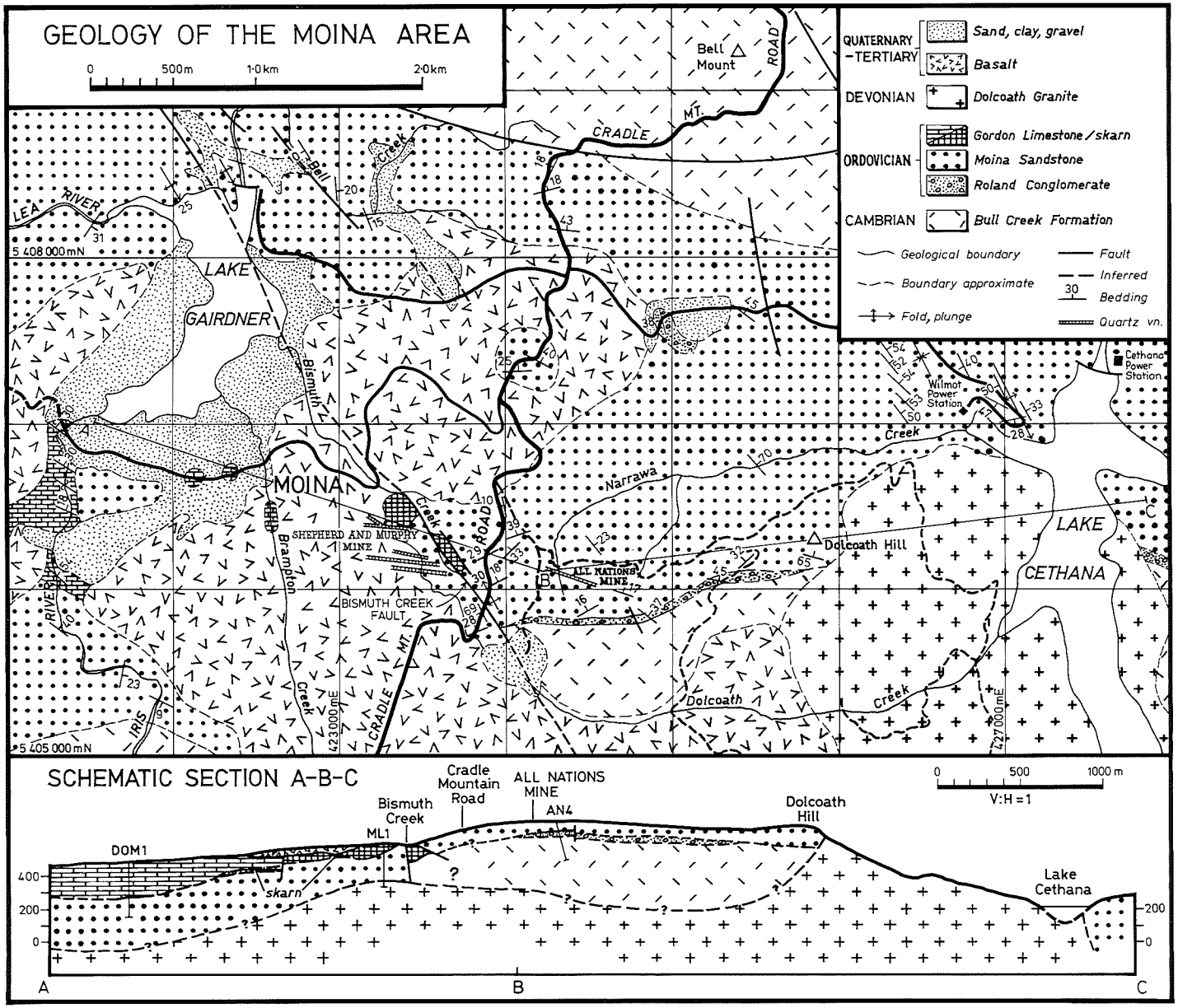

Figure 1.

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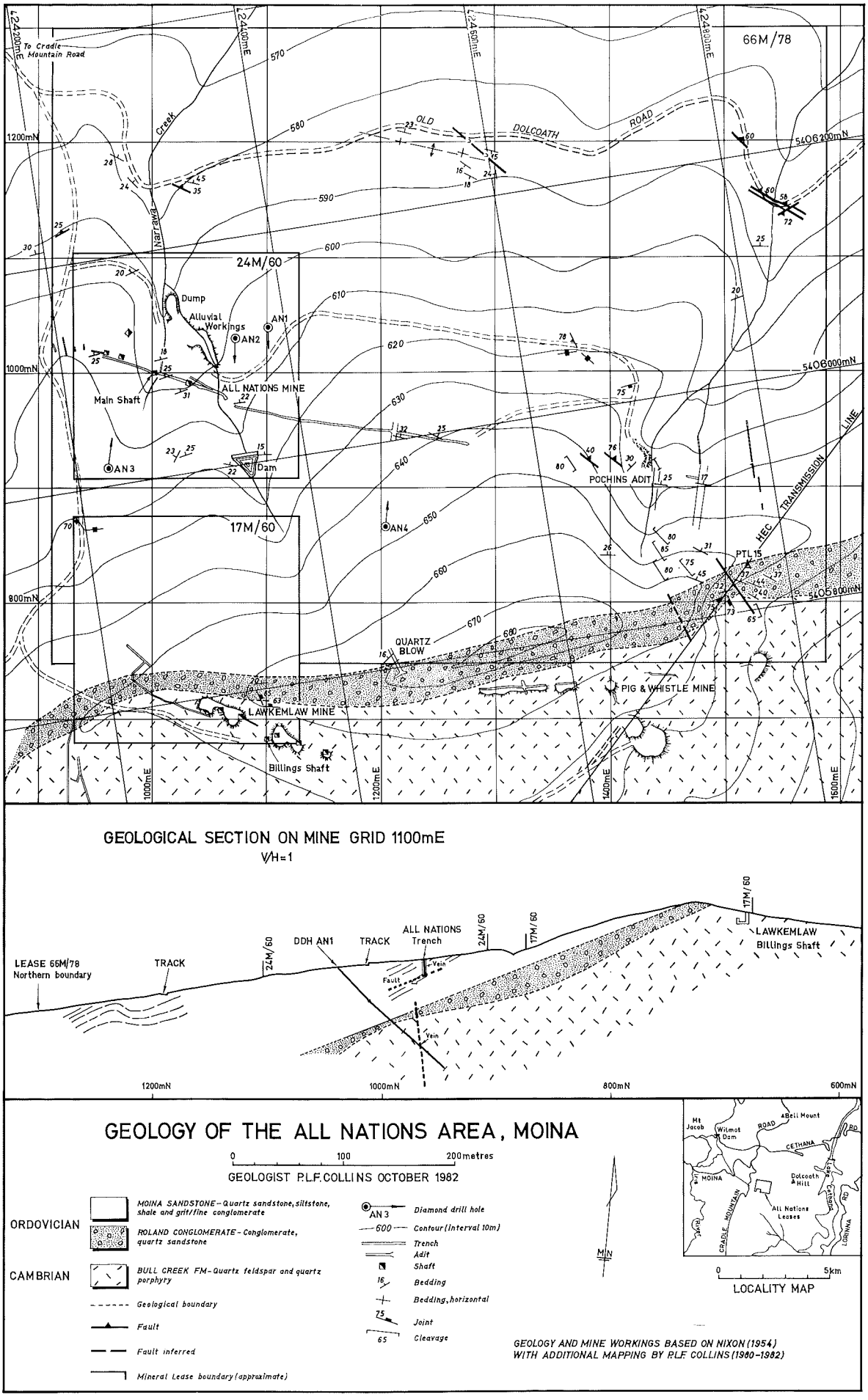
66M/78
24M/60
17M/60
To Cradle Mountain Road
Narrawa Creek
OLD DOLCOATH ROAD
Dump
Alluvial Workings
AN1
AN2
AN3
AN4
ALL NATIONS MINE
Main Shaft
Dam
POCHINS ADIT
TRANSMISSION LINE
HEC
PTL 15
QUARTZ BLOW
PIG & WHISTLE MINE
LAWKEMLAW MINE
Billings Shaft
1200mN
1000mN
800mN
5406200mN
5406000mN
5405800mN
1000mE
1200mE
1400mE
1600mE
GEOLOGICAL SECTION ON MINE GRID 1100mE
V/H=1
LEASE 66M/78
Northern boundary
TRACK
DDH AN1
ALL NATIONS
Trench
Vein
Fault
LAWKEMLAW
Billings Shaft
1200mN
1000mN
800mN
600mN
GEOLOGY OF THE ALL NATIONS AREA, MOINA
0 100 200 metres
GEOLOGIST P.L.F. COLLINS OCTOBER 1982
ORDOVICIAN
MOINA SANDSTONE - Quartz sandstone, siltstone, shale and grit/fine conglomerate
ROLAND CONGLOMERATE - Conglomerate, quartz sandstone
CAMBRIAN
BULL CREEK FM - Quartz feldspar and quartz porphyry
Geological boundary
Fault
Fault inferred
Mineral Lease boundary (approximate)
Diamond drill hole
Contour (interval 10m)
Trench
Adit
Shaft
Bedding
Bedding, horizontal
Joint
Cleavage
GEOLOGY AND MINE WORKINGS BASED ON NIXON (1954) WITH ADDITIONAL MAPPING BY P.L.F. COLLINS (1980-1982)
Mt Jacob
Wilmot Dam
ROAD
Bell Mount
RD
CETHANA
MOINA
Dolcoath Hill
All Nations Leases
CRADLE MOUNTAIN
LORINNA
0 5km
LOCALITY MAP

Figure 2.

ALL NATIONS MINE

Early reports of the All Nations mine were prepared by Twelvetrees (1913), referring to the Lady Barron workings, Reid (1919) and Keid (1943). A detailed investigation of the All Nations mine and the surrounding area was made by Nixon (1954), who also prepared detailed plans of the workings. Development since 1954 is described by Collins (1978), and more recently, Pochins Adit (fig. 2) has been extended in an attempt to trace the narrow veins on which the adit was originally established.

During intermittent production between 1910 and 1942, 28.748 t of tungsten and 0.528 t of bismuth were won from the All Nations mine. In 1978, an additional 2.8 t of wolframite concentrate was produced.

At the All Nations mine, quartz veins with wolframite and minor bismuth, pyrite, and molybdenite occur entirely in Ordovician quartz sandstone and siltstone (Moina Sandstone), strike about 105°M, and dip 75°-80°S (figs. 2, 4). The veins occur in an *en echelon* pattern, stepped off to the south and east, with their extremities overlapping, and at least three parallel veins are recognised with an average thickness of about 200 mm (Nixon, 1954). An indication of the grade of the veins may be gleaned from assay(?) data on a longitudinal section of the mine compiled in 1919 (Department of Mines Drawing Office plan 1949-37), which indicates that the central part of the lode contained very rich patches of ore (up to 52% WO_3(?)) and averaged about 7% WO_3(?).

At a relatively shallow depth the lode has been dislocated by a low angle reverse fault striking about 085°M and dipping 20°-25°N. This thrust fault consists of a brecciated zone with included vein fragments and a series of parallel faults over a thickness in excess of two metres. Slickensides on fault surfaces trend 025°-035°M, and drag on bedding indicates that the hanging wall moved south relative to the footwall (Nixon, 1954). The magnitude of the displacement along the fault surface is not known.

The extension to Pochins adit encountered several narrow (less than 50 mm thick) quartz-wolframite veins dipping steeply south and trending east-west (fig. 3). Projection of the low angle reverse fault at the All Nations mine intersects the ground surface west of Pochins adit, hence the narrow veins here may be the end of a lode system below the fault, but the situation is complicated by several NW to NNW-trending faults (fig. 3).

DRILLING

The diamond drilling programme was undertaken to test below the postulated low angle reverse (or thrust) fault for vein mineralisation in close proximity to the All Nations lode.

The first two diamond drill holes (AN1 and AN2), totalling 278.2 m, intersected a quartz vein (0.5 and 0.3 m thick respectively) almost directly beneath the All Nations lode (Collins, 1981*a*). These holes were drilled in February-May, 1980 from the northern side of the workings and were inclined to the south. Two additional holes (AN3 and AN4) totalling 414.7 m were drilled between August 1980 and April 1981. These holes were collared on the southern side of the workings and inclined to the north. In August, 1982, hole AN4 was extended a further 19.4 m.

Details of drill collar positions and hole orientation are given in Table 2. Down-hole survey data for the initial four holes are given in

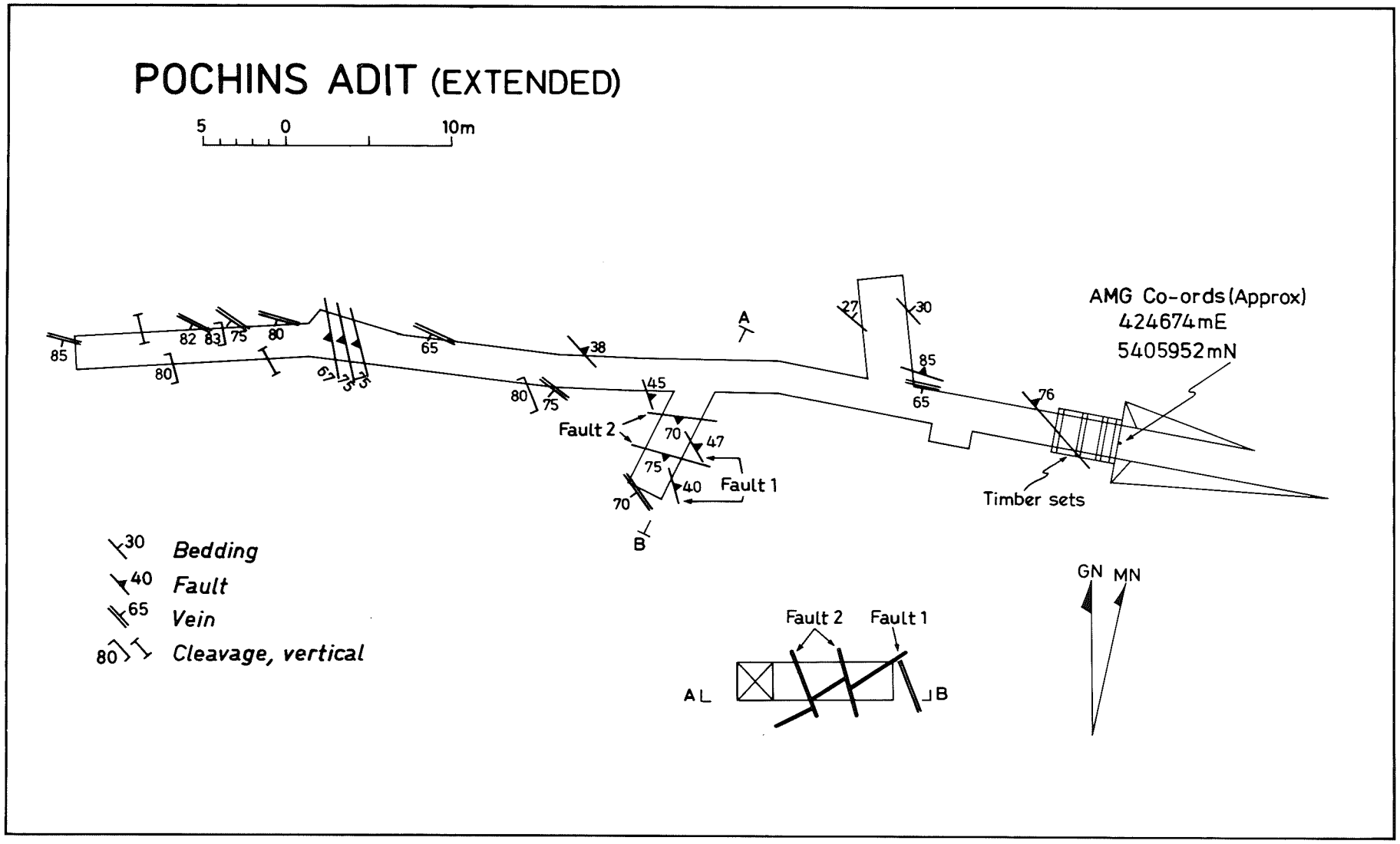

Figure 3. *Extension of Pochins Adit (at April, 1980; see fig. 4).*

Collins (1981*a*, *b*) and in Appendix 1 for the extension to AN4.

Table 2. SURVEY DETAILS OF DIAMOND DRILL HOLES AT THE ALL NATIONS MINE (SURVEYOR: G. BENN, DEPARTMENT OF MINES).

DDH	AMG co-ordinates	Mine Grid co-ordinates*	Orientation		Collar elevation*
			Bearing	Inclination	
AN1	424385.7 mE 5406115.3 mN	1100.92 mE 1039.33 mN	175°M	-45°	605.3 m
AN2	424355.2 mE 5406110.2 mN	1071.59 mE 1029.61 mN	179°M	-40°	600.5 m
AN3	424227.9 mE 5406016.7 mN	960.05 mE 917.85 mN	004°M	-53°	612.9
AN4	424460.7 mE 5405929.6 mN	1203.34 mE 867.24 mN	360°M	-69.5°	647.0

* Local mine grid and elevations are relative to assigned co-ordinates 1000 mE, 1000 mN and assigned level of 597.0 m at the south-west corner of the brace of the main shaft (figs. 2, 4).

A local mine grid has been established over the All Nations leases as a reference for plotting and surveying of the drill holes and for possible future development. The reference point for the grid is the south-west corner of the main shaft, with assigned co-ordinates of 1000.0 mE, 1000.0 mN, and an elevation of 597.0 m (see fig. 2). The grid has been tied into the AMG grid, as shown in Figures 2 and 4.

RESULTS AND DISCUSSION

The results of the drilling have been detailed in previous reports (Collins, 1981*a*, *b*, *c*), including stratigraphic data, types of mineralisation intersected, and analytical data. Results of the extension to AN4 are given in Appendix 1 of this report. Detailed diamond drill core records are available at the Department of Mines.

A synthesis of the data obtained from the drilling programme and its interpretation is presented below.

Geological data

The interpreted geology is illustrated in Figures 2 and 4 and in the sections in Figures 5 to 9. The position of the conglomerate intersections and the bedding to core axis angles are consistent with the 20°-35° northerly dip of the Ordovician sediments in the All Nations area. Possible bedding in the Cambrian volcanic rocks is rare, but thin carbonate(?) horizons (altered to skarn) indicate a steeply dipping sequence.

The thickness of the Roland Conglomerate varies considerably from hole to hole. In holes AN1 and AN2 it is 3-4 m thick, in AN3 it is 12-13 m thick, and in AN4 it is about 30 m thick (figs. 6-9). Contouring of the upper and lower surfaces of the Roland Conglomerate indicate that it is wedging out to the north and west (fig. 4), but the variation in thickness may also be a reflection of irregularities in the depositional surfaces.

ALL NATIONS MINE—MOINA

0 50 100 metres

0 100 200 feet

Contour interval: 5 metres

GEOLOGIST: P.L.F. COLLINS, NOV., 1982

LEASE 24M/60 (boundary approx)

LEASE 66M/78

LEASE 17M/60 (boundary approx.)

1100m N
5406200 mN

1000m N
5406100mN

900mN
5406000mN

900mE

1000mE

1100mE

1200mE

1300mE

1400mE

424300mE

424400mE

424500mE

424600mE

ALL NATIONS MINE

Main Shaft

DECLINE

OPEN CUT

COSTEAN

ALLUVIAL WORKINGS

DAM

POCHINS ADIT

Trench

QUARTZ BLOW

DDH AN1 605·3

DDH AN2 600·5

DDH AN3 612·9

DDH AN4 647·0

MAG.

ORDOVICIAN

MOINA SANDSTONE (siltstone, quartz sandstone quartzite, grit, fine pebble conglomerate)

ROLAND CONGLOMERATE (coarse pebble conglomerate, minor quartz sandstone)

Geological boundary

Bedding

Joint, vertical joint

Cleavage, vertical cleavage

Fault. Slickenside

Vein

DIAMOND DRILL HOLE DATA:

Collar

Roland Conglomerate

Quartz lode intersection.

Veined and altered porphyritic volcanics.

End of hole.

Levels in metres

ISOLINES:

Moina Sandstone—Roland Conglomerate boundary

Roland Conglomerate—Bull Creek Formation boundary (unconformity)

Quartz lode

NOTE: Contours based on assigned level of 597·0 metres (M.L.) at the brace of the main shaft. Local mine grid basis is south-west corner of main shaft with assigned co-ordinates 1000mE, 1000 mN

FIG. 4

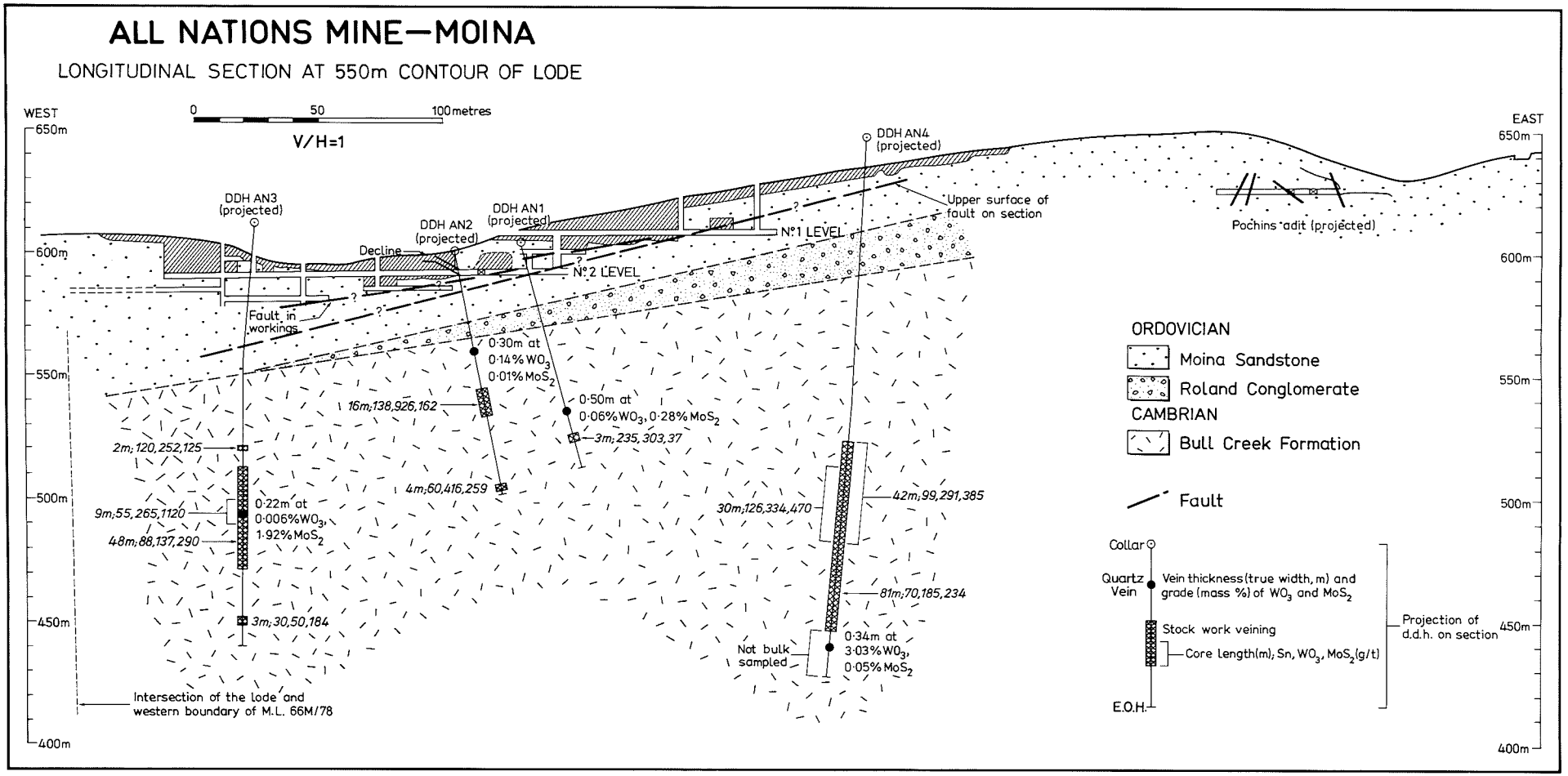
ALL NATIONS MINE—MOINA
LONGITUDINAL SECTION AT 550m CONTOUR OF LODE
WEST
EAST
0
50
100 metres
V/H=1
650m
600m
550m
500m
450m
400m
DDH AN3 (projected)
DDH AN2 (projected)
DDH AN1 (projected)
DDH AN4 (projected)
Upper surface of fault on section
Pochins adit (projected)
Decline
N°1 LEVEL
N°2 LEVEL
Fault in workings
0·30m at 0·14% WO3 0·01% MoS2
16m;138,926,162
0·50m at 0·06% WO3, 0·28% MoS2
3m;235,303,37
2m;120,252,125
4m;60,416,259
0·22m at 0·006% WO3, 1·92% MoS2
9m;55,265,1120
48m;88,137,290
3m;30,50,184
30m;126,334,470
42m;99,291,385
81m;70,185,234
0·34m at 3·03% WO3, 0·05% MoS2
Not bulk sampled
Intersection of the lode and western boundary of M.L. 66M/78
ORDOVICIAN
Moina Sandstone
Roland Conglomerate
CAMBRIAN
Bull Creek Formation
Fault
Collar
Quartz Vein
Vein thickness (true width, m) and grade (mass %) of WO3 and MoS2
Stock work veining
Core Length(m), Sn, WO3, MoS2(g/t)
E.O.H.
Projection of d.d.h. on section

Figure 5.

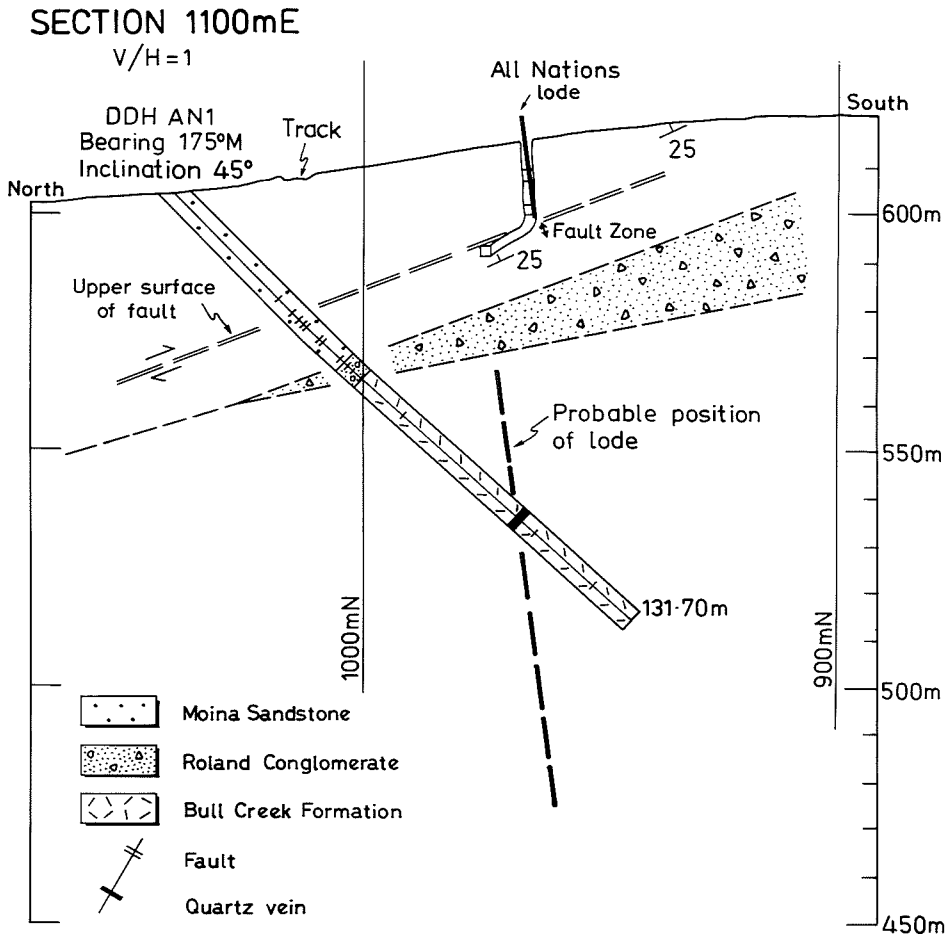

Figure 6. *Section, diamond drill hole AN1, All Nations mine, Moina*

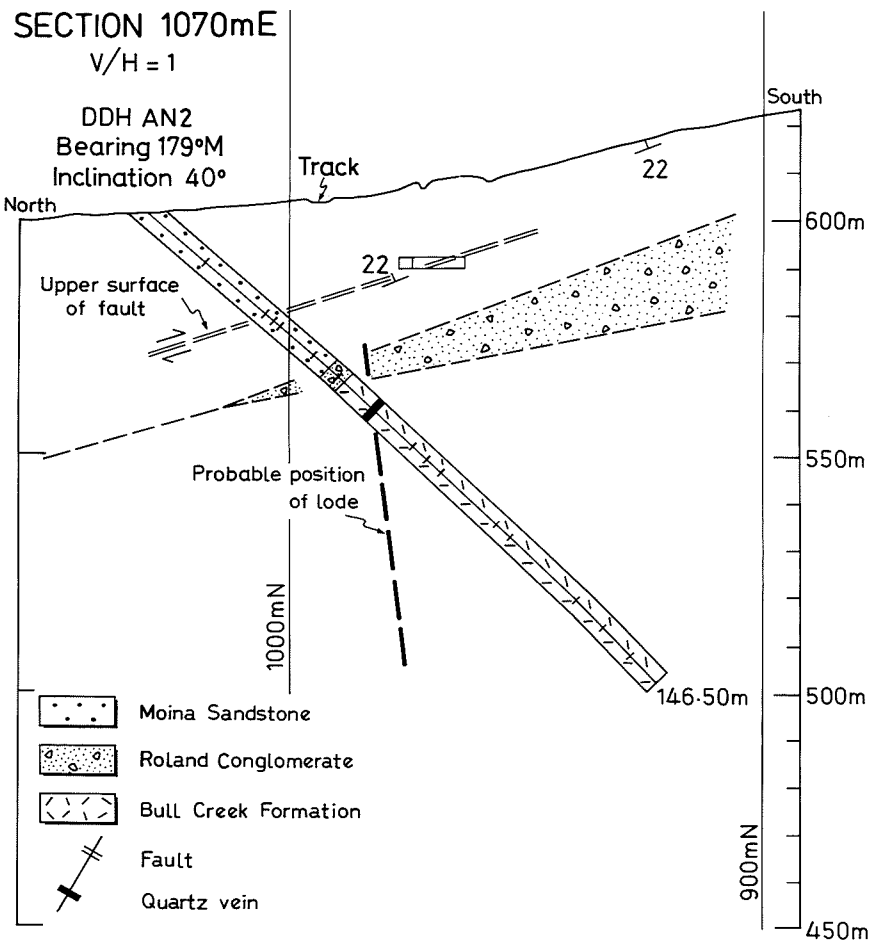

Figure 7. *Section, diamond drill hole AN2, All Nations mine, Moina*

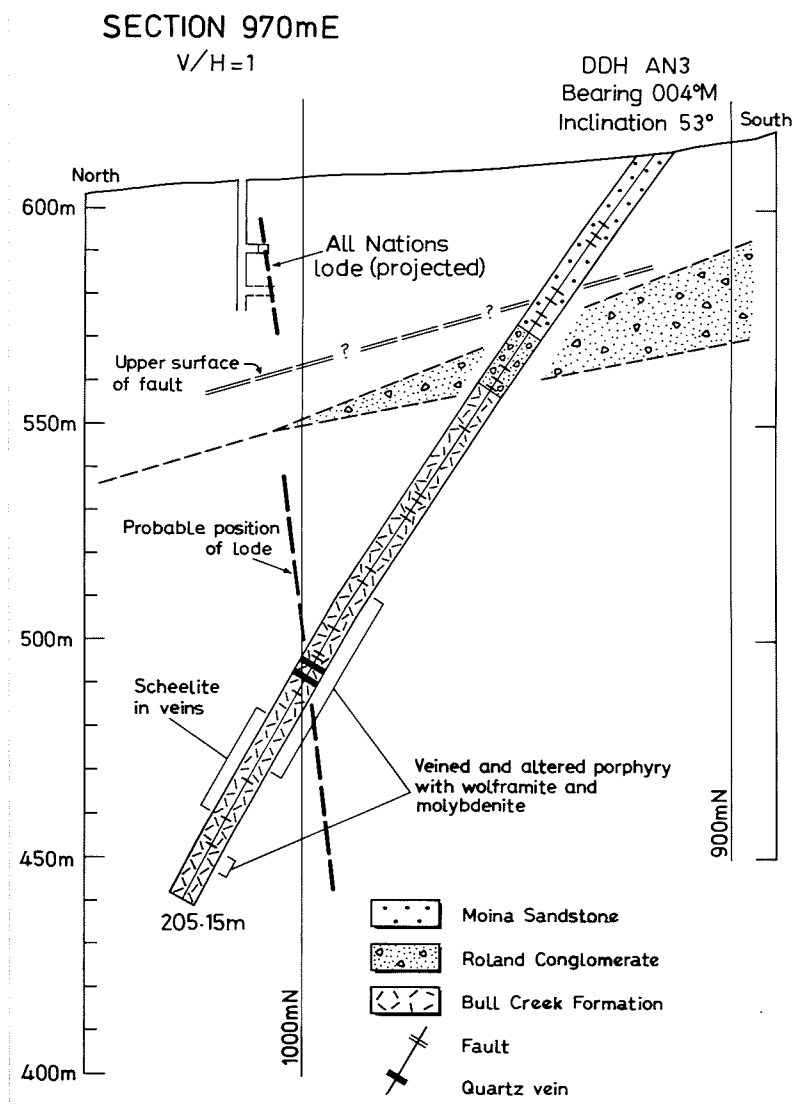

Figure 8. *Section, diamond drill hole AN3, All Nations mine, Moina.*

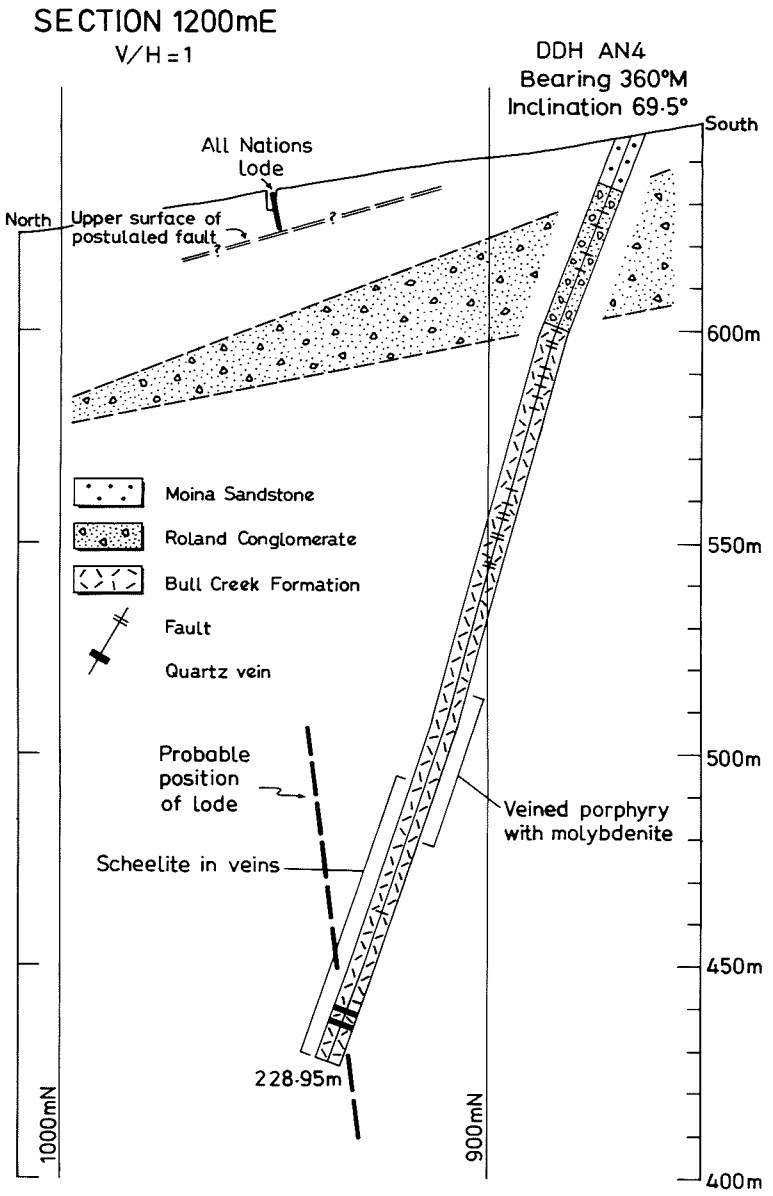

Figure 9. *Section, diamond drill hole AN4, All Nations mine, Moina*

The boundary between the sediments and underlying porphyry is an unconformable erosional surface, with porphyry-derived material in the basal 0.3-0.5 m of conglomerate, though in places the boundary is a fault surface (*e.g.* AN1 and the old Dolcoath Road).

In all holes there are numerous fault intersections which appear to be grouped. In holes AN1, AN2, and AN3, a set of faults occurs within the Moina Sandstone over a zone about 5 m wide, at a level consistent with the position of the postulated reverse fault (figs. 6-8). However, the eastern extension of this fault apparently occurs close to the surface, and thus was not intersected in drill hole AN4 (collared within or below the postulated fault) (fig. 9).

Projection of the stratigraphic boundary contours to the east indicates that the Roland Conglomerate should crop out in the gully east of Pochins adit (figs. 4, 5), but there is no evidence of conglomerate in this area. The absence of conglomerate east of Pochins adit is best explained by a NW-trending fault, with a downthrown block to the east, between hole AN4 and Pochins adit. Several NW-trending faults occur in the Moina area, paralleling the major Bismuth Creek Fault (fig. 1), and there are several NW-trending faults in Pochins adit and a prominent NW-trending cleavage in Moina Sandstone cropping out on the ridge to the south (fig. 4).

Mineralisation

The mineralisation intersected in the drill holes is divided into three types:

(i) major quartz vein intersections;

(ii) quartz-topaz and other veins and associated silica and tourmaline alteration of the porphyry; and

(iii) magnetiferous skarn-type alteration.

Major quartz veins

Each of the drill holes intersected a significantly thick quartz vein carrying wolframite, molybdenite, and bismuth. Details of each intersection are listed in Table 3 and illustrated in Figures 4 to 9.

In drill hole AN1 the vein is composed predominantly of quartz with minor wolframite, molybdenite, and bismuth, and tourmaline as needles in the quartz. Late stage pyrite occurs as a coating on quartz crystals in small vugs. Adjacent to the quartz vein the quartz porphyry exhibits silica and tourmaline alteration of the matrix of the porphyry over a core length of 0.5-0.6 m on either side of the vein. The alteration increases in intensity nearer to the vein, but the quartz phenocrysts in the porphyry are preserved throughout the alteration zone.

In drill hole AN2 the vein consists predominantly of quartz with wolframite blades up to 20 mm long and minor molybdenite and bismuth, and late pyrite in small vugs. Silicification of the porphyry extends approximately 100 mm either side of the vein, and the lower contact is probably faulted. There appear to be two types of vein quartz, with the lower 150 mm occurring as clear, crystalline quartz with pyrite, whereas the upper portion of the vein consists of coarse, milky quartz with wolframite blades.

Drill hole AN3 intersected two significantly thick quartz veins (Table 3) carrying molybdenite and bismuth. The veins are approximately 1.8 m apart (true width) and may be the overlapping ends of veins in an *en echelon* vein system. The vein intersection at 142.66-142.83 m consists of white quartz with a light green mixture of muscovite, chlorite, and sericite and minor purple fluorite and molybdenite. The porphyry adjacent to the vein exhibits a dark grey/brown coloured quartz-tourmaline alteration of the matrix (for about 200 mm either side of the vein). The deeper (northern) vein intersection (146.35-146.61 m) consists of white to clear quartz, with light green intermixed muscovite and chlorite, and coarse aggregates of molybdenite. The adjacent porphyry is altered between 145.90 m and 147.35 m. Neither of the veins contain visible wolframite nor scheelite.

The fourth hole, AN4, also intersected two significantly thick quartz veins in altered porphyry. The veins are approximately 1.9 m apart (true) and are probably overlapping ends of an *en echelon* vein system. The major vein intersection (216.79-217.33 m) consists of white quartz with topaz, purple fluorite, green intermixed chlorite and muscovite, arsenopyrite and late pyrite, and carbonate with relatively abundant wolframite, molybdenite, and native bismuth. The other vein (220.57-220.72 m) has a similar mineralogy.

All major vein intersections have a similar mineralogy, though wolframite and molybdenite contents vary considerably, and probably define a single vein system. Drilling has tested the ground for about 50 m to the north and 70 m south of the lode, but no other major veins have been intersected.

The veins in the All Nations lode occur in an *en echelon* pattern, with offsets to the south and east (fig. 10). If the same *en echelon* vein system has been intersected in the drill holes, then the narrow vein (0.095 m) offset 1.8 m south of the major vein intersection in AN3 may be near the western termination of a major vein, whereas the thicker intersection (0.22 m) may be the eastern end of vein thickening to the west (fig. 10). For the same *en echelon* vein system, the thicker (0.34 m) vein intersected in AN4 may be at the western end of a vein "making" to the east (fig. 10).

Assuming that the vein intersections are of the same vein system, then the probable attitude of the lode is: strike = 100°M and dip = 80°-85° south. The lode is sub-parallel to, and almost directly beneath the All Nations lode (fig. 4). Previously, it had been postulated (Collins, 1981*a*) that the vein intersections in the porphyry were of a different vein system to the All Nations lode. However, there is no conclusive evidence to indicate that two different parallel vein systems have been faulted into approximate juxtaposition, and it is now considered that the vein system intersected in the drill holes is most likely the depth extension of the All Nations lode.

The two lodes are dissected by a low-angle (dip 20°-25°N) reverse fault which is probably a bedding-plane slip fault associated with formation of the broad, open, east-west trending syncline. Most movement on the fault probably occurred during folding (*i.e.* pre-mineralisation) as a result of differences in competency of the Ordovician and Cambrian sequences. The lode probably originally passed through the reverse fault but later movement (shuffling) may have disturbed the vein in the fault zone, but did not cause any major displacement. The postulated position of the lode indicates an offset of 10-15 m to the north beneath the centre

Table 3. MAJOR QUARTZ VEIN INTERSECTIONS IN DIAMOND DRILL HOLES, ALL NATIONS MINE, MOINA

DDH	Depth (m)	Length (m)	VCA*	True width (m)	Elevation† (m)	Mine co-ordin-† ates	Sample depth (m)	Analytical data (g/t)x				Notes
								Sn	W	Mo	Bi	
AN1	109.67-110.36	0.69	40°	0.50	535.5	1103.5 mE, 968.0 mN	109.67-110.36	73	481	1690	720	
AN2	63.38- 63.79	0.41	45°	0.30	560.0	1069.5 mE, 982.5 mN	63.38- 63.79	41	1102	81	520	1
AN3	142.66-142.83	0.17	30°	0.095	494.0	976.5 mE 996.5 mN	142.62-142.87	140	9	110	32	
	146.35-146.61	0.26	45°	0.20	491.0	977.0 mE 998.0 mN	146.33-146.65	29	50	1.15%	0.21%	2
AN4	216.79-217.33	0.54	35°	0.31	439.0	1205.0 mE 933.0 mN	216.75-217.35	350	2.4%	300	160	3
	220.57-220.72	0.15	35°	0.085	436.0	1205.0 mE 934.5 mN	220.55-220.75	200	140	130	2000	4

* VCA = angle of vein intersection to the core axis.
† Elevation and mine co-ordinates refer to Figure 2.
x Analyses expressed in g/t, or as mass% where indicated.

Notes

1. Also contains 8 g/t Ag.

2. Molybdenum is equivalent to 1.92 mass% MoS_2.

3. Tungsten is equivalent to 3.03 mass% WO_3, vein also contains 1020 g/t As.

4. Vein also contains 250 g/t Pb.

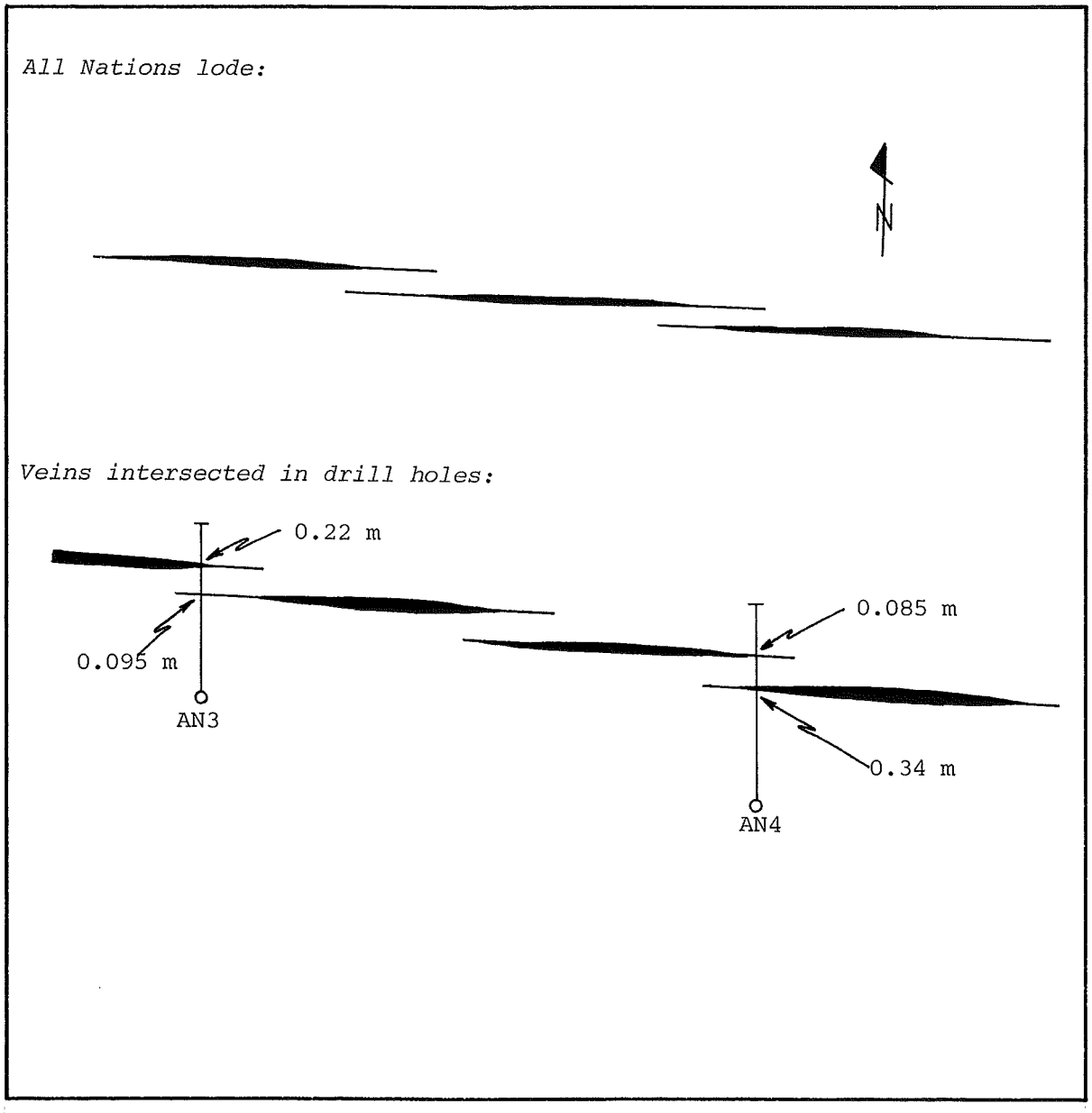

Figure 10. *Sketch plan showing possible drill hole intersections in an en echelon vein system, All Nations mine.*

of the All Nations lode (figs. 6, 7), but less than 5 m offset at the lateral extremities (figs. 8, 9).

Veined and altered porphyry

The Cambrian porphyritic tuff intersected in the drill holes is penetrated by numerous narrow veins, with the following five vein types having been distinguished:

(1) Quartz-topaz veins up to 80 mm thick with fluorite, clay (after feldspar?), chlorite/muscovite, tourmaline, wolframite, molybdenite, bismuth, pyrite, and chalcopyrite. Adjacent to these veins the porphyry commonly exhibits a dark grey to brown coloured silica and tourmaline alteration zone which decreases in intensity of alteration away from the vein, but with an abrupt change between the altered and unaltered porphyry. The alteration zones associated with the quartz-topaz veins, which are the most common vein type, are commonly disproportionately extensive when compared with the thickness of the veins. The mineralogy of the veins and alteration of the porphyry are similar to the major quartz veins and are probably the same generation of veining. However, some of these veins contain scheelite (not present in the major veins) indicating that there may be an additional vein type.

(2) Quartz-muscovite veins up to 40 mm in thickness.

(3) Quartz-chlorite veins (up to 5 mm thick) which are earlier than the quartz-topaz veins.

(4) Quartz-albite veins up to 10 mm thick with molybdenite and minor wolframite. Adjacent to these veins, the porphyry exhibits a narrow, pink, albite alteration zone.

(5) Quartz-molybdenite veins (up to 25 mm) and coatings on joint surfaces.

Veining in some sections of the porphyry is particularly well developed, with intervals of relatively closely spaced veins in each hole, but most prominent in AN2 and AN3.

In contrast to the porphyry, the overlying sedimentary rock contains only a few narrow quartz veins containing wolframite but no visible molybdenite, bismuth, topaz, beryl, chlorite, albite, or scheelite.

Skarn-type alteration

Magnetiferous skarn-type alteration zones occur within the Cambrian porphyry in drill holes AN1 and AN4.

In AN1 there are three skarn intersections. The best developed is between 119.40 m and 120.05 m, where it consists of magnetite, garnet, actinolite, quartz, carbonate, and chlorite, and exhibits an irregular banding at about 30° to the core axis. The skarn-type alteration is cut by a later quartz-albite vein. At 100.20 m to 100.60 m thin stringers of magnetite-actinolite occur within porphyry which exhibits silica and tourmaline alteration adjacent to an 8 mm thick quartz-topaz-wolframite vein. Similar magnetite-actinolite alteration is patchily developed at 121.00-121.55 m.

In AN4 there is a 2.40 m intersection of green and white, irregularly banded chlorite-magnetite-quartz-sericite-carbonate alteration at 192.35-194.75 m. Towards the base of this intersection, the matrix of agglomeratic volcanic rocks exhibits similar alteration. The banded skarn is cut by later veins carrying scheelite.

In addition to the above, the volcanic rocks in each hole contain sparsely disseminated stringers of magnetite-chlorite.

The occurrence of skarn-type mineralisation in the porphyry probably is the result of metasomatic replacement of thin, lenticular(?) beds of carbonate deposited during accumulation of the volcanic rocks. The irregular banding in the skarn may reflect original bedding. Vein-skarn relationships indicate that skarn development preceded most veining.

Analytical data

Quartz veins

The major quartz vein intersections in each hole have been analysed for Ag, Bi, Cu, Mo, Pb, Sn, W, and Zn, and some intersections for As, Au, Fe, Mn, and Sb. Results are detailed in Collins (1981*a*, *b*) for AN1, 2, and 3 and in Appendix 1 for AN4, and are summarised in Table 3.

Tin is consistently low (29-350 g/t), but is much higher in AN4 (200 and 350 g/t) than in the other three holes (29-140 g/t). Tungsten, molybdenum and bismuth show considerable variation, with ranges of 9 g/t to 2.4mass% W, 81 g/t to 1.15mass% Mo and 32 g/t to 0.21mass% Bi. Most other metals analysed are low, with 4 to 130 g/t Cu, up to 250 g/t Pb, up to 51 g/t Zn, and Ag values below 10 g/t (relatively high detection limit). Where analysed, Au is less than 0.3 g/t, Sb is less than 10 g/t, but arsenic ranges up to 1020 g/t in AN4.

The irregularity in metal content, particularly W and Mo, is consistent with the erratic distribution generally of ore minerals in this type of vein deposit but the analytical data indicate that relatively high grades of wolframite and/or molybdenite are present in deeper sections of the veins.

Stockwork veining

Analytical data for sections of veined and altered porphyry may be divided into two sample types: (i) short sections of intensely altered porphyry and associated veins in holes AN1 and AN2 (Table 4); and (ii) bulk samples of core containing relatively closely-spaced veins (Table 5). Full analytical details are given in Collins (1981*a*, *c*).

The data in Table 4 indicate that over short sections, the altered porphyry is relatively rich in W, Mo, Sn, and Bi, particularly in tungsten (up to 0.44% WO_3), though much of the metal content is derived from the associated veins. Comparison of these data with analyses of unaltered quartz porphyry (Table 4), indicate that W, Mo, Sn, Bi, and Zn have been introduced, but the Cu content of altered and unaltered porphyry is similar. Pb and Ag are irregular, but with no obvious relationships.

Bulk sampling of the Cambrian volcanic rocks indicates that sections of close-spaced veining and associated alteration are relatively enriched in tin, tungsten, and molybdenum (Table 5), but much of the metal content is due to one or two very rich samples (due to rich veins), and the

Table 4. ANALYSES OF VEINED AND/OR ALTERED PORPHYRY, AND OF UNALTERED PORPHYRY IN DRILL HOLES AN1 AND AN2, ALL NATIONS MINE.

DDH	Sample Depth (m)	WO_3 (g/t)	Mo (g/t)	Sn (g/t)	Bi (g/t)	Cu (g/t)	Pb (g/t)	Zn (g/t)	Sb (g/t)	Ag (g/t)	Au (g/t)	
Veined and altered porphyry												
AN1	109.17-109.67	569	100	140	36	22	29	110	<10	34	<0.3	(1)
	110.36-110.95	937	400	140	120	20	34	89	<10	<3	<0.3	(1)
	111.35-111.75	86	63	80	47	19	60	270	<10	48	<0.3	
	115.70-116.20	1190	120	84	280	12	100	150	<10	<3	<0.3	
	122.35-122.75	84	170	64	<11	<8	<12	79	<10	6	<0.3	
	126.30-126.70	732	<19	260	100	25	60	68	<10	<3	<0.3	
	130.80-131.30	4360	250	100	<11	17	<12	60	<10	8	<0.3	
AN2	74.20- 74.50	2230	63	100	<11	40	16	60	<10	10	<0.3	
	77.15- 77.70	2700	230	82	1130	20	100	68	<10	5	<0.3	
	108.20-108.80	278	820	89	53	<8	<12	120	<10	5	<0.3	
	121.00-121.50	126	230	76	20	14	<12	150	<10	89	<0.3	
Quartz porphyry												
AN2	54.75- 55.00	18	5	<12	<13	18	25	20	-	<3	<0.3	(2)
	145.90-146.15	39	<3	39	<13	20	10	13	-	<3	<0.3	(2)

Notes: 1. Altered porphyry adjacent to major quartz vein.
2. Not previously reported; reg. nos 813573 and 813574. Possible Sn and W contamination.

relatively high metal values are not sustained over the entire bulk sampled interval (*e.g.* the interval 121.15-169.15 m in hole AN3). The low grade (0.01-0.05% MoS_2, 0.02-0.04% WO_3) stockwork mineralisation appears to occur as a vertical(?) linear zone, sub-parallel to the quartz lode (fig. 4). It is thickest in the deeper intersections (approximately 25 m thick in holes AN3 and AN4) but apparently thins rapidly towards the surface (*c.f.* figs. 4, 5). Although the grade and size of this zone are low, as defined by drilling, there is potential for improved grades (particularly MoS_2) at depth and further exploration of the stockwork zone is warranted.

Bulk sampling of sections of best developed veining in the Ordovician sediments indicates relatively high tin (125-371 g/t Sn) and tungsten (243-1164 g/t WO_3) over short intervals of core (Table 5), but these values would not be sustained over extended widths.

Table 5. BULK SAMPLING ANALYTICAL DATA FOR STOCKWORK VEINING, ALL NATIONS MINE. DATA SUMMARISED FROM COLLINS (1981a, c).

DDH	Sample depth (m)	Sample length (m)	Sn (g/t)	W* (g/t)	Mo* (g/t)	Bi (g/t)	Notes
Moina Sandstone							
AN1	47.5- 51.5	4	371	424	<5	45	
AN2	38.0- 42.0	4	160	923	<5	65	
Roland Conglomerate							
AN2	51.5- 53.5	2	125	193	5	12	
Bull Creek Formation (porphyry)							
AN1	112.5-115.5	3	235	240(303)	22(37)	5	
AN2	84.0-100.0	16	138	734(926)	97(162)	<4	(1)
	140.0-144.0	4	60	330(416)	155(259)	<4	
AN3	114.0-116.0	2	120	200(252)	75(125)	<10	
	121.15-169.15	48	88	109(137)	174(290)	14	
	[121.15-139.15	18	134	138(174)	88(147)	<10]	
	[139.15-148.15	9	55	210(265)	672(1121)	78]	(2)
	[148.15-169.15	21	61	40(50)	34(57)	<10]	
	190.15-194.65	3	30	40(50)	110(184)	<10	
AN4	128.55-209.55	81	70	147(185)	140(234)	<10	
	[128.55-170.55	42	99	231(291)	231(385)	<10]	(3)
	[140.55-170.55	30	126	265(334)	282(470)	<10]	(3)

* WO_3 and MoS_2 respectively in brackets

Notes:

1. Includes one sample (801896) containing 4080 g/t WO_3.
2. Includes quartz vein at 146.33-146.65 m containing 1.15 mass% Mo and 0.21 mass% Bi (812221).
3. Includes one sample (813664) with 2113 g/t W and one sample (813672) with 1141 g/t Mo.

Skarn

Skarn units in Holes AN1 and AN4 generally have low metal values (Table 6). High tungsten (1.4% WO_3) in a 400 mm intersection in AN1 is due to a wolframite-bearing vein. The only other significant value is 30 g/t Ag in a 350 mm intersection of weakly developed skarn in AN1.

Table 6. ANALYTICAL DATA FOR SKARN MINERALISATION IN CAMBRIAN PORPHYRITIC VOLCANIC ROCKS, ALL NATIONS MINE.

DDH	Sample		Sn	W	Mo	Bi	Cu	Pb	Zn	Ag	Notes
	Depth (m)	Length (m)	(g/t)	(g/t)	(g/t)	(g/t)	(g/t)	(g/t)	(g/t)	(g/t)	
AN1	100.25-100.65	0.40	180	1.11%	53	52	39	75	170	<3	1, 2
	119.40-120.05	0.65	93	117	<19	13	20	<12	120	<3	1
	121.00-121.35	0.35	60	159	<19	<11	9	<12	55	30	1, 3
AN4	192.35-194.55	2.20	160	221	40	<10	-	-	-	-	

Notes:

1. Sb = <10 g/t, Au = <0.3 g/t
2. Skarn is dissected by a quartz-topaz-wolframite vein.
3. Weakly developed skarn.

ESTIMATION OF POTENTIAL ORE RESERVES

Introduction

The following estimation of potential reserves at the All Nations mine is based entirely on four diamond drill hole intersections and on data inferred from the old All Nations mine workings. Reserves are estimated for the quartz lode mineralisation only. An assessment of the tonneage of veined and altered porphyry has not been undertaken as the analytical results indicate that the bulk grade of this material is 'sub-ore' and there is insufficient data to establish the size and shape of the stockwork mineralisation.

Estimation of potential reserves of the wolframite-molybdenite bearing quartz lode is restricted by a lack of data for an accurate assessment of the grade of the vein, and by lack of evidence of continuity of the lode. Thus the following estimation is considered to be an estimate of a resource (possible ore category) rather than of ore reserves. In calculating the resource tonneage it is assumed that the density of the quartz lode is 2.65 t/m^3, and that the lode is continuous throughout the resource block.

Calculation of resource tonneage

The limits of the resource block are indicated in Figure 11. The western and eastern limits are assumed to be vertical, and located 20 m beyond the quartz vein intersections in drill holes AN3 and AN4. The upper

limit is 10 m below the upper surface of the postulated reverse fault which dissects the lode in the old workings (fig. 11). It is assumed that the lode passes uninterrupted through the Cambrian-Ordovician unconformity. The lower limit is assumed to be horizontal at 418 m (M.L.), but an intermediate inclined lower limit is also defined at 20 m below the quartz vein intersections in drill holes AN3 and AN4.

Only the deeper of the two vein intersections in drill hole AN3 is used in this evaluation as it is the wider and better mineralised vein. To include both vein intersections, which are 1.8 m apart (true width), would necessitate a mining width in excess of 2 m.

Two methods have been used to estimate the tonneage of vein within the resource block (fig. 11). In *method A*, the volume of quartz lode has been calculated using an average vein true width (0.33 m determined from the drilling intersections) for the entire resource block. This gives an estimated tonneage of 41 140 t of vein. *Method B* utilises a polygonal method in which vein true width in each drill hole is used to calculate the vein volume in the appropriate polygonal block. An assumed vein width is used for peripheral blocks without drilling data. The estimated tonneage using this method is 38 940 t of vein.

If the lateral limits of the resource block are extended to coincide with the surface expression of veining, as exposed in trenches and underground workings, the estimated tonneage may be increased by 4940 t of vein (fig. 11A). This assumes that the lode intersected in drill holes is the same as the lode in the All Nations mine workings.

The lode may extend for a short distance beyond the limits of the resource block, though the western end is close to the western boundary of lease 66M/78 (fig. 5). The lode is open at depth, and although the eastern limit is undefined, it may terminate against a postulated NW-trending fault between hole AN4 and Pochins adit.

Grade of resource

Due to the erratic distribution of ore minerals in this type of deposit, it is not possible to accurately estimate the grade of the vein from diamond drilling. Data obtained from drill hole intersections (Table 7) indicate an average grade of about 1.3mass% combined metals. However, this should be considered as a guide only, as much of the metal content is contributed by 1.92mass% MoS_2 in the vein in AN3 and 3.03mass% WO_3 in AN4.

Table 7. ANALYTICAL DATA FOR QUARTZ VEIN DDH INTERSECTIONS, ALL NATIONS MINE.

DDH	Sample depth (m)	Sample true width (m)	WO_3 (mass%)	MoS_2 (mass%)	Sn (mass%)	Bi (mass%)
AN1	109.67-110.36	0.50	0.06	0.28	0.007	0.072
AN2	63.38- 63.79	0.30	0.14	0.013	0.004	0.052
AN3	146.33-146.65	0.22	0.006	1.92	0.003	0.21
AN4	216.75-217.35	0.34	3.03	0.05	0.035	0.016
Average (weighted)		0.34	0.81	0.43	0.013	0.076

ALL NATIONS MINE-MOINA

LONGITUDINAL SECTION - OUTLINE OF POTENTIAL ORE RESERVES

Geologist: P.L.F. Collins, November 1982

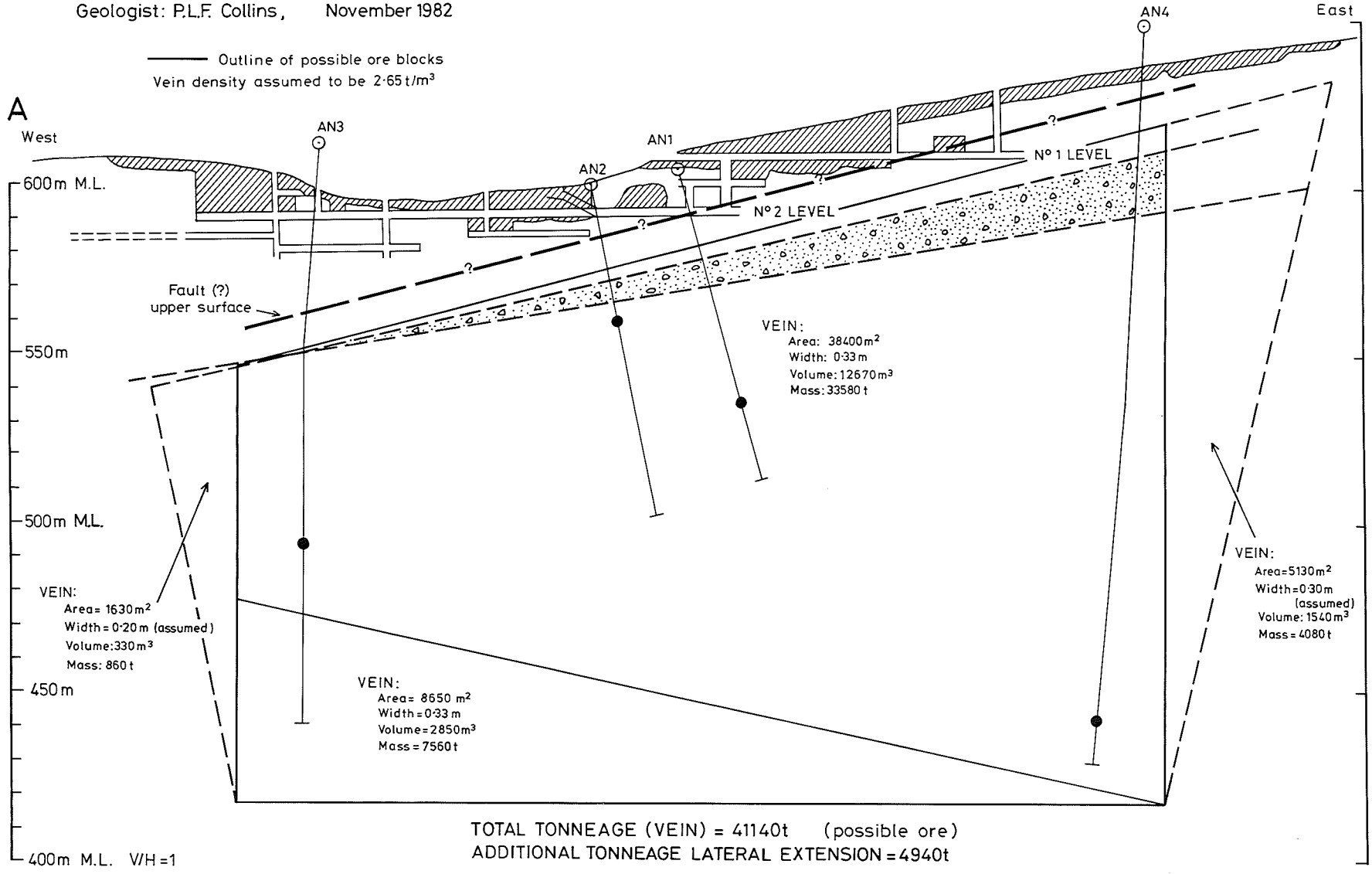

Figure 11A.

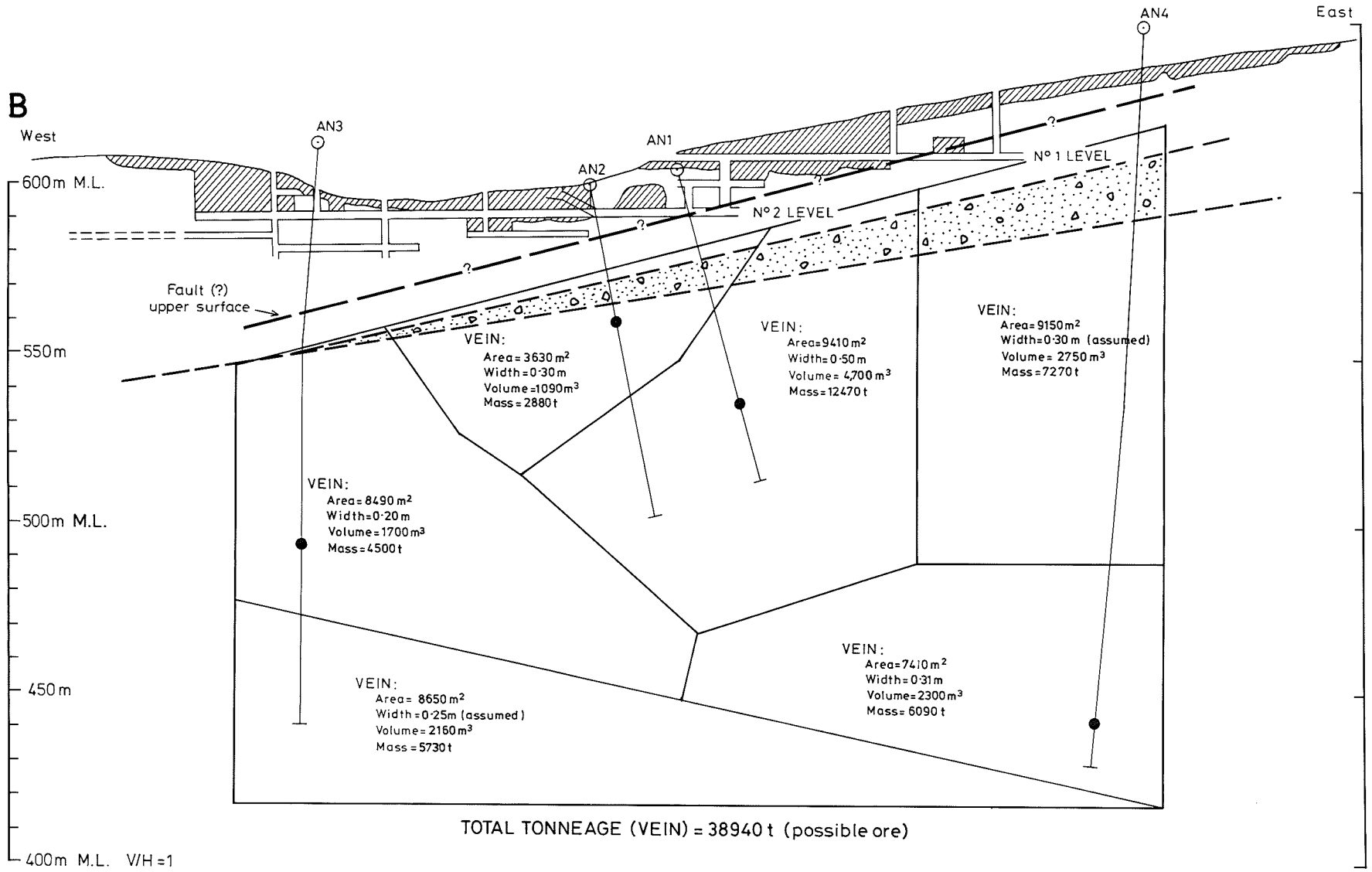
B
West
East
AN1
AN2
AN3
AN4
600m M.L.
550m
500m M.L.
450m
400m M.L. V/H=1
N° 1 LEVEL
N° 2 LEVEL
Fault (?)
upper surface
VEIN:
Area=3630m²
Width=0·30m
Volume=1090m³
Mass=2880t
VEIN:
Area=9410m²
Width=0·50m
Volume=4,700m³
Mass=12470t
VEIN:
Area=9150m²
Width=0·30m (assumed)
Volume=2750m³
Mass=7270t
VEIN:
Area=8490m²
Width=0·20m
Volume=1700m³
Mass=4500t
VEIN:
Area=8650m²
Width=0·25m (assumed)
Volume=2160m³
Mass=5730t
VEIN:
Area=7410m²
Width=0·31m
Volume=2300m³
Mass=6090t
TOTAL TONNEAGE (VEIN) = 38940t (possible ore)

Figure 11B.

An estimate of grade may also be derived from the old All Nations mine workings and recent past production. In 1978, three tonnes of concentrate (at a grade of 60% WO_3) was produced from about 300 t of ore mined from a stope above the south cross-cut (fig. 5). Analysis of a sample of tailings (dump at 1005 mE, 1025 mN) from this mining indicated 0.26% WO_3, 0.09% Bi, and <0.01% Sn (Reg. No. 791909). Allowing for recovery loss, the grade of the material mined in 1977 probably was about 1mass% WO_3.

Further estimates may be gleaned from information on a longitudinal section of the original workings (DOM plan 1949-37, dated 25/10/1919). Assuming that assay(?) values shown on this plan are mass% WO_3 in the quartz lode, then the ore ranged from trace amounts to in excess of 50% WO_3. In the No. 1 level tunnel, a 500 mm wide vein assayed at 2% WO_3 over a length of 76.2 m. In No. 2 level, 52 assays over a length of 114.3 m (42.7 m west, and 68.6 m east of the main shaft) indicate an average grade of 7.3% WO_3. In a sub-level below No. 2 level, between the main shaft and the inclined rises, 26 assays over 36.6 m average 6.3% WO_3, and 7.47% WO_3 over 6.1 m of winze connecting the two levels. These values indicate a very rich zone in the centre of the old All Nations workings, but could not be expected to be maintained over a large area.

Taking all analytical data into consideration, the mineable grade of ore would probably be in the range 0.5-1% combined metals (WO_3+MoS_2). However, to properly assess the grade, a development level and bulk sampling would be required.

SUMMARY AND CONCLUSIONS

A four-hole exploration diamond drilling programme at the All Nations mine has indicated that a 0.2-0.5 m thick quartz lode carrying wolframite, molybdenite, bismuth/bismuthinite, and minor cassiterite occurs within porphyritic volcanic rocks of the Cambrian Bull Creek Formation. Assuming that the vein intersection in each hole is of the same *en echelon* vein system, then the lode in the porphyry strikes 100°M and dips 80°-85°S. It is almost directly beneath the All Nations wolframite lode which trends 105°M and dips 75°-80°S. The All Nations lode occurs entirely within Ordovician sediments (*i.e.* Moina Sandstone) which unconformably overly Cambrian volcanic rocks.

The two lodes are dissected by a low-angle reverse fault trending 080°-090°M and dipping 20°-25°N. The fault is probably a bedding-plane slip fault associated with deformation of the Palaeozoic rocks into a broad, open east-west trending syncline. Most movement probably occurred during folding, and the major vein system probably originally passed through the fault but was disturbed within the fault zone by later post-granite/post-mineralisation movement.

It is concluded that the vein system intersected in the drill holes is the continuation, at depth, of the All Nations lode, and that the low-angle reverse fault has caused only minor displacement of the lode. The veins probably pass unaffected from the Cambrian volcanic rocks through the Roland Conglomerate to the hanging wall of the reverse fault.

Drilling indicates an estimated 40 000-45 000 t of mineralised (wolframite+molybdenite) vein below the reverse fault. The grade of the lode is not known, but drill hole intersections indicate up to 3.03mass% WO_3, up to 1.92mass% MoS_2 and up to 0.21mass% Bi.

The porphyry also contains numerous other wolframite, molybdenite

and scheelite-bearing quartz and quartz-topaz veins (1-80 mm thick) which appear to be concentrated in a vertical zone sub-parallel to the main lode and best developed in the deeper holes (AN3, AN4). Bulk sampling indicates approximately 25 m (true(?) width) of veined and altered porphyry containing 290 g/t MoS_2 and 137 g/t WO_3 in AN3, and at least 25 m (true(?)) of veined porphyry with 234 g/t MoS_2 and 185 g/t WO_3 in AN4. The zone appears to narrow rapidly towards the surface. Although grades are relatively low, the potential of this stockwork mineralisation, particularly as a low-grade molybdenite deposit, has not been fully tested.

Wolframite-bearing veins occur rarely in the Ordovician sediments, though the ground above the stockwork zone has not been tested.

Narrow bands of magnetiferous skarn-type mineralisation occurring within the porphyry contain minor amounts of Sn (<180 g/t) and W (<220 g/t), but there is limited potential for development of extensive skarn mineralisation.

Exploration at the All Nations mine has reached a stage where no further exploration of the quartz lode from the surface is warranted. Any further exploration of the lode should be through underground development by driving on the lode at a depth below the 550 m level. This will allow lateral continuity of the lode to be established and collection of bulk samples for determination of 'run-of-mine' ore grade. Additional exploration would depend upon the results of this development.

Further exploration of the stockwork vein mineralisation is warranted, to test its potential below the 400 m level. However, this would require deep drilling (holes in excess of 500 m), and is beyond the scope of this investigation.

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[10 January 1983]

APPENDIX 1

Extension of diamond drill hole AN4, All Nations mine, Moina.

INTRODUCTION

Diamond drill hole AN4 was initially drilled to a depth of 209.55 m, but was terminated in April, 1981 having neither intersected, nor considered to have reached its target (Collins, 1981*b*). The hole has been subsequently extended, and intersected a major quartz vein at about 217 m. Drilling of the extension commenced on 26 August, 1982 at 209.55 m and was completed on 28 August, 1982 at 228.95 m, for an extension depth of 19.40 m with 98% core recovery. Survey details are given in Tables 2 and 8.

GEOLOGICAL DATA

The hole intersected porphyritic rocks of the Cambrian Bull Creek Formation, as summarised below. Detailed diamond drill core records are available at the Department of Mines.

Interval (m)	*Width (m)*	*Recovery (%)*	*Description*
209.55-228.95	19.40	98	Pale grey-green to dark brown quartz-phyric lithic tuff, strongly tourmalinised at 213.60-217.85 m and 223.65-224.15 m, and albitised at 224.5-228.95 m. At 212.75-214.40 m occur several 1 mm thick veins with molybdenite, and joints coated with molybdenite splashes.

End of hole 228.95 m

MINERALISATION

Three types of veining occur within the extension: (i) narrow (1-2 mm) quartz veins with scheelite and/or molybdenite; (ii) thicker (>10 mm) quartz+topaz+fluorite+muscovite/chlorite veins with minor molybdenite, wolframite, bismuth/bismuthinite(?), pyrite, and arsenopyrite; and (iii) narrow (<3 mm) albite veins±molybdenite associated with albitisation of the porphyry.

Two significantly thick quartz veins carrying abundant wolframite and bismuth and/or bismuthinite have been intersected in the extension, as detailed in Table 9. The veins have a probable steep (about 75°) southerly dip, and are approximately 1.9 m apart (true width).

The major vein intersection at 216.79-217.33 m consists of white quartz with topaz, purple fluorite, green chlorite/muscovite, colloform carbonate, pyrite, arsenopyrite, wolframite as blades up to 25 mm in length, molybdenite as splashes up to 10 mm in diameter, and native bismuth. Vein margins are diffuse, with a strongly tourmalinised and silicified host porphyry.

Analytical data for the two vein intersections are given in Table 9. The major vein contains significant mineralisation with 2.4mass% W (3.03mass% WO_3) and a relatively high 350 g/t Sn and high As (0.1mass%).

The deeper intersection is enriched in Bi (0.2mass%) and is also relatively enriched in Pb (250 g/t). The high tungsten content of the main vein indicates that wolframite mineralisation still occurs at a depth of about 180 m below the surface.

CONCLUSION

The major quartz veins are in the target zone postulated from the results of holes AN1, AN2, and AN3, and are the probable eastern and depth extension of the mineralised lode intersected in the previous drill holes.

Table 8. SURVEY DETAILS OF DIAMOND DRILL HOLE AN4, ALL NATIONS MINE, MOINA*

Co-ordinates+ (mine grid)	Depth (m)	Bearing (magnetic)	Inclination	Elevation+ (m)
1203.34 mE, 867.24 mN	0	360°	-69.5°	647.0
	108	-	-75°	
	182	-	-72°	
	228.5	354°	-70°	

* Collar position surveyed by G. Benn, Surveyor, Department of Mines; down-hole surveys by P.L.F. Collins, using a Pajari instrument.

\+ Local mine grid and elevation (see Collins, 1981*a*, *b*; figs. 2,4).

Table 9. MAJOR MINERALISED QUARTZ VEIN INTERSECTIONS IN DDH AN4, ALL NATIONS MINE, MOINA.

Quartz vein:		
Depth (m)	216.79-217.38	220.57-220.72
Length (m)	0.54	0.15
VCA(*)	35°	35°
True width (m)	0.31	0.085
Elevation (m)(+)	439.0	436.0
Co-ordinates(+)	1205.0 mE 933.0 mN	1205.0 mE 934.5 mN
Analytical data(x):		
Sample no.	821107	821108
Depth (m)	216.75-217.35	220.55-220.75
Ag (g/t)	<10	<10
As (g/t)	1020	100
Au (g/t)	<0.3	<0.3
Bi (g/t)	160	2000
Cu (g/t)	130	24
Mo (g/t)	300	130
Pb (g/t)	98	250
Sn (g/t)	350	200
W	2.4mass%	140 g/t
Zn (g/t)	25	35
WO_3 (mass%)	3.03	0.018
MoS_2 (mass%)	0.050	0.022

* VCA = angle of vein to core axis.
\+ Local mine grid and elevation at centre of vein.
x Analyst: M. Frith, Department of Mines, Launceston.