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EL 2579 / 3197 / 4289

MOOLAWATANA

FOURTH PARTIAL SURRENDER REPORT AT LICENCE EXPIRY/RENEWAL, FOR THE PERIOD 27/1/1999 TO 28/7/2014

Submitted by
Red Metal Limited
2015

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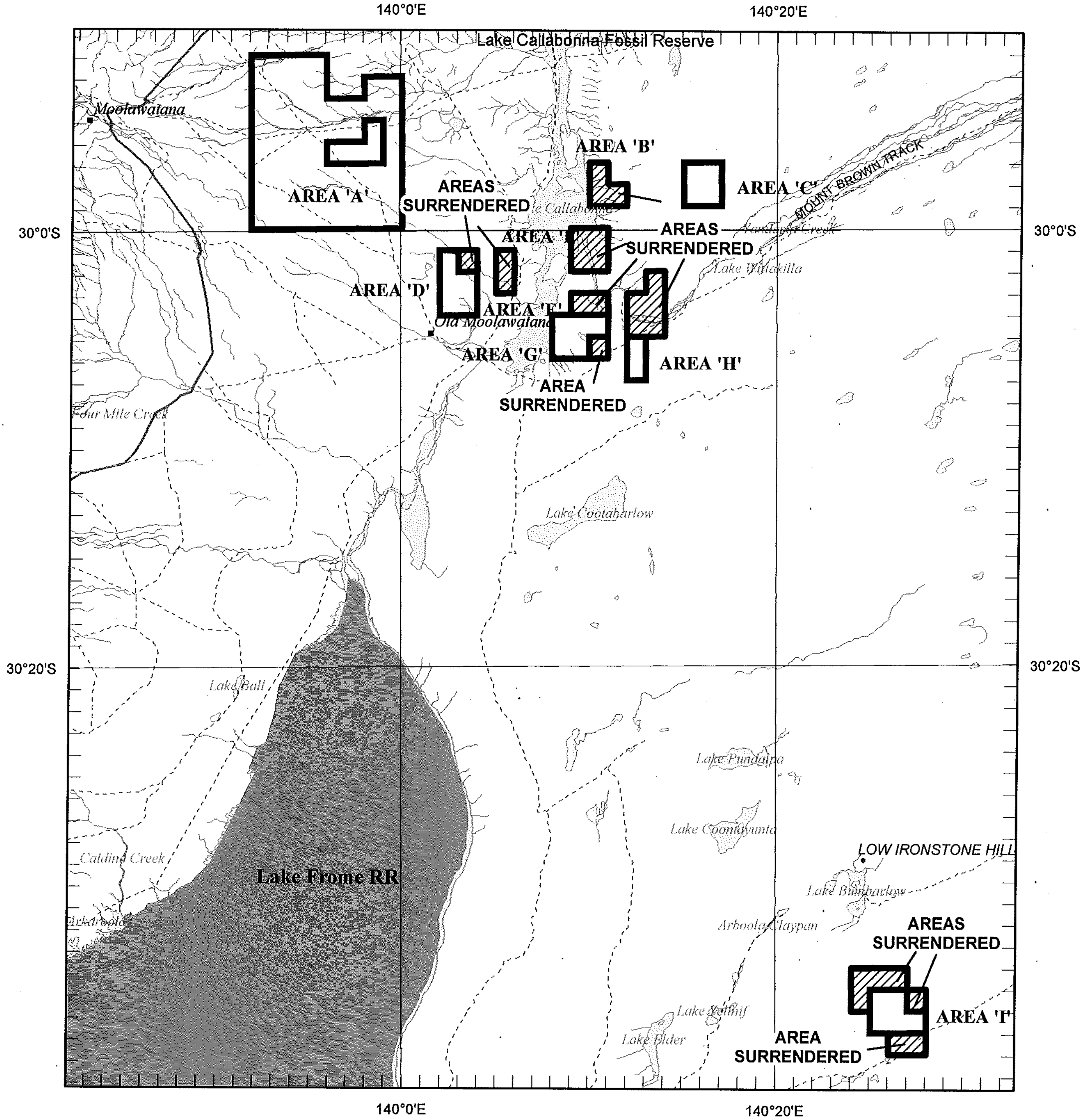
Government of South Australia
Department of State Development

SCHEDULE A



SCALE 1 : 500 000

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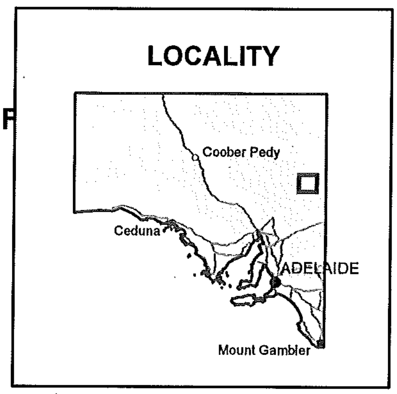
Kilometres

LICENCE BOUNDARIES IN : DATUM AGD66



APPLICANT : **PLATSEARCH NL, ALLENDER J F, AURELIUS RESOURCES PTY LTD, HOSKING A J, KENNEDY R M, HOULDSWORTH J F**

FILE REF : **2009/00046** TYPE : **MINERAL ONLY**

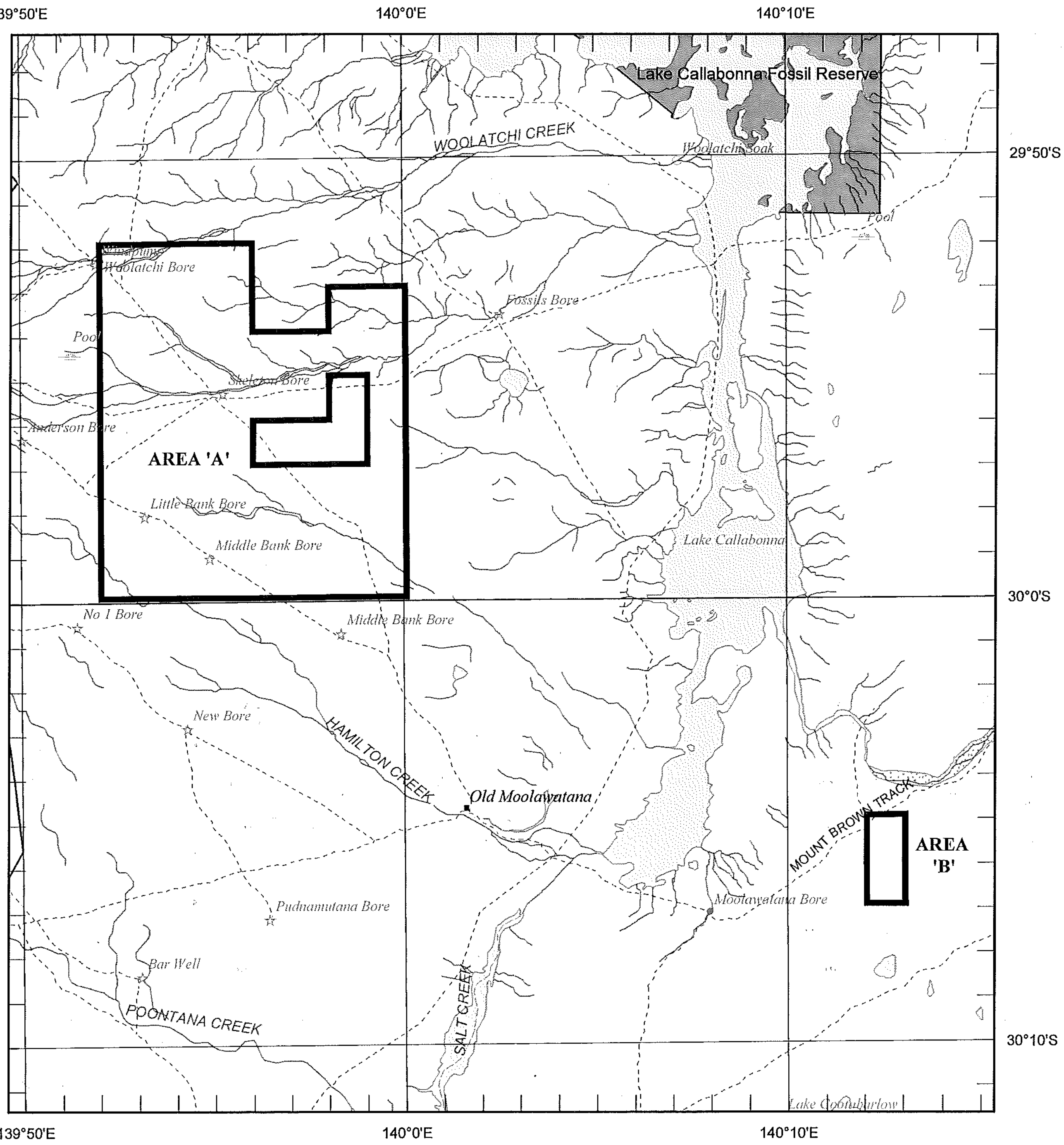
AREA : **223** sq km (approx)

1 : 250 000 MAPSHEETS : **CALLABONNA FROME**

LOCALITY : **MOOLAWATANA AREA - Approximately 180 km northeast of Leigh Creek**

DATE GRANTED: **29-Jul-2009** DATE EXPIRED: **28-Jul-2012** EL NO: **4289**

SCHEDULE A



GDA
GEOCENTRIC DATUM OF AUSTRALIA

LICENCE BOUNDARIES IN : DATUM AGD66

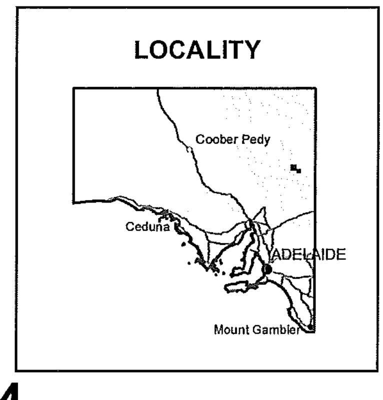
APPLICANT : **Kennedy, Robert Michael;Hosking, Anthony John;Houldsworth, Joseph Fred;Allender, James Fraser;Aurelius Resources Pty Ltd; Variscan Mines Limited;Red Metal Limited**

FILE REF : **2014/00062** TYPE : **MINERAL ONLY**

AREA : **166** sq km (approx)

1 : 250 000 MAPSHEETS : **FROME CALLABONNA**

LOCALITY : **MOOLAWATANA AREA - Approximately 180km NE of Leigh Creek**



DATE GRANTED: **29-Jul-2014** DATE EXPIRED: **28-Jul-2016** EL NO: **5464**

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EL 4289

QUINYAMBIE

PARTIAL SURRENDER REPORT

for period ended

28 July 2014

1:250,000 sheets SH54-06, SH54-10
1:100,000 sheets 6838, 6937, 6938

Tenement Holder:	Variscan Mines Limited syndicate
Operator:	Red Metal Limited
Date:	4 February 2015
Author:	G. McKay (Red Metal Limited)

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EL4289_2014_03 Assays QBE-1.xls
EL4289_2014_04 MagSusc QBE-1.pdf
EL4289_2014_05 Petrography QBE-1.pdf
EL4289_2014_06 Collar data QBE-2.csv
EL4289_2014_07 Location QBE-2.xls
EL4289_2014_08 Lithology log QBE-2.csv
EL4289_2014_09 MagSusc QBE-2.csv
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EL4289_2014_12 April 2004 Gravity.csv
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KEYWORDS

Curnamona province, iron oxide, copper, diamond core drilling, gravity, Proterozoic.

SUMMARY

EL 4289 Quinyambie was granted to PlatSearch NL together with several minority owners on 29 July 2009 for five years, replacing EL 3197 which in turn replaced EL 2579. It is due to be replaced with a subsequent licence from 29 July 2014.

The tenement covers magnetic and gravity anomalies within the northern Curnamona Province. The target models include high-grade Fe-Ox style Cu-Au in basement rocks as well as Tertiary sedimentary uranium in roll-front or other redox style mineralisation in sandstone units of the Namba or Eyre Formations.

This report covers the work conducted on the surrendered portion of EL 4289 since the tenement was granted as previous EL 2579 in January 1999 until 29 July 2014. The exploration activities included four gravity surveys and two deep diamond core holes, QBE-1 (504 metres) and QBE-2 (501.7 metres) drilled on a coincident magnetic/gravity anomaly at Dolores East Prospect.

1 INTRODUCTION

EL 4289 is located 180km north-east of Leigh Creek in the Lake Frome district (Figure 1).

The tenement area in part is the subject of a Native Title claim by the Adnyamathana People (Claim SC99/001). A Part 9B access agreement with the native title claimants was signed.

2 LICENCE DETAILS

EL 4289 Quinyambie was granted to Variscan Mines Limited (previously PlatSearch NL) together with several minority owners on 29 July 2009 over 297 sq km, replacing EL 3197. The area has been reduced to 223 sq km. It is due to be replaced with a subsequent licence from 29 July 2014 over a further reduced area.

A joint venture agreement between Red Metal Limited and the tenement owners Variscan Mines Limited, JF Allender, RM Kennedy, Aurelius Resources Pty Ltd, AJ Hosking and JF Houldsworth, was executed on 29 March 2004. Red Metal Limited is the operator for the joint venture.

Table 1: Tenement Details

Name	EL No.	Grant Date	Partial Surrender Date	Area Surrendered
Quinyambie	4289	29/7/2009	28/7/2014	131 sq km

Figure 2 shows the surrendered blocks.

3 REGIONAL GEOLOGY AND GEOPHYSICS

The project is located on the Cainozoic plains east of the Mount Painter Inlier.

EL 4289 covers magnetic and gravity anomalies within the northern Curnamona Province. The target model includes high-grade Fe-Ox style Cu-Au in Proterozoic basement rocks.

The tenement also covers the highly prospective Namba and Eyre sedimentary formations which host the known uranium mines and deposits in the region. The potential target is Tertiary sedimentary uranium in roll-front or other redox style mineralisation in sandstone units of the Namba or Eyre Formations.

4 PREVIOUS EXPLORATION

EL 4289 (subsequent to EL3197) was previously held as EL 2579 by the PlatSearch syndicate.

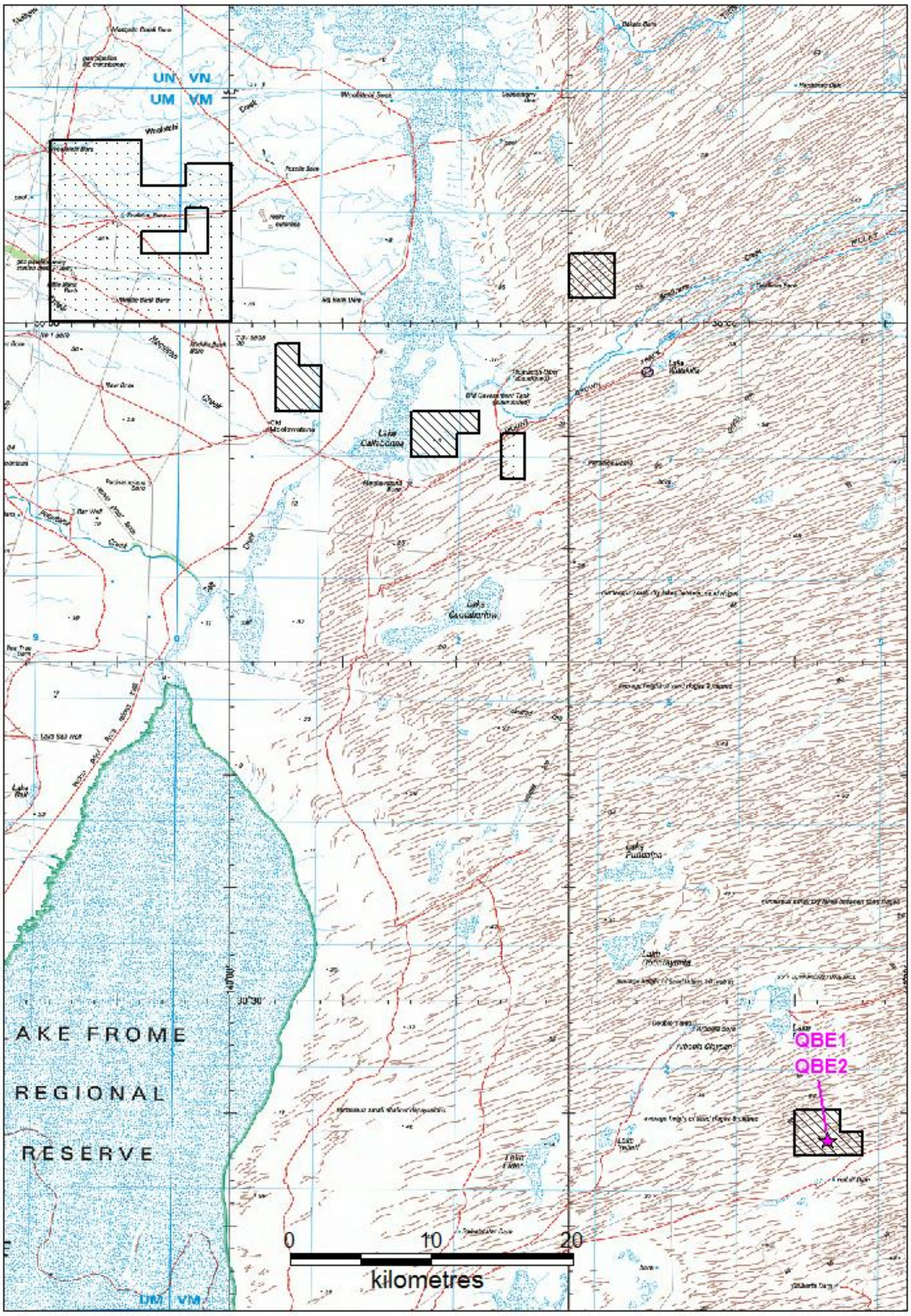


Figure 1: EL 4289 location (several portions) with surrendered areas hatched.
Drill hole locations QBE1 and QBE2 shown.

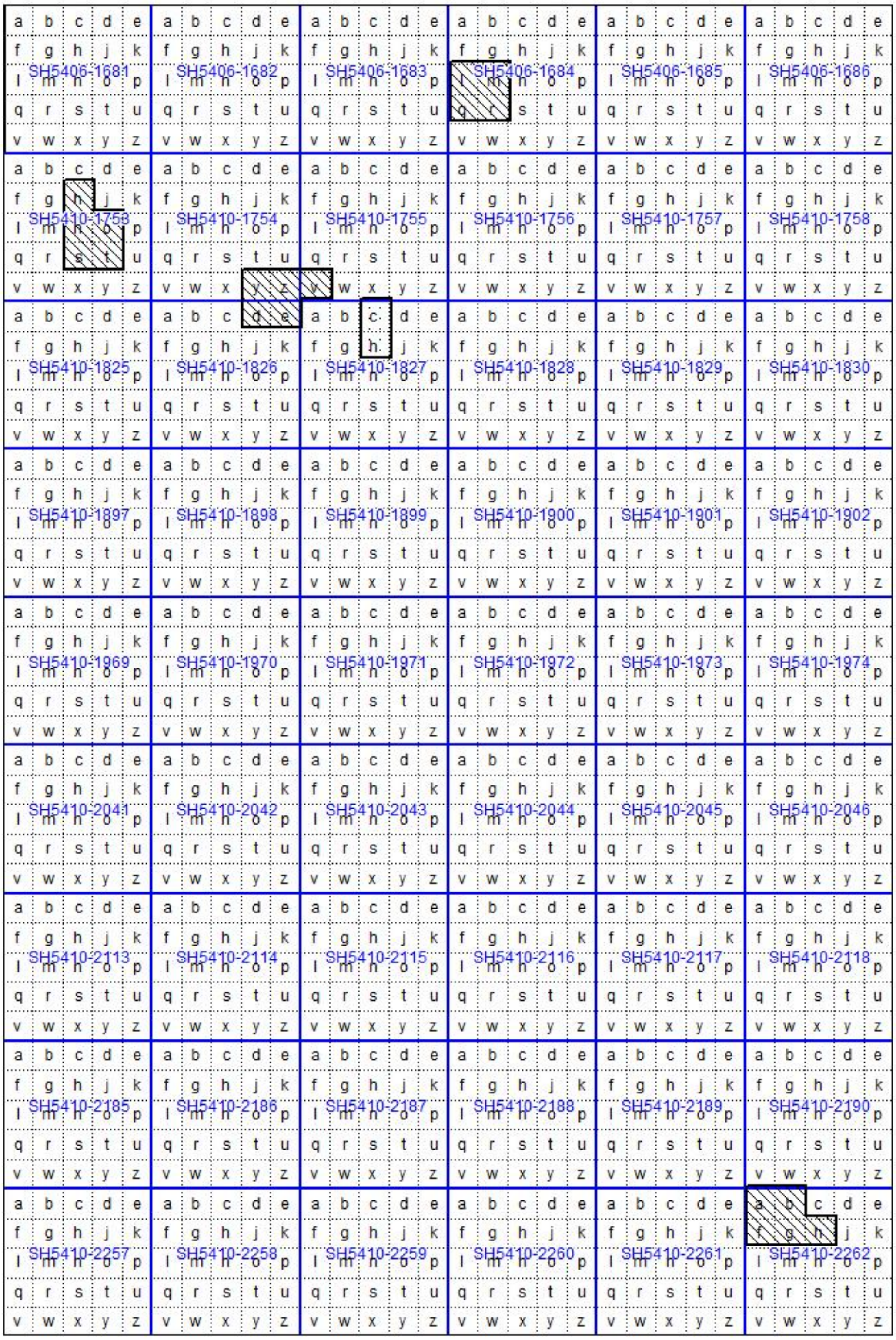


Figure 2: EL 4289 surrendered blocks hatched.

5 WORK COMPLETED

Exploration completed on the relinquished portions of EL 4289 included gravity surveys in June 2002, April 2004, November 2004 and March 2006. The digital data is provided with this report. Figure 3 shows gravity survey locations.

The Dolores East prospect, in the southern portion of the EL, is located at the intersection of a major NNW magnetic linear structure and a NE/SW trending structure. This anomaly is an isolated, discrete, previously untested, magnetic anomaly located in the middle of the Curnamona Craton.

In 2001 a ground magnetic survey was conducted on the Dolores East magnetic anomaly in the south-east portion of the EL. Precollar drilling of hole QBE-1 in November 2001 intersected Proterozoic basement rocks at 307m in highly altered and brecciated volcanics.

In 2002 core drilling of QBE-1 was completed to 504 metres. Magnetic susceptibility measurements, geological logging, petrology and geochemical analysis were carried out on the core. The entire core drilled section comprises volcanic breccia, suggestive of a volcanic vent complex, and is anomalous in copper averaging 655 ppm over 192 metres from 312 to 504 metres (including 3 metres at 0.60% Cu and 1 metre at 1.17% Cu). The core displays some of the key features that characterize systems which host major copper deposits.

Following the drilling, a gravity survey was completed over the Dolores East prospect with the results showing a discrete 1.5mGal magnitude anomaly roughly coincident with the magnetic anomaly.

As the drill site for drill hole QBE-1 lies within the known artesian part of the Eromanga Basin, a cased and pressure cemented precollar was required. The precollar part of the hole was drilled by Thompson Drilling in November 2001. Hole QBE-1 penetrated 307 metres of shale and sandstone before entering Proterozoic basement. A three metre diamond core was then drilled (from ~308.5 - 311.5 metres) to confirm the hole was in basement and not just a clast in conglomerate. The hole was subsequently cased with 100mm PVC casing, pressure cemented and with a cement plug left in the bottom of the casing. The diamond tail to 504m was completed in February/March 2002. Core recovery was excellent averaging 99%.

Table 2: Details of Drill Hole QBE1

Collar Location: (AGD84/z54)	446586E 6613982N	**Azimuth:**	N/A
Elevation:	~40m	**Inclination:**	vertical at 0m 88.4° at 504m
Grid Base GDA94	Map Sheets:	**Frome SH 5410**	Coonarbine 6936
Total depth:	504m	**<u>Contractors:</u>**	
Depth to basement	307m	**Precollar & 100mm coring:**	Thompson Drilling
Precollar depth:	311.5m	**NQ coring:**	Silver City Drilling

Hole size:		Start precollar:	23 Nov 2001
0-29m	218mm	**End precollar:**	26 Nov 2001
29-311.5m	150mm	**Start 100mm coring:**	27 Nov 2001
311.5-504m	NQ	**End 100mm coring:**	27 Nov 2001
		Start NQ coring:	26 Feb 2002
Logged by:	Kelpie Expl. & Euro Expl.	**End NQ coring:**	4 March 2002

Existing gravity data over the Dolores East prospect in the southern portion of EL 3197 was considered inadequate to position another drill hole. Therefore a resurvey of the gravity over the area was completed in March 2006 on a 100m x 400m grid spacing (212 stations). Modelling of the data confirmed the coincidence of the magnetic high with the gravity high.

In July 2006, Red Metal drilled rotary mud precollar hole QBE-2 to 318.5 metres on the Dolores East prospect near previous drillhole QBE-1 (see Figure 2).

Precollar hole QBE-2 was extended into basement rocks by diamond core drilling from 318.5 metres to 501.7 metres by Jerry's Drilling Service in September 2007.

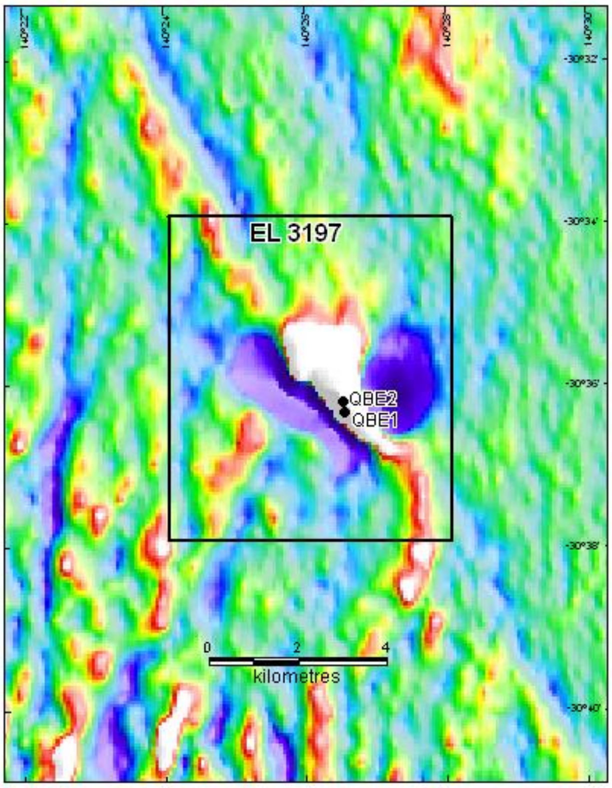


Figure 2: QBE-2 drill hole location on magnetic vertical derivative image.

Table 3: Drillhole QBE-2 Location

Hole_ID	East_MGA54	North_MGA54	Depth	Azim	Dip
QBE-2	446,549	6,614,205	501.7	0	-90

Table 4: Drillhole QBE-2 Summary Log

FROM	TO	UNIT	ROCK TYPE	COLOUR	G'SIZE	DESCRIPTION
0	16	Qua	Sand	Red/brown	slt-mSd	Aeolian sand & silt, minor white calcrete nodules
16	24		Shale	White/grey	silt	Grey fine clay / siltstone
24	44	Namba	Shale	Grey/orange	silt	As above with minor limonitic/oxidised component
44	74	Namba	Shale	Grey/Dk Grey	silt	Siltstone/shale
74	98	Namba	Shale	Grey/green	cy	Massive monotonous grey/green shale,carbonaceous shale
98	106	?Namba	Sand	White	sand	Qtz dom sand
106	118	?Namba	Sand	Grey/Dk Grey	sand	As above with increased dark component. Some hematite?
118	174	Marree	Shale	Grey	cy	Massive monotonous grey/green shale
174	290	Marree	Shale	Dk Grey/ Black	cy	As above with increased carbonaceous material
290	311.5	Cadnaowie	Shale /conglomerate	Dk Grey with white qtz	cy	Grey shale with harder qtz chips. Possible qtz cobbles ? Drillers refer to this as cap rock
311.5	314.65	Basement	Agglomerate / breccia	Brown	crs	Weathered, carbonate flooded volcanic agglomerate/breccia. Scattered hematite and rare chalcopyrite. Limonite specs more common. Agglomerate "cl;asts have difuse boundaries. Carbonate veining and cavity filling common. No core 314.65 to 316m. Recommenced coring at 316m.
316	318.6	Basement	Agglomerate / breccia	Brown /Hematitic green patches	crs	Fresher version of above. Pyrite / chalcopyrite more common in carbonate veins and as envelopes to veins. Total sulphide level less than 0.5%. Strong carbonate content. Hematite more obvious. Patches of green probable sericite altered host. Probable pervasively sericite altered with majority of sericite weathered to brown clay/mica? Agglomerate size dominantly 1 to 5cm, possible larger boulders to 30cm with sericite rim. Suggestions of horizontal banding locally.

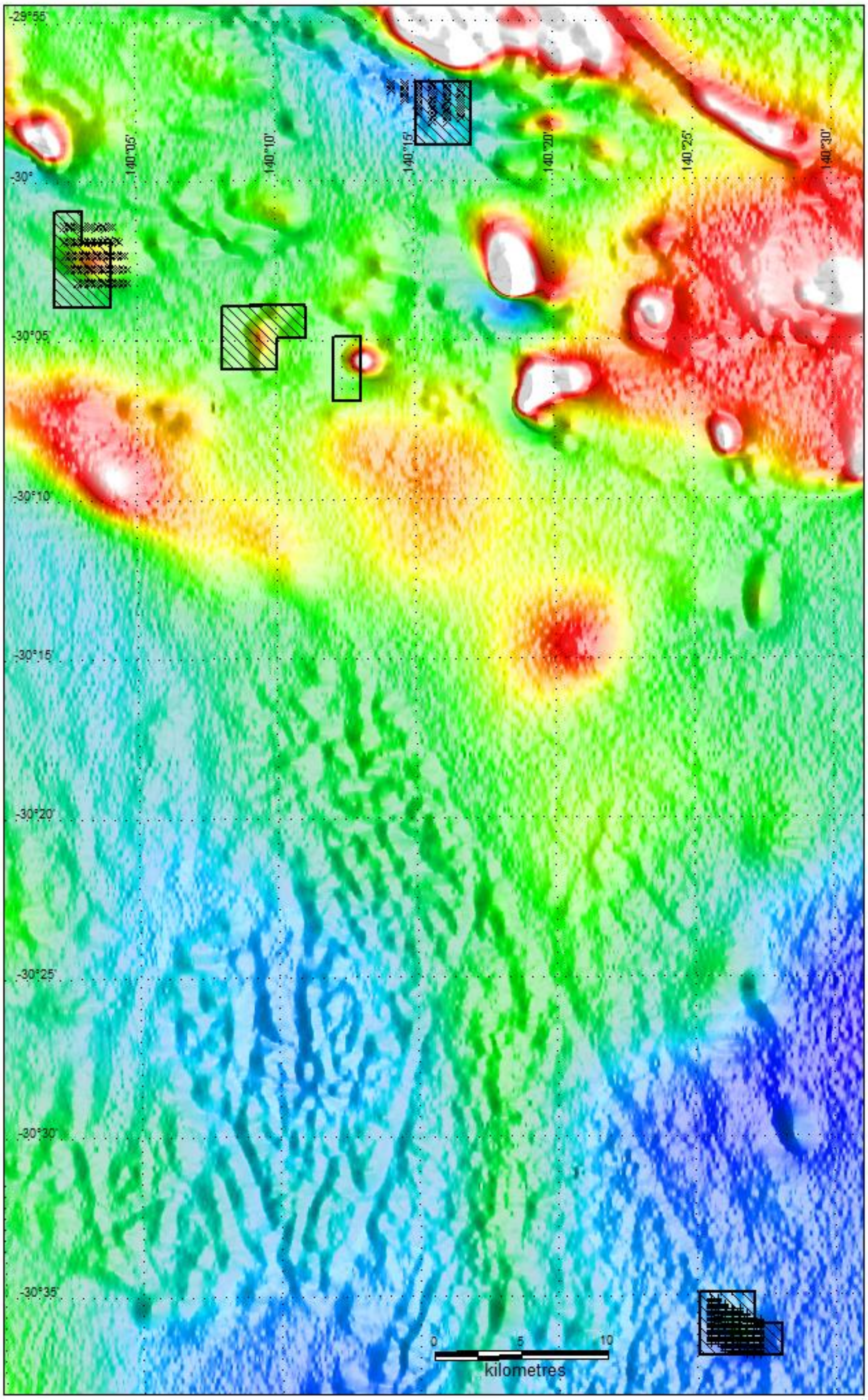


Figure 3: EL 4289 surrendered blocks with gravity survey locations.

6 CONCLUSIONS AND RECOMMENDATIONS

Drillhole QBE-2 was the second hole at Dolores East prospect. The previous hole QBE-1 intersected 190 metres of hematite-altered volcanic breccia averaging 605ppm copper. QBE-2 intersected a similar volcanic breccia. A visual estimate of copper minerals in the core of QBE-2 was low and assaying has not been undertaken to date.

Drilling on QBE-2 intersected encouraging altered breccia rock types similar to nearby hole QBE1. Possibly trial deep IP or deep EM methods could be used to evaluate the prospect further. However the joint venture decided not to continue exploration on the prospect.

APPENDIX 1
(by Wendy Corbett – Variscan Mines Limited)

DRILLHOLE QBE-1 AND DOLORES EAST PROSPECT

Drillhole Geology and Mineralisation

A distinct weathered zone is present at the top of the hole, manifest as a soft earthy haematite zone overlying a bleached pallid zone. Total thickness is about 10 metres. Basement intersected in the short core run of the pre-collar hole comprised altered and brecciated volcanics, ranging in composition from felsic/intermediate to mafic. Alteration is intense, though strong weathering hampered the distinction of alteration mineralogy. Haematite (some ex-magnetite) is abundant and K feldspar and albite appear common.

The diamond tail was completed to 504m and was dominated by volcanic breccias with lithologies ranging from mafic to felsic-andesitic. The mafic lithologies are generally dykes and some basalts. Overall the rock is consistent with a moderately alkaline magma suite that has been pervasively hydrothermally altered. Pyrite and chalcopyrite are irregularly distributed but commonly associated with hematite and/or (but less frequently) with magnetite and apatite.

Sulphides are present throughout and are dominated by pyrite with subordinate chalcopyrite. Total sulphide content is low with sulphides occurring both disseminated and in carbonate plus or minus magnetite veins.

The gross textural and compositional nature of the basement breccias is suggestive of an origin in a volcanic vent complex. Alteration appears to be strong and to reflect abundant fluid flow. Haematite is abundant and K-feldspar and albite are present in the alteration assemblage, suggesting fluid compositions capable of transporting significant quantities of base and precious metals.

A summary log is included in this Appendix. A pictorial view of downhole lithology, copper assay results and magnetic susceptibility is shown as Figure A1 and selected downhole assays, lithology and magnetic susceptibility profile as Figure A2. Figure A3 shows a cartoon of a possible section through QBE-1.

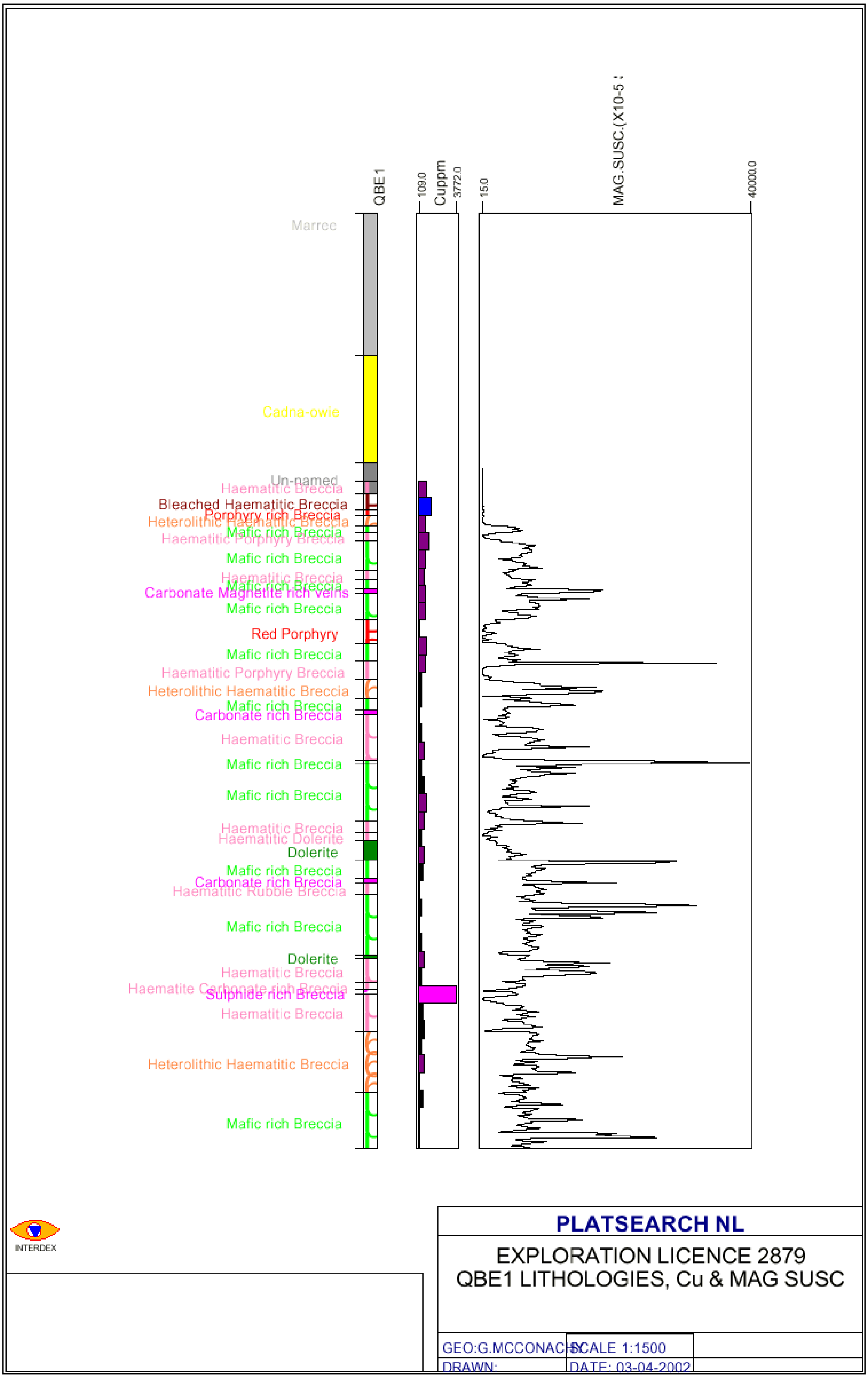


Figure A1: QBE-1 downhole lithology, copper geochemistry and magnetic susceptibility.

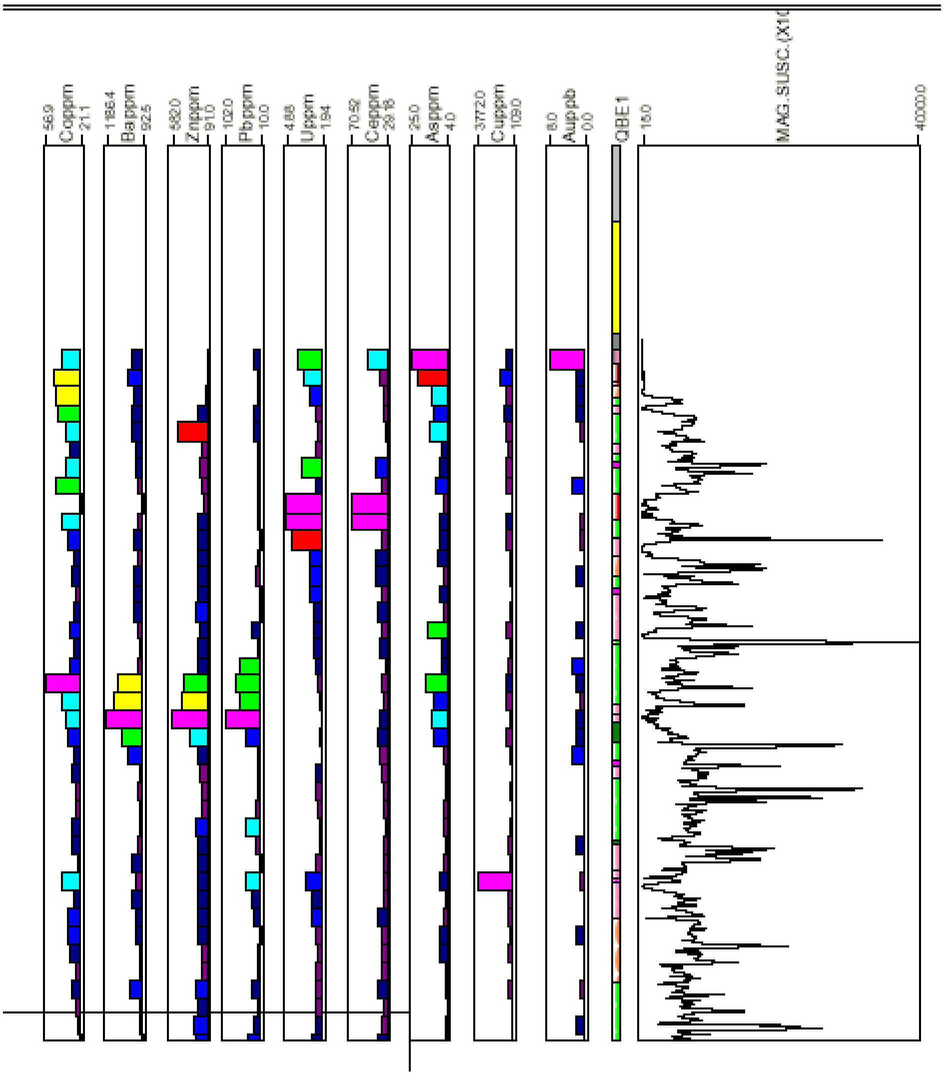


Figure A2: Graphic presentation of QBE-1 assay data, lithology and magnetic susceptibility profile.

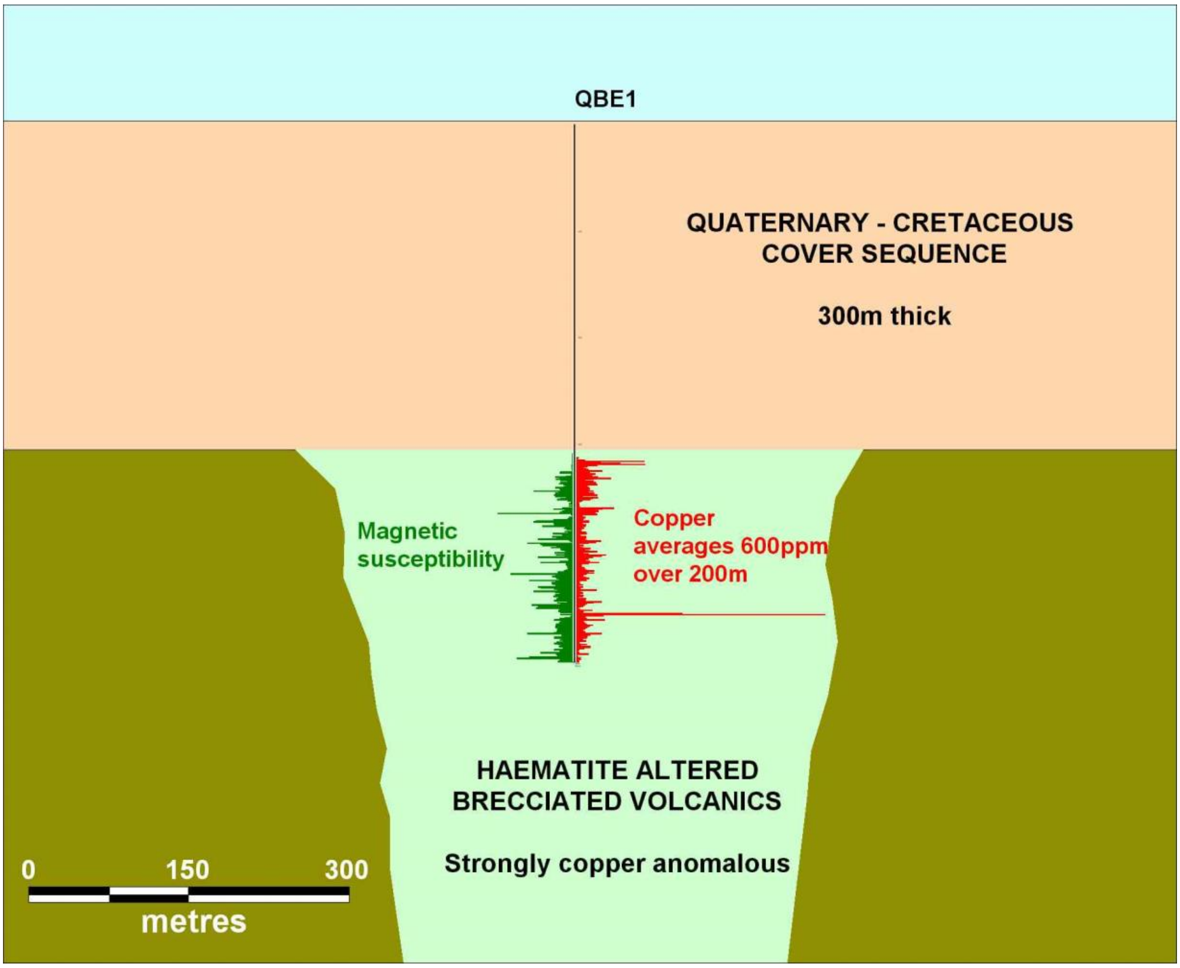


Figure A3: Section through QBE-1 showing copper and magnetic susceptibility profiles.

QUINYAMBIE QBE-1 SUMMARY GEOLOGY

FROM	TO	UNIT	AGE	GEOLOGY AND MINERALISATION
0.00	15.00	Qua	Cainozoic	Aeolian sand & silt, minor calcrete
15.00	16.00	Qua	Cainozoic	Medium quartz sandstone
16.00	74.00	Namba	Tertiary	Massive grey shale, very minor interbedded fine quartz sandstone
74.00	97.00	?Namba	Tertiary	Calc mudstone, subordinate grey/green shale
97.00	123.00	Eyre	Tertiary	Medium quartz sandstone
123.00	198.00	Marree	Cretaceous	Monotonous massive grey/green shale. Rare quartz sandstone
198.00	200.00	Marree	Cretaceous	Medium - coarse quartz sandstone
200.00	276.00	Marree	Cretaceous	Monotonous mid - grey shale
276.00	307.00	Cadna-owie	Cretaceous	Clayey fine to medium quartz sandstone, interbedded grey/brown siltstone/shale, trace coal laminae
307.00	315.80	Un-named	Proterozoic	Haematite/sericite altered brecciated acid to ?intermediate felsic volcanics, green clay alteration, minor pyrite
				and chalcopyrite disseminated and associated with fine carbonate veining
311.50	312.00			No Core
312.00	315.80	Haematitic Breccia		Haematite/sericite altered brecciated acid to ?intermediate felsic volcanics, green clay alteration, minor pyrite
315.80	320.40	Bleached Haematitic Breccia		Bleached light pink/brown haematitic matrix supported breccia with both dark green mafic and red porphyry clasts
320.40	322.00	Porphyry rich Breccia		Grey/brown porphyry dominant breccia, clasts: fine to medium grained. Minor thin sulphide veins (pyrite +/- chalcopyrite)
322.00	325.00	Heterolithic Haematitic Breccia		Haematite rich breccia with clasts of red feldspar porphyry (cf Mudguard 1) and fine grained chlorite dominant mafics.
325.00	327.00	Mafic rich Breccia		Dark grey green mafic clast (chlorite, biotite, magnetite), dominant breccia, minor pyrite trace chalcopyrite
327.00	329.40	Haematitic Porphyry Breccia		Haematitic rich medium grained porphyry clast dominant breccia. Carbonate veins host pyrite and trace chalcopyrite
				with coarse grained magnetite on vein margins.
329.4	337.8	Mafic rich Breccia		Mafic clast rich breccia in a weakly haematised brown/red matrix. Pyrite scattered as blebs throughout interval,
				with trace of chalcopyrite.
337.8	340.30	Haematitic Breccia		Matrix dominant magnetic breccia. Fine grained, dark green (chloritic-magnetite) mafic clasts cut by carbonate veining.
340.30	343	Mafic rich Breccia		Mafic clast dominant, matrix supported breccia tending to clast supported breccia.

FROM	TO	UNIT	AGE	GEOLOGY AND MINERALISATION
343	344.4	Carbonate Magnetite rich veins		Carbonate-magnetite veins dominant similar breccia to above, with a small number of red porphyry clasts.
344.4	352	Mafic rich Breccia		Mafic clast rich breccia tending to clast supported. Both matrix and clasts host magnetite and minor blebs of pyrite
				and trace of chalcopyrite.
352	359.00	Red Porphyry		Red feldspar porphyry dominant unit, either a clast supported breccia or a dyke
359.00	363.90	Mafic rich Breccia		Angular to rounded mafic (chloritic) clast rich breccia. Clasts heavily altered and carbonate veins and breccia infill
				on clast margins common.
FROM	**TO**	**UNIT**	**AGE**	**GEOLOGY AND MINERALISATION**
363.90	368.90	Haematitic Porphyry Breccia		Haematitic feldspar rich breccia with both rounded and jig-saw fit clasts.
368.90	374.3	Heterolithic Haematitic Breccia		Poorly sorted very coarse grained breccia with large mafic clasts and 15% red porphyry clasts. Veins with
				magnetite-carbonate-platy haematite-pyrite-chalcopyrite.
374.3	378.00	Mafic rich Breccia		Haematitic matrix rich breccia. Mafic clasts rounded, poorly sorted and diffuse/altered margins.
378.00	379.40	Carbonate rich Breccia		Carbonate dominant breccia with angular, poorly sorted, dark green mafic clasts as well as brecciation of earlier matrix.
379.40	392.20	Haematitic Breccia		Haematite rich breccia with late carbonate veins with associated platy haematite and pyrite. Minor clots of pyrite
				and chalcopyrite filling breccia voids
392.20	393.5	Mafic rich Breccia		Grey mafic rich breccia with fine grained magnetite overprint of most clasts and to a lesser degree matrix. Minor
				zones of orange haematite matrix.
393.5	410.00	Mafic rich Breccia		Poorly defined breccia with rounded and diffuse mafic (basaltic) magnetic clasts.
410.00	412.8	Haematitic Breccia		Haematite dominant breccia with mafic clasts. Late stage carbonate cement dykes with calcite margins - pyrite
				and minor chalcopyrite mineralisation.
412.8	415.3	Haematitic Dolerite		Strongly haematised mafic ?volcanic - altered dolerite (or large clast). Scattered pyrite and chalcopyrite mineralisation.
415.3	420.9	Dolerite		Massive fine grained mafic ?dyke, as above but no significant haematitic alteration. Finely disseminated sulphides
				(pyrite dominant) and thin carbonate veins
420.9	425.90	Mafic rich Breccia		Mafic ?volcanic clast dominant breccia. Carbonate clots - possibly replacing magma vesicles -pervades the unit.
425.90	427.70	Carbonate rich Breccia		As above with laminated carbonate cemented veins or dyke 0-15 deg to CA.

FROM	TO	UNIT	AGE	GEOLOGY AND MINERALISATION
427.70	430.90	Haematitic Rubble Breccia		Fine grained well sorted rubble breccia. Most clasts are fine grained mafic ?volcanics, and earlier brecciated matrix.
430.90	448.3	Mafic rich Breccia		Coarse grained mafic rich breccia. Carbonate blebs and veins associated with pyrite scattered throughout.
448.3	449.20	Dolerite		Fine grained mafic ?volcanic dyke or clast.
449.20	456.2	Haematitic Breccia		Matrix dominant breccia
456.2	458.4	Haematite Carbonate rich Breccia		Haematite - carbonate dominant breccia, minor amount of sulphides associated with carbonate.
458.4	459.5	Sulphide rich Breccia		Sulphide rich breccia. Pyrite with minor chalcopyrite (0.5%) in veins up to 1cm thick approximately 40deg to CA.
459.5	470.00	Haematitic Breccia		Haematite matrix with mafic - (magnetite-chlorite-biotite) clasts. Circular clots ?vesicles of carbonate common
				through both clasts and matrix.
470.00	487.50	Heterolithic Haematitic Breccia		Matrix supported heterolithic breccia with mafic ?basaltic, mafic feldspar porphyry and rare red feldspar porphyry
				clasts. Some fine grained mafic clasts highly magnetic (477.5m)
487.50	504.00	Mafic rich Breccia		Mafic clast dominant breccia. Clasts angular and of variable size (<1cm-15cm) and vary in composition from
				matrix to fine grained mafic ?volcanics. Carbonate blebs and void infills throughout interval.

Petrography and discussion

Selected samples from the basement have been subject to petrographic examination. Report 8201 by Pontifex and Associates. Petrographic study of QBE 1 pre-collar core has confirmed the rocks to be brecciated felsic volcanics, ranging compositionally from acid to intermediate, with mafics also present. These are tentatively correlated with Gawler Range Volcanics("GRV"), the hosts for Olympic Dam mineralisation. Assuming the correlation is valid, then the compositional range is significant as it implies a link to the basal GRV. The basal GRV compositions range from basalt to rhyolite, is oxidised and regarded as the fertile part of the GRV for generation of Cu/Au deposits. In contrast the upper GRV is dacite/rhyolite dominated, reduced and considered essentially post-mineralisation.

Petrography confirmed the brecciated nature of the rocks. However, the cause of the brecciation is still speculative origins though volcanic, hydrothermal, tectonic and regolithic processes may all have had some influence. The primary alteration assemblage includes haematite/magnetite, K feldspar, carbonate, albite and apatite. This assemblage is directly comparable with those at major iron oxide associated Cu/Au deposits in Australia and elsewhere. The copper in the core occurs mostly in samples that contain hematite, or in the case of the 459m sample of 1.17% Cu, where carbonate appears to replace bundles of earlier fine platy haematite. In looking at the assay results in relation to the mineralogy chemically copper correlates only with cobalt. There appears to be a paragenesis of 1:hematite; 2:pyrite; 3:chalcopyrite. However there is no chemical correlation between copper and iron.

The gross textural and compositional nature of the basement breccias is suggestive of an origin in a volcanic vent complex. Hydrothermal alteration appears to be strong and reflecting abundant fluid flow. Hematite is abundant and K-feldspar and albite are present in the alteration assemblage, suggesting fluid compositions capable of transporting significant base and precious metals. Mineralogically the Quinyambie breccia pipe has many similarities with known oxide-copper-gold provinces including:

- abundant albite and/or K-feldspar
- local development of scapolite, suggesting highly saline brines
- a combination of calc-silicates with oxides and albite
- carbonate-albite-apatite-hematite-magnetite associations.

Pontifex notes that "the relative sparseness of sulphides, and the lack of a uniform copper paragenesis present problems to interpretation/speculation of economic potential, but there may be zones in the broader breccia body that are more prospective." "It may be that potentially more significant mineralisation in this apparently very large hydrothermal/volcanic breccia domain may occur locally in zones with different characteristics (eg more abundant apatite) to those seen in this drillhole."

Assays

One-metre composite samples were taken from the basement core, combined into 5-metre composites (39 samples) and submitted to Genalysis in Adelaide for analysis for a range of elements. The one-metre splits (192 samples) for the interval 312-504m were then assayed for copper and iron.

The analytical methods were as follows:

- Au, Pt and Pd by standard fusion fire assay with a 25g charge, finished by mass spectrometry

- As, Ba, Bi, Ce, Co, La, Mo, Pb, Te U, W by multi-acid digest in Teflon beakers by inductively coupled plasma mass spectrometry

- Fe, Zn, Pb and Cu by multi-acid digest in Teflon tubes by flame atomic absorption spectrometry.

The entire core drilled section comprises volcanic breccia, suggestive of a volcanic vent complex, and is anomalous in copper averaging 655 ppm over 192 metres from 312 to 504 metres (including 3 metres, 458-461m, at 0.60% and 1 metre, 459-460m, at 1.17% Cu). The core displays some of the key features that characterize systems which host major copper deposits. As well as copper the core is anomalous in palladium (max 22ppm), platinum (max 9ppm), Tellurium (max 4ppm) and zinc (max 582ppm). Figures A1, A2 and A3 show a graphic presentation of copper results and other selected assays.

Magnetic Susceptibility

Magnetic susceptibility measurements were taken every metre from 312-504m. The measured susceptibilities for the QBE2 hole match the modelling derived values.

Gravity Survey

A gravity survey was carried out by Allender Exploration in May 2002 over the Dolores East Prospect.

Dolores East Anomaly

The localized gravity spot high on the north-west margin of the main anomaly at Dolores East was confirmed with check and fill-in gravity. The data better defined the main anomaly and a separate anomaly located approximately 1.5 km south-east of the main anomaly. This separate anomaly has no magnetic manifestation and is likely to be due to a more haematite-rich body (Figure A4). Initial modelling indicates a match to a body approximately 1.5 km long with an SG of 3.3.

A diagrammatic version of Figure A4 is shown in Figure A5 with the location of drill hole QBE-1, gravity contours and anomalies. The residual gravity is shown in Figure A6.

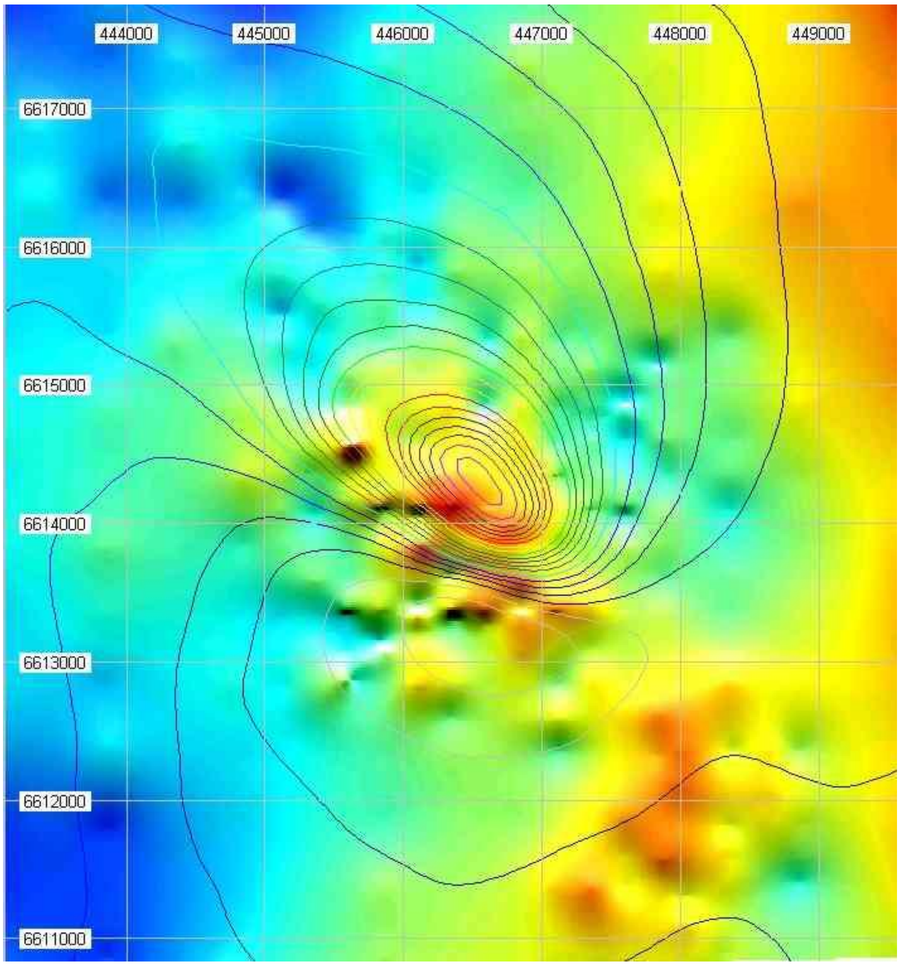


Figure A4: Dolores East gravity anomalies and aeromagnetic contours.

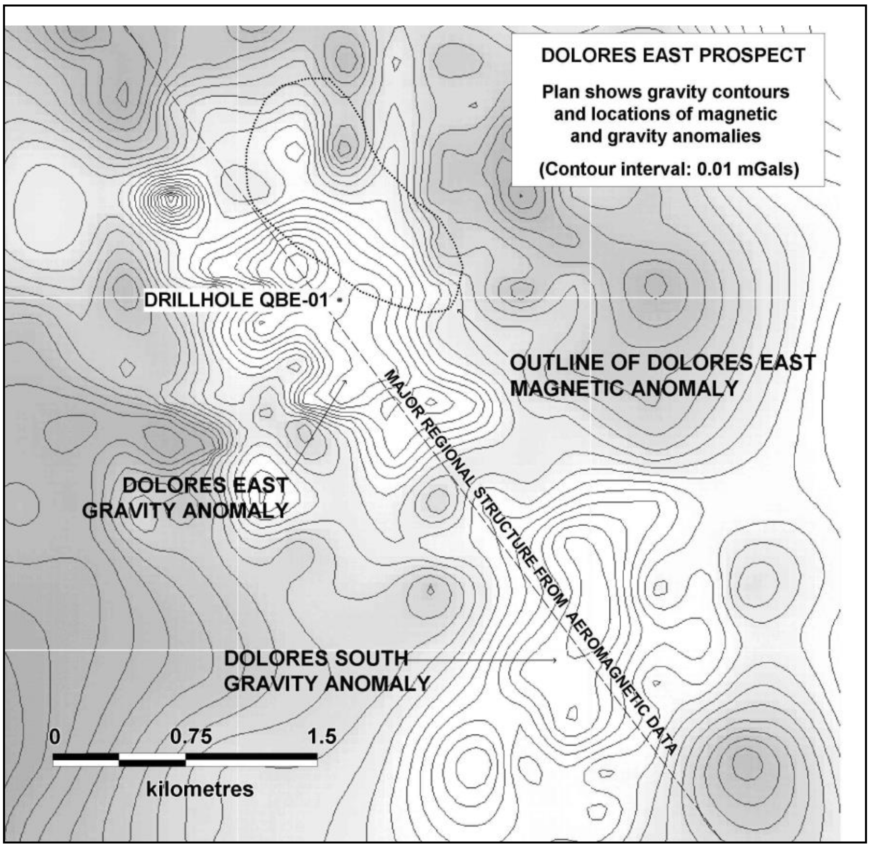


Figure A5: Gravity contours on Dolores East prospect with drill hole QBE-1 and magnetic anomalies.

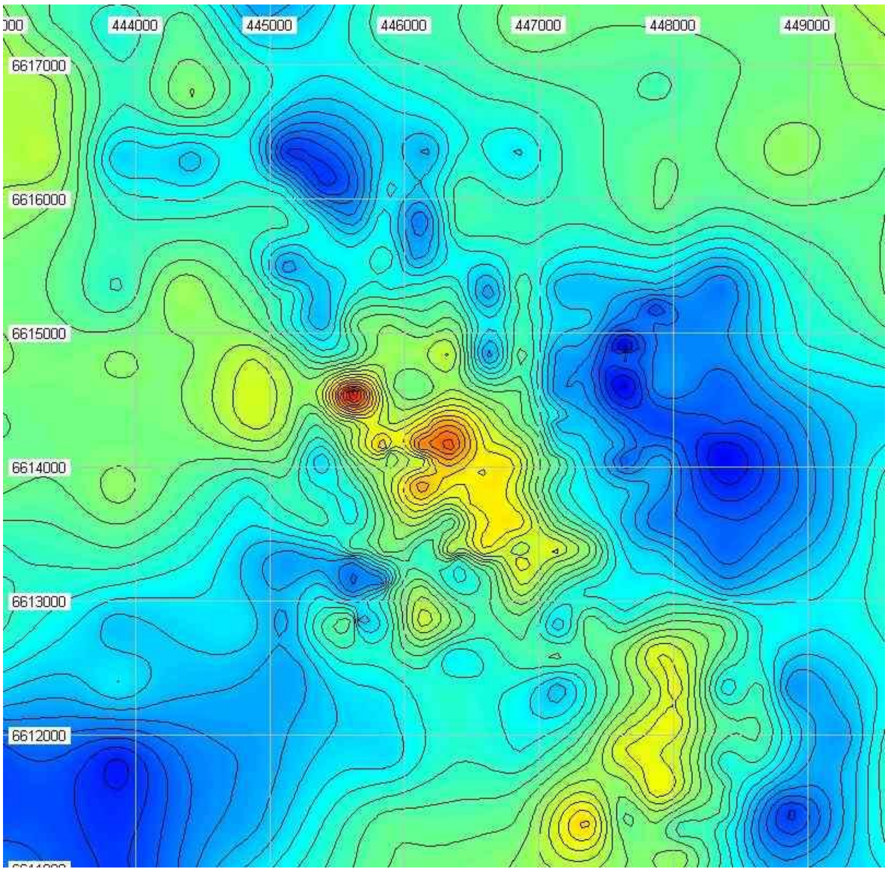


Figure A6: Residual gravity over the Dolores East prospect.

QUINYAMBIE QBE 1
MAGNETIC SUSCEPTIBILITIES

DEPTH	MAG.SUSC. (X10-5 SI)	DEPTH	MAG.SUSC. (X10-5 SI)	DEPTH	MAG.SUSC. (X10-5 SI)	DEPTH	MAG.SUSC. (X10-5 SI)
308.50	85	337.00	8900	365.50	700	394.00	5300
309.00	70	337.50	4000	366.00	83	394.50	14000
309.50	90	338.00	5000	366.50	80	395.00	5900
310.00	100	338.50	3100	367.00	84	395.50	7400
310.50	95	339.00	4000	367.50	75	396.00	14000
311.00	80	339.50	4000	368.00	350	396.50	9800
311.50	60	340.00	4400	368.50	1600	397.00	8000
312.00	85	340.50	8000	369.00	510	397.50	5700
312.50	78	341.00	6400	369.50	2000	398.00	4200
313.00	85	341.50	6000	370.00	6100	398.50	5300
313.50	86	342.00	7500	370.50	8800	399.00	4800
314.00	65	342.50	5500	371.00	9200	399.50	3900
314.50	62	343.00	3800	371.50	17000	400.00	5400
315.00	60	343.50	18000	372.00	6000	400.50	2900
315.50	61	344.00	15000	372.50	18000	401.00	6000
316.00	25	344.50	6300	373.00	15000	401.50	8200
316.50	40	345.00	5000	373.50	8700	402.00	5800
317.00	60	345.50	8000	374.00	160	402.50	3600
317.50	55	346.00	16000	374.50	7400	403.00	2900
318.00	150	346.50	7000	375.00	3200	403.50	7500
318.50	96	347.00	7300	375.50	8600	404.00	3400
319.00	95	347.50	8600	376.00	8900	404.50	3600
319.50	210	348.00	8700	376.50	14000	405.00	4000
320.00	80	348.50	7800	377.00	4200	405.50	16000
320.50	200	349.00	8500	377.50	3100	406.00	3000
321.00	150	349.50	3000	378.00	3300	406.50	2500
321.50	160	350.00	5500	378.50	3900	407.00	950
322.00	160	350.50	5500	379.00	4200	407.50	1800
322.50	190	351.00	8100	379.50	2600	408.00	2400
323.00	95	351.50	6900	380.00	4000	408.50	1900
323.50	82	352.00	2000	380.50	300	409.00	3400
324.00	180	352.50	2200	381.00	2500	409.50	5900
324.50	170	353.00	2800	381.50	3400	410.00	7600
325.00	2700	353.50	380	382.00	3100	410.50	15000
325.50	5600	354.00	300	382.50	2000	411.00	2000
326.00	4600	354.50	700	383.00	7300	411.50	3000
326.50	6000	355.00	28	383.50	9100	412.00	400
327.00	3000	355.50	1500	384.00	8100	412.50	2900
327.50	300	356.00	2200	384.50	4600	413.00	930
328.00	34	356.50	55	385.00	1700	413.50	520
328.50	550	357.00	15	385.50	2900	414.00	80
329.00	2500	357.50	1500	386.00	7800	414.50	2300
329.50	3000	358.00	25	386.50	9400	415.00	600
330.00	5500	358.50	45	387.00	7100	415.50	2000
330.50	8000	359.00	3500	387.50	7200	416.00	2400
331.00	7500	359.50	4600	388.00	6500	416.50	2100
331.50	6000	360.00	4300	388.50	16000	417.00	4000
332.00	7600	360.50	8800	389.00	3800	417.50	3000
332.50	7500	361.00	4700	389.50	1700	418.00	4500
333.00	6000	361.50	3400	390.00	1900	418.50	3800
333.50	5700	362.00	5500	390.50	950	419.00	5500
334.00	6000	362.50	4700	391.00	60	419.50	6600
334.50	2500	363.00	2500	391.50	50	420.00	4000
335.00	4100	363.50	5900	392.00	3200	420.50	4500
335.50	5700	364.00	4000	392.50	21000	421.00	2600
336.00	6600	364.50	35000	393.00	40000	421.50	29000
336.50	6100	365.00	4100	393.50	15000	422.00	24000

DEPTH	MAG.SUSC. (X10-5 SI)	DEPTH	MAG.SUSC. (X10-5 SI)	DEPTH	MAG.SUSC. (X10-5 SI)
422.50	8000	452.50	6500	482.50	5300
423.00	7600	453.00	16000	483.00	2700
423.50	9500	453.50	17000	483.50	6000
424.00	8200	454.00	14000	484.00	4500
424.50	8000	454.50	6000	484.50	4400
425.00	6600	455.00	6000	485.00	5500
425.50	7400	455.50	6500	485.50	7200
426.00	6100	456.00	3000	486.00	4000
426.50	6100	456.50	6500	486.50	8500
427.00	7500	457.00	6500	487.00	6100
427.50	20000	457.50	5500	487.50	6600
428.00	6000	458.00	4900	488.00	2500
428.50	8000	458.50	180	488.50	5500
429.00	8100	459.00	5000	489.00	6700
429.50	9700	459.50	5500	489.50	6200
430.00	8100	460.00	4600	490.00	5500
430.50	9400	460.50	180	490.50	4500
431.00	8600	461.00	92	491.00	12000
431.50	5200	461.50	860	491.50	4500
432.00	6500	462.00	2800	492.00	3400
432.50	8000	462.50	3600	492.50	8500
433.00	5700	463.00	6200	493.00	7200
433.50	16000	463.50	6000	493.50	6000
434.00	32000	464.00	4600	494.00	7500
434.50	15000	464.50	8500	494.50	5400
435.00	7500	465.00	6500	495.00	7000
435.50	8500	465.50	5200	495.50	15000
436.00	26000	466.00	8000	496.00	7300
436.50	7000	466.50	5900	496.50	7700
437.00	14000	467.00	3000	497.00	5200
437.50	18000	467.50	6100	497.50	6000
438.00	5000	468.00	6500	498.00	8800
438.50	8000	468.50	7500	498.50	7000
439.00	6400	469.00	9000	499.00	2600
439.50	6000	469.50	3600	499.50	20000
440.00	9200	470.00	400	500.00	17000
440.50	8000	470.50	8000	500.50	26000
441.00	6000	471.00	8500	501.00	5500
441.50	7000	471.50	7800	501.50	5100
442.00	6600	472.00	7500	502.00	9800
442.50	8900	472.50	7000	502.50	5800
443.00	7800	473.00	9100	503.00	4500
443.50	6300	473.50	7000	503.50	6600
444.00	8000	474.00	6600	504.00	9000
444.50	7200	474.50	7000		
445.00	6100	475.00	8000		
445.50	7000	475.50	7400		
446.00	8400	476.00	5900		
446.50	8500	476.50	8400		
447.00	7000	477.00	9000		
447.50	2500	477.50	21000		
448.00	3000	478.00	12000		
448.50	7000	478.50	5000		
449.00	6500	479.00	8400		
449.50	5500	479.50	4900		
450.00	6200	480.00	8600		
450.50	19000	480.50	8400		
451.00	9500	481.00	7600		
451.50	16000	481.50	8400		
452.00	11000	482.00	14000		

MINERALOGICAL REPORT No. 8201

by A.C. Purvis PhD. & Ian R. Pontifex MSc.

April 16th, 2002

TO :	Mr David Edgecombe Kelpie Exploration Pty Ltd PO Box 283 SUMMERTOWN SA 5141
YOUR REFERENCE :	Drill core sampled at Challenger Geological Services, March 14th and 19th February, 2002
MATERIAL :	QUINYAMBIE #1, [QBE#1], drill core 24 samples selected from 312m to 502m
WORK REQUESTED :	Polished thin section preparation, petrographic/mineragraphic description and report including photos. Also general assessment of geochemical assay data provided.
SAMPLES & SECTIONS :	Returned to you with this report.
DIGITAL COPY :	Enclosed with hard copy of this report.

<u>PONTIFEX & ASSOCIATES PTY. LTD.</u>

SUMMARY COMMENTS

Twenty-two core-segments from a single drillhole, QBE #1 (Quinyambie #1), were selected by Ian Pontifex and Alan Purvis, 15th and 19th March, 2002, together with Dave Edgecombe of Plat Search-Kelpie and Geoff McConachy of Euro Exploration. These samples were macrophotographed, and prepared as 24 polished thin sections which are described in this report with integrated photomicrographs. All section offcuts were stained by highlight the presence of any K-spar.

Drillhole QBE #1 is in the Benagerie Ridge area of the Curnamona Craton and was drilled on a geophysical anomaly under 308.5 metres of Mesozoic sediment. The drillhole initially intersected a short shallow section of bedrock of weathered volcanic breccias, 308.5m to 311.5m, from which selected samples were petrographically described in Pontifex Report No. 8168 (21/12/01). This current report describes samples from a far deeper intersection 330 to 501m, some of which have anomalous copper. Analytical data for selected elements were provided by Dave Edgecombe, each analysis representing a 5-metre interval of core, and subsequently Fe and Cu values at 1m intervals. Some downhole magnetic susceptibility data were also briefly considered with the petrology. The samples are as listed below, followed by discussion and a broad interpretation of the whole suite.

TABLE 1: CHARACTERISTICS OF SAMPLES DESCRIBED IN REPORT NO 8201, DRILLHOLE QBE1

Depth (m)	PTS	Comments
330.5	1	Breccias with mixed mafic and feldspathic clasts with carbonate-albite-hematite-magnetite and chalcopyrite ± pyrite. Pyroxene-porphyritic basalt was identified as well as possible andesites. Rare sericite occurs at 330.5m and a complex carbonate-albite-magnetite-apatite-chalcopyrite-hematite vein at 343.4m.
343.4	1	
351.7	2	These breccias have fragments of albitised porphyritic microsyenite as well as partly vesicular mafic and feldspathic volcanic clasts with secondary K-spar. Biotite at 351.7m. Scapolite occurs in some areas, with carbonate-albite-hematite-pyrite-chalcopyrite aggregates. There may be a small mafic dyke at 351.7m. Accessory pyrite and chalcopyrite associated with bladed hematite.
368.3	1	
374.1	1	
390	1	Breccia of K-spar-hematite and carbonate-hematite-chlorite-altered fragments without microsyenite. Hematite-carbonate-quartz patches occur. Complex carbonate-hematite-pyrite-chalcopyrite-fluorite veins with two generations of hematite and chalcopyrite. Earthy hematite has been replaced by fibrous chalcopyrite and similar chalcopyrite occurs in carbonate.
391.4	1	Breccia or a net-veined basalt to andesite, with K-spar-albite-oxide-chlorite alteration. Minor chalcopyrite disseminated and albite-chlorite-carbonate veins with chalcopyrite and pyrite. Late carbonate veins contain albite, hematite and pyrite.

TABLE 1: *CONTINUED*

Depth (m)	PTS	Comments
393.32	2	Possible basalt or dolerite but not apparently a breccia. Has K-spar, albite, chlorite and earthy hematite, and carbonate-apatite patches scattered in possible vesicles. Trace pyrite and chalcopyrite.
403.4	1	This interval includes breccias of mafic and feldspathic lithologies with chlorite, K-spar, albite, sphene and oxides, also massive lithologies as at 415.16 and 418.8m, possibly representing a mafic dyke with primary disseminated wide grains. Aegirine is distinctive throughout in fragments, in specific domains and in veins, locally rimming augite or diopside or enclosed in epidote. Biotite, epidote and sericite are also present/abundant for the first time. This interval is high in Ba and Pb, which seem to be in sericite as there is not much K-spar. Accessory chalcopyrite, mostly at 403.4m, and pyrite variably associated with bladed hematite and hydrothermal granular magnetite, also gangue of carbonate, albite.
408.2	1	
415.16	1	
418.8	1	
421.0	1	Like the sample from 391.4m this may be a net-veined massive mafic dyke rather than a breccia, with leucoxene, visible in hand-specimen, replacing sphene, rather than titanomagnetite. Biotite and sericite occur, as well as hematite and rare sulphide. This is on the shoulder of the high Ba-Pb zone, again partly in sericite, partly in K-spar. Late barren carbonate veins occur. This may be continuous with the massive mafic lithology at 415-418m but lacks aegirine. Late chalcopyrite ± pyrite associated with bladed hematite. Trace bornite.
429.24	1	Breccias of mafic (429.24) or mafic and feldspathic fragments (434 and 442m). Albite, chlorite, oxides and carbonate occur throughout, with biotite at 429.4 and 434m, but not at 442m. Carbonate-albite-apatite-oxide-sulphide cements are present throughout. Epidote occurs at 434m, with altered possible scapolite or epidote at 442m. Trace chalcopyrite, pyrite, micaceous hematite.
434.0	1	
442.0	1	
459.0	1	This is the most copper-rich sample mineralogically somewhat unique, with chalcopyrite and pyrite enclosing or interstitial to abundant apatite, with chlorite-smectite, carbonate possibly replacing coarse platy hematite and rare quartz. An altered feldspathic fragment is also present. Chemically, the high copper is not accompanied by Co, as in other samples.
460.9	1	Breccia of mafic and feldspathic fragments with chlorite, K-spar, carbonate, oxide, leucoxenised sphene and carbonate veins with rare chalcopyrite. There is neither sericite nor biotite in this sample.
470.2	1	These breccias again contain definite and possible microsyenite, altered to mostly checkerboard albite, as well as mafic and feldspathic clasts. Biotite is again common, as well as chlorite, albite, K-spar, oxides, carbonate, apatite and sphene. Carbonate-albite veins (± apatite) carry trace to accessory chalcopyrite. Larger patches at 480.4m, with altered tremolite and minor magnetite.
480.4	1	

TABLE 1: *CONTINUED*

Depth (m)	PTS	Comments
498.65	1	Mafic clasts dominate these breccias, with areas containing albite, mostly checkerboard albite, apparently fragmented with abundant carbonate, as well as chlorite, apatite and sphene. The larger clasts at 498.65m have epidote-rich cores and zones of altered possible epidote or scapolite, as well as chlorite-rich areas with K-spar. Biotite occurs only at 498.65m, and early carbonate lenses at 501.23m contain quartz. Elsewhere, quartz is seen only at 390m. Nil or negligible chalcopyrite, no pyrite.
501.23	1	

General Discussion

All samples described throughout this hole are dominated by volcanic and probable sub-volcanic lithologies, almost invariably as breccias of one or more rock type, with compositions broadly ranging from mafic to felsic-andesitic, and a porphyritic microsyenite lithology. All samples are pervasively hydrothermally altered, including common space filling hydrothermal minerals in veins or as a cement. Mafic lithologies include almost certain dykes, but some (vesicular) basalts, and these rock types occur as fragments in composite breccias, with more feldspathic fragments which are possibly analogous to andesites but lack the abundant plagioclase phenocrysts seen in typical calcalkaline andesites. They may therefore be more alkaline (related to the porphyritic microsyenite?). Quartz is rare and always of hydrothermal origin. Two intervals (350-375m and 470-481) include fragments of the rather distinctive porphyritic microsyenite noted above, which is albitised, but also without quartz, and therefore consistent with a moderately alkaline magma suite.

The possible dykes (whole sample or fragments of dykes in breccia) occur at 351.7, 391.4, 393.2, 415.16, 418.8 and 421m. The sample from 421m has spots of leucoxene visible in hand-specimen, which are seen microscopically to have formed from sphene rather than from titanomagnetite as in normal dolerites. The samples from 415.16 and 418.8m contain aegirine and minor colourless pyroxene (augite or diopside?), and aegirine is also seen in veins in the interval from 403 to 419m, so is not clear whether the aegirine is partly primary or entirely secondary.

Similar ambiguity is seen in magnetite parageneses, with primary (igneous) magnetite in some clasts, partly as microphenocrysts and partly as disseminated finer grains, as well as hydrothermal magnetite in veins and associated with sulphides. Some clearly hydrothermal magnetite occurs along margins of open-space fillings and as optically continuous overgrowths on apparently primary magnetite adjacent to veins and areas of cement. Both primary and secondary (hydrothermal) apatite occurs as euhedral crystals, but platy apatite crystals, elongate along the base, as seen in some low-sulphidation gold deposits, are absent.

The hematite in these samples is variably very fine micaceous to microplaty scattered as small simple composites, also in random bundles, and seems to be entirely hydrothermal.

Some of the mafic fragments are rich in magnetite (as noted above), rarer martite as oxidised ex-magnetite, also sphene or leucoxene. Some have former phenocrysts of olivine and/or pyroxene, with rare fresh pyroxene and these may also contain epidote, altered possible scapolite or epidote and K-spar, as well as chlorite and other secondary minerals. The paler, more feldspathic fragments vary from K-spar-rich to albite-rich with less oxide, chlorite and apatite than the mafic clasts.

Hydrothermal minerals in various modes of occurrence include albite, K-spar, chlorite, carbonate, apatite, (bladed micaceous) hematite, magnetite, chalcopyrite and pyrite. Trace bornite at 421.0m and trace sphalerite at 408.2m, are the only other sulphides. The hydrothermal cement and early vein systems commonly contain various proportions of (quite coarse) carbonate, albite, apatite, hematite, magnetite, pyrite and chalcopyrite. The hydrothermal mineralisation locally contains apatite and indeed the most copper-rich sample, at 459m, has abundant apatite intergrown with chalcopyrite and pyrite. Despite this, these samples have relatively low contents of light REE (La and Ce), the highest values (~70ppm Ce) being in the interval of breccias containing albitised microsyenite, between 350 and 375m. These elements correlate strongly with Th, which is more likely to be in monazite than in apatite, and less strongly with U, possibly present in apatite, but also possible in monazite.

Sericite, apart from minor occurrences at 330.5m and 351.7m, is restricted to depths below 400m, together with biotite and epidote. Most of the sericite occurs between 400 and 421m, corresponding with an interval of high Ba and Pb values. These elements are more commonly seen in K-spar, (as at Broken Hill) rather than in sericite, but the abundance of K-spar in this interval is lower than in less Ba-Pb-rich zones. Aegirine is confined to part of this zone, at 400-420m, and occurs partly with epidote, a most unusual association, although both minerals have only ferric iron and these samples also contain hematite. The aegirine-bearing samples have no higher REE or Th values than the aegirine-free samples, suggesting that they are not highly alkaline and the aegirine may be of hydrothermal origin. The assemblage aegirine-epidote is related to a higher-temperature, or more silica-rich, assemblage of andradite-albite-hematite.

$$\underset{\text{aegirine}}{12NaFeSi_2O_6} + \underset{\text{epidote}}{6Ca_2FeAl_2Si_3O_{12}(OH)} + 6SiO_2 = \underset{\text{andradite}}{4Ca_3Fe_2Si_3O_{12}} + \underset{\text{albite}}{12NaAlSi_3O_8} + \underset{\text{hematite}}{5Fe_2O_3} + 3H_2O$$

However, in these samples, the abundance of calcite and oxide minerals suggests a different reaction, such as:

$$4NaFeSi_2O_6 + 2Ca_2FeAl_2Si_3O_{12}(OH) + 4CO_2 = 2Fe_3O_4 + 4NaAlSi_3O_8 + 4CaCO_3 + 2SiO_2 + H_2O + ½O_2$$

Aegirine epidote magnetite albite Calcite

A similar reaction would relate the aegirine-epidote assemblage to the widespread and largely mineralised association of hematite, albite and carbonate (calcite?), which carries much of the chalcopyrite, apart from that in the most copper-rich sample at 459m. reactions relating aegirine-epidote to calcite-albite-oxide assemblages are dependent on silica activity and CO_2 fugacity as well as oxygen fugacity and temperature.

Biotite occurs only at 351.7m and below 400m, and varies from pale to dark and from green to brown. In some samples, a green to orange pleochroism is evident and this may suggest a transition towards tetraferriphlogopite as seen in carbonatites. Some of the deeper samples, notably the most copper-rich sample at 459m, but also those at 460.9 and 501.23m, lack biotite, but this mineral is otherwise widespread, mostly with magnetite rather than hematite and usually without very abundant copper.

Distribution of Magnetite

Magnetite is essentially the only magnetic mineral in this drillhole, although aegirine may be very weakly magnetic. As indicated above, magnetite occurs as a primary component in some mafic and some feldspathic clasts, and also occurs as a hydrothermal/epigenetic mineral. Typical examples of hydrothermal magnetite are illustrated in many of the photomicrographs, notably at 343.4m (Fig 5 and 6), and 480.4m (Fig 43), both with associated chalcopyrite. The microsyenite clasts have little or no magnetite, and core with abundant microsyenite are less magnetic than other segments according to a preliminary correlation between the petrology and down-hole magnetic data. Magnetic peaks partly reflect unusually magnetite-rich mafic clasts, and partly indicate zones containing hydrothermal magnetite, with or without hematite or sulphides. Carbonate-rich breccias may also be less magnetic than other types, but carbonate is much more widespread than is indicated on the core log supplied by Platsearch NL. The evidence indicates therefore that there is unlikely to be unique specific correlation between magnetic intensity and copper mineralisation.

Nature of Breccias and Hydrothermal Fluids

The breccias described in this report vary down-hole. As discussed above, some intervals are dominated by mafic fragments, commonly with disseminated primary magnetite, but most samples also contain abundant feldspathic fragments that may be of intermediate, rather than mafic character, albeit without abundant plagioclase phenocrysts. Some intervals contain porphyritic microsyenite clasts, and are termed porphyry-rich breccias on the drill-log supplied by Geoff McConachy of Euro Exploration. Hematite is irregularly distributed and, as indicated above is always hydrothermal, as is chalcopyrite and pyrite.

Overall, it is not clear whether these breccias represent a layered sequence or are part of a diatreme, consequently is also unclear whether the various volcanic lithologies represent a volcano that has vented to the surface or was entirely subsurface. Hydrothermal brecciation may have been basically contemporaneous with ubiquitous primary igneous brecciation or later, and these hydrothermal fluids were abundant and widespread. There is no clear evidence of a juvenile magmatic component in any of these breccias, and a phreatic style of eruption may be suggested, unless some of the vesicular mafic clasts represent juvenile material. The remaining clasts represent older, previously formed igneous units.

As described above, the fluids have mostly deposited carbonate, hematite and/or but probably greater than magnetite, also albite, apatite and sulphides, but were rarely saturated in silica, since quartz is the least abundant mineral in this suite. Rare quartz does occur in veins in three samples but the remaining hydrothermal assemblages seem to have been deficient in silica. It may be, for example, that the assemblage aegirine-epidote may not be stable in the presence of quartz, but this is a rare and unusual assemblage that has not been studied, to the best of my knowledge. The assemblages albite-hematite-calcite and albite-magnetite-calcite may be stable with quartz, albeit in more CO_2-rich fluids that those evident in this suite. In terms of oxygen and sulphur fugacities, the fluids would have been close to the triple-point for the assemblage magnetite-hematite-pyrite.

Diffuse reddening is seen, particularly in albite-rich clasts, but also in some K-spar-rich clasts, but there is no correlation between this style of oxidative alteration and mineralisation. This reddening may indicate that the original feldspar (plagioclase or K-spar) had iron substituting for aluminium in the crystal lattice. [High temperature alkali feldspars may have 1-3% Fe_2O_3 which would form very red feldspars with exsolution on cooling.] In these samples however, the reddening cannot be confidently or specifically correlated with the intensive "red-rock alteration" as seen in the Cloncurry area for example, which is more aggressively pervasive, destroying primary fabric, but this is not seen in this drill hole. The primary igneous component was also not silica-saturated and lacks magmatic quartz, even in the most fractionated microsyenite clasts, which suggests a moderately alkaline magma-type, although alteration makes characterisation of this suite difficult.

The relatively low REE contents are also problematic in this respect, especially in view of the abundance of hydrothermal and primary apatite. It would seem that the apatite in these rocks has very low REE contents, which is especially clear in the most copper-rich sample at 459m, with abundant apatite but only low REE contents. Data on Zr, Nb, Y and Ti may be useful, if a more clear evaluation of the magma-type is required.

Copper in the Quinyambie Breccia Pipe

Copper occurs mostly in samples that contain micaceous to platy hematite, or in the case of the 459m sample, where carbonate appears to replace bundles of earlier fine platy hematite.

Chemically, copper correlates only with cobalt, with cobalt in excess of 18-20ppm correlating well with copper values (correlation coefficient ~0.8), excepting the most copper-rich sample at 459m, which does not have high Co. This observation is consistent with the different paragenesis of copper in this sample. It also suggests that the average silicate fragment may have 18-20ppm Co, with any excess above this value present in sulphide (chalcopyrite or pyrite) and that all of the copper is present as sulphide. Mostly, there seems to be a paragenesis of 1: hematite; 2: pyrite and 3: chalcopyrite, although chalcopyrite may occur without pyrite and with magnetite rather than with hematite and in some samples there are several generations of hematite, pyrite and chalcopyrite. The deeper (>420m) magnetite-rich samples are mostly poor in copper and cobalt. In the sample from 390m there is a later generation of microplaty to earthy hematite followed by later fibrous or ‘earthy’ chalcopyrite replacing earthy hematite. This type of chalcopyrite is not seen in any other samples.

Plotting Cu against Fe showed no correlation (correlation coefficient R ~-0.095).

Comparison with Known Oxide-Copper-Gold Deposits

Mineralogically, this suite has many similarities with known oxide-copper-gold provinces. These include:

1. Abundant albite and/or K-spar, with checkerboard albite locally in clasts and also in the hydrothermal cement in breccias, suggesting temporal variation from K-rich to Na-rich brines.
2. Local development of scapolite, suggesting highly saline brines at least in some areas.
3. A combination of calc-silicates (epidote, possible tremolite) with oxides and albite, as seen in 'calc-albitites'.
4. Carbonate-albite-apatite-hematite-magnetite associations, commonly with pyrite and chalcopyrite, bridging the transition from 'Kiruna-style' oxide-apatite deposits and oxide-copper-gold associations.
5. The presence of aegirine, indicating NaFe metasomatism, although aegirine is not abundant in oxide-copper-gold associations. Aegirine at Bayan Obo in Mongolia has been used to suggest an association with carbonatite, but the low REE contents of these samples would seem to rule out any such association for QBE #1. Chemically, aegirine-epidote associations seen in veins in this suite is similar in bulk composition to more widespread calcite-magnetite/hematite-albite assemblages, with different silica and CO_2 activities.

The relative sparseness of sulphides, and the lack of a uniform copper paragenesis present problems to interpretation/speculation of economic potential, but there may be zones in the broader breccia body that are more prospective.

CONCLUDING REMARKS

The “Quinyambie Breccia” as described in this report seems to be a phreatic-hydrothermal breccia of mafic to felsic (microsyenite) clasts, with an extensive hydrothermal overprint including local and sporadic veins and small pods of mineralisation. The magma type seems to be moderately alkaline, with no primary quartz, but no primary feldspathoids (e.g. nepheline). The hydrothermal overprint is partly seen as pervasive alteration, involving albite, K-spar, chlorite, magnetite and micaceous to platy hematite as early alteration, plus chlorite and epidote ± aegirine in specific zones. Pyrite and chalcopyrite are commonly associated with hematite and/or (but less frequently) with magnetite and apatite. Later sericite and biotite are also evident, as well as earthy hematite and chalcopyrite. Concentrated space-filling minerals, forming cements and veins include carbonate, hematite, albite, apatite, magnetite, chalcopyrite and pyrite. Chlorite, epidote and aegirine are less abundant and less commonly seen in copper-rich samples than the carbonate-albite-apatite-oxide assemblages.

These samples have many of the characteristics of oxide-copper-gold and oxide-apatite associations, but relatively only very sparse copper sulphides (and it is understood that gold values are extremely low). It may be that potentially more significant mineralisation in this apparently very large hydrothermal/volcanic breccia domain may occur locally in zones with different characteristics (e.g. more abundant apatite) to those seen in this drillhole.

INDIVIDUAL DESCRIPTIONS

QBE #1, 330.5m

Inequigranular, unsorted breccia of chlorite-carbonate-albite-K-spar-magnetite-hematite-chalcopyrite-altered mafic fragments with rare sericite and narrow carbonate veins. A matrix of chlorite, carbonate, oxide and possible K-spar. Chalcopyrite shows various association with hematite, magnetite, pyrite, mostly in an immediate gangue of hydrothermal carbonate and albite. Also leucoxene-altered sphene.

Hand Specimen

Macroscopically, this core-segment seems to represent a relatively homogeneous lithology with abundant disseminated K-spar as seen on the stained offcut, as well as patches of oxide and sulphide. It is possible that there are some small fragments, however. On the macrophoto it can be seen that there is a band separating a possibly large fragment, at one (right hand) end of the area covered by the thin section, from an area with smaller fragments, mostly less than 8mm in size, at the other end. The large fragment has carbonate replacing probable pyroxene phenocrysts.

Thin Section

The thin section shows a degree of heterogeneity with domains, mostly at one end of the section, rich in plagioclase laths about 0.4-0.7mm long, as well as patches of carbonate and minor opaque oxide. There are also abundant irregular patches of carbonate, many of which contain laths of possible low temperature albite less than 1mm long, as well as oxide (magnetite and/or hematite) and minor sulphide (chalcopyrite). A rectangular block about 8mm long in this zone, has sparse patches of carbonate probably derived from pyroxene crystals to 2mm long in a fine-grained groundmass rich in chlorite, with apparent K-spar as well as abundant oxide. A large carbonate-hematite patch occurs adjacent to this block, which is possibly a fragment.

A band rich in chlorite seems to mark the passage from this lithology into a different lithology at the other end of the thin section. This band is only 3-4mm wide and is curved in outline. At the opposite end of the thin section to that containing the plagioclase-rich patches there are patches of carbonate with lamellae of fine-grained oxide apparently parallel to the cleavage planes of former pyroxene crystals. These patches indicate former pyroxene was present as crystals to 4mm long and also as much as 4mm in diameter. Small rectilinear patches of sericite appear to have replaced rare plagioclase laths about 0.5mm long. Minor granular oxide is also present. The groundmass in this area is rich in fine-grained massive chlorite, but plagioclase and K-spar are present in other areas. (The K-spar is not clearly evident in thin section and is best seen on the stained offcut.) This whole area may be part of a large altered mafic fragment.

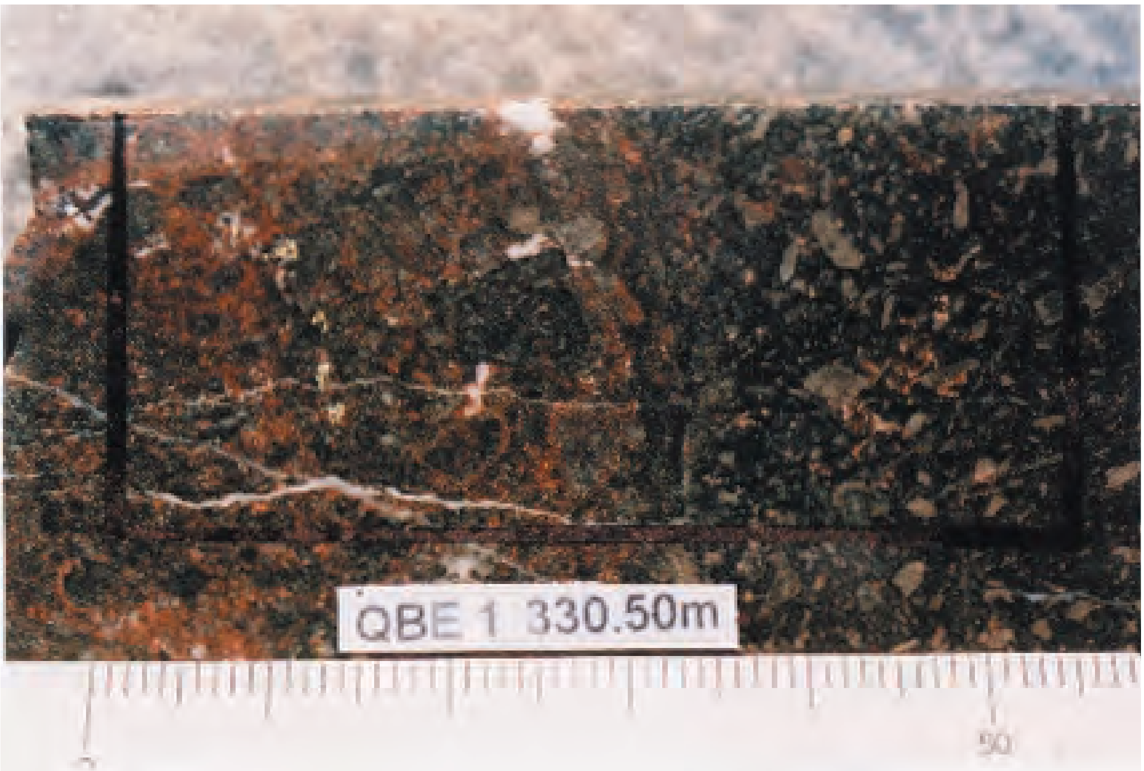
Reflected light microscopy shows the following 'ore' minerals:

		Estimated abundance
*	Magnetite, small microphenocrysts to 0.8mm diameter, fairly even distribution through all domains commonly corroded-looking and partly altered to hematite. Mostly inherent to the host rock, but also accompanies hydrothermal sulphide mineralisation.	2-3%
*	Leucoxene, small scattered grains after sphene	1%
*	Hematite (1) dispersed minute grains <0.03mm in host rock and in carbonate alteration, rarely in carbonate veins	1%
*	Hematite (2) very fine platy/specularitic crystals commonly in small patches of carbonate alteration, rarely in carbonate veins.	1%
*	Chalcopyrite scattered as small grains about 0.1mm, rarely to 1mm, scattered as individuals and in small clusters, mostly associated with carbonate ± albite, small patches and veins, some also associated with platy hematite. Some chalcopyrite has inclusions of magnetite, rarer finer hematite.	1%
*	Pyrite associated with chalcopyrite	<1%

Interpretation

All of the fragments in this thin section seem to be relatively mafic, but some, with minor to abundant carbonate-altered pyroxene phenocrysts, seem to be more mafic and may pass from basalt to ankaramite. Other fragments are richer in plagioclase, but oxides are abundant throughout. There is also abundant chlorite, as well as irregularly disseminated K-spar, most clearly seen on the stained offcut.

Disseminated magnetite and leucoxene after sphene are inherent to the host rock. The accessory scattered chalcopyrite > pyrite and more or less associated very fine platy hematite, carbonate ± albite, seems to be a late epithermal mineralisation. Some chalcopyrite does have inclusions of hydrothermal magnetite however.


QBE 1 330.50m
50

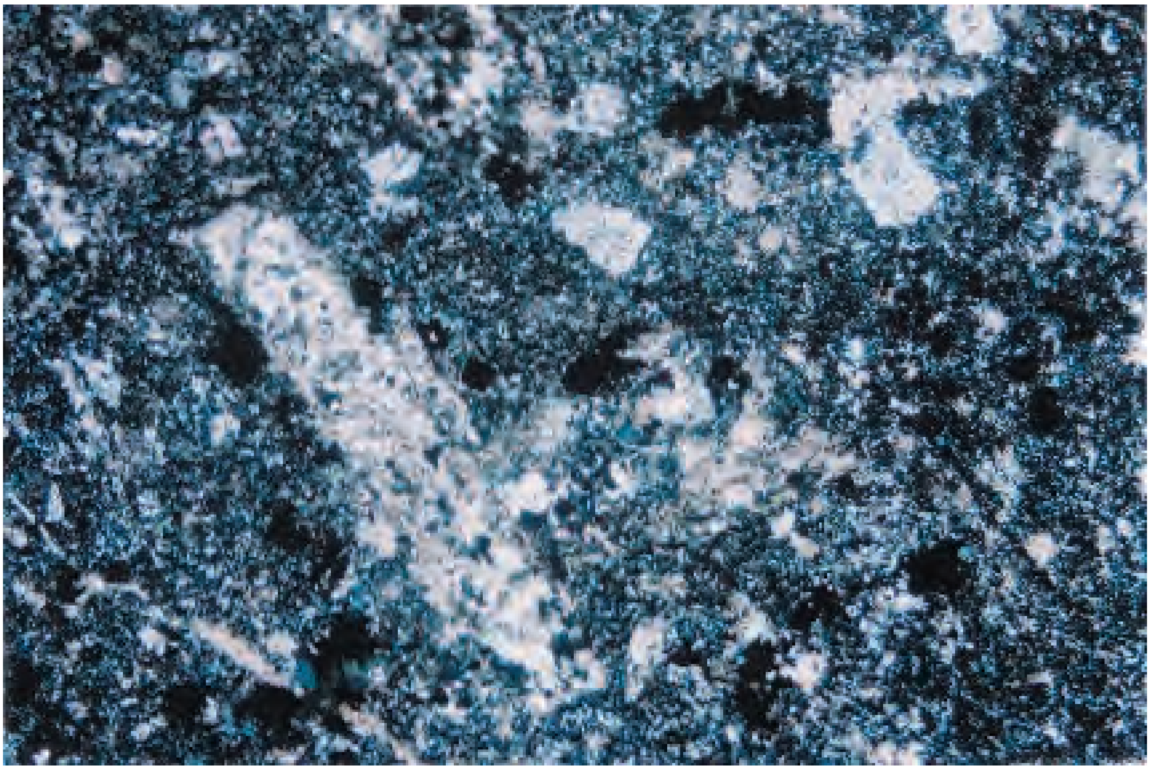


Fig 1 **QBE#1, 330.5m** **0.09 mm**

Thin section (TS), Xnic (x100). Host rock to minor mineralisation in this sample shown here as essentially a basalt, with large phenocrysts of ex-pyroxene replaced by bright white, fine granular carbonate, smaller phenocrysts of sericitised feldspar, in altered fine-grained groundmass. Note numerous disseminated black magnetite crystals (microphenocrysts) also much finer opaque oxide dispersed through the groundmass. These oxides are primary-igneous.

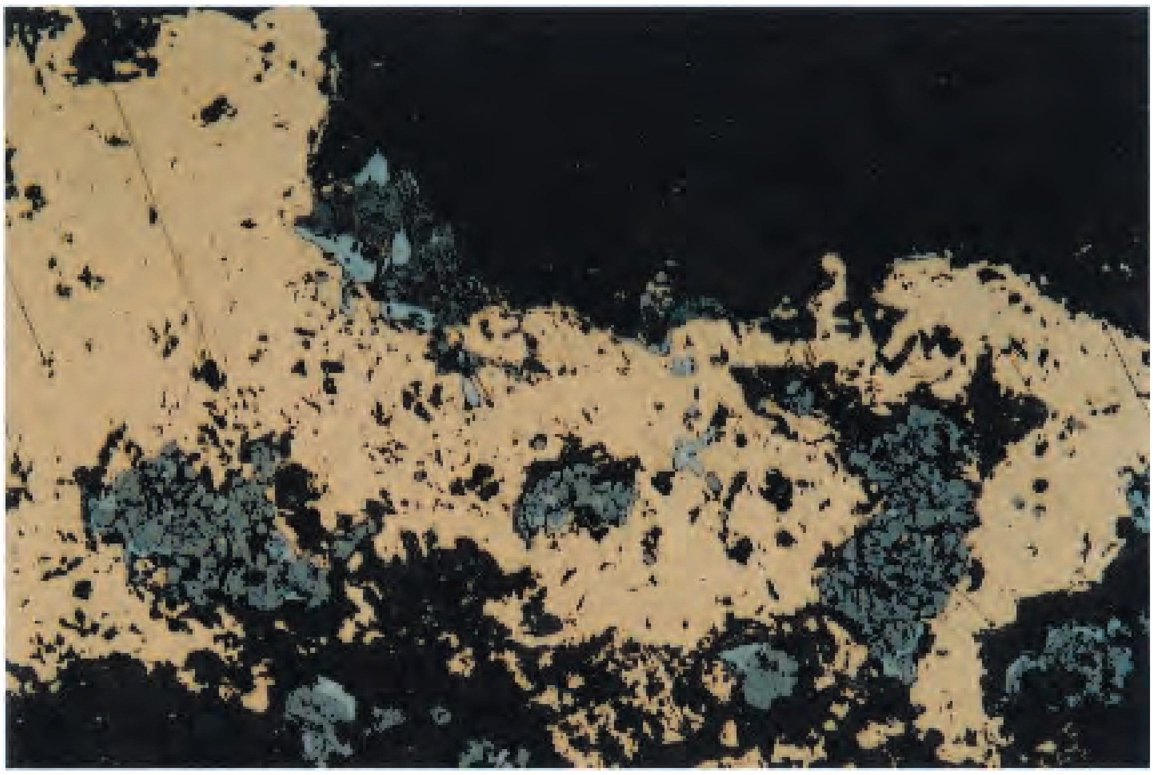


Fig 2 **QBE#1, 330.5m** **0.09 mm**

Polished section (PS), (x100). One example of chalcopyrite association, as a relatively coarse grain, incorporating several clusters of fine granular magnetite, (brownish grey), lesser scattered single very small blades of hematite (pale grey). These oxides seem to be hydrothermal.

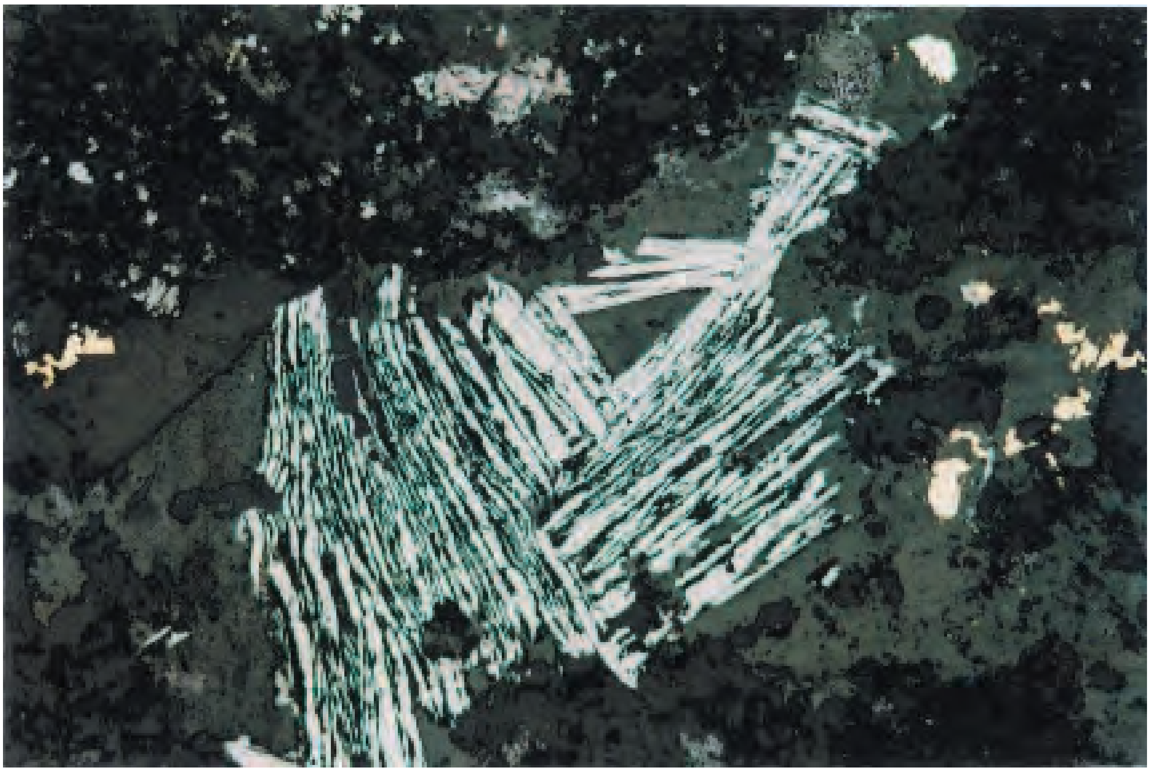


Fig 3 **QBE#1, 330.5m** **0.18 mm**
PS (x50). Another chalcopyrite association, as clusters of very small grains, adjacent to coarse bladed hematite, all enclosed in an immediate patchy-vein of carbonate gangue, all hydrothermal.

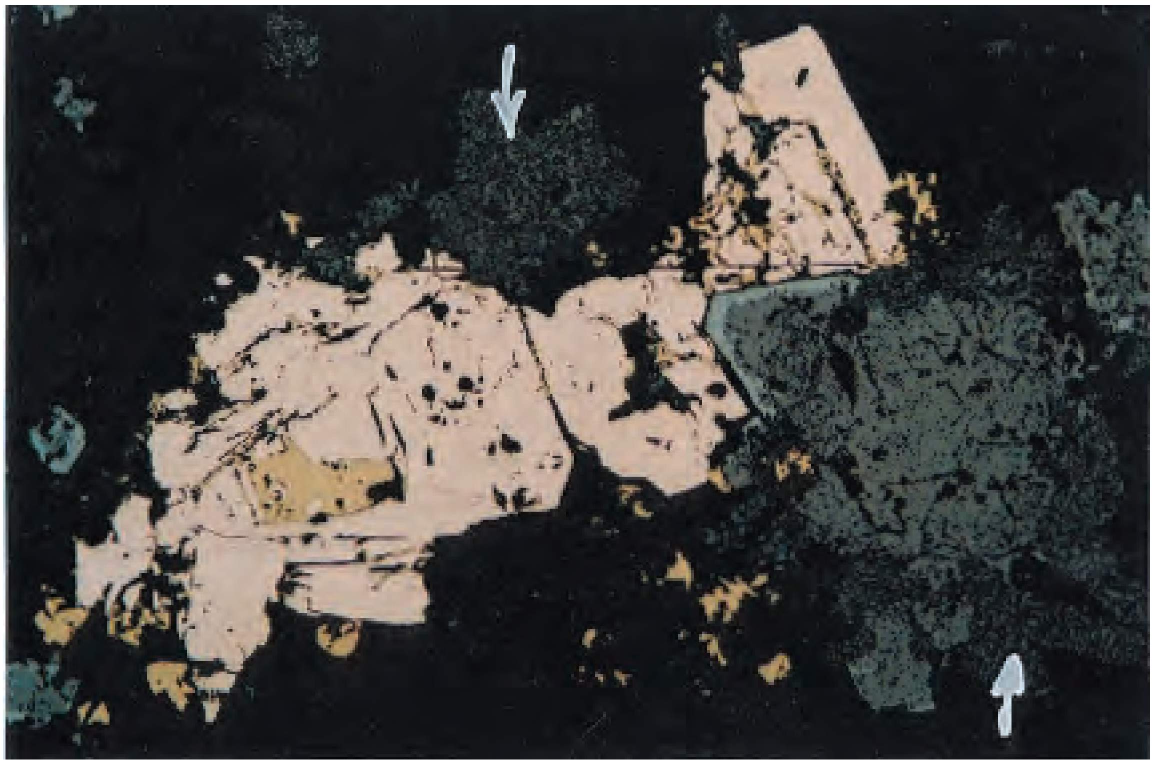


Fig 4 **QBE#1, 330.5m** **0.09 mm**
PS (x100). Another association of chalcopyrite here, as fine grains enclosed in (partly zoned) pyrite, which is composite with euhedral magnetite partly rimmed by hematite, also with several irregular pseudomorphs of leucoxene after sphene (arrowed).

QBE #1, 343.40m

Thin section selectively of a main vein filling, but enclosed in host rock with small areas of breccia including K-spar-rich fragments and albitised areas, cut by stringers containing various proportions of albite, carbonate, magnetite and apatite, leading from a large vein. The main vein has a core of coarse white carbonate and red albite, with several small grains of chalcopyrite, enclosed in a rim of coarse black magnetite crystals and coarse apatite crystals. The coarse magnetite has been altered to limonite and carbonate.

Hand Specimen

This whole core-segment consists of a host rock of inequigranular breccia of angular grey and red fragments but was selected to examine a prominent irregular vein rich in white carbonate surrounded by black magnetite crystals. The vein is at a low angle to the core axis but not completely uniform in orientation along the core segment. The thin section was cut at a very low angle to the plane of the vein, so that the width of the vein in the thin section is much greater than the true width as seen in hand-specimen. The true width is probably 5-10mm, but the vein as seen in the thin section is as much as 25mm wide.

The stained offcut shows that the fragments are rich in K-spar, in a matrix essentially free of K-spar. It also shows abundant probable albite in the vein. The albite is red in the macrophoto, with black magnetite, white carbonate and grey coarse-grained material. Planar red and white veins are also visible in the macrophoto, at higher angles to the core-axis.

Thin Section

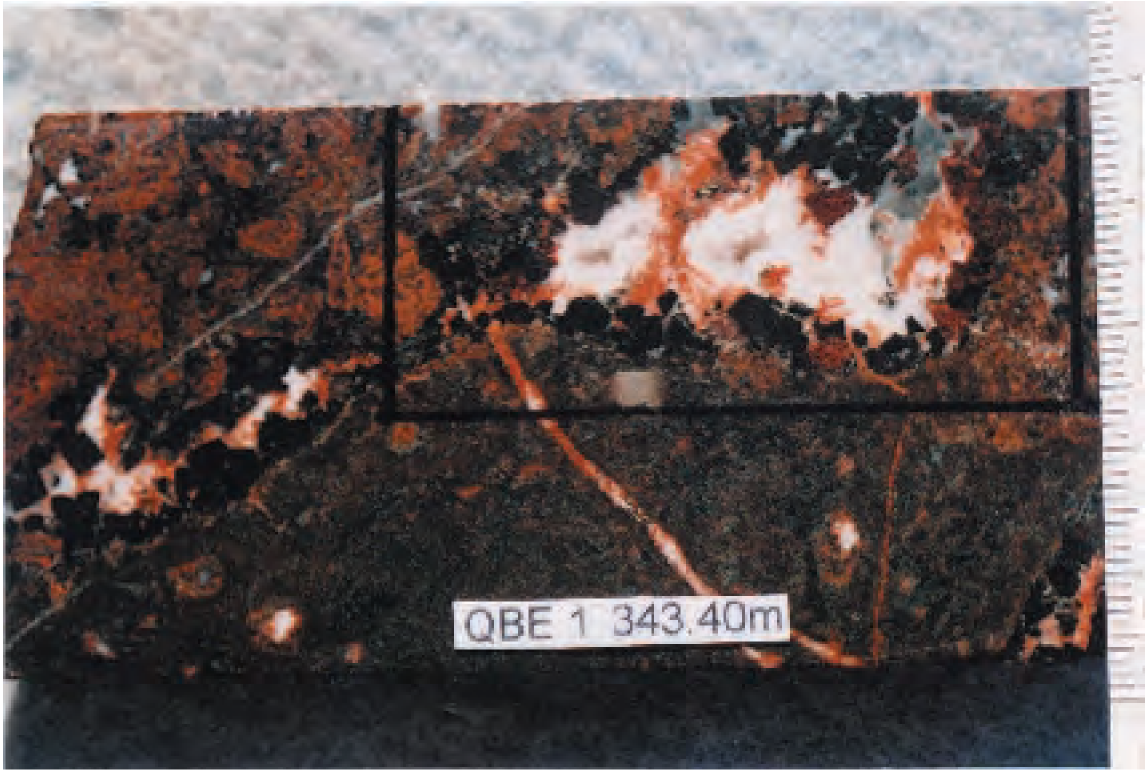
This section was cut to selectively enclose the mineralised vein, with only small areas of surrounding country rock, some of which are very fine-grained, apart from elliptical patches of clear, possibly albitised plagioclase laths to 1.5mm in diameter and minor sulphide. These areas are pale orange in thin section and seem to be rich in clay, oxide and carbonate, probably with abundant K-spar, although this is not clearly visible in thin section. Grey areas have plagioclase laths and poikilitic grains of checkerboard albite, probably derived from

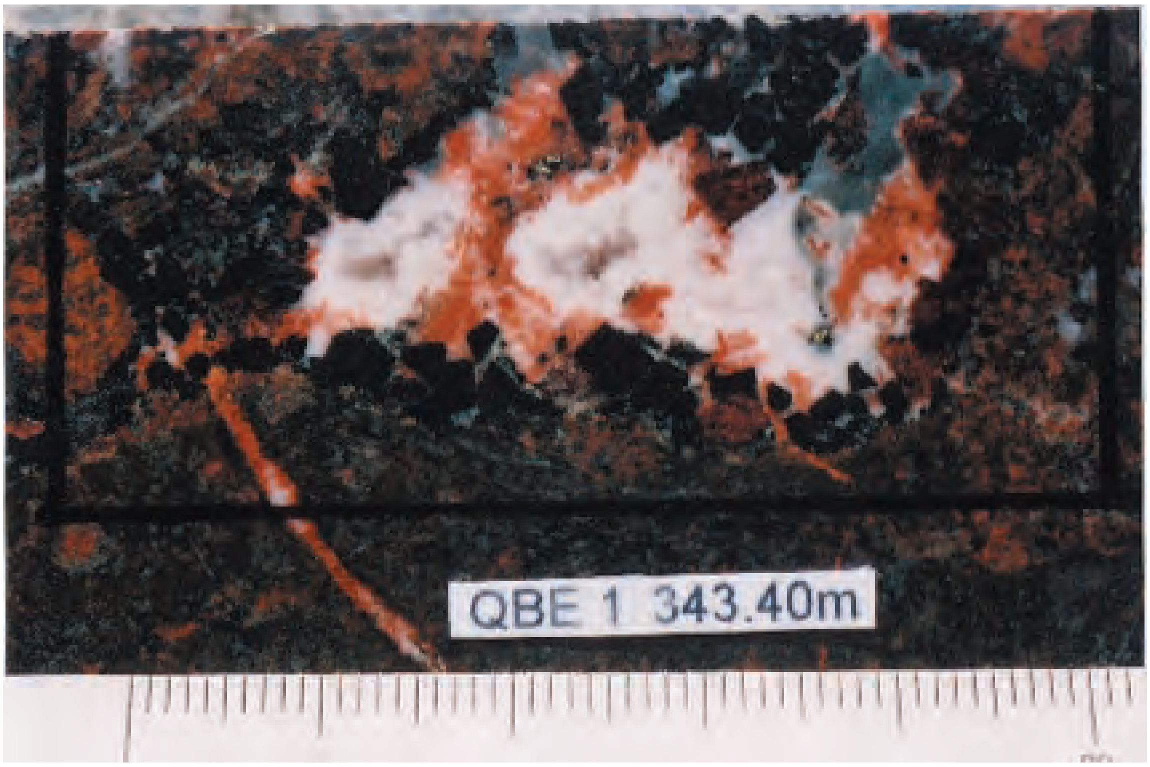
K-spar, as well as abundant very fine-grained oxide and minor carbonate. Stringers within the host rock are variously rich in albite, carbonate, apatite and magnetite representing offshoots from the main vein. The disseminated oxide in the country rock includes inequigranular magnetite as well as less abundant microplaty hematite. The magnetite occurs partly as microphenocrysts to 0.3mm in diameter, as well as more abundant grains less than 0.1mm in size and less abundant hematite. Rare pyrite and chalcopyrite are disseminated as small grains, with larger chalcopyrite grains in some carbonate-rich patches.

The main vein has a core of coarse white carbonate and red prismatic crystals of albite, with margins rich in coarse black magnetite crystals and coarse apatite. The core has mostly very coarse carbonate, with minor areas of very fine-grained, possibly recrystallised carbonate. Patches and lenses of decussate, bladed crystals of albite are up to 2.5mm long. On the margins there are partly euhedral crystals of apatite and magnetite as much as 4 or 5mm long. Most of the magnetite crystals have been fractured and veined by carbonate, with partial replacement by hematite and carbonate. Minor chalcopyrite occurs in fractures in both magnetite and apatite, as well as in core carbonate. Areas of carbonate and albite occur between the magnetite and apatite crystals and extend into the country rock. Minor sulphide is present in the carbonate-albite zone in the core of this vein, with large patches of chalcopyrite to 3 x 2mm locally containing fragmented pyrite inclusions.

Interpretation

This host rock has probably less mafic fragments compared with the previous sample. The major and subsidiary complex veins involve Na-Ca-Fe-P-CO_2-rich fluids with minor associated chalcopyrite.


QBE 1 343.40m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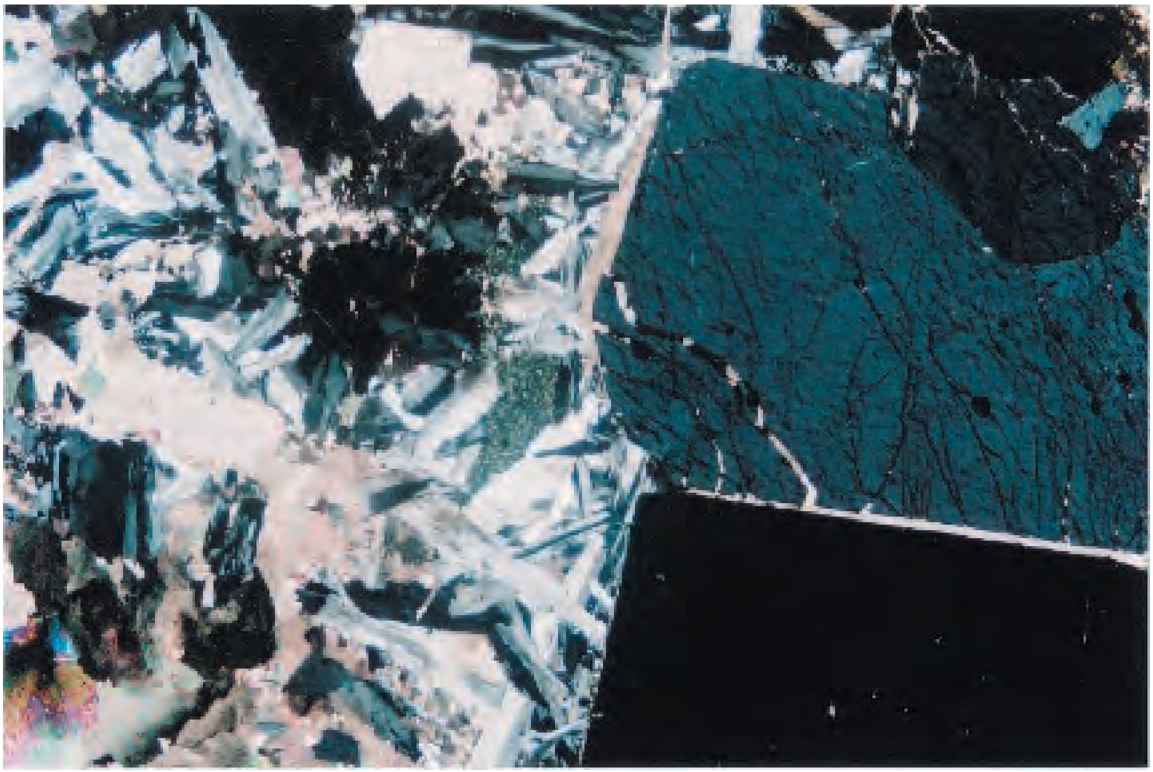


Fig 5 **QBE#1, 343.4m** **0.45 mm**

TS. Xnic. (x20). Part of the hydrothermal mineralised vein as described, core of carbonate with random laths of albite. Coarse euhedral crystals along the margin of this carbonate-albite, here shows as cubic magnetite (black-opaque), in contact with two large apatite crystals (mid and dark grey).

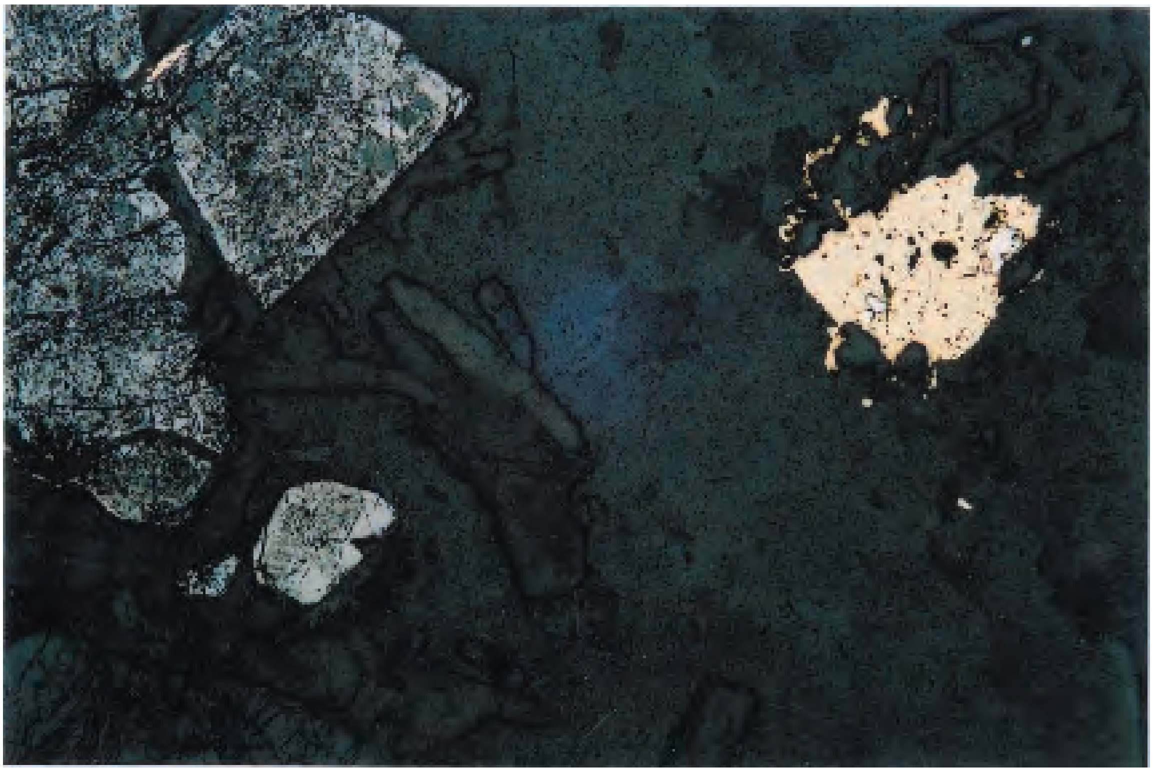


Fig 6 **QBE#1, 343.4m** **0.45 mm**

PS (x20). As above, reflected light shows coarse euhedral magnetite crystals, partly altered to corroded looking carbonate and hematite, located within loosely clustered albite laths, all within carbonate which also encloses chalcopyrite, which has minute inclusions of white pyrite.

QBE #1, 351.7m

Volcanic breccia with grey, K-spar-rich mafic to intermediate fragments (including a possible dyke), and reddish albitised fragments (partly porphyritic microsyenite).
Heterogeneous hydrothermal mineralisation as a cement between fragments, also disseminated through them include carbonate, albite, fresh to altered scapolite, numerous hematite, chlorite, green-biotite, pyrite, chalcopyrite and apatite. Albite-carbonate and carbonate veins are present.

Hand Specimen

Two thin sections were cut from this long core segment, as shown on the macrophoto, one on either side of a dark grey lithology, possibly a dyke or a rectilinear fragment, 45-50mm wide, in contact with a breccia of pale red and grey fragments. This sample seems to vary rapidly in the direction at 90º to the plane of the thin sections however, as the distribution of lithologies, as seen in each section, is somewhat different to that seen on the stained offcut. In thin section ‘A’, which contains a lens of specular hematite and chalcopyrite, the area of grey lithology is much less than that on the stained offcut, and the lens rich in platy hematite crystals is larger than retained on the offcut. The grey vein, which in the thin section is partly along the margin of the grey lithology, is well within the grey lithology in the offcut, with a parallel vein rich in K-spar, also within the grey lithology, not visible in the thin section. Differences between the offcut and thin section are less obvious in thin section ‘B’, but the shapes of the fragments and hematite-sulphide patches are different.

Thin Section ‘A’

This thin section has two areas of the grey lithology referred to above, separated by a pale grey vein 2mm wide. On the stained offcut the grey lithology is seen to have a groundmass rich in fine-grained K-spar, and in thin section is seen to have scattered phenocrysts of albitised plagioclase and checkerboard albite, possibly derived from K-spar. These phenocrysts occur singly or in aggregates and are mostly less than 2mm long. There are also sparse chlorite-oxide-altered mafic phenocrysts, pyroxene or hornblende, to 1.5mm long, and abundant microphenocrysts of magnetite. The groundmass has clays, oxide and carbonate as well as pale pink K-spar and disseminated very fine magnetite, rarely accompanied by finer rare hematite. Accessory extremely fine (0.1mm) grains of chalcopyrite are scattered. The pale grey vein is composed of fine granular carbonate.

Other fragments in this section seem to be richer in feldspar, including irregularly disseminated K-spar and probable albite, but are also irregularly flooded by carbonate and lenses and lamellae rich in fine prismatic apatite, probably of hydrothermal origin. Phenocrysts are sparse and mostly smaller than those in the grey areas, but include albite after plagioclase and checkerboard albite. Very fine accessory magnetite grains > hematite are disseminated and there are irregular masses of chlorite ± smectite, locally with fresh or clay-altered biotite.

Hydrothermal mineralisation within this thin section A is manifest as coarse sparry carbonate enclosing prismatic apatite and aggregates of bladed hematite crystals, between fragments. In particular, this is seen as a mass of coarse bladed hematite crystals, in parallel or radiating aggregates to 10mm long, accompanied by abundant granular or prismatic scapolite (partly altered to clay) as well as carbonate and minor apatite. The hematite is partly planar and partly bent or contorted and accompanied by pyrite as partly euhedral crystals to 2mm in diameter, and larger masses of chalcopyrite to 5 x 2mm, some of which enclose residual masses of pyrite, commonly fractured and resorbed. Green biotite dominates a lens 4 x 2mm, adjacent to a carbonate apatite-chalcopyrite veinlet.

Thin Section 'B'

This section contains part of the same mass of grey rock seen in thin section 'A', also with sparsely disseminated phenocrysts of albitised plagioclase and of checkerboard albite. There are also larger, more abundant mafic phenocrysts, to 2mm long, altered to carbonate with only minor oxide and chlorite. The groundmass is rich in K-spar but also has oxides, carbonate and quite abundant chlorite in irregular aggregates ± green biotite. Smaller, ragged fragments of probably more K-spar-rich lithologies occur, largely without phenocrysts or with smaller and fewer phenocrysts, as in thin section 'A'. These fragments have a similar oxide assemblage as that seen in the more mafic clasts in thin section 'A', with magnetite partly as microphenocrysts and partly disseminated and much finer grained. However, there is minor leucoxene, possibly derived from sphene, as well as very minor microplaty hematite. Very minor fine-grained chalcopyrite is present.

A large reddish fragment is seen to be composed largely of granular checkerboard albite, with abundant scattered phenocrysts to 4mm in diameter also altered to checkerboard albite. This fragment also has minor carbonate and rare fine-grained oxide and may have been a microsyenite. There are only rare oxides in the microsyenite, mostly microplaty hematite and leucoxene derived from sphene.

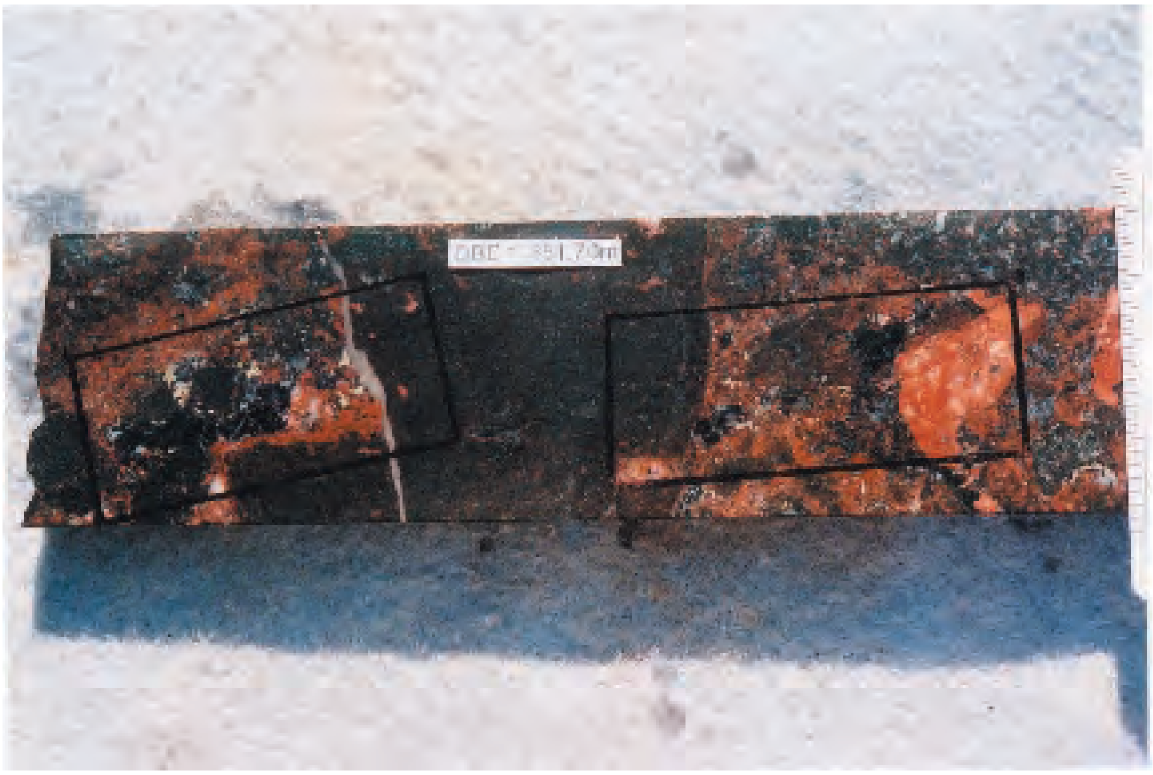
Hydrothermal mineralisation is manifest as poorly defined areas of carbonate flooding, fine green biotite and chlorite, also with albite and/or prismatic apatite between fragments, with patches of micaceous hematite associated chalcopyrite and pyrite. As in thin section A, the hematite occurs as parallel and sub-radiating bundles of platy crystals, but these are commonly mantled by small nodular aggregates of earthier hematite. The albite is mostly anhedral and may represent fragments, with albitised plagioclase laths partly enclosed in checkerboard albite. Minor chlorite, green biotite and apatite are also disseminated. In this thin section, pyrite is more abundant than chalcopyrite, largely as euhedral crystals to 0.7mm in diameter. The sulphides occur separately or as composites, locally with hematite, which they seem to postdate. A vein of coarse bladed albite crystals and interstitial carbonate is present in the grey lithology.

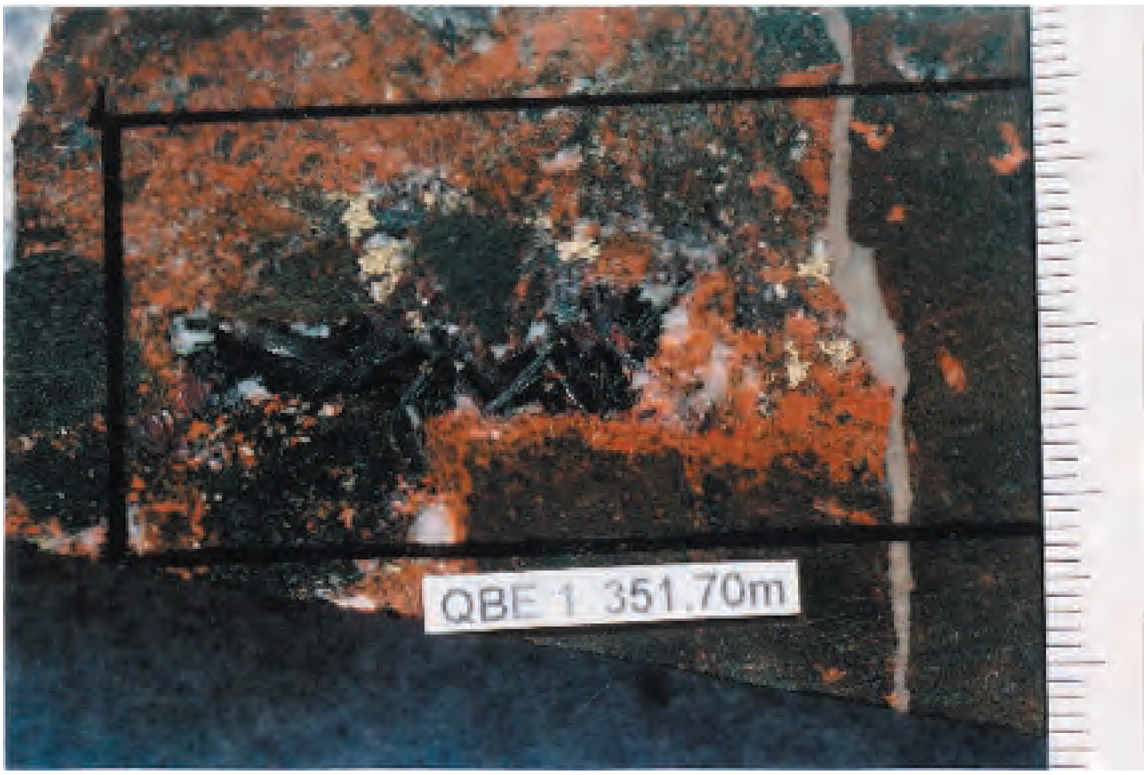
Interpretation

The two thin sections from this long core segment of heterogeneous breccia include a band of K-spar-rich grey, possibly mafic lithology that may represent a small dyke or an unusually rectilinear fragment, cut by carbonate veins and albite-carbonate veins. Other numerous reddened fragments are more feldspathic, including K-spar-rich lithologies, as well as albitised, formerly K-spar-rich porphyritic microsyenite. Hydrothermal mineralisation, mostly between fragments (as a cement) but also as flooding and disseminated through fragments, involve a mineral assemblage of fine to coarse carbonate, weakly to strongly altered scapolite, albite, chlorite, micaceous hematite, pyrite and chalcopyrite.

The ore mineral abundances in the thin sections are biased because these sections selectively cover the most mineralised areas (25 x 65mm) within the core segment. Representation in these two areas however are :

Micaceous hematite	5%
Magnetite	3-5%
Chalcopyrite	1-2%
Pyrite	1-2%


QBE 1 351.70m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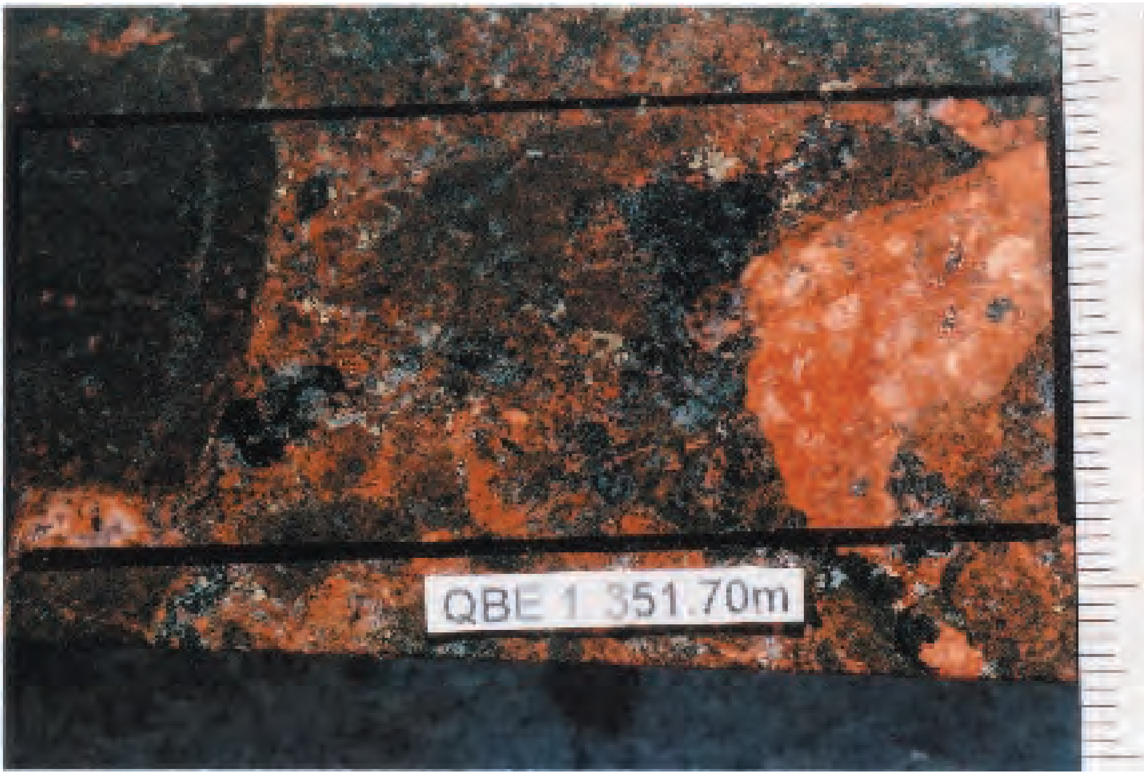
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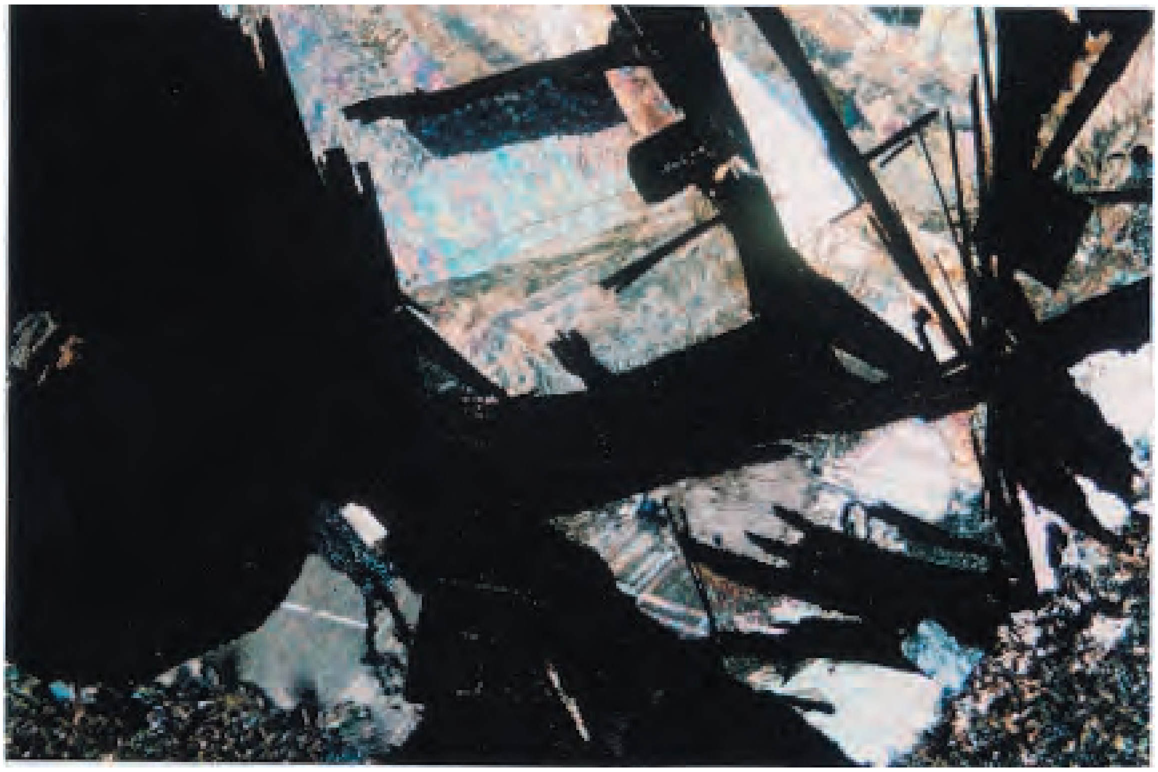


Fig 7 **QBE#1, 351.7A** **0.45 mm**

TS (x20) Further example of coarse hydrothermal veining, with randomly bladed hematite, cubic pyrite crystals, irregular chalcopyrite grains all in coarse carbonate.

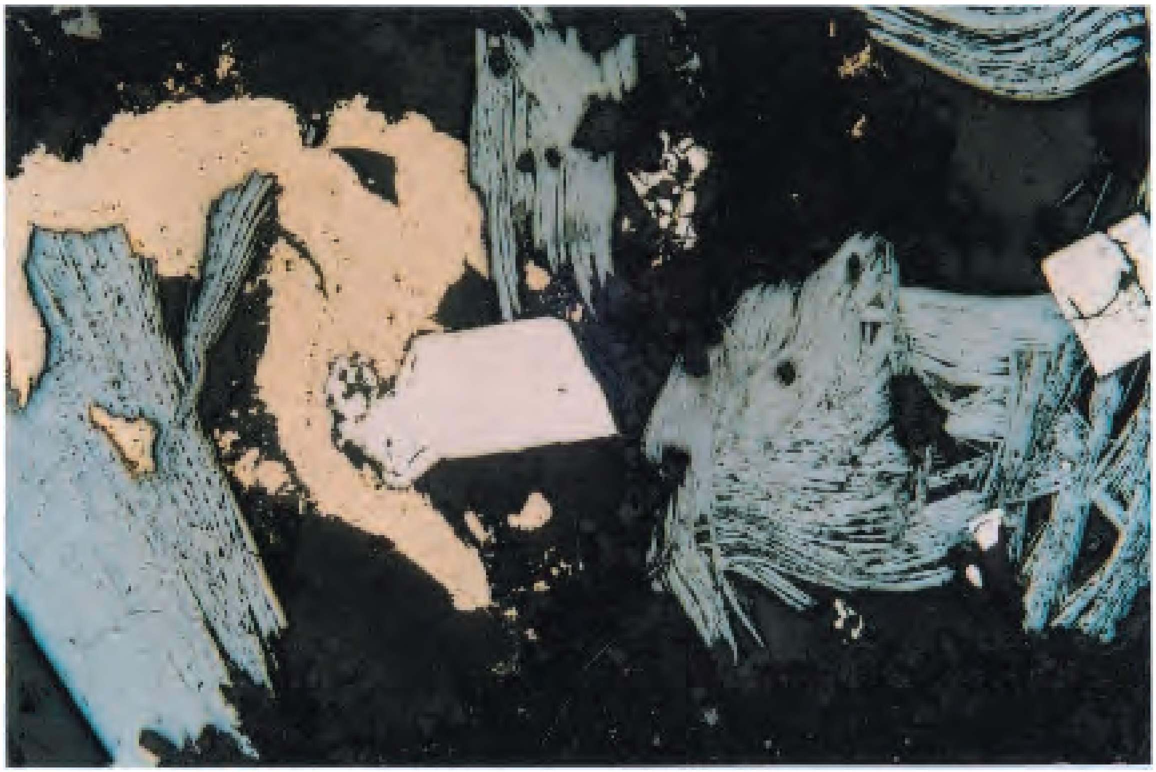


Fig 8 **QBE#1, 351.7A** **0.45 mm**

PS (x20). As above with reflected light showing detail of bladed hematite, pyrite crystals and chalcopyrite.

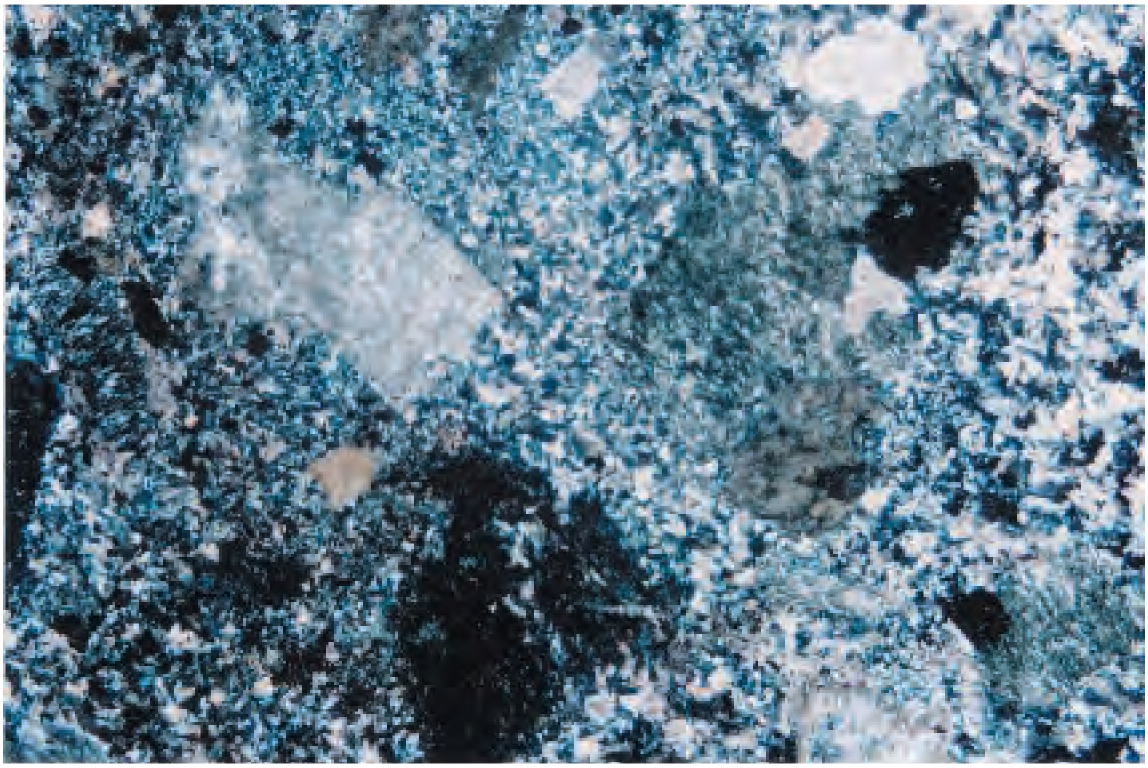


Fig 9 **QBE#1, 351.7B** **0.45 mm**

TS. Xnic (x20) Host rock of albitised porphyritic microsyenite, which forms one clast in this breccia, with accessory scattered black-opaque magnetites.

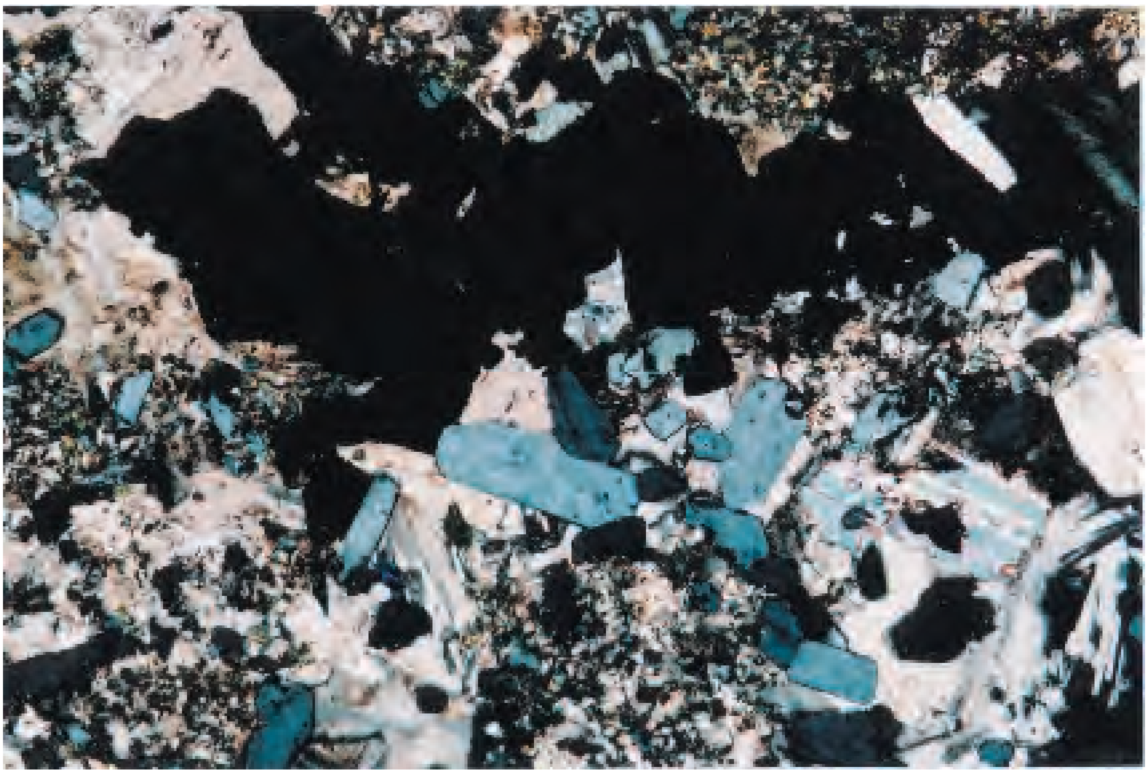


Fig 10 **QBE#1, 351.7B** **0.18 mm**

TS. Xnic (x50). Further example hydrothermal vein, showing numerous apatite crystals, lesser albite crystals, in carbonate, together with black opaque sulphide and iron oxide.

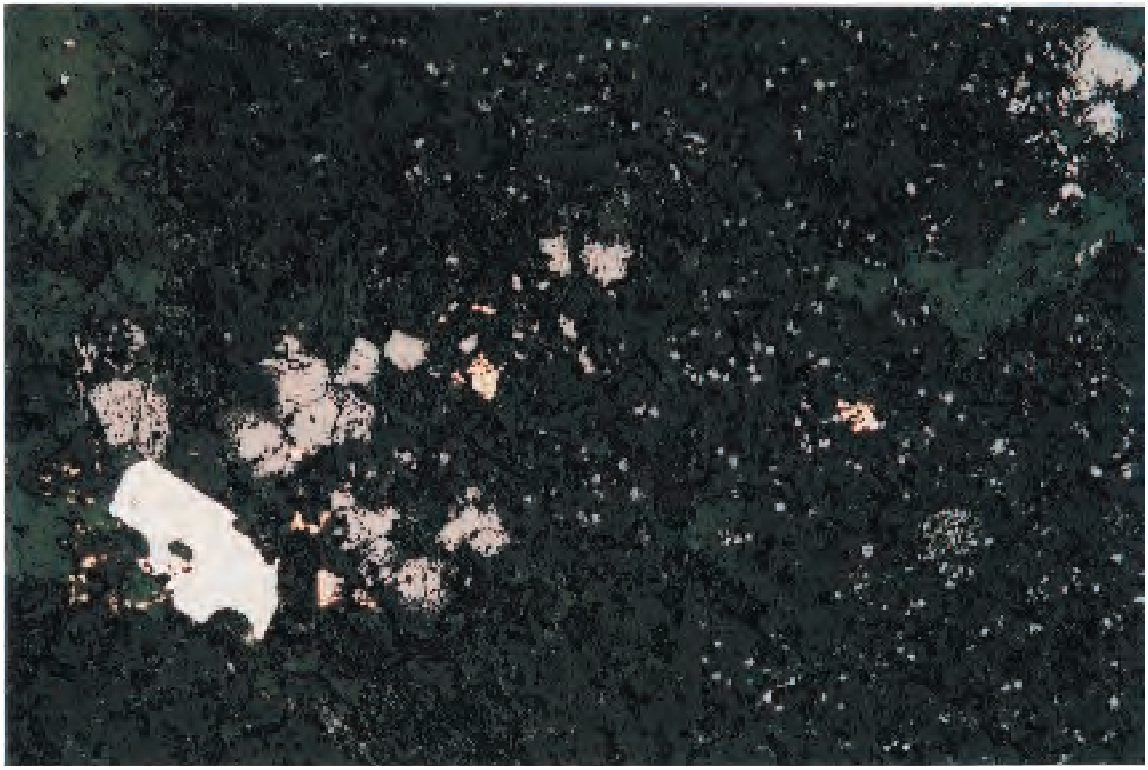


Fig 11 **QBE#1, 351.7B** **0.18 mm**

TS (x50). Another clast in this sample is reddened (K-spar altered) probable original mafic volcanic seen in most of the photos with fine disseminated magnetite. A cluster of coarser magnetite crystals (and a pyrite crystal) adjacent to a vein. Is this coarser magnetite hydrothermal or a primary igneous component of the host rock?

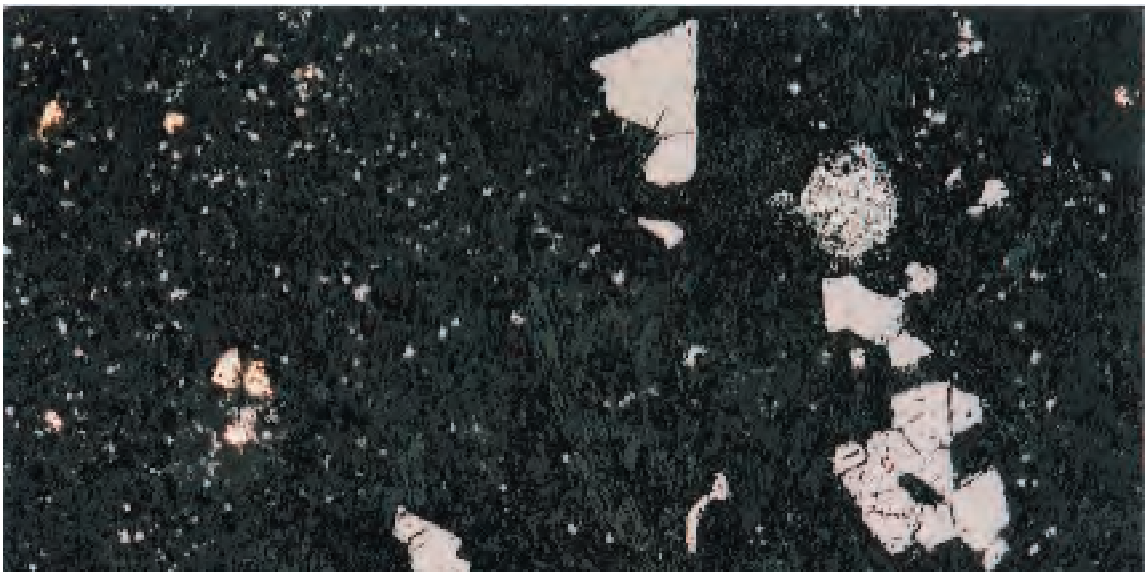


Fig 12 **QBE#1, 351.7B** **0.18 mm**

PS (x50). Same question as above applies to coarser magnetic crystals in this photo. Small cluster of yellow chalcopyrite grains in carbonate.

Fig 13 **QBE#1, 351.7B** **0.45 mm**

PS (x20). Coarse cube of pyrite with fine inclusions of chalcopyrite within cluster of coarse bladed hematite bundles.

QBE #1, 368.3m

Breccia with large, reddish fragments of albitised microsyenite porphyry also of more K-spar-rich aphyric and originally more mafic fragments. Frequent areas of carbonate and of smectite ± chlorite, as well as various poorly defined veins with carbonate, quartz, albite sparse (<<1%) extremely fine chalcopyrite > pyrite, micaceous hematite.

Hand Specimen

This is again from a long core-segment with a large reddish sparsely porphyritic felsic volcanic fragment about 80mm long together with numerous fractured greenish-grey and apparently more mafic fragments, clustered in areas to 30mm long. Space-filling irregular lenses of clay or chlorite are present, to 20mm long. Several white carbonate veins at a low angle to the core-axis.

Thin Section

Petrographically the large reddish fragment is seen to have been albitised with phenocrysts of checkerboard albite to 6mm long, mostly anhedral, in a fine-grained albite-rich groundmass. Inequigranular carbonate is scattered, with trace minute flakes of hematite, accessory leucoxene after sphene and rare unidentified and possibly clay-altered, leucoxene-rimmed grains. This red fragment seems to represent an albitised microsyenite porphyry and may be related to the microsyenite fragment in the previous sample. Rare chalcopyrite grains (<<1%) to 0.2mm occurs in this fragment, locally with minute inclusions of pyrite.

The other fragments are rich in fine granular K-spar but seem to have originally been more mafic. These fragments are mostly aphyric with fine chlorite, carbonate, oxide and leucoxene alteration, as well as K-spar and possibly some plagioclase or albite. Small fragments, to 2mm in diameter, are composed largely of decussate fine-grained albite with very minor oxide. As in other mafic clasts, minor disseminated opaque oxide grains include magnetite microphenocrysts, much finer dispersed magnetite ± hematite in the groundmass, and rare microplaty hematite. Stylolites, with chlorite and oxide ± leucoxene, are present and pass into chlorite-rich microshears to 2mm wide.

Large and small areas of coarse sparry carbonate are present. The patches visible in hand-specimen seem to be composed of inequigranular, massive smectite ± chlorite, with rare pyrite crystals to 0.2mm in size.

Early quartz and albite-rich veins are followed by carbonate veins with rims of chlorite. Later carbonate veins and carbonate-quartz veins occur, partly parallel to the core-axis, as seen in hand-specimen. Sparse very small grains of chalcopyrite ± trace pyrite are loosely clustered in some early, boudinaged veins with quartz and carbonate. Total sulphide content in the thin section is <<1%.

QBE #1, 374.10m **Breccia with reddish fragments of albitised microsyenite porphyry and of darker grey albite-chlorite-carbonate-altered vesicular mafic rock with carbonate filled vesicles. Patches of carbonate with chlorite, accessory micaceous hematite, lesser very small pyrite grains, rare-trace minute chalcopyrite.**

Hand Specimen

Fragments randomly scattered throughout this sample consist of red porphyritic volcanic, darker grey possibly porphyritic or vesicular probable mafic fragments up to 40mm in diameter. Some fragments, seen on the macrophoto, seem to have been fractured and fragmented in situ and show a jigsaw-fit on the core segment. There is little or no K-spar in this sample, as seen on the stained offcut.

Thin Section

The red fragment is again an albitised porphyritic rock with abundant phenocrysts of checkerboard albite to 6mm long, mostly anhedral, as well as less abundant albitised plagioclase phenocrysts to 4mm long. The plagioclase phenocrysts are mostly euhedral and enclose ragged patches of carbonate. Patches of carbonate are up to 4mm in diameter, variously enclosing minor fine epidote, fine platy hematite and fine-grained albite. The groundmass is microgranular and rich in albite with minor disseminated oxide, mostly microplaty hematite, as well as leucoxene apparently derived from sphene.

The dark fragment in this section is an altered mafic and has abundant carbonate in patches to 5mm long, partly coalescent and apparently representing vesicles. There are also abundant small aggregates of chlorite and oxide, possibly representing large skeletal oxides. The bulk of this rock type is rich in feldspar, mostly albite, with chlorite and oxide. Poikilitic, inclusion-rich pyrite crystals occur to 0.6mm in diameter and there is minor leucoxene after sphene as well as rare chalcopyrite.

This dark area seems to pass into pale areas with albite and carbonate but only minor chlorite and oxide. Irregular stylolites are present in this area, mostly rich in chlorite and oxide, and there are irregular patches of sulphide. Irregular masses of carbonate occur, partly between the fragments, with decussate chlorite or large radiating plates of hematite to 5mm long. There may be some separate fragments in this area, some of which are dominated by decussate albitised plagioclase laths about 1mm long, as well as abundant fragments of more typically mafic material, mostly richer in albitised plagioclase than the darker areas described above.

Interpretation

This is a volcanic breccia with a combination of reddish albitised microsyenite porphyry fragments, as in the previous sample, and albite-chlorite-carbonate-altered mafic rock with carbonate-filled vesicles and carbonate-rich patches containing chlorite or hematite. 'Mineralisation' is represented by several small clusters of fine micaceous hematite (1%), associated with carbonate, rarer scattered small grains of pyrite, rare trace minute chalcopyrite grains.


QBE 1 374.10m


QBE 1 374.10m

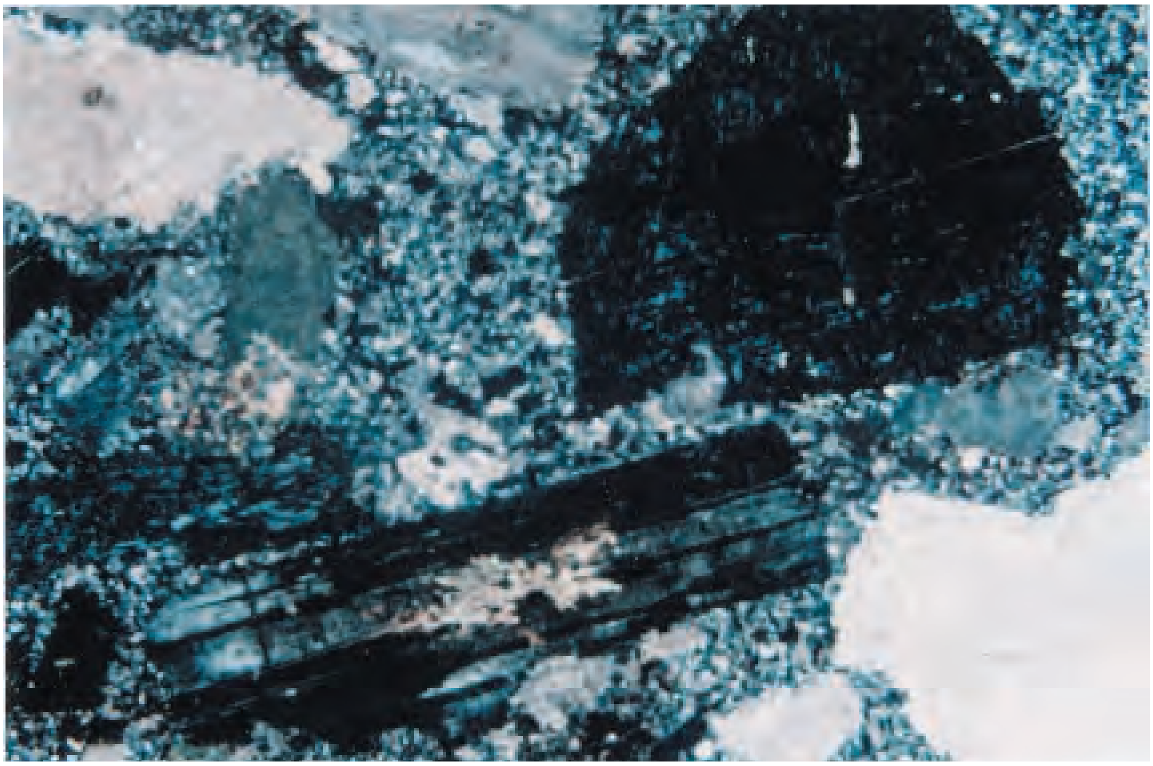


Fig 14 **QBE#1, 374.10m** **0.45 mm**

TS. (x20) One clast in this breccia of albitised porphyritic microsyenite. Albitised plagioclase occurs as a phenocryst, containing a patch of carbonate, at the bottom of the photo. The other phenocrysts are mostly checkerboard albite and were probably K-spar.

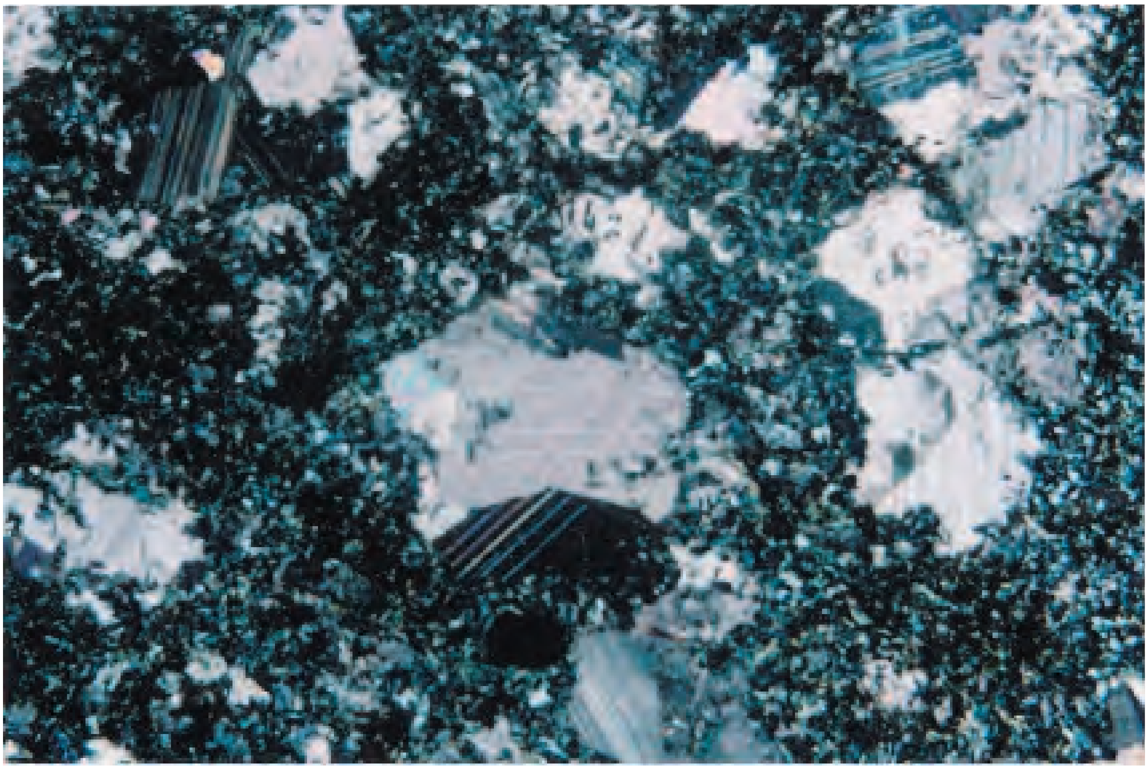


Fig 15 **QBE#1, 374.1m** **0.45 mm**

TS (x20). A second clast in this breccia, essentially mafic/basaltic, here seen to incorporate numerous vesicles filled by carbonate.

QBE#1, 390m

Breccia with volcanic fragments extensively altered to K-spar-hematite and carbonate-hematite, with veins of hematite, chalcopyrite, and chlorite, plus late carbonate veins. Mineralisation genesis involves complex intergrowths of platy hematite and granular chalcopyrite-pyrite plus fluorite, followed by microfeathery to earthy hematite, partly replaced by earthy and fibrous chalcopyrite.

Hand Specimen

This small sample was selected to represent quite coarse specularite sulphide mineralisation up to 25mm across between altered reddened volcanic rock fragments. The hematite and chalcopyrite are well displayed on the macrophoto. Most of the fragments are rich in K-spar, as seen on the stained offcut, but one fragment, which is deep red in hand-specimen, is rich in carbonate.

Thin Section

Most of the fragments in this sample have a primary aphyric microcrystalline to cryptocrystalline volcanic texture, but together with very irregular masses of hematite with reddened carbonate and rare quartz. The groundmasses are fine-grained and heavily clouded by limonite ± hematite and clay, also seen on the stained offcut to be rich in K-spar. The darkest fragment is rich in microspherulitic carbonate, quite densely reddish, stained by hematite and with interstitial granular or microplaty hematite. In some areas there are interstitial masses of chlorite ± smectite, partly clouded by limonite. Rare aggregates of albitised plagioclase phenocrysts occur, with individual crystals to 2mm or more in length, and there are elongate parallel bundles of hematite plates to 8mm long are scattered. In the more feldspathic fragments there are abundant patches and veins of microplaty and massive or microspherulitic fibrous to earthy hematite. These locally enclose patches of massive and ‘earthy’ chalcopyrite, mostly as a fine grained aggregate enclosed in granular carbonate, to 2mm long.

The most concentrated mineralisation, in an irregular area between fragments about 15mm across, consists of a cluster of coarse pyrite crystals to 6mm across, scattered irregular patches of chalcopyrite to 3mm and random sheafs of micaceous to platy hematite to 7mm long, enclosing small clusters of albite crystals to 1.5mm long. Very small inclusions of pyrite occur in the chalcopyrite. This aggregate is adjacent to the massive hematite-stained microspherulitic carbonate domain, also adjacent to clearer vein carbonate. Numerous very irregular patches of extremely fine feathery to earthy and microspherulitic hematite are scattered, some with intricately intergrown chalcopyrite with this same ultrafine earthy to microspherulitic chalcopyrite (not seen elsewhere) suggesting late stage replacement, of this hematite by the chalcopyrite.

Irregular veins or bands of chlorite occur adjacent to the hematite-sulphide masses, and one area of coarse hematite passes into a lens of granular fluorite with veins of carbonate on grain-boundaries. There are also two later carbonate veins at about 40º to each other. The main vein is parallel to the core-axis, and is filled by carbonate, mostly fibrous and microspherulitic, in two main veins to 3mm wide.

Interpretation

This sample has a chalcopyrite-hematite association, with hematite-K-spar and carbonate-rich altered fragments and late carbonate veins, but no apatite. Hematite occurs in two generations, an early coarse platy hematite in sheaf-like clusters, followed by coarse pyrite and chalcopyrite and a later generation of microfeathery to microspherulitic hematite, replaced by feathery and earthy chalcopyrite. The paragenesis in the veins seems to be:

- Coarse platy hematite, together with carbonate, albite and fluorite;
- Pyrite, clustered euhedral crystals locally fractured and veined
- Chalcopyrite, largely granular in irregular patches, enclosing a second generation of fine-grained pyrite inclusions
- Fine microplaty, microspherulitic and earthy hematite, partly along fractures in the early coarse pyrite, partly enclosing magnetite
- Feathery and earthy chalcopyrite locally replacing the earthy and microspherulitic hematite. In the volcanic fragments, massive and earthy chalcopyrite, partly enclosed in carbonate, may belong to this generation.
- Later veins of largely spherulitic carbonate

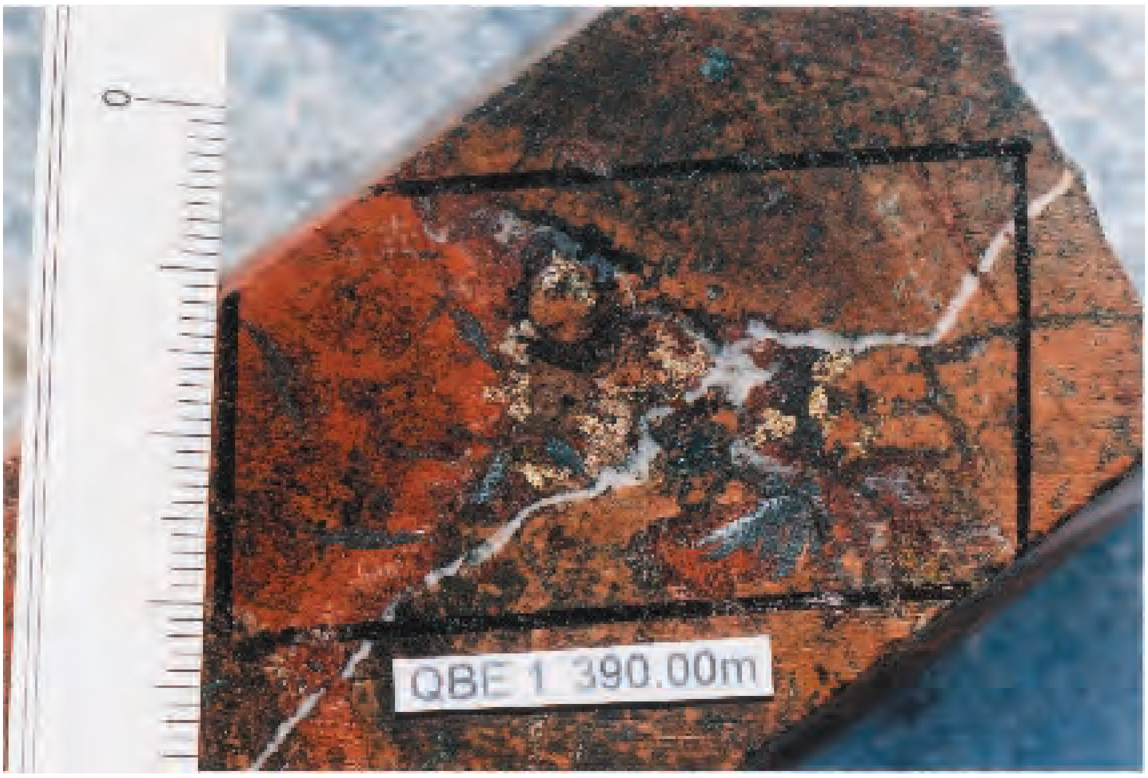
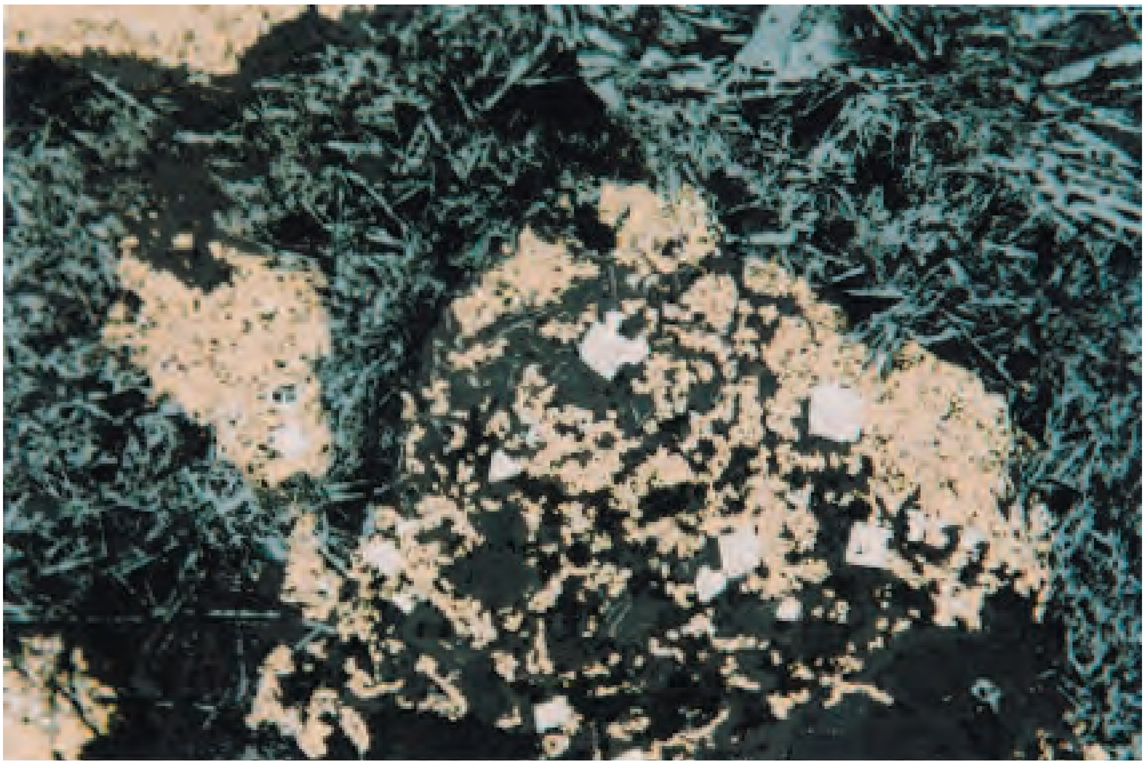
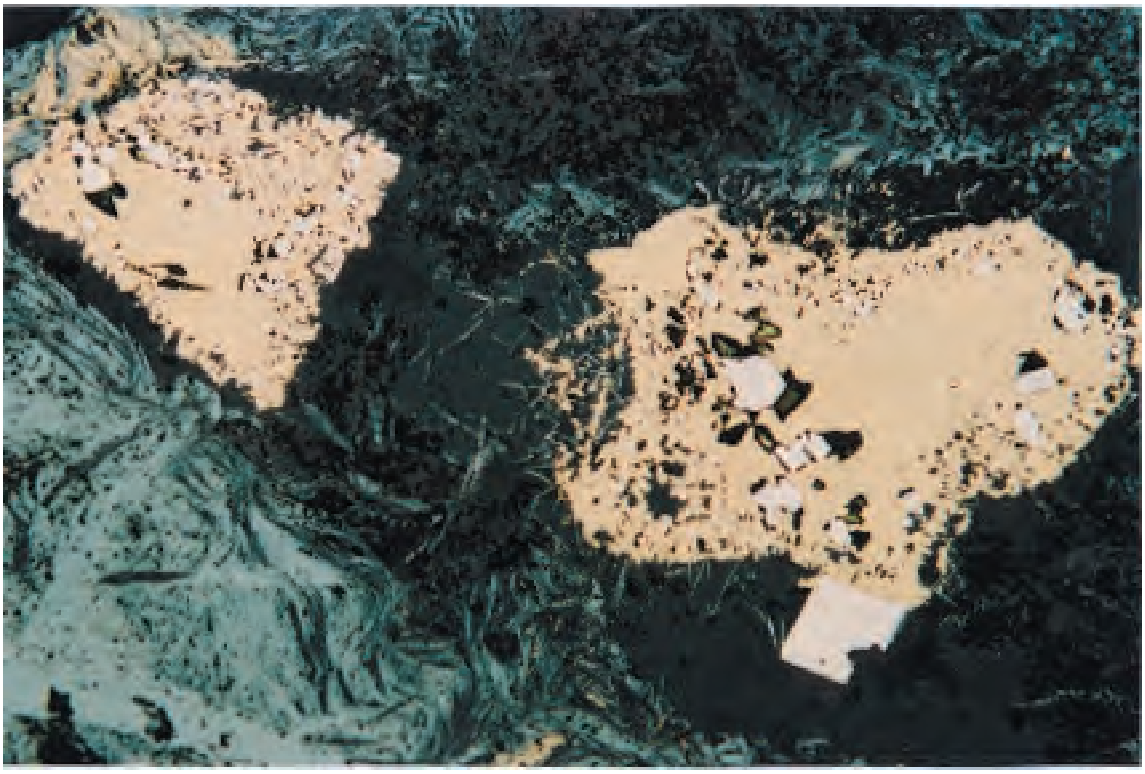

QBE 1 390.00m

Fig 16 **QBE#1, 390.0m** **0.18 mm**

PS (x50). Shows persistence of chalcopyrite-pyrite-bladed hematite association. Pyrite seems to occur in two generations: coarse, fractured pyrite has cut across hematite on the left-hand side, followed by chalcopyrite and a later generation of very fine-grained pyrite within the chalcopyrite.





Figs 17 & 18 **QBE#1, 390.0m** **0.09 mm**

PS (x100). Variation on a theme however, with massive, coarse-grained and porous microcrystalline chalcopyrite and fine cubic pyrite, all in carbonate gangue, but also associated here by extremely fine fibrous to decussate microplaty hematite.

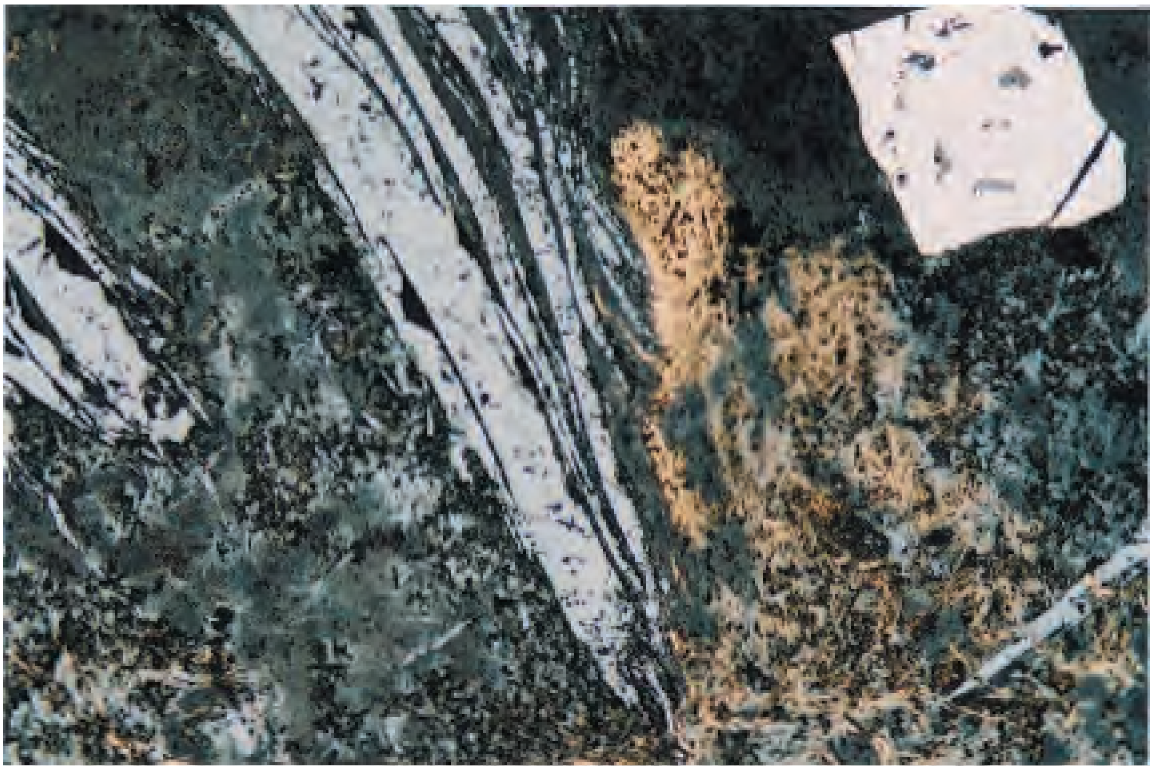


Fig 19 **QBE#1, 390.0m** **0.09 mm**

PS (x100). Another variation on a theme, showing pyrite and coarse bladed hematite, together with later low-temperature hematite which is decussate extremely fine platy/fibrous (left half of photo) as in Fig 17, but also intricately intergrown with chalcopyrite with the same mode of occurrence and probably being replaced by the chalcopyrite.

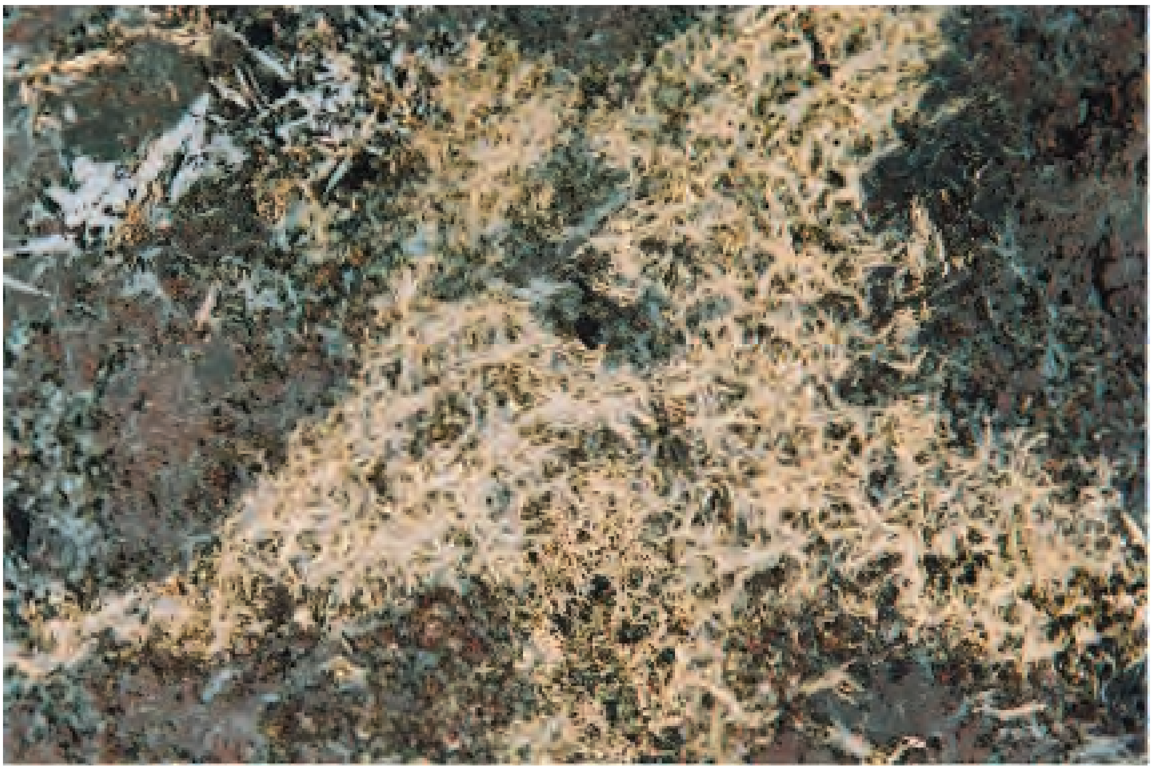


Fig 20 **QBE#1, 390.0m** **0.04 mm**

PS (x200). Detail of chalcopyrite replacing earthy, microfibrous to subspherulitic masses of hematite.

QBE #1, 391.4m

Fractured and veined domains of K-spar-rich altered possible basalt or andesite, with rare disseminated extremely fine chalcopyrite. Cut by veins with albite, chlorite, sporadic small crystals of pyrite and chalcopyrite, locally with carbonate. Late veins of fine-grained carbonate, with micaceous hematite, albite and rare pyrite.

Hand Specimen

This core segment has orange-pink and greyish pink lithologies as closely appressed possible fragments separated by pale grey late carbonate infills, with some veins and lenses containing hematite as well as or instead of carbonate. The thin section has a large mass of orange-pink rock that is seen on the stained offcut to be very rich in K-spar, with hematite-carbonate and late carbonate veins.

This Section

The orange-pink lithology is divided into irregular domains from 2mm to 20mm long, separated by irregular veins, stringers and patches containing albite, chlorite, micromosaic of carbonate, minor small grains to ultrafine pyrite > chalcopyrite and hematite. The different domains of orange-pink rock are mostly composed of feldspar, with reddish, hematite-stained K-spar and less abundant albite, partly hematite-stained and partly clear, possibly representing a separate generation. Fine granular oxide is also present, as well as minor dark green, probably iron-rich chlorite. Minor very fine-grained chalcopyrite is disseminated in some areas. The original lithology was most probably a basalt or andesite.

A very small area of the paler lithology has small albitised plagioclase phenocrysts to 1mm long and small patches of carbonate, possibly in vesicles, but is otherwise similar to the darker lithology, albeit with less abundant hematite.

Veins to 4mm wide separate the pink domains. Most have bladed crystals of albite to 3mm long, commonly overgrown by K-spar, with interstitial massive fine-grained, iron-rich chlorite. Irregular clusters and single small pyrite > chalcopyrite grains occur sporadically in this vein, but in one corner of the thin section, the main sulphide grains are chalcopyrite. One area of albite and chlorite encloses a large mass of carbonate about 5mm in diameter, but there is no sulphide in this area. This carbonate consists of large curved crystals to 3mm in size, contrasting with that in the later veins.

The later veins are irregular, from 1 to 10mm wide, and have fine granular carbonate with minor albite as elongate crystals and elongate parallel plates of hematite to 3mm long. Rare fine-grained sulphide is all pyrite.

Interpretation

The pink lithologies in this sample seem to have been basalt or andesite, but now with abundant apparently secondary K-spar and albite as well as earthy hematite. Early albite-chlorite veins carrying sparse grains of chalcopyrite and pyrite are common, with later carbonate veins containing rare hematite, albite and pyrite. Total sulphide content about 10%. There seems to have been some variation in fluid composition with time in this sample.

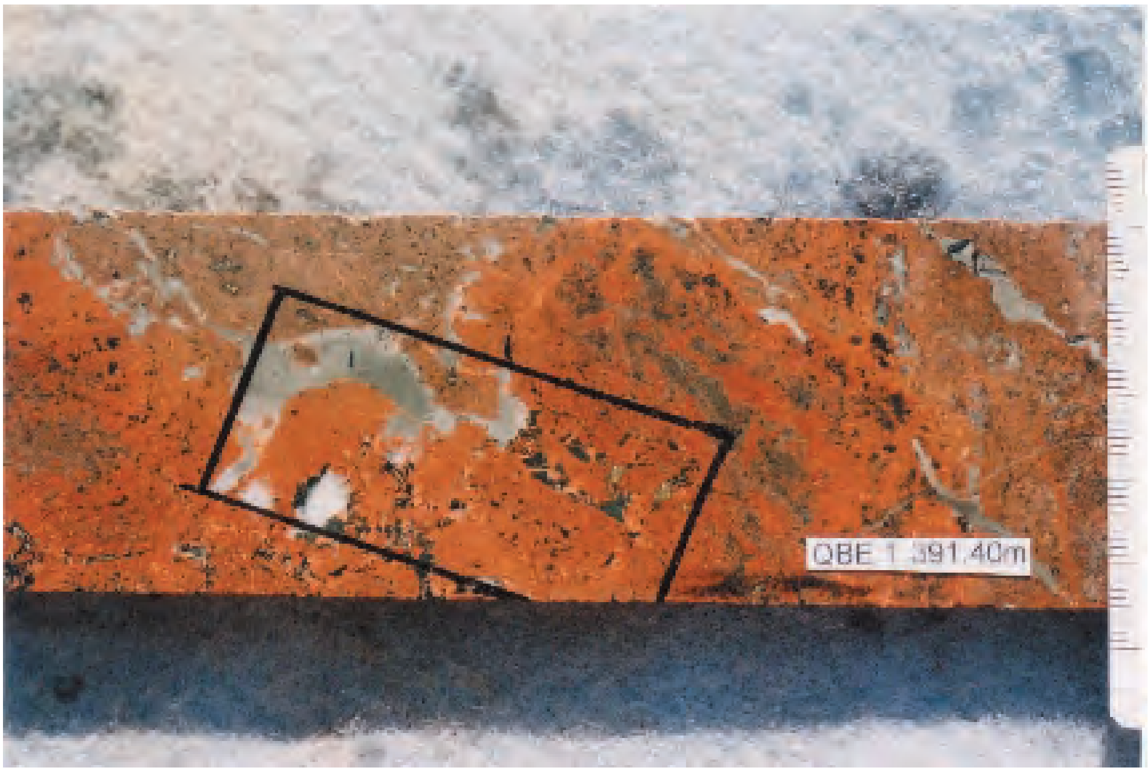


Fig 21 **QBE#1, 391.4m** **0.09 mm**

TS. Xnic (x100). Unusual hydrothermal vein assemblage, central crystal of albite rimmed by K-spar, clustered with other albite crystals, all within massive extremely fine chlorite. Black-opaque coarse bladed hematite.

QBE #1, 393.32m **Albite-chlorite-carbonate-leucoxene-altered dolerite with scattered magnetite (7-10%) in some bands more than in others (2-3%), also accessory apatite. Numerous irregular carbonate patches + coarse apatite and carbonate veins, accessory very fine hematite but only rare trace minute grains of pyrite and chalcopyrite.**

Hand Specimen

This core-segment is quite long and has been made into two thin sections. It is mostly a relatively uniform pinkish-grey rock that may represent a mafic dyke, but has some heterogeneity, including a vague macrolayering, partly manifest as zones unusually rich in (disseminated) magnetite, in both thin sections. The stained offcuts show that there is only rare K-spar in this interval. Carbonate-filled veinlets are visible on the macrophoto.

Thin Section 'A'

This section has a central zone (band?) relatively poor in disseminated magnetite with more magnetite-rich sections (7-10%) at either end of the section. Larger albite crystals, to 1mm long, are also scattered, as well as abundant fine-grained albite intergrown with fine-grained magnetite and chlorite basically within groundmass. The scattered crystals of magnetite are mostly less than 0.5mm in diameter, but with some in aggregates to 1.5mm long in the more magnetite-rich zones. Patches of carbonate are abundant, to 2mm in diameter, with apatite commonly in and adjacent to the carbonate. Apatite grains, mostly less than 0.5mm are disseminated as a common accessory phase, but some prisms of apatite to 2mm long occur in carbonate patches. Albite crystals and small flakes of olive-green biotite are also present in the carbonate. Leucoxene has replaced oxides to 0.3mm in grainsize.

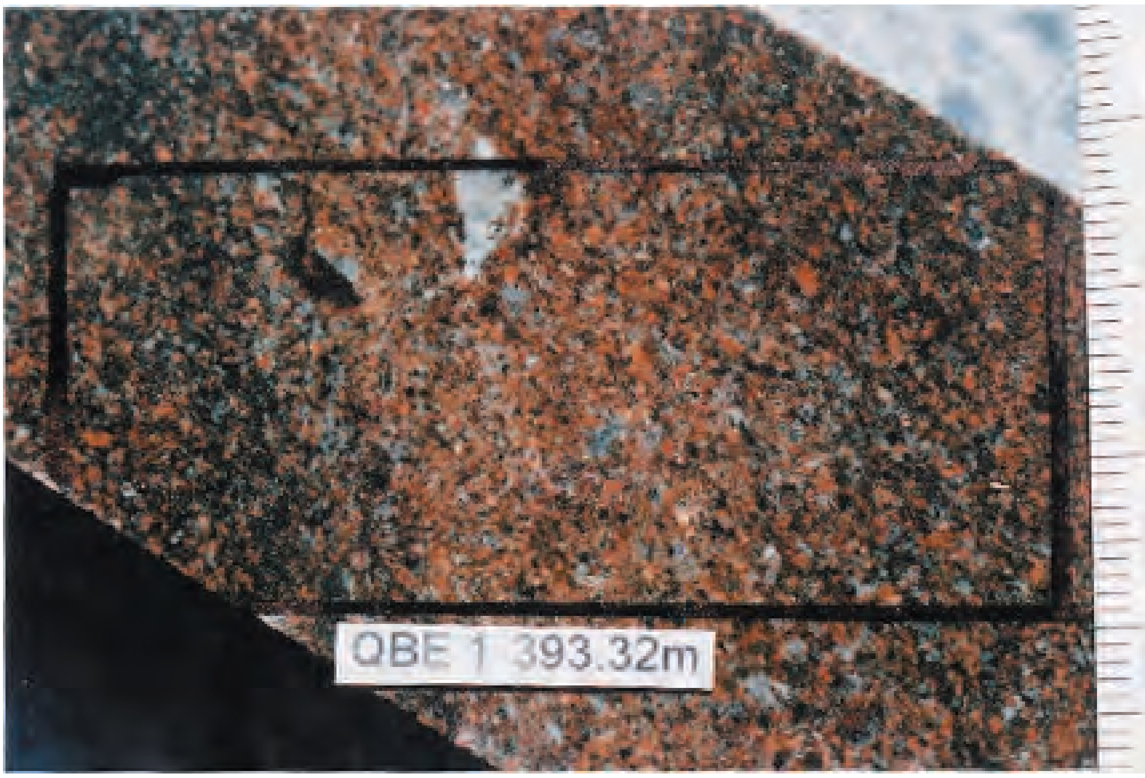
Later, very narrow veins of dark, clouded carbonate are present.

Thin Section 'B'

In this thin section there is a wedge of magnetite-rich material close to the centre of the section, with a magnetite-poor zone on one side and a zone with moderately abundant magnetite on the other. The magnetite-poor zone is almost entirely free of magnetite but has leucoxene after skeletal oxides to 1.5mm in grainsize. In the more magnetite-rich zones there is also disseminated leucoxene, mostly derived from oxides less than 0.5mm in diameter. Larger albite laths are disseminated through a groundmass of albite, magnetite and chlorite as seen in thin section 'A'. Irregular masses of magnetite are common and are quite abundant in the magnetite-rich wedge seen in hand-specimen and also shown in the macrophoto. Very minor hematite occurs in and adjacent to the magnetite grains and aggregates, but no sulphide was seen. Patches of carbonate and disseminated prisms of apatite are common, and, as in thin section 'A', there are narrow veins of clouded brown carbonate.

Interpretation

This sample seems to represent a dolerite dyke with leucoxene after skeletal titanomagnetite. A hydrothermal alteration of assemblage, albite-chlorite-carbonate-magnetite-apatite with sparse fine hematite but only rare-trace minute grains of pyrite and chalcopyrite.


QBE 1 393.32m

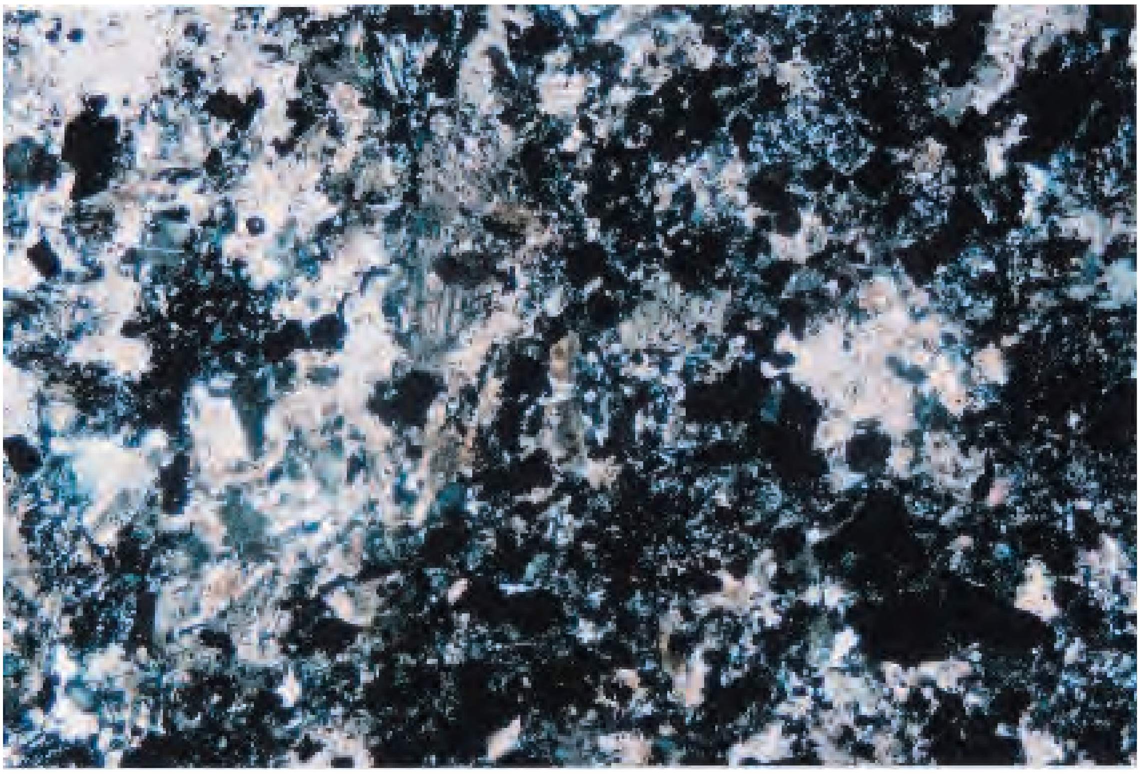


Fig 22 **QBE#1, 393.32m** **0.45 mm**

TS. Xnic. (x20). Host rock of basalt/microdolerite, extensive patchy albite, chlorite, carbonate alteration. Scattered black opaque magnetite, primary igneous or hydrothermal.

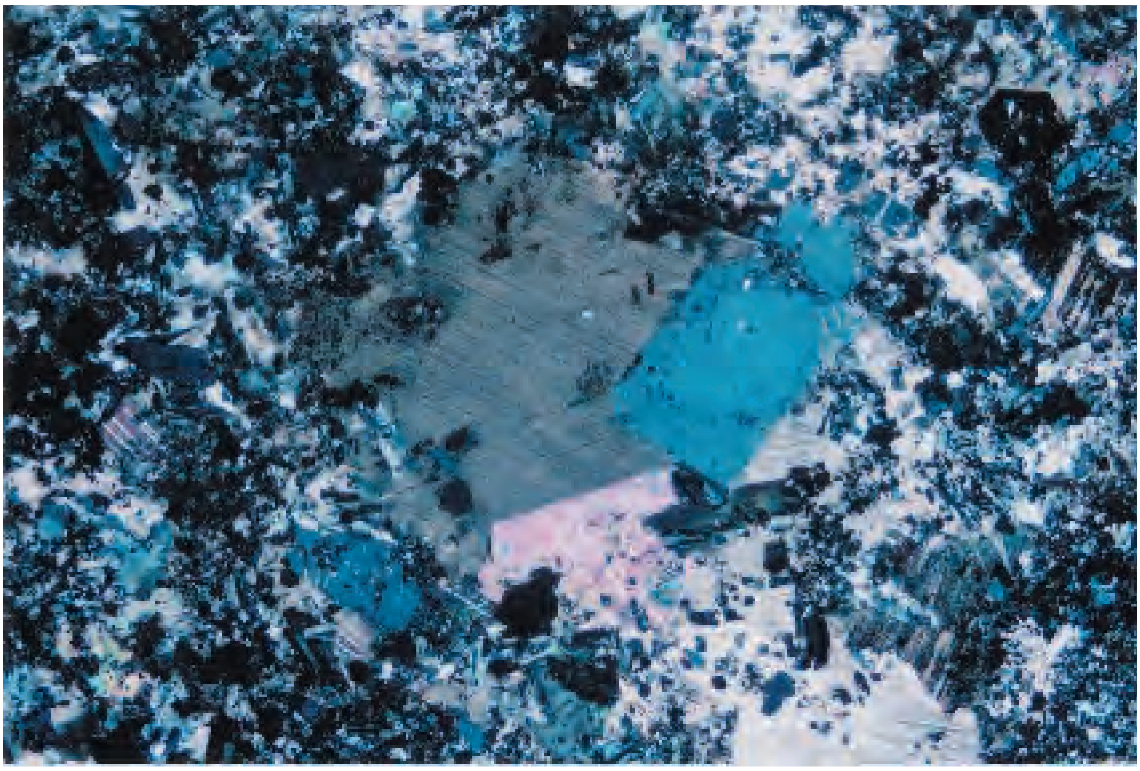


Fig 23 **QBE#1, 393.32m** **0.45 mm**

TS. Xnic. (x20). Mafic rock type as in Fig 22, showing patchy coarse carbonate alteration, with associated coarse apatite crystals. Scattered black-opaque magnetite forming igneous or hydrothermal.

QBE #1, 403.4m **Breccia of oxide-rich ex-volcanic fragments extensively altered to various combinations of chlorite, albite, K-spar, green to brown biotite, epidote, amphibole, pyroxene (including aegirine) and sulphides, all in a matrix of coarse checkerboard albite and carbonate with minor chalcopyrite and pyrite. These sulphides may be composite with microplaty hematite and/or granular magnetite.**

Hand Specimen

Dark, possibly chlorite-rich fragments occur in this sample as well as pale fragments with minor to abundant K-spar visible on the stained offcut. Carbonate-rich lenses seem to contain albite or apatite and there are disseminated sulphides in the matrix.

Thin Section

A large green chlorite-rich area in this section is probably a clast, with abundant decussate iron-rich chlorite and abundant disseminated fine-grained oxide. Patches of decussate yellowish brown biotite are scattered up to 1mm in diameter. There are also fractured and carbonate-veined prisms of colourless prisms of possible amphibole (tremolite or pargasite) or pyroxene (diopside) to 2mm long. This lithology passes into areas flooded by carbonate with abundant disseminated very fine-grained oxide and sphene. Lenses of biotite occur in the carbonate and there are rare grains and aggregates of albite.

A less chlorite-rich probable fragment has abundant fine-grained albite with rare lenses of adularia. Very minor brown biotite occurs as single flakes but there is abundant green pyroxene as prisms to 0.7mm long that appear to be rich in aegirine and are partly intergrown with green or greenish-brown biotite. Parts of the clast have more abundant adularia than albite and there are large irregular areas flooded by fine-grained decussate muscovite or sericite. In these areas the aegirine has been replaced by green or greenish-brown biotite. Elongate needles of apatite in this area seem to be of primary igneous origin and are locally bent.

The other, smaller clasts are variable in character. Some are fine-grained and feldspathic with partly red-stained albite and/or K-spar accompanied by oxides and sphene, but others are composed of coarse granular and prismatic yellow iron-rich epidote with minor actinolite and oxides. Some moderately feldspathic clasts have probable aegirine-rich pyroxene as well as albite and/or K-spar, with minor green to brown biotite.

Small scattered magnetite grains commonly about 0.5mm are mostly in the red feldspar altered areas of volcanic rock and primary, but there is also accessory, much finer (<0.05mm) hematite as presumably an alteration phase. In patchy veins (matrix) of albite, adjacent to epidote, where most of the pyrite and chalcopyrite grains are scattered, these sulphides are commonly and variably composite within hydrothermal platy hematite, and with granular magnetite, which also must be hydrothermal.

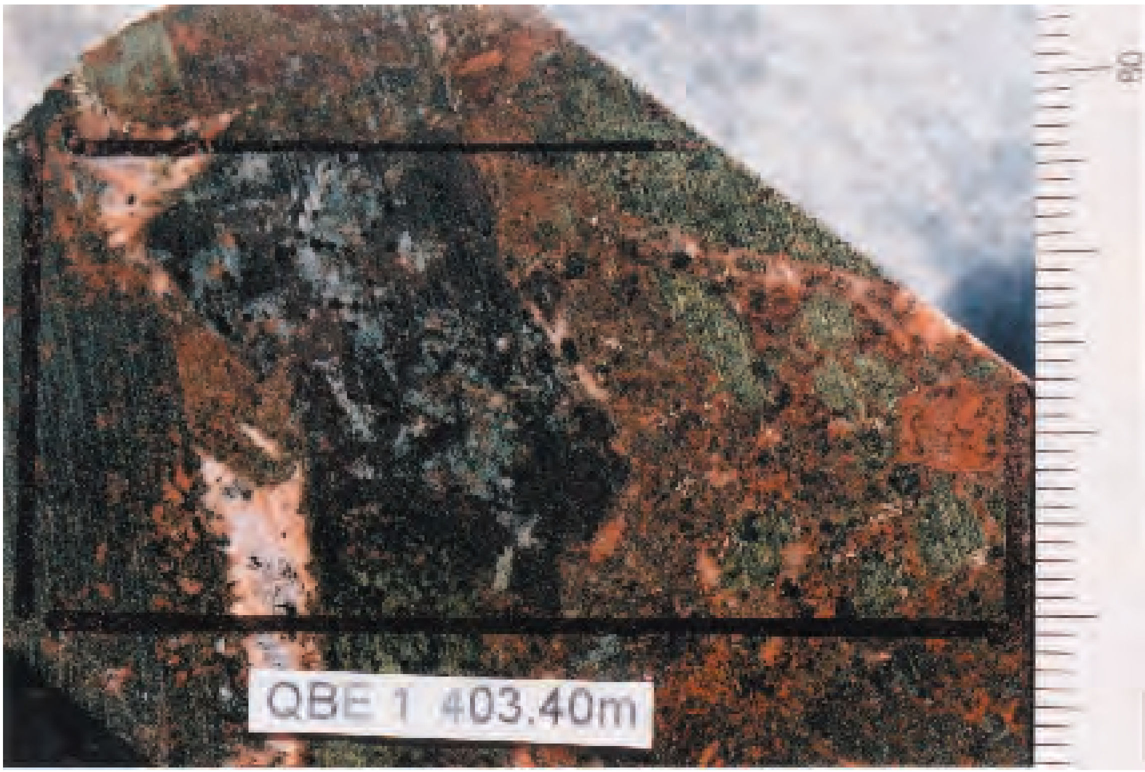
Interpretation

This sample has some unusual minerals related to Ca-Fe and Na-Fe metasomatism, as well as sulphides (chalcopyrite and pyrite). [Aegirine is known from some oxide-copper-gold-REE deposits such as Bayan Obo in Mongolia, but this, like Phalaborwa in South Africa, may be related to carbonatites.] The abundance of checkerboard albite in the matrix of this rock is unusual, as is the presence of late sericite alteration superimposed on aegirine-albite-K-spar-oxide-sulphide alteration.

The assemblage aegirine-pistacite is equivalent to andradite-albite-hematite with more water and less silica:

$$12NaFeSi_2O_6 + 6Ca_2FeAl_2Si_3O_{12}(OH) + 6SiO_2 = 4Ca_3Fe_2Si_3O_{12} + 12NaAlSi_3O_8 + 5Fe_2O_3 + 3H_2O$$

Minor scattered pyrite and chalcopyrite, total about 2%, commonly in albite, may be variably composite with platy hematite and granular magnetite which must also be hydrothermal (in addition to disseminated primary magnetite).


QBE 1 403.40m
80

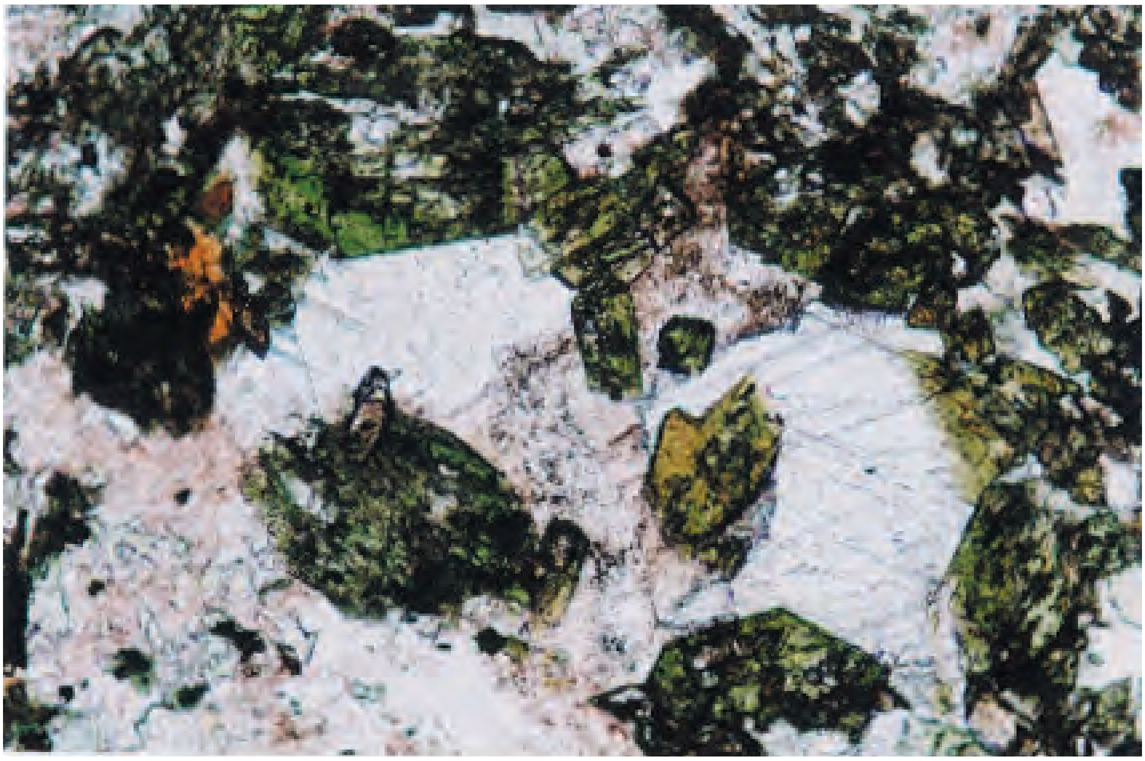
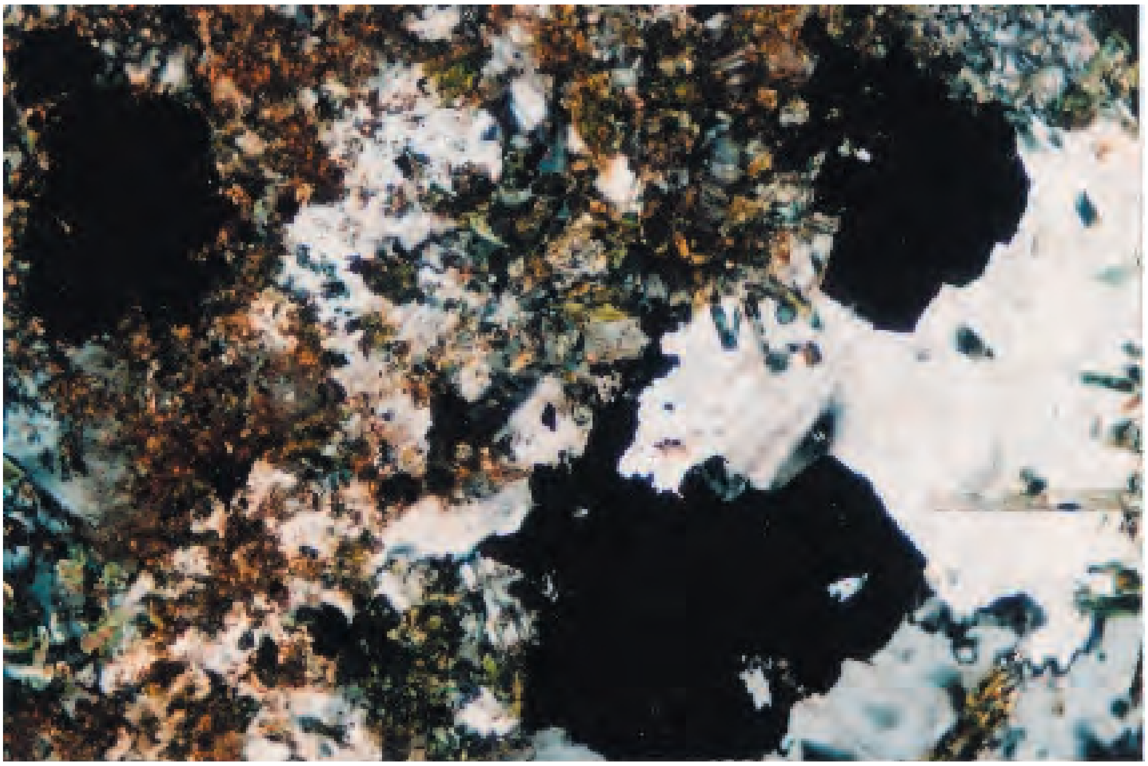


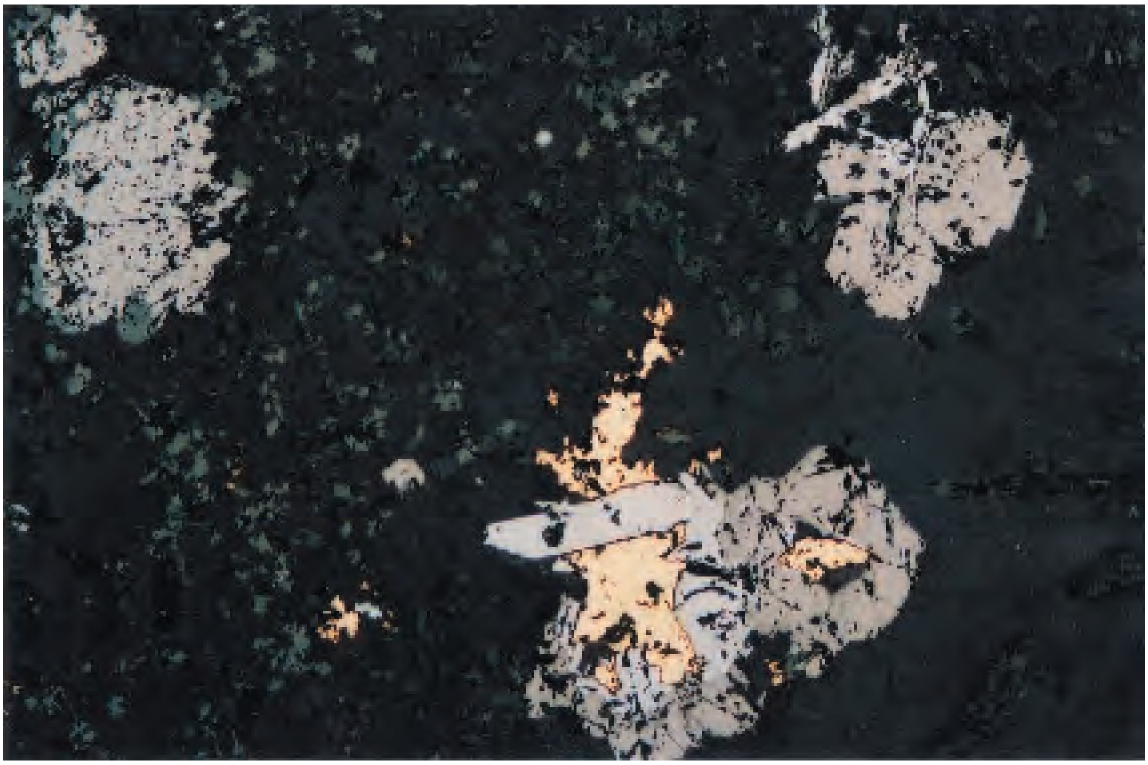
Fig 24 **QBE#1, 403.4m** **0.09 mm**

TS. OL (x100). This sample marks the first down-hole appearance of epidote aegerine-rich rocks, and although contained hydrothermal veins consist largely of clear carbonate and dusty albite, they also carry green aegerine hydrothermal crystals, plus accessory small sphene crystals.

Fig 25 **QBE#1, 403.4m** **0.09 mm**

PS (x100) Ore mineral veins also in this sample, with typical composites of pyrite, chalcopyrite associated hydrothermal hematite (pale grey) and magnetite minor grey-brown granular.





Figs 26 & 27 **QBE#1, 403.4m** **0.09 mm**

Fig 26 TS. Xnic. Fig 27 PS.

In Fig 26, black opaque grain in a vein of carbonate + albite, are seen in polished section Fig 27, as composite (yellow) chalcopyrite, (pale grey) laths of hematite, (pale brown-grey) granular hydrothermal magnetite. Adjacent mafic volcanic host rock altered to albite, brown biotite, fine epidote and scattered magnetite in this may be primary.

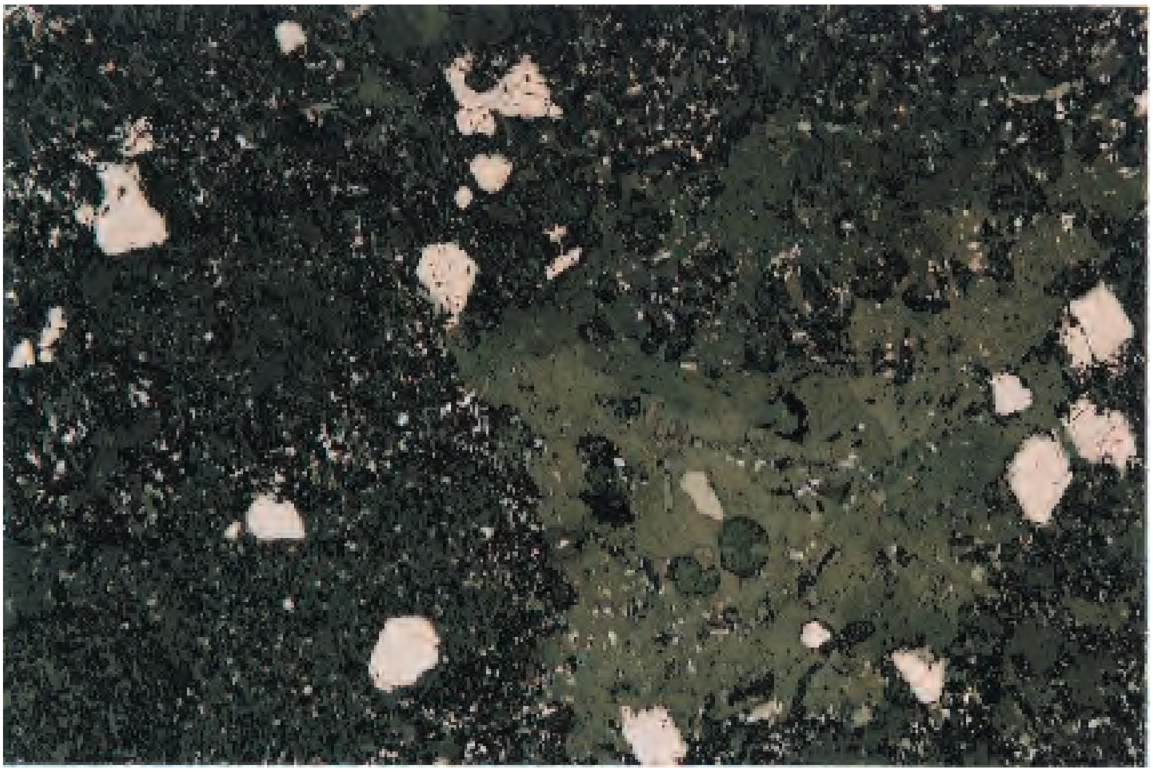


Fig 28 **QBE#1, 403.4m** **0.09 mm**

PS (x100). Further example of this altered mafic rock, with a patch of 'coarse' carbonate alteration within bulk groundmass which is chlorite-altered, but disseminated magnetite as microphenocrysts and much finer dispersed particles, both of which may be inherent, primary-igneous.

QBE #1, 408.2m **Patchy areas of albite-sphene-carbonate-apatite-altered volcanic rock, cut by a heterogeneous vein with epidote, albite, carbonate, aegirine, also numerous quite coarse, platy hematite, granular magnetite, pyrite, chalcopyrite, rare apatite, trace sphalerite.**

Hand Specimen

This core-segment is dominated by a mass of diffuse-patchy grey-green altered apparent volcanic fragments, with a central vein like band containing lemon-yellow possible epidote as well as abundant reddish feldspar. The stained offcut shows minor K-spar on both sides of the main mass of the ?epidote, rimming bladed red crystals of probable albite. Numerous quite coarse grains of iron oxide and sulphide occur in and adjacent to the vein.

[This sample is from the beginning of a high-Ba interval (402-422m) with 859-1164ppm Ba.]

Thin Section

There are only small areas of the wall host rock enclosing the mineralised epidote-rich vein which dominates this thin section. These areas are predominantly fine grained albite as small laths, locally enclosed in poikilitic grains of checkerboard albite, apparently derived from K-spar. There is relatively abundant fine-grained sphene, with minor green biotite, and patches of carbonate are disseminated, rarely with fine-grained apatite. One area has albitised feldspar phenocrysts to 3mm long and phenocrysts of clinopyroxene to 2mm long, largely altered to carbonate. This area has more abundant green biotite and also has disseminated grains of opaque material.

The major vein area has large irregular domains with different mineralogies, some areas dominated by coarse granular and prismatic epidote to 8mm in grainsize, locally with coarse bladed hematite. Other areas contain aggregates of coarse normal and/or checkerboard albite to 3mm in grainsize, with rims of K-spar on some of the albite grains, as seen on the stained offcut. Small prisms of apatite are present as inclusions in some of the albite laths. Areas rich in granular carbonate are also abundant, enclosing prisms of apatite to 1.5mm long and small prisms of aegirine, as well as minor opaque minerals. Aegirine is also present as rare inclusions in epidote. Later narrow fractures are abundant and have been filled with carbonate, without any sulphides.

The opaque minerals in the vein include hematite (about 1% of this section area), as aggregates of large bladed crystals, mostly in epidote-rich areas, also clusters of partly fractured and veined magnetite grains (1%), mostly in areas rich in carbonate and albite. There are also partly fractured cubes of pyrite (1-2%) and irregular grains of chalcopyrite (<1%) with the largest pyrite crystals also in areas of epidote. A composite inclusion of sphalerite and carbonate occurs in one of the pyrite crystals in a carbonate-rich area (and is he only observed occurrence of sphalerite in the whole suite).

Interpretation

This sample has a complex vein with Ca-Fe and Na-Fe-Cu-S assemblages as well as apatite and aegirine. Variations in fO_2 are seen in the carbonate-albite-magnetite assemblages and contrasting epidote-hematite assemblages in the same vein, with aegirine also containing iron essentially as Fe^{3+}.

QBE #1, 415.16m **Contact between green sericite-aegirine-hematite-K-spar-carbonate-altered volcanic rock (olivine-augite basalt) and red sericite-carbonate-hematite-altered basalt. A veinlet about 1mm wide with carbonate, albite, bladed hematite, rare garnet, pyrite, trace bornite and chalcopyrite occupies the contact. Later narrow carbonate veinlets parallel to the core-axis.**

Hand Specimen

This sample was taken from a relatively uniform lithology, possibly representing a (second) dolerite dyke. The stained offcut shows that it is relatively poor in K-spar throughout, but has an abundant pale yellow-stained mineral that may be sericite or muscovite. There is a sharp planar contact, within the area of the thin section, occupied by a veinlet to 2mm wide. The rock on one side of this is grey-green, on the other side it is pale pink. Sparse sulphide occurs in and adjacent to the vein. Chemically, the interval including this sample (412-417m) has the highest Ba content in the drillhole (1186.4ppm).

Thin Section

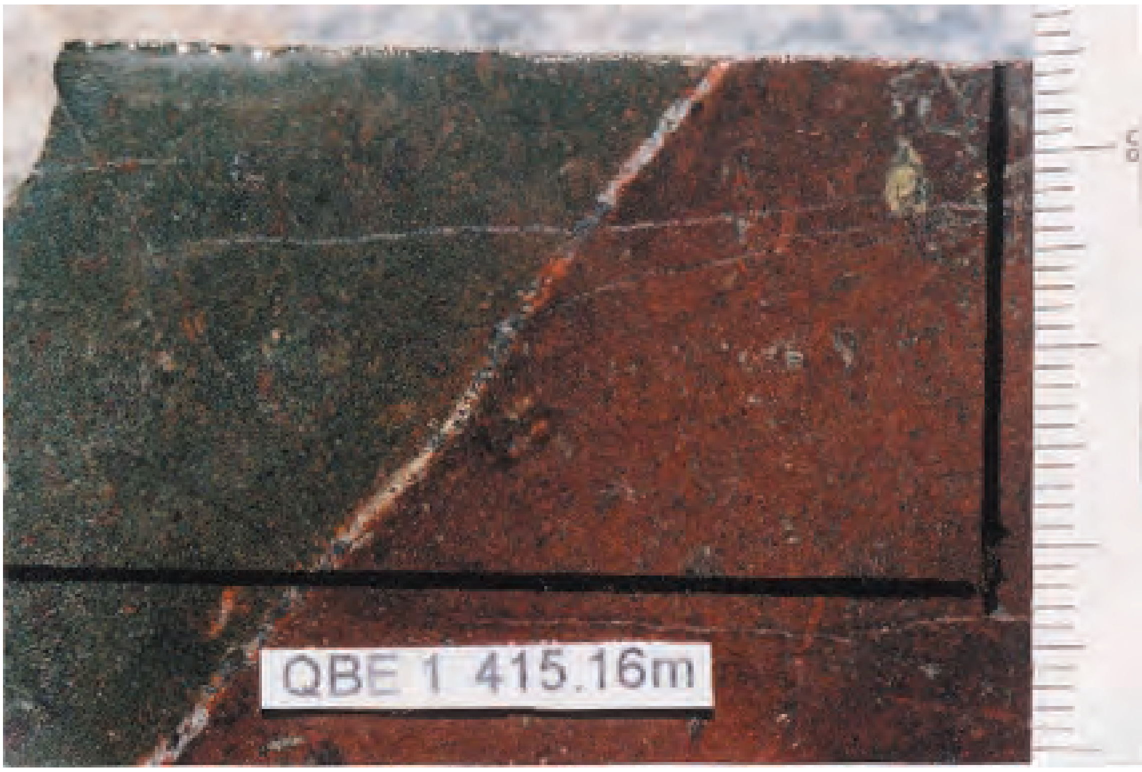
The green area of rock mentioned above has aggregates of decussate very fine probable muscovite and minor hematite replacing probable olivine phenocrysts to 1.5mm long, also less abundant fresh phenocrysts of clinopyroxene (augite or diopside) to 1mm long, locally in small clusters. The groundmass in the green lithology is largely composed of sericite or very fine muscovite and fine granular aegirine, but there are some areas with larger prisms of aegirine, to 0.5mm long, and some pyroxene grains with colourless cores (augite or diopside) and green aegirine-rich rims. Minor K-spar is present in some areas and there are scattered prisms of apatite. Some of these are as much as 0.4mm long and occur partly in clusters. Small grains and aggregates of hematite are also present.

The red-brown lithology has a groundmass dominated by sericite and carbonate, with a dusting of hematite, and also has scattered microphenocrysts of magnetite. Rare K-spar is present. There are muscovite-rich patches to 3mm long, possibly including fragments as well as phenocrysts. Rare pyroxene phenocrysts show initial alteration to actinolite and later veining by carbonate. Hematite in the red area increases in abundance towards the main vein, visible in hand specimen and in the macrophoto.

The divisional veinlet mostly is about 1mm wide and is predominantly carbonate, but with lesser albite, anisotropic garnet, platy hematite, rarer pyrite and trace minute grains of bornite. There are also narrow later veins, roughly parallel to the core axis, filled with carbonate.

Interpretation

This sample has a complex petrology, possibly derived from a former uniform olivine-pyroxene porphyritic basalt with aegirine and later sericite on one side of a divisional veinlet, contrasting with sericite-carbonate-hematite alteration on the other side of the vein. The veinlet represents an oxidised fluid with carbonate, lesser hematite and sulphides as well as albite and probable garnet. Later carbonate veins are similar to those elsewhere in the core. There is a suggestion that the sericite in this sample is rich in Ba, but this would be unusual as Ba usually enters biotite or K-spar.



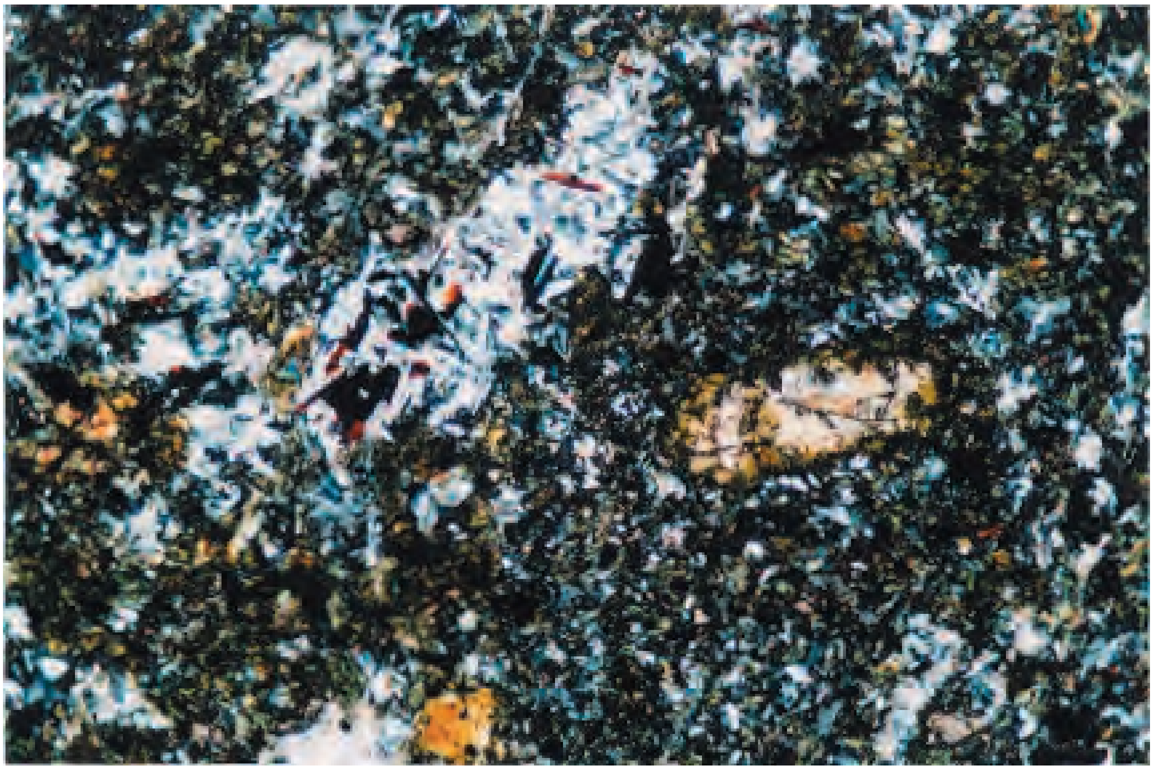


Fig 29 **QBE#1, 415.16m** **0.09 mm**

TS. Xnic (x100). Green half of this rock: altered basaltic host rock, showing a large central phenocryst of olivine altered to decussate sericite + hematite, and a smaller right hand phenocryst of augite rimmed by aegirine-rich zones, in a matrix rich in aegirine and dispersed fine hematite.

QBE #1, 418.8m **Albite-chlorite-hematite-altered volcanic rock with augite and aegirine and a large irregular, heterogeneous hydrothermal mass of albite, carbonate, epidote, aegirine, fine platy hematite (but locally quite coarse in veins), apatite and sphene, rare very small grains of chalcopyrite. Minor phlogopite in the host rock seems to be transitional to tetraferriphlogopite. Narrow late carbonate veins are present.**

Hand Specimen

This core segment is similar to that at 408.2m, but taken to check the continuity of the distinctive green mineralogy which is relatively rare in the suite as a whole. This has irregular dark masses of altered volcanic rock, commonly microfissured, with larger areas containing apparent epidote and pale to dark red possible albite as well as possible carbonate. The stained offcut shows disseminated K-spar adjacent to pale veins with albite or carbonate. Hematite and rare chalcopyrite occur in the vein material.

Thin Section

Irregular masses of altered rock dominate this thin section, mostly composed of unoriented small crystals of albite, associated with sparse sericite, and interstitial chlorite, and abundant aggregates of fine platy hematite. Some areas have coarser albite and abundant pyroxene crystals. Some of the pyroxene has pale areas of augite or diopside, altered to carbonate, and others are irregularly zoned in shades of green but seem to be variably rich in aegirine throughout. Green rims, rich in aegirine, occur on some of the pale cores. Coarse sphene is present in some areas, with elongate prisms of apatite, to 1.5mm long, in other areas. Pale green to orange pleochroic phlogopite is disseminated and seems to be transitional towards the tetraferriphlogopite seen in carbonatites. In other areas green phlogopite and fine sphene has replaced probably aegirine-rich pyroxene with a decussate arrangement.

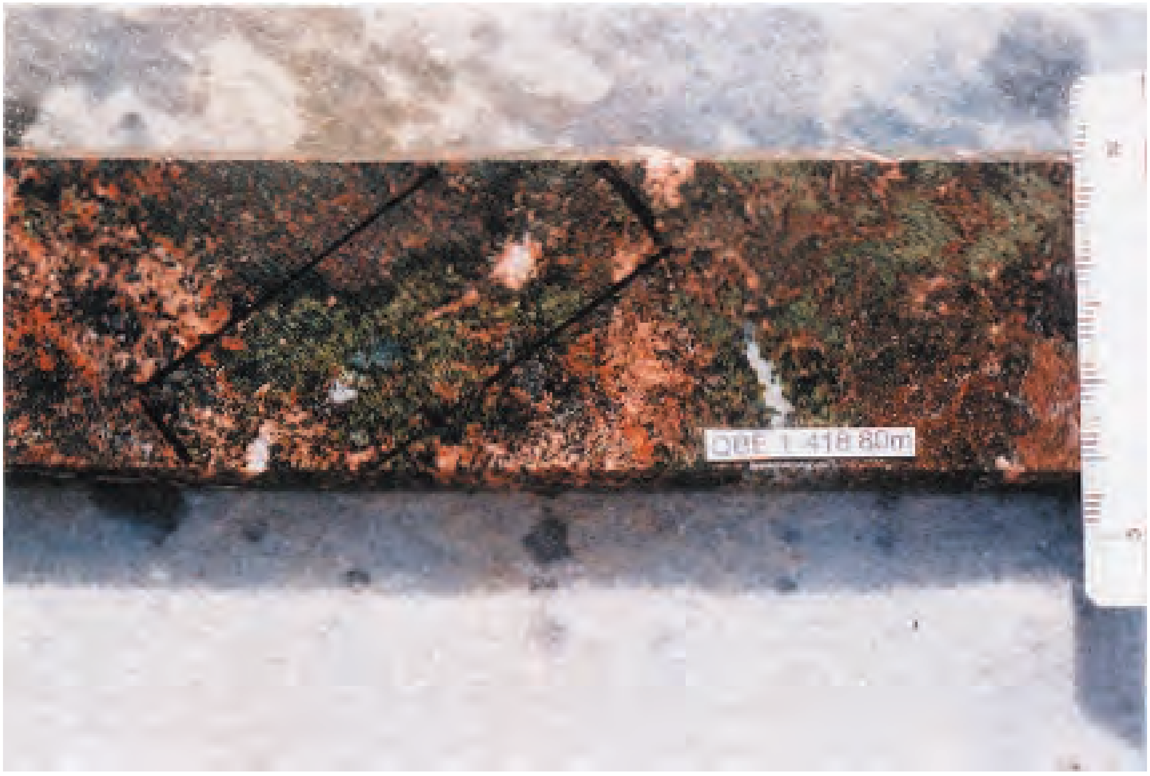
Patches of granular to prismatic epidote are abundant, with coarse platy hematite, in parallel or radiating bundles to 4mm, associated with similarly coarse prismatic epidote. Patches of fibrous possible amphibole occur in some of the epidote crystals. There are also patches of coarse normal and checkerboard albite and of carbonate, both of which may have rare or abundant fine prismatic aegirine. The albite-rich patches are partly vein-like and white as seen on the stained offcut. Along the margins of the albite vein there are locally developed lenses of decussate fine prismatic aegirine, with sphene and/or hematite in some areas. A separate patch of coarse albite occurs, on the edge of the thin section, enclosing rounded grains of sphene to 2mm long.

Patches of relatively coarse prismatic aegirine are partly composite with epidote, and partly enclosing patches of carbonate ± actinolite after augite or diopside. Two large patches of carbonate 5-7mm long, one has a rim of irregular grains of checkerboard albite and the other has coarse euhedral albite to 3mm in grainsize along the margin. Sparse very small grains of chalcopyrite occur in these carbonate-albite veins. Grains of apparently primary magnetite are scattered and overall form up to 7% of this rock.

Irregular, narrow late veins have been filled with carbonate and/or quartz (as one of the rare occurrences of quartz in this suite).

Interpretation

This sample contains altered volcanic areas, possibly fragments, with augite and aegirine, as in the two samples described above. There is some possibility of primary aegirine in these areas, although aegirine in more clearly hydrothermal areas is probably of secondary origin. The areas of hydrothermal alteration contain variously mixed chlorite, albite, epidote, sphene, apatite, and possible K-spar, very fine to locally coarse platy hematite, sparse very small grains of chalcopyrite. There is also minor phlogopite, partly transitional towards tetraferriphlogopite at least optically, as well as green phlogopite apparently after aegirine.


QBE 1 418.80m

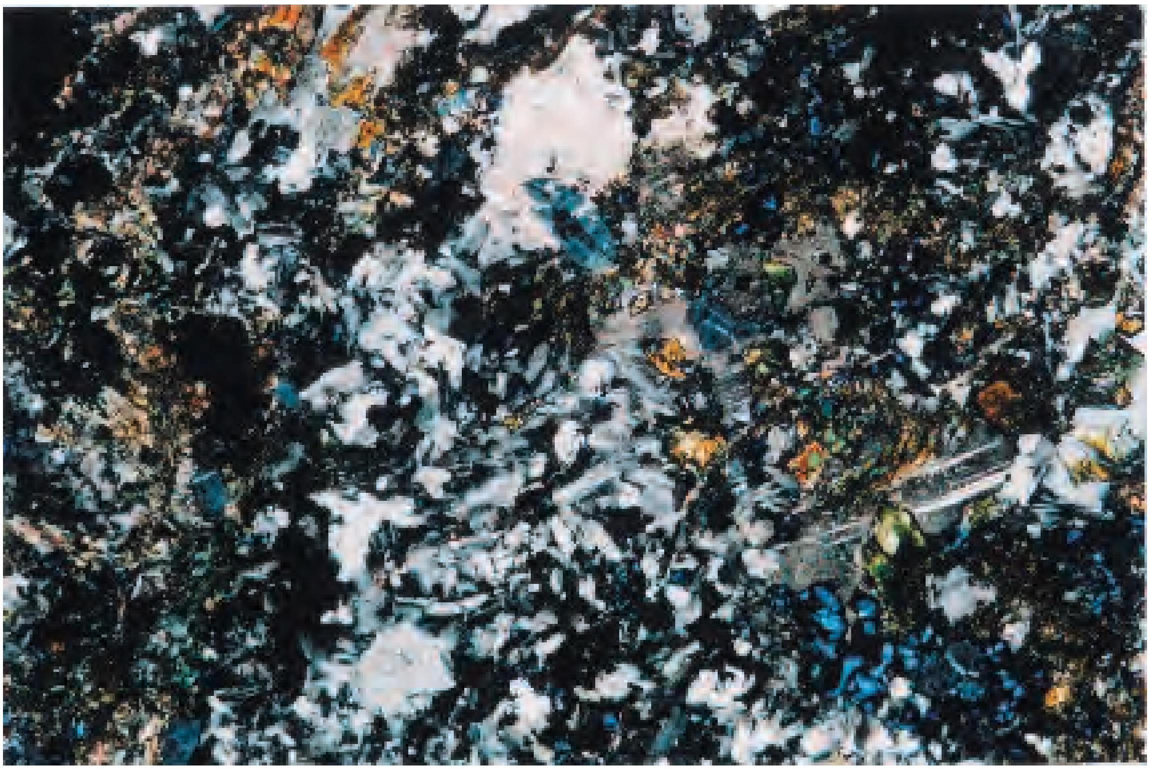


Fig 30 **QBE#1, 418.8m** **0.18 mm**
TS. Xnic (x50). Basaltic host rock with a central zone of albite mosaic, adjacent rock altered also to albite, fine epidote, chlorite.

Fig 31 **QBE#1, 418.8m** **0.18 mm**
TS. OL (x50) vein in above rock, of coarse hydrothermal epidote (pale), aegirine (green), coarse bladed hematite (black).

QBE #1, 421.00m **Original probable mafic rock with accessory primary magnetite and apatite, altered to albite-K-spar-chlorite-biotite-sericite-carbonate with very fine microplaty hematite associated accessory small grains of chalcopyrite, trace bornite and pyrite dispersed. Also with leucoxene replacing scattered sphene and hydrothermal apatite. Several subparallel laminated and lenticular carbonate veins.**

Hand Specimen

This core-segment has a relatively uniform lithology. Patches of leucoxene are scattered, and there are irregular areas rich in K-spar visible on the stained offcut. Much of the rock has a pale brown colour, but there are irregular pinkish areas and disseminated oxide grains, all suggesting an altered mafic. Numerous subparallel bifurcating veins/veinlets are at a low angle to the core axis.

Thin Section

Areas rich in small, unoriented K-spar and/or albite laths occur in one corner of the thin section, adjacent to carbonate veins. These areas also contain crystals of sphene to 1mm long, partly altered to leucoxene, and also have inequigranular zoned flakes of phlogopite and possible biotite. The biotite has colourless, pale orange and green zones and occurs partly as elongate flakes to 1mm long. Patches of chlorite ± illite are present and commonly contain very small grains of hematite.

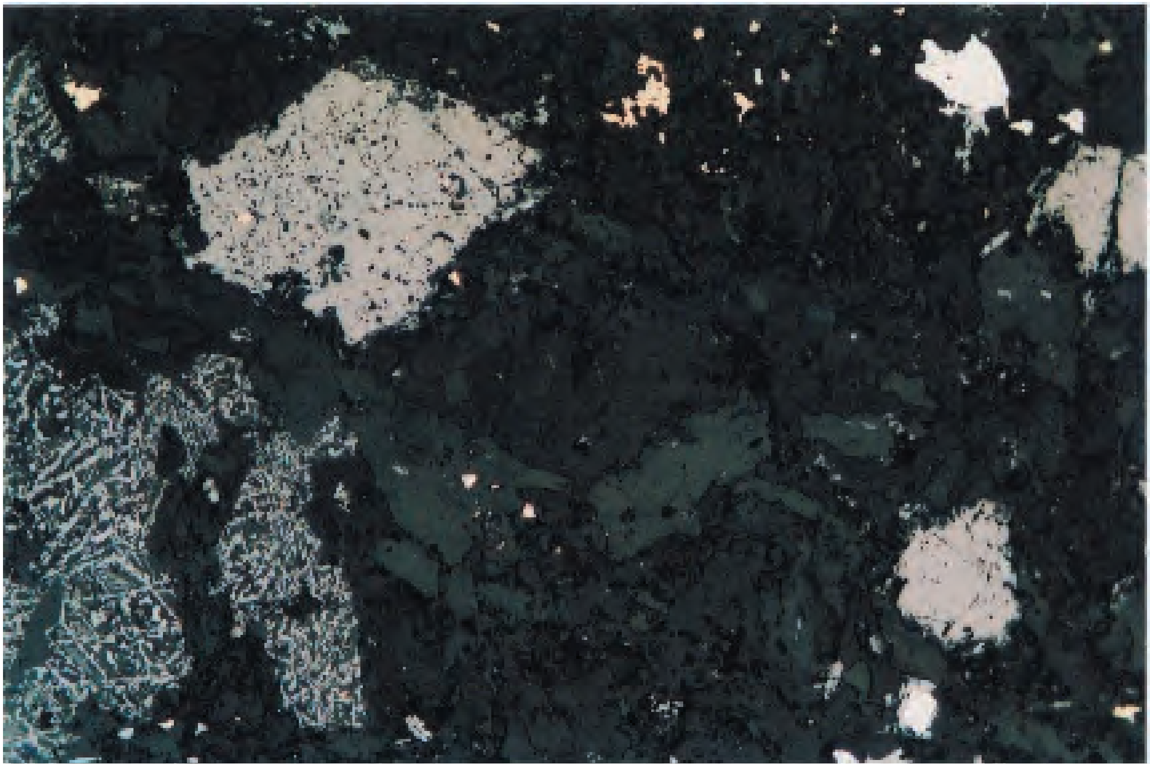
In most of the rock the fine-grained decussate feldspar is albite and there are grains of mostly checkerboard albite to 2mm in diameter, apparently after K-spar. Irregular grains of sphene (7-10%) to 2mm are scattered with 40-100% alteration to leucoxene, and there are also accessory scattered grains of probably primary magnetite and of secondary microplaty hematite.

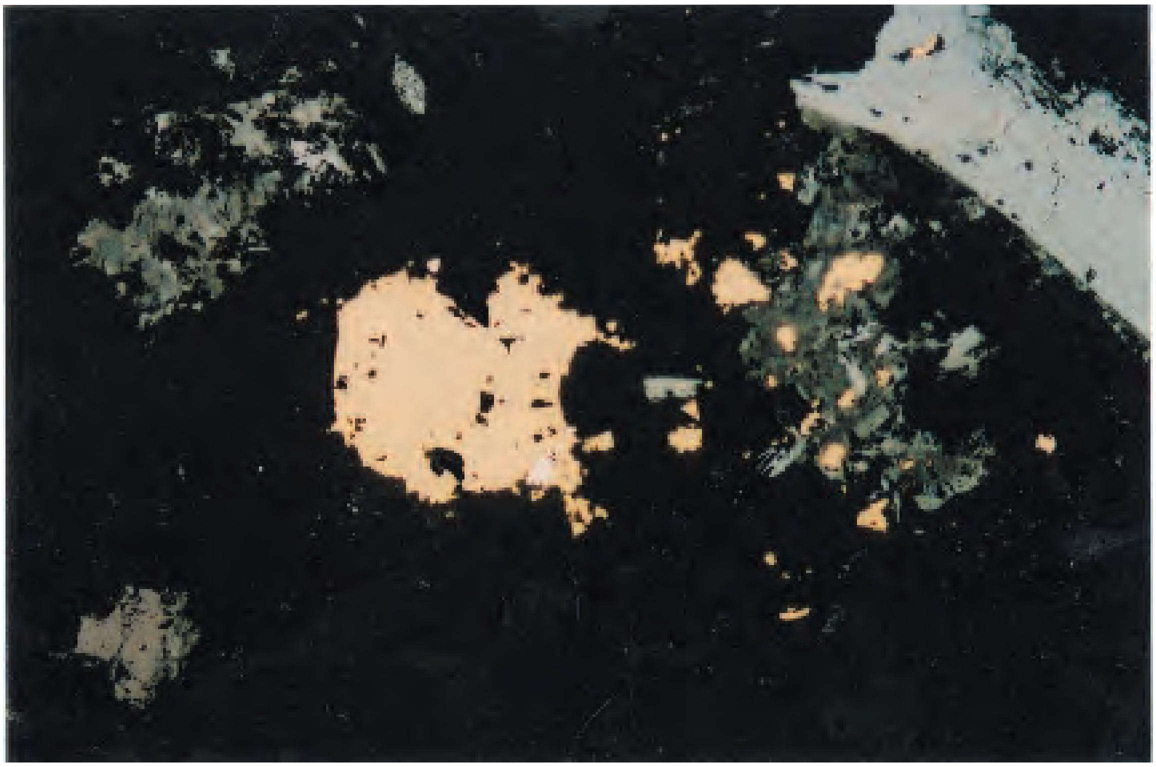
Decussate, mostly green biotite or phlogopite is abundant and some areas have been replaced by decussate fine sericite. Apatite occurs as prisms to 0.8mm long and may be of primary igneous origin. However there is possibly hydrothermal apatite in large patches of checkerboard albite, some of which pass into carbonate patches. In one area, a large grain of K-spar is visible, about 2mm long, interstitial to massive sericite. Sparse extremely fine chalcopyrite and pyrite is disseminated.

The veins are mostly bifurcating/lenticular but the largest vein is mostly about 4mm wide. These are mostly filled with carbonate, with thin lamellae of yellowish carbonate, possibly siderite, as well as more abundant colourless carbonate. Screens of feldspar-rich fine-grained rock occur in some of the smaller veins and may be composed of K-spar, but this is most clearly seen on the stained offcut.

Interpretation

This sample may have been a basalt with accessory primary magnetite, apatite, but has scattered sphene, rather than titanomagnetite. The alteration includes albite, K-spar, chlorite ± illite and biotite as well as very fine microplaty hematite, pyrite and chalcopyrite. Later sericite as seen in the Ba-rich samples described above. The carbonate veins are free of sulphide and may represent the same late, barren veins seen in other samples, or carbonate from a different source.





Figs 32 & 33 **QBE#1, 421.0m** **0.09 mm**

PS (x100). This rock is a massive fairly homogeneous basalt/microdolerite, here showing scattered opaque minerals: patches with internal micronetwork are leucoxene after sphene. Pale grey-brown crystals are magnetite, yellow grains of chalcopyrite, pale grey laths, blades and decussate fibrous hematite.

QBE #1, 429.24m **Relatively fine volcanic breccia of mostly mafic fragments. Pervasive alteration to albite, chlorite, extremely fine hematite and minor biotite, all in a carbonate-rich cement with hydrothermal albite, apatite, biotite, magnetite, accessory micaceous hematite, trace pyrite > chalcopyrite.**

Hand Specimen

About 60% of this core-segment consists of a loose packed aggregate of unsorted corroded looking volcanic rock fragments mostly <10mm in diameter. The smaller fragments seem to be more angular than the larger ones, many of which are rounded. The matrix or cement seems to contain pink feldspar as well as possible carbonate. K-spar is not clearly identified on the stained offcut, the pale yellow stain that has developed being more typical of sericite.

Thin Section

Petrographically, the fragments are fine-grained and mostly vary from albite-rich to chlorite-rich, with abundant disseminated oxide including magnetite and much more finely dispersed secondary hematite and very minor biotite. Albite occurs as laths in some fragments but is granular in others, with abundant apatite as small needles in some areas and abundant microcrystalline sphene in other areas. There is commonly a weak clouding by clays or sericite, but no obvious K-spar is visible. Chlorite-rich areas are decussate and fine-grained with optically negative, probably iron-rich chlorite and minor to abundant hematite.

The whole rock matrix or cement is mostly granular vein carbonate mosaic, about 1mm in grainsize, but there are partly euhedral albite crystals to 1.5mm long protruding into masses of carbonate. Anhedral, granular albite, mostly checkerboard albite, occurs in some areas with or without carbonate. Some of the albite contains abundant fine-grained oxide. Stubby prisms of apatite occur in some areas and may be of hydrothermal origin. Other areas contain biotite as crystals mostly elongate at a high angle to their cleavage planes, and there is relatively minor chlorite in some areas. Trace pyrite and chalcopyrite occur as very small grains.

Interpretation

The fragments in this breccia seem to be of mafic igneous origin with apatite and sphene as well as various combinations of albite, chlorite, oxide and biotite. The cement is hydrothermally introduced permeations, typical assemblage of carbonate and albite, accessory apatite but has only rare pyrite and chalcopyrite.

The mode of occurrence of magnetite grains commonly about 0.5mm, through the intergranular cement of carbonate vein-network suggests that these grains are also hydrothermal.

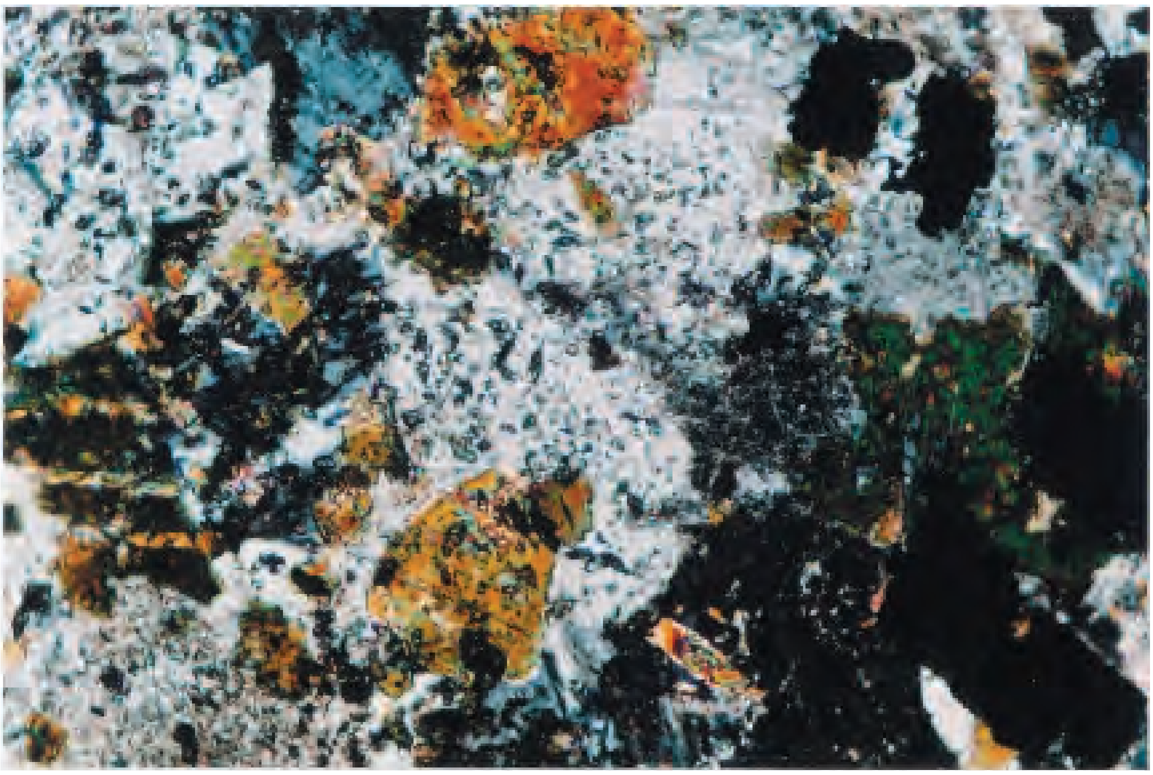


Fig 34 **QBE#1, 429.24m** **0.09 mm**

TS. Xnic (x100> This rock a loose packed aggregate of mafic volcanic rock, consistently about 5mm in size, here seen to consist of patchy pale carbonate and albite alteration, scattered biotites (coloured) apatite, also disseminated primary-igneous magnetite grains.

Fig 35 **QBE#1, 429.24m** **0.45 mm**

TS. OL. (x2). Patches with diffuse margins are corroded fragments/clasts of altered basalt with disseminated fine magnetite. Networks of carbonate veining between with scattered opaque grains of sulphide.

QBE #1, 434.00m **Breccia with dark fragments and paler fragments of altered volcanic rock. The dark fragments have an alteration assemblage of epidote-phlogopite-chlorite-magnetite-albite-tremolite-K-spar, also a magnetite-chlorite-rich fragment with minor apatite. Paler, more albite-rich fragments also occur with scattered magnetite, phlogopite and chlorite ± carbonate-albite-apatite patches. The hydrothermal cement permeating between fragments contains carbonate, albite, apatite, magnetite and rare chalcopyrite.**

Hand Specimen

This sample was chosen to include two quite distinctive dark-coloured fragments about 20 and 40mm in diameter. There is a dark brown rim on the larger fragment, which is mostly dark green, in a finer-grained breccia with orange-pink fragments and abundant carbonate. The core-segment is highly magnetic and abundant magnetite is suspected. The stained offcut shows only rare K-spar, mostly in the very dark fragment.

Thin Section

The largest fragment has areas flooded by coarse prismatic epidote as prisms to 2mm long, in a decussate arrangement, but is mostly rich in pale green, fine-grained decussate phlogopite and fine-grained oxide. Very minor K-spar and carbonate occur in interstitial patches. There are also rare prisms of tremolite to 2mm long and some of the epidote encloses parallel fibres that may be tremolite. Patches of chlorite and/or carbonate are also disseminated and some of these contain grains and aggregates of K-spar, apparently adularia. Albite is locally abundant, mostly along the dark brown margins of the fragment, with flakes and aggregates of brown phlogopite, rather than the greenish phlogopite seen elsewhere in the fragment.

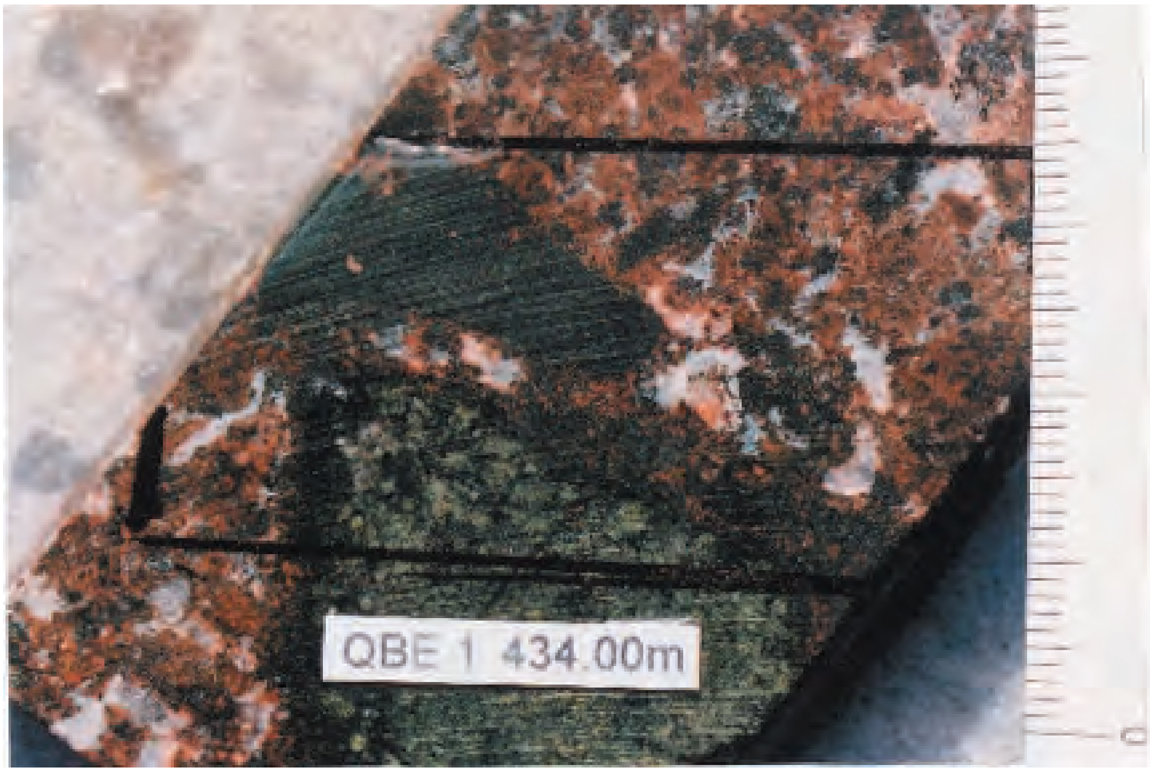
The smaller, dark grey to brown fragment has abundant inequigranular oxide, from a few microns to 0.15mm in grainsize, as well as abundant chlorite and very minor apparently residual pale brown phlogopite. Very minor granular apatite is present.

The pink fragments are mostly dominated by very fine-grained iron-stained albite with abundant disseminated oxide and rare chlorite. Some fragments, close to the dark fragments described above, have moderately abundant decussate fine-grained phlogopite as well as or instead of chlorite, and locally contain patches of coarse albite and/or carbonate, locally with relatively large apatite prisms.

The cement between fragments is a heterogeneous mixture of hydrothermal carbonate and bladed crystals of albite, partly euhedral magnetite crystals, and locally very abundant prismatic apatite. Large crystals of magnetite occur and pass into irregular masses of magnetite intergrown with secondary minerals in the adjacent rock fragments. The larger areas of cement, to 5mm or more in diameter, are mostly filled by large, partly deformed grains of carbonate, with albite and apatite protruding into the carbonate. Albite and more abundant apatite are more abundant in narrower areas of cement, where the fragments are closer together. Sulphide is rare, with chalcopyrite enclosed in coarse carbonate.

Interpretation

This sample has abundant magnetite but only rare sulphide. There are dark, magnetite and chlorite-phlogopite-rich fragments, one of which has areas flooded by epidote and a rim with albite and brown phlogopite rather than green phlogopite as seen in the core of the fragment. The cement is composed of hydrothermal carbonate, albite, apatite and oxide, but the oxide is all magnetite, nil or negligible hematite and only rare-trace sulphide.


QBE 1 434.00m

QBE #1, 442.0m **Breccia of dark, aphyric, probable basaltic fragments with pervasive alteration to albite, magnetite, chlorite and carbonate (in vesicles?), or altered prismatic crystals, and paler, iron-stained, albite-rich fragments with oxide, apatite and chlorite. Interstitial areas of hydrothermal cement are carbonate-rich, with a zone of albite between the fragments and the carbonate, locally with apatite and magnetite. Nil or negligible sulphide.**

Hand Specimen

This core-segment has dark, possibly magnetite-rich fragments and pale orange-pink fragments with abundant interstitial carbonate. Variation at right angles to the plane of the thin section means that the arrangement and size of fragments in the thin section is quite different to that seen in the macrophoto. The white veins of late carbonate are similar in the photo and in the thin section, however. The stained offcut shows two areas rich in K-spar, apparently overprinting albite within fragments and along the margins of carbonate-filled interstitial areas. This hand specimen seems to lack sulphide.

Thin Section

In one corner of the thin section there is a green fragment that is rich in chlorite and also has large areas of clay-altered prismatic crystals that may have been scapolite, although other minerals (epidote or amphibole) are also possible. This fragment has accessory disseminated magnetite and micaceous hematite, as well as albite and would appear, from the stained offcut, to contain K-spar. No obvious K-spar is visible in thin section, however. Adjacent to this fragment there is a dark brown fragment, angular in outline and 20-25mm long. This fragment has internal fractures containing carbonate, albite and apatite. The rock is rich in fine-grained albite and chlorite as well as abundant fine-grained oxide. At the other end of the thin section there is another large, dark-coloured fragment over 25mm in diameter. This fragment is also very fine-grained and variously rich in albite laths and decussate, fine-grained chlorite. There is less abundant magnetite that in the dark, angular fragment, partly as possible microphenocrysts to 0.5mm in diameter and partly as much smaller grains. Patches of carbonate, to 1mm in diameter, occur in this fragment and may represent vesicles.

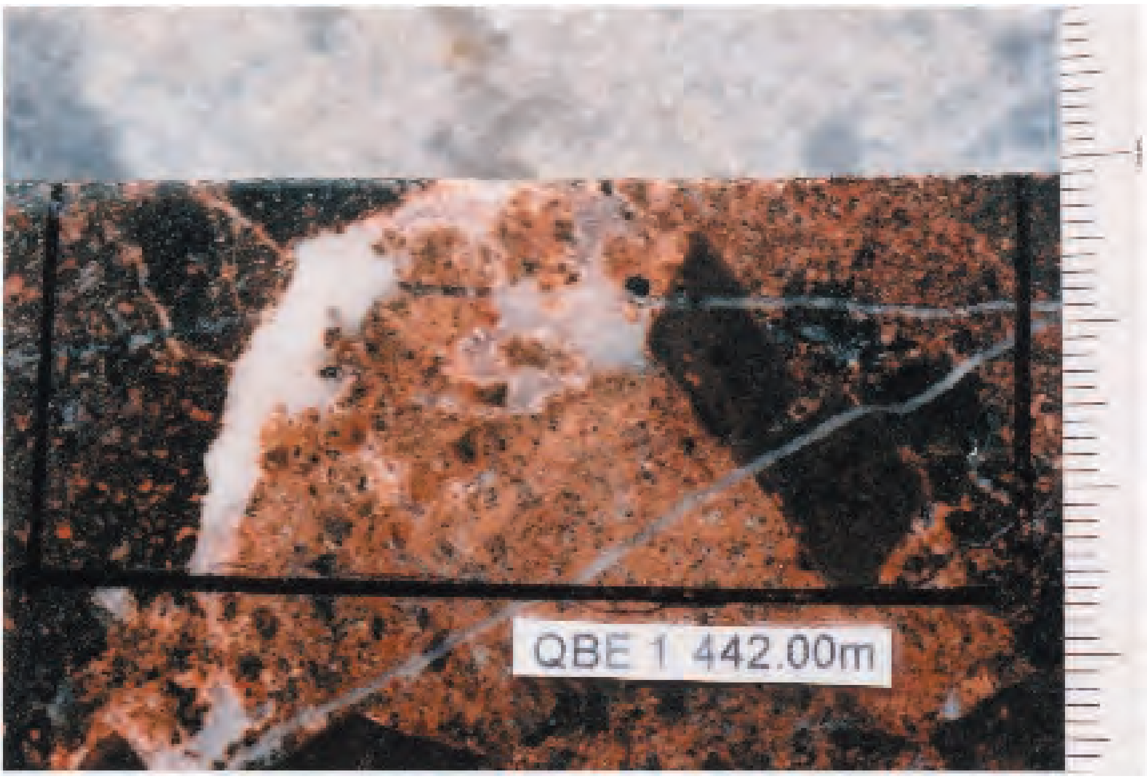
The paler fragments are rich in coarser, slightly iron-stained albite laths mostly from 0.05 to 0.5mm in length, with minor magnetite, chlorite and apatite. All of the fragments are enveloped by areas of hydrothermal cement with an outer zone/margin of albite crystals, mostly protruding into internal core filling of carbonate, which makes the margins of these paler fragments less clear than those of the fine-grained, darker fragments. The green fragment also has some clay-altered elongate crystals (scapolite, epidote or amphibole?) protruding into the carbonate.

Some narrower interstitial areas are commonly rich in, or composed of randomly interlocking albite laths to 1mm long, but wider areas, to 10mm wide, have an infill of very large grains of carbonate, with albite only adjacent to the fragments. Minor apatite and magnetite occur in the albite-rich areas, but are less abundant than in other albite and carbonate rich areas as described above.

The late carbonate veins differ from those described above in having minor granular or prismatic quartz as well as coarser carbonate than that usually seen in the later carbonate veins.

Interpretation

This breccia has a mixture of dark, aphyric probable basaltic fragments and paler more feldspathic fragments cemented by permeating hydrothermal vein networks of carbonate infill with albite crystals along margins. There is minor oxide and rare apatite in the veins, but no sulphide.


QBE 1 442.00m

QBE #1, 459.00m **This is the most chalcopyrite-rich sample in the whole suite of the core examined, corresponding to a 1m assay interval of 1.16% Cu and a 5-metre segment, with 3772ppm Cu. It consists of an albite-chlorite-magnetite-carbonate-leucoxene-altered feldspathic volcanic incorporating a large area of coarse pyrite-chalcopyrite aggregate, crowded with anomalously abundant apatite crystals, also chlorite-smectite, carbonate (partly after micaceous/bladed hematite?), and unaltered micaceous/bladed hematite, rare quartz.**

Hand Specimen

This core-segment was selected to represent the most concentrated massive sulphide (maximum length 70mm) within pale orange-pink altered felsic volcanic fragments. The abundance of sulphide is not clear on the macrophoto as chalcopyrite is green in the photo, contrasting with pale pyrite and gangue minerals. There is no K-spar in this thin section. Away from the sulphide-rich band the core-segment is mostly composed of pink material with possibly minor chlorite.

Thin Section

A small fragment of the pale altered volcanic host rock has been captured at one end of the thin section. This is typical of pale orange-pink albitised fragments with abundant albite, partly as laths derived from plagioclase and partly as poikilitic checkerboard albite, possibly derived from K-spar. Chlorite, magnetite and leucoxene are also present, with some suggestion that the leucoxene was formed from sphene. There are also abundant patches of carbonate, mostly irregular and possibly filling vesicles, but there are less abundant rectilinear patches that may represent phenocrysts (pyroxene?) and contain oxides. This fragment is mantled with granular carbonate and areas composed of carbonate and albite. In some areas there are rare prisms of quartz protruding into the sulphide-rich areas adjacent tot the fragment and there are also patches of carbonate with abundant apatite as small unoriented prisms.

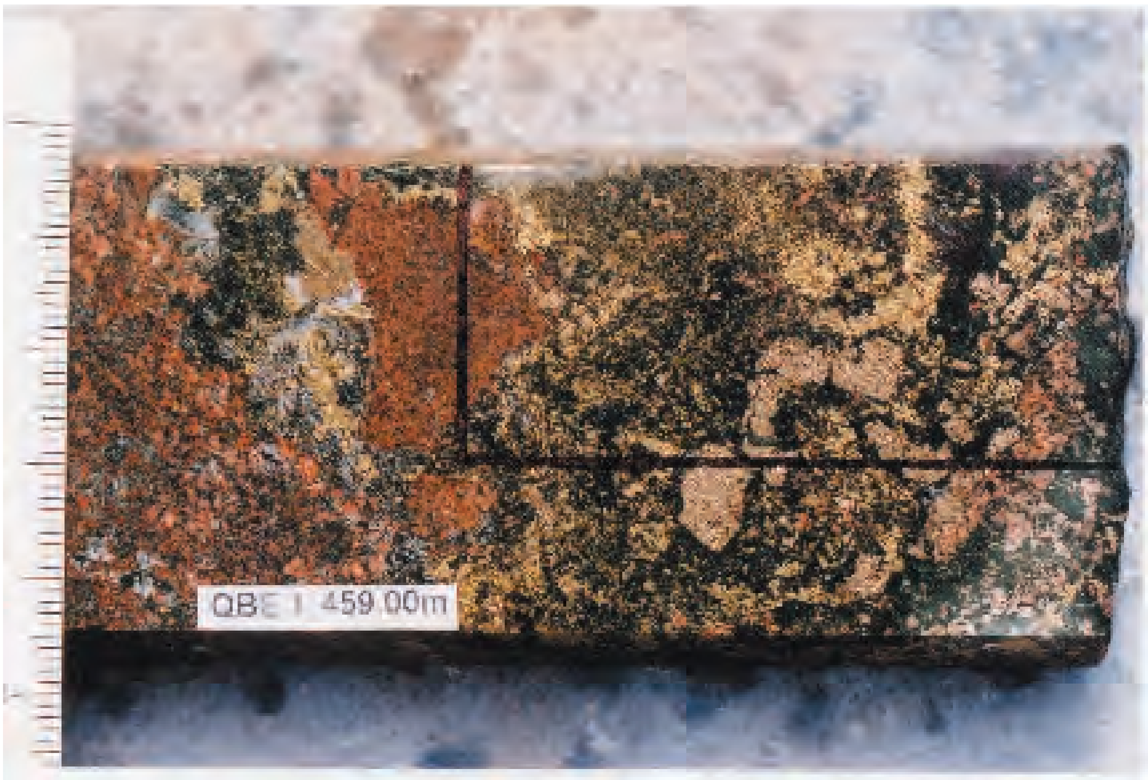
The sulphide-rich area has large masses of pyrite, to 15mm long, enclosing apatite prisms, but the bulk of this area is characterised by scattered and patchy matrix of coarse chalcopyrite with various gangue minerals. Disseminated chlorite ± smectite is common to abundant, with less abundant carbonate and very minor quartz, but the main gangue is apatite as crowded/clustered inequigranular prisms from 0.05 to 1.5mm long. The quartz is also prismatic and occurs in lenses to 2.5mm long.

One area also has large masses of long fine bladed carbonate crystals in a parallel or fan-like arrangement with a texture identical to that in aggregates of fine long bladed hematite, and considering the possibility of residual hematite as well as chlorite-smectite, it is suggested that the carbonate may have replaced earlier platy hematite.

Although there is some pyrite adjacent to the host rock fragment, most of the pyrite is more than 15mm away from the fragment within sulphide aggregate. In this area the chalcopyrite is more abundant and has fewer inclusions of mostly coarser-grained apatite and other gangue minerals. Rare checkerboard albite occurs at the edge of the thin section in an area rich in probable chlorite-smectite, with disseminated magnetite. This area may represent a highly altered fragment, but this is not certain.

Interpretation

This sample has the best copper mineralisation seen in this drillhole, (usually rare in this hole) with an unusual gangue assemblage dominated by clustered small apatite crystals, but also containing minor quartz, which is rarely seen with apatite in any of the samples described above. There also seems to have been replacement of hematite by carbonate, possibly siderite, and the formation of large crystals and lenses of pyrite. The sulphides are interstitial to, or contain inclusions of apatite.


QBE 1 459.00m

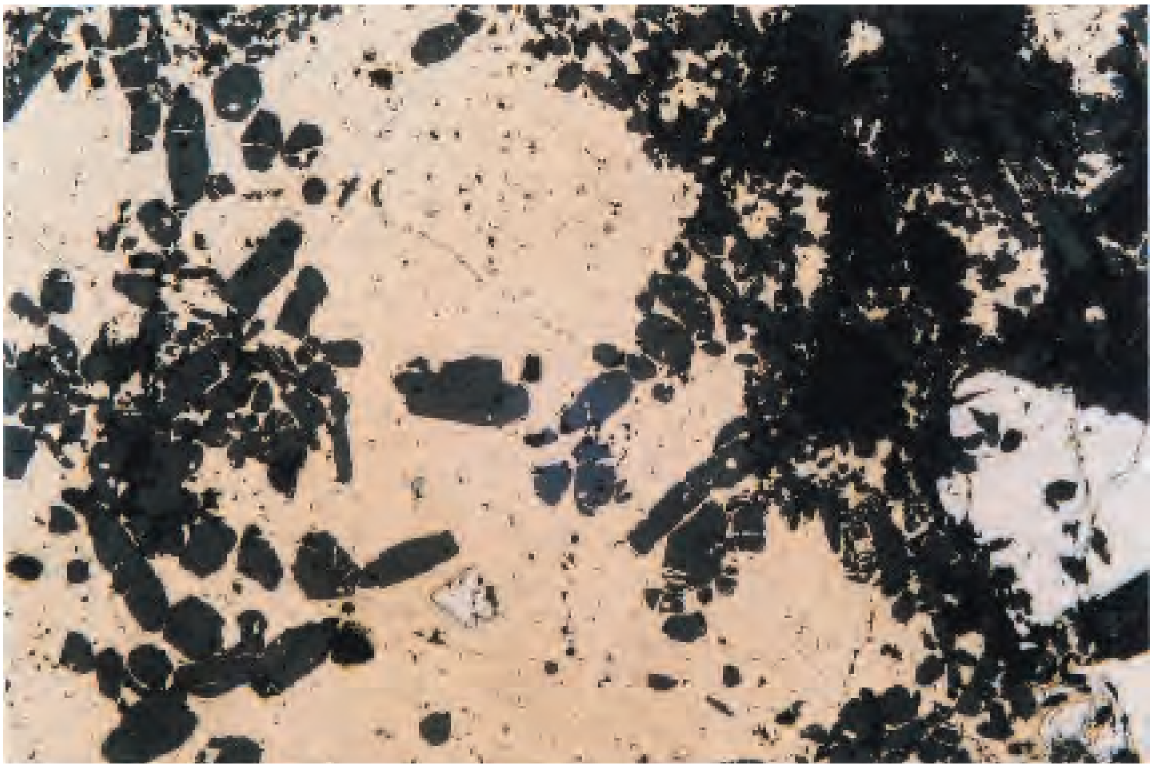


Fig 36 **QBE#1, 459.0m** **0.45 mm**

[Most Cu-sulphide + pyrite-rich sample in the suite.]
PS (x20). Coarse massive chalcopyrite (very pale yellow due to overexposure), incorporating scattered clusters of apatite crystals. Two adjacent white pyrite crystals, also in apatite aggregate.

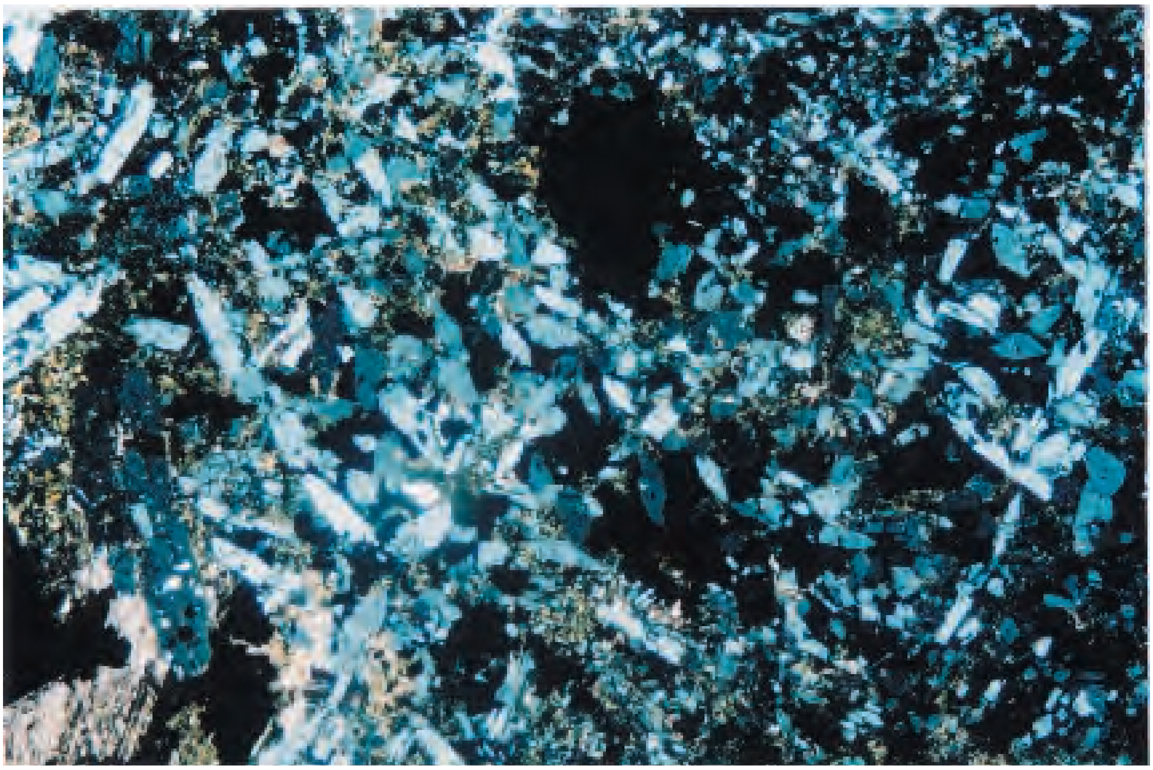


Fig 37 **QBE#1, 459.0m** **0.45 mm**

TS. Xnic (x20). Example of aggregate of abundant apatite crystals, interstitial chlorite and carbonate, patches of opaque chalcopyrite.

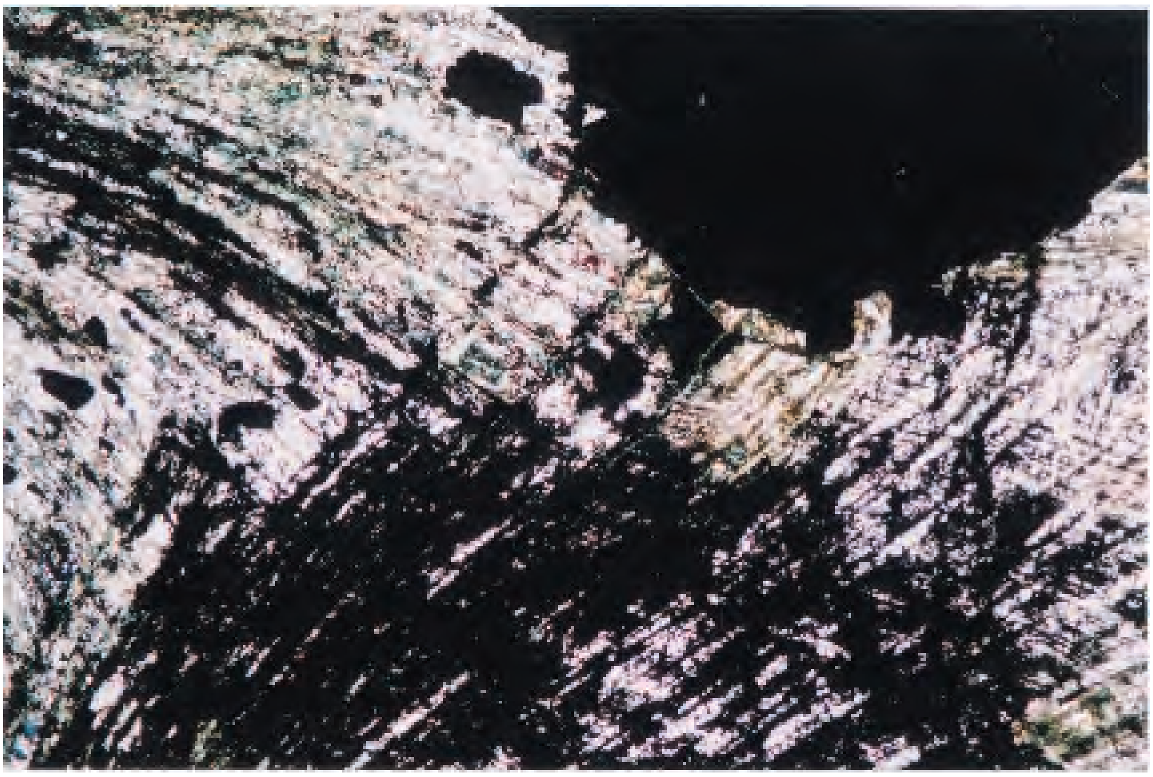


Fig 38 **QBE#1, 459.0m** 0.18 mm

TS. Xnic (x50). Transmitted light photo of pale carbonate + rare associated fine chlorite which, according to the overall fabric, appears to be replacing former sheafs of fine bladed hematite with relicts of the black-opaque hematite remaining as residuals. Next to coarse granular sulphide.

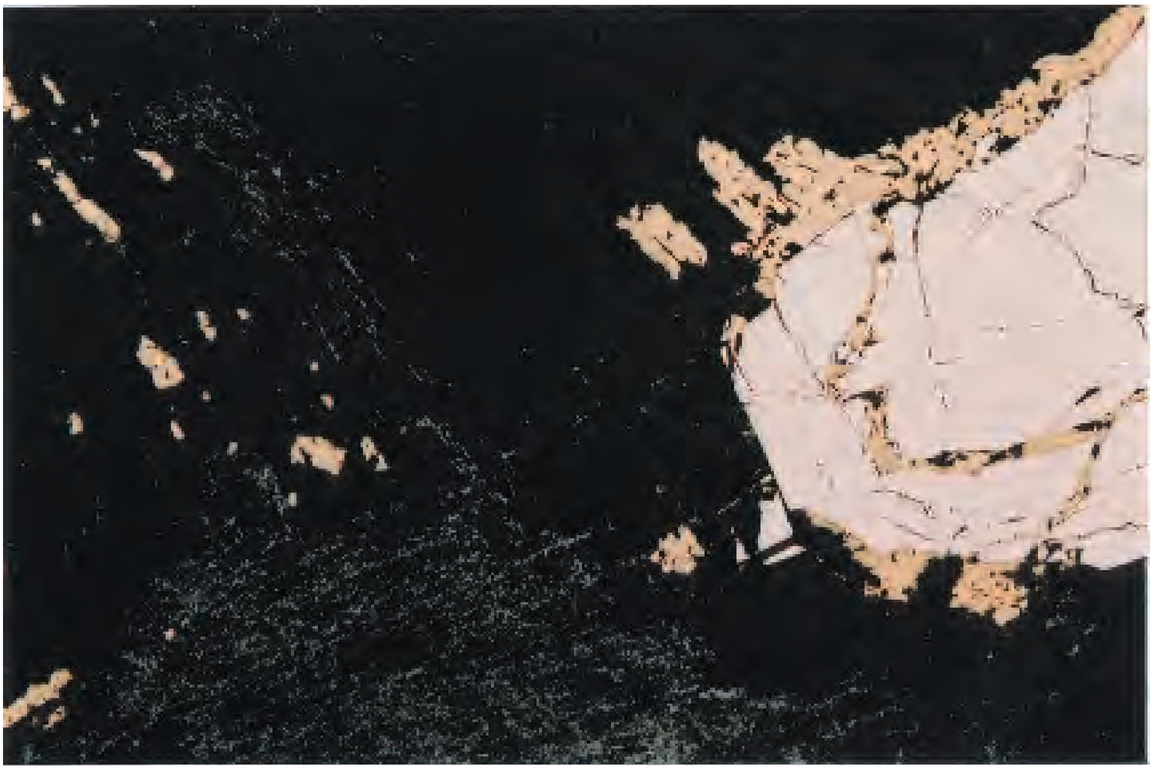


Fig 39 **QBE#1, 459.0m** 0.18 mm

PS (x50). Coarse granular pyrite partly surrounded by and rimmed by yellow chalcopyrite next to carbonate and residuals of fine hematite as in above photos.

QBE #1, 460.9m **Breccia with minor dark chlorite-rich fragments and extensive pale K-spar-rich areas probably a fragmental-altered felsic volcanic. Extensive patchy carbonate, scattered fine hematite and leucoxene (partly after sphene), as well as chlorite and K-spar (probably adularia). Accessory very fine chalcopyrite mostly associated with poorly defined veins of carbonate ± chlorite, some composite with leucoxene/fine hematite.**

Hand Specimen

This sample has numerous irregular white carbonate veins within extensive fractured but not clearly fragmental areas of pale and dark red rock. A more clearly defined fragment of grey rock is seen at one end of the thin section and is clearly visible on the macrophoto, with smaller dark probable fragments within the area of the thin section. The stained offcut indicates abundant K-spar in all areas.

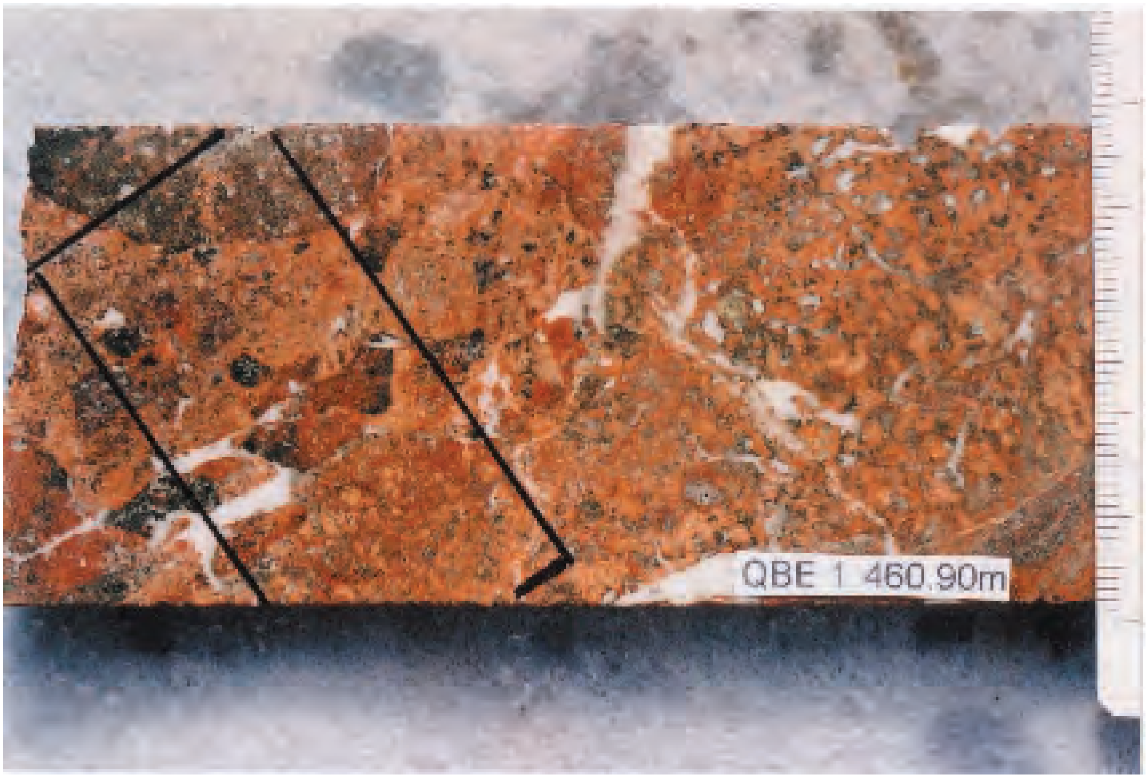
Thin Section

The dark fragment is relatively rich in chlorite and also has abundant carbonate, partly fine-grained and disseminated, partly in patches to 1mm long. Some of the patches are elliptical and may represent vesicles but others are more rectilinear and may represent former phenocrysts. There are lamellae of oxide in some of the more rectilinear patches. In some areas there are patches of decussate muscovite or sericite and granular K-spar, also possibly derived from phenocrysts. Fine-grained feldspar, probably mostly K-spar, is disseminated, with oxide and leucoxene.

The remainder of the rock seems to have roughly centimetre-scale domains with different textures and may be fragmental, although there is little obvious matrix or cement, and the possible fragments have been cut by veins. K-spar, probably adularia, and minor to common carbonate are the main components, with pale orange iron staining in the K-spar. In some domains the K-spar is very fine-grained and clouded, but in others it is clear and over 0.1mm in grainsize. Some of the carbonate may have replaced phenocrysts, but this is not as clear as in the dark fragment. Accessory fine-grained hematite and leucoxene are disseminated, with leucoxene and carbonate replacing crystals of sphene to 0.5mm long. Accessory fine chalcopyrite (<<1%) tends to accompany short veinlets and patches of carbonate ± chlorite and K-spar, also is composite with some of the fine leucoxene ± hematite grains.

Interpretation

This sample has mafic and feldspathic (intermediate) fragments with K-spar, chlorite and carbonate as abundant components as well as oxides and sphene. Numerous white carbonate veins differ from the poorly defined irregular stringers and patches of typical late carbonate, with rare associated chalcopyrite.



QBE #1, 470.20m **Breccia with fragments of red albitised microsyenite porphyry, also darker altered mafic fragmental domains with various combinations of chlorite, biotite, albite, K-spar, scattered primary grains of magnetite, carbonate, apatite, leucoxene and sphene in pale or dark fragments. Sparse fine grains of chalcopyrite, pyrite and micaceous hematite adjacent to an in veinlets of carbonate.**

Hand Specimen

This sample has a large pink, albitised porphyritic fragment, as seen in samples from 351-374m, with a dark rim and separate pale and dark fragments, all as shown on the macrophoto. The stained offcut indicates that K-spar occurs mostly in the dark fragments. Late carbonate veinlets are present and there is very minor sulphide, mostly in pale areas.

Thin Section

The pale pinkish albitised fragment has abundant scattered white feldspar phenocrysts from 1 to 6mm long, some of which, including the smaller phenocrysts, are albitised plagioclase, and are subhedral, but others are more anhedral and seem to have formed from K-spar. The groundmass is very fine granular albite with minor aggregates of very fine micaceous hematite, albite, carbonate and apatite containing rare zircon to 60µm long. There is also a patch of carbonate enclosing an amoeboid grain of chalcopyrite 1.5mm long. This pink fragment has a rim about 3mm wide composed largely of clay-altered granular and prismatic epidote with very minor phlogopite and K-spar (adularia?). The original lithology was apparently a microsyenite porphyry.

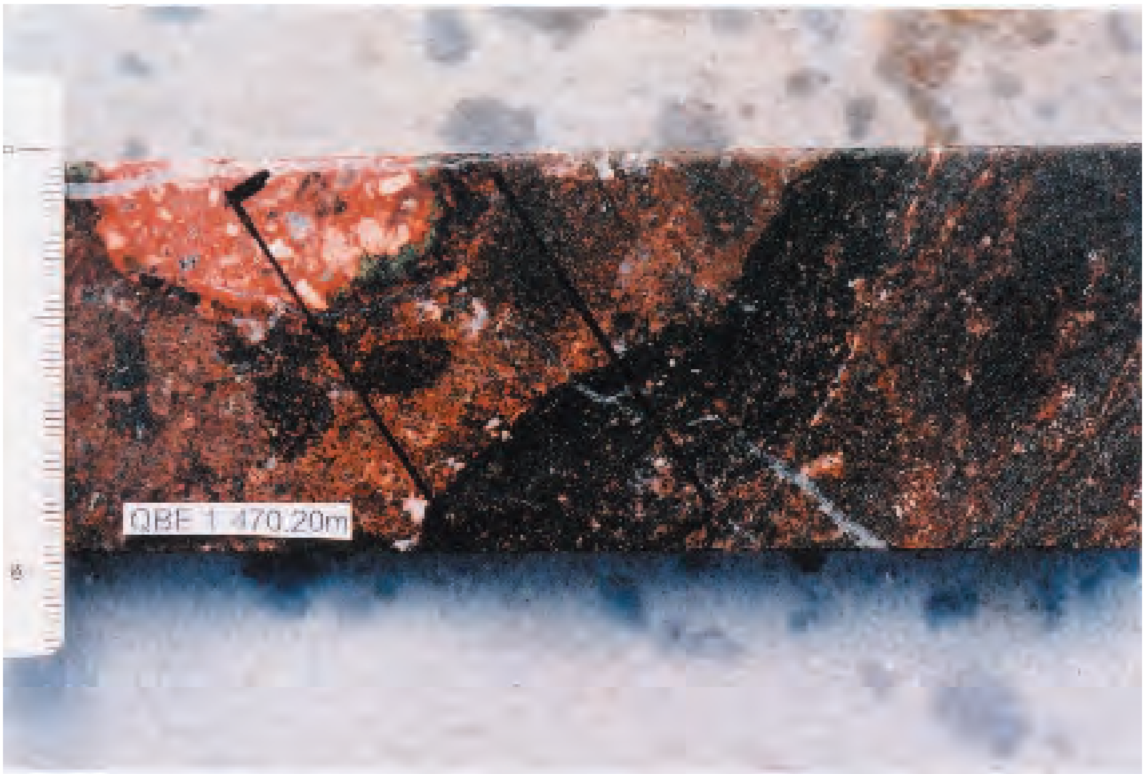
At the opposite end of the thin section there is part of a dark fragment that is seen on the macrophoto to be elongate and at least 60mm long. This fragment has been flooded by very fine and essentially isotropic chlorite, but also has clay pseudomorphs of prismatic crystals to 2mm long. The original mineral is uncertain, but scapolite, epidote or an amphibole would seem to be possible. Fine granular magnetite is disseminated, to 0.3mm in grainsize, with partly leucoxenised sphene to 1mm in diameter. Irregular patches of carbonate are also scattered and contain needles of apatite to 1mm long. The other dark fragment has disseminated biotite and rare clay pseudomorphs of elongate crystals, but is richer in albite and K-spar, with disseminated oxides and apatite. These dark domains almost certainly represent altered mafic/basaltic volcanics.

The paler areas tend to be albite-rich with albite after plagioclase laths enclosed in relatively small grains of checkerboard albite apparently derived from K-spar. Oxides are disseminated as well as chlorite ± smectite and pale biotite or phlogopite.

Irregular, tension-gash veins occur with carbonate and minor granular to bladed albite, with some carbonate veins lacking albite, but with sparse very small grains of chalcopyrite adjacent to them (rather than precisely in them).

Interpretation

This sample has a fragment of albitised microsyenite porphyry, as seen in much shallower samples, but more extensive altered mafic volcanic which are chlorite-rich and biotite-bearing fragments, with clay-altered elongate crystals of uncertain origin, containing albite and K-spar. Paler albitised fragments seem to have contained plagioclase and K-spar. Carbonate veins ± albite have sparse small grains of chalcopyrite loosely associated with them.


QBF 1 470.20m

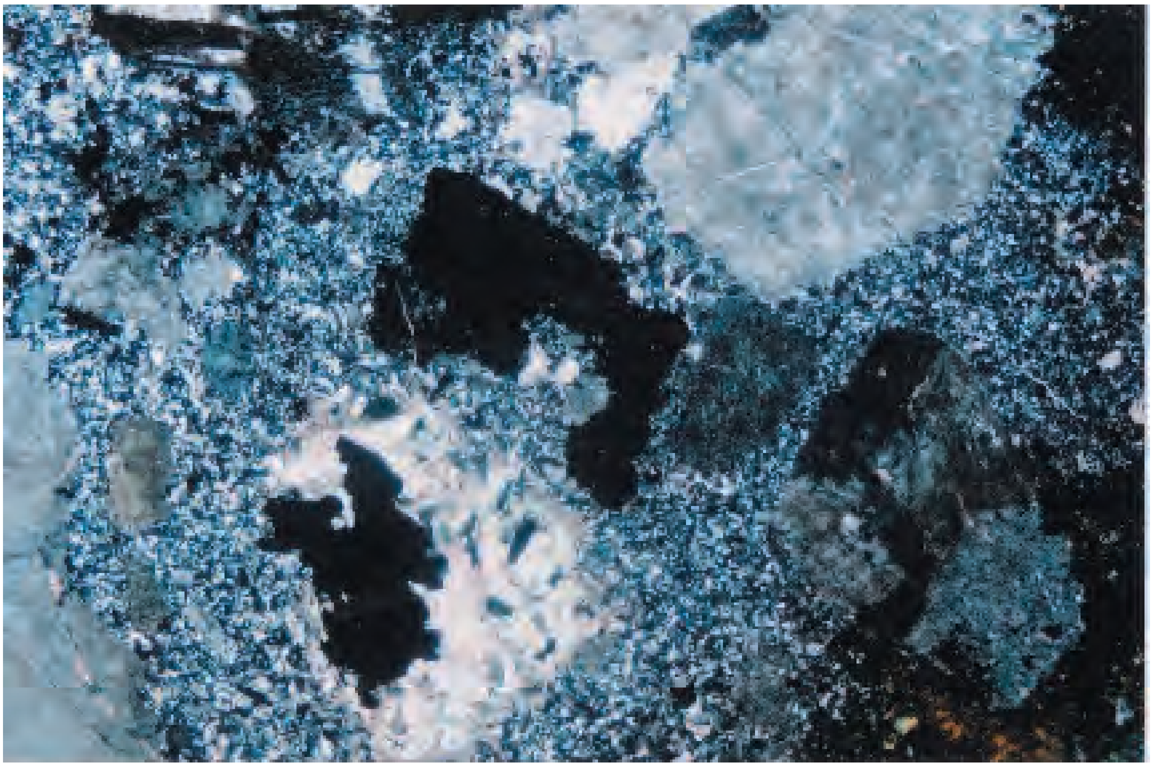


Fig 40 **QBE#1, 470.2m** **0.45 mm**

TS. Xnic (x20). This sample marks a return to a volcanic breccia with fragments of carbonate and albite-altered porphyritic microsyenite shown above, with opaque grains of chalcopyrite enclosed in patches of carbonate alteration.

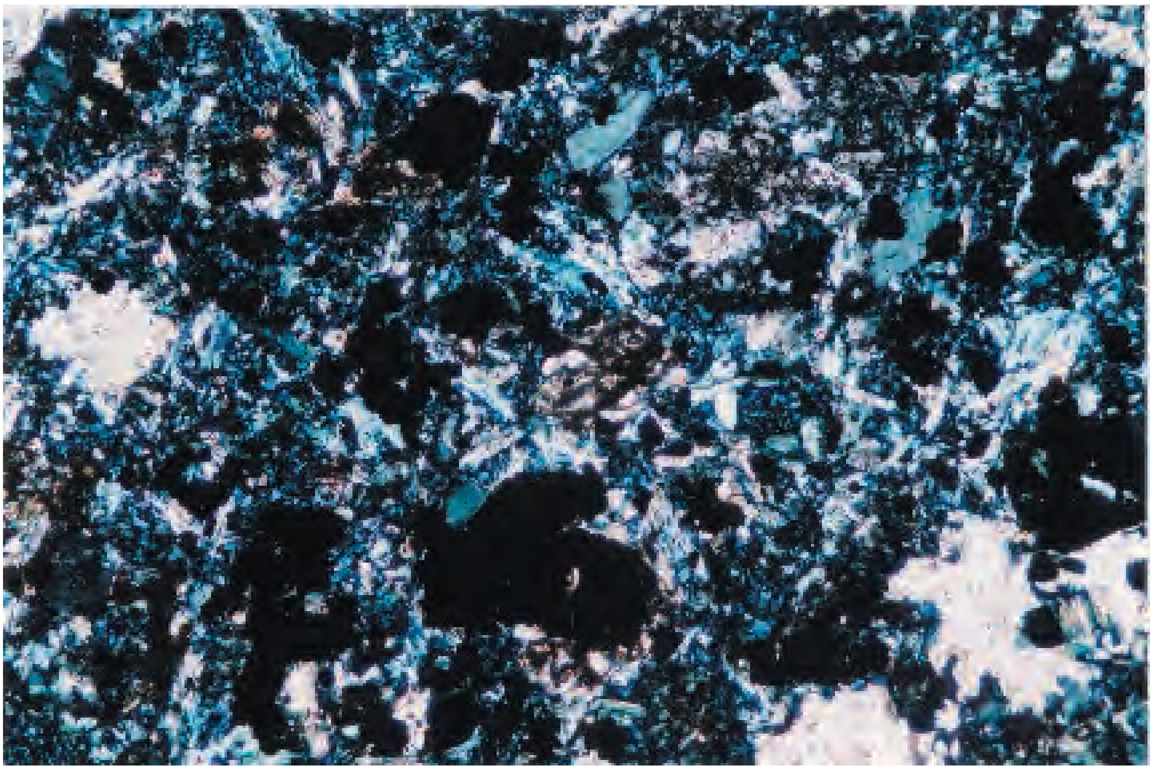


Fig 41 **QBE#1, 470.2m** **0.09 mm**

TS. Xnic (x100). Also however, this same breccia includes fragments of altered basaltic composition (as well as syenite), detail shown here, with albitic alteration of feldspars, interstitial chloritic alteration, bright patches of carbonate (incipient vesicle fillings), disseminated probably primary opaque magnetite.

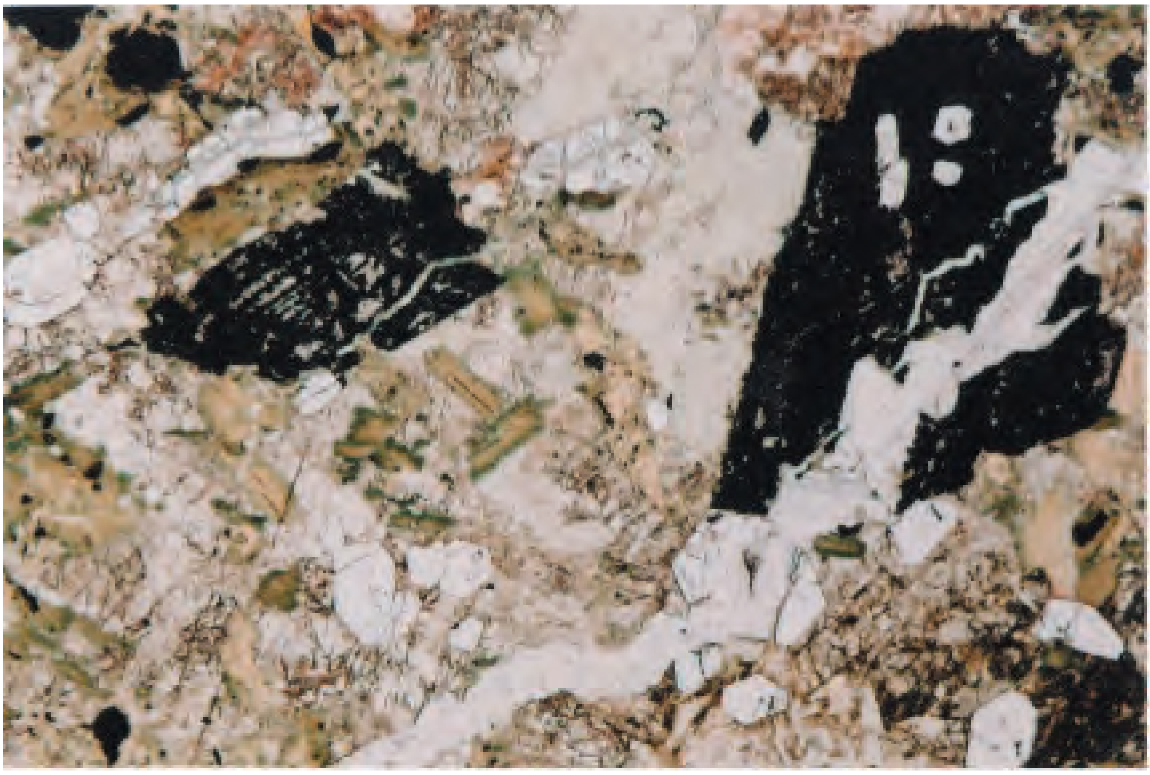


Fig 42 **QBE#1, 470.2m** 0.18 mm

TS. PL. (x50). Carbonate veining between clasts, adjacent alteration in syenite involving zoned biotite flakes, scattered clear apatites, dark patches of sphene and cloudy areas of altered scapolite.

QBE #1, 480.4m **Breccia with a dark biotite-epidote-albite-oxide-K-spar-rich fragment probably altered mafic. Also more feldspathic, reddish albitised feldspathic fragments with biotite, oxide, carbonate and apatite, and accessory scattered magnetite grains, typically much finer and sparser micaceous hematite. One fragment may represent groundmass-poor microsyenite. Large areas of interstitial carbonate are typically rimmed by normal and checkerboard albite ± apatite, and enclose magnetite + chalcopyrite and tremolite. Several mm-size grains of chalcopyrite adjacent to other carbonate areas, with albite-tremolite-epidote-apatite patches.**

Hand Specimen

Several zoned dark and pale green fragments occur in this core segment as well as large mottled orange-pink fragments of altered felsic volcanic and several large white infills of carbonate-vein material. The largest green fragment has a dark rim. Several small grains of chalcopyrite and of hematite occur in and adjacent to the largest patch of carbonate. Very minor K-spar is seen in the margin of the large green fragment and adjacent to some areas of carbonate. Most of the rock lacks K-spar, however.

Thin Section

The dark green fragment has areas rich in fine-grained decussate green biotite as well as abundant areas rich in fine bladed crystals of albite. Accessory ‘coarse’ granular magnetite, and much finer groundmass magnetite and hematite are disseminated as well as carbonate and apatite. Other areas have clay-altered prisms of probable tremolite as well as very clouded granular epidote and patches containing chlorite, albite and K-spar close to adularia in optical properties. Oxide is also abundant in these areas. Lenses rich in clouded epidote are as much as 4mm wide and form a large part of the fragment. The rim is rich in decussate green biotite, mostly fine-grained but including flakes to 2mm long. Oxides, albite and small aggregates of K-spar (adularia?) are scattered through this zone but are mostly less than 1mm in diameter. Patches of carbonate occur, to 1.5mm in diameter, and there is minor apatite, especially in the areas adjacent to carbonate masses.

The other (pale and reddish) fragments are rich in albite, mostly after unoriented small laths of plagioclase, to 0.4mm long, with rare checkerboard albite possibly after poikilitic K-spar grains. Minor to abundant oxide is disseminated and is mostly fine-grained. Flakes of variously uniform or zoned green or brown biotite or phlogopite occur, mostly fine-grained but locally as much as 2mm long. Some fragments also contain clouded prisms of epidote.

One fragment is largely composed of granular checkerboard albite to 1.5mm in grainsize, with less abundant carbonate in patches to 2mm in diameter. Small areas of fine-grained albite occur and there is disseminated oxide, partly as microphenocrysts to 0.5mm in diameter and partly very fine-grained. Minor pale brown biotite or phlogopite is present, partly as flakes elongate at a high angle to their cleavage planes.

Large interstitial areas of carbonate up to 15mm in diameter, usually (and typically) have a rim of euhedral albite crystals with or without pale biotite or phlogopite. Some of the albite has a checkerboard texture and the shape of euhedral crystals of adularia, but bladed euhedral normal albite is also present. Minor to abundant fine prismatic apatite accompanies the albite in some areas. A composite grain of magnetite 2.5mm across, enclosing chalcopyrite and partly rimmed by albite enclosed in this coarse carbonate seems to be hydrothermal. There are also parallel aggregates of clay-clouded probable tremolite prisms to 2mm long. Patches of chalcopyrite to 4mm, adjacent to the coarse infill of carbonate with tremolite, epidote, albite and apatite.

Interpretation

This sample has fragments with varied alteration, including calc-silicates and biotite, but mostly poor in K-spar. Albite is abundant and has partly replaced K-spar in more feldspathic fragments. Coarse carbonate mosaic infill between fragments also encloses composite hydrothermal magnetite + chalcopyrite and altered tremolite, and it rimmed by albite ± apatite, as seen in many samples above. One of the fragments may represent microsyenite, but the texture is not as clear as in the previous sample.

Fig 43 **QBE#1, 480.4m** **0.45 mm**

TS. Xnic (x20). Hydrothermal vein of coarse carbonate with a margin of much smaller albite crystals and several equant (grey) apatite crystals. The large black-opaque grains are composite chalcopyrite and magnetite. Coloured irregular prisms (with partings) within the carbonate are altered tremolite.

QBE #1, 498.65m **Thin section of breccia of volcanic material centred on a large dark-rimmed and split mafic clast with disseminated magnetite and altered to fine chlorite, biotite, altered unidentified grains and apatite. This passes into carbonate-rich areas with albite, biotite, chlorite, oxides and altered sphene. Smaller clasts with albite, chlorite, biotite and oxides are also present. Sulphide is absent.**

Hand Specimen

This core-segment has a small number of dark, partly zoned fragments to 50mm long, as well as more abundant smaller orange-pink fragments and a relatively sparse carbonate cement. The thin section covers a fractured clast, with a pattern similar to that on a moth's wings, with some zones rich in K-spar and very minor sulphide. This clast is shown on the macrophoto.

Thin Section

The large dark green split and darker rimmed clast of altered mafic/basaltic composition is dominated by fine granular and prismatic epidote crystals to 1mm long, commonly with parallel fibres of possible amphibole. Interstitial chlorite is common, with a low birefringence, and there is abundant fine granular oxide, as well as zoned brown to green biotite/phlogopite. The adjacent zones have abundant clay-altered grains that may have been scapolite, epidote or, less probably, amphibole, ad were about 0.5mm long. Interstitial K-spar is shown in this zone on the stained offcut. Outer dark zones in some areas have abundant chlorite, possibly after olivine crystals about 0.5 to 2mm in diameter, in a matrix or groundmass rich in green to brown phlogopite or biotite, minor to abundant chlorite and abundant oxide. Patches and lamellae of clays, similar to those replacing the unknown crystals referred to above, occur in the chlorite. Larger flakes of brown biotite occur, mostly towards the edges of the clast, but are not abundant, and no K-spar is visible in thin section. A narrow vein composed of albite and chlorite has split this clast into two. Areas of chlorite adjacent to this vein have biotite and partly altered prisms of probable tremolite.

In one corner of the thin section there is a patch rich in clouded albite, partly checkerboard albite, to 1mm in grainsize. There is also abundant carbonate as irregular patches, as well as disseminated granular oxide and minor biotite. This area may contain a fragmented microsyenite but the texture is unclear. On the other side of the large clast there are finer-grained areas rich in albite, magnetite and biotite, again with abundant interstitial carbonate. Leucoxene is present in this area, partly derived from euhedral crystals of sphene.

This area passes into a fragment rich in fine-grained albite, with oxides, biotite and chlorite. Most of the grains are less than 0.2mm in length but there are grains and aggregates of magnetite to 0.5mm in diameter. This fragment has areas flooded by chlorite and also has minor disseminated apatite, possibly of igneous origin.

Interpretation

The large dark clast in this sample was originally mafic/basaltic, with disseminated magnetite, and now altered to fine epidote, chlorite and biotite and has rims that may have been derived from olivine basalt, as well as a zone rich in altered unidentified crystals. Albite-carbonate-biotite-rich patches, partly matrix and partly possibly derived from microsyenite, occur and separate the large clast from a smaller albite-chlorite-biotite-oxide-altered mafic clast. There is no sulphide in this sample.

QBE #1, 501.23m **Breccia with chlorite-magnetite-K-spar/albite altered mafic fragments, with disseminated magnetite crystals and much finer groundmass magnetite and hematite dispersed. Subordinate possible fragments rich in albite, also containing carbonate, oxide, chlorite and quartz (microsyenite). Early carbonate-rich areas contain minor quartz, with later carbonate-rich patches containing rare albite. Rare trace minute grains of chalcopyrite.**

Hand Specimen

Dark and light fragments of altered volcanic rock are abundant in this sample, with irregular patches of interstitial carbonate shown clearly on the macrophoto. The stained offcut shows common to abundant K-spar in the dark clasts and albitised pale clasts.

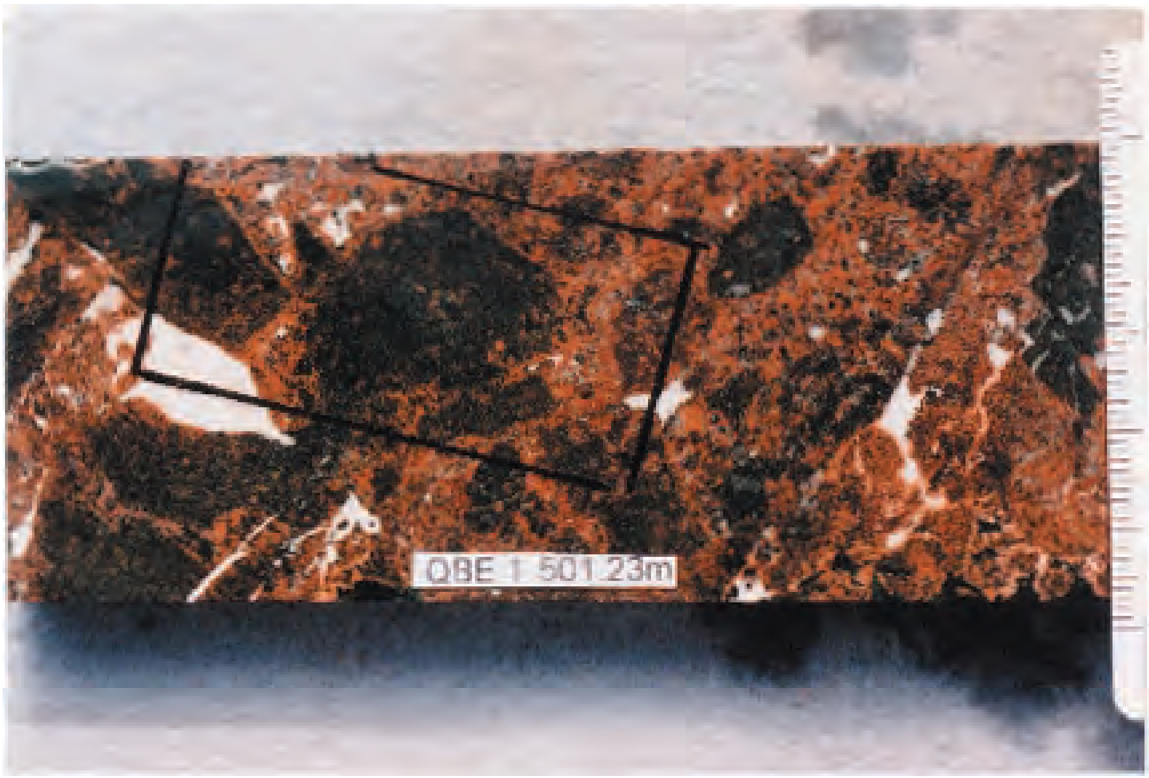
Thin Section

The largest dark clast has possible vesicles to 4mm long, largely filled by chlorite. Some of the possible vesicles also contain carbonate and albite, but others have irregular masses of probable magnetite. The host is also rich in chlorite, with irregularly disseminated oxide, partly as microphenocrysts and partly fine-grained groundmass material. Minor fine-grained feldspar is disseminated and would seen to be K-spar. The other dark clasts are also rich in chlorite, with much less abundant oxide in some clasts as well as rare feldspar, including areas rich in albitised plagioclase laths as well as very minor K-spar. These dark clasts are identified as altered mafic/basaltic.

Irregular masses rich in pale iron-stained albite are present, with grains mostly less than 0.5mm in size, possibly representing altered microsyenite. These areas also contain carbonate and opaque oxide, and one area has a possible xenolith composed of chlorite and oxide. Irregular grains of quartz occur in some of these areas, enclosing oxide, sphene and chlorite. Similar grains of quartz occur in patches of carbonate adjacent to these possible fragments, possibly representing an early generation of hydrothermal cement. Larger areas of granular and spherulitic carbonate occur, locally with rare crystals of probably low temperature albite.

Interpretation

This sample lacks calc-silicate minerals and biotite, but alteration typically involves fine chlorite, albite, K-spar, carbonate, oxides as in other samples, but also local fine quartz. The presence of quartz marks a departure from the alteration seen in the previous samples described above, and the lack of calc-silicates and biotite also separates this sample from the other deep samples. There is only rare trace minute grains of chalcopyrite.



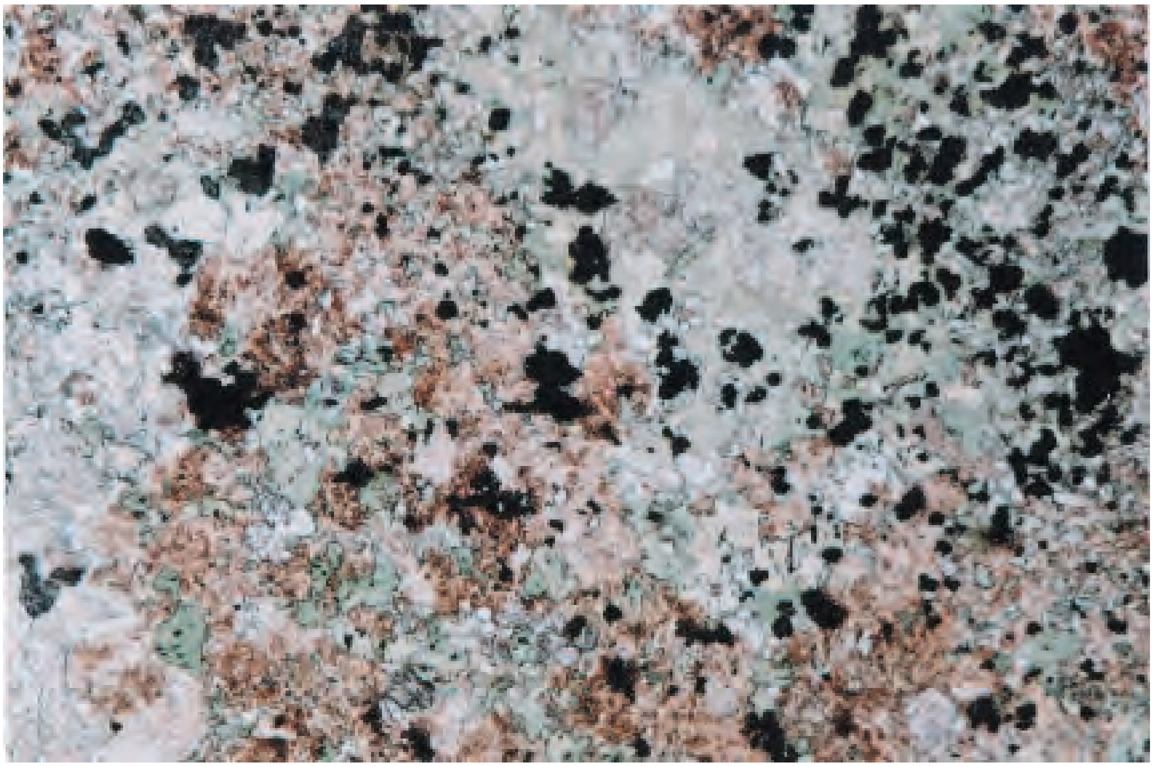


Fig 44 **QBE#1, 501.23m** **0.18 mm**

TS. OL. (x50). Part of an altered mafic/basaltic fragment in this breccia, with diffuse alteration involving reddish-albitic patches, greenish chlorite and pale-colourless carbonate. Disseminated black-opaque magnetite must surely be relict primary, although these grains are partly altered to hematite.