Mineral Resources Tasmania

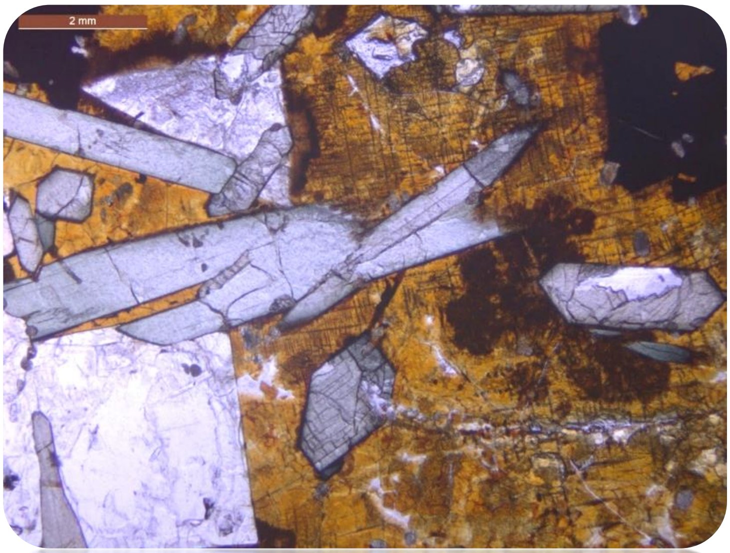
Laboratory Report

LJN2018-084b and LJN2020-041

LJN2018-034b, LJN2019-092-8, 2014-101, LJN2016-100

MINERALOGICAL ANALYSES

EAGLE RD QUARRY, SIDLING



An unpublished Mineral Resources Tasmania Report for:

M. Latham

By: R S Bottrill, K Goemann & T Coyte

Date: **1** May 2020

Mineral Resources Tasmania
Department of State Growth

Tasmanian Government

Mineral Resources Tasmania

SUMMARY

This basaltic sample was analysed for mineralogy and petrology. It is a mineralogical association that appears undescribed in Tasmania, with well crystallised nepheline, diopside and perovskite in late stage cavities with zeolites, in a tertiary basanite with lherzolite xenoliths.

INTRODUCTION

One mineral sample was received from Mathew Latham, for mineralogical analysis. Details are shown in Table 1. As it appeared to contain nepheline, and possibly other minerals not common in Tasmania, it was selected for a detailed mineralogical study.

Table 1: Sample Details

Lab Job No.	Reg. No	Location	Process	Description
LJN2014-101	G405731	Eagle Rd Qy	TS	Lherzolite Xenoliths in basalt
LJN2014-101	G405732	Eagle Rd Qy	TS	Feldspar in basalt?
LJN2016-100	G407352a	Eagle Rd Qy	TS	peridotite nodules in basalt
LJN2016-100	G407352b	Eagle Rd Qy	TS	Basalt + zeolites
LJN2016-100	G407355	Eagle Rd Qy	TS, XRD	basalt + white veins
LJN2018-034b	G408090a	Eagle Rd Qy	PTS, Probe	Basalt + vesicles
LJN2018-084b	G408090b	Eagle Rd Qy	TS	Basalt
LJN2018-084b	G408090c	Eagle Rd Qy	TS	Basalt
LJN2019-092-8	G409294	Eagle Rd Qy	SEM	Yellow clay

SAMPLE PROCESSING

The samples were cut and prepared as a thin or polished thin section. One sample was used for microprobe analysis. Some subsamples were also extracted for XRD analysis.

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SAMPLE DESCRIPTIONS

G405731 Lherzolite Xenoliths in basalt

Under the stereomicroscope sample, G405731 is mostly composed of a basaltic rock with abundant xenoliths of coarse grained, spinel lherzolite, containing black spinel and enstatite, bright green chrome-diopside and paler green olivine, in fine grained (<0.3mm) grey basaltic matrix (Fig. 1).

Fig. 1: Lherzolite xenolith in basalt, Eagle Rd quarry. FOV: about 45 mm. J. Melville.

G407355 Basalt and white veins

Under the stereomicroscope sample, G407355 is mostly composed of a basaltic rock with abundant white, vein-like to vesicle-like patches or segregations of fine grained zeolites, black pyroxene crystals, magnetite, calcite and other minerals in a grey basaltic matrix (Figs. 2 - 3). The patches may represent a hydrothermal space-filling to a basaltic breccia.

Fig. 2: G407355. White zeolite veins, with black pyroxenes, in basalt. FOV: about 45 mm.

G408090a Basalt and vesicles

Under the stereomicroscope sample, G408090a shows a fine grained, grey basaltic rock with very thin segregations; vesicles and amygdules containing glass, with needles of green to black pyroxenes and colourless apatite, plus zeolites, nepheline, magnetite, perovskite, carbonates, clays and other minerals (Figs. 2 - 7).

Other minerals that visually appear to occur in these vesicles are aragonite, opal, erionite, gonnardite, thomsonite, levyne, gismondine, natrolite, phillipsite and pyrite, but these are all unverified (Mindat.org).

Fig. 3: Sample G408090a, showing cavities containing zeolites, nepheline, pyroxene and other minerals, in cavities in basalt. FOV: about 60 mm.

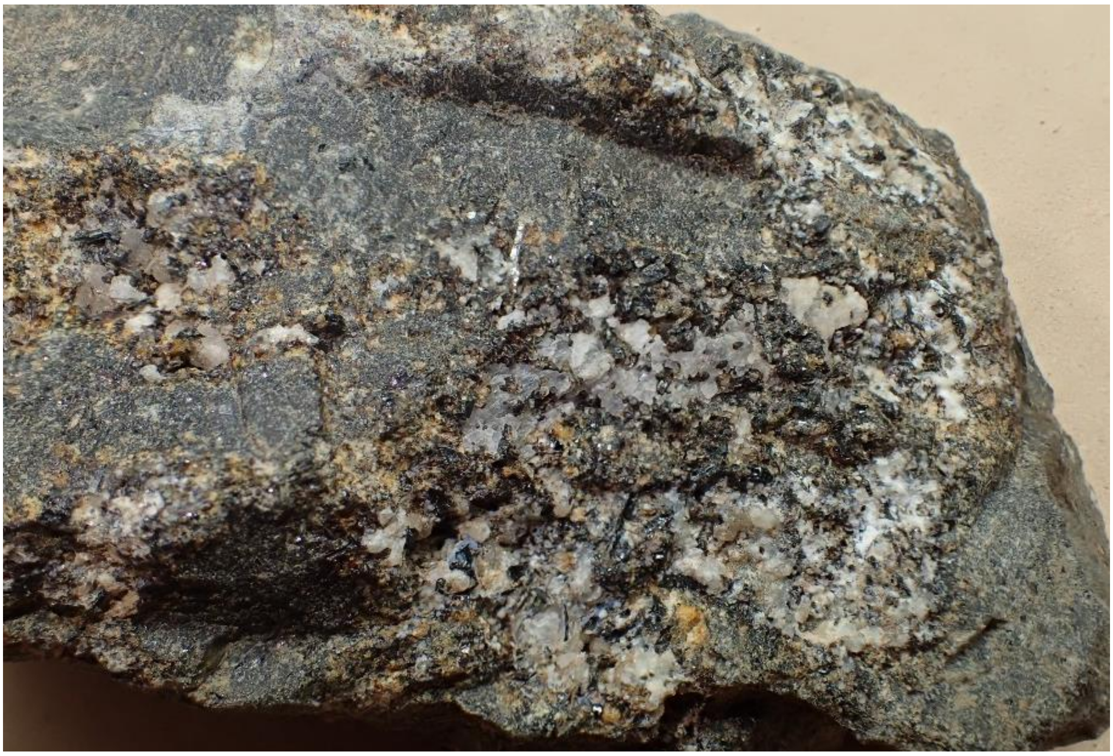

Fig. 4: Sample G408090a, showing cavities containing zeolites, nepheline, pyroxene and other minerals, in cavities in basalt. FOV: about 60 mm. FOV: about 20 mm.

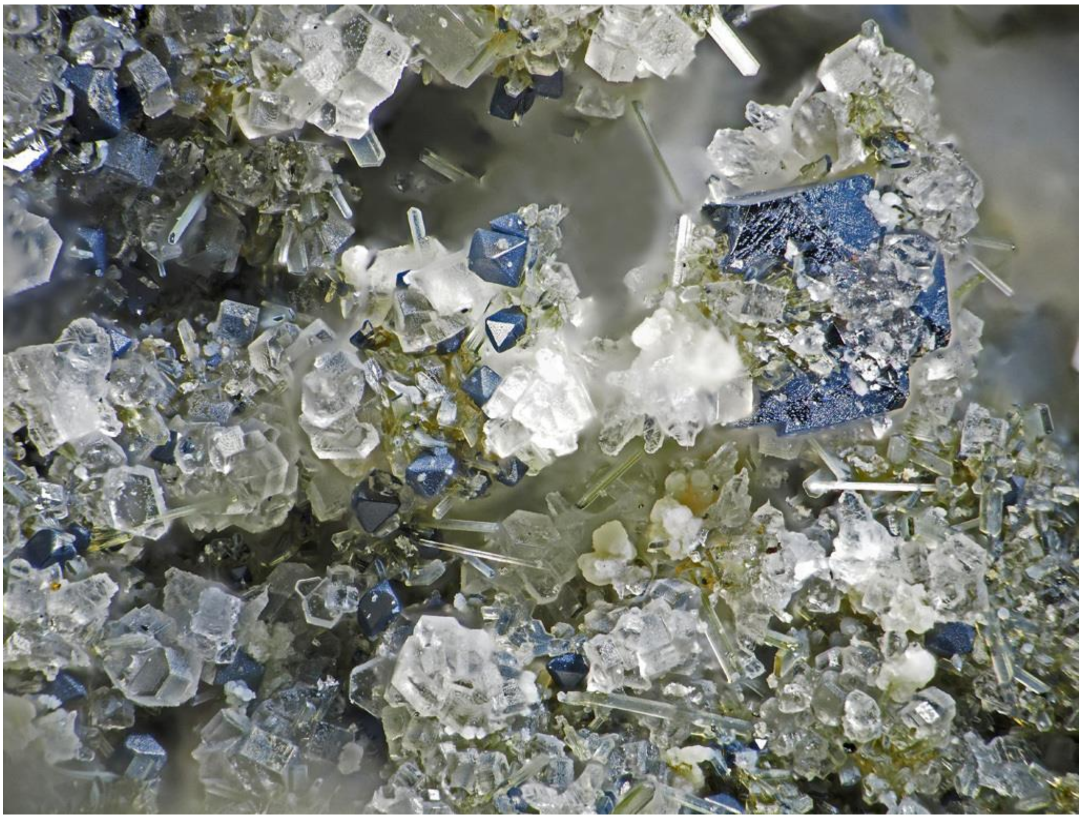

Fig. 5: Nepheline crystals to ~0.5mm across, with prismatic apatite, grey magnetite octahedra, bladed diopside and other minerals, in cavities in basalt. FOV: about 3 mm. J. Haupt.

Fig. 6: Apatite crystals with balls of zeolites (phillipsite?), in cavities in basalt. FOV: about 20 mm. M Latham.

Fig. 7. White octahedral gismondine crystals to ~1 mm across, with prismatic green diopside, glassy phillipsite, and other minerals, in cavities in basalt. FOV: about 4 mm. J. Haupt.

PETROLOGY

Several thin and polished thin sections were used to study the microscopic petrology of the samples.

The sample G405731 is mostly composed of olivine, nepheline, clinopyroxene, spinel, apatite and magnetite (Figs 8 - 14). It has abundant xenoliths of enstatite-rich, spinel lherzolite in fine grained (<0.3mm) nephelinite matrix.

The ground mass is a basaltic rock, probably nephelinite, with abundant brown glass (sideromelane), fine needles of clinopyroxene (<0.3mm long), anhedral olivine (largely altered to brown iddingsite), colourless to pale yellow nepheline, and minor magnetite and apatite.

The spinel lherzolite xenoliths contain coarse grained olivine and enstatite, with abundant spinel and sparse clinopyroxene (Fig. 8 – 10). The enstatite is partly broken down to brown glass (sideromelane), and a dendritic aggregate of olivine, apatite and green clinopyroxenes (aegirine-augite?). The spinel is dark brown and commonly has a black rim of magnetite or chromite.

There are abundant segregations, mostly flattened, mostly vein-like or lensoidal, to few mm wide and a few cm long (Fig. 10 – 13). They are variably filled with brown glass (sideromelane, weakly anisotropic), finely prismatic pale green clinopyroxene (diopside), botryoidal zeolites (thomsonite?), nepheline, carbonates (calcite?), magnetite, finely prismatic fluorapatite, dark brown perovskite (<2 mm) and smectite clays. The crystals are up to 1mm in size.

The sample G408090a is a similar basaltic rock, but lacking xenoliths, with more vesicular patches (Figs 15 - 19). The crystals in these zones are similar to G405731 but much coarser, up to 8mm long.

The mineralogy is consistent with a basanite, and the textures suggest the rock may have formed by explosive volcanism and partial welding of lava blocks and lherzolite xenoliths. The cavities between blocks partly filled with nepheline, perovskite, diopside and glass, and as the rock cooled, zeolites, carbonates and other minerals formed in the remaining open spaces.

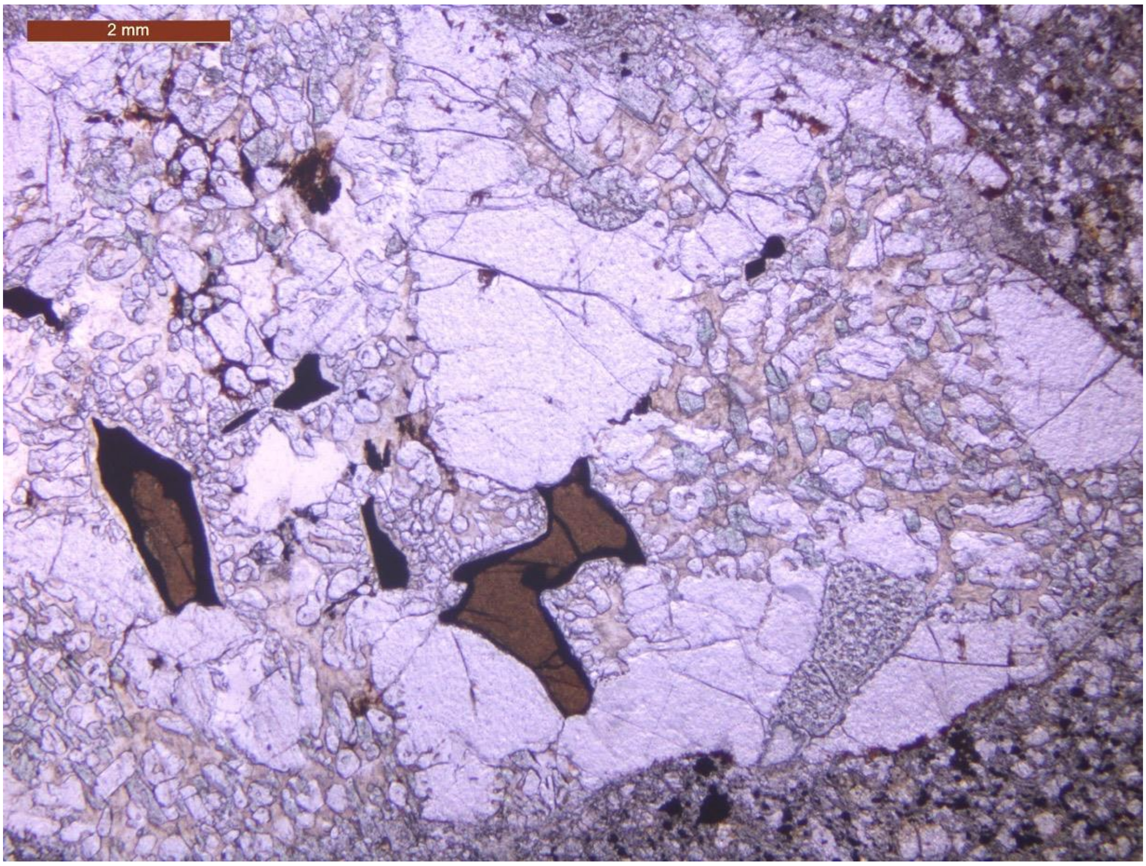

Fig. 8. Sample G405731, Polarised light, uncrossed polars, showing a spinel lherzolite xenolith, in a basaltic matrix. Coarse colourless crystals are mostly olivine and enstatite, dark brown is spinel; light brown is glass. Enstatite has broken down to green clinopyroxenes, olivine and glass. FOV 10mm.

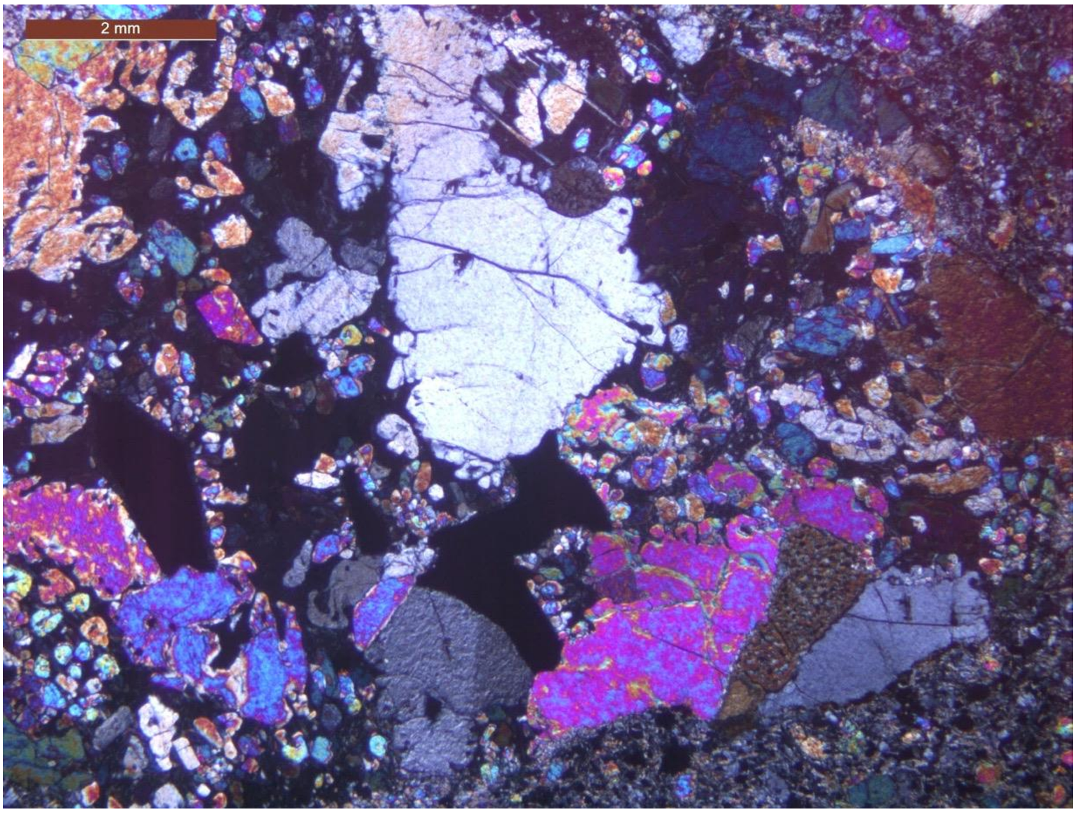

Fig. 9. Sample G405731, Polarised light, crossed polars, showing a spinel lherzolite xenolith partly broken down to glass and pyroxenes, as above. FOV 10mm.

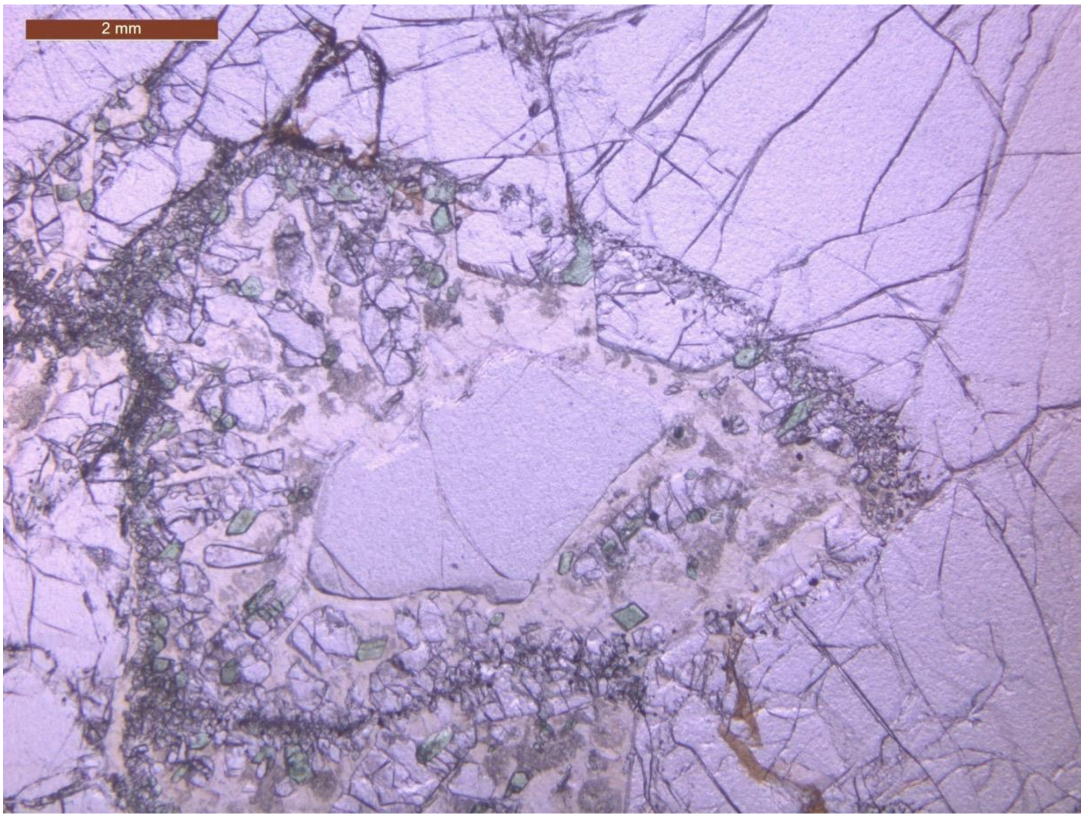

Fig. 10. Sample G405731, Polarised light, uncrossed polars, showing a spinel lherzolite xenolith partly broken down glass and pyroxenes. Coarse colourless crystals are mostly olivine, dark brown is spinel; light brown is glass. Enstatite has broken down to green clinopyroxenes, olivine and glass. FOV10mm.

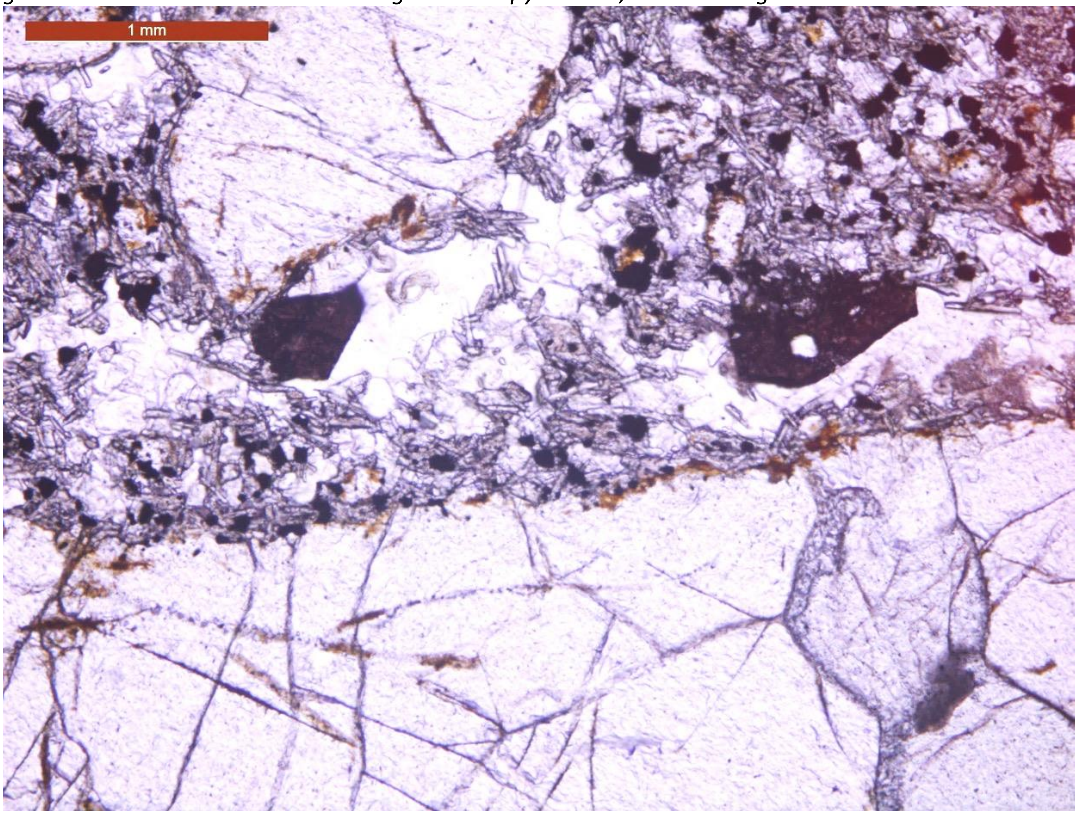

Fig. 11. Sample G405731, Polarised light, uncrossed polars, showing a spinel lherzolite xenolith (bottom) and an olivine xenocryst (top) in basalt. In between the two is a late segregation, with colourless nepheline, zeolites and calcite, plus very dark brown perovskite crystals. FOV 5mm.

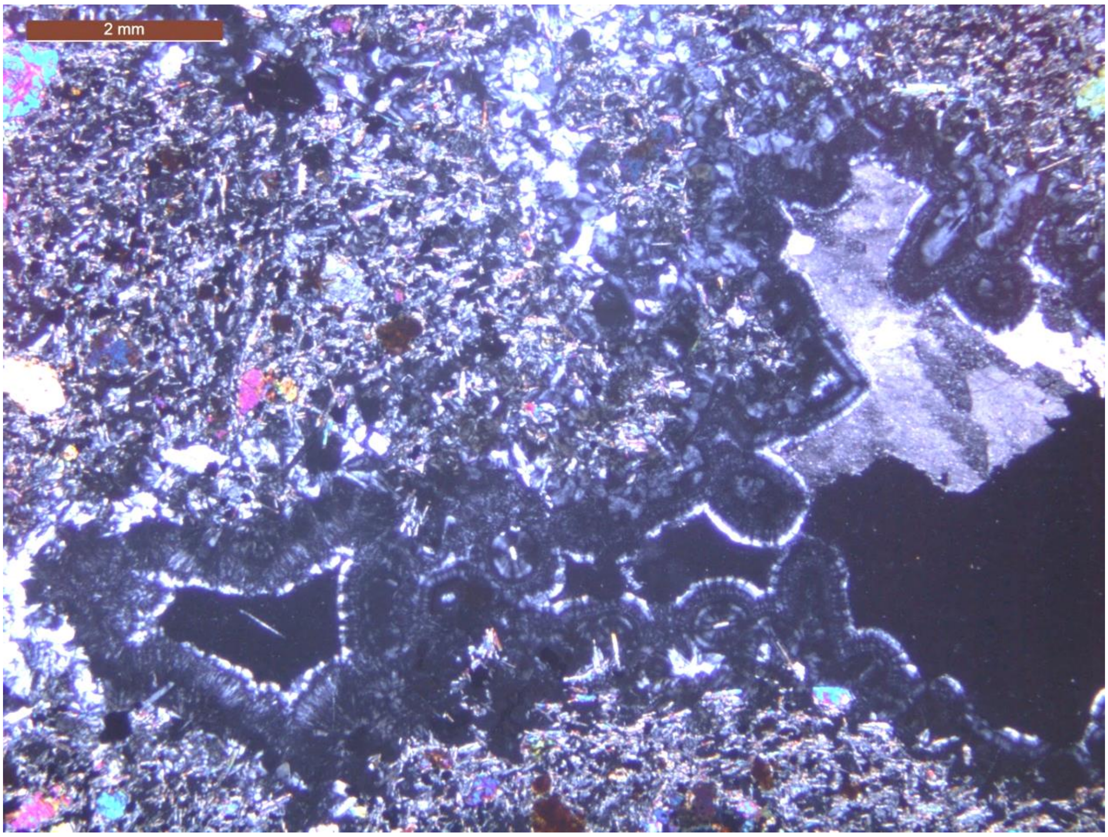

Fig. 12. Sample G405731, Polarised light, crossed polars, showing an irregular vesicle in basalt, part-filled with botryoidal zeolites, and calcite (RHS). FOV 10mm.

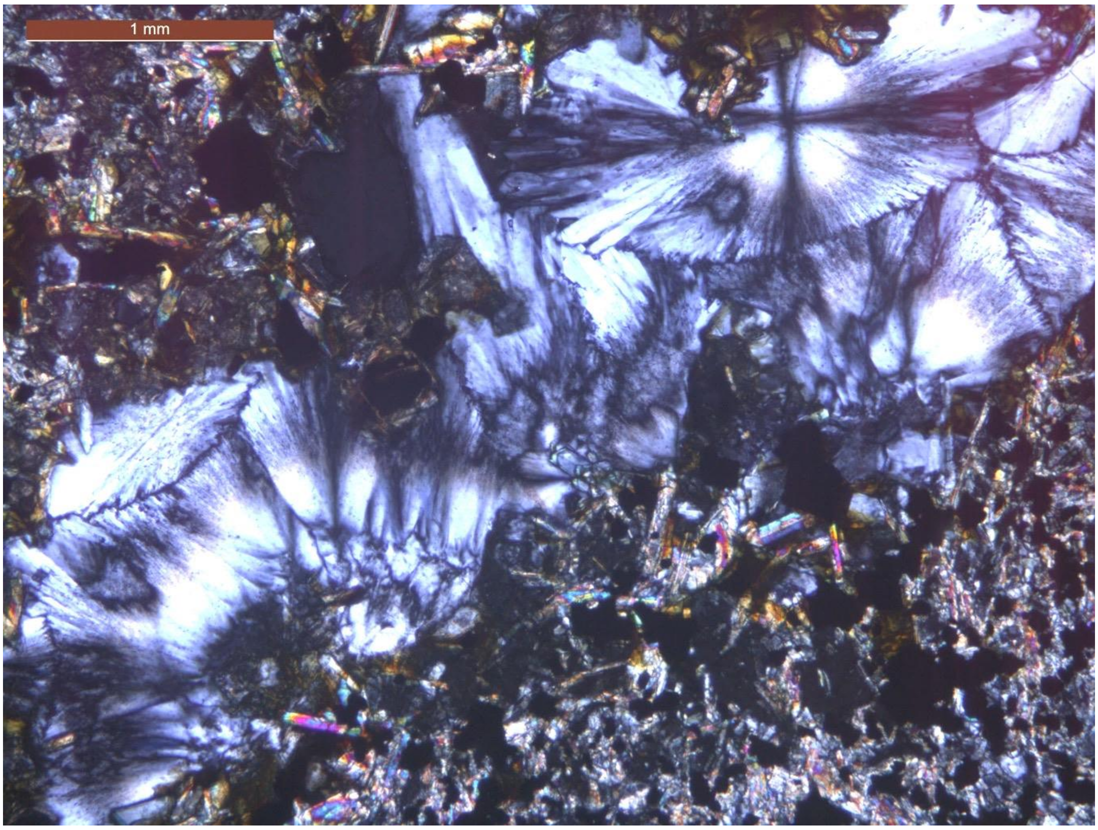

Fig. 13. Sample G405731, Polarised light, crossed polars, showing an irregular vesicle in basalt, part-filled with botryoidal, radio-fibrous zeolites (thomsonite?), and black magnetite and perovskite (RHS). FOV 5mm.

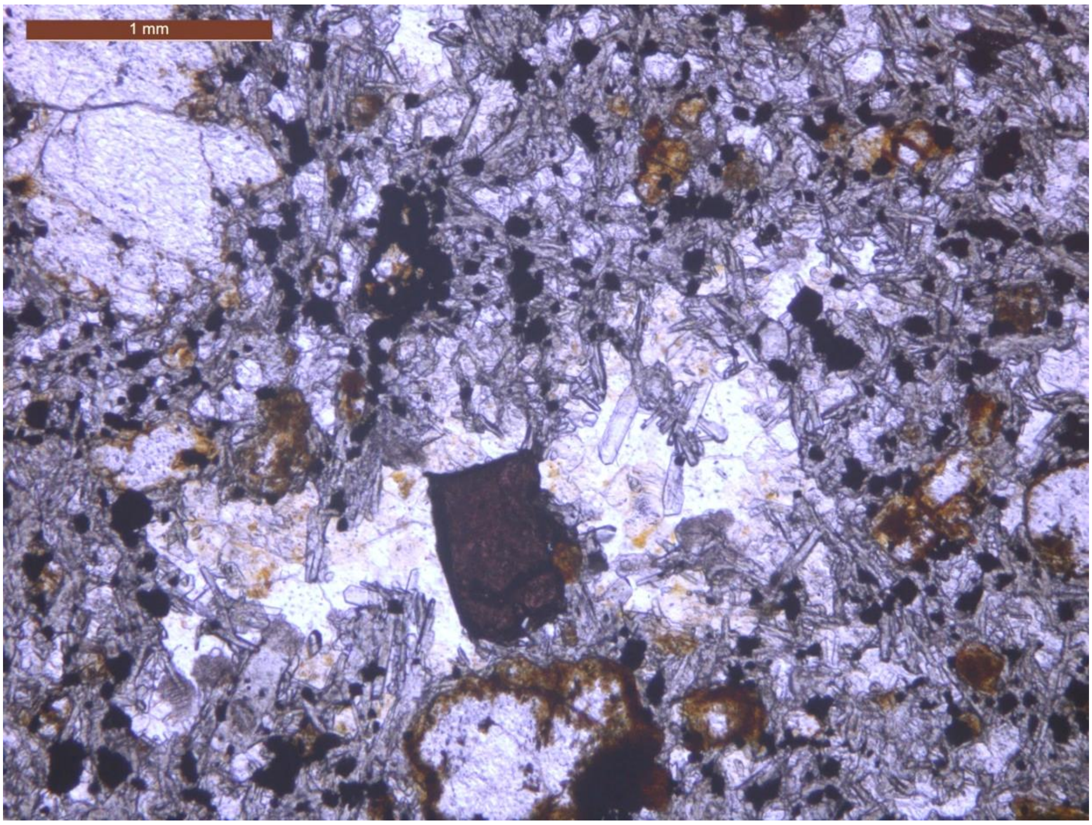

Fig. 14. Sample G405731, Polarised light, uncrossed polars, showing an irregular vesicle in basalt, part-filled with colourless zeolites and nepheline, with dark brown perovskite. FOV 5mm.

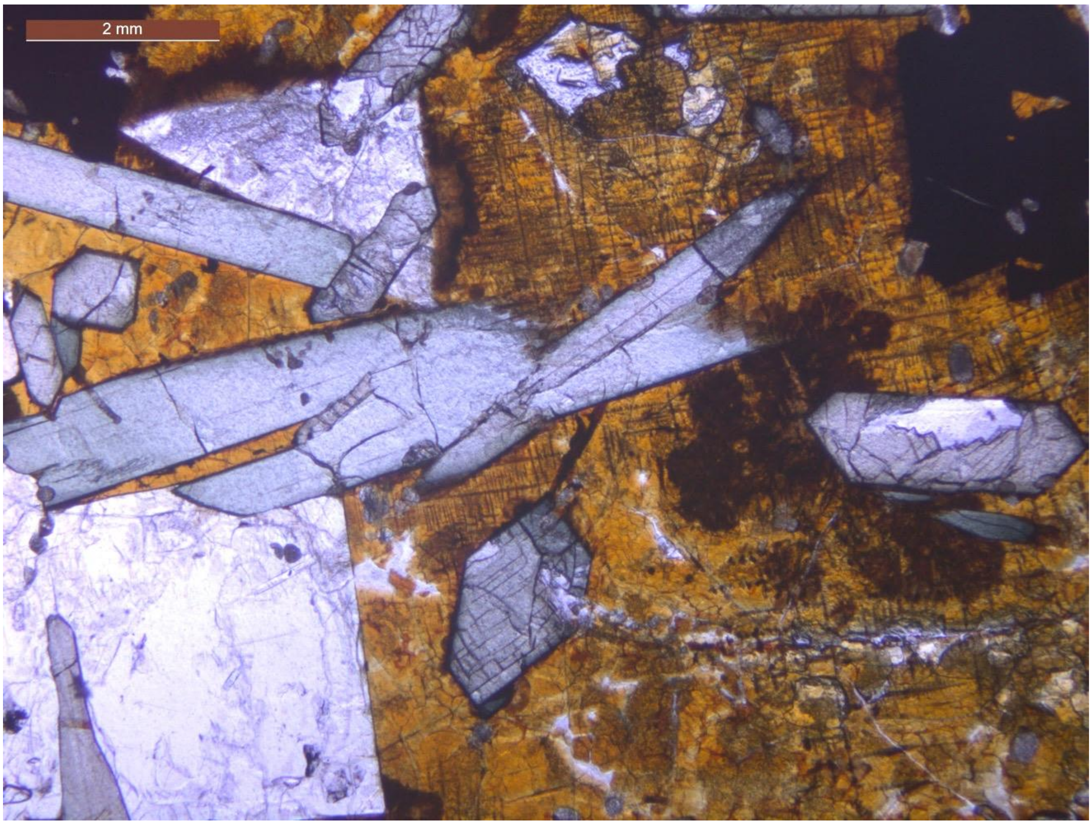

Fig. 15. Sample G408090b, Polarised light, uncrossed polars, showing a glassy segregation in basalt, with brown sideromelane containing finely dendritic magnetite, plus coarse, colourless crystals of nepheline, pale grey clinopyroxenes and dark brown perovskite. FOV.10mm

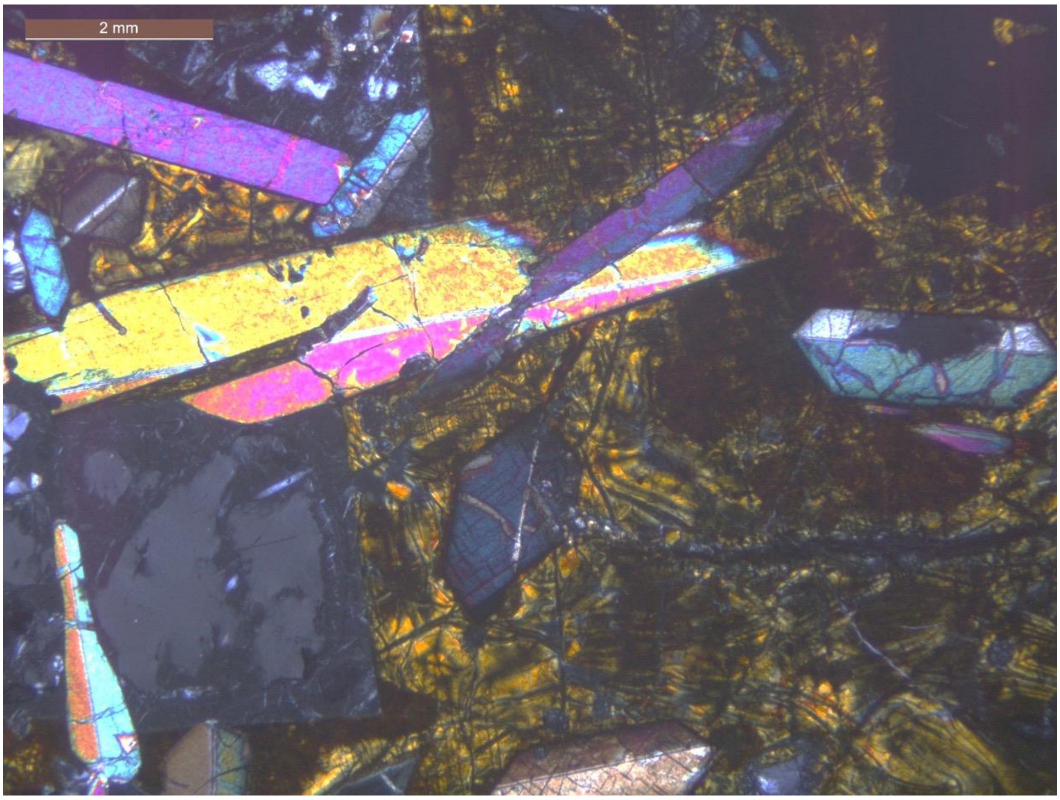

Fig. 16. Sample G408090b, Polarised light, uncrossed polars, as above, showing a glassy segregation in basalt, with brown anisotropic sideromelane containing finely dendritic magnetite, plus coarse, mid-grey crystals of nepheline (part-altered to zeolites), brightly birefringent clinopyroxenes and dark brown perovskite. FOV 10mm.

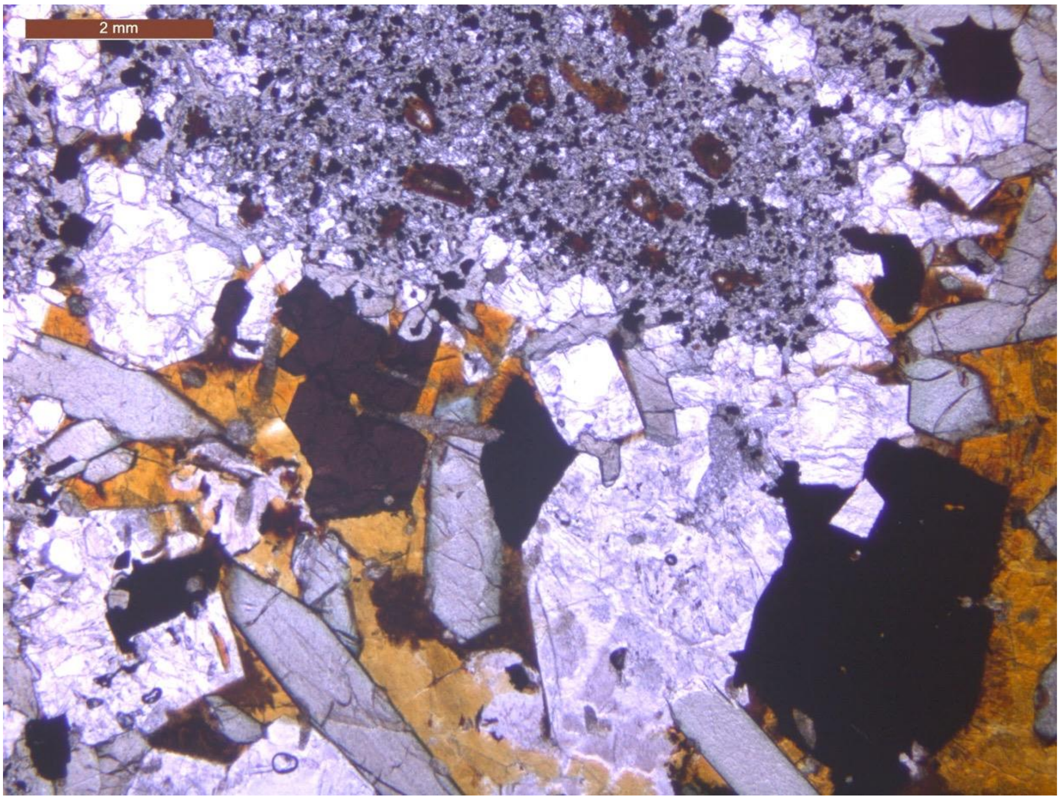

Fig. 17. Sample G408090b, Polarised light, uncrossed polars, showing a glassy segregation in basalt, with brown sideromelane containing black magnetite, plus coarse, colourless, altered crystals of nepheline, pale grey clinopyroxenes and dark brown perovskite. FOV 10mm.

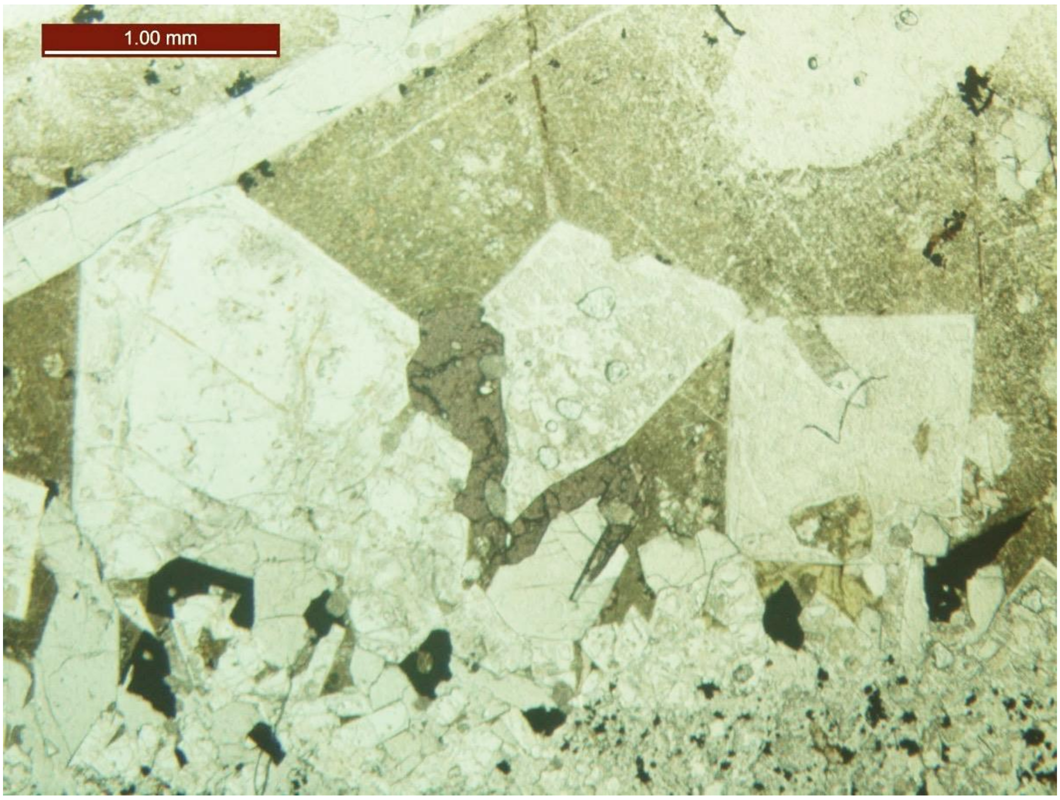

Fig. 18. Sample G408090b, Polarised light, uncrossed polars, showing a glassy segregation in basalt, with brown sideromelane coarse, colourless, blocky crystals of nepheline, prismatic clinopyroxenes and dark brown to black magnetite and perovskite. FOV 5mm.

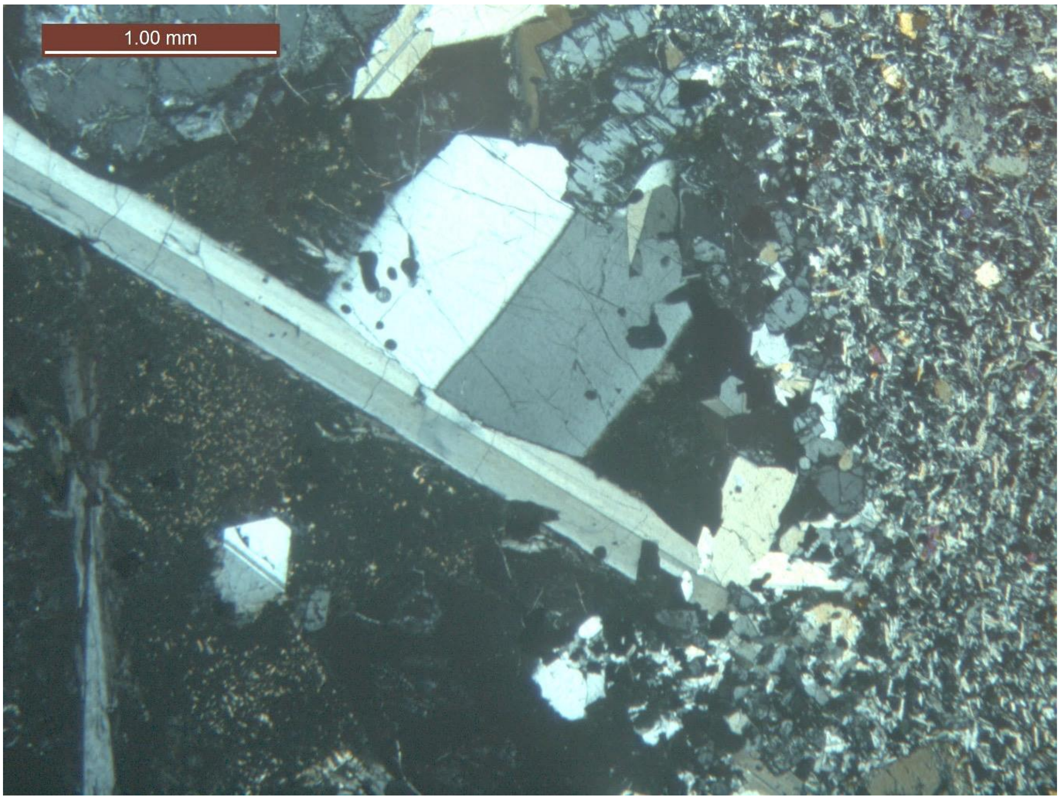

Fig. 19. Sample G408090b, Polarised light, crossed polars, showing a glassy segregation in basalt, with speckled black sideromelane, coarse, colourless, blocky crystals of nepheline (top), twinned prismatic clinopyroxenes and prismatic apatite (lower left). FOV 5mm.

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MICROPROBE ANALYSES

The polished thin section of G408090a was analysed by electron microprobe and results given in Appendices 1 - 7. The analytical conditions are shown in

Appendix 8.

- The apatite is Sr-bearing Fluorapatite with an average composition: $(Ca_{4.9} Sr_{0.1})_5 (PO_4)_3 (F_{0.8} (OH)_{0.2})$
- The chlorite is an Al-rich clinochlore with an average composition: $(Mg_{2.5} Fe_{0.5} Al_{2.1}) (Si_{3.4} Al_{0.6})_4 0_{10} (OH)_8$
- The clinopyroxene is a ferroan diopside with an average composition: $(Ca_{0.95} Na_{.0.05}) (Mg_{0.8} Fe_{0.2}) Si_2O_6$
- The nepheline is iron-bearing and has an average composition: $Na_{2.9} K_{1.0} Fe_{0.1} Al_{3.9} Si_{4.1}O_{16}$.
- The olivine is an iron-bearing forsterite and has an average composition: $(Mg_{1.7} Fe_{0.3})SiO_4$
- The spinel is iron and Chromium rich and has an average composition: $(Mg_{0.6} Fe_{0.4})(Fe_{0.1} Cr_{0.3} Al_{1.6})O_4$
- The ulvospinel is magnesian and has an average composition: $(Mg_{0.2} Fe_{1.8}) (Fe_{0.3}Ti_{0.7})O_4$
- The magnetite is rich in Cr, Ti and Al, and has an average composition: $(Mg_{0.2} Fe_{0.8}) (Fe_{1.1} Cr_{0.4} Ti_{0.3} Al_{0.3})O_4$
- The perovskite is sodic and has an average composition: $(Na_{0.1} Ca_{0.9}) Ti_{1.0} O_3$
- The glass is rich in Na, K, Ca, Mg, Fe and Si, and relatively Al poor.
- The zeolite mineral has an average composition: $(Na_{0.1} K_{1.2} Ca_{1.2}) Al_{4.5} Si_{7.5} O_{23}$, which is possibly phillipsite.

SEM/EDAX ANALYSES

The sample G409294 was analysed by SEM-EDS, with analytical conditions shown in Appendix 9, and results given in Appendix 10.

The yellow, non-crystalline material, is smectite, with compositions that can be interpreted as mostly varying from montmorillonite to saponite in composition, with some ferrosaponite:

- Montmorillonite: $Ca_{0.5}$ $(Mg_{1.0}\ Fe_{0.2}\ Al_{0.8})$ $(Si_{3.0}\ Al_{1.0})_4$ 0_{10} $(OH)_8$
- Saponite: $Ca_{0.5}$ $(Mg_{2.0}\ Fe_{0.3}\ Al_{0.7})$ $(Si_{2.9}\ Al_{1.1})_4$ 0_{10} $(OH)_8$
- Ferrosaponite: $Ca_{0.5}$ $(Mg_{1.3}\ Fe_{1.4}\ Al_{1.3})$ $(Si_{2.9}\ Al_{1.1})_4$ 0_{10} $(OH)_8$

XRD ANALYSES

The samples were prepared, examined and analysed in the Mineral Resources Tasmania (MRT) laboratories, Rosny Park, Tasmania. They were run on a Rigaku Miniflex 600 X-Ray Diffractometer system: a 600W generator 150mm goniometer with a Cu tube; 40kV/15mA, sample spinner and a Scintillation counter (SC) with Be window, -3^o to 145^o 2Ø scanning range and 2^o - 145^o 2Ø measuring range, with a scanning speed of 0.01 to 100^o/min, a graphite counter monochromator and a Kß Ni- filter. The analysis software used is the PDXL2 using the ICCD database.

The results are shown in Appendix 11 and Table 2. They indicate all zeolites: mostly gonnardite, with lesser phillipsite.

Table 2: XRD Summary for G407355

Phase Name	Content - Estimate
Gonnardite	Dominant
Phillipsite-(K)	Sub major

DISCUSSION

This is a mineralogical association that appears undescribed in Tasmania, with well crystallised nepheline, diopside and perovskite in late stage cavities with zeolites and calcite, in a Tertiary basanite rich in spinel lherzolite xenoliths.

R S Bottrill
MINERALOGIST/PETROLOGIST

T Coyte
TECHNICAL OFFICER

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This and other data collected in MRT laboratories may enter the MRT databases but every attempt will be made to ensure it remains closed file and not be available externally, unless at your request.

Appendix 1: Probe Analyses: Apatite, Chlorite

SAMPLE	G408090a-ap3-large
ID	Ap
SiO2	0.54
TiO2	<0.04
ZnO	<0.11
Al2O3	<0.02
V2O3	<0.04
Cr2O3	<0.07
FeO	0.08
NiO	<0.07
MnO	<0.06
MgO	0.04
CaO	53.23
SrO	1.43
BaO	<0.07
Na2O	0.11
K2O	<0.02
P2O5	39.99
SO3	<0.05
Cl	0.20
F	2.86
O*	-1.25
H2O	0.00
TOTAL	97.24
number	12
Si	0.05
Ti	0.00
Zn	0.00
Al	0.00
V	0.00
Cr	0.00
Fe	0.01
Ni	0.00
Mn	0.00
Mg	0.01
Ca	4.92
Sr	0.07
Ba	0.00
Na	0.02
K	0.00
P	2.92
S	0.00
Cl	0.03
F	0.78
O	12.00
H	0.19

SAMPLE	G408090a-chl1 core	G408090a-chl 2 rim
ID	Chl	Chl
SiO2	34.98	37.63
TiO2	<0.03	0.06
ZnO	0.10	<0.09
Al2O3	21.33	28.17
V2O3	<0.03	<0.03
Cr2O3	<0.05	<0.05
FeO	7.59	4.84
NiO	<0.06	<0.05
MnO	0.15	0.12
MgO	22.19	14.23
CaO	0.47	1.37
SrO	<0.05	<0.05
BaO	<0.06	0.06
Na2O	0.11	0.20
K2O	0.15	0.19
P2O5	<0.04	<0.04
SO3	<0.04	<0.03
Cl	0.03	0.04
F	<0.04	0.05
O*	-0.01	-0.03
H2O	12.70	13.04
TOTAL	99.79	99.97
number	18	18
Si	3.31	3.46
Ti	0.00	0.00
Zn	0.01	0.00
Al	2.38	3.05
V	0.00	0.00
Cr	0.00	0.00
Fe	0.60	0.37
Ni	0.00	0.00
Mn	0.01	0.01
Mg	3.13	1.95
Ca	0.05	0.14
Sr	0.00	0.00
Ba	0.00	0.00
Na	0.02	0.04
K	0.02	0.02
P	0.00	0.00
S	0.00	0.00
Cl	0.00	0.01
F	0.00	0.01
O	18.00	18.00

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Appendix 2: Probe Analyses: Clinopyroxene

SAMPLE	G408090a-cpx1	G408090a-di2	G408090a-cpx4	G408090a-cpx2 matrix	G408090a-cpx3
ID	Cpx	Cpx	Cpx	Cpx	Cpx
SiO2	53.19	53.40	51.27	51.71	49.00
TiO2	1.55	1.57	2.06	2.04	3.07
ZnO	<0.1	<0.1	<0.09	<0.09	<0.1
Al2O3	0.67	0.75	2.02	2.36	3.83
V2O3	<0.03	<0.03	0.06	0.05	0.06
Cr2O3	<0.05	<0.06	<0.06	<0.05	<0.05
FeO	5.96	6.18	6.05	5.82	6.45
NiO	<0.06	<0.06	<0.06	<0.06	<0.05
MnO	0.14	0.13	0.12	0.12	0.10
MgO	14.75	14.40	13.92	14.10	13.01
CaO	23.39	23.21	23.42	23.27	23.14
SrO	0.16	0.12	0.06	0.12	<0.05
BaO	<0.06	<0.06	<0.06	<0.06	<0.06
Na2O	0.72	0.82	0.80	0.69	0.89
K2O	<0.02	<0.02	0.04	0.08	0.09
P2O5	<0.05	<0.05	0.14	<0.04	0.09
SO3	<0.05	<0.05	<0.04	<0.04	<0.04
Cl	<0.02	<0.02	<0.02	<0.02	<0.02
F	<0.04	<0.04	<0.04	<0.04	0.05
O*	0.01	0.00	-0.01	-0.01	-0.02
H2O	0.00	0.00	0.00	0.00	0.00
TOTAL	100.55	100.58	99.94	100.35	99.75
number	6	6	6	6	6
Si	1.96	1.96	1.91	1.91	1.83
Ti	0.04	0.04	0.06	0.06	0.09
Zn	0.00	0.00	0.00	0.00	0.00
Al	0.03	0.03	0.09	0.10	0.17
V	0.00	0.00	0.00	0.00	0.00
Cr	0.00	0.00	0.00	0.00	0.00
Fe	0.18	0.19	0.19	0.18	0.20
Ni	0.00	0.00	0.00	0.00	0.00
Mn	0.00	0.00	0.00	0.00	0.00
Mg	0.81	0.79	0.77	0.78	0.73
Ca	0.92	0.91	0.93	0.92	0.93
Sr	0.00	0.00	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00
Na	0.05	0.06	0.06	0.05	0.06
K	0.00	0.00	0.00	0.00	0.00
P	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00
F	0.00	0.00	0.00	0.00	0.01
O	6.00	6.00	6.00	6.00	6.00

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Appendix 3: Probe Analyses: Nepheline

SAMPLE	G408090 a-neph core	G408090 a-neph rim	G408090 a-neph-6	G408090 a-neph7	G408090 a-ne3	G408090 a-neph4	G408090 a-neph5
ID	Neph	Neph	Neph	Neph	Neph	Neph	Neph
SiO2	42.04	42.16	41.99	42.27	41.71	41.90	41.95
TiO2	<0.03	0.03	0.06	<0.03	0.07	0.03	0.04
ZnO	<0.09	<0.1	<0.09	<0.08	<0.09	<0.09	<0.09
Al2O3	33.01	32.91	33.52	33.44	33.34	33.32	33.41
V2O3	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Cr2O3	<0.05	<0.05	<0.05	<0.05	<0.06	<0.05	<0.05
FeO	1.37	1.45	1.16	1.02	1.07	1.37	1.08
NiO	<0.05	<0.05	<0.06	<0.06	<0.06	<0.06	<0.06
MnO	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
MgO	0.20	0.21	0.19	0.18	0.19	0.20	0.15
CaO	0.13	0.13	0.04	0.03	0.47	0.05	0.04
SrO	<0.05	<0.05	<0.05	<0.05	<0.06	<0.05	<0.05
BaO	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Na2O	15.09	14.83	15.28	15.23	15.40	15.36	15.08
K2O	8.12	8.08	8.14	8.01	7.73	8.04	8.05
P2O5	<0.04	<0.05	<0.04	<0.03	0.35	<0.04	<0.06
SO3	<0.05	<0.04	<0.04	<0.05	<0.04	<0.04	<0.05
Cl	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
F	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
O*	0.00	-0.01	0.00	0.01	-0.01	0.01	0.01
TOTAL	99.97	99.80	100.38	100.20	100.31	100.28	99.83
number	4	4	4	4	4	4	4
Si	1.03	1.03	1.02	1.03	1.01	1.02	1.02
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al	0.95	0.95	0.96	0.96	0.95	0.96	0.96
V	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.03	0.03	0.02	0.02	0.02	0.03	0.02
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.72	0.70	0.72	0.72	0.73	0.72	0.71
K	0.25	0.25	0.25	0.25	0.24	0.25	0.25
P	0.00	0.00	0.00	0.00	0.01	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Appendix 4: Probe Analyses: Olivine

SAMPLE	G408090a-ol1	G408090a-ol4	G408090a-ol2	G408090a-cpx5 - Ol?	G408090a-ol3
ID	Ol	Ol	Ol	Ol	Ol
SiO2	39.95	39.59	41.02	38.61	41.39
TiO2	<0.03	<0.03	<0.03	0.03	<0.03
ZnO	<0.09	<0.09	<0.09	<0.09	<0.09
Al2O3	0.03	<0.03	<0.03	<0.03	<0.03
V2O3	<0.03	<0.03	<0.03	<0.03	<0.03
Cr2O3	<0.05	<0.05	0.05	<0.05	0.05
FeO	15.84	17.17	10.12	22.17	8.39
NiO	0.25	0.19	0.35	0.12	0.40
MnO	0.20	0.31	0.15	0.59	0.12
MgO	44.56	43.08	49.29	38.86	50.89
CaO	0.16	0.39	<0.02	0.57	0.11
SrO	<0.05	<0.05	<0.05	<0.05	<0.05
BaO	<0.06	<0.06	<0.06	<0.06	<0.06
Na2O	<0.03	<0.04	<0.04	<0.04	<0.04
K2O	<0.02	<0.02	<0.02	<0.02	<0.02
P2O5	<0.05	<0.05	<0.05	0.14	<0.05
SO3	<0.04	<0.05	<0.04	<0.05	<0.03
Cl	<0.02	<0.02	<0.02	<0.02	<0.02
F	<0.04	<0.04	<0.04	<0.04	<0.04
O*	0.01	0.00	0.00	0.00	0.00
TOTAL	101.01	100.72	101.00	101.09	101.34
number	4	4	4	4	4
Si	1.00	1.00	1.00	0.99	1.00
Ti	0.00	0.00	0.00	0.00	0.00
Zn	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00
V	0.00	0.00	0.00	0.00	0.00
Cr	0.00	0.00	0.00	0.00	0.00
Fe	0.33	0.36	0.21	0.48	0.17
Ni	0.01	0.00	0.01	0.00	0.01
Mn	0.00	0.01	0.00	0.01	0.00
Mg	1.66	1.62	1.79	1.49	1.82
Ca	0.00	0.01	0.00	0.02	0.00
Sr	0.00	0.00	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00
Na	0.00	0.00	0.00	0.00	0.00
K	0.00	0.00	0.00	0.00	0.00
P	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00
F	0.00	0.00	0.00	0.00	0.00
sum	4.00	4.00	4.00	4.00	4.00

Appendix 5: Probe Analyses: Oxides

SAMPLE	G408090a-ulvospinel1	G408090a-ulvospinel2	G408090a-spinel3 rim 3	G408090a-ulvospinel	G408090a-perov3-spinel?	G408090a-spinel1	G408090a-spinel2	G408090a-spinel4	G408090a-spinel3 rim	G408090a-spinel3 rim 2	G408090a-spinel4-rim
ID	Usp	Usp	Usp	Usp	Usp	Sp	Sp	Sp	Mt	Mt	Mt
SiO2	0.07	<0.05	<0.05	0.10	0.13	0.05	0.06	0.08	<0.05	<0.05	<0.05
TiO2	24.74	23.07	19.31	21.32	23.74	0.19	0.16	0.62	10.88	13.91	11.26
ZnO	<0.12	<0.11	0.13	<0.11	<0.11	0.34	0.17	0.55	0.12	0.19	<0.11
Al2O3	0.26	0.44	0.96	0.17	0.21	49.20	49.62	47.77	9.19	4.04	9.47
V2O3	0.20	0.25	0.18	0.17	0.23	0.05	0.07	0.08	0.17	0.16	0.18
Cr2O3	<0.05	<0.07	4.31	0.54	0.18	15.62	16.39	14.53	13.43	12.32	11.81
FeO	65.74	68.92	68.18	70.44	65.87	19.05	18.10	24.50	58.00	61.72	59.37
NiO	0.09	0.16	0.08	<0.08	0.12	0.34	0.27	0.18	0.13	<0.07	0.13
MnO	1.06	0.84	0.67	0.84	0.98	0.29	0.26	0.31	0.61	0.63	0.52
MgO	2.53	3.12	3.17	2.08	2.50	14.81	15.42	12.66	4.40	3.65	4.45
CaO	0.03	<0.02	0.18	0.12	0.10	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
SrO	<0.05	<0.05	<0.05	<0.06	<0.05	<0.05	<0.05	<0.05	<0.06	<0.05	<0.05
BaO	<0.07	<0.07	<0.07	<0.07	<0.07	<0.06	<0.06	<0.06	<0.07	<0.07	<0.07
Na2O	<0.06	<0.06	<0.06	<0.06	<0.07	<0.04	<0.05	<0.05	<0.07	<0.06	<0.06
K2O	<0.02	<0.02	0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
P2O5	<0.04	<0.05	0.19	<0.05	<0.05	<0.05	<0.05	<0.05	<0.04	<0.06	<0.05
SO3	<0.05	<0.05	<0.05	<0.05	<0.05	<0.04	<0.04	<0.05	<0.05	<0.05	<0.05
Cl	<0.02	<0.02	<0.03	<0.03	<0.02	<0.02	<0.02	0.03	<0.03	<0.03	<0.02
O*	0.03	0.01	0.03	0.03	0.02	0.02	0.00	0.00	0.03	0.04	0.03
TOTAL	94.73	96.80	97.40	95.83	94.08	99.97	100.51	101.31	96.97	96.66	97.21
number	4	4	4	4	4	4	4	4	4	4	4
Si	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Ti	0.76	0.70	0.58	0.66	0.74	0.00	0.00	0.01	0.31	0.41	0.32
Zn	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Al	0.01	0.02	0.05	0.01	0.01	1.60	1.60	1.57	0.41	0.19	0.42
V	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Cr	0.00	0.00	0.14	0.02	0.01	0.34	0.35	0.32	0.41	0.39	0.36
Fe	2.25	2.33	2.29	2.44	2.27	0.44	0.41	0.57	1.85	2.05	1.89
Ni	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Mn	0.04	0.03	0.02	0.03	0.03	0.01	0.01	0.01	0.02	0.02	0.02
Mg	0.15	0.19	0.19	0.13	0.15	0.61	0.63	0.53	0.25	0.22	0.25
Ca	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
O	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Appendix 6: Probe Analyses: Glass and Zeolites

SAMPLE	G408090a-	G408090a-	G408090a-zeolite vein	G408090a-Ze rim to Ne?
ID	glass	glass	phillipsite?	phillipsite?
SiO2	49.67	51.04	48.06	49.39
TiO2	5.56	4.17	<0.03	<0.03
ZnO	<0.1	<0.09	<0.09	<0.09
Al2O3	2.09	1.73	26.84	23.04
V2O3	<0.03	0.04	<0.03	<0.03
Cr2O3	<0.05	<0.05	<0.06	<0.05
FeO	8.93	9.50	0.05	0.10
NiO	<0.06	<0.06	<0.06	<0.05
MnO	0.12	0.12	0.04	<0.05
MgO	16.08	16.03	<0.02	1.82
CaO	5.59	5.43	8.83	6.77
SrO	0.39	0.59	<0.05	0.17
BaO	0.30	0.18	0.42	0.51
Na2O	4.58	4.75	0.48	0.39
K2O	3.66	3.83	7.69	3.93
P2O5	<0.05	<0.05	<0.04	<0.05
Cl	<0.02	<0.02	0.02	<0.02
F	3.14	3.20	<0.04	<0.04
O*	-1.32	-1.35	0.00	0.01
TOTAL	98.78	99.27	92.43	86.14
number	24	24	24	24
Si	7.89	8.08	7.27	7.75
Ti	0.66	0.50	0.00	0.00
Zn	-0.01	0.00	0.00	0.01
Al	0.39	0.32	4.78	4.26
V	0.00	0.01	0.00	0.00
Cr	0.00	0.00	0.00	0.00
Fe	1.19	1.26	0.01	0.01
Ni	0.00	0.00	0.00	0.00
Mn	0.02	0.02	0.00	0.00
Mg	3.81	3.78	0.00	0.43
Ca	0.95	0.92	1.43	1.14
Sr	0.04	0.05	0.00	0.02
Ba	0.02	0.01	0.03	0.03
Na	1.41	1.46	0.14	0.12
K	0.74	0.77	1.48	0.79
P	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.01	0.00
F	1.58	1.61	0.00	-0.02
O	24.00	24.00	24.00	24.00

Appendix 7: Probe Analyses: Perovskite

SAMPLE	G408090a-perovskite1	G408090a-perov2	G408090a-perovskite3	G408090a-perovskite4	G408090a-perovskite5
ID	Prv	Prv	Prv	Prv	Prv
SiO2	<0.05	<0.05	<0.05	<0.04	<0.05
TiO2	52.93	53.42	53.24	54.33	53.68
ZnO	<0.12	<0.12	<0.11	<0.11	<0.11
Al2O3	<0.03	0.03	0.03	0.09	0.05
V2O3	<0.04	0.09	<0.04	0.09	0.06
Cr2O3	<0.07	<0.06	<0.07	<0.07	<0.07
FeO	0.43	0.62	0.64	0.71	0.60
NiO	<0.07	<0.07	<0.07	<0.07	<0.07
MnO	<0.06	<0.06	<0.07	<0.07	<0.07
MgO	<0.03	<0.03	<0.03	<0.03	<0.03
CaO	31.33	31.73	31.97	33.06	31.74
SrO	2.08	1.89	1.80	1.07	1.70
BaO	<0.07	<0.07	<0.08	<0.07	<0.07
Na2O	1.88	1.74	1.76	1.47	1.71
K2O	0.02	<0.02	0.03	<0.02	<0.02
Cl	<0.02	<0.02	<0.02	<0.02	<0.02
F	<0.07	0.13	0.08	<0.07	<0.07
CO2	0.00	0.00	0.00	0.00	0.00
O*	-0.01	-0.05	-0.04	-0.01	-0.02
TOTAL	88.65	89.59	89.52	90.80	89.52
number	3	3	3	3	3
Si	0.00	0.00	0.00	0.00	0.00
Ti	1.03	1.02	1.02	1.02	1.03
Zn	0.00	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00	0.00
V	0.00	0.00	0.00	0.00	0.00
Cr	0.00	0.00	0.00	0.00	0.00
Fe	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00
Mn	0.00	0.00	0.00	0.00	0.00
Mg	0.00	0.00	0.00	0.00	0.00
Ca	0.87	0.87	0.87	0.89	0.87
Sr	0.03	0.03	0.03	0.02	0.03
Ba	0.00	0.00	0.00	0.00	0.00
Na	0.09	0.09	0.09	0.07	0.08
K	0.00	0.00	0.00	0.00	0.00
Cl	0.00	0.00	0.00	0.00	0.00
F	0.00	0.01	0.01	0.00	0.00
C	0.00	0.00	0.00	0.00	0.00
O	3.00	3.00	3.00	3.00	3.00

Appendix 8: Microprobe Conditions

Compositional analyses were acquired on an electron microprobe (JEOL 8230/8530 (TCP/IP Socket and EIKS)) equipped with five tuneable wavelength dispersive spectrometers. EDS spectra were acquired and processed using a Thermo NSS/Pathfinder EDS system. Operating conditions were 40 degrees take-off angle, and a beam energy of 15 keV. The beam current was 10 nA, and the beam diameter was 5 microns.

Elements were acquired using analyzing crystals LiFL for Cr ka, Mn ka, Fe ka, Ni ka, Zn ka, PETL for Ti ka, V ka, P ka, S ka, Cl ka, K ka, Ca ka, Sr la, Ba la, TAP for Al ka, Si ka, Na ka, Mg ka, and LDE1L for F ka.

The standards were Rutile TiO_2 P&H (B13) for Ti ka, $SrTiO_3$ P&H (D3) for Sr la, Rhodonite $MnSiO_3$ P&H (B14) for Mn ka, Eskolaite P&H (D12) for Cr ka, Nickel Oxide NiO P&H (A8) for Ni ka, Barite $BaSO_4$ P&H (A15) for Ba la, Orthoclase P&H (D2) for K ka, Celestine $SrSO_4$ P&H (A16) for S ka, Fluor-Apatite P&H (D11) for P ka, Hematite Harvard (F3) for Fe ka, Tugtupite Astimex (K18) for Cl ka, Olivine San Carlos NMNH 111312-44 (J14) for Mg ka, Anorthoclase Kakanui, NMNH 133868 (J9) for Na ka, Plagioclase Lake County NMNH 115900 (J7) for Al ka, Wollastonite UNE (B5) for Ca ka, Si ka, Topaz (UTAS4 block) for F ka, Zinc oxide JEOL for Zn ka, and Calcium vanadate $Ca_3(VO_4)_2$ JEOL for V ka.

The counting time was 10 seconds for Si ka, S ka, 20 seconds for Al ka, Na ka, P ka, Mg ka, Cl ka, K ka, Ca ka, Ti ka, V ka, Cr ka, Mn ka, Fe ka, Ni ka, Zn ka, Ba la, 30 seconds for F ka, and 50 seconds for Sr la. The off peak counting time was 10 seconds for Si ka, S ka, 20 seconds for Al ka, Na ka, P ka, Mg ka, Cl ka, K ka, Ca ka, Ti ka, V ka, Cr ka, Mn ka, Fe ka, Ni ka, Zn ka, Ba la, 30 seconds for F ka, and 50 seconds for Sr la.

Off Peak correction method was Linear for Al ka, Si ka, P ka, Cl ka, K ka, Ca ka, Fe ka, Zn ka, Exponential for S ka, Ti ka, Cr ka, Mn ka, Mg ka, Ni ka, Na ka, Sr la, Ba la, Slope (Hi) for V ka, and Slope (Lo) for F ka. Unknown and standard intensities were corrected for dead time.

Interference corrections were applied to F for interference by Fe, Mn, Mg, Cr, and to Na for interference by Zn, and to Ti for interference by Ba, and to V for interference by Ti, Ba, and to Cr for interference by V, and to Mn for interference by Cr, and to Fe for interference by Mn, and to Sr for interference by Cr, and to Ba for interference by Ti.
See J.J. Donovan, D.A. Snyder and M.L. Rivers, An Improved Interference Correction for Trace Element Analysis in Microbeam Analysis, 2: 23-28, 1993

Oxygen was calculated by cation stoichiometry and included in the matrix correction. The exponential or polynomial background fit was utilized.
(See John J. Donovan, Heather A. Lowers and Brian G. Rusk, Improved electron probe microanalysis of trace elements in quartz, American Mineralogist, 96, 274282, 2011).

The matrix correction method was ZAF or Phi-Rho-Z Calculations and the mass absorption coefficients dataset was LINEMU Henke (LBL, 1985) < 10KeV / CITZMU > 10KeV. The ZAF or Phi-Rho-Z algorithm utilized was Armstrong/Love Scott (default).
(See J. T. Armstrong, Quantitative analysis of silicates and oxide minerals: Comparison of Monte-Carlo, ZAF and Phi-Rho-Z procedures, Microbeam Analysis-1988, p 239-246).

Mineral Resources Tasmania

Appendix 9: Laboratory Report –SEM analytical conditions

Hitachi SU-70 analytical field emission SEM

- Installed February 2011.
- Schottky thermal field emission source.
- Ultra-high resolution (1.0 nm @ 15kV, 1.6 nm @ 1kV for SE imaging).
- High vacuum operation only (i.e. no variable pressure in chamber).
- Hitachi in-chamber and in-lens scintillation detectors, Super ExB filter, beam deceleration.
- Hitachi in-chamber 5-segment solid state BSE detector, retractable.
- In-column Faraday cup with picoammeter for beam current measurement.
- Anti-contamination cold plate, liquid nitrogen cooled.
- 5 axis motorised fully eucentric stage, XYZ range 110x110x40mm.
- Oxford AZtec EDS/EBSD system with
    - X-Max 80 SDD EDS, MnKa 125 eV resolution, elements B-U, large area hyperspectral mapping, standardless and standards-based quantification, feature analysis
    - HKL NordlysNano EBSD camera & forescatter detector system, HKL & Channel 5 software packages, Synergy EDS/EBSD integration, HKL, ICSD & American Mineralogist phase databases.
- NEW June 2017: Gatan ChromaCL2 colour cathodoluminescence imaging system with integrated BSE detector, Digital Micrograph 3 software, automated mosaic acquisition, simultaneous acquisition of SE, iBSE and colour CL images.

Label:	am 179
Element List Type:	Current Spectrum
Processing Option:	All Elements
Specimen Coating:	On
Beam Calibration Element Coating:	Off
Coating Element:	Carbon
Coating Thickness:	20 nm
Coating Density:	2.25 g/cm³
Automatic Line Selection:	Disabled
Normalization:	Enabled
Thresholding:	Sigma level = 1
Detector Window Correction:	Enabled
Deconvolution Elements:	None
Selected Standards:	Minerals_15kV_2017-10-20 [User]
Pulse Pile Up Correction:	Succeeded
Detector file:	X-Max 3
Efficiency:	File based

Appendix 10: SEM/EDS analyses: Clays, G409294-

Atomic proportions to 6.3 cations

min	O	Na	Ca	K	Mg	Ti	Mn	Fe	Ni	Al6	Al4	Si	P
mont	16.4	0.0	0.2	0.0	0.4	0.0	0.0	0.0	0.0	2.7	0.7	3.3	0.0
mont	16.0	0.0	0.2	0.0	0.4	0.0	0.0	0.2	0.0	2.5	0.7	3.3	0.0
mont	12.9	0.0	0.1	0.1	0.8	0.0	0.0	0.6	0.0	1.7	0.9	3.1	0.0
mont	13.4	0.0	0.1	0.1	0.9	0.1	0.0	0.8	0.0	1.3	1.2	2.8	0.0
mont	9.9	0.0	0.1	0.1	1.0	0.0	0.0	0.7	0.0	1.4	0.9	3.1	0.0
mont	17.3	0.0	0.0	0.0	1.0	0.0	0.0	0.1	0.0	2.2	0.9	3.1	0.0
mont	15.5	0.0	0.3	0.0	1.1	0.0	0.0	0.2	0.0	1.4	1.1	2.9	0.2
mont	16.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	2.0	1.0	3.0	0.0
mont	9.1	0.0	0.3	0.0	1.3	0.0	0.0	0.2	0.0	1.4	0.8	3.2	0.0
mont	12.2	0.0	0.0	0.0	1.3	0.0	0.0	0.1	0.0	1.8	0.9	3.1	0.0
mont	16.5	0.0	0.0	0.0	1.3	0.0	0.0	0.1	0.0	1.9	1.0	3.0	0.0
Fe-sap	15.5	0.0	0.1	0.2	1.4	0.0	0.0	1.4	0.0	1.4	1.1	2.9	0.0
sap	17.4	0.0	0.1	0.0	1.6	0.0	0.0	0.1	0.0	2.5	1.0	3.0	0.0
sap	11.9	0.0	0.1	0.0	1.6	0.0	0.0	0.3	0.0	1.3	1.0	3.0	0.0
sap	7.9	0.0	0.1	0.0	1.8	0.0	0.0	1.1	0.0	0.4	1.2	2.8	0.0
sap	9.8	0.0	0.1	0.0	1.9	0.0	0.0	0.8	0.0	0.5	1.2	2.8	0.0
sap	11.3	0.0	0.1	0.0	2.0	0.0	0.0	0.2	0.0	1.0	1.2	2.8	0.0
sap	13.3	0.0	0.1	0.0	2.1	0.0	0.0	0.4	0.0	0.7	1.1	2.9	0.0
sap	7.5	0.0	0.1	0.0	2.4	0.0	0.0	0.3	0.0	0.6	0.8	3.2	0.0
sap	7.5	0.0	0.1	0.0	2.7	0.0	0.0	0.0	0.0	0.6	0.8	3.2	0.0
sap	11.9	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.6	1.3	2.7	0.0
sap	15.5	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.5	1.4	2.6	0.0
sap	10.7	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.4	0.9	3.1	0.0
sap	13.4	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.1	1.1	2.9	0.0
sap	13.9	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.1	1.2	2.8	0.0
ave.	12.9	0.0	0.1	0.0	1.7	0.0	0.0	0.3	0.0	1.2	1.0	3.0	0.0

Mineral Resources Tasmania

Appendix 11: XRD Analyses

Client: MRT
Sample Location: Sidling
Job Number: LJN2018-084b
Analyses: Approximate Mineralogy
Methods: XRD
Analyst: T Coyte
Lab Manager: R Bottrill
Date: 28/4/2020

Analysis Results – G407355 Selective

General information

Measurement date:	28/4/2020	**Analysis date:**	28/4/2020
Job Number:	LJN2020-041	**XRD**	Rigaku Miniflex 600
Registration Number:	G407355	**Analyst:**	T.Coyte
Quantitative Method:	PDXL	**Process Medium:**	Selective
Comment:	Selective samples from white veins in rock, run on glass disk.		

Analysis results

Phase Name	Content - Estimate	Formula
Gonnardite	Dominant	$(Na,Ca)_2(Si,Al)_5O_{10} \cdot 3H_2O$
Phillipsite-(K)	Sub major	$(K,Na,Ca_{0.5},Ba_{0.5})_{4-7}[Al_{4-7}Si_{12-9}O_{32}] \cdot 12H_2O$

Notes
Peak overlap may interfere with identifications and quantitative calculations.
Amorphous minerals and minerals present in trace amounts may not be detected.

Phase Data Pattern