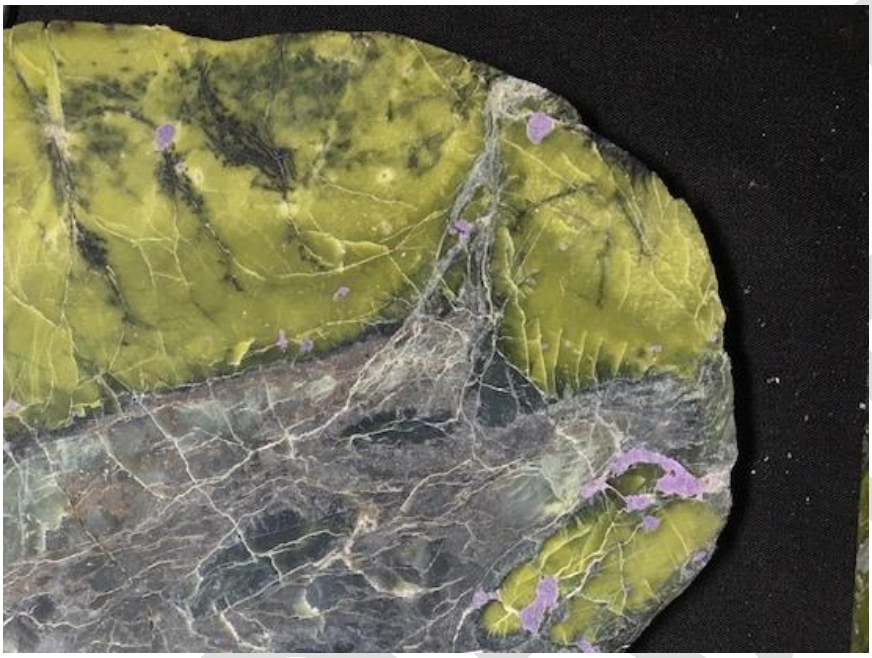
Mineral Resources Tasmania

Laboratory Report
LJN2019-122-2

PETROLOGY AND MINERALOGY - STICHTITE HILL, DUNDAS



An Unpublished Mineral Resources Tasmania Report for:

John McLoughlin

By: R.S. Bottrill and L Unwin

Date: 10 October 2022

Mineral Resources Tasmania
Department of State Growth

Tasmanian Government

SUMMARY

"Stichtite" samples from the Stichtite Hill mine were examined and found to be yellow-green Cr-rich serpentinised dunite cut by brown chlorite - serpentine veins. The stichtite is replacing chromite in the serpentinised dunite and is mostly Al and Fe rich, grading into chromian hydrotalcite. The serpentine in the vein is mostly very Al-rich lizardite, also rich in Fe and Cr; in contrast, in the matrix it is relatively poor in Fe, Cr and Al. The stichtite is mostly restricted to the dunite but some is remobilised into small veinlets which crosscut the dark serpentine-chlorite zone. The vein is thought to be a fine grained orthopyroxenite which intruded the dunite prior to serpentinisation and stichtite formation.

INTRODUCTION

One unusual sample of veined serpentinite with stichtite was submitted for analysis and interpretation. This is part of a project to attempt to understand the formation of the rare mineral stichtite, important locally in Tasmania as a gemstone and ornamental stone (Bottrill and Brown, 2000; Bottrill and Graham, 2006; Melchiorre, et al. 2017).

The sample details are given in Table 1.

Table 1: Sample details

MRT Reg. No.	Location	Sample Description	Process
G410113	Stichtite Hill, Dundas	brown vein in serpentine, with stichtite	XRD, PTS, SEM

METHODOLOGY

To determine the nature and mineralogy of the rock, a representative portion of the material was prepared as a polished thin section to study the mineralogy and textures. This was tested by SEM/EDS to confirm the mineral chemistry. An additional subsample was tested by XRD to confirm the mineral content.

PETROGRAPHIC EXAMINATION

In hand specimen, the sample G410113 consists of pea-green serpentine with grey-brown veins, and a dark green selvage between them (Fig. 1). Stichtite occurs in small blebs, probably replacing chromite, in the pea-green serpentine, and also in some irregular blebs that seem to be partly remobilised and some cut the dark coloured vein.

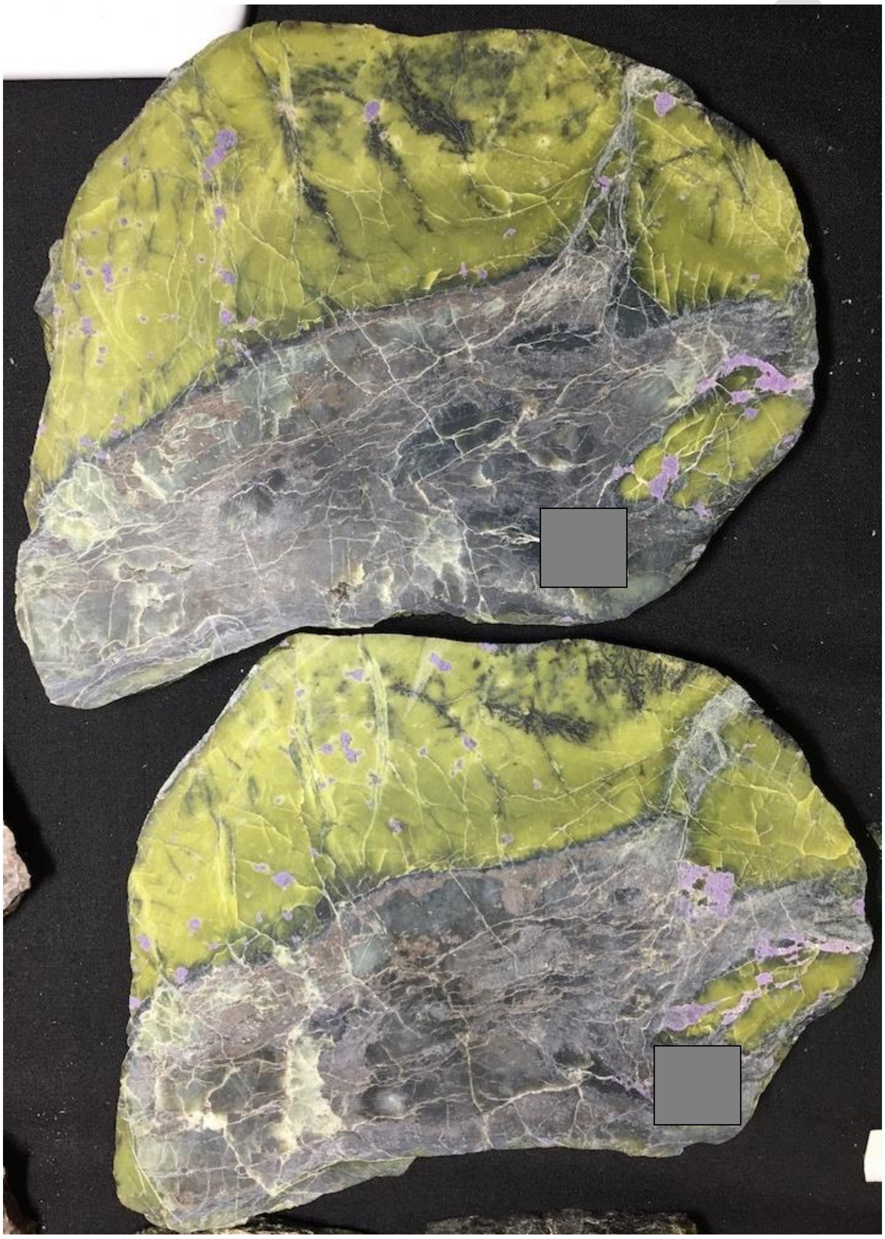


Figure 1: Sample G410113, Polished slabs of serpentine with a dark green vein, and blebs of lilac stichtite. FOV ~100 mm.

In thin section the sample consists mostly of serpentine, chlorite, stichtite and minor chromite, with trace magnetite (Fig. 2 - 4). The stichtite blebs are between 1 – 10 mm in size, rounded to highly angular and in places deformed into lenses and veinlets. They contain very angular fragments of chromite that often appear to have a jigsaw-fit (Fig. 2 - 4). The host to most of the stichtite is a fine mesh-textured serpentine that has the characteristic texture of lizardite pseudomorphing a fine grained dunite, cut by small veinlets and lenses of chrysotile (Fig. 3). Some is adjacent to the vein material, shown as a relatively granular mixture of chlorite and lizardite, and some is smeared along the contact (Figs. 4 & 5). The vein material is possibly a fine grained orthopyroxenite or picrite.

Serpentinisation and stichtite formation appear to post-date the veining and predate the deformation; which may be late Cambrian or Devonian.

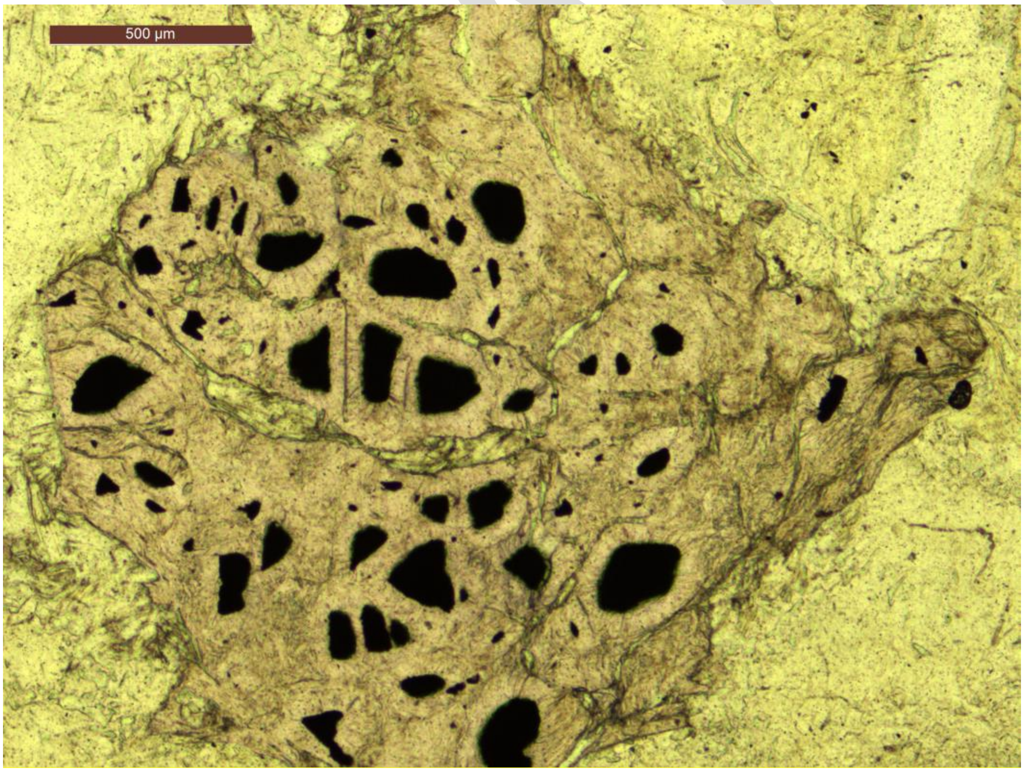


Figure 2: Sample G410113*, A pink bleb of fibrous stichtite partly replacing a b recciated chromite crystal (black), in a pale green serpentine matrix. PPTL (Plane Polarised Transmitted light).*

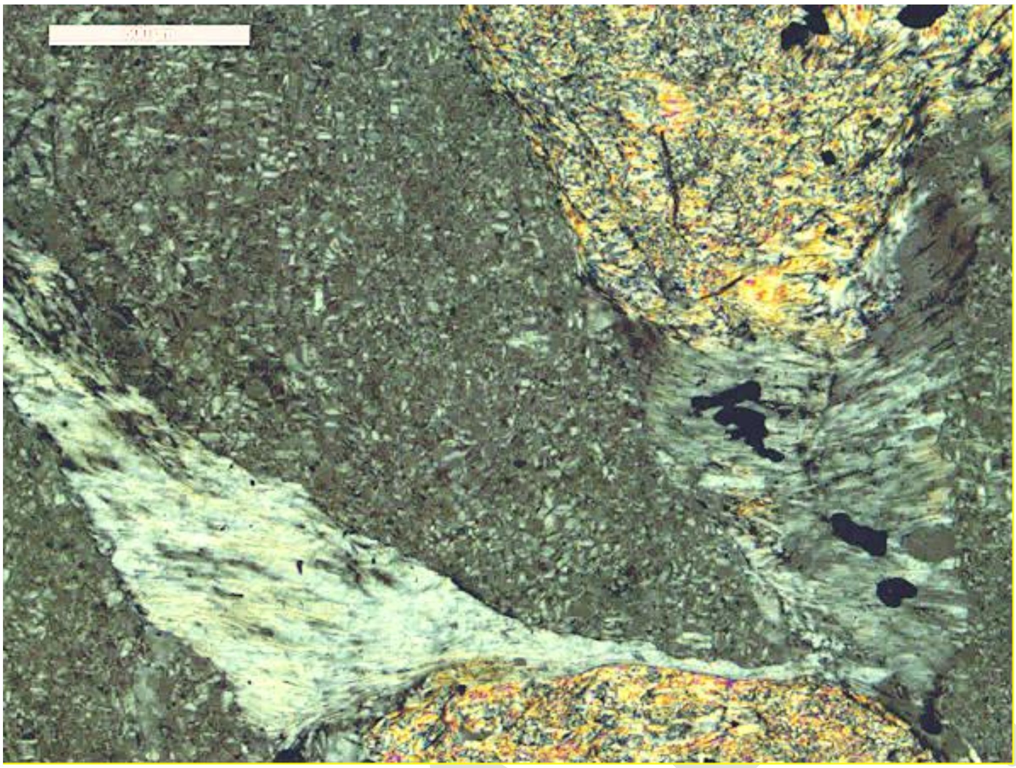


Figure 3: Sample G410113, *High birefringent blebs of fibrous stichtite largely replacing chromite crystals (black), in a finely mesh-textured serpentine (lizardite) matrix, replacing dunite. The coarser white-pale grey patches are chrysotile veins or shears, with some black magnetite. XPTL (Cross Polarised Transmitted light).*

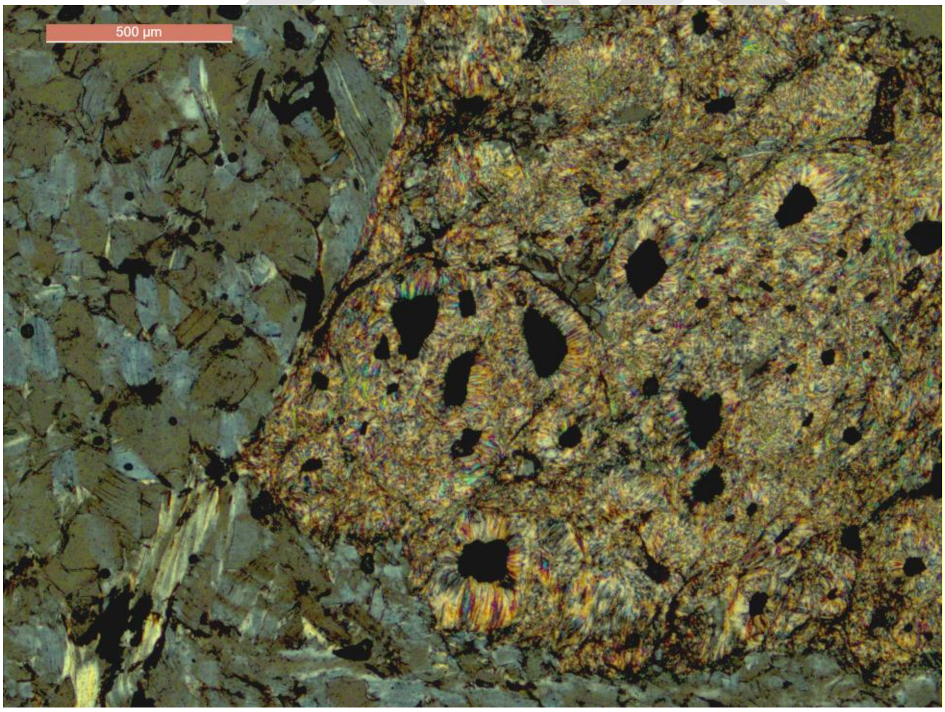


Figure 4: Sample G410113, *High birefringent blebs of fibrous stichtite largely replacing chromite crystals (black), adjacent to a granular serpentine, comprising chlorite and Al-rich lizardite, probably replacing an orthopyroxenite. The coarser white-pale grey patches are chrysotile veins or shears. XPTL.*

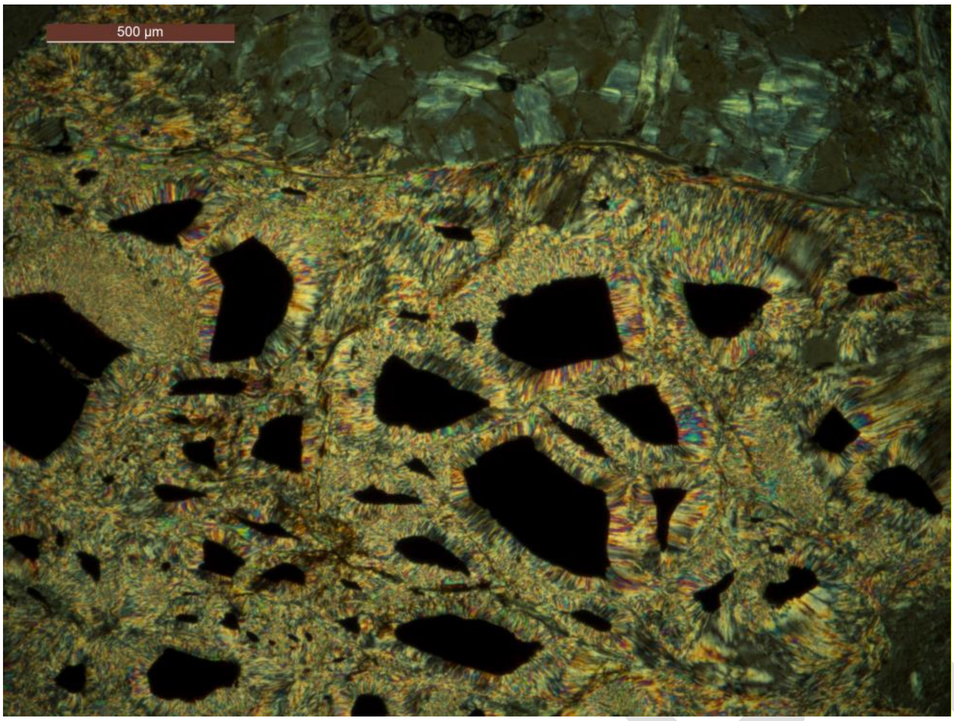


Figure 5: Sample G410113*, High birefringent blebs of fibrous stichtite largely replacing chromite crystals (black), adjacent to a granular serpentine, comprising chlorite and Al-rich lizardite, probably replacing an orthopyroxenite. XPTL.*

XRD ANALYSES

A sample of the brown vein was separated and analysed in the MRT laboratories, Rosny Park, Tasmania. It was run on a Rigaku Miniflex 600 X-Ray Diffractometer (XRD) system provided with a 600W generator 150mm goniometer with a Cu tube; 40kV/15mA, sample spinner and a Scintillation counter (SC) with Be window, a graphite counter monochromator and a Kß Ni- filter. The MRT validated XRD analysis procedure scans over the range 3 - 63° 2Theta-2Theta range, with a scanning speed of 0.5º /min, and sample rotation of 15 rpm. The raw data were processed using the Rigaku PDXL2 software, linked to the ICCD database.

Quantification is largely manual, using a series of prepared standards of the more common minerals to enable some semi-quantitative analysis. Quartz, if present, is used as an internal standard; and if not present, it is often added to the sample for a supplementary scan. Our semi-quantitative results are calculated using single-peak calibration factors derived from scans of known mixtures of minerals.

The results are shown in Appendix 1 and indicate the brown vein is mostly composed of serpentine (lizardite) and chlorite (clinochlore), the latter probably underestimated greatly by XRD; there may be a trace of olivine, but the reported quartz may be contamination.

SEM/EDAX ANALYSES

To check the mineralogy the sample was analysed by SEM-EDS, in the CSL, University of Tasmania, with analytical conditions shown in Appendix 2. The sample contains serpentine, chlorite, stichtite, chromite and magnetite. Some back-scattered electron (BSE) images are shown (Figs. 3 & 4) with analysis points.

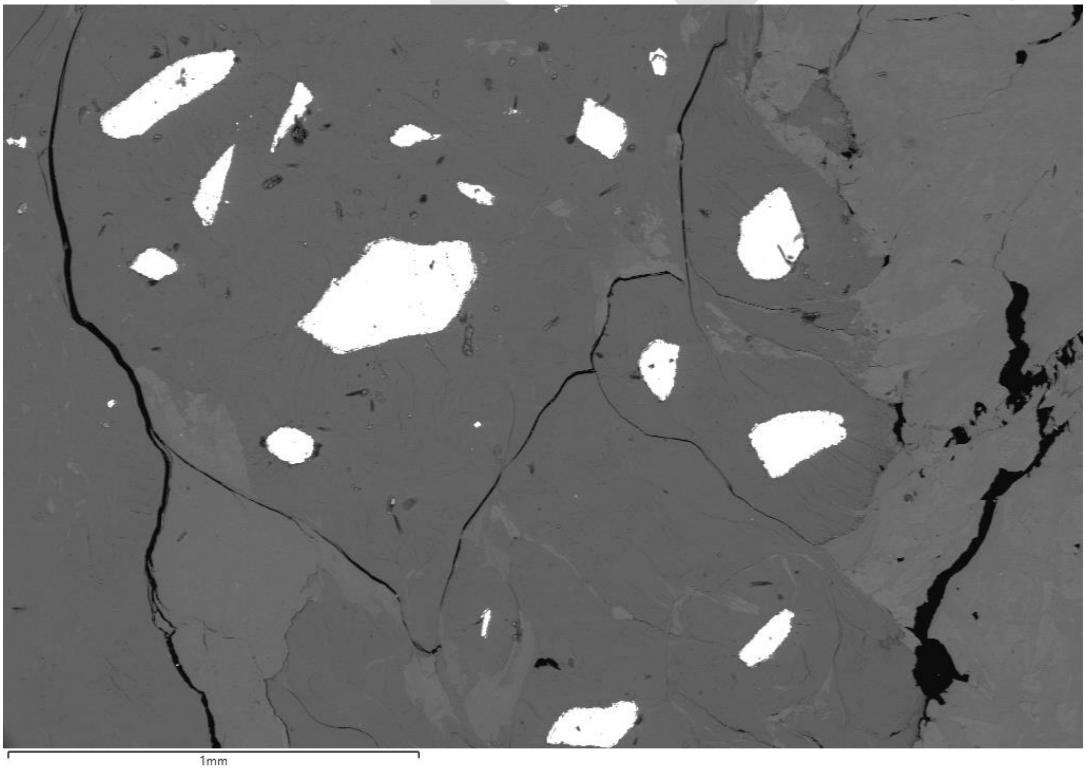


Fig. 3: Sample G4100113. White material is chromite, replaced, brecciated and veined by stichtite (dark grey); mid-grey material is serpentine. BSE (back scattered electron) image.

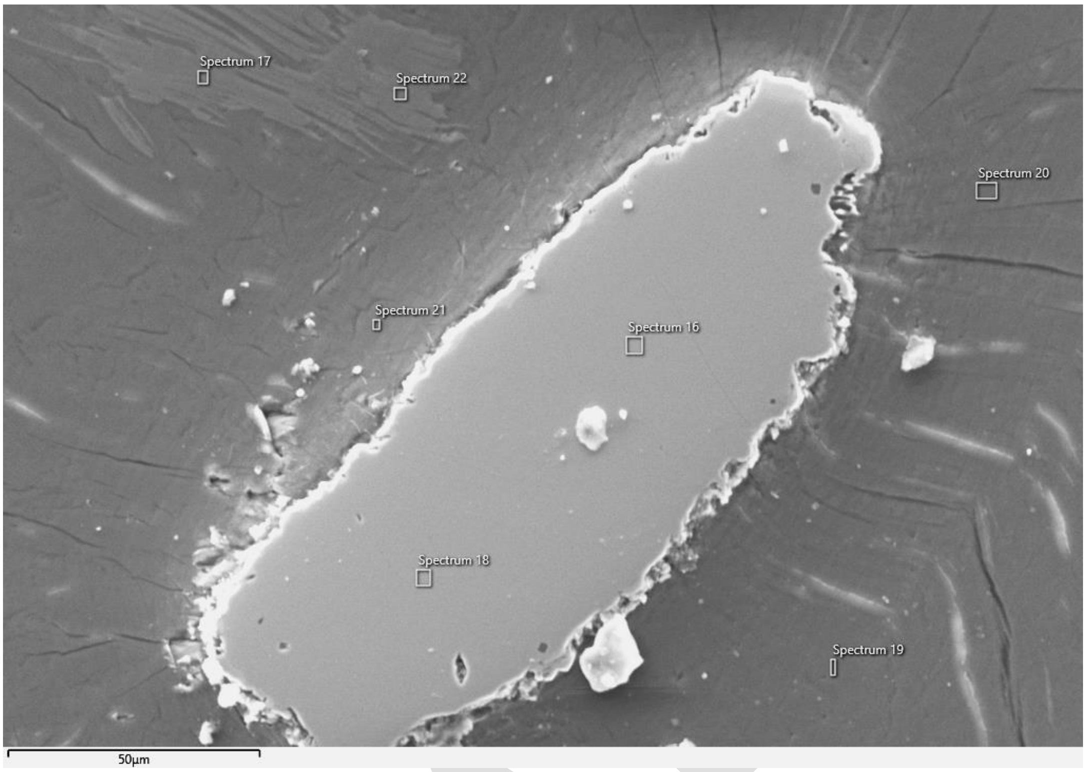


Fig. 4: Sample G4100113. Light grey material is chromite, surrounded by replacive radiating/bladed stichtite (dark grey); mid-grey material is chlorite. BSE image.

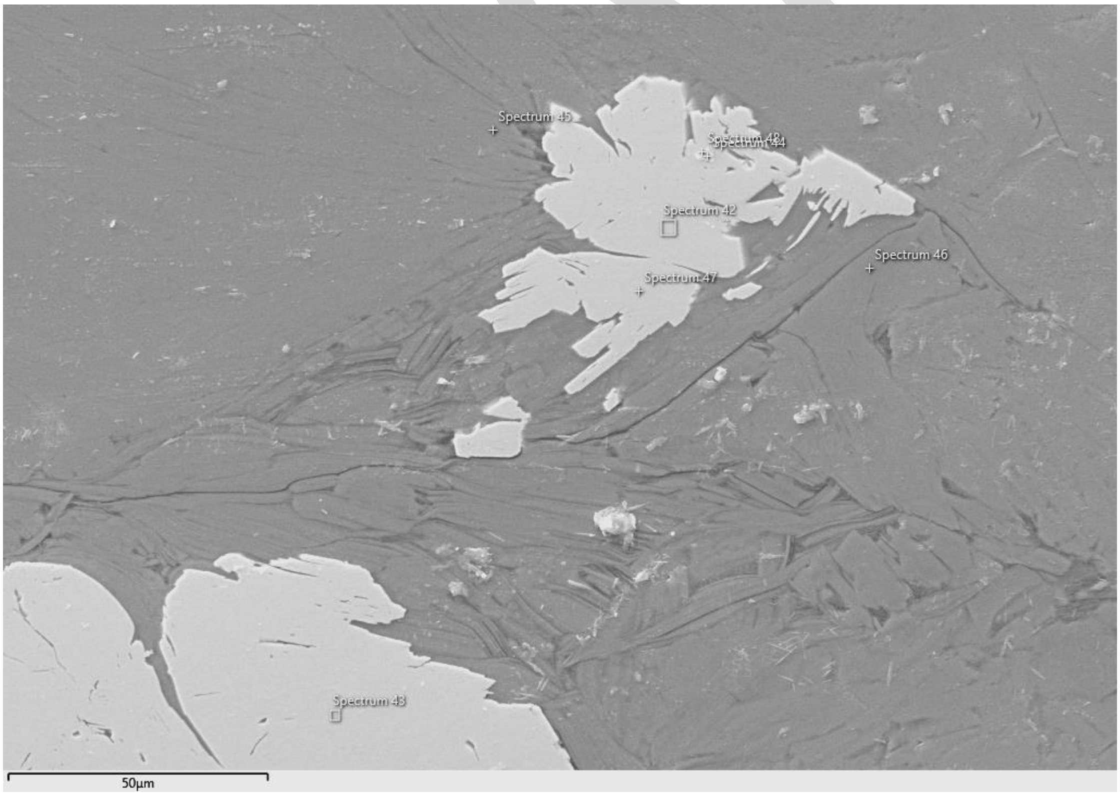


Fig. 45: Sample G4100113. Light grey bladed material is magnetite; mid-grey bladed material is chlorite. BSE image.

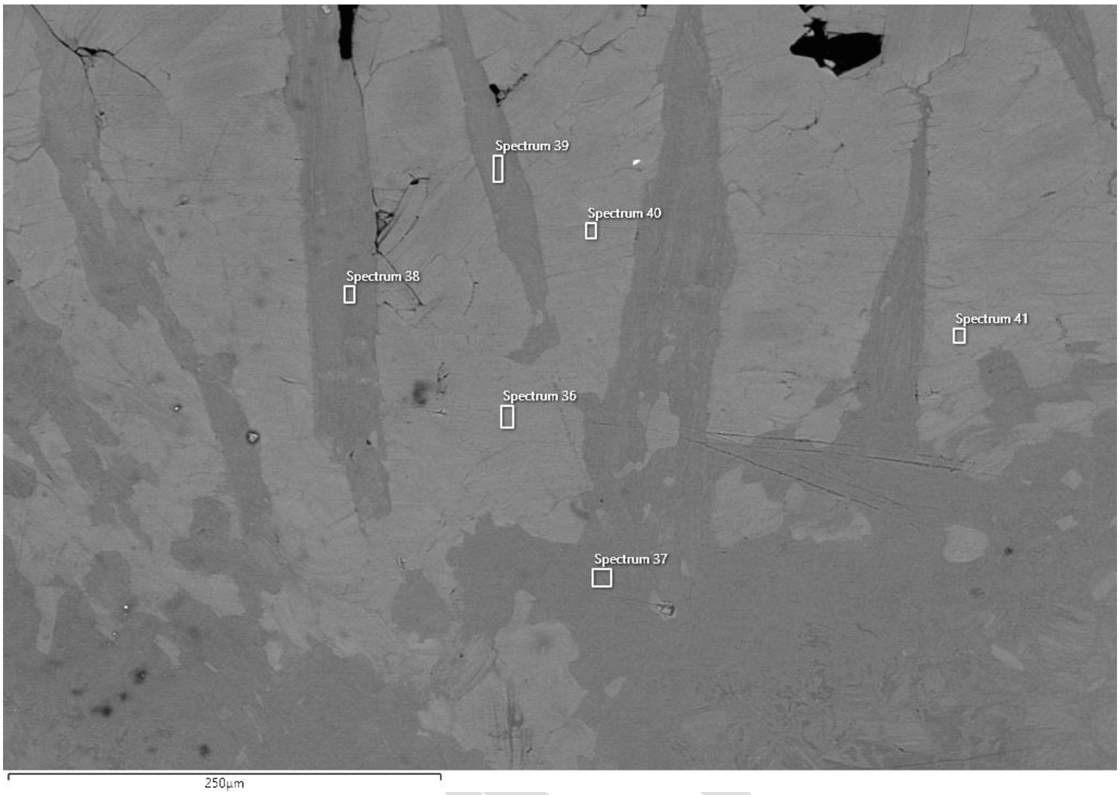


Fig. 6: Sample G4100113. Light grey material is Al-rich lizardite; mid-grey material is Al-poor chlorite. BSE image.

MINERAL CHEMISTRY SUMMARY

The minerals found are summarised below and in Figs. 7 – 9:

Al-Lizardite: $(Mg_{5.6}\ Fe_{0.3}\ Al_{0.1})\ (Si_{3.5}\ Al_{0.5})O_{10}(OH)_8$; high Al and Fe; see Fig. 8

Clinochlore: $(Mg_{5.0}\ Fe_{0.5}\ Al_{0.5})\ (Si_{3.0}\ Al_{1.0})O_{10}(OH)_8$; very Mg-rich; see Fig. 8

Chromite $(Mg_{0.4}\ Fe_{0.6})(Cr_{1.5}\ Al_{0.5}\ Fe_{0.1})O_4$; chromite, not magnesiochromite; see Fig. 7

Magnetite: Fe_3O_4

Serpentine: $(Mg_{2.9}\ Fe_{0.1})\ (Si_{1.9}\ Al_{0.1})O_5(OH)_4$; probably chrysotile, see Fig. 8

Stichtite: $(Mg_{5.8\text{-}6.3}\ Fe_{0.3\text{-}0.5})\ (Cr_{0.6\text{–}1.5}\ Al_{0.4\text{-}0.8})(CO_3)(OH)_{16}.4H_2O$; grades into hydrotalcite, see Fig. 6; also Fe-rich but not pyroaurite.

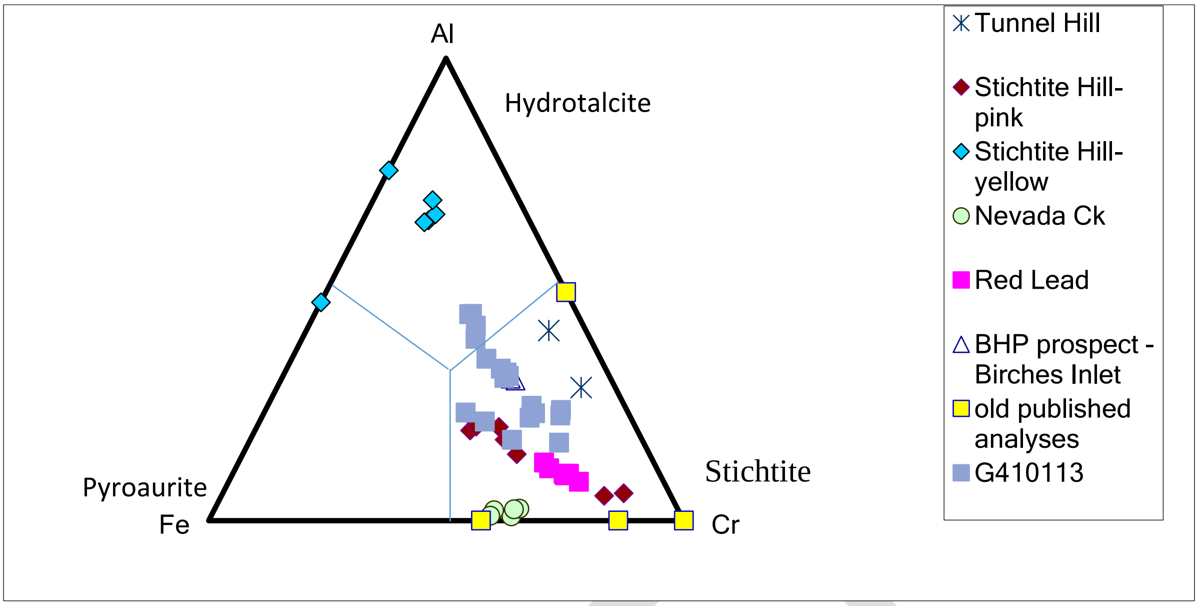


Fig. 7: Sample G4100113. Compositions of stichtite group minerals.

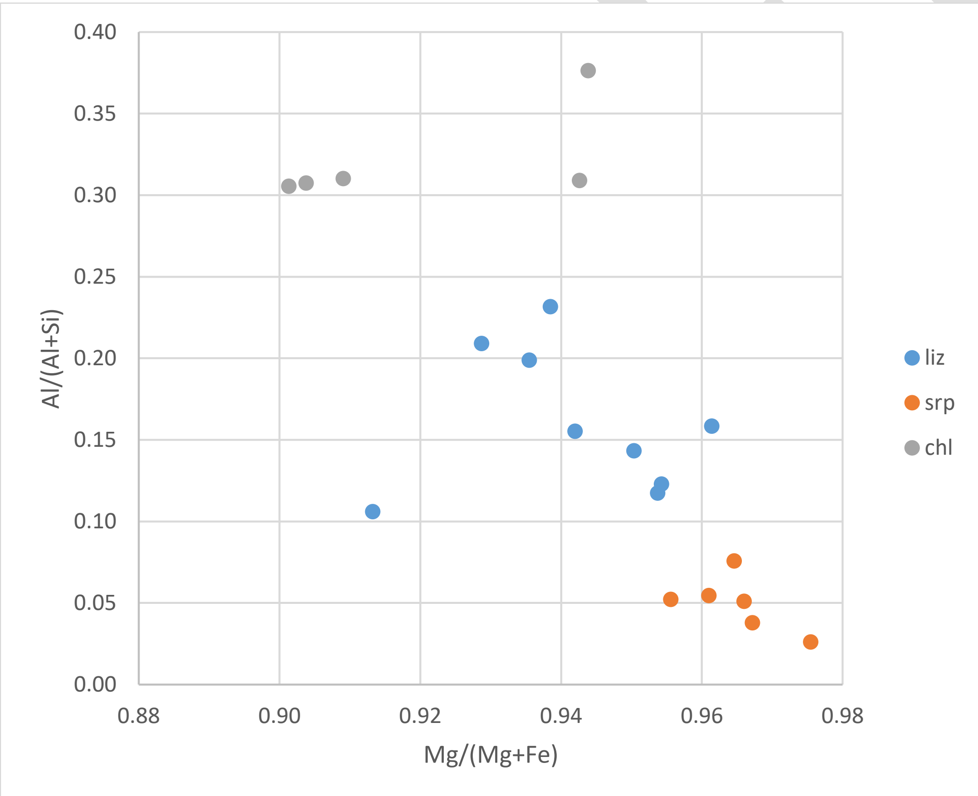


Fig. 8: Sample G4100113. Compositions of chlorites and serpentines.

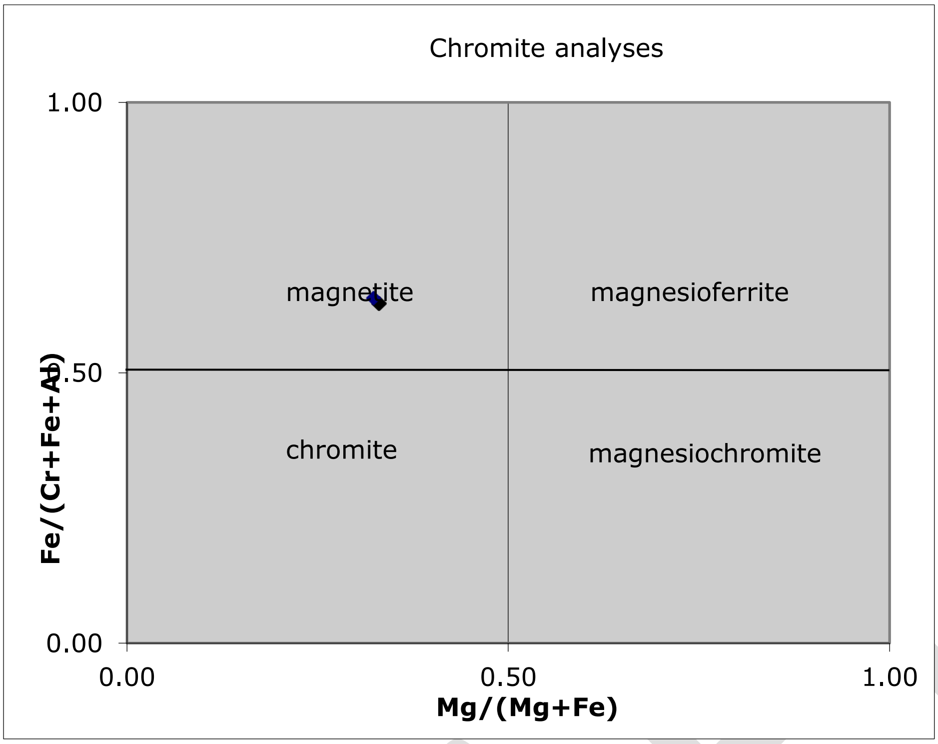


Fig. 9: Sample G4100113. Compositions of spinel group minerals.

DISCUSSION AND CONCLUSIONS

This is a Serpentinised chromite-rich dunite with a dark green chlorite-serpentine vein, and lilac blebs of stichtite partly replacing chromite in the serpentinised dunite. There are two types of serpentine, one unusually Al-rich and is possibly a mixed layer mineral with chlorite?

REFERENCES

Bottrill, R. S., and Brown, G., 2000, Rare Australian Gemstones: stichtite. *Australian Gemmologist*, v. 20, p. 391-393.

Bottrill, R.S., and Graham, I. (2006). Stichtite from western Tasmania. *Australian Journal of Mineralogy. 12, 101-107*

Melchiorre, Erik B.; Bottrill, Ralph; Huss, Gary R.; Lopez, Amanda 2017. Conditions of stichtite (Mg6Cr2(OH)16[CO3]·4H2O) formation and its geochemical and isotope record of early Phanerozoic serpentinizing environments. *Geochimica et Cosmochimica Acta,* Volume 197, p. 43-61.

Mineral Resources Tasmania

R.S. Bottrill
MINERALOGIST/PETROLOGIST

Lia Unwin
TECHNICAL OFFICER

Mineral Resources Tasmania

Appendix 1: XRD Analyses: MRT Laboratory Report

Client: R Bottrill
MRT Job Number: LJN2019-122-2
Method: X-Ray Diffraction
Lab Manager: R Bottrill
Sample Source: Stichtite Hill
Analysis: Approximate Mineralogy
Analyst: L Unwin
Date: 18/2/2021

XRD RESULTS-G410113-LJN2019-122-QA2-18/2/2021

General Information

Measurement date:	18/12/2019	Interpretative date:	18/2/2021
Job Number/Client:	LJN2019-122	XRD	Rigaku Miniflex 600
Registration Number:	G410113	Analyst:	LUnwin
Quantitative Method:	PDXL Rel. heights	Process Medium:	Wholerock
Sample Holder:	Standard	Speed (deg/min):	0.5
Comment:	Shifted -0.08		

Analysis Results

Phase name	Content wt% (± error)	Formula
Lizardite	95(10)	$Mg_3Si_2O_5(OH)_4$
Chlorite*	3(2)	$(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$
Olivine*	2(2)	$(Mg,Fe)_2SiO_4$
Quartz	<1	SiO_2

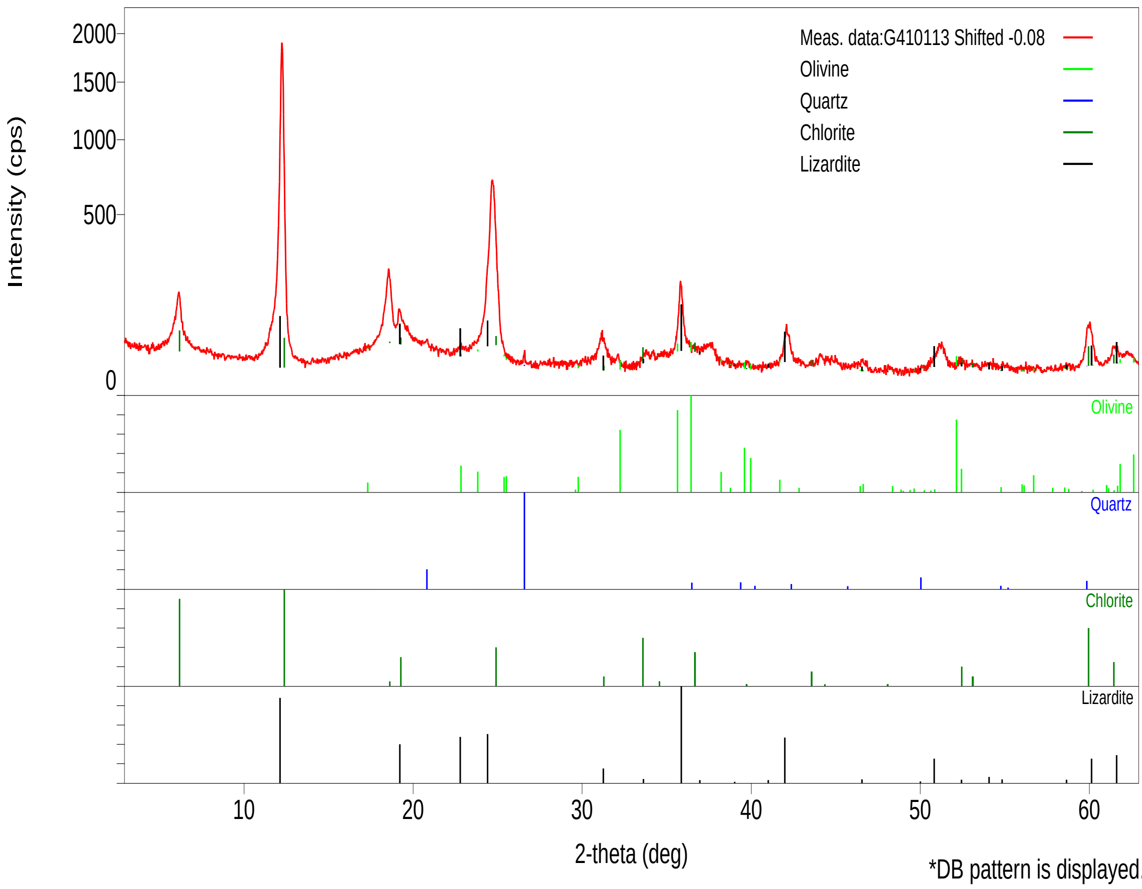
Notes
Peak overlap may interfere with identifications and quantitative calculations.
Amorphous minerals and minerals present in trace amounts may not be detected.
Olivine* probably Forsterite
Chlorite* probably Mg-Chamosite

Peak List

No.	2-theta(deg)	d(ang.)	Phase name	Rel. int. I(a.u.)
1	6.07477	14.5373	Chlorite(0,0,1)	11.08
2	12.2345(1	7.2285(1	Lizardite(0,0,1)	100.00
3	12.4601	7.09815	Chlorite(0,0,2)	1.64
4	18.577(5)	4.7723(1	Chlorite(0,0,3)	9.48
5	19.2112	4.61629	Chlorite(1,1,0),Lizardite(1,0,0)	8.66
6	20.8192	4.26323	Olivine(1,0,1),Quartz(1,0,0)	1.31
7	22.82(5)	3.894(8)	Olivine(2,1,0),Lizardite(1,0,1)	0.53
8	24.6891	3.60305	Chlorite(0,0,4),Lizardite(0,0,2)	57.22
9	26.5989	3.34852	Quartz(1,0,1)	0.31

10	31.16(4)	2.868(4)	Chlorite(0,0,5),Lizardite(1,0,2)	6.27
11	32.1327	2.78336	Olivine(3,0,1)	0.54
12	33.7488	2.65368	Chlorite(1,3,0),Lizardite(1,1,0)	1.27
13	35.864(11)	2.5019(7)	Lizardite(1,1,1)	9.07
14	37.6015	2.39016	Olivine(0,0,2),Lizardite(0,0,3)	2.34
15	42.113	2.14395	Quartz(2,0,0),Lizardite(1,1,-2)	4.34
16	44.1331	2.05039	Chlorite(0,0,7)	0.63
17	44.803	2.02127	Unknown	0.23
18	46.6067	1.94716	Olivine(3,0,2),Lizardite(2,0,2)	0.62
19	51.24(5)	1.7815(1	Lizardite(1,1,3)	3.41
20	52.4711	1.74251	Olivine(4,0,2),Chlorite(2,4,0),Lizardite(2,1,	0.31
21	59.9537	1.54167	Quartz(2,1,1),Chlorite(0,6,0),Lizardite(3,0,	4.66
22	61.5099	1.50635	Olivine(5,1,2),Chlorite(3,3,-	1.45
23	62.252	1.49016	Olivine(6,2,0)	0.66

Phase Data Pattern



*DB pattern is displayed.

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Appendix 1: SEM Analyses: MRT Laboratory Report

Client: R Bottrill
MRT Job Number: LJN2019-122-2
Method: SEM/EDS
Lab Manager: R Bottrill

Sample Source: Stichtite Hill
Analysis: Approximate Mineralogy
Analyst: R Bottrill
Date: 8/1/2021

Table 1: Al-lizardite: formulae to 10 cations

Project Path	Mg	Al	Si	Cl	K	Ti	Cr	Mn	Fe	Ni	Zn	Label
2021-01-08/G410113 Dun/Site 6	2.8	0.3	1.8	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	13
2021-01-08/G410113 Dun/Site 6	2.8	0.3	1.8	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	14
2021-01-08/G410113 Dun/Site 7	2.8	0.4	1.5	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	17
2021-01-08/G410113 Dun/Site 7	2.8	0.4	1.5	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	22
2021-01-08/G410113 Dun/Site 8	2.8	0.3	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	23
2021-01-08/G410113 Dun/Site 8	3.0	0.2	2.2	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	26
2021-01-08/G410113 Dun/Site 8	2.8	0.3	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	27
2021-01-08/G410113 Dun/Site 9	3.0	0.2	1.5	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	32
2021-01-08/G410113 Dun/Site 10	2.8	0.4	1.8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	37
2021-01-08/G410113 Dun/Site 6	2.8	0.5	1.5	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	9
ave.	2.8	0.3	1.7	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	

Table 2: Chlorite: formulae to 10 cations

Project Path	Mg	Al	Si	Cl	K	Ti	Cr	Mn	Fe	Ni	Zn	Label
2021-01-08/G410113 Dun/Site 10	5.1	1.3	3.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	36
2021-01-08/G410113 Dun/Site 11	5.1	1.4	3.1	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	45
2021-01-08/G410113 Dun/Site 11	4.7	1.8	3.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	46
2021-01-08/G410113 Dun/Site 10	5.1	1.4	3.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	40
2021-01-08/G410113 Dun/Site 10	5.0	1.3	3.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	41
ave.	5.0	1.4	3.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	

Table 3: chromite and magnetite: formulae to 3 cations

Project Path	min	Mg	Al	Si	Cl	K	Ti	Cr	Mn	Fe	Ni	Zn	Label
2021-01-08/G410113 Dun/Site 4	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	1
2021-01-08/G410113 Dun/Site 7	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	16
2021-01-08/G410113 Dun/Site 7	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	18
2021-01-08/G410113 Dun/Site 4	chr	0.3	0.4	0.0	0.0	0.0	0.0	1.6	0.0	0.7	0.0	0.0	2
2021-01-08/G410113 Dun/Site 4	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	3
2021-01-08/G410113 Dun/Site 9	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	30
2021-01-08/G410113 Dun/Site 9	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	34
2021-01-08/G410113 Dun/Site 4	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	4
2021-01-08/G410113 Dun/Site 13	chr	0.4	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	49
2021-01-08/G410113 Dun/Site 13	chr	0.4	0.5	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	50
2021-01-08/G410113 Dun/Site 13	chr	0.4	0.5	0.0	0.0	0.0	0.0	1.5	0.0	0.7	0.0	0.0	54
2021-01-08/G410113 Dun/Site 11	mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	42
2021-01-08/G410113 Dun/Site 11	mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	43
2021-01-08/G410113 Dun/Site 11	mt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	47

Table 4: serpentine: formulae to 5 cations

Project Path	Mg	Al	Si	Cl	K	Ti	Cr	Mn	Fe	Ni	Zn	Label
2021-01-08/G410113 Dun/Site 6	2.9	0.1	2.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	12
2021-01-08/G410113 Dun/Site 6	2.9	0.1	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	15
2021-01-08/G410113 Dun/Site 8	2.9	0.1	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	29
2021-01-08/G410113 Dun/Site 10	2.8	0.1	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	38
2021-01-08/G410113 Dun/Site 10	2.8	0.1	1.9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	39

Table 5: stichtite: formulae to 8 cations

Project Path	Mg	Al	Si	Cl	K	Ti	Cr	Mn	Fe	Ni	Zn	Label
2021-01-08/G410113 Dun/Site 6	6.2	0.7	0.0	0.0	0.0	0.0	0.6	0.0	0.4	0.0	0.0	11
2021-01-08/G410113 Dun/Site 7	6.2	0.6	0.0	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	19
2021-01-08/G410113 Dun/Site 6	6.1	0.8	0.1	0.0	0.0	0.0	0.6	0.0	0.4	0.0	0.0	10
2021-01-08/G410113 Dun/Site 7	6.2	0.6	0.0	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	20
2021-01-08/G410113 Dun/Site 7	6.3	0.4	0.0	0.0	0.0	0.0	1.0	0.0	0.3	0.0	0.0	21
2021-01-08/G410113 Dun/Site 8	6.1	0.8	0.1	0.0	0.0	0.0	0.6	0.0	0.4	0.0	0.0	24
2021-01-08/G410113 Dun/Site 8	6.2	0.6	0.1	0.0	0.0	0.0	0.7	0.0	0.4	0.0	0.0	25
2021-01-08/G410113 Dun/Site 8	6.1	0.8	0.1	0.0	0.0	0.0	0.6	0.0	0.4	0.0	0.0	28
2021-01-08/G410113 Dun/Site 9	6.3	0.3	0.0	0.0	0.0	0.0	1.0	0.0	0.5	0.0	0.0	31
2021-01-08/G410113 Dun/Site 9	6.0	0.4	0.3	0.0	0.0	0.0	0.8	0.0	0.5	0.0	0.0	33
2021-01-08/G410113 Dun/Site 9	6.1	0.4	0.1	0.0	0.0	0.0	0.8	0.0	0.6	0.0	0.0	35
2021-01-08/G410113 Dun/Site 4	5.9	0.5	0.0	0.0	0.0	0.0	1.2	0.0	0.5	0.0	0.0	5
2021-01-08/G410113 Dun/Site 13	5.8	0.5	0.1	0.0	0.0	0.0	1.3	0.0	0.3	0.0	0.0	51
2021-01-08/G410113 Dun/Site 13	5.6	0.4	0.0	0.0	0.0	0.0	1.5	0.0	0.4	0.0	0.0	52
2021-01-08/G410113 Dun/Site 13	6.1	0.5	0.0	0.0	0.0	0.0	1.2	0.0	0.3	0.0	0.0	53
2021-01-08/G410113 Dun/Site 4	6.3	0.4	0.0	0.0	0.0	0.0	0.9	0.0	0.3	0.0	0.0	6
2021-01-08/G410113 Dun/Site 4	6.1	0.6	0.0	0.0	0.0	0.0	0.9	0.0	0.4	0.0	0.0	7
2021-01-08/G410113 Dun/Site 4	6.2	0.6	0.0	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	8

Mineral Resources Tasmania

Appendix 2: 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
- anticontamination 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