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Miscellaneous mineral analyses from near Balfour and Temma

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Introduction

Miscellaneous minerals were analysed as part of the study of mineralisation around Balfour and Temma in northwest Tasmania. These analyses include chlorites, stilpnomelane, carbonates, amphiboles, hisingerite and apatite.

The locations and descriptions of the samples are given below.

Sample No.	*Location*	*Rock type*	*Mineral analysed*
C108267	Kanunnah Bridge	Basalt	Chlorite
C108257	Clump Prospect	Black slate	Chlorite
C108249	Blocks Prospect	Chloritic slate	Chlorite
C108248	Blocks Prospect	Chloritic slate	Chlorite
C108454	Possum Creek	Siderite-magnetite lode	Carbonates
C108454	Possum Creek	Siderite-magnetite lode	Amphibole
C108454	Possum Creek	Siderite-magnetite lode	Hisingerite
C108414	Strickland	Sulphide-magnetite ore	Stilpnomelane
C108409d	South Balfour	Quartz lode	Apatite

Mineral Compositions

Analytical procedures and formulae calculation

The minerals were analysed (Tables 1–6) with a Cameca SX-50 electron microprobe, using WDS spectrometers at 15 kV, at the University of Tasmania.

The amphibole formulae and calculated Fe^{3+} were determined from the analysed weight percent oxides using the method of Schumacher (1997). The amphibole nomenclature is that of Leake *et al*. (1997). The cation distributions were calculated in accord with the standard amphibole formula: $AB_2C_5{}^{vi}T_8{}^{iv}O_{22}(OH,O,Cl,F)_2$. The FeO/Fe_2O_3 ratios were not determined separately but were calculated by crystal chemical considerations and the average of minimum and maximum constraints (Schumacher, 1997).

Results and interpretation

Chlorites

The chlorites are mostly Fe-Al rich clinochlore, with some chamosite.

Chlorite compositions, especially Al contents, are known to be largely temperature dependant in metamorphic and metasomatic rocks (Laird, 1988). On this basis a chlorite geothermometer has been devised empirically from low pressure hydrothermal systems (Cathelineau and Nieva, 1985; Cathilineau, 1988). This geothermometer gives sensible results where tested in both pelites and hydrothermal veins formed in regionally metamorphosed rocks (Cathilineau, 1988; Bevins *et al*., 1991; Taheri and Bottrill, 1994) although it does assume an open chemical system (Cathilineau, 1988). Applying the chlorite geothermometer to some rocks from the Balfour copper deposits gave a range of temperatures from 180–402°C, comparable to those obtained from fluid inclusion studies (Bottrill and Taheri, 2004).

Stilpnomelane

The stilpnomelane group minerals from the Strickland mine are all magnesian stilpnomelane $((K,Na,Ca)(Fe,Mg.Al)_{12}(Si,Al)_{16}(O,OH)_{54}.nH_2O)$. This is a mineral typical of greenschist or lower amphibolite facies metamorphosed iron formations. It is abundant in the sample, as large brown flakes.

Carbonates

The hydrothermal carbonates from the Possum Creek prospect were found to be of two types; a magnesian siderite and another near the rhodochrosite-siderite midpoint. These two carbonates presumably formed during different mineralisation episodes, although the paragenesis is uncertain.

Amphiboles

The amphibole from Possum Creek is a manganoan grunerite $(Fe_{1.2}Mn_{0.8})(Fe_{3.0}Mg_{1.9})Si_8O_{22}(OH)_2$. This is a

mineral typical of amphibolite-grade metamorphosed iron manganese-rich formations.

Hisingerite

This serpentine-like mineral from Possum Creek is probably a Mg-Al bearing hisingerite (an iron-rich phyllosilicate of the allophane group; ~$(Fe_{1.3}Mg_{0.3}Al_{0.2})Si_{2.2}O_5(OH)_4.nH_2O$). It is typically formed by retrogression of other iron silicates.

Apatite

The apatite from South Balfour is quite pure fluorapatite with no detectable Cl content and only 6 mol.% hydroxylapatite. There are only traces (<0.1%) of impurities, mostly Ba, Sr, Ce, La and Mn.

References

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[1 December 2004]

Table 1

Microprobe analyses and structural formulae of chlorites, Balfour area

No.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	#16	#17	#18	#19	#20
Sample No.	C108267	C108267	C108267	C108267	C108267	C108267	C108267	C108267	C108257	C108257	C108257	C108257	C108257	C108257	C108257	C108249	C108249	C108249	C108249	C108249
Location	Arthur R	Arthur R	Arthur R	Arthur R	Arthur R	Arthur R	Arthur R	Arthur R	Clump	Clump	Clump	Clump	Clump	Clump	Clump	B. Blocks	B. Blocks	B. Blocks	B. Blocks	B. Blocks
SiO_2	31.00	30.49	29.51	29.01	28.36	28.61	29.60	30.07	27.21	28.67	27.78	27.21	27.10	25.67	27.16	26.93	26.46	26.11	25.14	25.90
TiO_2	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.08	0.02	0.07	0.04	0.06	0.06	0.08	0.03	0.09	0.06	0.02	0.05
Al_2O_3	15.16	15.31	14.41	15.08	15.20	15.04	14.43	15.02	20.93	18.61	20.42	20.68	20.97	22.00	21.04	23.86	23.20	23.05	23.24	23.45
Cr_2O_3	0.07	0.01	0.07	0.01	0.03	0.00	0.00	0.04	0.09	0.00	0.02	0.05	0.03	0.00	0.06	0.03	0.00	0.00	0.03	0.02
FeO(t)	28.33	27.13	29.61	29.33	29.51	30.56	27.28	28.08	16.07	20.67	16.52	20.56	21.19	23.29	21.54	15.07	15.10	17.80	18.48	16.53
MnO	0.21	0.13	0.12	0.36	0.35	0.30	0.19	0.26	0.80	1.77	0.95	1.32	1.55	2.07	1.58	0.07	0.14	0.28	0.17	0.01
MgO	14.14	15.06	13.49	13.67	12.90	12.90	14.63	14.67	20.43	17.90	20.03	18.08	16.72	14.02	16.44	22.60	21.85	19.40	18.39	20.89
CaO	0.18	0.17	0.23	0.13	0.13	0.14	0.22	0.19	0.00	0.03	0.04	0.05	0.02	0.02	0.01	0.02	0.04	0.01	0.04	0.00
Na_2O	0.11	0.00	0.00	0.00	0.01	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
K_2O	0.02	0.01	0.00	0.02	0.01	0.00	0.03	0.00	0.02	0.00	0.03	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
ZnO	0.03	0.23	0.00	0.02	0.00	0.00	0.29	0.00	0.00	0.08	0.02	0.00	0.06	0.08	0.00	0.00	0.23	0.01	0.11	0.20
NiO	0.00	0.01	0.09	0.02	0.00	0.15	0.03	0.04	0.00	0.00	0.03	0.07	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00
H_2O(c)	11.49	11.45	11.13	11.15	10.97	11.07	11.14	11.36	11.67	11.64	11.68	11.69	11.61	11.36	11.61	12.21	11.96	11.75	11.53	11.86
Sum Ox%	100.73	100.01	98.66	98.82	97.47	98.81	97.86	99.77	97.32	99.40	97.60	99.77	99.45	98.60	99.53	100.81	99.09	98.48	97.15	98.92
Formulae per 36 oxygen atoms																				
Si	6.471	6.386	6.363	6.242	6.204	6.203	6.375	6.351	5.593	5.910	5.705	5.582	5.599	5.421	5.610	5.291	5.307	5.331	5.231	5.237
Al ^{IV}	1.529	1.614	1.637	1.758	1.796	1.797	1.625	1.649	2.407	2.090	2.295	2.418	2.401	2.579	2.390	2.709	2.693	2.669	2.769	2.763
Total ^{IV}	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*
Al^{VI}	2.199	2.167	2.023	2.068	2.124	2.046	2.036	2.088	2.662	2.431	2.645	2.582	2.705	2.899	2.731	2.817	2.789	2.879	2.931	2.825
Ti	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.002	0.012	0.003	0.010	0.006	0.010	0.009	0.012	0.004	0.013	0.010	0.003	0.008
Cr	0.011	0.001	0.012	0.002	0.005	0.000	0.000	0.006	0.014	0.000	0.003	0.008	0.004	0.000	0.010	0.004	0.000	0.000	0.004	0.003
Fe^{2+}	4.944	4.753	5.338	5.279	5.398	5.540	4.913	4.959	2.762	3.563	2.837	3.527	3.661	4.114	3.721	2.477	2.532	3.040	3.215	2.795
Mn^{2+}	0.037	0.022	0.022	0.065	0.065	0.055	0.035	0.047	0.139	0.309	0.166	0.230	0.271	0.371	0.277	0.011	0.023	0.048	0.030	0.002
Mg	4.400	4.702	4.336	4.384	4.207	4.168	4.697	4.617	6.259	5.500	6.129	5.529	5.149	4.413	5.060	6.621	6.533	5.904	5.704	6.296
Ca	0.040	0.039	0.053	0.030	0.031	0.033	0.051	0.043	0.000	0.006	0.008	0.011	0.005	0.005	0.001	0.004	0.010	0.003	0.010	0.000
Na	0.043	0.001	0.001	0.000	0.006	0.016	0.012	0.009	0.002	0.002	0.006	0.006	0.011	0.007	0.004	0.000	0.000	0.000	0.000	0.001
K	0.005	0.003	0.000	0.006	0.003	0.000	0.008	0.000	0.006	0.001	0.008	0.000	0.006	0.005	0.000	0.000	0.000	0.000	0.000	0.000
Zn	0.005	0.036	0.000	0.003	0.000	0.000	0.047	0.000	0.000	0.013	0.003	0.000	0.010	0.013	0.000	0.000	0.000	0.035	0.002	0.016	0.030
Ni	0.000	0.001	0.016	0.003	0.000	0.026	0.006	0.007	0.000	0.000	0.004	0.011	0.012	0.000	0.000	0.000	0.003	0.000	0.000	0.000
Total ^{VI}	*11.684*	*11.725*	*11.801*	*11.843*	*11.839*	*11.884*	*11.805*	*11.778*	*11.856*	*11.828*	*11.819*	*11.910*	*11.844*	*11.836*	*11.816*	*11.938*	*11.938*	*11.886*	*11.913*	*11.960*
OH	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Sum Cations	35.683	35.725	35.801	35.844	35.838	35.884	35.804	35.78	35.858	35.828	35.82	35.91	35.845	35.836	35.815	35.939	35.939	35.885	35.914	35.96
XMg	0.471	0.497	0.448	0.454	0.438	0.429	0.489	0.482	0.694	0.607	0.684	0.61	0.584	0.518	0.576	0.728	0.721	0.66	0.64	0.693
T°C	180	195	199	220	226	226	196	201	332	277	313	334	331	362	329	385	382	378	395	394
(from Cathilineau chlorite geothermometer)															325.1834333					

Table 1

Microprobe analyses and structural formulae of chlorites, Balfour area (continued)

No.	#21	#22	#23	#24	#25	#26	#27	#28	#29	#30	#31	#32	#33	#34	#35	#36	#37	#38
Sample No.	C108249	C108249	C108249	C108249	C108248	C108248	C108227	C108227	C108227	C108242	C108242	C108242	C108227	C108248	C108248	C108248	C108248	C108248
Location	B. Blocks	B. Blocks	B. Blocks	B. Blocks	B. Blocks	B. Blocks	Tatlows	Tatlows	Tatlows	Premier	Premier	Premier	Tatlows	B. Blocks	B. Blocks	B. Blocks	B. Blocks	B. Blocks
SiO_2	25.89	26.20	25.91	25.52	23.95	24.23	23.09	23.39	23.71	25.91	24.74	25.59	23.76	25.03	26.04	25.28	24.81	24.41
TiO2	0.06	0.07	0.09	0.08	0.05	0.04	0.01	0.07	0.04	0.03	0.07	0.08	0.15	0.08	0.03	0.08	0.09	0.07
Al_2O3	22.99	23.75	22.99	23.80	22.58	22.97	22.13	22.01	22.12	22.02	21.89	22.23	22.01	21.75	22.32	22.77	22.65	23.23
Cr_2O_3	0.02	0.00	0.00	0.07	0.00	0.02	0	0	0.04	0.05	0	0.04	0.02	0	0	0.02	0.02	0
FeO(t)	16.06	13.86	19.33	20.89	28.60	27.49	33.48	33.16	32.72	23.58	28.62	27.43	32.48	27.65	19.57	22.04	24.47	25.54
MnO	0.14	0.12	0.11	0.27	0.39	0.32	0.88	0.76	0.93	0.15	0.4	0.35	0.86	0.39	0.2	0.31	0.38	0.29
MgO	20.80	22.66	18.57	17.51	11.40	12.12	7.99	8	8.77	16.01	11.72	12.42	8.94	12.53	18.44	16.32	14.69	13.72
CaO	0.01	0.00	0.02	0.02	0.00	0.00	0	0.01	0.02	0.03	0.02	0.05	0.06	0.02	0.01	0.02	0.02	0.01
Na_2O	0.00	0.00	0.06	0.03	0.00	0.01	0.01	0.02	0.01	0.04	0.03	0.05	0.02	0.01	0.02	0	0.03	0.05
K_2O	0.00	0.00	0.00	0.01	0.00	0.00	0	0	0.06	0.05	0	0.03	0.06	0	0	0	0.02	0.02
ZnO	0.00	0.00	0.03	0.33	0.03	0.14	0.07	0.05	0.15	0.07	0	0.11	0	0.01	0.11	0.06	0	0.07
NiO	0.05	0.09	0.01	0.05	0.01	0.05	0.04	0.04	0.03	0	0.09	0.07	0.01	0	0.03	0.02	0	0
$H_2O(c)$	11.75	12.00	11.71	11.77	11.07	11.19	10.8	10.81	10.97	11.54	11.15	11.36	10.97	11.2	11.63	11.49	11.36	11.32
Sum Ox%	97.78	98.75	98.84	100.33	98.09	98.57	98.49	98.33	99.58	99.48	98.72	99.8	99.33	98.67	98.4	98.41	98.54	98.72
Formulae per 36 oxygen atoms																		
Si	5.286	5.238	5.310	5.198	5.192	5.193	5.128	5.189	5.183	5.385	5.322	5.402	5.196	5.358	5.372	5.281	5.241	5.171
Al ^{IV}	2.714	2.762	2.690	2.802	2.808	2.807	2.872	2.811	2.817	2.615	2.678	2.598	2.804	2.642	2.628	2.719	2.759	2.829
Total ^{IV}	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*	*8.000*
Al ^{VI}	2.817	2.835	2.861	2.913	2.960	2.997	2.921	2.943	2.884	2.78	2.873	2.932	2.87	2.845	2.798	2.885	2.878	2.972
Ti	0.009	0.010	0.014	0.012	0.009	0.006	0.002	0.012	0.007	0.005	0.012	0.013	0.024	0.013	0.005	0.013	0.015	0.011
Cr	0.003	0.000	0.001	0.011	0.000	0.003	0	0.001	0.007	0.008	0	0.007	0.003	0	0	0.003	0.003	0
Fe^{2+}	2.743	2.317	3.312	3.559	5.184	4.928	6.219	6.153	5.982	4.099	5.149	4.843	5.941	4.95	3.376	3.85	4.323	4.524
Mn^{2+}	0.025	0.021	0.019	0.046	0.072	0.058	0.165	0.143	0.172	0.026	0.072	0.063	0.16	0.071	0.035	0.055	0.069	0.052
Mg	6.331	6.754	5.670	5.316	3.682	3.872	2.645	2.647	2.859	4.961	3.757	3.907	2.915	3.999	5.67	5.081	4.625	4.334
Ca	0.002	0.000	0.004	0.005	0.000	0.000	0	0.003	0.004	0.006	0.005	0.01	0.013	0.004	0.002	0.004	0.004	0.002
Na	0.000	0.000	0.025	0.011	0.002	0.004	0.005	0.01	0.003	0.015	0.013	0.02	0.01	0.004	0.006	0	0.012	0.021
K	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0	0.018	0.012	0	0.007	0.016	0.001	0.001	0	0.005	0.005
Zn	0.000	0.000	0.005	0.049	0.005	0.022	0.012	0.008	0.024	0.01	0	0.017	0	0.001	0.016	0.009	0	0.01
Ni	0.008	0.014	0.002	0.008	0.002	0.009	0.006	0.008	0.005	0	0.015	0.011	0.001	0.001	0.006	0.003	0	0
Total ^{VI}	*11.938*	*11.951*	*11.913*	*11.933*	*11.916*	*11.899*	*11.976*	*11.928*	*11.965*	*11.922*	*11.896*	*11.830*	*11.953*	*11.889*	*11.915*	*11.903*	*11.934*	*11.931*
OH	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Sum Cations	35.938	35.953	35.913	35.934	35.916	35.899	35.976	35.927	35.966	35.922	35.897	35.831	35.954	35.888	35.914	35.903	35.933	35.931
XMg	0.698	0.745	0.631	0.599	0.415	0.44	0.298	0.301	0.323	0.548	0.422	0.447	0.329	0.447	0.627	0.569	0.517	0.489
T°C	385	394	381	401	402	402	413	402	403	368	379	365	401	373	371	386	393	405
				378.8232761														

Table 2

Microprobe analyses and structural formulae of stilpnomelane, Temma area

No.	#1	#2	#3
Sample No.	C108414	C108414	C108414
Location	Strickland	Strickland	Strickland
SiO_2	44.49	45.33	46.56
TiO_2	0.01	0.00	0.03
Al_2O_3	5.47	5.03	5.19
Cr_2O_3	0.00	0.00	0.00
FeO(t)	31.90	30.54	31.11
MnO	0.32	0.29	0.15
MgO	4.47	4.67	4.67
CaO	0.00	0.04	0.00
K_2O	2.01	0.66	1.20
Na_2O	0.06	0.01	0.05
Sum Ox%	88.74	86.57	88.96
Formulae per 21 cations			
Si	10.708	11.211	11.190
Al ^{IV}	1.292	0.789	0.810
Total tet.	*12.000*	*12.000*	*12.000*
Al ^{VI}	0.260	0.679	0.658
Ti	0.001	0.000	0.005
Cr	0.000	0.000	0.000
Fe	6.421	6.316	6.243
Mn	0.066	0.062	0.030
Mg	1.604	1.723	1.673
Total oct.	*8.353*	*8.779*	*8.609*
Ca	0.000	0.009	0.000
Na	0.617	0.207	0.023
K	0.030	0.004	0.368
Total alk.	*0.647*	*0.220*	*0.391*
	21.000	21.000	21.000

Table 3

Microprobe analyses and structural formulae of the carbonates, Temma area

No.	#1	#2	#3	#4
Sample No.	C108454	C108454	C108454	C108454
Location	Possum Creek	Possum Creek	Possum Creek	Possum Creek
Mineral	Mg-siderite	Mg-siderite	Mn-siderite	Fe-rhodochrosite
SiO_2	0.09	0.05	0.02	0.08
FeO	43.97	45.17	27.99	22.85
MnO	5.09	4.25	25.26	29.08
MgO	12.38	12.40	4.96	4.95
CaO	0.22	0.17	0.67	0.60
ZnO	0.00	0.06	0.00	0.06
CO_2(c)	38.13	38.20	36.08	35.92
Sum Ox%	99.87	100.30	94.98	93.54
Si	0.002	0.001	0.000	0.002
Fe^{2+}	0.660	0.675	0.458	0.381
Mn^{2+}	0.077	0.064	0.417	0.489
Mg	0.255	0.255	0.112	0.113
Ca	0.005	0.003	0.013	0.013
Zn	0.000	0.001	0.000	0.001
Sum Cations	0.999	1.000	1.000	1.000

Table 4

Microprobe analyses and structural formulae of the apatite, South Balfour

No.	#1
Sample No.	C108409
Location	South Balfour
SO_3	0.01
P_2O_5	43.05
SiO_2	0.04
Y_2O_3	0.00
La_2O_3	0.01
Ce_2O_3	0.01
FeO(t)	0.00
MnO	0.02
CaO	57.95
Na_2O	0.06
K_2O	0.06
BaO	0.00
SrO	0.01
F	3.68
Cl	0.00
O=F	1.55
O=Cl	0.00
Sum Ox%	103.34
Formula per 8 cations	
S	0.001
P	2.955
Si	0.003
Total tet.	*2.958*
Ca	5.034
Y	0.000
La	0.000
Ce	0.000
Fe	0.000
Mn	0.001
Sr	0.003
Ba	0.002
K	0.000
Na	0.002
Tot. oct.	*5.042*
F	0.944
Cl	0.000
OH	0.065

Table 5

Microprobe analyses and structural formulae of the amphiboles, Temma area

Sample No.	C108454
Location	Possum Creek
SiO_2	51.11
TiO_2	0.00
Al_2O_3	0.14
Cr_2O_3	0.03
FeO(t)	32.42
MnO	5.95
MgO	8.37
CaO	0.21
K_2O	0.00
Na_2O	0.02
Sum Ox%	98.25
Formulae per 15 cations (Fe''' by minimum constraints: see text)	
Si	7.974
Al ^{IV}	0.026
Total ^{IV}	*8.000*
Al ^{VI}	0.000
Ti	0.000
Fe'''	0.015
Cr	0.004
Mg	1.946
Fe''	3.035
Mn	0.000
Total ^{VI}	*5.000*
Fe''	1.180
Mn	0.786
Ca	0.035
Na	0.000
sum B	*2.001*
Na	0.006
K	0.000
sum A	*0.006*

Table 6

Microprobe analyses and structural formulae of the hisingerite, Temma area

Sample No.	C108454	C108454
Location	Possum Creek	Possum Creek
SiO_2	47.13	45.41
TiO_2	0.00	0.00
Al_2O_3	4.42	4.37
Cr_2O_3	0.00	0.01
FeO(t)	32.59	31.82
MgO	4.82	4.43
CaO	0.02	0.04
NiO	0.00	0.00
Na_2O	0.24	0.27
MnO	0.19	0.18
K_2O	1.04	1.07
Sum Ox%	90.45	87.60
Formulae per 4 cations		
Si	2.125	2.116
Al	0.235	0.240
Ti	0.000	0.000
Cr	0.000	0.001
Fe	1.227	1.239
Mg	0.324	0.308
Ca	0.001	0.002
Ni	0.000	0.000
Na	0.021	0.024
Mn	0.007	0.007
K	0.059	0.063
XMg	0.209	0.199