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MINERAL CHEMISTRY AND CRYSTALLIZATION PARAMETERS OF THE A-TYPE PALEOPROTEROZOIC

BANNACH GRANITE, CARAJÁS PROVINCE – PARÁ

Caio José Soares Mesquita, Roberto Dall’Agnol, José de Arimatéia Costa de Almeida

Table 1: Representative electron microprobe analyses of ferromagnesian amphiboles of the Bannach Granite.

Facies Sample Analyses Type	GC ADR-136i				BAMzG ADR-136C			ABMzG ADR-55A	
	C3_3.1 Gru	C3_3.5 Cum	C4_3.2 Cum	C4_3.6 Gru	C5_1.1 Gru	C5_1.2 Gru	C5_1-3 Gru	C6_2.2 Gru	C6_2.3 Gru
SiO ₂ (wt%)	50.90	50.47	51.83	51.22	51.05	51.22	51.44	50.81	50.72
TiO ₂	0.07	0.09	0.13	0.04	0.07	0.10	0.06	0.12	0.05
Al ₂ O ₃	0.54	1.18	0.44	0.37	0.61	0.69	0.54	0.50	0.77
FeO	31.84	30.94	30.75	32.43	32.70	31.86	32.42	33.85	32.66
MnO	1.91	1.85	1.87	2.09	1.69	1.68	1.71	2.16	1.99
MgO	9.63	10.26	11.47	9.78	9.78	9.89	10.20	8.53	8.47
CaO	1.83	2.16	1.26	1.07	1.73	2.13	1.37	1.37	2.77
Na ₂ O	0.22	0.38	0.21	0.16	0.26	0.24	0.24	0.25	0.31
K ₂ O	0.02	0.06	0.00	0.01	0.02	0.05	0.02	0.00	0.04
F	0.21	0.23	0.19	0.11	0.21	0.20	0.27	0.45	0.36
Cl	0.03	0.03	0.02	0.02	0.03	0.02	0.01	0.03	0.03
(OH)	2.87	2.26	1.90	2.23	1.89	1.86	1.73	1.90	1.75
Subtotal:	100.1	99.9	100.1	99.5	100.0	99.9	100.03	100.0	99.9
O-F-Cl	0.09	0.10	0.08	0.05	0.09	0.09	0.12	0.20	0.16
Total	99.97	99.80	99.98	99.48	99.94	99.84	99.91	99.76	99.76
Number of cations per formula unit based on twenty three oxygen atoms									
Si	7.940	7.807	7.917	7.978	7.891	7.905	7.925	7.916	7.854
Al ^{IV}	0.060	0.193	0.079	0.022	0.109	0.095	0.075	0.084	0.141
Ti ⁺⁴	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.005
Soma T	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al ^{VI}	0.040	0.022	0.000	0.045	0.003	0.031	0.023	0.008	0.000
Ti ⁺³	0.008	0.011	0.011	0.005	0.008	0.011	0.007	0.014	0.001
Fe ⁺³	0.000	0.023	0.000	0.000	0.007	0.000	0.000	0.121	0.224
Fe ⁺²	2.459	2.336	2.134	2.403	2.507	2.464	2.403	2.591	2.558

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SiO ₂ (wt%)	50.90	50.47	51.83	51.22	51.05	51.22	51.44	50.81	50.72
Mn	0.252	0.242	0.242	0.276	0.221	0.219	0.224	0.285	0.261
Mg	2.240	2.366	2.613	2.272	2.255	2.275	2.343	1.981	1.956
Soma C	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Fe ⁺²	1.695	1.643	1.794	1.821	1.713	1.648	1.773	1.697	1.447
Ca	0.305	0.357	0.206	0.179	0.287	0.352	0.227	0.229	0.460
Na	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.074	0.093
Soma B	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
Na	0.065	0.114	0.061	0.049	0.079	0.071	0.071	0.000	0.000
K	0.003	0.012	0.000	0.002	0.004	0.010	0.005	0.000	0.008
Soma A	0.068	0.126	0.061	0.051	0.083	0.081	0.076	0.000	0.008
Al _{total}	0.100	0.215	0.079	0.068	0.111	0.126	0.098	0.092	0.141
Fe/(Fe+Mg)	0.523	0.497	0.450	0.514	0.526	0.520	0.506	0.567	0.567
Mg/(Mg+Fe)	0.477	0.503	0.550	0.486	0.474	0.480	0.494	0.433	0.433

CG - even-grained cumulatic granite; cBAMz - even coarse-grained biotite-amphibole monzogranite.

cABMz - even coarse-grained amphibole-biotite monzogranite; Cum = cummingtonite; Gru = grunerite.

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Table 2: Electron microprobe analyses of titanite of the Bannach Granite.

Facies Sample Analyses	cABMz ADR-55A						
	C1_1.1	C1_1.2	C1_1.3	C1_1.4	C1_1.5	C1_1.6	C1_1.7
SiO ₂ (wt%)	30.43	30.51	30.52	30.35	30.35	30.43	30.47
TiO ₂	31.16	30.89	30.98	30.77	30.83	30.94	31.11
Al ₂ O ₃	4.06	4.30	4.18	3.98	3.98	4.21	3.95
Cr ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.03	0.01
FeO	3.27	3.10	3.05	3.02	3.17	2.89	3.23
MnO	0.21	0.16	0.16	0.17	0.20	0.16	0.17
MgO	0.12	0.15	0.13	0.13	0.14	0.12	0.17
CaO	26.38	26.70	26.88	26.26	26.25	27.16	26.98
Na ₂ O	0.06	0.03	0.05	0.06	0.05	0.05	0.08
K ₂ O	0.03	0.03	0.03	0.02	0.02	0.01	0.05
Total	95.73	95.87	95.98	94.75	95.00	95.96	96.20
Number of cations per formula unit based on five oxygen atoms							
Si	1.040	1.040	1.040	1.046	1.044	1.037	1.038
Ti	0.801	0.792	0.794	0.798	0.798	0.793	0.797
Al	0.163	0.173	0.168	0.162	0.162	0.169	0.159
Cr	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Fe	0.093	0.088	0.087	0.087	0.091	0.082	0.092
Mn	0.006	0.005	0.005	0.005	0.006	0.005	0.005
Mg	0.006	0.008	0.006	0.006	0.007	0.006	0.009
Ca	0.966	0.975	0.981	0.970	0.968	0.991	0.984
Na	0.004	0.002	0.003	0.004	0.003	0.003	0.005
K	0.001	0.001	0.001	0.001	0.001	0.000	0.002
Fe/Al	0.571	0.511	0.517	0.538	0.565	0.488	0.579

cABMz - even coarse-grained amphibole-biotite monzogranite.

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Table 3: Electron microprobe analyses of ilmenite of the Bannach Granite.

Facies Sample	GC ADR-136I			BAMzG ADR-136C		ABMzG ADR-55A			ADR-32B	LMzG ADR-32B1			LMzMt ADR-140
	C3_1-12	C3_2-8	C4_2-1	C3_1-6	C1_1-11	C1_2-15	C1_1-10	C1_2-12		C3_1-7	C2_3-9	C2_1-5	
Analyses Type	T Ilm	C Ilm	I Ilm	T Ilm	C Ilm	T Ilm	C Ilm	P Ilm	T Ilm	C Ilm	I Ilm	P Ilm	C Ilm
SiO ₂ (wt%)	0.02	0.03	0.00	0.02	0.02	0.01	0.04	0.00	0.02	0.02	0.01	0.02	0.014
TiO ₂	51.93	51.24	51.18	51.37	50.95	51.65	50.77	52.08	51.49	52.87	51.88	52.23	50.38
Al ₂ O ₃	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.002
Fe ₂ O ₃	1.72	2.04	1.77	2.51	2.47	2.35	4.04	1.89	3.59	2.07	2.62	2.07	5.25
FeO	42.52	41.97	42.11	43.18	42.13	42.07	42.57	43.08	40.49	41.64	41.02	40.95	38.51
MnO	4.12	4.09	3.84	2.98	3.67	4.35	3.09	3.69	5.76	5.85	5.54	5.97	6.721
MgO	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0
CaO	0.03	0.01	0.02	0.03	0.01	0.00	0.00	0.01	0.02	0.01	0.03	0.01	0.012
Total	100.36	99.37	98.92	100.09	99.24	100.44	100.51	100.77	101.02	102.46	101.12	101.26	100.89
Number of cations per formula unit based on three oxygen atoms													
Si	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.950
Ti	0.983	0.980	0.983	0.976	0.976	0.977	0.961	0.982	0.966	0.980	0.975	0.980	0.000
Al	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.099
Fe ⁺³	0.033	0.039	0.034	0.048	0.047	0.044	0.077	0.036	0.067	0.038	0.049	0.039	0.807
Fe ⁺²	0.895	0.892	0.899	0.912	0.897	0.885	0.896	0.903	0.844	0.858	0.857	0.854	0.143
Mn	0.088	0.088	0.083	0.064	0.079	0.093	0.066	0.078	0.122	0.122	0.117	0.126	0.000
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Total	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000

CG - even-grained cumulatic granite; cBAMz - even coarse-grained biotite-amphibole monzogranite ; cABMz - even coarse-grained amphibole-biotite monzogranite;

cLMz - even coarse-grained leucomonzogranite ; LmLMz - late even medium-grained leucomonzogranite.

T Ilm = trellis ilmenite; C Ilm = composite ilmenite; I Ilm = individual ilmenite; P Ilm = patch ilmenite.

Structural formula and ratio of FeO e Fe₂O₃ calculated according to Carmichael (1967).

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Table 4: Electron microprobe analyses of magnetite of the Bannach Granite.

Facies Sample Analyses Type	CG ADR-136I				cBAMz ADR-136C		cABMz ADR-55A			cLMz ADR-32B1		LmLMz ADR-140	
	C3_2-2	C3_1-5	C3_2-3	C3_3-3	C1_1-3	C1_2-7	C1_1-1	C2_1-1	C4_1-5	C2_4-6	C2_2-2	C3_1-1	C5_1-1
	Mt + T Ilm	Mt + TIlm	Mt + C Ilm	H-Mt	Mt + T Ilm	Mt + C Ilm	Mt + T Ilm	Mt + C Ilm	H-Mt	Mt + T Ilm	Mt + C Ilm	Mt + T Ilm	Mt + C Ilm
SiO ₂ (wt%)	0.06	0.04	0.06	0.10	0.07	0.06	0.08	0.08	0.12	0.28	0.08	0.08	0.07
TiO ₂	2.28	1.74	1.98	0.08	2.49	1.13	0.80	1.43	0.04	0.67	1.49	0.13	0.36
Al ₂ O ₃	0.11	0.32	0.14	0.00	0.14	0.18	0.18	0.22	0.02	0.09	0.22	0.05	0.21
Fe ₂ O ₃	63.12	64.69	64.01	67.02	63.45	65.51	66.74	65.08	67.24	66.89	66.27	68.40	68.45
FeO	32.61	32.48	32.46	30.38	33.24	31.88	31.74	32.16	30.57	31.92	32.70	31.22	31.79
MnO	0.19	0.13	0.14	0.09	0.17	0.01	0.06	0.09	0.01	0.08	0.13	0.01	0.01
MgO	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.02	0.00	0.06	0.04	0.00	0.05	0.04	0.01	0.04	0.03	0.00	0.00	0.00
Cr ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V ₂ O ₃	0.27	0.13	0.18	0.00	0.24	0.31	0.18	0.15	0.00	0.06	0.00	0.00	0.11
Total	98.67	99.54	99.03	97.70	99.80	99.17	99.82	99.22	98.04	100.02	100.89	99.89	100.99
Number of cations per formula unit based on four oxygen atoms													
Si	0.002	0.002	0.002	0.004	0.003	0.002	0.003	0.003	0.005	0.011	0.003	0.003	0.002
Ti	0.067	0.051	0.058	0.002	0.072	0.033	0.023	0.042	0.001	0.019	0.043	0.004	0.010
Al	0.005	0.014	0.007	0.000	0.006	0.008	0.008	0.010	0.001	0.004	0.010	0.002	0.009
Fe ⁺³	1.849	1.877	1.868	1.988	1.837	1.910	1.934	1.896	1.987	1.934	1.899	1.984	1.962
Fe ⁺²	1.061	1.048	1.053	1.001	1.069	1.033	1.022	1.041	1.004	1.026	1.041	1.006	1.012
Mn	0.006	0.004	0.005	0.003	0.006	0.000	0.002	0.003	0.000	0.003	0.004	0.000	0.000
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.001	0.000	0.002	0.002	0.000	0.002	0.002	0.000	0.002	0.001	0.000	0.000	0.000
Cr	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.008	0.004	0.006	0.000	0.007	0.010	0.006	0.005	0.000	0.002	0.000	0.000	0.003
Ulvöspinel.(%)	6.715	5.095	5.815	0.223	7.261	3.332	2.328	4.200	0.118	1.939	4.298	0.386	1.037

CG - even-grained cumulatic granite; cBAMz - even coarse-grained biotite-amphibole monzogranite ; cABMz - even coarse-grained amphibole-biotite monzogranite;

cLMz- coarse-grained leucomonzogranite ; LmLMz- late medium-even grained leucomonzogranite.

T Ilm = trellis ilmenite; C Ilm = composite ilmenite; I Ilm =individual ilmenite; P Ilm = patch ilmenite; Mt = magnetite

Structural formula and ratio of FeO e Fe₂O₃ calculated according to Carmichael (1967); % of Ulvöspinel calculated according to Lindsley and Spencer (1982).