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Magnetic granulometry of igneous and meta-sedimentary rocks from northern Graham Land, Antarctic Peninsula

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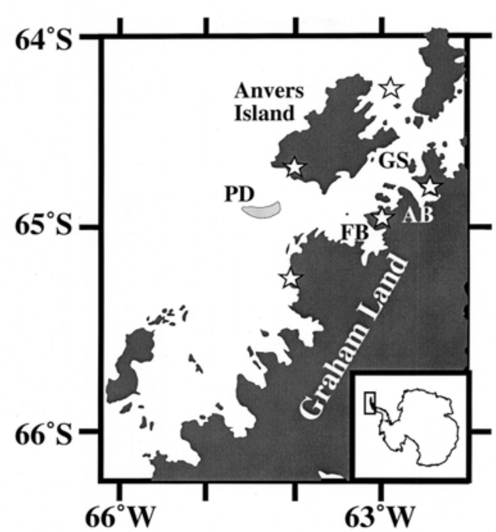
The application of magnetic methods to plate tectonic reconstructions, interpretation of aeromagnetic data, and the construction of sedimentary paleoclimate records requires an understanding of the magnetic mineral assemblage that carries the paleomagnetic or rock-magnetic signal. To that end, there has been interest in establishing a rock magnetic database for antarctic rocks to make magnetic data accessible by region and rock type. Here we present preliminary rock magnetic analyses of Cretaceous igneous rocks from Northern Graham Land and suite of rocks obtained from a dredge of Flandres Bay. We discuss the potential for development of magnetic provenance tracers in glacial-marine sediments from the western Antarctic Peninsula.

Sample localities, lithology, and rock magnetic data are summarized in tables 1 and 2. Koenisberger ratios (Q) have been calculated for an ambient field of 50 μT. Magnetic susceptibilities are consistent with values previously reported for this region and these rock-types (e.g., Vaughan et al. 1998). The coarse-grained intrusives (granites, granodiorites, gabbros, and tonalites) have multi-domain hysteresis parameters, while volcanic rocks and meta-sediments have pseudo-single domain hysteresis parameters.



Northern Graham Land with sample locations (stars). PD = Palmer Deep, AB = Andvord Bay, GS = Gerlache Strait, FB = Flandres Bay.

Table 1. Sample Descriptions

Locality	Sample ID	Long (E)	Lat (S)	Lithology	Age (Ma)
Graham Land Intrusives					
Forbes Point, Andvord Bay	AV5A3	297.45	64.88	granite	98
Birdsend Bluff	BB1A6	297.45	64.75	diorite	98
Coughtrey Peninsula	CP1D1	297.12	64.90	volcanic	128 ± 3
Duthiers Point	DP1B1	297.18	64.80	diorite	98
Ferguson Channel	FC2A3A	297.00	64.92	volcanic	98
Rassmussen Island	LM5B3	295.92	65.25	granite	128±3
Cape Tuxen	LM6B4	295.87	65.27	gabbro	85
Lambda Island, Melchoirs	ML1A4	297.02	64.30	granodiorite	98
Gamma Island Melchoirs	ML1E2	297.02	64.33	tonalite	98
South Neko Harbor	NH1B2B	297.45	64.83	pink granite	114±11
Pitt Island	PT1B3	294.52	65.43	gabbro	
Flandres Bay Series					
Flandres Bay	FB1	296.497	64.991	porphyritic andesite	
Flandres Bay	FB2	296.497	64.991	altered mafic intrusive	
Flandres Bay	FB3	296.497	64.991	syenite	
Flandres Bay	FB4	296.497	64.991	aplite	
Flandres Bay	FB5	296.497	64.991	phyllite	
Flandres Bay	FB6	296.497	64.991	granite	
Flandres Bay	FB7	296.497	64.991	schist	
Flandres Bay	FB8	296.497	64.991	calc-arenite	
Flandres Bay	FB9	296.497	64.991	syenite	

Table 2. Rock magnetic Properties

Sample ID	κ (SI)	χ (m^3/kg)	χ_{HF} (m^3/kg)	NRM (A/m)	Q	M_S (Am^2/Kg)	M_R (Am^2/Kg)	H_C (mT)	H_{CR} (mT)	M_R/M_S	H_{CR}/H_C	T_T K	T_C (˚C)
Graham Land Igneous series													
AV5A3	1.148E-02	4.08E-06	9.63E-08	6.96E-02	0.152	4.84E-01	6.85E-03	1.4	10.9	0.014	7.79	113.4	583
BB1A6	4.013E-02	1.41E-05	1.15E-07	7.52E-02	0.047	1.66E+00	5.09E-02	3.83	19.9	0.031	5.20	108.6	584
CP1D1	2.689E-02	9.38E-06	1.95E-07	0.63 - 16.78	0.589 - 15.68	1.17E+00	1.21E-01	12.1	51.1	0.103	4.22	102.7	588
DP1B1	7.465E-02	2.89E-05	2.44E-07	1.79E-01	0.060	4.74E+00	1.09E-01	2.55	13.6	0.023	5.33	113.5	583
FC2A3A	3.307E-04	1.23E-07	7.72E-08	5.37E-01	40.817	5.80E-03	1.34E-03	22.8	60.4	0.231	2.65	117.5	-
LM5B3	1.308E-02	5.23E-06	1.19E-08	1.58E-01	0.303	2.39E-01	8.07E-03	3.87	24.8	0.034	6.41	112.6	585
LM6B4	5.411E-02	1.85E-05	1.29E-07	1.06E+00	0.492	1.88E+00	6.90E-02	4.74	24.5	0.037	5.17	103.5	587
ML1A4	3.187E-02	1.25E-05	1.13E-07	1.03E-01	0.081	6.07E-01	6.33E-03	1.29	14.6	0.01	11.32	102.5	587
ML1E2	9.255E-02	3.43E-05	1.34E-08	4.89E-01	0.133	3.90E+00	5.34E-02	1.35	10.2	0.014	7.56	102.5	588
NH1B2B	7.501E-03	3.00E-06	5.55E-09	9.90E-03	0.033	4.48E-01	9.85E-03	3.03	27.9	0.022	9.21	102.5	593
PT1B3	8.955E-02	2.22E-05	1.03E-07	9.57E-01	0.269	2.72E+00	6.87E-02	3.34	20.5	0.025	6.14	102.6	586

Table 2. Rock magnetic Properties (continued)

Sample ID	κ (SI)	χ (m^3/kg)	χ_{HF} (m^3/kg)	NRM (A/m)	Q	M_S (Am^2/Kg)	M_R (Am^2/Kg)	H_C (mT)	H_{CR} (mT)	M_R/M_S	H_{CR}/H_C	T_T K	T_C (˚C)
Flandres Bay Series													
FB1	6.53E-03	2.12E-06	1.04E-07	9.91E-02	0.381	5.64E-01	4.88E-02	7.61	47.6	0.087	6.25	93.5	573
FB2	3.72E-02	1.32E-05	5.07E-08	6.91E-01	0.466	1.29E+00	5.58E-02	3.04	14.6	0.043	4.8	-	520, 588
FB3	7.41E-02	2.38E-05	4.95E-08	3.16E+00	1.073	2.09E+00	7.94E-02	3.98	16.8	0.038	4.22	113.6	585
FB4	1.63E-03	4.67E-07	4.33E-08	5.34E-02	0.825	1.71E-01	8.46E-03	4.8	15.8	0.049	3.29	112.6	587
FB5	1.98E-04	6.74E-08	5.99E-08	8.45E-04	0.107	1.01E-03	9.12E-05	6.81	22.5	0.09	3.31	-	-
FB6	2.41E-03	8.79E-07	7.57E-08	3.70E-03	0.039	4.37E-01	2.51E-02	8.31	70.6	0.057	8.5	113.5	600
FB7	3.84E-04	1.10E-07	1.53E-07	1.20E-03	0.078	1.66E-03	1.00E-04	6.74	35.9	0.06	5.33	115	-
FB8	9.44E-04	3.12E-07	1.91E-07	1.17E-01	3.112	7.44E-03	1.30E-03	15	38.1	0.174	2.54	122.7	587
FB9	2.86E-04	9.63E-08	4.23E-08	1.68E-03	0.147	7.73E-03	2.33E-03	40.2	187	0.301	4.65	117.6, 250	588

Diagnostic temperature-dependent magnetic behavior, such as Curie temperatures and low-temperature transitions [see Dunlop and Özdemir 1997 for full discussion], were measured to assess each sample's magnetic mineralogy. The granites and diorites have typical magnetite Curie temperatures (~580 to 584 ˚C). The gabbros, tonalites, and granodiorites have elevated Curie temperatures (585 to 590 ˚C). Readman and O'Reilly (1972) observed that titanomagnetite Curie temperatures increased with the degree of oxidation, possibly resulting from strong interactions between the increasing number of Fe^{3+} ions. Further, the gabbros, granodiorites and tonalites have low Verwey transitions at 102 to 104 K, which also suggests some degree of oxidation or non-stoichiometry (Özdemir et al. 1993). In contrast, the granites and diorites have higher Verwey transitions at 108 to 118 K.

The rock magnetic analyses of the Cretaceous igneous rocks from Graham Land suggest that granites, diorites, tonalites, and gabbros have distinctive combinations of Curie temperatures and low-temperature transitions that may be useful as provenance tracers in sediments. These two parameters were compared with similar measurements made on magnetic extracts from the Palmer Deep and Andvord Bay. Intervals from the Palmer Deep and Andvord Bay have magnetic characteristics that are more consistent with a diorite or granite source (Brachfeld and Banerjee 2000). The low-temperature magnetic properties of the sediments do not correlate well with the granodiorites, tonalites, or gabbros, suggesting that these rock types can be excluded as source rocks. Establishing magnetic fingerprints of source rocks that can be detected in sediments can potentially yield information on sediment transport paths and processes such as IRD dispersal patterns, paleowind strength and paleocurrent directions.

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