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16. Data Report: Compositions of Garnet Sand Grains from Elan Bank, Kerguelen Plateau (ODP Site 1137)[1]

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INTRODUCTION

On Elan Bank, a southwestern promontory of the Kerguelen Plateau in the southern Indian Ocean, we cored an interval of conglomerate and minor sandstone within a thick section of Cretaceous flood basalts. Most of the detritus in these sedimentary rocks is volcanic with the exception of a small amount of conspicuous material of probable continental derivation. The anomalous clasts include several pebbles of gneiss (Nicolaysen et al., 2001) and garnet sand grains. The presence of continental material on the plateau bears significantly on the interpretation of Indian Ocean basalts (Weis et al., 2001). The purpose of the present study was to determine the composition of the garnets to provide additional constraints on the nature of the source area.

STRATIGRAPHY AND SEDIMENTOLOGY

The garnets analyzed in this study are from Sample 183-1137A-33R-3, 50–53 cm (Shipboard Scientific Party, 2000). They occur as sedimentary grains within the sandstone of Unit 5, beneath Unit 4 subaerial flood basalts, and above Unit 6 conglomerate. Both the Unit 5 and Unit 6 sediments are interpreted as braided stream facies deposited during a hiatus between flood basalt eruptions.

Unit 5 comprises medium-grained sandstone to siltstone. Garnet sand grains are somewhat smaller (0.15–0.2 mm) than the dominant lithic and feldspar grains. They are angular, consistent with their hard-

[1]Reusch, D.N., and Yates, M., 2002. Data report: Compositions of garnet sand grains from Elan Bank, Kerguelen Plateau (ODP Site 1137). *In* Frey, F.A., Coffin, M.F., Wallace, P.J., and Quilty, P.G. (Eds.), *Proc. ODP, Sci. Results,* 183, 1–8 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/183_SR/VOLUME/CHAPTERS/006.PDF>. [Cited YYYY-MM-DD]
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ness (6.5–7.5) and occurrence in immature sediment. Some of the grains have a purplish shade in plane-polarized light.

METHODS

A total of 74 analyses on nine garnet sand grains were made with an ARL SEMQ electron microprobe, automated with Advanced Micro Beam, Inc.'s PC-based, Micro-3WD system, at the University of Maine (Tables T1, T2). The accelerating potential was 15 kV, and the beam current was 10 nA with simple silicate and oxide standards and fracture zone corrections. Oxides analyzed were SiO_2, TiO_2, Al_2O_3, FeO, MnO, MgO, CaO, K_2O, and Na_2O.

RESULTS

The range of garnet composition within single sand grains is minimal (Table T1). The mean garnet compositions of individual sand grains range from almandine to almandine with a significant pyrope content (Table T2). Figure F1 shows the mean garnet compositions of nine sand grains arranged in order of increasing pyrope content.

DISCUSSION

FeO and MgO contents (in weight percent) vary inversely in accordance with MgO substituting for FeO. The almandine to pyrope-rich almandine compositions (Table T2; Fig. F1) are typical for pelitic materials metamorphosed under relatively high-temperature/low-pressure conditions. The pelitic nature of the source area is inferred from the high Al_2O_3 and low CaO contents (Deer et al., 1966), indirect evidence for a past weathering history that leached soluble components and concentrated insoluble residues. The higher MgO compositions and lack of evidence for zoning (Table T1) suggest relatively high temperatures. The grossular content is only 2 wt% in the Mg-rich end-member compared to 5 wt% in the Fe-rich end-member, consistent with (FeO + MgO) substituting for (CaO + MnO) at higher grades (Deer et al., 1966).

These garnet data complement the provenance information provided by a small number of gneiss pebbles (Nicolaysen et al., 2001). Specifically, the garnets apparently sample a much wider range of metamorphic materials, with pyrope contents ranging from 17 to 38 wt%. This suggests that the source area was extensive enough to expose a modestly wide range of metamorphic facies and/or a variety of bulk compositions.

CONCLUSIONS

The garnets from Site 1137 sample a high-temperature/low-pressure pelitic source. Their compositions are in the low-calcium pyralspite field and range from 77 to 57 wt% almandine (17–38 wt% pyrope), the latter high-Mg contents and lack of evidence for zoning suggesting relatively high temperatures. These compositions are entirely consistent with a continental source area of pelitic and granitic materials.

T1. Garnet analyses, Sample 183-1137A-33R-3, 50–53 cm, p. 6.

T2. Mean compositions of nine garnet sand grains, Sample 183-1137A-33R-3, 50–53 cm, p. 8.

F1. Mean compositions of nine garnet sand grains, Sample 183-1137A-33R-3, 50–53 cm, p. 5.

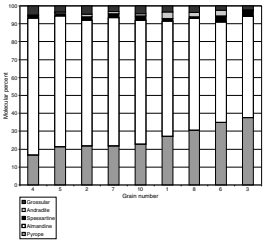

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Figure F1. Mean compositions of nine garnet sand grains by increasing pyrope content, Sample 183-1137A-33R-3, 50–53 cm.

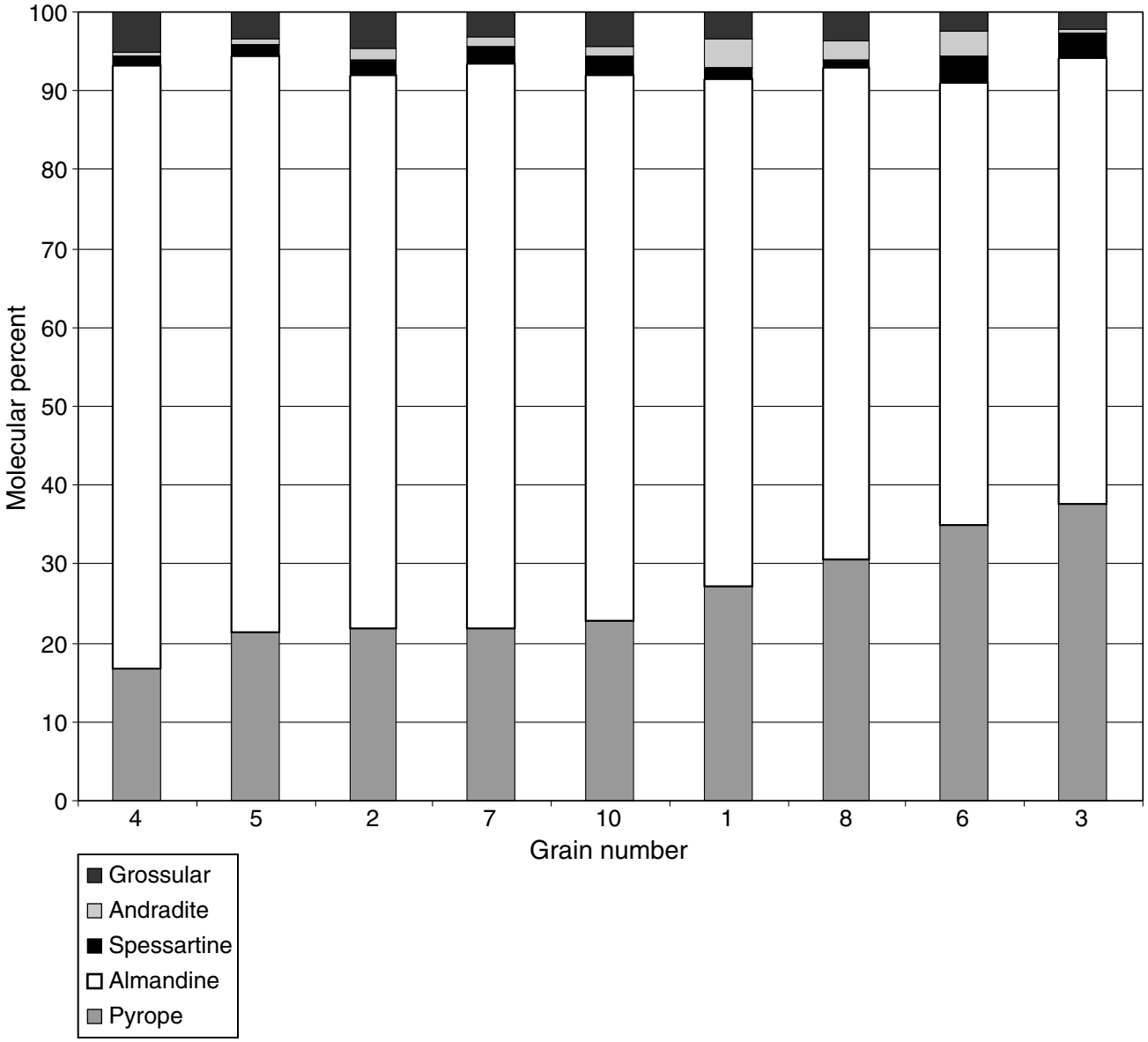

Table T1. Garnet analyses, Sample 183-1137A-33R-3, 50–53 cm. (See table note. Continued on next page.)

Grain	Analysis	Major element oxides (wt%)									
		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	Total
gn1:											
	1	37.68	0.02	20.82	31.50	0.64	7.11	2.48	0.01	0.00	100.26
	2	37.39	0.03	20.62	32.27	0.75	7.29	2.55	0.01	0.00	100.91
	3	37.51	0.01	20.77	31.71	0.64	6.94	2.61	0.01	0.00	100.21
	4	37.54	0.01	20.53	31.85	0.64	7.15	2.54	0.00	0.00	100.28
	5	38.05	0.03	20.62	32.48	0.67	7.25	2.53	0.00	0.00	101.64
	6	37.79	0.00	21.18	32.09	0.63	6.76	2.53	0.01	0.00	100.99
	7	37.54	0.03	21.24	31.76	0.59	7.26	2.47	0.00	0.00	100.89
	8	37.55	0.03	21.05	31.45	0.61	7.27	2.60	0.02	0.00	100.56
	9	37.71	0.00	20.80	31.56	0.59	7.00	2.71	0.03	0.00	100.39
	10	37.23	0.01	20.97	31.50	0.57	7.16	2.66	0.03	0.00	100.13
Average:		37.60	0.02	20.86	31.82	0.63	7.12	2.57	0.01	0.00	100.62
gn2:											
	1	36.64	0.05	21.31	33.62	0.87	5.47	2.20	0.04	0.02	100.22
	2	37.45	0.02	21.23	33.41	0.81	5.44	2.07	0.04	0.01	100.47
	3	37.53	0.02	21.18	32.93	0.80	5.78	2.16	0.03	0.00	100.43
	4	37.02	0.00	21.48	32.39	0.79	5.76	2.18	0.04	0.00	99.67
	5	37.50	0.00	21.22	32.29	0.93	5.48	2.22	0.02	0.01	99.67
	6	37.35	0.01	21.42	32.51	0.83	5.60	2.19	0.02	0.01	99.93
Average:		37.25	0.02	21.31	32.86	0.84	5.59	2.17	0.03	0.01	100.06
gn3:											
	1	38.06	0.02	21.96	26.81	1.23	9.93	1.12	0.00	0.00	99.12
	2	38.38	0.00	21.98	26.64	1.52	9.83	0.93	0.02	0.02	99.31
	3	38.57	0.04	22.12	26.68	1.48	9.79	1.03	0.01	0.00	99.70
	4	37.92	0.06	22.15	26.04	1.52	9.92	1.04	0.00	0.00	98.65
	5	38.09	0.04	22.12	27.23	1.56	9.83	1.01	0.00	0.00	99.88
	6	38.77	0.04	22.04	26.81	1.48	9.85	1.03	0.02	0.00	100.03
Average:		38.30	0.03	22.06	26.70	1.46	9.86	1.02	0.01	0.00	99.45
gn4:											
	1	37.76	0.07	20.86	33.35	0.53	4.34	1.90	0.01	0.09	98.91
	2	37.23	0.04	21.23	35.55	0.49	4.20	1.95	0.02	0.00	100.71
	3	36.81	0.03	21.65	34.30	0.56	4.38	2.03	0.00	0.01	99.77
	4	36.40	0.04	21.52	35.04	0.46	4.18	1.92	0.02	0.00	99.58
	5	36.65	0.03	21.40	34.69	0.58	4.27	1.97	0.00	0.00	99.59
	6	36.75	0.03	21.45	34.75	0.48	4.11	1.98	0.00	0.00	99.55
	7	37.29	0.05	21.20	35.69	0.54	4.32	2.05	0.01	0.01	101.15
	8	36.90	0.00	21.34	34.77	0.47	4.22	2.00	0.01	0.04	99.74
	9	36.79	0.02	21.65	34.75	0.45	4.14	2.06	0.03	0.03	99.92
Average:		36.95	0.04	21.37	34.77	0.51	4.24	1.99	0.01	0.02	99.88
gn5:											
	1	37.35	0.04	21.66	33.00	0.70	5.32	1.48	0.05	0.00	99.60
	2	36.96	0.06	21.60	33.65	0.63	5.63	1.48	0.02	0.00	100.02
	3	36.70	0.05	21.25	32.35	0.63	5.34	1.44	0.02	0.01	97.78
	4	37.42	0.03	21.32	32.77	0.63	5.37	1.44	0.02	0.06	99.06
	5	37.47	0.03	21.06	33.46	0.75	5.52	1.48	0.02	0.00	99.79
	6	36.23	0.03	21.46	33.89	0.68	5.34	1.41	0.02	0.00	99.06
	7	37.71	0.00	21.18	33.53	0.71	5.42	1.39	0.01	0.00	99.95
Average:		37.12	0.03	21.36	33.23	0.68	5.42	1.45	0.02	0.01	99.32
gn6:											
	1	38.04	0.05	21.42	28.83	1.44	9.20	2.07	0.03	0.00	101.07
	2	38.91	0.05	21.27	27.63	1.55	9.24	2.04	0.03	0.00	100.73
	3	38.23	0.05	21.47	28.12	1.59	9.43	2.04	0.01	0.05	100.98
	4	38.45	0.12	21.53	28.25	1.66	9.29	2.19	0.01	0.00	101.50
	5	38.41	0.01	21.25	28.01	1.56	8.97	2.10	0.02	0.00	100.32
	6	38.82	0.00	21.46	28.53	1.57	9.48	2.15	0.01	0.00	102.02
	7	38.05	0.06	21.74	28.71	1.55	9.40	2.17	0.01	0.00	101.70
	8	38.70	0.11	21.26	28.07	1.56	9.54	2.20	0.00	0.00	101.44
Average:		38.45	0.05	21.43	28.27	1.56	9.32	2.12	0.02	0.01	101.22
gn7:											
	1	37.77	0.04	21.30	33.67	0.84	5.67	1.69	0.01	0.09	101.09
	2	37.41	0.01	21.46	34.21	0.75	5.59	1.66	0.00	0.04	101.13
	3	36.82	0.05	21.75	34.02	0.90	5.67	1.71	0.00	0.00	100.90
	4	37.71	0.01	21.36	33.20	0.97	5.95	1.67	0.00	0.00	100.87
	5	37.55	0.05	21.53	33.62	0.92	5.62	1.64	0.00	0.00	100.93
	6	37.06	0.00	21.45	32.38	0.90	5.60	1.55	0.01	0.00	98.94

Table T1 (continued).

Grain	Analysis	Major element oxides (wt%)									
		SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	Total
	7	38.48	0.00	21.52	32.92	0.87	5.60	1.59	0.01	0.00	100.99
	8	36.68	0.05	21.35	33.59	0.87	5.33	1.56	0.01	0.00	99.44
	9	36.99	0.06	21.70	33.61	0.90	5.69	1.56	0.00	0.00	100.50
	10	37.75	0.06	21.35	32.46	0.88	5.29	1.55	0.00	0.00	99.35
	11	37.38	0.00	21.36	34.27	0.93	5.71	1.46	0.01	0.00	101.11
Average:		37.42	0.03	21.46	33.45	0.89	5.61	1.60	0.00	0.01	100.48
gn8:											
	1	37.51	0.00	21.59	30.49	0.44	8.02	2.29	0.03	0.03	100.41
	2	37.99	0.04	21.65	30.75	0.43	7.89	2.20	0.02	0.00	100.96
	3	38.11	0.02	21.90	30.94	0.48	8.05	2.25	0.01	0.00	101.77
	4	37.32	0.04	21.66	30.30	0.54	8.37	2.17	0.02	0.00	100.41
	5	38.15	0.01	21.72	29.81	0.46	8.28	2.18	0.02	0.00	100.62
	6	37.81	0.06	21.77	30.43	0.39	8.16	2.27	0.02	0.00	100.91
	7	37.47	0.00	21.51	31.01	0.44	7.74	2.25	0.02	0.00	100.44
	8	37.70	0.02	21.91	30.73	0.40	8.18	2.35	0.00	0.00	101.28
	9	37.36	0.00	21.91	30.87	0.46	8.17	2.23	0.01	0.00	101.02
Average:		37.71	0.02	21.74	30.59	0.45	8.09	2.24	0.02	0.00	100.87
gn10:											
	1	37.30	0.04	21.60	32.27	1.14	5.70	2.07	0.02	0.00	100.13
	2	36.80	0.10	21.63	31.69	0.93	5.95	2.05	0.01	0.00	99.16
	3	37.34	0.04	21.59	32.06	0.91	5.80	2.10	0.01	0.03	99.88
	4	37.62	0.05	21.51	31.83	1.10	5.89	1.98	0.00	0.00	99.98
	5	37.40	0.05	21.66	33.05	0.95	6.03	2.04	0.01	0.00	101.19
	6	37.85	0.06	21.53	32.95	1.12	5.88	1.95	0.00	0.08	101.44
	7	37.47	0.07	21.40	32.24	1.02	5.66	2.09	0.00	0.00	99.95
	8	37.06	0.04	21.38	32.19	1.10	6.10	2.05	0.03	0.00	99.95
Average:		37.36	0.06	21.54	32.28	1.03	5.88	2.04	0.01	0.01	100.21

Note: Individual sand grains are identified as gn1–8 and gn10.

Table T2. Mean compositions of nine garnet sand grains, Sample 183-1137A-33R-3, 50–53 cm.

Grain ID:	gn1	gn2	gn3	gn4	gn5	gn6	gn7	gn8	gn10
Major element oxides (wt%):									
SiO_2	37.60	37.25	38.30	36.95	37.12	38.45	37.42	37.71	37.36
TiO_2	0.02	0.02	0.03	0.04	0.03	0.05	0.03	0.02	0.06
Al_2O_3	20.86	21.31	22.06	21.37	21.36	21.43	21.46	21.74	21.54
FeO	31.82	32.86	26.70	34.77	33.23	28.27	33.45	30.59	32.28
MnO	0.63	0.84	1.46	0.51	0.68	1.56	0.89	0.45	1.03
MgO	7.12	5.59	9.86	4.24	5.42	9.32	5.61	8.09	5.88
CaO	2.57	2.17	1.02	1.99	1.45	2.12	1.60	2.24	2.04
K_2O	0.01	0.03	0.01	0.01	0.02	0.02	0.00	0.02	0.01
Na_2O	0.00	0.01	0.00	0.02	0.01	0.01	0.01	0.00	0.01
Total:	100.62	100.06	99.45	99.88	99.32	101.22	100.48	100.87	100.21
Number of ions on the basis of 12 O:									
Si	2.96	2.96	2.96	2.96	2.97	2.96	2.96	2.93	2.95
Al	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.07	0.05
Al	1.89	1.95	1.98	1.98	1.98	1.90	1.96	1.92	1.96
Ti	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe^{+3}	0.11	0.05	0.02	0.02	0.02	0.10	0.04	0.08	0.04
Fe^{+2}	1.98	2.14	1.71	2.31	2.20	1.72	2.18	1.91	2.10
Mn	0.04	0.06	0.10	0.03	0.05	0.10	0.06	0.03	0.07
Mg	0.83	0.66	1.14	0.51	0.65	1.07	0.66	0.94	0.69
Ca	0.22	0.18	0.08	0.17	0.12	0.17	0.14	0.19	0.17
Molecular percent:									
Almandine	64.5	70.3	56.5	76.5	73.0	56.1	71.7	62.4	69.2
Andradite	3.6	1.5	0.5	0.6	0.6	3.3	1.2	2.5	1.2
Grossular	3.4	4.6	2.0	5.0	3.5	2.4	3.3	3.6	4.5
Pyrope	27.1	21.8	37.7	16.8	21.4	34.9	21.8	30.6	22.8
Spessartine	1.4	1.9	3.2	1.1	1.5	3.3	2.0	1.0	2.3