Mineral chemistry of Kirkpatrick Basalts

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Geochemical studies at The Ohio State University (Elliot, 1970, 1972; Faure *et al.*, 1974) have shown that the Kirkpatrick Basalts from Storm Peak, Beardmore Glacier, have high initial strontium-87/strontium-86 and low potassium/rubidium ratios similar to the Ferrar Dolerites from the Transantarctic Mountains and the Jurassic dolerites from Tasmania (Compston *et al.*, 1968). Strontium-87/strontium-86 ratios, strontium concentrations, and major element chemistry all exhibit systematic stratigraphic variations within a sequence of 12 flows at Storm Peak (Faure *et al.*, 1974). The chemical variations are incompatible with an origin by fractionational crystallization processes. Faure *et al.* (1974) show quantitatively that the chemical and isotopic variations could result from contamination of a tholeiitic basalt magma with iron-rich granitic material enriched in strontium-87.

In continuing geochemical studies of the Kirkpatrick Basalts, we have made preliminary microprobe analyses of mineral phases and the groundmass glass in samples from Storm Peak and a sample from Brimstone Peak, northern Victoria Land

Table 1. Representative analyses of minerals in Kirkpatrick Basalt samples from Storm Peak.

	Pyroxene 1	Pyroxene 2	Pyroxene 3	Pyroxene 4		Plagioclase 5		Titanomagnetite 6
SiO_2	53.1	50.6	50.7	49.3		52.5		0.29
Al_2O_3	1.07	1.58	1.59	0.89		29.2		1.80
TiO_2	0.35	0.68	0.80	0.55		0.05		24.8
FeO*	21.0	14.9	18.6	31.0		0.87		68.3
MnO	0.42	0.33	0.36	0.62		—		0.34
MgO	19.9	13.4	11.0	6.63		0.13		0.14
CaO	5.11	17.65	17.6	11.2		13.7		0.08
Na_2O	n.d.	n.d.	n.d.	n.d.		3.42	Sum	95.75
K_2O	n.d.	n.d.	n.d.	n.d.		0.23		
Sum	100.95	99.14	100.65	100.19		100.10	Fe_2O_3	16.6
							FeO	53.4
							Total	97.45
		Structural formulae						
Oxygen	6	6	6	6		32		
Si	1.970	1.938	1.943	1.980		9.556		
Al	0.047	0.071	0.072	0.042		6.263		
Ti	0.010	0.020	0.023	0.017		0.006		
Fe	0.652	0.479	0.595	1.041		0.132		
Mn	0.013	0.011	0.012	0.021		—		
Mg	1.101	0.764	0.630	0.397		0.034		
Ca	0.203	0.725	0.723	0.484		2.680		
Na	—	—	—	—		1.206		
K	—	—	—	—		0.053		
Wo	10.4	36.8	37.1	25.2	An	68.0	Usp	75.0
En	56.3	38.8	32.3	20.6	Ab	30.6		
Fs	33.3	24.3	30.6	54.2	Or	1.4		

*Total Fe as FeO; n.d., not determined; —, not detected. 1, 2: sample 27.36 grains 5 and 3 respectively. 3, 4: sample 27.41 grains 8 and 11 respectively. 5: sample 27.24. 6: sample 27.36 grain 5.

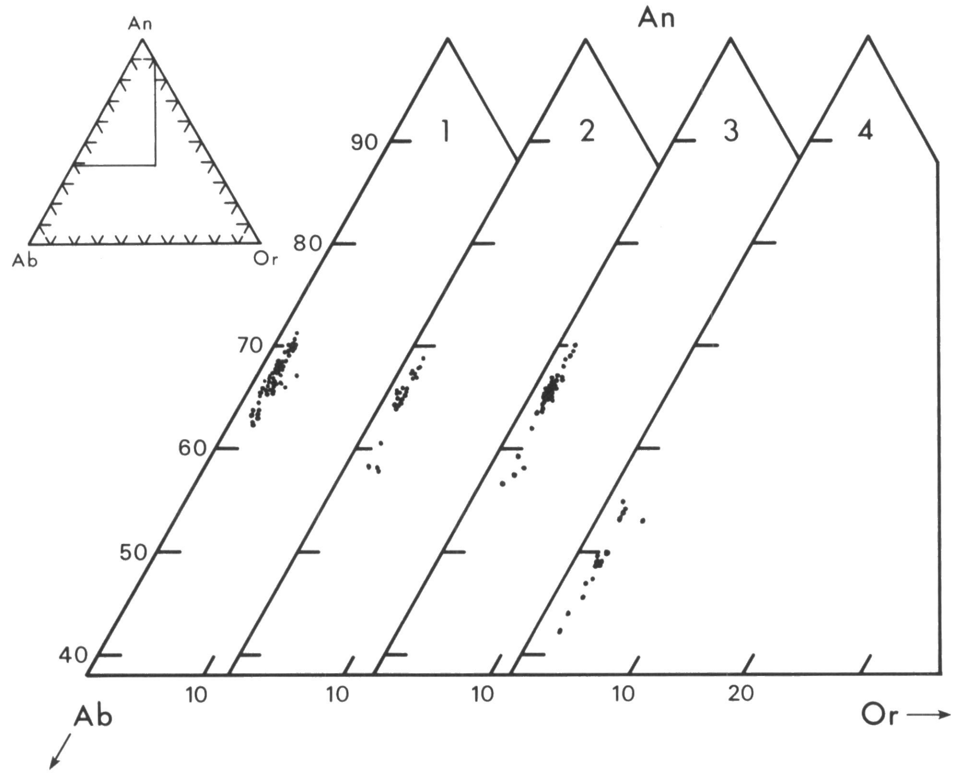

Figure 1. Electron microprobe analyses of plagioclase in Kirkpatrick Basalt samples, Storm Peak, Queen Alexandra Range. 1: 27.1, flow 2. 2: 27.24, flow 7. 3: 27.36, flow 11. 4: 27.41, flow 12.

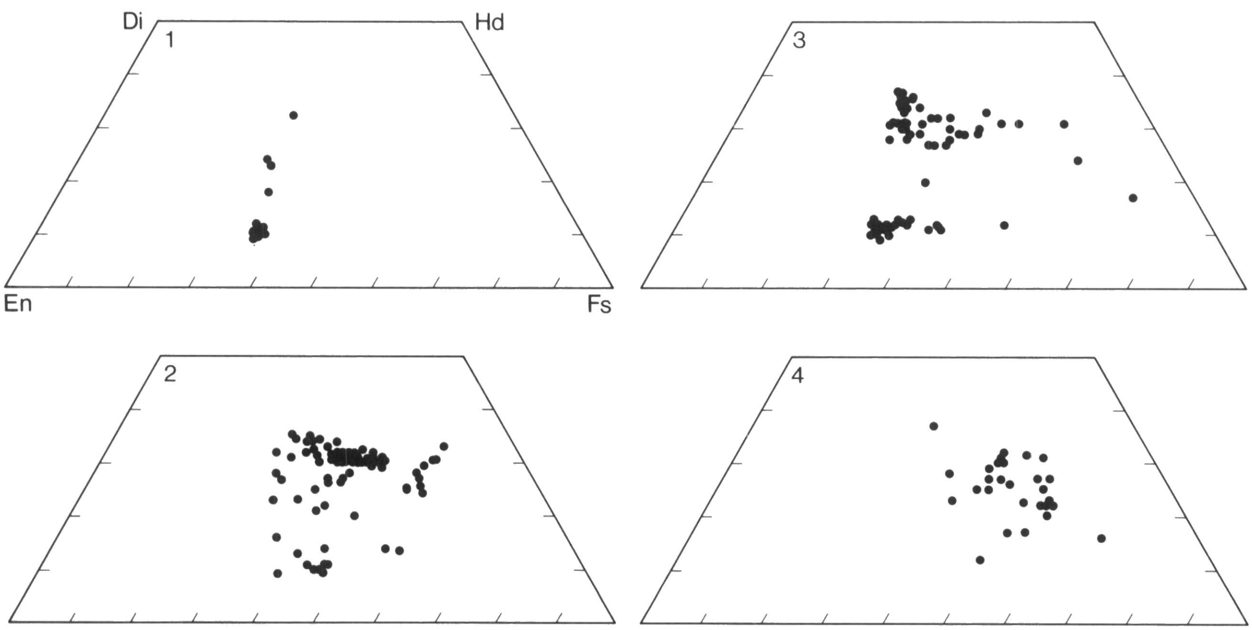

Figure 2. Electron microprobe analyses of pyroxene in Kirkpatrick Basalt samples, Storm Peak, Queen Alexandra Range. Sample identification same as for figure 1.

(Skinner and Ricker, 1968). Analyses were made at the University of Otago (Dunedin, New Zealand) using a JEOL microprobe. Table 1 gives representative analyses.

Plagioclase in Storm Peak lavas shows little compositional variation within a sample (figure 1) and also between samples (with one exception). Phenocrysts in three samples have cores of labradorite (An_{70}-An_{65}) with weakly zoned rims that may reach An_{56}. Flow 12 (sample 27.41) from the top of the sequence at Storm Peak has plagioclase that is compositionally distinct (An_{55}-An_{42}), being more sodium rich. Chemically, the four samples are generally similar except for Al_2O_3, which is lower in sample 27.41.

Pyroxene analyses show an extremely wide range in composition (figure 2) and consist of pigeonite, augite, and ferroaugite with minor subcalcic augite and subcalcic ferroaugite. The extreme iron enrichment of Storm Peak pyroxenes is unusual and shows a closer resemblance to the crystallization trends observed in lunar basalts than to most terrestrial tholeiitic magmas (figure 3). Pyroxenes in deep-sea tholeiitic basalts are generally diopsidic augite, although in some samples iron enrichment adjacent to residual mesostasis may be similar to that shown by the Storm Peak pyroxenes (Hodges *et al.*, 1976).

The range in pyroxene composition is probably a metastable effect due to rapid (quench) crystalli-

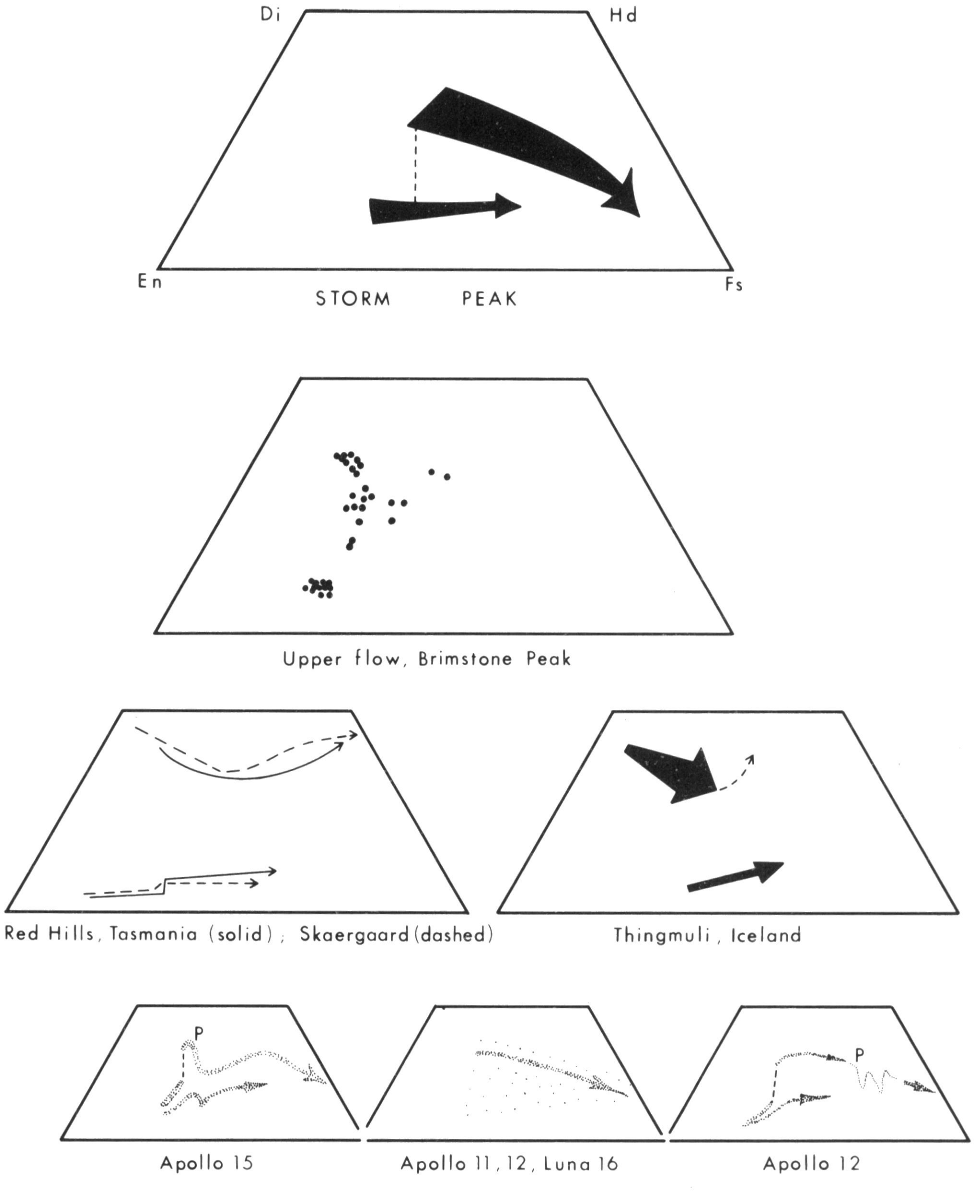

Figure 3. Pyroxene crystallization trends in Kirkpatrick Basalt from Storm Peak and Brimstone Peak, northern Victoria Land. Comparative trends for lunar rocks and terrestrial tholeiitic magmas are from McDougall (1961), Brown (1957), Carmichael (1967), and Bence and Papike (1972).

zation. Well-developed skeletal magnetites and textures indicative of quenching are common in many samples.

A single partial analysis of a pyroxene rim has a composition of $Ca_{17}Mg_{10}Fe_{73}$ and an FeO content of 35.1 percent. This is within the forbidden region of the pyroxene quadrilateral (Lindsley and Munoz, 1969) in which pyroxene is not stable. It also lies within the range of chemical composition of pyroxferroite, a new pyroxenoid mineral discovered in lunar basalts from Apollo 11 (Frondel, 1975). Further analyses are necessary to determine the extent of iron enrichment and to confirm the iron-rich compositions.

Partial analyses of pyroxenes in the uppermost of nine flows from Brimstone Peak (figure 3) are the most magnesium-rich pyroxenes analyzed to date in the Kirkpatrick Basalts.

Magnetite in Storm Peak lavas is titanium rich and shows little compositional variation. Recalculation of the iron oxidation state (table 1) gives low totals, suggesting that the magnetite probably has been oxidized. In some samples, the magnetite has oxidation "exsolution" lamellae of ilmenite.

Faure *et al.* (1974) estimate a composition for the iron-rich granitic contaminant (table 2) they consider responsible for the high strontium-87/strontium-86 ratios in the Storm Peak lavas. Many of the basalt samples have glassy groundmasses, the amounts of which show a positive correlation with increases in strontium-87/strontium-86. If granitic melt was assimilated into the basalt magma, then the glassy basaltic groundmass might have a composition approaching that of the contaminant. A broad-beam microprobe analysis of the glass from a single sample (table 2) shows many similarities to the suggested contaminant. A few differences occur particularly in the FeO* (total Fe as FeO) contents; the suggested contaminant has 16.6-percent FeO* whereas the glass contains only 6.2 percent. The difference could be explained partly by crystallization of pyroxene after addition of the contaminant. The pyroxenes are extremely iron rich. The pyroxene crystallization trends may therefore be a metastable effect or may reflect the addition of a contaminant to a primary tholeiitic basalt magma.

Table 2. Estimated composition of a granitic contaminant of the Kirkpatrick Basalts and a measured composition of groundmass glass in a lava flow from Storm Peak.

	1	2
SiO_2	66.7	69.1
TiO_2	0.60	0.72
Al_2O_3	7.1	10.6
FeO*	16.6	6.22
MgO	~0	0.21
CaO	1.2	2.52
Na_2O	4.5	2.65
K_2O	3.1	3.33

(1) Granitic contaminant of the Kirkpatrick Basalts calculated by Faure *et al.* (1974). (2) Groundmass glass of Kirkpatrick Basalt sample 27.24 from flow 7, Storm Peak. *Total Fe as FeO. Electron microprobe analysis.

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