SHORT NOTES

A MORPHOMETRIC STUDY OF THE MITE, *OPPIA LOXOLINEATA*, IN THE MARITIME ANTARCTIC

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A new species of cryptostigmatid mite, *Oppia loxolineata*, was described by Wallwork (1965) from six adult specimens collected on Livingston Island and Deception Island, South Shetland Islands, but no holotype was designated. Subsequently, Covarrubias (1968) described a new subspecies, *O. l. longipilosa*, from Deception Island, three other islands in the South Shetland Islands, and two localities on the Antarctic Peninsula, but again no holotype was designated. Since it is generally accepted that zoological subspecies cannot be sympatric, *O. l. longipilosa* must be either a synonym of *O. loxolineata* or a full species because both co-occur on Deception Island. The aim of this study was to examine the morphological variation of *O. loxolineata* throughout its geographical range in the maritime Antarctic and to determine whether morphologically distinct populations occur.

MATERIALS AND METHODS

Observations were made on 43 adult *O. loxolineata*, collected during the austral summers of 1980/81 and 1981/82, from 16 localities along an 8° latitudinal transect [Lynch Is. (60° 39′ S, 45° 36′ W) and Steepholm (60° 46′ S, 45° 09′ W) in the South Orkney Islands; Ardley Is. (62° 12′ S, 58° 54′ W), Livingston Is. (62° 39′ S, 60° 38′ W) and Deception Is. (several collection localities, *c.* 62.0° S, 64.5° W) in the South Shetland Islands; Hope Bay (63° 24′ S, 57° 00′ W), Cape Roquemaurel (63° 33′ S, 58° 51′ W), Andrée Is. (64° 31′ S, 61° 30′ W), Cuverville Is. (64° 41′ S, 62° 37′ W), Argentine Islands (*c.* 65° 15′ S, 64° 15′ W), Green Is. (65° 19′ S, 64° 10′ W), Takaki Promontory (65° 31′ S, 64° 12′ W), Orford Cliff (66° 55′ S, 66° 29′ W), Roman Four Promontory (68° 13′ S, 66° 58′ W) and Red Rock Ridge (68° 17′ S, 67° 11′ W) on a north–south transect along the Antarctic Peninsula]. In addition, two of Wallwork's (1965) syntypes were examined and included in the analysis.

For all 45 mites a total of 60 characters were scored; these characters are listed by Buryn (1986). A number of length measurements was changed to ratios and hence the analysis was performed on a data matrix of 45 individuals by 52 measured and derived characters. A principal coordinates analysis was used so that the results could be compared with those of analyses on other Antarctic mite genera and species, notably *Gamasellus racovitzai* (Trouessart) with two subspecies (Jumeau and Usher, 1987), *Eupodes* (Booth and others, 1985) and *Tydeus s. lat.* (Usher and Edwards, 1986).

RESULTS

The first principal coordinate axis accounted for 14% of the variance, the second for 10%, and all subsequent axes for 6% or less of the variance. A plot of the 45 individual mites on the first two axes is shown in Fig. 1. It can be seen that there is no clustering

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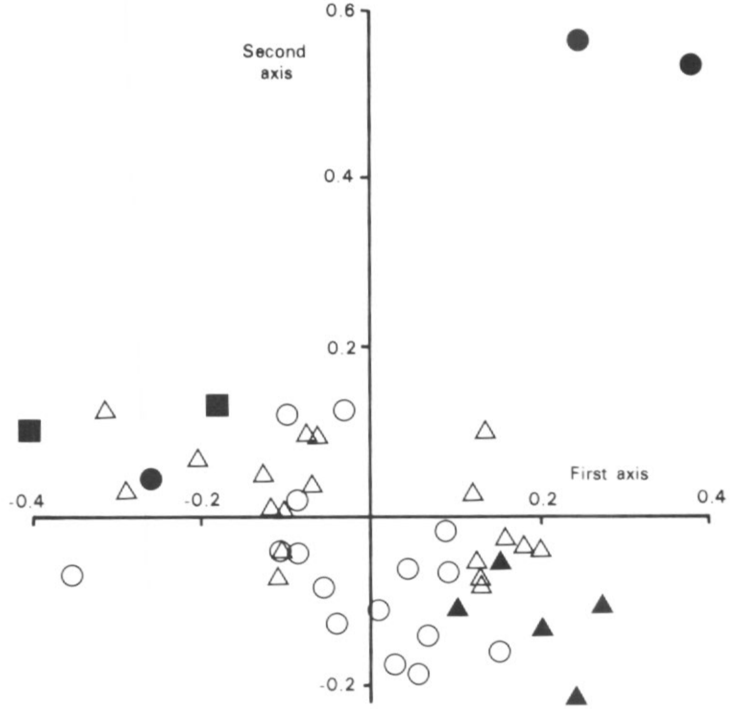

Fig. 1. The first and second axes of a principal coordinate analysis of 52 characters scored in a sample of 45 individuals of *Oppia loxolineata*. Collection localities are indicated by the following symbols: (●) South Orkney Islands, (○) South Shetland Islands, (△) northern section, north of 66° S, of the Antarctic Peninsula, (▲) southern section, south of 66° S, of the Peninsula, and (■) the two syntypes, from Deception Island.

of points except for the two mites from Lynch Island, which appear in the top right quadrant of the diagram. There is no geographical separation of the mites in the main cluster in Fig. 1. Plotting other pairs of principal coordinate axes also failed to provide any geographical separation of mites, except for the two Lynch Island specimens. The first axis, as in many morphometric studies (Blackith and Reyment, 1971), is associated with body size, the larger mites being to the left of Fig. 1. The second axis is less easy to interpret, but it appears to be related to the lengths and relative positions of several of the notogastal setae.

Discussion

The results of the principal coordinate analysis can be considered in two ways. First, in Fig. 1 there appear to be no clusters unless the two Lynch Island specimens are considered separately from the remainder of the specimens (the single specimen from Steepholm, also in the South Orkney Islands, is located in the general cluster). Second, the amount of variance accounted for by the first two axes, 14 and 10%, is extremely small. In similar analyses involving the genera *Eupodes* (Booth and others, 1985) and *Apotriophtydeus* (Usher and Edwards, 1986) the amount of variance accounted for by the first two axes was 41/17% and 25/19% respectively. These figures tend to indicate that it is unlikely that two or more species exist in the sample of *O. loxolineata* included in the analysis. The amount of variance accounted for is, however, similar to that in an analysis of *Gamasellus racovitzai* by Jumeau and Usher (1987) where there were two subspecies clearly separated on the ordination diagram. Both the small amount of variance accounted for in the principal coordinate analysis, and the lack of clusters or geographical trends in Fig. 1, indicate that *O. loxolineata* has not formed separate species or subspecies in the maritime Antarctic.

In the original description of *O. l. longipilosa*, Covarrubias (1968) listed the characters that distinguished his new subspecies from the nominate subspecies. The lamella–translamella system is extremely variable; the variation seen in the sample of 45 mites in Fig. 1 spans the whole range illustrated by Wallwork (1965) and Covarrubias (1968). *O. l. longipilosa* was described as having longer setae on the notogaster, but setal length is very variable and the specimens included in Fig. 1 showed a large variation in length (e.g. the mean lengths, with standard deviations, of setae *r1*, *r2*, *r3*, *p1*, *p2* and *p3* are 54 ± 9, 62 ± 8, 57 ± 7, 59 ± 18, 54 ± 9 and 48 ± 6 μm respectively). Hence, neither the comparative length of setae nor the development of the lamella–translamella system seem to be reliable characters for separating two subspecies, which can, therefore, be synonymized. Formally, this can be stated as

Oppia loxolineata Wallwork (1965)
= ***Oppia loxolineata longipilosa*** Covarrubias (1968).

Finally, it would have been unusual, biogeographically, to have a subspecies on one of the South Shetland Islands and another subspecies elsewhere in these islands and on the Antarctic Peninsula. Besides species restricted to either the South Orkney Islands or the South Shetland Islands, three biogeographical patterns can be observed in the distribution of terrestrial arthropods in the maritime Antarctic, namely:

(1) Ubiquitous species, occurring in the South Orkney and South Shetland Islands and along the Antarctic Peninsula [e.g. *Alaskozetes antarcticus* (Michael)].

(2) Species with a zoogeographical break between the Antarctic Peninsula and the South Orkney Islands [e.g. *Gamasellus racovitzai racovitzai* which is widespread along the Peninsula and in the South Shetland Islands but is replaced in the South Orkney Islands by *G. r. neo-orcadensis* (Trouessart)].

(3) Species which do not reach the South Orkney Islands [e.g. the two species of Diptera or *Rhagidia gerlachei* (Trouessart)].

Until Usher and Edwards (1984) recorded the occurrence of *O. loxolineata* on Lynch Island, this species appeared to follow distribution pattern (3). However, it has now been recorded from two of the South Orkney Islands, Lynch Island and Steepholm, but on both it is rare. It has not been recorded from Signy Island. If it is accepted that there is continuous variation in the morphological characters, then *O. loxolineata* is now known to follow distribution pattern (1). However, there is a slight indication in Fig. 1 that there may be a morphological distinction between mites from the South Orkney Islands and those from elsewhere in the maritime Antarctic. Whether this variation is sufficient to be considered as of subspecific status must await the collection of further mites in the South Orkney Islands.

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THE GEOCHEMISTRY AND TECTONIC SETTING OF GABBROIC ROCKS IN THE SCOTIA ARC REGION

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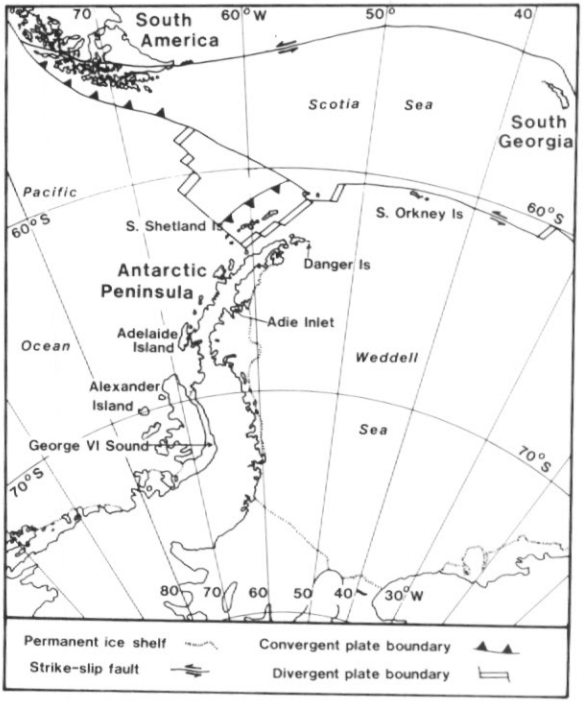
ABSTRACT. The petrography, mineral and whole-rock chemistry of gabbroic rocks from within the extensional back-arc basin of South Georgia and the calc-alkaline Mesozoic magmatic arc of the Antarctic Peninsula indicate (i) there are some mineralogical and chemical similarities between the South Georgia gabbros and some of the gabbros within the west coast province of the Antarctic Peninsula and (ii) there are some mineralogical differences between gabbros that formed farthest from (east coast) and those that formed closest to the plate margin (west coast) within the Antarctic Peninsula arc. The South Georgia and west coast gabbros are controlled by crystallization of clinopyroxene, orthopyroxene and olivine whereas amphibole is the most abundant ferromagnesian mineral in the east coast and olivine is absent. All the gabbros are enriched in LIL elements; the South Georgia rocks are the most primitive and there is a progressive increase in the concentration of most elements in the sequence South Georgia-west coast-east coast. The most significant variation is in the REE.

The chemical differences between the South Georgia gabbros and the majority of the Antarctic Peninsula gabbros suggest the gabbros were derived from different parental magmas controlled by tectonic features in the crust. On the other hand the chemical similarities between the South Georgia gabbros and some of the west coast gabbros indicate an extensional phase of arc development in the Antarctic Peninsula.

INTRODUCTION

The Scotia arc is an eastward-curving chain of rugged islands and submarine ridges between southern South America and the Antarctic Peninsula (Fig. 1a). Prior to opening of the Drake Passage (35 Ma) the region was a continuous part of the proto-Pacific margin of Gondwanaland. The geology of this once continuous margin was dominated during the Mesozoic and Cenozoic by subduction-related processes involving both compressional and extensional phases of arc development (Storey and Garrett, 1985). The Antarctic Peninsula is mainly formed of a Mesozoic calc-alkaline plutonic and volcanic complex, subduction complex rocks and contemporaneous fore- and back-arc basins (Storey and Garrett, 1985). In southern South America and South Georgia (part of the Scotia arc) an extensional back-arc basin, locally termed the 'Rocas Verdes' formed during the late Jurassic and early Cretaceous (Dalziel, 1981). It was infilled by a thick sequence of arc-derived volcaniclastic sedimentary rocks and deformed during mid Cretaceous closure of this basin. During the early Tertiary a further extensional inter-arc basin developed in southern South America (45° S) (Bartholomew and Tarney, 1985) and Tertiary extensional features have been recognized along the western margin of the Antarctic Peninsula (Storey and Garrett, 1985).

Gabbroic rocks (*sensu lato*), although volumetrically subordinate to more felsic and intermediate lithologies, form a significant part of the plutonism within the magmatic arc terrane. In South Georgia they are clearly associated with formation of the extensional back-arc basin (Storey, 1983). They are part of the Drygalski Fjord



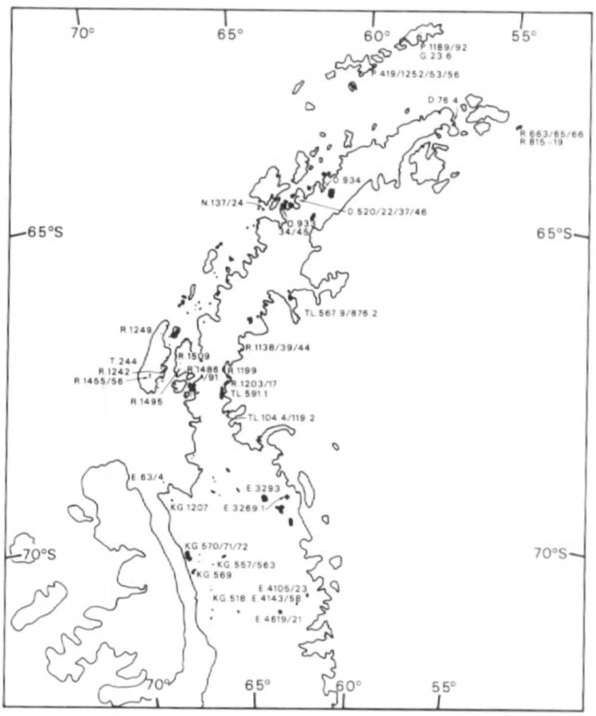


Fig. 1a. Location map for Antarctic Peninsula region, showing present-day plate boundaries.
Fig. 1b. Distribution map of the gabbros and analyzed samples within the Antarctic Peninsula.

Complex (Storey, 1983) and were emplaced into continental crust during the initial rifting stages of back-arc basin development in the Middle Jurassic ($\simeq$ 180 Ma). They crystallized from a magma similar to that which formed the oceanic-type floor of part of the rifted basin (Larsen Harbour Formation, Mair 1983) and are correlated with the Tortuga and Sarmiento complexes of the Rocas Verdes basin of southern South America. The gabbroic rocks were intruded into paragneisses and metasedimentary rocks of crustal basement formations and are surrounded by extensive migmatitic aureoles. They are closely associated with tholeiitic differentiates and granitic rocks formed by partial melting of the metasedimentary rocks.

In contrast to this, in the Antarctic Peninsula the association of the gabbros to the voluminous calc-alkaline rocks and to compressional or extensional phases of arc development is enigmatic. They are commonly interpreted as the earliest members of the abundant calc-alkaline plutonic suite (Hooper, 1962; Curtis, 1966; Dewar, 1970; Saunders and others, 1982) although their precise relationships to more evolved types is not usually known. On the west coast they commonly reach a high level in the crust, intruding the calc-alkaline volcanic and volcaniclastic rocks of the contemporaneous arc with minor hornfelsing and localized migmatization (Adie, 1955; Curtis, 1966; Dewar, 1970). On the east coast, intrusive relationships are rarely exposed although contacts with metasedimentary and volcanic rocks have been recorded (Singleton, 1980; Davies, 1984). Throughout the peninsula the gabbros are intruded by more evolved members of the plutonic suite often resulting in net-veining and schlieren zones. In some localities there is evidence of mixing of more than one magma phase which suggests that some of the gabbros are not comagmatic with the granitic differentiates (West, 1974; Smellie and others, 1985). The magma mixing often results in extensive areas of hybridization and acidic host rock containing up to 50% of included mafic pillows (Moyes, 1986). At Adie Inlet and the Danger Islands, on the east coast of the peninsula, gabbros are clearly associated with more alkaline differentiates (Hamer and Hyden, 1984) and not to the calc-alkaline rocks.

Although gabbroic rocks occur throughout the Antarctic Peninsula (Fig. 1b) they are particularly abundant in the west coast archipelago. A large magnetic anomaly along this western margin suggests a distinct linear zone of mafic rocks (Storey and Garrett, 1985) of which some of the gabbros may represent the surface expression.

Although the age of calc-alkaline intermediate and granitic rocks within the Antarctic Peninsula magmatic arc is well known (Pankhurst, 1982) the age control on the gabbroic plutons is poor. As the felsic rocks were emplaced between the late Triassic and late Tertiary (Rex, 1976; Pankhurst, 1982) it is most likely that the gabbroic rocks span a similar time period. The gabbroic rocks with alkali differentiates were emplaced during a distinct phase of arc development in the late Cretaceous (80–90 Ma) (Rex, 1976; Hamer and Hyden, 1984).

Proir to this study most research has concentrated on the intermediate and felsic members of the magmatic suite. In contrast this paper focuses on the gabbroic rocks within the region, and new data are presented here on the mineral and rare earth element chemistry, in addition to major and trace element data collated from the literature of a range of samples. Gabbroic rocks from two different tectonic environments are considered; the extensional back-arc basin system of South Georgia and the Antarctic Peninsula convergent margin magmatic arc. The latter is divided into a western province, closest to the trench, and an eastern province, furthest from the trench. The east coast gabbros which are clearly associated with the alkaline differentiates form a separate subdivision. With this exception, differentiation trends are not considered as in most cases the relationship of the mafic and felsic rocks within the magmatic arc is not certain. The gabbros from the different tectonic settings and from across the Antarctic Peninsula magmatic arc are compared.

The study indicates there are: (1) mineralogical and chemical differences between gabbroic rocks emplaced in the extensional back-arc basin system of South Georgia and those of the convergent margin magmatic arc of the Antarctic Peninsula; (2) transverse mineralogical variations across the Antarctic Peninsula arc and (3) some gabbros within the west coast magnetic anomaly zone that have a chemical signature identical to the gabbros within the South Georgia extensional back-arc basin.

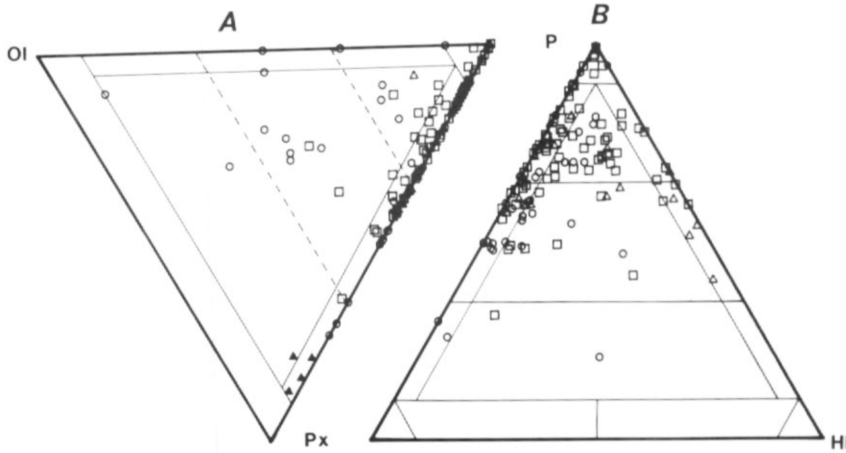


Fig. 2. Modal data for gabbro samples, based on IUGS recommended classification (Streckeisen, 1973). P = plagioclase, Ol = olivine, Px = total pyroxene, Hb = amphibole (hornblende). Circles = South Georgia; squares = west coast Antarctic Peninsula; triangles = east coast Antarctic Peninsula; filled symbol = alkali gabbros.

Petrography and Mineral Chemistry

Modal data for 133 samples collated from the available literature (Adie, 1955; Curtis, 1966; Davies, 1984; Dewar, 1970; Elliot, 1964; Fraser, 1964; Goldring, 1962; Hamer and Hyden, 1984; Hooper, 1962; Marsh, 1968; Moyes, 1985; Singleton, 1980; Smith, 1977; Storey, 1983; Stubbs, 1968; West, 1974) are given in Fig. 2 and plotted according to the IUGS classification (Streckeisen, 1973). South Georgia samples are dominated by gabbronorite, olivine gabbronorite and leuco-pyroxene-hornblende gabbronorite, with minor mela-gabbronorite, troctolite and more ultrabasic varieties. Antarctic Peninsula samples are commonly leuco-gabbronorite and leuco-pyroxene-hornblende gabbronorite, with hornblende gabbronorite becoming increasingly important from west to east (i.e. away from the trench); the alkali gabbros, which contain olivine, are mainly leuco-gabbro with lesser amounts of leuco-olivine gabbronorite.

Microprobe data were obtained from 36 representative samples (12 South Georgia; 16 west coast; 8 east coast) using an energy-dispersive electron probe built and housed at the Department of Earth Sciences, Cambridge University. A total of 895 analyses have been obtained from all the major rock-forming minerals, and representative analyses are given in Tables I–VI. Data for the alkali gabbros are given in Hamer and Hyden (1984).

Table I. Representative olivine analyses.

	South Georgia			West coast		
	1	2	3	4	5	6
SiO_2	38.54	38.57	37.61	39.46	38.56	37.23
FeO*	21.76	23.78	27.59	17.27	21.98	29.57
MnO	0.27	0.32	0.32	0.23	0.35	0.34
MgO	38.92	37.62	34.72	43.12	39.23	33.41
CaO	0.21	0.29	0.11			
NiO	0.14					
Total	99.84	100.58	100.35	100.07	100.12	100.55
Cations on the basis of 4 *oxygens*						
Si	1.002	1.004	1.000	1.000	1.000	0.998
Fe	0.473	0.518	0.613	0.366	0.477	0.663
Mn	0.006	0.007	0.007	0.005	0.008	0.008
Mg	1.508	1.459	1.376	1.629	1.516	1.334
Ca	0.006	0.008	0.003			
Ni	0.003					
Total	2.998	2.996	2.999	3.000	3.001	3.003
% Fo	75.9	73.5	68.9	81.5	75.8	66.5

* Total Fe as FeO.

1, M.4177.15, olivine gabbro; 2, M.2174.17, olivine gabbro; 3, M.2053, gabbro; 4, KG.572.2, peridotite; 5, R.1252.1, leuco-hornblende gabbronorite; 6, KG.570.3, olivine gabbro.

Olivine

Olivine which is found only in the South Georgia and west coast samples occurs as subhedral crystals often poikilitically enclosed by clinopyroxene and amphibole. It often has a reaction corona of orthopyroxene or amphibole and varies in composition from Fo_{86} to Fo_{64} (Table I and Fig. 3). There is no geographic distinction between samples. There appears to be a compositional gap between Fo_{75-68}, although this may be due to sampling bias. The alkali gabbros contain olivine with the lowest fosterite content (Fo_{50-54}).

Orthopyroxene

Orthopyroxene is found as subhedral or anhedral crystals with a distinctive reddish-brown colour and faint pleochroism. It is either bronzite or hypersthene (Table II and Fig. 3) and varies towards more Fe-rich varieties in east coast samples, where altered crystals of ferro-hypersthene occur in one sample. South Georgia samples have a compositional gap (as with olivine), which again may be due to restricted sampling.

Clinopyroxene

Clinopyroxene occurs as unzoned anhedral crystals commonly poikilitically enclosing plagioclase. It does not show any marked compositional trends, but the most Mg- and Ca-rich varieties occur in South Georgia gabbronorites, and the most Fe-enriched in east coast samples (Table III and Fig. 3). Clinopyroxene compositions from South Georgia are dominantly diopside or salite, whereas those from the east coast are augite. The alkali gabbros from the Danger Islands contain augite or salite

Table II. Representative orthopyroxene analyses.

	South Georgia			*West coast*			*East coast*		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
SiO_2	54.66	54.91	53.61	54.62	53.32	53.66	54.14	53.67	52.86
TiO_2	0.28	0.12	0.23	0.22	0.26	0.29	0.38	0.29	0.36
Al_2O_3	1.66	1.86	1.79	1.75	1.67	1.41	1.31	1.22	0.87
FeO*	13.37	15.12	17.87	14.64	17.53	21.06	16.13	19.48	23.52
MnO	0.23	0.22	0.29	0.43	0.41	0.43	0.32	0.28	0.51
MgO	28.45	27.64	24.65	27.08	24.69	21.45	25.92	23.31	20.70
CaO	1.35	1.03	1.44	1.34	1.84	1.75	1.58	1.83	1.63
Cr_2O_3	0.24	—	0.15	—	—	—	—	0.16	—
Total	100.24	100.90	100.03	100.08	99.82	100.05	99.78	100.24	100.45
				Cations on the basis of 6 oxygens					
Si	1.950	1.956	1.957	1.962	1.953	1.987	1.966	1.971	1.976
Al	0.070	0.078	0.077	0.074	0.072	0.061	0.056	0.053	0.038
Ti	0.008	0.003	0.006	0.006	0.007	0.008	0.010	0.008	0.010
Cr	0.007	—	0.004	—	—	—	—	0.005	—
Fe	0.399	0.450	0.545	0.440	0.540	0.652	0.490	0.598	0.735
Mn	0.007	0.007	0.009	0.013	0.013	0.013	0.010	0.009	0.016
Mg	1.513	1.468	1.341	1.449	1.347	1.184	1.402	1.276	1.253
Ca	0.052	0.039	0.056	0.052	0.072	0.069	0.061	0.072	0.065
Total	4.006	4.001	3.995	3.996	4.004	3.974	3.995	3.992	3.993
Mol % Mg	76.8	74.8	68.7	74.2	68.3	61.7	71.4	65.3	58.6
Ca	2.6	2.0	2.9	2.7	3.7	3.6	3.1	3.7	3.3
Fe+Mn	20.6	23.2	28.4	23.1	28.0	34.7	25.5	31.0	38.1

* Total Fe as FeO.

1, Bronzite, M.2149.6A, olivine gabbronorite; 2, Bronzite, M.4177.1, gabbronorite; 3, Bronzite, M.4140.9, olivine gabbronorite; 4, Bronzite, R.1242.2, leuco-hornblende norite; 5, Bronzite, leuco-pyroxene-hornblende gabbronorite; 6, Hypersthene, R.1491.1, leuco-gabbronorite; 7, Bronzite, R.1139.1, gabbronorite; 8, Hypersthene, R.1199.1, gabbronorite; 9, Hypersthene, R.1203.1, gabboronorite.

(Hamer and Hyden, 1984) and are essentially similar to other east coast gabbros, whereas the Adie Inlet gabbro has only diopside.

Plagioclase

Plagioclase compositions fall into two distinct groups – South Georgia and some west coast gabbros contain unzoned plagioclase of An_{95-85} (anorthite or bytownite) whereas the east coast and remaining west coast samples contain plagioclase of $<An_{80}$ (Fig. 4). The group of less calcic compositions can be divided further into west coast samples which have An_{75-50} (bytownite-labradorite) and east coast samples (including the alkali-rich gabbros) which contain dominantly An_{65-45} (labradorite-andesine). In both cases, the plagioclase may be significantly zoned, varying from core to rim by as much as 15 mol % An.

Amphibole

Amphibole compositions have been classified according to IMA recommendations (Leake, 1978), and formulae recalculated on the basis of 13 cations exclusive of Ca,

Table III. Representative clinopyroxene analyses.

	South Georgia			West coast			East coast		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
SiO_2	52.33	52.17	52.01	53.20	51.97	52.43	52.22	52.71	52.19
TiO_2	0.35	0.49	0.55	0.27	0.60	0.62	0.18	0.55	0.34
Al_2O_3	3.13	2.67	2.79	1.58	2.70	1.99	1.16	1.63	1.20
FeO*	6.28	6.80	9.46	6.23	8.92	10.27	8.69	9.96	11.69
MnO	0.15	0.15	0.23	0.21	0.27	0.25	0.79	0.18	0.22
MgO	14.09	16.12	14.84	15.02	14.51	15.09	13.27	14.10	13.12
CaO	23.49	21.06	19.93	23.22	20.48	19.25	22.35	20.34	21.01
Cr_2O_3	0.51	0.20	0.31	0.15	0.23	0.18	—	—	—
Total	100.33	99.66	100.12	99.88	99.68	100.08	98.66	99.47	99.77
				Cations on the basis of 6 oxygens					
Si	1.928	1.927	1.929	1.965	1.935	1.943	1.978	1.971	1.969
Al	0.136	0.116	0.122	0.069	0.119	0.087	0.052	0.071	0.053
Ti	0.010	0.014	0.015	0.007	0.017	0.017	0.005	0.016	0.010
Cr	0.015	0.006	0.009	0.004	0.007	0.005	—	—	—
Fe	0.193	0.210	0.294	0.193	0.278	0.318	0.275	0.312	0.369
Mn	0.005	0.005	0.007	0.007	0.009	0.008	0.025	0.006	0.007
Mg	0.774	0.887	0.821	0.827	0.805	0.833	0.749	0.786	0.737
Ca	0.927	0.834	0.792	0.919	0.817	0.765	0.907	0.815	0.849
Total	3.988	3.999	3.989	3.991	3.987	3.976	3.991	3.977	3.994
Mol % Mg	40.8	45.8	42.9	42.5	42.2	43.3	38.5	40.9	37.6
Ca	48.8	43.1	41.4	47.2	42.8	39.8	46.6	42.5	43.3
Fe+Mn	10.4	11.1	15.7	10.3	15.0	16.9	14.9	16.6	19.2

* Total Fe as FeO.

1, Salite, M.2149.1, gabbro; 2, Salite, M.2174.17, olivine gabbro; 3, Augite, M.4140.9, olivine gabbronorite; 4, Salite, P.419.3, olivine gabbro; 5, Augite, R.1491.1, leuco-gabbronorite; 6, Augite, R.1486.1, leuco-olivine gabbronorite; 7, Salite, E.3269.1, gabbro; 8, Augite, R.1144.1, gabbronorite; 9, Augite R.1203.1, gabbronorite.

Na and K. All the amphibole examined is calcic in composition, and two groups may be identified both optically and chemically (Table IV and Fig. 5).

The first occurs commonly in South Georgia and west coast samples and in some east coast samples, and forms large poikilitic, intercumulus crystals enclosing plagioclase and olivine. It has a distinctive red-brown colour (although zoning to a green rim can occur) and is Al-rich in composition. In South Georgia and the west coast rocks it is tschermakite, tschermakitic hornblende or magnesio-hastingsitic hornblende whereas in east coast samples it is a more Fe-rich ferro-tschermakitic hornblende and ferro-hornblende. The second variety is more common in east coast samples, and typically has a yellowish- to olive-green pleochroism, higher birefringence, and commonly occurs as a clinopyroxene reaction product. It is magnesio-hornblende in composition, with less abundant actinolitic hornblende or actinolite, the latter probably being secondary in origin (Fig. 5). There is a marked tendency for this group to show lower Al contents in east coast samples, although some are transitional towards ferro-tschermakitic hornblende (see Fig. 5).

A plot of Ti versus Al^{iv} indicates that there is an overall trend of decreasing Ti with decreasing Al^{iv} (Fig. 6) and, in addition, a significant variation in the Ti content, at constant Al^{iv} content between brown core and green rim compositions of some samples. Very low Ti contents may be attributed to control by whole-rock

Table IV. Representative amphibole analyses.

	South Georgia			*West coast*			*East coast*		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
SiO_2	43.11	43.87	50.09	43.17	43.11	50.40	42.45	43.62	45.72
TiO_2	2.19	2.18	0.64	3.06	3.15	1.20	2.44	1.95	1.44
Al_2O_3	12.72	12.48	6.97	11.50	10.96	4.74	10.05	9.01	8.86
FeO*	8.36	9.82	11.24	10.78	10.38	11.35	21.64	22.96	15.56
MnO	—	—	—	0.13	0.17	0.20	0.18	0.25	0.37
MgO	15.80	14.27	16.21	14.04	15.25	15.82	7.21	7.21	11.76
CaO	12.25	12.50	11.95	11.74	11.20	11.58	11.39	10.96	11.97
Cr_2O_3	0.52	0.30	0.19	—	0.13	—	—	—	—
Total	97.62	97.34	98.15	97.36	97.02	98.05	97.86	98.22	97.72
	13 cations on the basis of 23 oxygens, exclusive of Ca, Na and K								
Si	6.179	6.341	7.040	6.300	6.224	7.175	6.483	6.604	6.747
Al^{iv}	1.821	1.659	0.960	1.700	1.776	0.825	1.517	1.396	1.[illegible]
Al^{vi}	0.329	0.467	0.194	0.279	0.090	0.138	0.292	0.213	0.288
Cr	0.059	0.035	0.022	0.004	0.015	—	—	—	—
Fe^{3+}	0.193	0.210	0.294	0.193	0.278	0.318	0.275	0.312	0.369
Mg	3.375	3.073	3.396	3.054	3.281	3.357	1.641	1.627	2.586
Fe^{2+}	0.486	0.881	0.536	1.004	0.455	0.911	2.451	2.238	1.550
Mn	—	—	—	0.016	0.020	0.024	0.023	0.032	0.046
Ca	1.882	1.935	1.800	1.836	1.732	1.767	1.863	1.778	1.893
Na^B	0.118	0.065	0.200	0.164	0.268	0.233	0.137	0.222	0.107
Na^A	0.454	0.379	0.009	0.477	0.412	0.164	0.273	0.140	0.203
K	0.112	0.063	0.016	0.126	0.045	0.057	0.216	0.198	0.181
Total	15.565	15.441	15.026	15.603	15.458	15.221	15.489	15.339	15.385
$Mg/(Mg+Fe^{2+})$	0.87	0.78	0.86	0.75	0.88	0.79	0.40	0.42	0.63

* Total Fe as FeO.

1, Magnesio-hastingsite, M.2149.6A, olivine gabbronorite; 2, Tschermakitic hornblende, M.2174.17, olivine gabbro; 3, Magnesio-hornblende, M.4140.4, gabbronorite; 4, Magnesio-hastingsitic hornblende, P.419.3, gabbro; 5, Tschermakite, R.1242.1, leuco-hornblende norite; 6, Magnesio-hornblende, R.1455.1, gabbronorite; 7, Ferro-tschermakitic hornblende, E.3293.1, gabbro; 8, Ferro-hornblende, E.3293.1, gabbro; 9, Magnesio-hornblende, E.3269.1, gabbro.

composition in some samples (such as peridotite) but the colour zoning probably reflects crystallization under near-isobaric conditions, the Ti content of amphibole being temperature sensitive (see Leake, 1965, 1968; Raase, 1974). Fig. 6 also indicates that amphibole from east coast rocks is generally less Al- and Ti-rich than that from other localities.

Mica

Biotite (*sensu lato*), which is also found occasionally as anhedral interstitial crystals, has a limited range of Si values from 5.5 to 5.7 cations per unit formula but shows a moderate variation in Fe/(Fe+Mg) ratios (Fe*) (Table V). The mica from South Georgia and the west coast (with the exception of one sample) is mainly phlogopite (Fe* <0.33), whereas that from the east coast is biotite (Fe* >0.33). Comparison of the data indicates that Ti varies sympathetically with increasing Fe* ratio, east coast biotite being enriched in Ti and having higher Fe* ratios.

Table V. Representative mica analyses.

	South Georgia	West coast	East coast	
	1	*2*	*3*	*4*
SiO_2	36.74	37.69	36.13	34.02
TiO_2	2.10	4.11	06.20	3.76
Al_2O_3	15.98	14.24	14.19	14.54
FeO*	10.54	11.91	16.58	25.20
MnO	0.11	—	—	0.13
MgO	17.47	17.16	13.67	6.89
CaO	0.66	—	0.18	0.23
K_2O	6.94	8.47	8.79	8.85
Cl	0.16	0.15	0.14	—
Total	90.70	93.73	95.88	
	Cations on the basis of 22 oxygens			
Si	5.575	5.615	5.418	5.473
Al^{iv}	2.425	2.385	2.509	2.527
Al^{vi}	0.434	0.115	—	0.231
Ti	0.240	0.460	0.699	0.455
Fe	1.337	1.484	2.079	3.391
Mn	0.014	—	—	0.017
Mg	3.951	3.811	3.054	1.652
Ca	0.107	—	0.029	0.040
K	1.343	1.611	1.682	1.817
Cl	0.041	0.038	0.036	—
Total	15.467	15.519	15.506	15.603
Fe/(Fe+Mg)	0.25	0.28	0.41	0.67

* Total Fe as FeO.

1, Phlogopite, M.2053, gabbro; 2, Phlogopite, R.1242.1, leuco-hornblende norite; 3, Biotite, R.1139.1, gabbro; 4, Biotite, E.3293.1, gabbro.

Opaque phases

Opaque phases vary considerably in modal abundance, commonly from <2% up to (rarely) 15%, higher modal contents being typical of west coast samples. The opaque phase forms both anhedral equidimensional crystals included in pyroxenes and amphibole, and as a reaction product from olivine and orthopyroxene.

Compared to the minerals discussed above, the opaque phases display the clearest compositional distinction between the geographical areas studied. Gabbros from South Georgia commonly contain pyrite, less commonly magnetite and chalcopyrite, and rarely Cr-spinel and ilmenite (Table VI). West coast samples are dominated by magnetite/titanomagnetite with lesser ilmenite and Cr-spinel (in peridotite), whereas east coast samples principally have ilmenite with lesser magnetite (Table VI). The rarity of Cr-spinel precludes detailed discussion, but there is an apparent trend from Mg-Al-rich compositions (South Georgia) towards Fe^{3+}-Ti-rich compositions (west coast). The latter appear to be essentially similar to 'basalt trend 2' of Haggerty (1976) and characteristic of island-arc magmatism, whereas the former may also be found in mid-ocean ridge basalts.

Table VI. Representative spinel analyses.

	South Georgia		*West coast*			*East coast*	
	1	*2*	*3*	*4*	*5*	*6*	*7*
SiO_2	1.12	0.67	0.97	1.57	1.30	1.38	1.04
Al_2O_3	0.58	0.84	12.43	1.59	0.59	0.64	0.20
TiO_2	0.43	0.71	1.31	0.81	45.13	2.34	48.18
Cr_2O_3	4.26	1.42	22.80	0.23	–	1.63	0.19
FeO*	86.58	89.00	54.04	86.89	48.82	86.58	47.77
MnO	0.21	—	0.53	—	1.96	—	2.78
MgO	—	—	4.50	—	0.26	—	—
CaO	0.16	0.13	—	0.18	0.14	0.29	0.13
NiO	—	—	0.21	—	—	—	—
Total	93.34	92.77	96.79	91.27	98.20	92.86	100.29
			6 or 4 cations on the basis of 8 or 6 oxygens				
Si	0.086	0.051	0.067	0.122	0.066	0.106	0.0[illegible]
Al	0.052	0.077	1.009	0.146	0.035	0.058	0.012
Ti	0.025	0.041	0.068	0.048	1.719	0.135	1.810
Cr	0.258	0.086	1.241	0.014	—	0.099	0.007
Fe^{3+}	3.457	3.652	1.480	3.500	0.395	3.360	0.258
Fe^{2+}	2.084	2.082	1.631	2.155	1.674	2.218	1.737
Mn	0.014	—	0.031	—	0.084	—	0.117
Mg	—	—	0.461	—	0.020	—	—
Ca	0.013	0.010	—	0.015	0.007	0.024	0.007
Ni	—	—	0.011	—	—	—	—
Total	6.000	6.000	6.000	6.000	4.000	6.000	4.000

* Total Fe as FeO.

1, Cr-spinel, M.4140.4, gabbronorite; 2, Cr-spinel, M.2053, gabbro; 3, Cr-spinel, KG.572.2, perioditite; 4, Magnetite, R.1456.1, leuco-pyroxene, gabbronorite; 5, Ilmenite, R.1456.1; 6, Magnetite, R.1139.1, gabbro; 7, Ilmenite, R.1139.1.

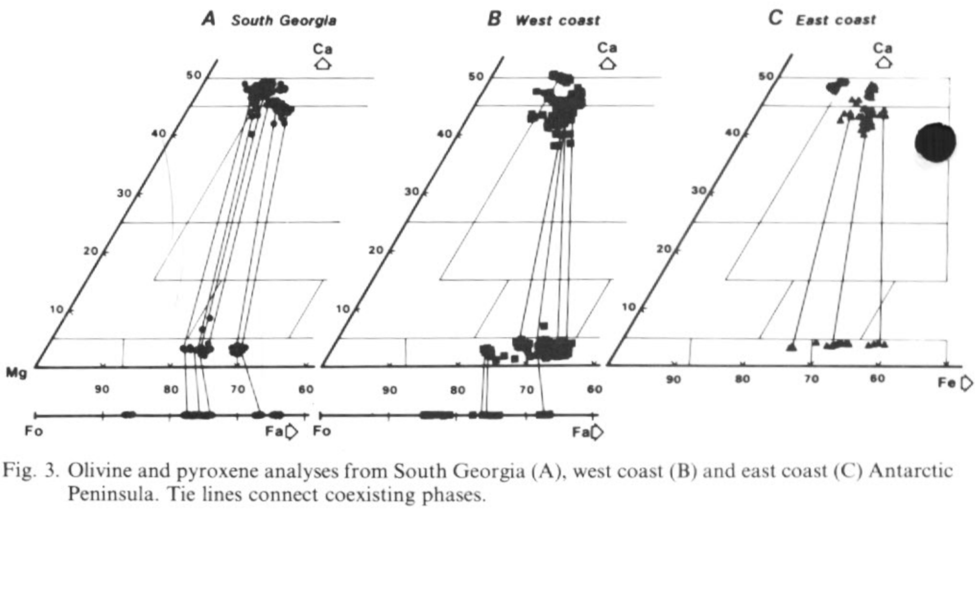


Fig. 3. Olivine and pyroxene analyses from South Georgia (A), west coast (B) and east coast (C) Antarctic Peninsula. Tie lines connect coexisting phases.

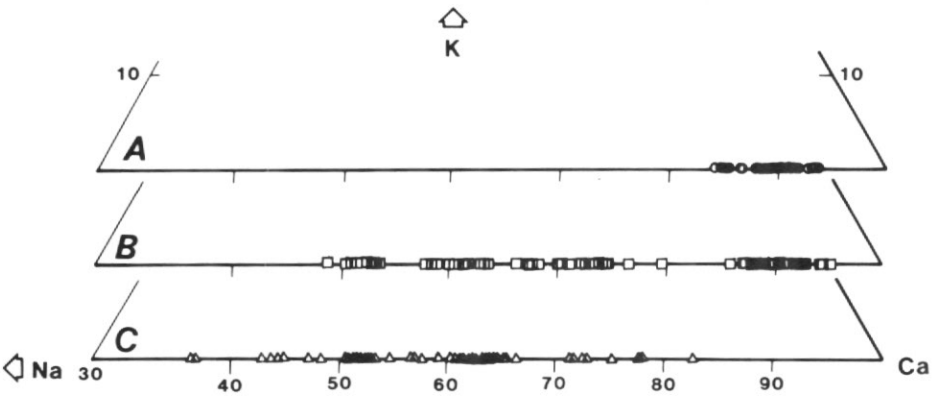


Fig. 4. Plagioclase analyses from South Georgia (A), west coast (B) and east coast (C) Antarctic Peninsula, plotted as molecular proportions.

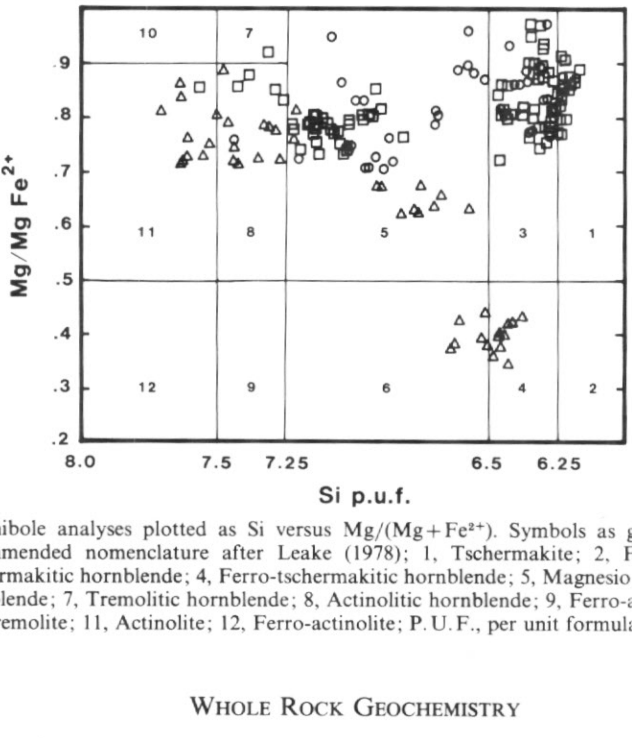


Fig. 5 Amphibole analyses plotted as Si versus $Mg/(Mg+Fe^{2+})$. Symbols as given in Fig. 2. IMA recommended nomenclature after Leake (1978); 1, Tschermakite; 2, Ferro-tschermakite; 3, Tschermakitic hornblende; 4, Ferro-tschermakitic hornblende; 5, Magnesio hornblende; 6, Ferro-hornblende; 7, Tremolitic hornblende; 8, Actinolitic hornblende; 9, Ferro-actinolitic hornblende; 10, Tremolite; 11, Actinolite; 12, Ferro-actinolite; P.U.F., per unit formula.

Whole Rock Geochemistry

Major elements

A compilation of whole-rock geochemical data collated from the literature (Adie, 1955; Davies, 1984; Dewar, 1970; Hamer and Hyden, 1984; Hooper, 1962; Marsh, 1968; Moyes, 1985; Saunders and others, 1982; Singleton, 1980; Smellie and others, 1984; Smith, 1977; Storey, 1983; Stubbs, 1968; and West, 1974) is presented in Table VII and Fig. 7 for a total of 139 gabbroic samples, comprising 48 from South Georgia, 49 from the west coast of the Antarctic Peninsula, 31 from the east coast and 11 alkaline gabbros. The west coast rocks have been sub-divided in Table VII on the basis of their rare earth element (REE) contents, as discussed below.

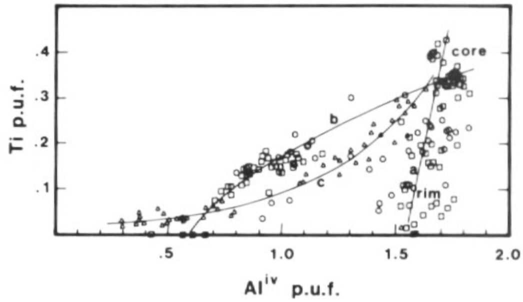


Fig. 6. Amphibole analyses plotted as Al^{iv} versus Ti. symbols as given previously. Trend a = brown core to green rim in Al-rich intercumulus amphibole. Trend b = South Georgia and west coast amphibole. Trend c = east coast amphibole.

Table VII. Comparative whole-rock geochemistry (average values).

		West coast				
Sample area / *Sample No.*	*South Georgia* *48*	*49 (all samples)*	*4 LREE-depleted*	*6 LREE-enriched*	*East coast* *31*	*Alkaline* *11*
SiO_2	46.25	48.08	46.39	47.42	48.68	49.82
TiO_2	0.59	0.81	0.85	0.72	1.13	1.14
Al_2O_3	17.50	18.50	16.25	19.73	18.30	20.33
Fe_2O_3	7.90	9.30	11.36	8.67	10.25	6.58
MnO	0.03	0.13	0.18	0.18	0.15	0.13
MgO	9.83	7.44	10.36	7.70	7.36	3.88
CaO	13.54	11.28	12.27	10.84	10.72	9.78
Na_2O	1.64	2.34	1.67	2.14	2.77	4.34
K_2O	0.19	0.60	0.18	0.43	0.82	0.73
P_2O_5	0.05	0.12	0.05	0.11	0.21	0.20

The AFM diagram (Fig. 7) illustrates that there is a large variation in the concentration of major elements within the gabbro suite. The South Georgia gabbros are enriched in magnesium whereas the Antarctic Peninsula gabbros show both iron and magnesium enrichment trends. Most gabbro samples are tholeiitic on a plot of Fe/Mg versus SiO_2 (defined by Miyashiro, 1974), but straddle the calc-alkaline to tholeiitic boundary on a plot against total Fe. Ti is the only element which correlates with Fe/Mg ratio, increasing with increasing Fe/Mg ratio (Fig. 8). A comparison of the different gabbro suites (Table VII) indicates a progressive change in the concentration of the major elements in the sequence South Georgia–west coast–east coast. Gabbros from South Georgia are more 'primitive' in composition and are poorer in SiO_2, TiO_2, total Fe, Na_2O, K_2O and P_2O_5 compared to east coast samples, and richer only in MgO and CaO. The alkaline gabbros are essentially similar to other east coast samples, but with substantially lower contents of MgO and Fe_2O_3, and higher contents of Na_2O and Al_2O_3 (Table VII). They plot within the alkaline field of Irvine and Barager (1971), although those from Adie Inlet appear transitional towards the subalkaline field. The west coast gabbros as a whole are transitional between South Georgia and east coast samples, but the two REE-defined subgroups are distinct from each other (see Table VII). With the exception of TiO_2 and Fe_2O_3 the light REE-depleted rocks are similar to the South Georgia rocks and the light REE-enriched rocks to the east coast gabbros.

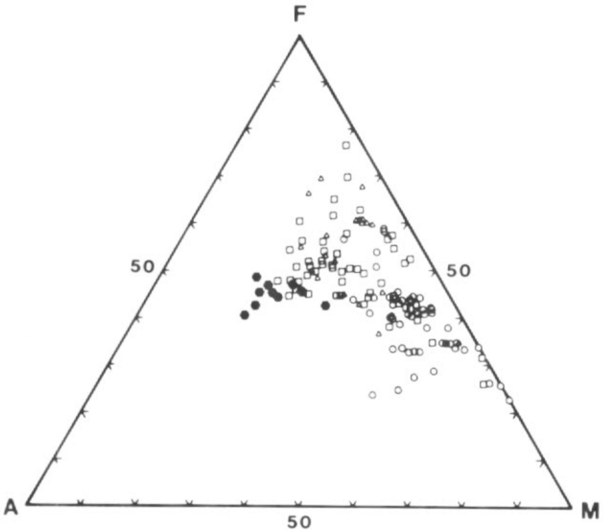


Fig. 7. AFM plot for gabbroic rocks. Symbols as given for Fig. 2.

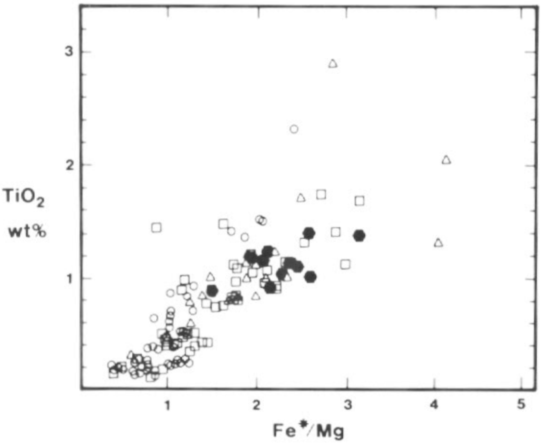


Fig. 8. Variation of whole rock TiO_2 contents with total Fe/Mg (molecular proportions). Symbols as given for Fig. 2.

Trace Elements

The variation in trace element and selected major and rare earth element abundances between the major gabbro groups is presented in Fig. 9 using mantle-normalized values of Pearce (1980). All the gabbros are enriched in the large ion lithophile (LIL) elements relative to the high field strength elements, and show a progressive increase in the concentration of all elements except Cr (and Ni) in the sequence South Georgia–west coast–east coast. The South Georgia and west coast samples are particularly enriched in Cr relative to the east coast samples as reflected in their higher modal proportions of olivine, clinopyroxene and Cr-spinel. The east coast gabbros have higher abundances of Sr, K, Rb and Ba and have a relative Nb depletion. The

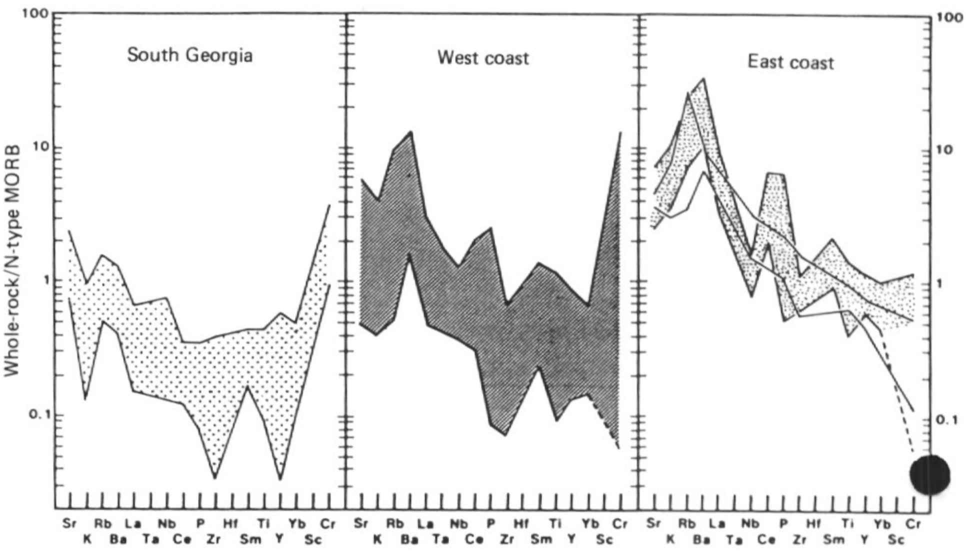


Fig. 9. Normalized trace element data for selected symbols. Normalizing values and element order taken from Pearce (1980). East coast samples with alkaline affinities shown separately (unshaded) from other east coast samples (shaded).

alkali gabbros are essentially similar to the east coast gabbros; on average they contain lower abundances of most elements but are markedly enriched in Nb and Zr.

Rare Earth Elements (*REE*)

A total of 29 specimens were analysed for REE content (Table VIII) using either instrumental neutron activation analysis (utilizing irradiation facilities at the University of London Reactor Centre and counting facilities at Goldsmiths College and Bedford College) or plasma-source spectroscopy (utilizing facilities at Kings College, University of London). Comparison of the different methods was achieved by duplicate analysis and agreement was found to be within 10%, neutron activation analysis giving slightly higher values. The analyses are plotted in Fig. 10, using chondrite-normalizing values of Evensen and others (1978), and two groups of REE pattern are distinguished: Group 1. Generally flat REE pattern. Group 2. Light REE (LREE)-enriched pattern.

Group 1 has neither light REE (LREE) nor heavy REE (HREE) enrichment, and a variable degree of Eu enrichment (Fig. 10). These patterns are typical of South Georgia and some west coast samples.

Group 2 may be subdivided into two on the basis of HREE contents:

(*a*) LREE-enriched patterns, with variable degrees of Eu enrichment or depletion, and with high ΣREE contents compared to group 1 (Fig. 10). These patterns are typical of east coast and some west coast samples, and the alkaline gabbros. Two samples from the Danger Islands alkali gabbro have significantly larger Eu-enrichment than observed in the majority of samples.

(*b*) Middle REE (MREE, Sm-Ho)-depleted patterns, but otherwise similar to group 2(*a*) (Fig. 10).

Table VIII. Representative REE analyses.

	South Georgia		*West coast*		*East coast*
	1	*2*	*3*	*4*	*5*
La	1.00	1.16	1.57	9.24	27.61
Ce	2.01	2.42	3.10	20.15	65.25
Pr	0.31	0.32	0.52	2.90	8.22
Nd	1.72	1.94	2.08	11.80	30.88
Sm	0.62	0.70	0.79	2.72	6.54
Eu	0.26	0.26	0.18	1.09	1.94
Gd	0.61	0.67	0.70	2.31	6.30
Dy	0.78	0.81	0.73	2.04	5.99
Ho	0.18	0.19	0.23	0.49	1.24
Er	0.50	0.53	0.78	1.39	3.59
Yb	0.49	0.47	0.56	1.08	3.28
Lu	0.08	0.08	0.11	0.20	0.55

M.4177.1; 2, M.4137.15; 3, KG.572.2; 4, KG.1207.4; 5,E.3293.1.

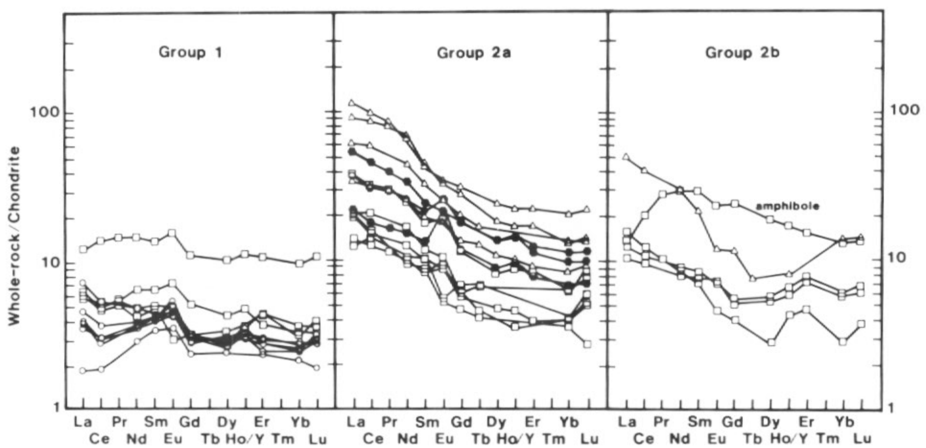


Fig. 10. Chrondrite-normalized REE data, chrondrite values from Evensen and others (1978). See text for discussion. Symbols as given for Fig. 2.

SUMMARY

The petrography, mineral and whole-rock chemistry of the gabbros indicate: (i) there are some mineralogical and chemical similarities between the extensional back-arc basin gabbros of South Georgia and some of the gabbros within the west coast province of the Antarctic Peninsula and (ii) there are some mineralogical differences between the west and east coast provinces of the Antarctic Peninsula arc. The South Georgia and west coast gabbros are controlled by crystallization of clinopyroxene, orthopyroxene and olivine whereas amphibole is the most abundant ferromagnesian mineral in the east coast province and olivine is absent. South Georgia and west coast samples contain the most Mg-rich mineral compositions whereas the east coast rocks are more enriched in Fe and Ti; sulphides are the dominant opaque phase on South Georgia, magnetite on the west coast and ilmenite on the east coast.

All the gabbros are enriched in LIL elements; the South Georgia rocks are the most primitive and there is a progressive increase in the concentration of most elements in the sequence South Georgia–west coast–east coast. The alkali gabbros are relatively enriched in Na_2O, K_2O, Nb and Zr. The most significant variation, however, is in the REE; the South Georgia gabbros and some of the west coast (group 1) have a flat REE pattern whereas the remainder are enriched in LREE and have higher ΣREE abundances. Although the age control on most plutons is lacking the initial $^{87}Sr/^{86}Sr$ ratio varies geographically, being generally <0.7038 on the west coast and >0.7040 on the east (Pankhurst, 1982).

Discussion

The mineralogical and chemical variations within the gabbros may be due to either initial differences in parental magma composition or to subsequent modification of a single parent magma type by mixing of different magma phases, assimilation, or fractionation. Many of the observed chemical variations are compatible with differentiation of a single magma source, the South Georgia and west coast gabbros being the most primitive and the east coast gabbros the most evolved. However, the two distinctive REE patterns and particularly the lack of intermediate REE patterns between the two groups, suggest that more than one magma type was involved. Different degrees of fractionation may result in much of the variation in ΣREE contents within each group but cannot account entirely for other chemical trends. For example, the east coast gabbros contain higher concentrations of all trace elements (except for Cr and Ni), not only those of an 'incompatible' nature. Also, comparison between samples at equivalent SiO_2 contents or Fe/Mg ratios indicate that the REE groups remain distinctive. There is no apparent relationship between the REE pattern and variations in the modal mineralogy, except for the generalizations noted above, namely that olivine is absent, and amphibole more abundant, in east coast samples. Differences in the proportion of 'trapped, interstitial liquid' (the degree of compaction) may cause variations within each group, but are also considered unlikely as the prime source of both mineralogical and chemical differences between both groups. The enrichment of the group 2 gabbros in the REE and the LIL elements is typical of convergent margin arcs such as the Aleutian arc (Perfit and others, 1980; Kay and others, 1982, 1983) and is widely attributed to material derived from the dehydration of the subducted oceanic crust and added to the overlying mantle wedge. Variation in the amount of this subduction component may give rise to the observed chemical changes, the parental magmas for group 1 gabbros containing a smaller proportion of this dehydration component. The REE patterns of group 1 gabbros are more LREE-enriched than ocean-floor basalts and are similar to those observed in gabbroic rocks associated with marginal basins (Saunders and others, 1979; Stern, 1979; Bodinier and others, 1981). They may be derived from a mantle previously enriched in incompatible elements during subduction but emplaced during an extensional phase of arc development (e.g. formation of a back or intra-arc basin).

The mineralogical variations between the east (amphibole gabbros) and west coast (olivine-pyroxene gabbronorites) gabbros within the Antarctic Peninsula may be controlled by different physical conditions of magmatic evolution; in the gabbros of the west coast these may be superimposed on magmas of different initial composition. The amphibole gabbros from the east coast are the most evolved, were generated farthest from the trench, crystallized from a more hydrous magma, are associated with thicker subcontinental lithosphere and may have involved assimilation of crustal material (higher initial $^{87}Sr/^{86}Sr$ ratio). The olivine-pyroxene gabbros, on the other hand are more primitive, less hydrous, reached higher levels in the crust and avoided significant interaction with pre-existing continental crust. The change in opaque phase from magnetite to limenite from west to east across the arc may indicate that fO_2 conditions also varied; magnetite crystallizes under relatively higher fO_2 conditions which may be due to the higher level of intrusion. Smith and others (1983), in a study of plutonic rocks within the Peninsula Ranges batholith, a typical cordillera-type convergent margin magmatic arc, concluded that the mafic rocks were not related by fractionation to the granitic rocks and that an olivine-pyroxene gabbronorite series (South Georgia and west coast) and an amphibole gabbro series (east coast) were cogenetic and formed by crystal accumulation and *in situ* differentiation of a parental hydrous high Al basaltic melt. Kay and others (1983) in a study of the Aleutian arc also concluded that tholeiitic and calc-alkaline fractionation trends can be derived from the same parental magma and that the different fractionation trends are due to different physical conditions in the crust during magmatic evolution; the tholeiitic trends formed during an extensional or strike slip regime whereas the calc-alkaline magmas involve more mixing of different magma phases within a compressional stress regime. In the same way, the olivine-pyroxene gabbros typical of South Georgia and the west coast localities may reflect an extensional phase of arc development whereas the slightly more evolved, amphibole-gabbros may have crystallized during a compressional phase. The presence of both types of gabbros within the west coast zone of the Antarctic Peninsula supports this conclusion.

The alkaline gabbros of the east coast are similar to group 2 but have higher Na_2O, K_2O, Nb and Zr contents. Although they may simply reflect increasing distance from the trench, the fact that they occur close to the eastern margin of the bordering Weddell Sea (Fig. 1), and were emplaced within the same period (80–90 Ma) may be tectonically significant. Alkaline rocks are characteristic of anorogenic, intraplate extensional environments (Sorensen, 1974) and these rocks may represent an anorogenic period during arc development following mid-Cretaceous closure of the back-arc basin and uplift of the arc in southern South America (Dalziel, 1981) and the Antarctic Peninsula. Alternatively, they may be related to extension within the Weddell Sea basin.

Conclusions

The chemical differences between the gabbros emplaced in the extensional back-arc basin environment (group 1) and the Andean-type magmatic arc of the Antarctic Peninsula (group 2) suggests the gabbros were derived from different parental magmas and that composition was controlled by tectonic features in the crust. In the extensional stress system there was less influence of the subducting slab than in the compressional phase of arc development reflected by lower concentrations of LIL elements and LREE. The presence of some gabbros in the Antarctic Peninsula similar to those found in South Georgia suggests that extensional phase or phases of arc development may have been important in the Antarctic Peninsula. This is supported by the mineralogical differences between the east and west coast gabbros. The alkali gabbros may represent an anorogenic phase of arc development.

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