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Composition of plagioclases in volcanic rocks of King George Island, Antarctica with reference to the petrogenetic significance

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Abstract Plagioclases occur mainly as phenocrysts in volcanic rocks of King George Island, South Shetland Islands, West Antarctica. In basaltic andesites and andesites of Keller Peninsula and Ullman Spur (Admiralty Bay), they are high structure state labradorite-andesines; and in high-Al basalts and basaltic andesites of Barton and Weaver peninsulas (Maxwell Bay), they are high structure state bytownite-anorthites. ΣREE, La/Yb ratios and δEu values of plagioclases from Admiralty Bay are higher than those from Maxwell Bay. All plagioclases have rather identical chondrite-normalized transitional element distribution patterns, probably reflecting that crystal structure rather than composition of plagioclase controls their diversity. Compositions of plagioclases depend chiefly on those of their host rocks, compositional differences of plagioclases reveal that basaltic magmas in the Admiralty Bay area are more evolved than in the Maxwell Bay area.
Key words composition of plagioclases, volcanic rocks, King George Island, Antarctica.

1 Introduction

King George Island is the largest island in the South Shetland Islands, West Antarctica, where the Tertiary volcanic rocks outcrop in most of the island. Different volcanic rocks have evident genetic relationship, and they tend to be younger and more evolved from SW to NE along the Island. In contrast with many other studies such as stratigraphy, petrology and geochemistry (Hawkes 1961; Barton 1965; Birkenmajer *et al*. 1985, 1991; Weaver *et al*. 1982; Davies 1982; Watts 1982; Pankhurst and Smellie 1983; Smellie *et al*. 1984; Barbieri *et al*. 1989; Zheng and Liu 1989; Li *et al*. 1992; Jin *et al*. 1992), the study on minerals of volcanic rocks is so far little made.

Plagioclases are major rock-forming minerals of volcanic rocks and occur mainly as phenocrysts. The studied plagioclase samples are from Keller Peninsula and Ullman (Admiralty Bay of central Island), Barton and Weaver peninsulas (Maxwell Bay in the SW of Island) (Fig. 1). They have been selected on the base of observing sections and chemical analysis of their host rocks to assure them fresh. Separated plagioclases are arranged to determine their structure state, major element, REE and trace element abundances by different methods such as X-ray powder diffraction, eletron microprobe, chemical analysis and neutron activation. After that, petrogenetic significance of various plagioclases is discussed.

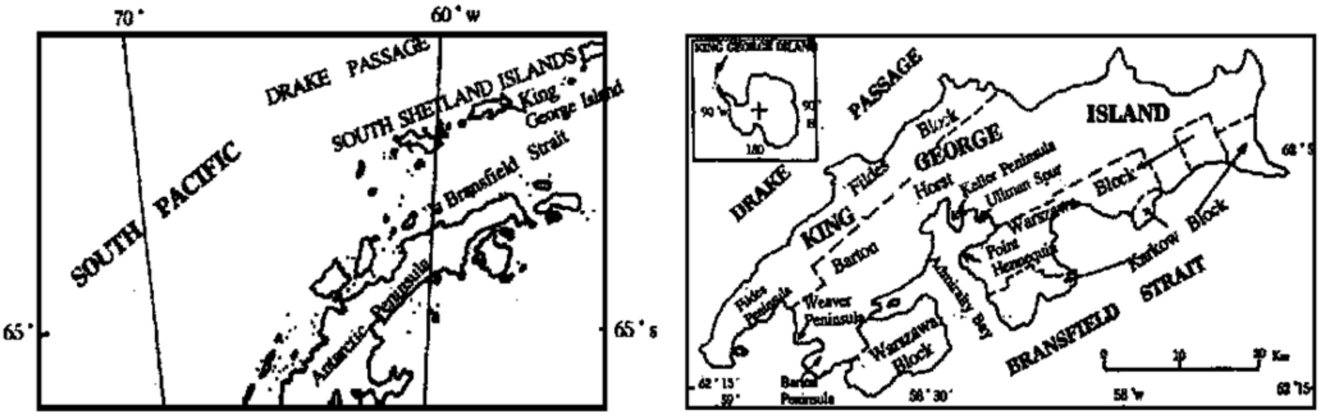

Fig. 1. Location of the study area.

2 Geological setting

King George Island is composed mainly of island arc mantle-derived volcanic rocks in which basalts are predominant, basaltic andesites and andesites are secondary, and dacites are sparse (Table 1 and Fig. 2). Volcanic rocks include lavas and pyroclastic rocks (volcanic agglomerate, breccia and tuff, etc.). Most lavas have porphyritic texture, their groundmasses develop microcrystalline, hypocrystalline-porphyritic and cryptocrystalline textures. On Keller Peninsula and Ullman Spur of the Admiralty Bay, there outcrops a suite of volcanics consisting of high-Al basalt-basaltic andesite-andesite-dacite; on both Barton and Weaver Peninsulas of the Maxwell Bay, there occur high-Al basalt-basaltic andesite-andesite but dacite is lacking. Plagioclases are dominant phenocrysts in porphyritic lavas. A few plagioclases with megaphenocrysts up to 1 – 2 cm long are seen in high-Al basalts from both Barton and Weaver Peninsulas. Most of plagioclase phenocrysts or megaphenocrysts are euhedral to subeuhedral and often show obvious zoning and twining texture. In addition, Fildes Peninsula in the northwestern part of King George Island also has a suite of rocks composed of high-Al basalt to dacite. Some plagioclase data of Fildes Peninsula are quoted later for discussion.

Table 1. Chemical compositions of studied volcanic rocks from King George Island (wt%)

Sample	Rock	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O^+	CO_2	SO_3	F	Cl	Total
Keller Peninsula																		
KI-9	high-Al basalt	48.78	1.04	17.52	3.32	5.83	0.20	4.62	8.54	2.80	0.18	0.38	3.46	2.24	0.012	0.024	0.0020	99.15
KI-38	basaltic andesite	53.24	0.82	18.23	3.44	4.64	0.15	4.33	6.92	3.48	0.35	0.25	2.61	0.85	0.012	0.031	0.0036	99.36
KI-45	basaltic andesite	51.19	0.66	19.05	2.70	3.49	0.28	2.47	8.15	2.94	0.48	0.22	3.82	3.90	0.007	0.010	0.0064	99.37
KW-11	basaltic andesite	53.66	0.77	18.16	3.71	4.65	0.18	5.09	6.35	3.82	0.49	0.24	2.54	0.38	0.010	0.030	0.023	99.11
KW-67	basaltic andesite	52.42	0.53	18.61	2.92	4.05	0.14	4.11	7.65	3.54	0.25	0.16	2.69	2.45	0.13	0.013		99.55
KE-24	andesite	58.42	1.08	16.59	3.08	4.70	0.20	2.42	5.04	4.12	0.26	0.54	2.27	0.48	0.21	0.090	0.023	99.52
Ullman Spur																		
UI-9	basaltic andesite	55.44	0.86	17.19	2.88	4.32	0.13	4.28	6.52	3.80	2.08	0.22	2.03	0.34	0.020	0.023	0.0012	100.03
UI-14	basaltic andesite	52.83	0.76	17.52	1.14	5.93	0.16	2.52	5.88	5.11	0.62	0.32	4.62	1.70	0.007	0.039	0.0040	99.26
Barton Peninsula																		
BⅠ-5	high-Al basalt	50.82	0.84	19.67	2.33	5.25	0.14	5.52	9.53	2.52	0.24	0.17	2.27	0.10	0.26	0.010	0.028	99.70
BⅡ-6	andesite	57.25	0.69	18.08	3.45	4.11	0.20	3.00	7.22	3.21	1.05	0.21	0.99	0.06	0.046	0.013	0.066	99.65
BⅢ	high-Al basalt	46.99	0.86	20.75	2.55	5.28	0.16	6.49	9.73	2.51	0.42	0.12	3.35	0.10	0.48		0.0080	99.80
Weaver Peninsula																		
WⅡ-4	high-Al basalt	46.02	0.48	21.11	2.08	4.52	0.11	5.08	9.64	2.00	0.48	0.09	4.56	3.23	0.013	0.011		99.42

Samples KI-37 and KI-38, KW-67 and KR-4, BI-4 and BI-5 are from the same rock layers respectively.

The ages of the studied rocks are ascribed mainly to Early Tertiary and only a few belong to Late Cretaceous (Fig. 3). The rocks in the Admiralty Bay area are rather younger than those in the Maxwell Bay, indicating a NE-directional migration of volcanism on King George Island (Watts 1982; Pankhurst and Smellie 1983; Birkenmajer *et al*. 1985, 1990). Jwa *et al*. (1992) also reported that volcanic rocks of Barton Peninsula are younger than those of Fildes Peninsula.

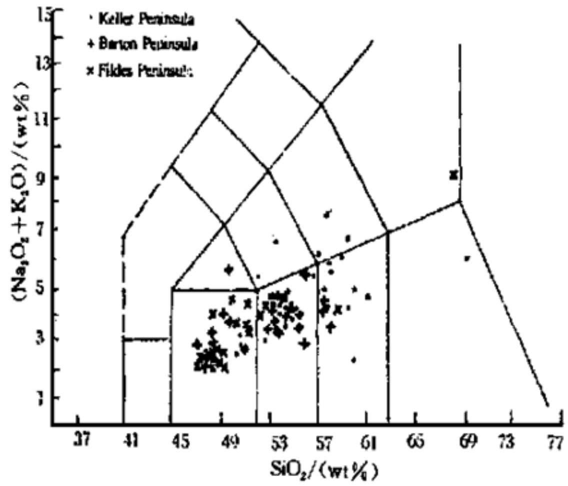

Fig. 2. SiO_2-(K_2O + Na_2O) diagram of Tertiary volcanic rocks on King George Island (after Le Bas *et al*. 1986). Data from Smellie *et al*. (1984), Birkenmajer *et al*. (1985), Li *et al*. (1992), Jin *et al*. (1992), and Table 1.

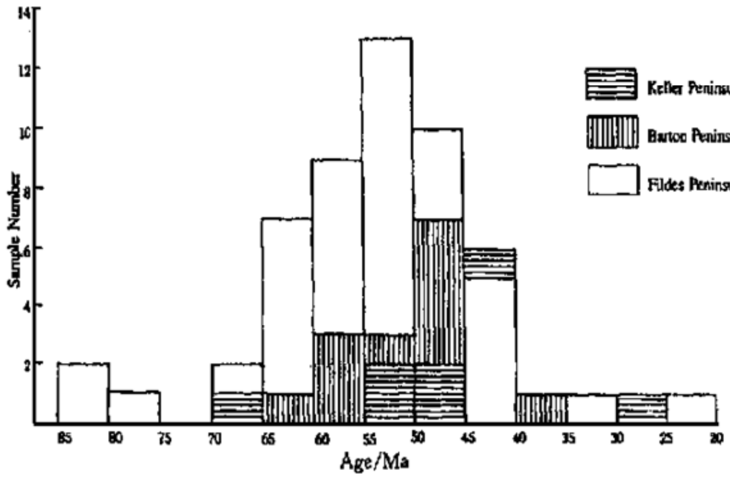

Fig. 3. Age comparison of volcanic rocks on King George Island. Data from Grikurov *et al*. (1970), Valencio *et al*. (1979), Watts (1982), Pankhurst and Smellie (1983), Smellie *et al*. (1984), Birkenmajer *et al*. (1985), Jin *et al*. (1992), Li *et al*. (1992) and this paper.

3 Chemical composition of plagioclases

Table 2 presents major element compositions of plagioclases, whose terminology is used after Smith's (1974) triangular An-Ab-Or diagram (Fig. 4). Plagioclases from different areas have different chemical features. In the Admiralty Bay area, plagioclases from Keller Peninsula and Ullman Spur are labradorite (*An*51.61 ~ 61.26) to andesine (*An*41.47 ~ 49.99) and have ortho-zoning texture (sample: KI-45) and anti-zoning texture (samples: KI-37, UI-14). In the Maxwell Bay area, plagioclases from Barton and Weaver peninsulas are mainly bytownite (*An*72.05 ~ 87.90), a little of anorthite (*An*90.71 ~ 90.97) and occasionally labradorite. Besides, they show normal zoning texture (samples: BI-5, BII-6). On Barton Peninsula, even andesite (sample: BII-6) has bytownite (*An*72.05) phenocryst. Similar to Barton and Weaver Peninsulas, plagioclase phenocrysts of Fildes Peninsula are mainly bytownite (*An*72.69 ~ 89.79) and anorthite (*An*91.86 ~ 92.63) with a little labradorite (Jin *et al*. 1992).

X-ray powder diffraction (XRD) is also used to determine both structure states and composition of plagioclases (Table 3), in which *An* values are estimated by following two experience formulas advanced by Sun (1982):

$$An = 5323 d_{002} - 8928 d_{\bar{2}04} - 1053 \quad (1)$$

$$An = 623 + 7314 d_{113} - 7733 d_{\bar{2}04} \quad (2)$$

The assurances have been verified to be > 90% for formula (1) and > 87% for formula (2) respectively. The *d* values in above formulas are reckoned by unit cell parameters rather than measured ones. Unit cell parameters are combined and calculated according to the X-ray scanning patterns. Many tests have been made, indicating that *An* values determined by XRD are close to but less slightly than those determined by EMP. All the experiments are routine powder scanning by copper radiation X-ray. The wavelength is $CuK_{\alpha 1}$ (λ= 1.54056Å).

Table 2. Chemical compositions and terminology of plagioclases (wt%)

Sample	Host rock	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	Or	Ab	An	Name
Keller Peninsula																	
KI-9	high-Al basalt	54.73	0.05	27.85		0.75		0.02	11.64	4.50	0.34		99.88	2.00	40.28	57.72	labradorite
KI-37(core)	basaltic andesite	56.18	0.05	27.79		0.42		0.09	10.23	5.59	0.28		100.63	1.60	48.62	48.78	andesine
KI-37(margin)	basaltic andesite	54.37	0.08	28.87		0.33	0.07	0.15	11.45	3.93	0.22		99.47	1.38	37.38	61.26	labradorite
KI-38	basaltic andesite	54.74	0.10	27.38	0.83	0.27	0.01	0.23	10.35	4.86	0.46	0.07	99.25	2.74	43.94	53.32	labradorite
KI-45(core)	basaltic andesite	55.22	0.06	27.38		0.48		0.14	9.42	5.24	0.37	0.29	98.91	2.26	48.53	49.22	andesine
KI-45(margin)	basaltic andesite	57.11	0.07	25.11		0.52	0.04	0.24	7.57	5.91	0.39	0.23	97.19	2.44	56.09	41.47	andesine
KW-11	basaltic andesite	54.05	0.15	28.73		0.64		0.26	10.97	4.42	0.23		99.46	1.40	40.79	57.81	labradorite
KW-67	basaltic andesite	55.50	0.09	27.78		0.63		0.27	10.00	4.87	0.35		99.69	2.13	44.95	52.93	labradorite
KR-4	basaltic andesite	56.52	0.04	27.58		0.37	0.09	0.23	9.61	5.36	0.33		100.11	1.96	48.44	49.60	andesine
KE-24	andesite	57.04		26.82		0.21		0.58	9.05	5.80	0.45		100.18	2.57	50.25	47.19	andesine
Ullman Spur																	
UI-9	basaltic andesite	56.18	0.06	27.19		0.65		0.10	9.79	5.22	0.41		99.60	2.46	47.55	49.99	andesine
UI-14(core)	basaltic andesite	56.32	0.11	26.83		0.93		0.23	9.40	6.08	0.48		100.36	2.68	51.67	45.65	andesine
UI-14(margin)	basaltic andesite	55.14	0.04	27.52		0.58		0.28	10.18	5.28	0.30		99.31	1.74	46.65	51.65	labradorite
Barton Peninsula																	
BI-4	high-Al basalt	46.55		35.18		0.66		0.13	16.75	1.30			100.56	0.01	12.19	87.80	bytownite
BI-5(core)	high-Al basalt	46.41	0.01	35.29		0.66		0.08	17.31	0.96	0.04		100.76	0.25	9.04	90.71	anorthite
BI-5(margin)	high-Al basalt	49.88	0.07	31.89		0.72	0.06	0.42	14.12	2.93	0.11		100.20	0.65	26.33	73.02	bytownite
BII-6(core)	andesite	50.22		32.34		0.71		0.14	14.18	3.03	0.08		100.70	0.48	27.48	72.05	bytownite
BII-6(margin)	andesite	52.29	0.07	29.88		0.85		0.33	12.07	4.05	0.07		99.61	0.42	36.75	62.84	labradorite
BIII-28-1	high-Al basalt	46.35	0.08	34.54		0.57		0.40	16.74	1.41			100.08		12.85	87.15	bytownite
BIII-28-2	high-Al basalt	46.37	0.04	34.63		0.52	0.09	0.14	16.71	1.24	0.07		99.81	0.43	11.66	87.90	bytownite
Weaver Peninsula																	
WII-4*	high-Al basalt	45.18	0.14	34.58		0.48		0.15	17.11	0.95			98.59		9.03	90.97	anorthite

* plagioclase megaphenocryst. Sample KI-38 is determined by chemical analysis, the others by EMP (type: FMX-SM7, system error: 000121).

Table 3. Unit cell parameters, composition and structure state of plagioclases*

Sample	Standard error	Unit cell parameter						An	$t_1\theta - \langle t_1m \rangle$	δ	Structure state	Name	Space group
		a	b	c	α	β	γ						
KI-38	+ 0.0006597	8.16033	12.85173	7.10631	93.44476	116.22064	90.25528	41.73	0.1922	0.330	High	andesine	$C\bar{1}$
KI-40	+ 0.0005223	8.16737	12.85538	7.10100	93.36459	116.08098	90.36142	63.56	0.2440	0.670	High	labradorite	$C\bar{1}$
KE-24	+ 0.0005907	8.16921	12.85922	7.10154	93.35857	116.20163	90.25775	48.28	0.2586	0.500	High	andesine	$C\bar{1}$
KW-11	+ 0.0003448	8.17363	12.84810	7.11720	93.46083	116.28139	90.08231	36.24	0.2611	0.409	High	andesine	$C\bar{1}$
KR-4	+ 0.0004370	8.17571	12.87513	7.10513	93.42833	116.17927	90.42150	47.15	0.1301	0.246	High	andesine	$C\bar{1}$
UI-9	+ 0.0005224	8.15696	12.84593	7.10018	93.42138	116.14174	90.22701	54.84	0.2575	0.570	High	labradorite-andesine	$C\bar{1}$
BIII-28	+ 0.0004513	8.17927	12.88732	14.1887	93.32186	115.93607	91.12752	72.10	0		**	bytownite	$I\bar{1}/P\bar{1}$
WII-4	+ 0.0004505	8.17859	12.85669	14.1719	93.17371	115.92983	91.09821	77.40	0		**	bytownite	$I\bar{1}/P\bar{1}$

* determined by XRD, ** Si-Al ordering meaningless.

In Table 3, plagioclases from Keller Peninsula and Ullman Spur are high structure state labradorites-andesines (*An*36.24 − 63.56), and those from Barton and Weaver peninsulas are high structure state bytownites (*An*72.10 − 77.40), similar to results of EMP in Table 2. On the other hand, both order degree δ(0 − 0.670) and Al occupation deviation $t_1\theta - \langle t_1m \rangle$ (0 − 0.2834) of all plagioclases are generally low, indicating rapid cooling of effusive rocks. Similar to those of Barton and Weaver peninsulas, plagioclases of Fildes Peninsula have been determined by XRD to be high structure state bytownites (*An*73.6 − 82.8) (Jin *et al*. 1992).

From Tables 1, 2, and 3, it can be concluded that plagioclase compositions are fully consistent to the lithologies of their host rocks, i. e., bytownites and anorthites are present in high-Al basalts, labradorites and andesines exist in basaltic andesites and andesites. But a exception is the andesite of Barton Peninsula which also contains bytownite (sample: BII-6).

4 REE geochemistry of plagioclases

Table 4 lists REE abundances of plagioclases determined by neutron activation analysis (NAA). Plagioclases from Keller Peninsula and Ullman Spur have rather high ΣREE (14.04×10^{-6}– 21.40×10^{-6}), high La/Yb ratios (17.75 – 41.79) and high δEu values (2.03 – 6.79, most> 4). Plagioclases from Barton and Weaver peninsulas have low ΣREE (2.82×10^{-6}– 6.34×10^{-6}), low La/Yb ratios (7.79 – 10.15) and low δEu values (1.09 – 4.62).

Table 4. REE abundances of plagioclases ($\times10^{-6}$)*

Sample	La	Ce	Nd	Sm	Eu	Gd	Tb	Ho	Tm	Yb	Lu	ΣREE	La/Yb	δEu
KI-38	4.34	7.15	2.60	0.467	0.708	0.369	0.059	0.063	0.022	0.128	0.019	15.93	33.91	4.82
KI-40	4.14	5.70	2.24	0.476	0.702	0.427	0.064	0.078	0.028	0.016	0.021	14.04	24.79	4.13
KW-11	3.71	7.76	4.39	0.965	0.808	0.857	0.135	0.132	0.040	0.209	0.027	19.03	17.75	2.03
KE-24	5.14	9.44	3.72	0.586	1.19	0.463	0.064	0.068	0.023	0.123	0.017	20.83	41.79	6.79
KR-4	4.73	9.69	4.13	0.766	1.10	0.598	0.089	0.093	0.029	0.156	0.021	21.40	18.38	4.54
UI-9	0.54	1.07	0.60	0.164	0.146	0.179	0.031	0.001	0.053	0.007	2.82	10.15	1.91	1.91
BI-4	1.13	2.50	1.45	0.352	0.219	0.362	0.059	0.074	0.026	0.145	0.019	6.34	7.79	1.09
BIII-28	1.39	1.86	0.92	0.202	0.326	0.194	0.033	0.046	0.018	0.105	0.015	5.11	8.02	4.62
WII-4	3.62	6.41	2.69	0.542	0.796	0.465	0.071	0.086	0.029	0.161	0.021	14.89	22.48	4.41

* determined by NAA at the Institute of High Energy Physics, Chinese Academy of Sciences. Chondrite values after Coryell (1963). δEu= [$Eu_N/(Sm_N\ Gd_N)$] − 1, N means the chondrite-normalized value.

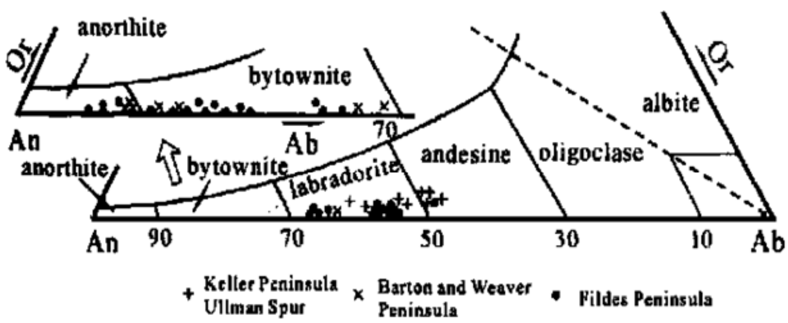

Fig. 4. An-Ab-Or triangular diagram of plagioclase (after Smith 1974).

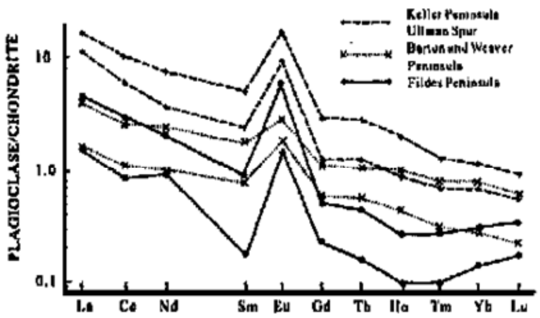

Fig. 5. Chondrite-normalized REE distribution patterns of plagioclases. (Fildes Peninsula data from Jin *et al*. 1992; chondrite values after Coryell 1963).

In chondrite-normalized REE distribution patterns of plagioclases (Fig. 5) which include REE patterns of Fildes Peninsula plagioclases. Keller Peninsula and Ullman Spur plagioclases contain the highest ΣREE (especially LREE) abundance; and plagioclases from both Barton, Weaver and Fildes peninsulas have close ΣREE and LREE abundances, in which plagioclases from Fildes Peninsula show the most conspicuous depletions of HREE. Barton Peninsula plagioclases yield the weakest positive Eu anomalies, which probably is related to incomplete evolution of volcanic suite (lacking dacites) of this peninsula.

Chondrite-normalized REE distribution patterns of host rocks of plagioclases

(Fig. 6) are quoted for comparison. Figs. 5 and 6 demonstrate that, plagioclases and their host rocks have consistent REE features (for example, both plagioclases and their host rocks of Keller Peninsula contain the highest ΣREE and LREE abundances), and that REE differences between plagioclases are larger than those between their host rocks.

Wang *et al.* (1989) proposed that, the more acid the rock is, the higher the abundance and diversity of REE; and acid plagioclase has likewise higher ΣREE and La/Yb ratios than basic one. Our study here proves Wang *et al.*´s view.

5 Trace elements of plagioclases

Rb, Sr, Ba and transitional metallic element abundances of plagioclases are presented in Table 5. Rb, Sr and Ba abundances of plagioclases from Keller Peninsula and Ullman Spur at Admiralty Bay are 0.597×10^{-6}–7.80×10^{-6}[most frequently $(3-4)\times10^{-6}$], $(997-1120)\times10^{-6}$ and $(120-243)\times10^{-6}$ respectively. Plagioclases of Barton and Weaver peninsulas at Maxwell Bay have higher Rb [$(3.64-18.9)\times10^{-6}$, averagely 11.8×10^{-6}], lower Sr [$(674-792)\times10^{-6}$] and higher Ba [$(99.6-558)\times10^{-6}$, averagely 318.5×10^{-6})]. Thus increasing *An* values, plagioclases contain more Rb, Ba and less Sr. Similarly, host rocks of these plagioclases also have evident differences in Rb, Sr and Ba abundances. For example, basaltic andesites of Keller Peninsula and Ullman Spur of Admiralty Bay contain average Rb, Sr, Ba abuncances of 20×10^{-6}, 510×10^{-6}, 306×10^{-6} respectively; and high-Al basalts of Barton and Weaver peninsulas of Maxwell Bay have average Rb, Sr and Ba abundances of 7×10^{-6}, 540×10^{-6} and 155×10^{-6} respectively. Thus plagioclases and their host rocks have a negative correlation in Rb, Sr and Ba abundances, which implies strong fractional crystallization of plagioclases in volcanic magmas. General weak positive Eu anomalies and even negative Eu anomalies of plagioclases in Fig. 2 also reflect their notable fractional crystallization.

Table 5. Trace element abundances of plagioclases ($\times10^{-6}$)*

Sample	Rb	Sr	Ba	Cr	Co	Ni	Zn
KI-38	3.74	1090	166	< 0.57	1.44	< 0.644	7.71
KI-40	3.10	1010	179	1.50	1.80	< 0.730	< 2.24
KW-11	7.80	1120	120	1.61	1.27	< 0.993	< 2.20
KE-24	< 0.60	1040	241	< 0.57	1.57	< 0.645	4.00
KR-4	4.45	977	148	1.96	2.57	< 0.857	< 2.69
UI-9	3.42	1100	243	2.11	1.39	< 0.759	6.72
BI-4	13.0	781	558	4.10	2.73	< 0.770	< 2.23
BIII-28	3.64	792	99.6	0.84	1.70	< 0.508	4.91
WII-4	18.9	674	298	1.40	0.85	< 0.862	< 2.15

* determined by NAA at the Institute of High Energy Physics, Chinese Academy of Sciences.

Rb, Sr and Ba all belong to compatible elements for plagioclase. But relative to high-*An* plagioclases (bytownites and anorthites) of Barton and Weaver peninsulas, low-*An* plagioclases (labradorites and andesines) of Keller Peninsula and Ullman Spur obviously enrich Sr and deplete Rb and Ba. A reasonable explanation is: along with magmatic evolution, small Sr ion can diffuse quicker in plagioclases than both large Rb ion and larger Ba ion (Ribbe 1983).

In Fig. 7, various plagioclases from different areas of King George Island display nearly indistinguishable chondrite-normalized transitional element distribution patterns,

i. e., distinctly depleting strong incompatible Cr, Co, Ni, and slightly depleting incompatible Mn, Fe and Zn. This case indicates that the factor affecting both abundance and diversity of transitional elements in plagioclases is mainly crystal structure rather than composition of plagioclases.

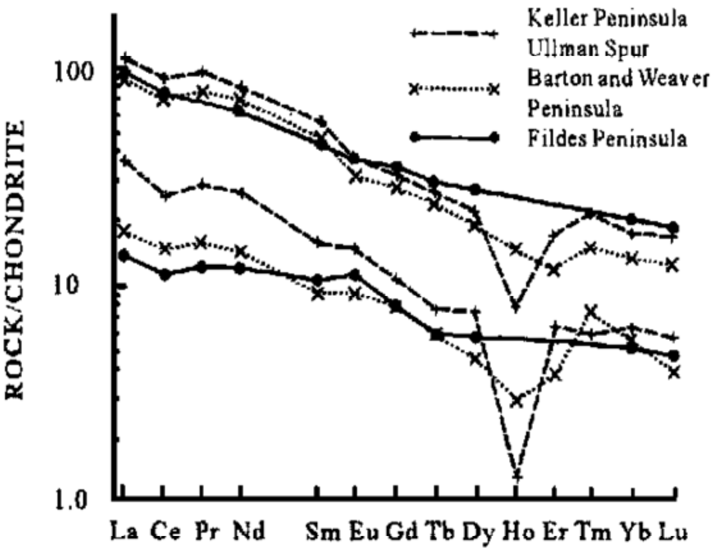

Fig. 6. Chondrite-normalized REE distribution patterns of host volcanic rocks (chondrite values after Coryell 1963).

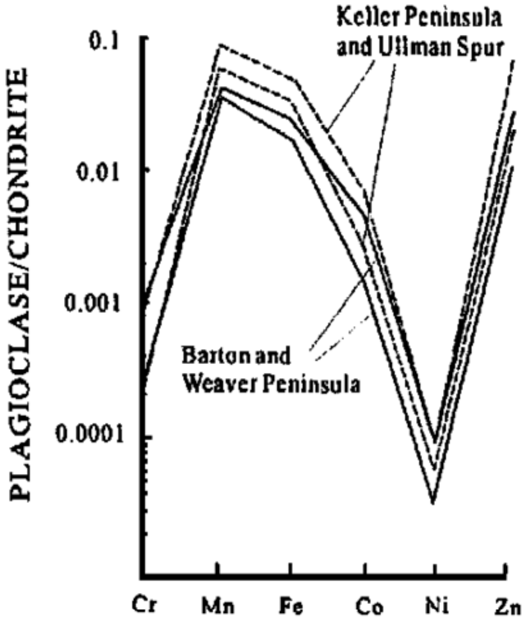

Fig. 7. Chondrite-normalized transitional element distribution patterns of plagioclases (chondrite values after Coryell 1963).

6 Discussion

As mentioned above, Tertiary volcanic rocks of King George Island appear to be more felsic in composition from SW to NE, and *An* values of their plagioclases vary from high-*An* at SW Maxwell Bay to low-*An* at NE Admiralty Bay. The fact shows that in the Admiralty Bay high-Al basalts are more evolved than in the Maxwell Bay, although in the two areas there exist the same rock suites consisting of high-Al basalt-basaltic andesite-andesite-dacite. This conclusion can also be verified from Table 1 in which high-Al basalts of Barton and Weaver peninsulas have lower SiO_2 and higher MgO contents than those of Keller Peninsula and Ullman Spur. In other words, it can be inferred from chemical variations of plagioclase that high-Al basaltic magmas of Maxwell Bay correspond to parent magmas of volcanic suite of Admiralty Bay.

Calc-alkaline high-Al basalts (HABs) and basaltic andesites (BAs) are the major rock types in the arcs, and their plagioclases are unusually calcic. Kuno (1950) suggested that plagioclase phenocrysts of *An*90 are common in arc high-Al basalts. Such calcic plagioclase crystals can not reach phase equilibrium with relatively felsic groundmasses of host rocks (Falloon and Green 1986; Baker and Eggler 1986; Crawford *et al*. 1987). But H_2O plays positive role for calcic plagioclase growing in high-Al basaltic magmas. H_2O released from subducted slab initiates mantle wedge to melt (Green 1973; Tatsumi *et al*. 1983; Sisson and Grove 1993a, b) and produces high-*An* melts (Yoder and Tilley 1962; Yoder 1965). Green *et al*. (1967) and Baker and Eggler (1983) also emphasized significant impact of H_2O on generation of arc high-Al basalts, and showed that under moderate pressure, addition of H_2O will favor earlier crystallization of both olivine and clinopyroxene than plagioclase. Sisson and Grove (1993a) proposed that, existence of H_2O causes Fe-Mg silicates to crystallize earlier than plagioclases, and as a result, residual Ca-rich, SiO_2-poor, NaO_2-poor magmas produce calcic plagioclases. They also declared that, H_2O (2% − 4%) dominates fractional crystallization of H_2O-saturated arc basalt or basaltic andesite magmas to form typical calc-alkaline rock suite. Sisson and Grove (1993b) pointed out that, 4% or more H_2O is required for formation of porphyritic low-MgO HABs under crustal pressure in arcs. and that such wet HAB magmas must degas at shallow depths so that abundant phenocrysts will be generated within the mid-upper crust.

Tertiary volcanic rocks on King George Island belong to arc calc-alkaline series and have prevailing porphyritic textures (Barton 1965; Davies 1982; Weaver *et al*. 1982; Smellie *et al*. 1984; Birkenmajer *et al*. 1985, 1991; Li *et al*. 1992; Jin *et al*. 1992). Based on least-squares approximation of fractional crystallization, Xing and Jin (1992) reported a genetic model of high-Al basalts in King George Island: a upper mantle of Ol50Opx30Cpx15Sp5 produces primary magmas by its 20% − 25% partial melting, then the primary magmas evolve high-Al basalts through 40% fractional crystallization of olivine (occupying 30%) and clinopyroxene (occupying 70%); the estimated abundances of both REE and trace elements of supposed HABs perfectly resemble their measured values of natural HABs on Fildes Peninsula. By studying melt inclusions in diopside from Fildes Peninsula, Wang and Zhang (1988) noticed earlier crystallization of kirschsteinite-monticellites and diopsides than plagioclases.

Abundant volatile such as H_2O will force mantle-derived magmas to penetrate quicker through the overlying crust and erupted explosively on the surface. On King George Island, pyroclastic rocks such as volcanic agglomerates, breccias and tuffs occur extensively, meaning the existence of abundant volatile in volcanic magmas. High-Al basalts of King George Island often contain amphibole phenocrysts, implying the existence of H_2O in their magmas (Xing 1998). Although there is thick continental crust (23 − 30 km) and 14 km thick lower crust in the South Shetland Islands (Ashcroft 1972; Birkenmajer *et al*. 1990). Sr, Nd and Pb isotopes indicate that crustal contamination is negligible for King George Island volcanic rocks (Xing *et al*. 1997). Thus H_2O in high-Al basalts should come from their mantle source.

H_2O within mantle wedge is reasoned to release from subducted slab. Xing *et al*. (1997) argued that mantle sources of King George Island volcanic rocks were enriched by metasomatism of fluids from subducted slab. According to study on fluorine and boron geochemistry of volcanic rocks from Deception Island, Smellie *et al*. (1992) indicated that, even in the Bransfield Strait, slab-derived component was present in the upper mantle source. Birkenmajer *et al*. (1991) conducted geochemical simulations for King George Island rocks, and stressed a critical addition of sediments into their mantle source. But in Birkenmajer *et al*. (1991) ′s simulations, some measured abundances of incompatible elements such as Th are too higher than estimated ones. Probably this can be explained by metasomatism of LILE-rich fluid from pelagic sediments. Xing (1998) have testified that subducted pelagic sediments play a key role for enrichment of the upper mantle under King George Island.

In a word, addition of fluids such as H_2O from subducted slab (oceanic crust +

pelagic sediments) must exerts important impacts on plagioclase compositions and eruptive pattern of Tertiary volcanic rocks on King George Island.

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