POST-MIOCENE VOLCANIC PETROGRAPHIC PROVINCE OF WEST ANTARCTICA AND THEIR RELATION WITH THE SOUTHERN ANDES OF SOUTH AMERICA

722

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INTRODUCTION

The purpose of this report is to review and systematize the petrography and petrology of the post-Miocene to recent volcanic series of the Marie Byrd Land, Victoria Land, South Shetland Islands and the South Sandwich Islands relating these series to the Late Cenozoic volcanic serie of the Southern Andes of Chile. Forty five chemical analyses of major elements and seventeen of trace elements are given of samples from Marie Byrd Land, collected by one of the authors (O. González) during the Marie Byrd Land Traverse of the United States Antarctic Research Program, National Science Foundation.

THE MARIE BYRD LAND SERIE

Figure 1 shows the distribution of the upper Cenozoic volcanism in Marie Byrd Land, in an area over 700 kilometers long, starting from the vicinity of Mt. Perkin and reaching as far as Mt. Jones. Compound strato volcanoes are dominant and are built upon a pyroclastic plateau. Geologic and petrographic studies of this area have been made by FENNER (1938), ANDERSON (1960), DOUMANI and EHLERS (1962), DOUMANI (1964), WADE (1969), LE MESURIER (1969), GONZALEZ (1969), and GONZALEZ and GONZALEZ (1970).

From a petrographic point of view two volcanic lines are recognized: a northern one with a predominance of porphyritic trachytes and olivine basalts and mugearites, the latter in a minor proportion, and a southern line with olivine basalts, andesites, basalts, trachyandesites, hawaiites, phonolites and mugearites. Abundant ultramaphic inclusions have been described by GONZALEZ (1969).

Table 1 and 2 contains forty three chemical analyses of major elements and seventeen traceelements of samples from Marie Byrd Land serie. Figure 1 indicated the exact volcanic groups and the number of samples analyses from each of them.

VICTORIA LAND SERIES

Upper Cenozoic volcanic rocks in Victoria Land extends from the Ross Sea Island (McMurdo Volcanic Group) to the northernmost tip of Victoria Land, Figure 1. The geology and petrography of this region has been described by HARRINGTON (1958, 1965), TREVES (1967,1969), COLE and EWART (1968), NATHAN (1968), and SKINNER and RICKER (1968).

The volcanic rocks from Victoria Land are augite and olivine basalts, hornblend basalts, pyroxene and hornblend trachytes (COLE and EWART, 1968), and alkaline differentiates, trachybasalts and trachyte phonolites (NATHAN and SCHULTE,1968). Thirty eight chemical analyses of this region have been published, twenty eight of them are from the McMurdo area (Figure 1), and four analyses of trance elements from Mt. Melbourne (NATHAN and SCHULTE,1968).

According to their petrography and chemistry, these rocks have an alkaline character, similar to the ones described in the Marie Byrd Land series. In Figure 2 the chemical analyses of the Marie Byrd Land and Victoria Land series have been jointly plotted. They make up a single group with the exception of a minor interruption in the section comprised between 50% and 52% of SiO_2. Its alkalinlime index is 46.5, showing the chemically alkaline character of these series.

Figure 3 corresponds to an AFM diagram of the Marie Byrd Land and Victoria Land samples and shows a slight increase of iron in the middle stage of the differentiation, and a residual phase which is very rich in alkalis.

THE SOUTH SHETLAND ISLANDS SERIE

The South Shetland Island Serie are located on ten of the largest of the South Shetland Islands, northwest of the Antarctic Peninsula. On these islands the Upper Cenozoic volcanic rocks show ample development and volcanic activity continues to the present time, as described in Deception Island by VALENZUELA and others (1968), BAKER and others (1969), and WILLIAMS (1969).

Several authors have described the geology and petrography of Bridgeman, Penguin, Deception and King George islands (Figure 1): GOURDON (1914), FERGUSON (1922), BARTH and HOLMSEN (1939),TYRREL (1945), HAWKE (1961 b), GONZALEZ and KATSUI (1970). The rocks of these series are mainly olivine basalts, olivine andesites and augites.

Figure 4 is a compilation of chemical analyses of the South Shetland Island volcanic series, published by the above mentioned authors. The sequence is gradational in relation to the increase of the percentage of ($NaO + K_2O$), as well as the decrease of the CaO related to the increase of SiO_2 content. The absence of extremely basic lythologic types (less than 46% of SiO_2) and of extremely acid ones (More than 69% of SiO_2) is to be observed here. The alkali-lime index is 56.5, which according to PEACOK's classification shows the calc-alkaline chemical character of this serie.

Figure 5 is an AFM diagram of the same rocks. There is a moderate increase of iron in the middle stage of the differentiation.

THE SOUTH SANDWICH ISLANDS SERIE

The South Sandwich Islands are distributed in the form of an arch of eleven volcanic islands, KEMPT (1931); eight of them had recent fumarolic activity, witnessed by BAKER (1968). The geology and petrographic of this area has been noted by TYRREL (1945), GAST and others (1963), and BAKER (1968), showing that most of the volcanic rocks of these islands are basalts, andesites, and a lesser proportion of dacites that, according to BAKER (1968, p. 204) might originate in a primary tholeiitic magma.

CONCLUSIONS

A distribution pattern on the basis of two volcanic provinces (Figure 5) is proposed for the post miocene to contemporary volcanic series:

I. Alkaline Province, Atlantic type,

II. Calc Alkaline Province, Pacific type.

The alkaline Province comprises the Marie Byrd Land and Victoria Land Series, and the Calc Alkaline Province comprises the South Shetland and South Sandwich Islands series. The calc-alkaline character of the Antarctic Province is found again in the volcanic series of the South Andes of Chile, and for this reason this will be discussed in the light of the recent data gathered in the Andean region.

I. The Alkaline Province of Marie Byrd and Victoria Lands. This province is represented by the series of olivine basalts, basaltic-andesites, trachytes, mugearites and phonolites. The alkali-lime index is 46.5 and the percentage of (Na_2O + K_2O) versus the 60% of SiO_2 amounts to 12.5, being more alkaline than the series of Hawaii, Scotland, Atumi, Morota and Gough (KUNO, 1968, p. 671). These data lead to the classification of these series as of an alkaline nature. HAMILTON and BOUDETTE (1962) considered the upper Cenozoic volcanic rocks of Marie Byrd Land and Victoria Land as belonging to the Alkaline-volcanic province which is rich in sodium.

Figure 6 plots the values of (Na_2O + K_2O) versus percentage of SiO_2 of samples of these volcanic series. The samples are considerably richer in alkalis than samples of the other series mentioned in this report. The serial value of RITTMANN (1963) is almost 7, which is equivalent to that of the "Mean Atlantic" series in the sense employed by RITTMANN.

II. The Calc-Alkaline Province comprises the series: a) "High alumina basalt" of the South Shetland Islands and the Southern Andes of Chile, and b) "Tholeiitic" of the South Sandwich Islands.

The South Shetland Islands serie has a Peacock index of 56.5 and the value of the (Na_2O + K_2O) in relation to the 60% of SiO_2 is almost 7, which is similar to the value of the lower limit of the alkaline series of Iki-Higasi-Matuura and Sidara (KUNO, 1968, p. 671). The serial value of RITTMANN is variable between 1.8 and 3, and this would indicate a "Mean Pacific" character. ADDIE (1964, p. 545) states that these series are characterized by an increase of sodium and a deficit in potassium in the last stages of the differentiation.

The upper Cenozoic volcanism of the Southern Andes of Chile, has mineralogical and chemical features similar to the "High alumina basalt" series as described by KUNO (1960) for the Japanese Islands (KATSUI and GONZALEZ, 1968, p. 58). However, there is in relation to its average, a larger content of sodic-alkali in the rocks of the Southern Andes of Chile (VERGARA,1970). The alkali-lime index of this serie is 56.2 and the percentage of (Na_2O + K_2O) in relation to the 60% of SiO_2 amounts to approximately 6.5, which is similar to the value of the "High alumina Basalt" series of the Skaergasrd intrusive and of the "Werner basalt" (KUNO,1968, p. 655, figure 24). The RITTMANN serial value varies between 1.8 and 3, showing a "Mean Pacific" character (VERGARA, 1970). The pertinent values are very close to those of the South Shetland Islands rocks. The petrographic character of both is also similar, and this has led up to consider both sequences as belonging to the same serie of volcanic rocks.

In Figure 6 there is a plot of the values of ($Na_2O + K_2O$) versus the percentage of SiO_2 for both the Antarctic areas and the Southern Andes region. They have very similar chemical features, which are characterized by a minor content of alkali in relation to the alkaline serie of Marie Byrd and Victoria Land, and a larger content of alkali in relation to the South Sandwich Islands series. Nevertheless, the most basic rocks of the South Shetland Islands appear united with the samples of the alkaline serie by their high content of alkali.

According to BAKER (1968, p. 204) the volcanic serie of the South Sandwich Islands could derive from fractional crystalization of a primary tholeiitic magma. Figure 6 shows the values ($Na_2O + K_2O$) of the samples of this region, according to data provided by TYRRELL (1945), GAST and others (1963), and BAKER (1968, p. 202, Figure 4). They represent a serie which has the lower content of alkali in relation to the other series herewith studied. Most of the points fall within the tholeiitic series of Japan (BAKER, 1968, p. 201), KATSUI (1969) also attributes a tholeiitic character to this serie. The RITTMANN serial value varies between 1 and 1.8, demonstrating the calc-alkaline character of the "Strong Pacific" type.

The pattern of distribution and petrographic systematization of the volcanic series presented in this report and proposed by it, has a tentative character only. Thus, it has a provisional character until an availability is established of more petrographic, chemical and isotopic data of the volcanic rocks in the south-eastern Pacific basin.

ACKNOWLEDGEMENTS

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SPECIMEN FROM TABLE 1 AND 2

Specimen	Rock type	Locality	Analyst
-46	Aphyric olivine basalt lava flow.	Berlin Group. Parasite cone at the end of west side.	J.V.;J.O. R.J.;C.M.
-8	Trachyte porphyric lava dome.	Bursey Group. Koerner dome, upper level in the North side.	J.V.;J.O. R.J.;C.M.
G-10	Trachyte porphyric lava dome.	Bursey Group. Koerner dome central part.	J.V.;J.O. R.J.;C.M.
G-11	Trachyte lava flow.	Bursey Group. Koerner center. West parasite cone.	J.V.;J.O. R.J.;C.M.
G-21	Olivine basalt lava flow.	Bursey Group. Main cone. West side.	J.V.
OG-37	Basaltic lava.	Caldera Andrus. Parasite crater No 2. Northwest side.	J.V.;J.O. R.J.;C.M.
OG-39	Obsidiane block	Caldera Andrus. Parasite crater No 2.Northwest side.	J.V.;J.O. R.J.;C.M.
OG-40	Aphyric basalt lava flow.	Caldera Andrus.Parasite crater No 1.Northwest side.	J.V.
OG-52	Olivine basalt lava flow.	Caldera Andrus. Main cone. West side.	J.V.;J.O. R.J.;C.M.
OG-56	Trachyte porphyric columnar lava flow.	Caldera Andrus. West side of the main cone.	J.V.
OG-58	Trachyte lava flow.	Caldera Andrus. Upper level of the West side.	J.V.;J.O. R.J.;C.M.
OG-87	Trachyte porphyritic lava flow.	Caldera Andrus. Near the South Summit.	J.V.;J.O. R.J.;C.M.
OG-34	Porphyric Trachyte lava flow.	Volcan Kauffman Northwest side.	J.V.;J.O. R.J.;C.M.
OG-154	Basaltic	V.Waesche. Southwestern parasitic cone.	J.V.
OG-158	Mugearite lava flow.	V.Waesche. Center cone at the parasitic field.	J.V.
OG-160	Mugearite dikes	V.Waesche. In the vicinity of the main crater.	J.V.;J.O. R.J.;C.M.
OG-165	Picrytic basalt lava flow.	V.Waesche. Southeast side at parasitic field.	J.V.
OG-166	Basalt lava flow.	V.Waesche. Southeast side at parasitic field.	J.V.
OG-168	Basalt lava dike	V.Waesche. Southeast end at the parasitic field.	J.V.
OG-169	Vesicular porphyritic olivine basalt lava flow.	V.Waesche. SE. slope.	J.V.

OG-149	Porphyritic trachyte lava flow.	Caldera Chang. Northeast rim of Caldera.	J.V.
OG- 93	Vesicular porphyritic Hawaiite lava flow.	V.Flint. Parasitic cone (2.478m). Near the north part of the crater.	J.V.
OG-177	Trachyte lava flow	Mt.Hartigan. Boudette.Peak.	J.V.
OG-161	Trachyandesite porphyric lava flow.	Caldera Sidley. Younger flow. Southeastern part.	J.V.
OG-180	Phonolite Nephelinic lava flow.	Caldera Sidley. East rim of Caldera.	J.V.
OG-181	Trachyandesite porphyric lava flow.	Caldera Sidley. Younger Lava flow. Southeastern part.	J.V.
OG-185	Porphyritic trachyte.	Caldera Sidley. Near Doumani Peak.	J.V.
OG-186	Fluidal trachyte lava.	Caldera Sidley. Northward from Doumani Peak.	J.V.
OG-188	Porhpyritic Anorthoclase Trachyte.	Caldera Sidley. Base of the inner walls.	J.V.
OG-146	Porose trachyte lava flow.	Caldera Cumming. La Veaux Peak.	J.V.
OG-178	Trachyte porphyric lava flow.	Caldera Cumming. South part of the rim.	J.V.
OG-110	Fluidal porphyritic trachyte lava.	Caldera Whitney. Parasitic crater.	J.V.;J.O R.J.;C.M
OG-116	Vesicular porphyritic basalt lava flow.	Caldera Whitney. West outer side of the rim.	J.V.
OG-124	Olivine basalt. Lava flow.	Caldera Hampton. Parasitic cone.	J.V.;J.O R.J.;C.M
OG-133	Piroxenite, piroclastic.	Caldera Hampton. Parasitic cone.	J.V.
OG-141	Aphanitic basaltic lava flow.	Caldera Hampton. Southwest slope near the crater rim.	J.V.;J.O R.J.;C.M
OG-144	Trachyte lava flow.	Caldera Hampton. South slope of Mark Peak.	J.V.
OG-147	Porphyritic anorthoclase Trachyte lava flow.	Caldera Hampton. Southwest slope at Caldera.	J.V.;J.O R.J.;C.M
OG-224	Porphyritic olivine basalt lava flow.	Crary Group. Volcan Frakes. Western slope of the main cone.	J.V.
OG-235	Hawaiites lava flow.	Caldera Toney. North slope Point 1515.	J.V.

G-214	Basalt lava flow.	Caldera Takahe. Northwest slope.	J.V.
G-217	Vesicular porphyritic olivine basalt lava flow.	Caldera Takahe. Point Roper.	J.V.
G-2o6	Olivine basalt lava flow.	Caldera Murphy. Southwest slope.	J.V.

.V. J. Villalobos, Chemical of Major Element, Univ. of Chile.

.O. J. Oyarzún, Trace Element, Univ. of Chile.

.J. R. Joecke, Atomic Absoption, Univ. of Chile.

.M. C. Molina, X-Ray Fluorescence Analysis, Univ. of Chile.

Figure 1. Distribution of the chemical analyses of the upper cenozoic volcanic rocks from Marie Byrd Land.

Figure 2. Parcial Harker variation diagram of % (Na_2O + K_2O) and % CaO vs. % SiO_2 for Marie Byrd Land and Victoria Land volcanic rocks series. The arrow shows the alkali-lime index.

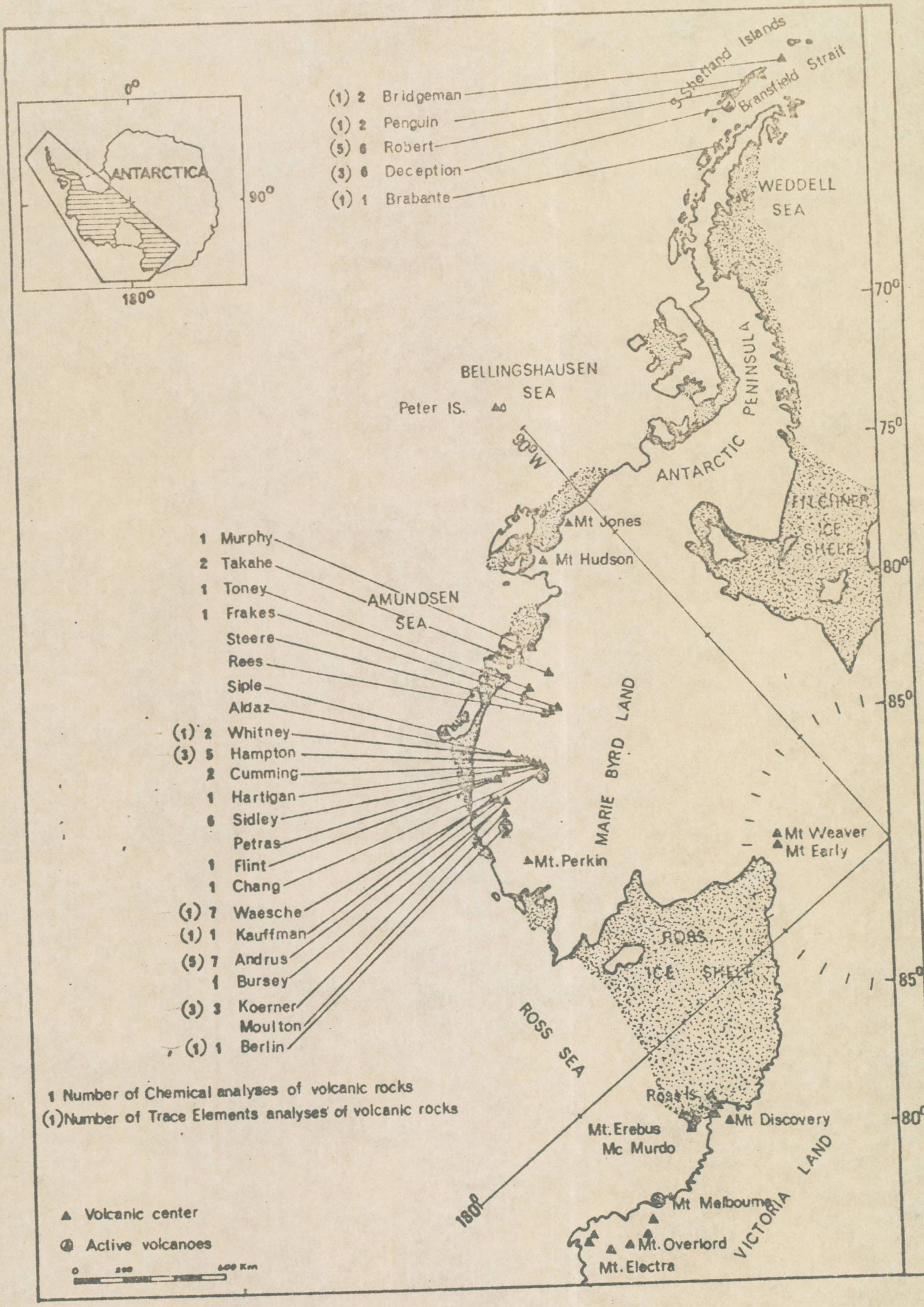
Figure 3. FMA diagram for Marie Byrd Land and Victoria Land volcanics rocks series.

Figure 4. Parcial Harker variation diagram of % (Na_2O + K_2O) and % CaO vs. % SiO_2 for South Shetland Islands volcanic rocks series.

Figure 5. FMA diagram for South Shetland Island volcanic rocks series.

Figure 6. Pattern of distribution of the upper cenozoic volcanic rocks series from West Antarctic and Southern Andes of South America.

Figure 7. Alkali-silica variation diagram for volcanic rocks series from Marie Byrd Land.



0°
ANTARCTICA
90°
180°
(1) 2 Bridgeman
(1) 2 Penguin
(5) 6 Robert
(3) 6 Deception
(1) 1 Brabante
Shetland Islands
Bransfield Strait
WEDDELL SEA
BELLINGSHAUSEN SEA
Peter IS.
ANTARCTIC PENINSULA
90°W
Mt Jones
Mt Hudson
AMUNDSEN SEA
1 Murphy
2 Takahe
1 Toney
1 Frakes
Steere
Rees
Siple
Aldaz
(1) 2 Whitney
(3) 5 Hampton
2 Cumming
1 Hartigan
6 Sidley
Petras
1 Flint
1 Chang
(1) 7 Waesche
(1) 1 Kauffman
(5) 7 Andrus
1 Bursey
(3) 3 Koerner
Moulton
(1) 1 Berlin
MARIE BYRD LAND
Mt. Perkin
Mt Weaver
Mt Early
ROSS ICE SHELF
ROSS SEA
Ross Is.
Mt Discovery
Mt. Erebus
Mc Murdo
Mt Melbourne
Mt. Overlord
Mt. Electra
VICTORIA LAND
180°
70°
75°
80°
85°
1 Number of Chemical analyses of volcanic rocks
(1) Number of Trace Elements analyses of volcanic rocks
Volcanic center
Active volcanoes

Figure 1

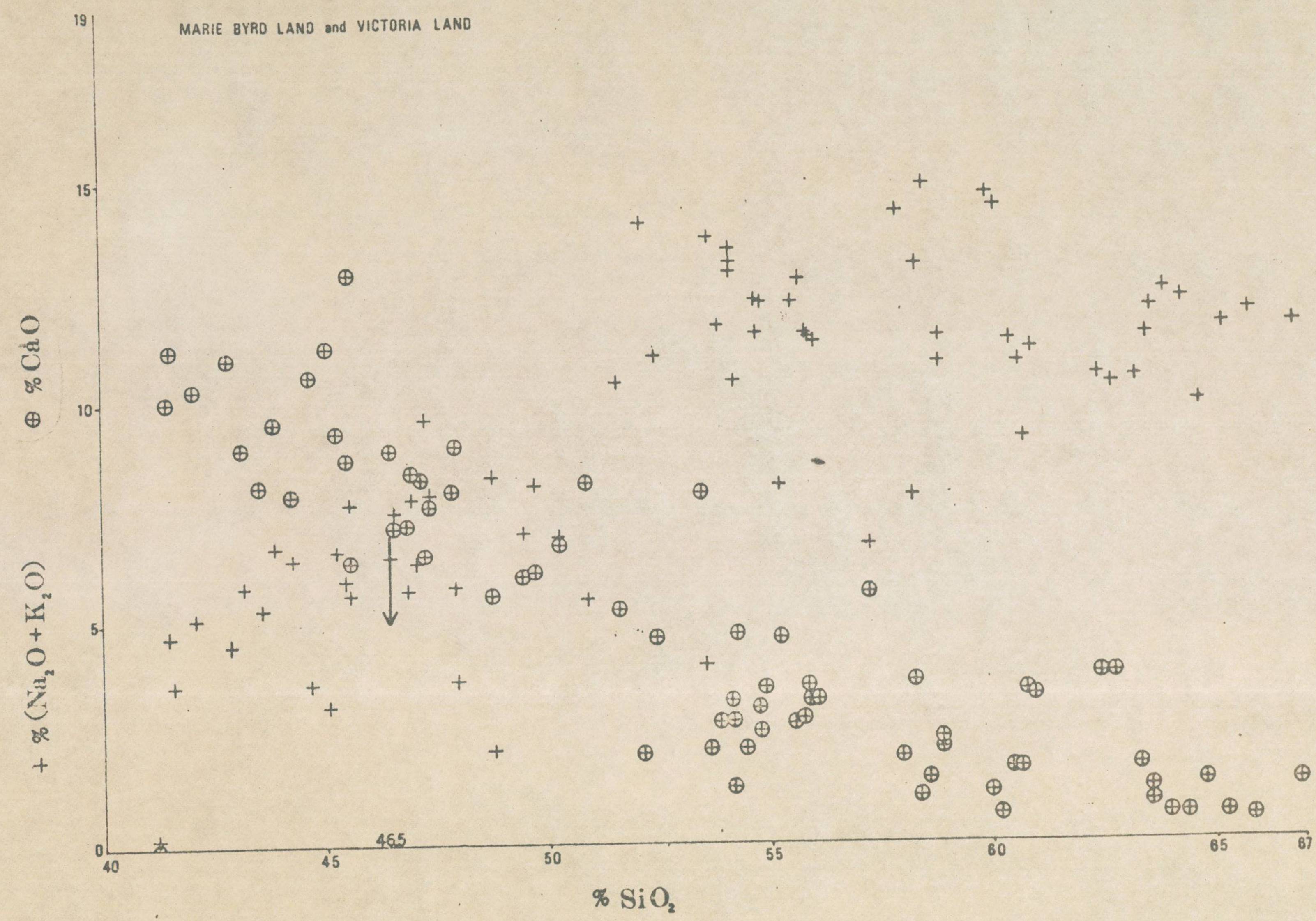

MARIE BYRD LAND and VICTORIA LAND
⊕ % CaO
+ % (Na₂O + K₂O)
0
5
10
15
19
40
45
46.5
50
55
60
65
67
% SiO₂

Figure 2

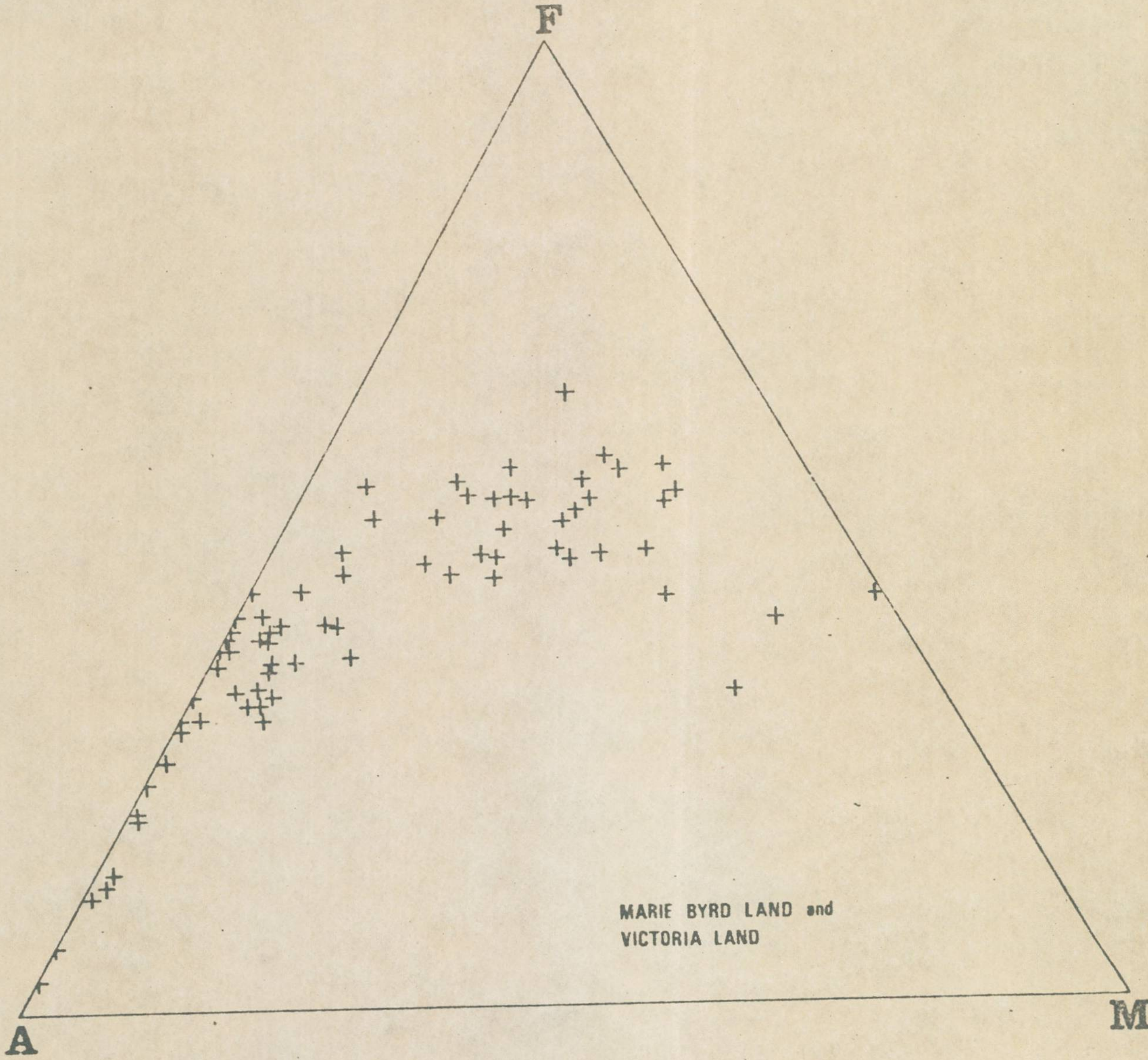


Figure 3

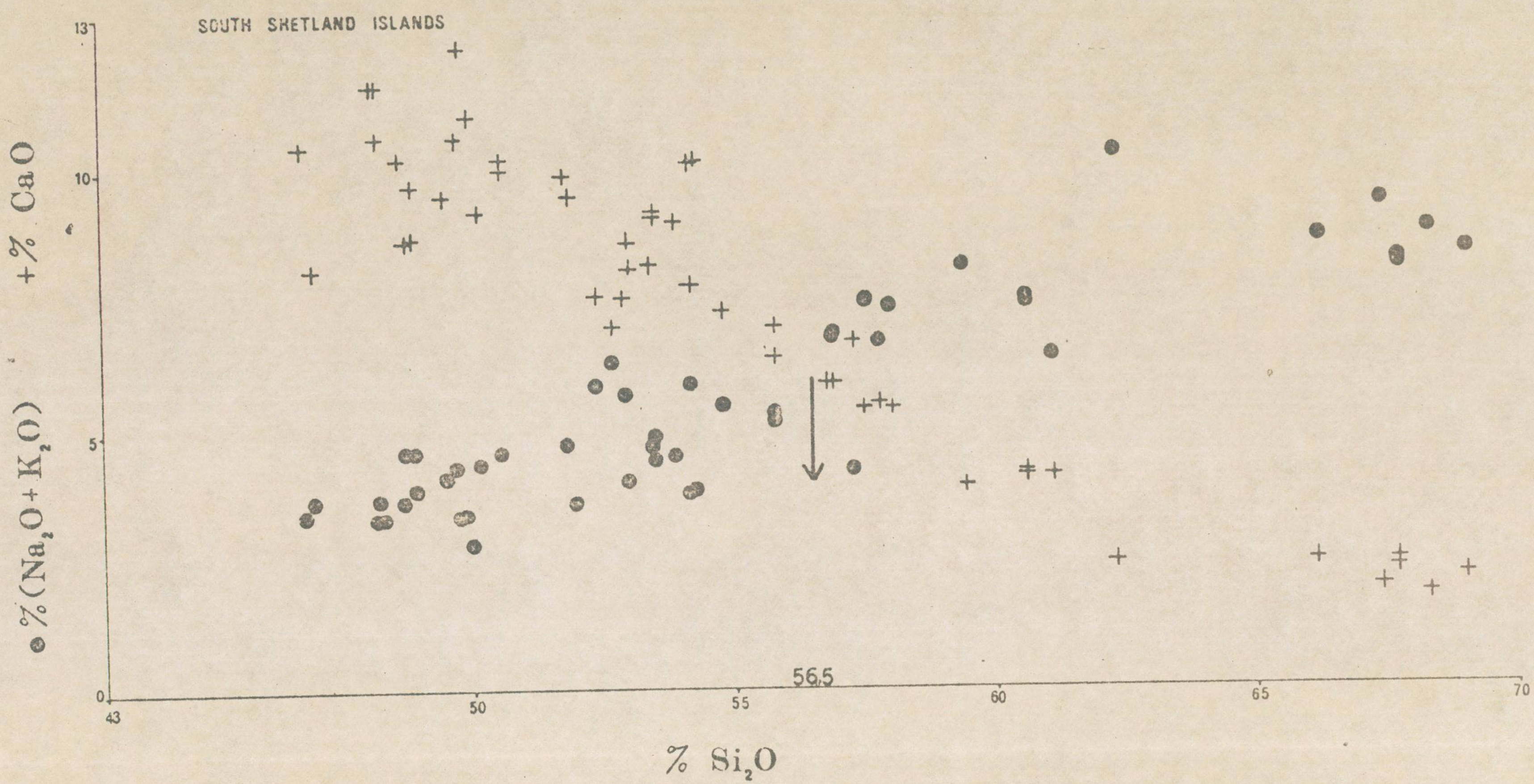

SOUTH SHETLAND ISLANDS
13
10
5
0
43
50
55
56.5
60
65
70
● % (Na$_2$O + K$_2$O)
+ % CaO
% Si$_2$O

Figure 4.

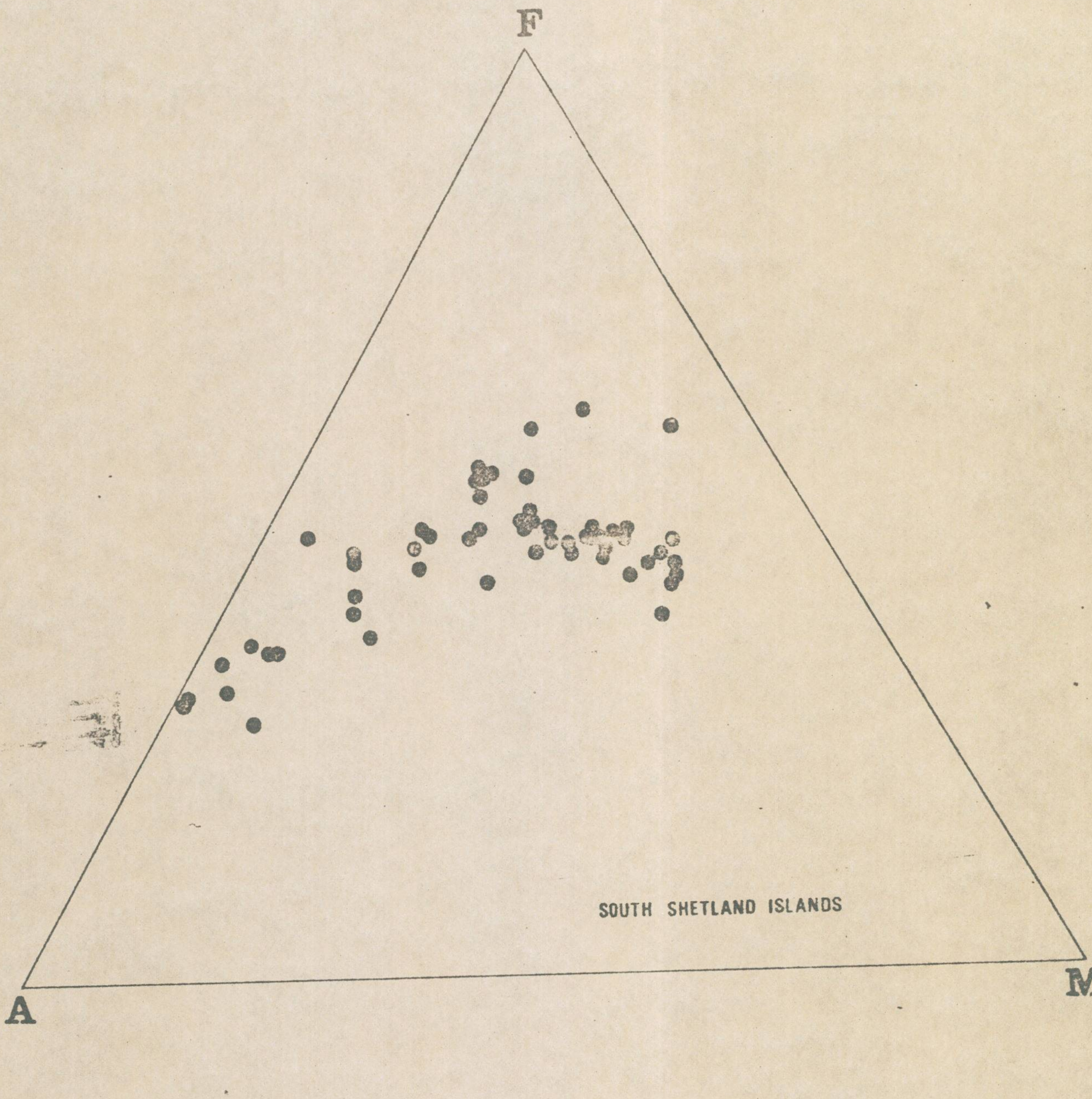


Figure 5

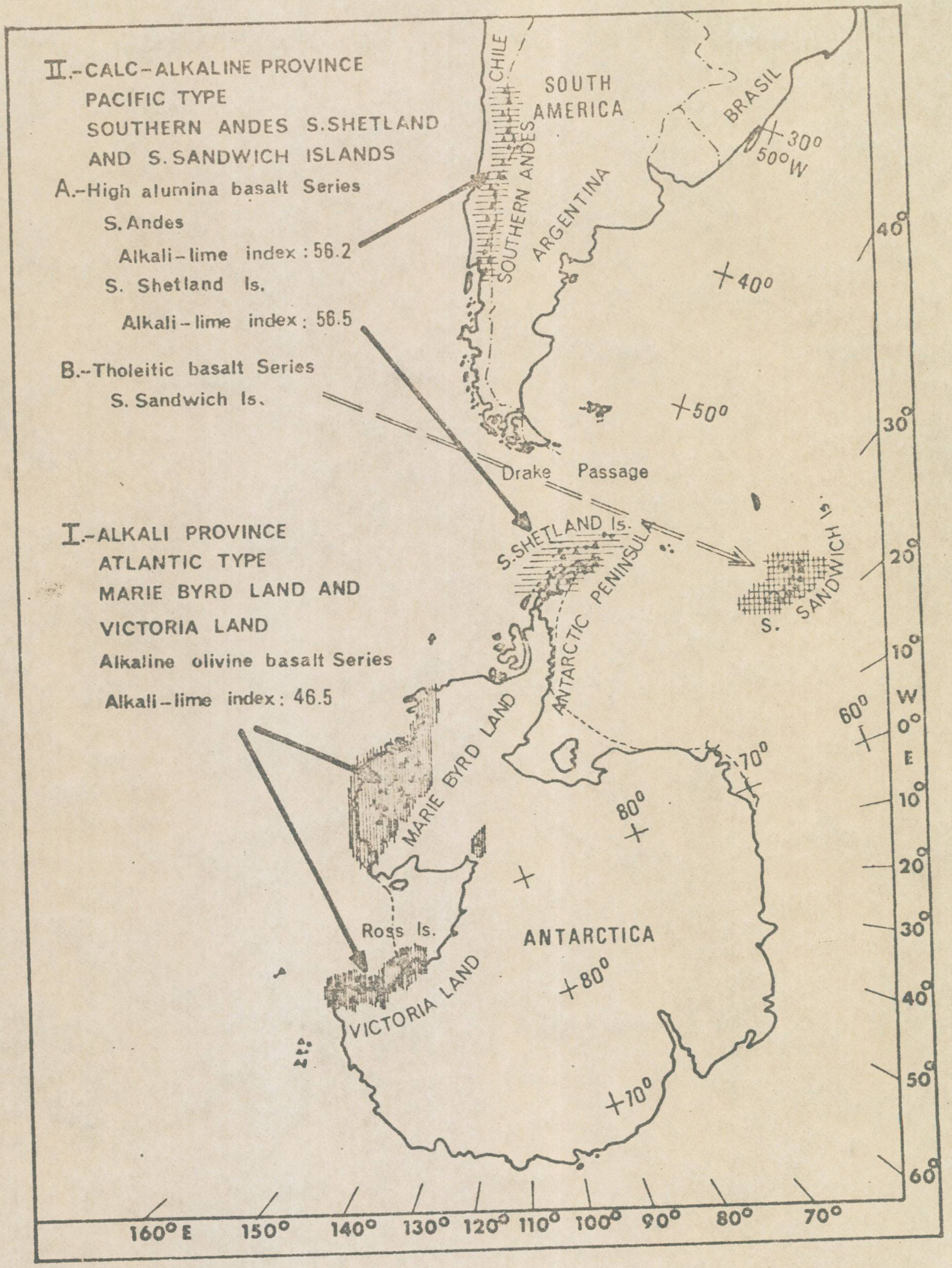

II.-CALC-ALKALINE PROVINCE
PACIFIC TYPE
SOUTHERN ANDES S.SHETLAND
AND S.SANDWICH ISLANDS
A.-High alumina basalt Series
S. Andes
Alkali-lime index: 56.2
S. Shetland Is.
Alkali-lime index: 56.5
B.-Tholeitic basalt Series
S. Sandwich Is.
I.-ALKALI PROVINCE
ATLANTIC TYPE
MARIE BYRD LAND AND
VICTORIA LAND
Alkaline olivine basalt Series
Alkali-lime index: 46.5
CHILE
SOUTH AMERICA
SOUTHERN ANDES
ARGENTINA
BRASIL
30°
50°W
40°
50°
Drake Passage
S.SHETLAND Is.
ANTARCTIC PENINSULA
S. SANDWICH Is.
MARIE BYRD LAND
Ross Is.
VICTORIA LAND
ANTARCTICA
80°
70°
60°
10°
W
0°
E
20°
30°
40°
50°
60°
160° E
150°
140°
130°
120°
110°
100°
90°
80°
70°

Figure 6

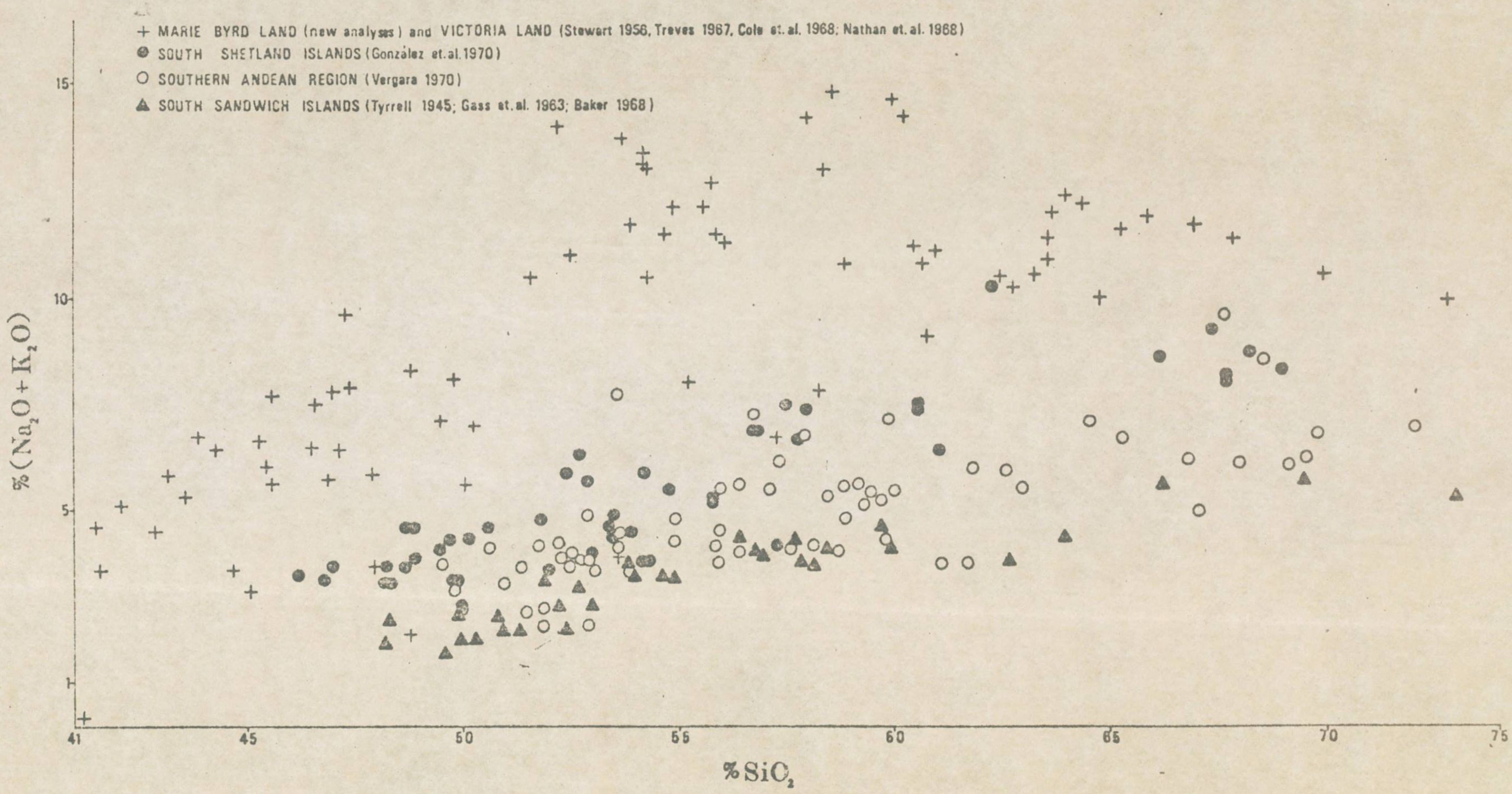

+ MARIE BYRD LAND (new analyses) and VICTORIA LAND (Stewart 1956, Treves 1967, Cole et. al. 1968; Nathan et. al. 1968)
● SOUTH SHETLAND ISLANDS (González et.al.1970)
○ SOUTHERN ANDEAN REGION (Vergara 1970)
▲ SOUTH SANDWICH ISLANDS (Tyrrell 1945; Gass et. al. 1963; Baker 1968)
15
10
5
1
$\%(Na_2O + K_2O)$
41
45
50
55
60
65
70
75
$\% SiO_2$

Figure 7

TABLE 1. MAJOR ELEMENT ANALYSES OF VOLCANIC ROCKS FROM MARIE BYRD LAND

WEST ANTARCTICA

Volcan	Berlin	Koerner			Dursey	Andrus						
Nº Specimen	OG-46	OG-8	OG-10	OG-11	OG-21	OG-37	OG-39	OG-40	OG-52	OG-56	OG-58	OG-87
SiO_2	49,75	60,18	60,66	60,51	44,34	63,59	64,38	46,92	43,79	65,32	65,85	64,02
Al_2O_3	17,34	18,61	17,22	17,11	15,92	15,48	9,99	17,15	16,93	13,24	13,24	12,16
Fe_2O_3	0,83	3,63	5,11	5,52	2,13	6,60	2,04	9,31	4,48	3,35	6,74	2,45
FeO	11,24	1,20	2,80	2,22	10,53	0,66	8,83	4,34	8,28	3,90	0,57	6,42
CaO	6,08	0,56	1,69	1,71	7,83	0,94	0,63	7,13	5,53	0,58	0,51	0,63
MgO	3,50	0,06	0,08	0,12	5,29	0,16	0,13	4,80	3,24	0,02	0,00	0,00
Na_2O	6,09	9,60	6,43	6,46	5,25	6,70	8,28	4,36	6,10	6,97	7,04	7,65
K_2O	2,00	4,65	4,40	4,85	1,17	4,65	3,90	1,35	2,19	4,59	4,86	4,75
TiO_2	1,66	0,07	0,39	0,37	4,37	0,56	0,76	3,67	2,09	0,41	0,59	0,59
P_2O_5	0,07	0,31	0,12	0,10	2,31	0,09	0,07	0,94	1,64	0,03	0,09	0,06
MnO	0,26	0,20	0,22	0,21	0,18	0,21	0,30	0,10	0,21	0,19	0,11	0,28
ppc	0,71	0,79	0,63	0,68	0,27	0,61	0,34	0,39	0,31	1,14	0,42	0,85
TOTAL	99,53	99,86	99,75	99,86	99,69	100,25	99,65	100,46	99,79	99,75	100,02	99,86

TABLE 1. MAJOR ...
(Continuation)

Volcan	Kauffman	Waescho							Ohang	Flint	Hartigan
Nº Specimen	OG-34	OG-154	OG-158	OG-160	OG-165	OG-166	OG-168	OG-169	OG-149	OG-93	OG-177
SiO_2	58,41	47,98	54,23	54,27	44,66	55,28	51,62	50,89	67,87	46,46	69,89
Al_2O_3	19,20	16,39	18,47	17,81	15,38	18,71	17,97	18,82	11,59	15,77	13,96
Fe_2O_3	3,95	11,69	2,81	4,08	2,68	3,21	1,00	3,33	4,76	3,59	2,56
FeO	2,30	1,89	5,17	4,17	10,70	6,61	9,03	6,56	2,00	7,97	0,69
CaO	0,97	8,96	3,23	4,69	10,56	4,61	5,32	8,18	0,68	8,87	0,64
MgO	0,22	4,22	1,19	1,99	8,54	1,54	1,70	3,43	0,03	6,42	0,01
Na_2O	8,20	3,15	8,96	7,50	2,79	4,61	7,84	4,24	5,60	4,37	4,82
K_2O	4,81	0,55	4,00	2,96	0,85	3,45	2,57	1,28	5,73	2,08	5,67
TiO_2	0,28	2,86	0,90	1,18	2,41	1,14	1,39	1,73	0,40	2,81	0,13
P_2O_5	0,04	1,30	0,32	0,31	0,37	0,55	0,52	0,45	0,04	0,83	0,02
MnO	0,17	0,30	0,22	0,19	0,21	0,29	0,27	0,18	0,12	0,21	0,06
ppc	1,25	0,57	0,71	0,66	0,52	0,23	0,48	0,60	0,96	0,39	1,94
TOTAL	99,80	99,86	100,21	99,81	99,67	100,23	99,71	99,74	99,78	99,77	100,39

TABLE 1. MAJOR ...
(Continuation)

Volcan	Sidley						Cumming		Whitney	
Nº Specimen	OG-161	OG-180	OG-181	OG-185	OG-186	OG-188	OG-146	OG-178	OG-110	OG-116
SiO_2	58,29	54,18	63,34	54,78	60,00	53,83	66,89	64,81	63,71	49,48
Al_2O_3	17,00	20,35	17,03	17,37	17,08	17,77	11,24	14,84	14,35	16,78
Fe_2O_3	8,99	4,19	4,87	6,61	3,37	5,90	6,11	5,16	4,18	9,84
FeO	1,51	1,65	1,41	1,84	2,64	1,82	1,34	2,51	3,42	2,49
CaO	3,56	1,25	1,70	2,51	1,06	2,66	1,33	1,33	1,17	5,96
MgO	1,06	0,33	0,11	0,88	0,15	0,69	0,06	0,04	0,08	4,35
Na_2O	4,54	7,04	4,61	8,25	9,06	7,41	5,94	4,24	7,04	5,57
K_2O	3,25	6,07	5,85	4,00	5,53	4,27	5,67	5,70	5,00	1,49
TiO_2	0,83	0,48	0,38	0,98	0,35	0,88	0,44	0,33	0,45	2,04
P_2O_5	0,70	0,11	0,09	0,40	0,06	0,36	0,10	0,07	0,13	0,56
MnO	0,27	0,23	0,17	0,34	0,15	0,27	0,26	0,33	0,16	0,05
ppc	0,17	3,87	0,23	2,24	0,52	4,00	0,60	1,13	0,25	1,85
TOTAL	100,17	99,75	99,79	100,20	99,97	99,91	99,98	100,49	99,94	100,46

TABLE 1. MAJOR ...
(continuation)

Volcan	Hampton					Frakes	Toney	Takahe		Murphy
Nº Specimen	OG-124	OG-133	OG-141	OG-144	OG-147	OG-224	OG-235	OG-214	OG-217	OG-206
SiO_2	47,31	53,60	46,58	53,73	52,17	47,23	72,80	47,95	50,31	45,53
Al_2O_3	14,81	18,93	15,93	20,17	17,65	16,82	11,25	16,49	15,69	16,44
Fe_2O_3	5,12	1,74	2,21	3,47	2,17	1,46	2,11	1,48	1,46	3,14
FeO	7,49	6,42	10,31	3,65	6,82	9,57	2,11	10,96	10,10	9,46
CaO	8,53	7,93	7,13	2,10	1,97	8,35	0,33	7,96	6,79	8,67
MgO	7,76	5,27	6,60	0,81	1,18	6,66	0,02	3,93	3,35	6,31
Na_2O	8,57	3,28	5,93	9,00	9,83	4,32	4,36	4,26	4,39	4,30
K_2O	1,04	0,66	1,56	4,67	4,17	2,05	5,48	1,55	2,55	1,64
TiO_2	2,33	0,83	2,30	0,79	1,13	2,03	0,29	3,23	2,77	2,80
P_2O_5	0,53	0,25	0,73	0,39	0,44	0,75	0,03	1,39	1,28	0,90
MnO	0,14	0,13	0,15	0,22	0,26	0,23	0,11	0,20	0,35	0,23
ppc	1,79	0,44	0,32	0,53	1,89	0,24	0,88	0,03	0,54	0,40
TOTAL	100,42	99,53	99,75	99,53	99,93	99,71	99,82	99,53	99,58	99,82