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PETROLOGY AND GEOCHEMISTRY OF LATE PRECAMBRIAN MAFIC DYKE SWARMS IN SOUTHWESTERN SINAI, EGYPT

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ABSTRACT

The dyke swarms in southwestern Sinai consist of mafic (old) and felsic (young) suites. The mafic one is studied in terms of field, petrography and geochemistry. The mafic suite ranges in composition from basalt to quartz latite with 49—69 % SiO_2 and 1—4.5 % K_2O. They consist of dominant porphyritic basalt, pyroxene and hornblende andesite and hornblende quartz latite and minor plagiophyre and lamprophyre. Porphyritic varieties contain phenocrysts of plagioclase and amphibole and/or clinopyroxene. The eruption of these dyke swarms have been invaded directly before or contemporaneously with the emplacement of a late Precambrian pink granites.

Chemically, these volcanics are K-rich calc-alkaline series, largely peraluminous to metaaluminous nature. They are almost derived from continental crust slightly contaminated by upper mantle materials in orogenic belt. The tectonic setting reveals a mineralogic and chemical similarity with the island arc rather than the continental margin.

INTRODUCTION

The present study deals with the mafic dyke swarms (e.g. pre younger granite volcanics) of the Wadi Baba area in the southwestern part of Sinai (*Fig. 1*). The area is dominantly covered by Precambrian basement rocks including migmatite and gneiss, metagabbro-diorite association, older granite, old (mafic) dykes, younger granite (phase II), young (felsic) dykes and younger granite (phase III) which are partly or totally covered by Paleozoic sediments. Basalt dykes are invaded both the basement and sedimentary cover.

EL-AREF *et al.* (1988) studied the basement rocks east of Abu Zenima and concluded that these dykes represent the limit of Pan-African compression event. They include lamprophyre, andesite, plagiophyre and dolerite cutting the basement rocks except the pink granites. The mafic dyke swarms have age dating range from 586—536 Ma ago (ABDEL-KARIM and AZZAZ, in prep.)

More than 45 samples were collected, of which 21 thin sections, 12 modal and 11 chemical analyses were carried out to complete this work.

GEOLOGICAL SETTING

The geological setting based on field observations and cutting relationships suggest two suites of the dyke swarms. The old suite is mostly rich in the mafics and ranges from basalt to quartz latite including basalt, andesite and quartz latite

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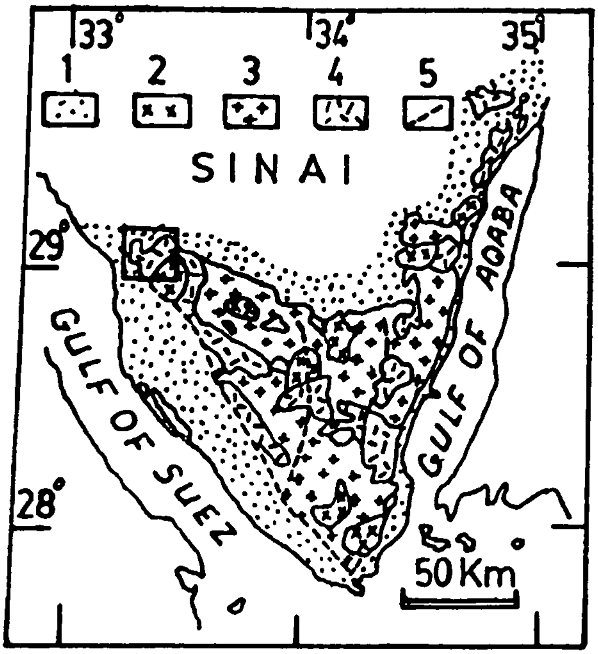

Fig. 1. Generalized geological map of the Precambrian of the Sinai Peninsula (after SHIMRON 1980), used as a location map of the studied dykes. 1: Phanerozoic sediments, 2: Young (alkaline) granitic rocks, 3: Calc alkaline granitic to dioritic rocks, 4: Other Precambrian formations, 5: Major fault lines.

with minor lamprophyre and plagiophyre dykes belonging to the late Precambrian event. The mafic dykes are dominantly strike N—S to NNE—SSW trends. They are invaded the basement rock-units (e.g. migmatites, gneisses, metagabbro-diorite association and older granites) in the examined area except the younger granites, indicating their eruption were directly before or contemporaneously with these granites. The mafic dyke swarms are frequently distributed in the northeastern part of the mapped area (Wadi Nasib, Wadi Lahian, Wadi el-Seih, Wadi Bala and north Wadi Baba). In the middle of Wadi Baba Lamprophyres are cut by basalts, consequently both these dykes cut by younger granites phase-II.

The studied dyke swarms generally vary in width from 0.5 to >10 m and length from few metres to several hundred metres. They are slightly overprinted by a rather low greenschist facies. These swarms are injected in fractures and faults which may be resulted from the effect of variable tectonic deformations in age and style, affected on the northern Arabian Shield.

PETROGRAPHY AND MODAL ANALYSIS

The present mafic dykes have a wide variety of lithologies including porphyritic basalt, pyroxene and hornblende andesite, hornblende quartz latite, plagiophyre and lamprophyre.

The basalt exhibits porphyritic and trachytic textures. Porphyritic varieties are common and usually contain phenocrysts (3—12.8%) of calcic plagioclase

(An_{40-50}) and/or clinopyroxene (augite) embedded in a fine grained groundmass (72—79%) consists of the same minerals (*Fig.* 2) with minor amounts of hornblende, biotite, quartz, chlorite and iron oxides. Andesites have the same textures,

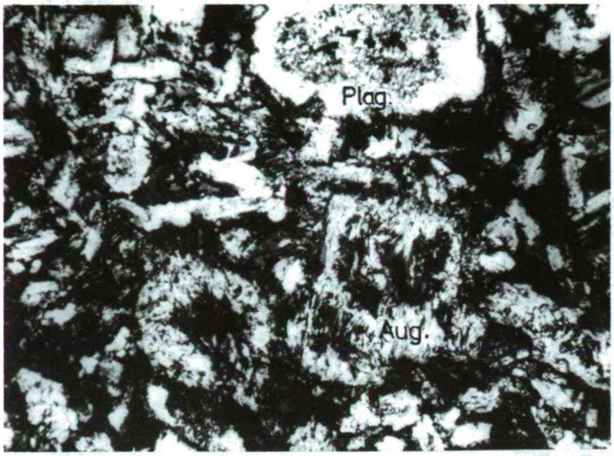

Fig. 2. Photomicrograph of basalt dyke showing phenocrysts of altered plagioclase and augite embedded in a fine grained groundmass of plagioclase, pyroxene, hornblende, biotite and iron oxides. +N., 30x.

porphyritic varieties compose of phenocrysts (14—32%) of pyroxene and hornblende and/or plagioclase (An_{35-45}) embedded in a fine grained groundmass of the same composition and subordinate quartz, biotite, chlorite and iron oxides. The hornblende quartz latite consists of phenocrysts (18.5—31%) of plagioclase (An_{35-40}), hornblende and biotite enclosed in a microcrystalline trachytoid groundmass of the same minerals together with quartz and K-feldspar and minor amounts of chlorite, epidote and titanite (*Fig. 3*). Plagiophyre consist of plagioclase phenocrysts (25—29%) embedded in a fine grained granophyric groundmass of

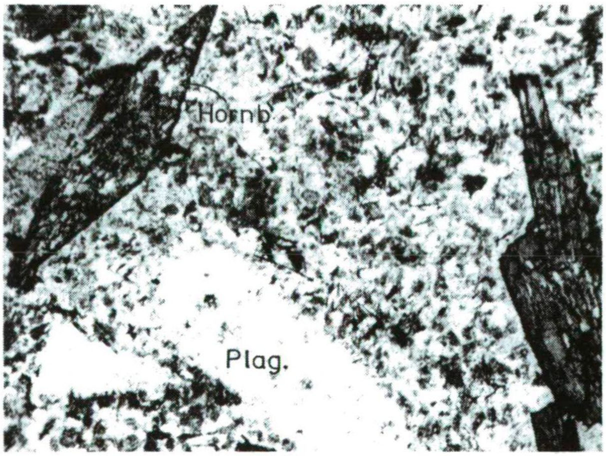

Fig. 3. Photomicrograph of hornblende quartz latite showing phenocrysts of hornblende and plagioclase enclosed in a microcrystalline trachytoid groundmass of the same minerals together with quartz, K-feldspar, biotite, chlorite and iron oxides. 1N., 30x.

plagioclase, K-feldspar, quartz, biotite and hornblende (*Fig. 4*). Lamprophyre consists mainly of fine grained plagioclase and amphibole or their phenocrysts together with subordinate tremolite and chlorite. The partial alteration of the plagioclase to epidote and calcite: the clinopyroxene and amphibole to chlorite and iron oxides (*Fig. 3*) and the amphibole to biotite may suggest a low greenschist facies for these volcanics.

The modal composition of selected twelve mafic dyke samples are plotted on STRECKEISEN's diagram (1979). These dyke swarms range from basalt to andesite and quartz latite (*Fig. 5*).

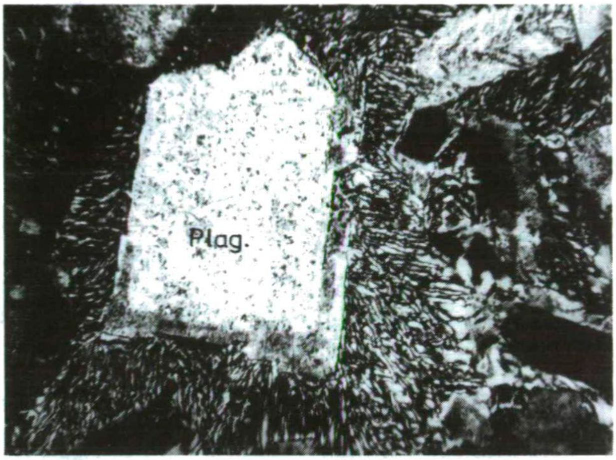

Fig. 4. Photomicrograph of plagiophyre showing phenocrysts of plagioclase embedded in a granophyric groundmass of quartz, plagioclase and K-feldspar. +N., 30x.

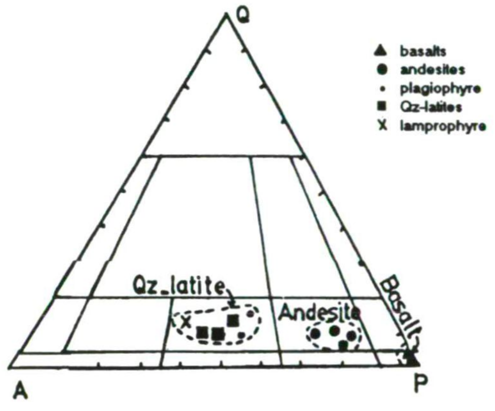

Fig. 5. Plot of the mafic dyke on the Streckeisen's diagram (1979).

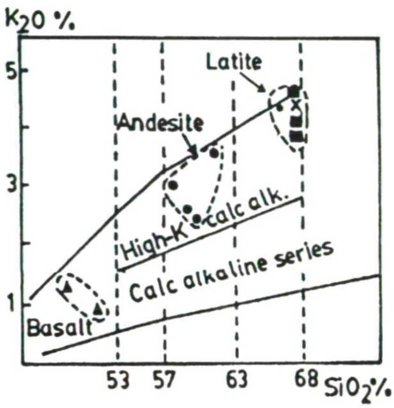

Fig. 6. Plot of the mafic dyke swarms on the K_2O—SiO_2 classification diagram after TAYLOR *et al.* (1981).

Selected eleven samples from the investigated mafic dykes were analyzed for their major element contents by standard wet chemical techniques. The analyses were carried out in the Department of Petrology and Geochemistry of Eötvös University, Hungary. The results appear in Table 1. These data have been utilized to predict the classification, magma type and tectonomagmatic setting of the investigated dyke swarms.

TABLE 1

Major elements composition of the mafic dyke swarms, southwestern Sinai.

	Basalt		High-K Andesite				Quartz Latite				
	Porph.	Bas.	Px and Hb Andesite				Plag.	Hb Quartz Latite			Lamp.
	161	100	271	152	269	284	273	286	140	260	92
SiO_2	49.01	51.50	58.34	59.36	60.90	61.62	66.90	68.55	68.68	69.32	68.99
TiO_2	2.50	1.06	1.07	0.29	0.79	0.50	0.30	0.14	0.24	0.18	<0.10
Al_2O_3	12.50	17.02	14.10	16.25	14.90	14.20	13.90	13.15	14.45	12.72	14.02
Fe_2O_3	3.90	2.37	0.56	1.94	1.13	0.41	1.05	0.89	0.85	0.19	1.15
FeO	5.71	5.88	5.59	4.61	5.08	4.41	1.81	2.40	2.16	3.39	1.84
MnO	0.33	0.10	0.07	0.08	0.06	0.18	0.03	0.05	0.03	0.05	0.04
CaO	10.93	8.53	4.67	5.60	4.30	4.05	1.31	1.78	1.72	2.23	1.23
MgO	6.70	5.69	2.99	2.28	2.17	2.92	1.01	0.76	0.48	1.27	0.51
Na_2O	3.32	4.45	4.87	4.09	4.60	4.21	4.99	4.45	4.97	4.53	4.73
K_2O	1.31	0.90	2.93	2.48	2.36	3.50	4.40	4.61	3.85	4.12	4.48
$+H_2O$	1.90	0.99	2.72	1.73	2.16	2.95	1.74	1.50	1.36	1.08	1.56
$-H_2O$	0.92	0.19	0.27	0.22	0.22	0.37	0.54	0.98	0.68	0.68	0.67
P2O5	0.81	0.29	0.42	0.24	0.22	0.18	0.09	0.05	0.05	0.60	0.05
Sum	99.84	98.97	98.51	99.17	98.89	98.38	98.06	99.31	99.52	99.84	99.37
$\frac{FeO^t}{MgO}$	1.30	1.41	2.03	2.79	2.81	1.64	2.73	4.21	6.09	2.80	5.63

Chemical Classification

The present mafic dykes are classified according to the potash-silica diagram (*Fig. 6*) after TAYLOR *et al.* (1981). On this diagram, the data points spread over the fields of basalt, andesite and quartz latite.

Magma type

The present dyke swarms are high-K calc-alkaline series (*Fig. 6*). The K-enrichment of these volcanics probably suggests their generation in extensional regime at a continental margin. Their calc-alkaline character is also emphasized on the conventional AFM diagram (*Fig. 7*) after IRVINE and BARGAR (1971). On this diagram the data points show a typical calc-alkaline trend. This trend is emphasized again by increase of both TiO_2 and FeO_t contents with the increase of FeO_t/MgO ratios (MIYASHIRO 1974, 1975) (Table 1). However, the calc-alkaline trend of the dyke swarms (*Fig. 7*) probably suggest their compressional regime environment (PETRO *et al.* 1979). Furthermore, on the NaO_2+K_2O - Al_2O_3 - CaO diagram (*Fig. 8*) after SHAND (1972) the dyke suite is peraluminous to slightly metaaluminous, probably suggest their origin from an attenuated crust near the continental margin.

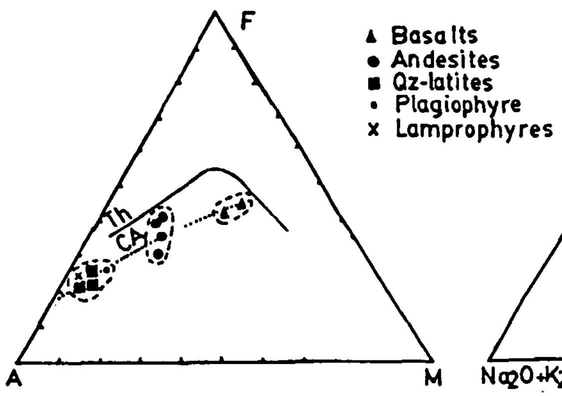

Fig. 7. Plot of the mafic dyke swarms on the AFM diagram after IRVINE and BARAGAR (1971). Dotted line represents the trend of compressional regime after PETRO *et al.* (1979).

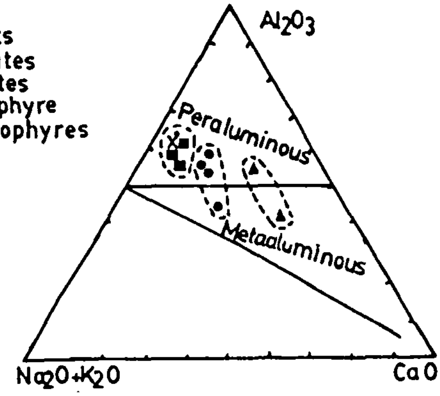

Fig. 8. Plot of the mafic dyke swarms on the Na_2O+K_2O-Al_2O_3-CaCO diagram after SHAND (1972).

TECTONIC SETTING

Using the discriminant diagram of GOTTINI and RITTMANN (*Fig. 9*) after RITTMANN (1973), the examined samples plot in the field of an orogenic belt and island arc volcanics indicate their lower crustal materials probably contaminated by a batch of upper mantle. The orogenic environment of an extensional regime of the present dykes is evident again on the MgO - FeOt - Al_2O_3 diagram (*Fig. 10*) after PEARCE *et al.* (1977). Furthermore, the continental origin of the examined suite is emphasized again on the K_2O - TiO_2 - P_2O_5 diagram (*Fig. 11*) after PEARCE *et al.* (1975). The dykes are, moreover, analogous to the mature island arc volcanics from the Western Americas. That is appear on the calc-alkali ratio — silica diagram (*Fig. 12*) after BROWN (1982).

Finally, the present suite of dykes is considered as a cogentic magmatic series, probably derived from continental crust slightly contaminated by an uper mantle material. This magmatic series is subsequently fractionated to variable pulses given rise to three dyke rock groups including basalt, andesite and quartz latite variants. Each group of dykes distinguishes by a definite mineralogic and chemical characteristics. These features can be noticed on the diagrams of *Figs. 5 to 11.* Moreover based on these mineralogic and chemical features (Table 2), the dyke swarms can be comparable with the calc-alkaline island arc volcanics (GREENWOOD *et al.* 1980, BAKER 1982).

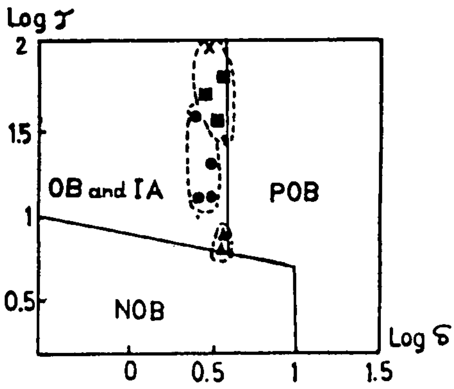

Fig. 9. Plot of the mafic dyke swarms on the log~ — log diagram after RITTMANN (1973). OB: Orogenic belt, IA: Island arc, NOB: Non-orogenic belt, POB: Post-orogenic belt.

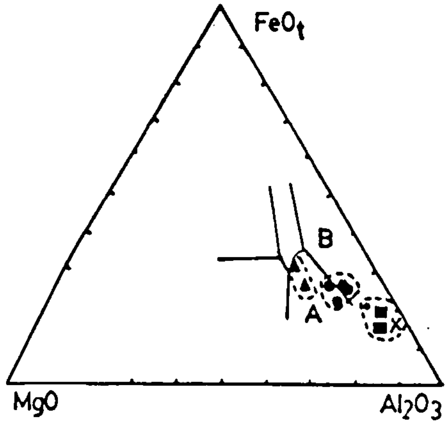

Fig. 10. Plot of the mafic dyke swarms on the MgO—FeO$_t$—Al_2O_3 diagram after PEARCE *et al.* (1977). A and B: Orogenic domain.

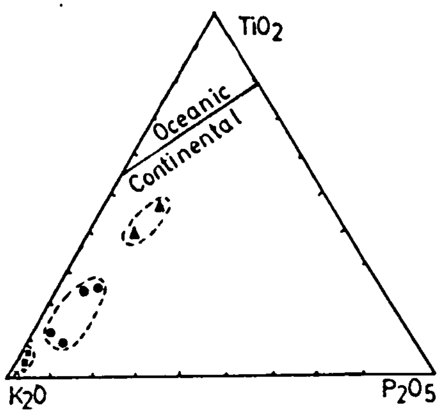

Fig. 11. **Plot of the mafic dyke swarms on the K_2O—TiO_2—P_2O_5 digram after PEARCE et al. (1975).**

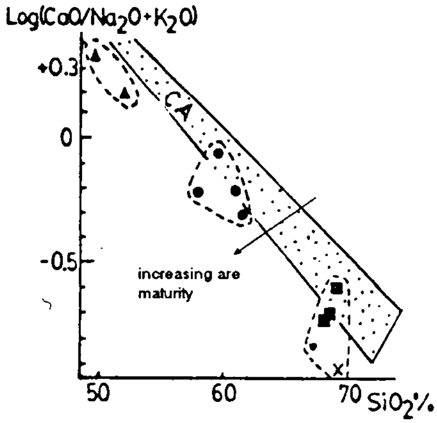

Fig. 12. **Plot of the mafic dyke swarms on the log (CaO/Na_2O+K_2O)-SiO_2 digram after BROWEN (1982). CA: Calc-alkaline andesites filed of the mature island arc.**

TABLE 2

Comparison of the typical calc-alkaline island arc volcanics (GREENWOOD et al. 1980; BAKER 1982) with the studied dyke swarms.

	Calc-alkaline island arc	The studied dyke swarms
Mafic min.	abundantly	abundantly
Phenocrysts	pyroxene	pyroxene and hornblende
Grain size	mostly porphyritic with calcic plagioclase	porphyritic with calcic plagioclase
Andesite	dominantly	dominantly
SiO_2	50—66 %	49—69 %
Na_2O+K_2O	4—7.7 %	4.3—9 %
Na_2O/K_2O	1.8—2.9	1—2.5 %

CONCLUSION

The conclusion of the foregoing field, petrographic and geochemical study reveals the following.

The late Precambrian mafic dyke swarms of southwestern Sinai consist of a wide variety of lithologies including porphyritic basalt, pyroxene and hornblende andesites, plagiophyre, hornblende quartz latite and lamprophyre. The eruption of these mafic dykes have been invaded directly before or contemporaneously with the emplacement of the late Precambrian younger granites. Based on mineralogic and chemical characteristics, the dyke swarms can be distinguished to three distinctive groups (trimodal ?).

Geochemically, the dyke swarms have high-K calc-alkaline affinity, largely peraluminous to metaaluminous. They represent a cogenetic magmatic series, probably derived from continental crust slightly contaminated by a batch of the upper mantle. This magma is subsequently fractionated to variable pulses range from basalt to quartz latite.

Tectonomagmatic setting reveals that these volcanics are similar to the late Precambrian island arc rather than the continental margin magmatism.

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