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PETROCHEMISTRY OF VOLCANIC ARC METABASALTS BETWEEN WADI KAREIM - WADI ENDIA, EASTERN DESERT, EGYPT

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ABSTRACT

The studied metavolcanics cover 315 km^2 and comprise seven seperate occurrences which appear to have been originally continuous. Petrography and petrochemistry of these rocks are discussed. Metabasalt is the main petrographic type. Twenty samples were chemically analyzed for major and trace elements. The studied rocks consist wholly of subalkaline tholeiitic basalt and shows low - K tholeiitic magmatic differentiation trend. The past tectonic setting of these rocks appear to be immature island arc

INTRODUCTION

Application of the recent global tectonics to the Precambrian belt of Egypt, revealed that the early stages in the geologic evolution of the central Eastern Desert of Egypt reflect an intense episode of ensimatic volcanic activity similar to modern magmatism of the ocean floor and island arcs (Stern, 1981). The present paper deals with the petrochemistry of metabasalts from seven occurrences of the Egyptian metavolcanics. The metavolcanics, in question, are distributed in the Eastern Desert between latitudes 25° 34' and 26° N and longitudes 34° and 34° 23' E (Fig. 1).

The studied metavolcanics cover collecctively an area of about 315 km^2 and comprise essentially metabasalts, tuffaceous metabasalts, metadolerites and amphibolites. The original rocks have undergone various degrees of regional metamorphism up to the greenschist facies of Fyfe *et al.* (1958) and Heitanen (1967). They include the following seven occurrences:

1- The Abu Tundub - Kareim occurrence (73 km^2) is an elongate low lying belt and comprising an association of regionally metamorphosed basaltic and andesitic pyroclastics, basaltic lava flows and basaltic tuffaceous lava flows. It crops out at latitude 25° 55', longitude 34° 11' and extends further north and west.

2- The mouth of Wadi Esel occurrence (51 km^2) forms an elongate belt, consists essentially of regionally metamorphosed basaltic to andesitic pyroclastics together with basaltic flows. It lies at latitude 25° 53', extends further north and longitude 34°, 34° 20' E.

3- The Esel occurrence (60 km^2) forms triangular outcrop, consists of metabasalts and corresponding pyroclastics. It is bounded by latitude 25° 48', 25° 55' N and longitude 34° 8' 30", 34° 14' E.

4- The Sherm El Bahari occurrence includes small scattered irregular low lying outcrops, covering collectively about 16 km^2. It consists of basaltic metapyroclastics intercalated with metabasalts and metadolerites. It is bounded by latitude 25^0 43', 25^0 49' N and longitude 34^0 16', 34^0 23' E.

5- The El Dabbah occurrence (22 km^2) possesses a triangular exposure, consists essentially of metabasalts and amphibolitic metabasalts together with subordinate basaltic metatuffs. It is bounded by latitude 25^0 46', 25^0 49' N and longitude 34^0 5', 34^0 10' 30" E.

6- The Nasb El-Azrak occurrence (38 km^2) forms an elongate belt and including Gabal Nasb El-Azrak. It comprises a distinct association of metabasalts, metadolerites, amphibolites, together with tuffaceous metabasalts. It is bounded by latitude 25^0 38', 25^0 42' 30" N and longitude 34^0, 34^0 6' 30" E.

7- The Endia occurrence (55 km^2) comprises metabasalts, metadolerites and amphibolites. It crops out at latitude 25^0 37', longitude 34^0 8' and extends further south and west.

PETROGRAPHY

The present metavolcanics comprise essentially the following varieties:

1- <u>Metabasalts</u>

a. Porphyritic metabasalt, consists of porphyritic crystals of plagioclase, An_{20-25} (6 mm long), augite (0.9 mm) and actinolite (1.2 mm) set in a much finer microcrystalline groundmass of plagioclase, actinolite, chlorite, calcite and epidote.

b- Aphyric metabasalt resembles the porphyritic type except for the absence of phenocrysts.

c. Intergranular metabasalt, consists of fine laths (up to 0.3 mm) of plagioclase (An_{35}), the angular interstices between which are occupied by actinolite, augite and iron oxide of random orientation.

d. Amygdaloidal metabasalt, amygdules are usually spherical or ovoid in shape and range in size from 0.14 to 1.4 mm and are filled with chlorite, calcite, quartz and epidote.

e. Tachylitic metabasalt, consists of microcrystalline plagioclase, hornblende, chlorite, granular epidote together with flow glassy material.

2- Tuffaceous metabasalts.

a. Lapilli lithic tuffaceous metabasalt consists essentially of lithic fragments (up to 5 mm) made mainly of amygdaloidal metabasalt together with few sporadic crystal ashes (up to 1.8 mm) mainly of enstatite and diopside embedded in a fine metabasaltic groundmass

b. Coarse crystal tuffaceous metabasalt, consists mainly of crystal fragments (up to 2 mm) of hornblende, diopside, plagioclase, chlorite, epidote and opaques embedded in a metabasaltic groundmass.

c. Coarse crystal lithic tuffaceous metabasalt, composed of roughly equal amounts of lithic fragments (amygdaloidal metabasalt) and crystal ashes (augite) set in palotaxitic groundmass of basaltic composition.

3- Metadolerites.

Metadolerites consist of subidiomorphic laths of

plagioclase (An$_{[illegible]}$), green hornblende together with subordinate relics of augite. Epidote and kaolinite are secondary minerals whereas iron oxide and apatite are accessories.

c- Amphibolites.

They consist of hornblende and/ or actinolitic hornblende and plagioclase with very rare quartz. Iron oxide and apatite are accessories. Epidote, clinozoisite and [illegible] are secondary constituents. Subophitic and diabasic textures are still preserved.

GEOCHEMISTRY

Twenty selected samples were chemically analyzed for major and trace elements (Tab. 1). The CIPW normative [illegible] are calculated (Tab. 2).

[illegible] elements were largely [illegible] (Fluorescence and atomic [illegible]) [illegible] samples ([illegible]) were [illegible] for major and selective trace elements in [illegible] University [illegible]. Another [illegible] samples [illegible] chemically and [illegible] for major and trace elements [illegible] Mineralogy and Petrology, Padova, Italy. [illegible] samples [illegible] the Central Laboratories of the Geological Survey of Egypt.

NOMENCLATURE

A number of different schemes for classifying rocks have been developed based principally on whether prime emphasis is placed upon the chemistry or on the mineralogy and texture.

Chemical classification.

The use of the R_1R_2 chemical variation diagram for the present samples (Fig. 2) revealed that they are basalts (tholeiite, olivine basalt and andesi-basalt).

On the TAS diagram (Fig. 3), it was found that the present samples lie well within the basalt (olivine or quartz normative) and or alkali basalt (nepheline normative) fields. The studied rocks, however, are devoid of normative nepheline, 13 samples contain normative quartz and 7 samples have normative olivine. Accordingly, the analyzed rocks are quartz basalt and olivine basalt (not alkaline) and one sample lie in the basaltic andesite field.

Normative calssification

The plots of the analyzed metavolcanics on the QAPF double triangle (Fig. 4) reveal that the samples lie in the basalt and / or andesite field. Although the basalt and andesite fields are the same in the QAPF diagram; the andesites have a colour index of 10-30, whereas the basalts have a colour index of 35-50 (Streckeisen, 1976). The colour index of the studied rocks varies from 25 to 51 (except one sample have CI 30) indicating a basaltic composition of these rocks.

Irvine and Baragar (1971) plotted normative plagioclase against normative colour index to discriminate between basalt, andesite, dacite and rhyolite. Using their diagram (Fig. 5) the present samples fall within the basalt field.

MAGMA TYPE

Using the alkali - silica variation diagram (Fig. 6) we can discriminate between alkaline and subalkaline volcanic rocks. The samples plot firmly within the field of subalkaline magma type except few samples, which lie just above the separating line because of the enrichment of Na due to metamorphism.

The AFM diagram (Fig. 7) and Al_2O_3 versus normative plagioclase diagram (Fig. 8) proved that the metabasalts were derived from a tholeiitic magma with minor calc alkaline one, i.e. transitional magma.

Bellieni *et al.* (1981) classified the basalts into three main groups:

1- alkaline basalts
2- transitional basalts
   2.1. alkaline transitional basalts
   2.2. subalkaline trasitional basalts
3- subalkaline basalts

By plotting the data of the metabasalts on R_1R_2 - diagram (Fig. 9) of Bellieni *et al.* (1981), it is found that half of the samples fall within the subalkaline basalts, whereas the other half fall within the subalkaline transitional basalts.

OROGENIC BELT

Gill (1981) used Ni-MgO relationship and drew field of orogenic basalt and andesite. Figure 10 shows that the studied metabasalts lie within or close to the orogenic basalt field.

Recent studies indicate two main tectonic environments of the volcanic rocks, within plate and plate margin volcanics. The latter include most of the orogenic belts. On plotting Zr/Y versus Ti/Y to discriminate between within plate and plate margin (Pearce and Gale, 1977). Figure 11 shows that the available data of metavolcanics fall mainly within the plate margin field.

The above diagrams and data support the idea which suggest that the studied metabasalts are formed in orogenic belt.

TECTONIC IMPLICATION

Miyashiro (1975) used Na_2O/K_2O versus $Na_2O + K_2O$ in case in old metamorphosed rocks to indicate any alkali migration during metamorphism. Figure 12 shows that metabasalts lie below the v-v line indicating little migration of alkalies during metamorphism. The majority of the present rocks behave similar to the island arc volcanic rocks and island arc tholeiites.

The distribution of the present metabasalts in the Ni versus FeO^* / MgO (Fig. 13) shows that the immature island arc and / or active continental margin environment is dominant for the majority of the metabasalts.

Pearce (1976) has compiled a large number of major element oxide analyses for basaltic rocks from different tectonic settings and by using discriminant functions, it was possible to differentiate between different tectonic settings. The metabasalts lie in the $F_1 - F_2$ diagram (Fig. 14) in the island arc tholeiite and or calc alkaline basalt field. In the

F_2 - F_3 diagram (Fig. 15) the samples fall mainly in the island arc tholeiite field.

Condie (1982) classified the environments of magma production into plate - margin and intra - plate environments. Figure 10 shows that the majority of metabasalts plot within the field of plate - margin basalt (island arc basalt not ocean floor basalt).

Miyashiro (1974) stated that the main rocks in the immature island arc are usually basalts and basaltic andesites of the tholeiitic series which are built on thin oceanic type crust, whereas these in well - developed island arcs with a thick continental - type crust are andesites and dacites of the tholeiitic and calc alkalic series. Based on this assumption, the metabasalts are considered as immature island arc of tholeiitic series.

SUMMARY

The volcanic rocks between latitudes 25° 34' and 26° N in the eastern half of the Precambrian belt of the Eastern Desert comprise seven occurrences covering 315 km^2 which appear to have been originally continuous. The volcanic rocks represent an association of regionally metamorphosed basalt with corresponding primary pyroclastics. Petrographically, metabasalt is the main type and includes porphyritic, aphyric, intergranular, amygdaloidal, and trachytic metabasalt. Tuffaceous metabasalts include lapilli lithic, coarse crystal and coarse crystal lithic-tuffaceous metabasalt. The studied metabasalts are regionally metamorphosed up to the greenschist facies and derived from tholeiitic magma formed in orogenic belt.

The generation of an island arc (s) volcanism starting with the eruption of tholeiitic basalts with their corresponding primary pyroclastics, forming immature phase of the island arc.

CAPTIONS TO FIGURES

Fig. 1 : Lacation map of the studied metavolcanics.

Fig. 2 : R_1 R_2 - diagram for classification of volcanic rocks (De la Roche *et al.*, 1980).

Fig. 3 : TAS diagram for classification of volcanic rocks (Zanettin, 1984).

Fig. 4 : Distribution of the studied rocks in the QAPF double triangle (Streckeisen, 1967).

Fig. 5 : Plots of normative plagioclase composition versus normative colour index for the studied rocks. (Irvine and Baragar, 1971).

Fig. 6 : Alkali - Silica variation diagram. The field boundary separate alkaline from subalkaline volcanic rocks. (Irvine and Baragar, 1971).

Fig. 7 : AFM variation diagram. Solid line separate tholeiitic (above) from calc alkaline composition. (Irvine and Baragar, 1971).

Fig. 8 : Normative plagioclase composition versus Al_2O_3 wt % (Irvine and Baragar, 1971).

Fig. 9 : R_1 R_2 variation diagram for the studied basalts (Bellieni *et al.*, 1981).

Fig. 10 : Ni - MgO relationship for orogenic basalts and andesites (Gill, 1981).

Fig. 11 : Zr/y - Ti/y discrimination diagram (Pearce and Gale, 1977).

Fig. 12 : Na_2O/ K_2O versus $Na_2O + K_2O$ diagram. The field boundries are after Miyashiro (1975).

Fig. 13 : Ni versus FeO^{*}/ MgO diagram. The field boundaries are after miyashiro (1975).

Fig. 14 : Plot of discriminant functions F_1 against F_2 for the studied rocks (Pearce, 1976)

LKT = low potassium tholeiites
OFB = Ocean floor basallts
CAB = Calc - alkali basalts
SHO = Shoshonites

Fig. 15 : Plot of discriminant functions F_2 against F_3 (Pearce, 1976).

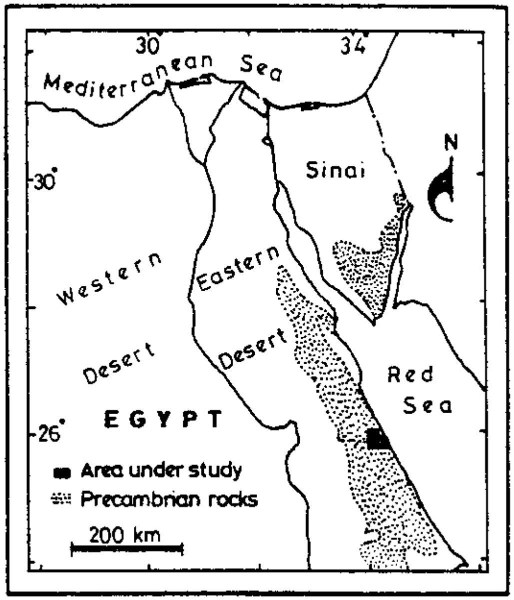
30
34
Mediterranean Sea
30
Sinai
N
Western Desert
Eastern Desert
Red Sea
26
EGYPT
Area under study
Precambrian rocks
200 km

FIG. 1

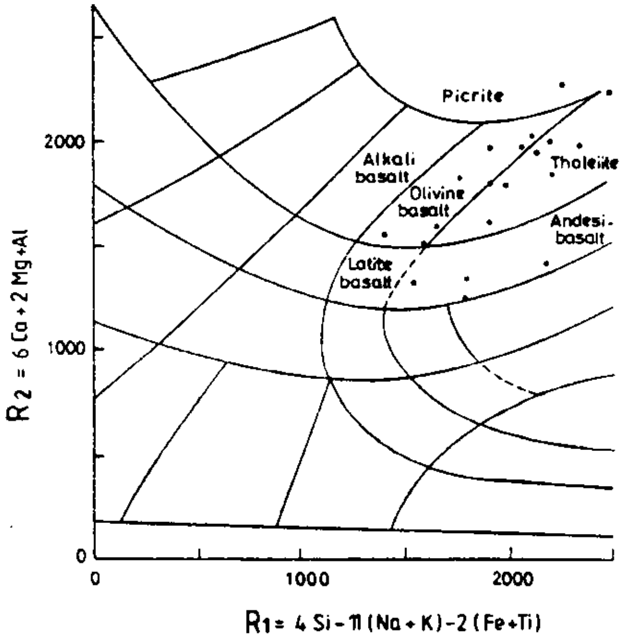
Picrite
Alkali basalt
Olivine basalt
Tholeiite
Andesi-basalt
Latite basalt
2000
1000
0
0
1000
2000
R_2 = 6 Ca + 2 Mg + Al
R_1 = 4 Si - 11 (Na + K) - 2 (Fe + Ti)

FIG. 2

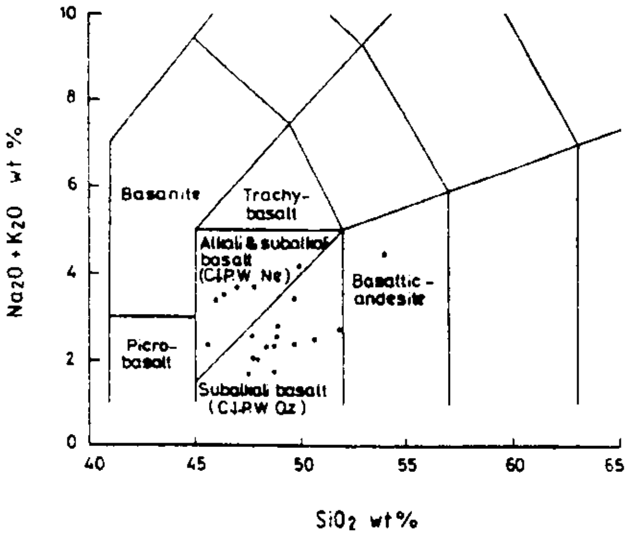
10
8
6
4
2
0
Basanite
Trachy-basalt
Alkali & subalkal basalt (C.I.P.W. Ne)
Basaltic-andesite
Picro-basalt
Subalkal basalt (C.I.P.W. Qz)
40
45
50
55
60
65
$Na_2O + K_2O$ wt %
SiO_2 wt %

FIG. 3

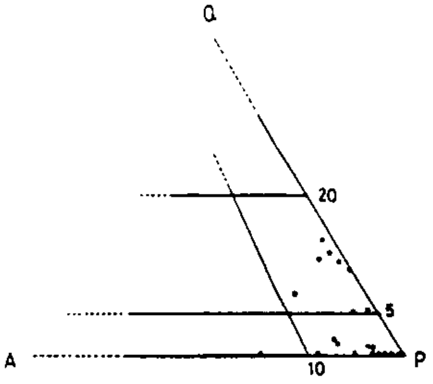

FIG. 4

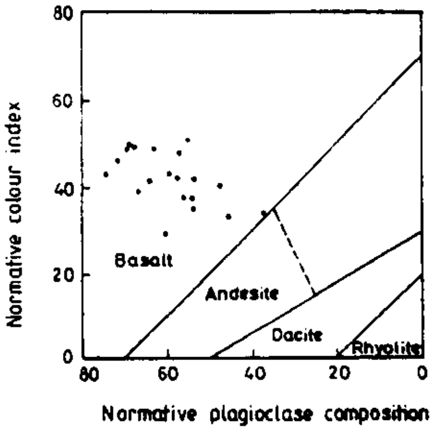

FIG. 5

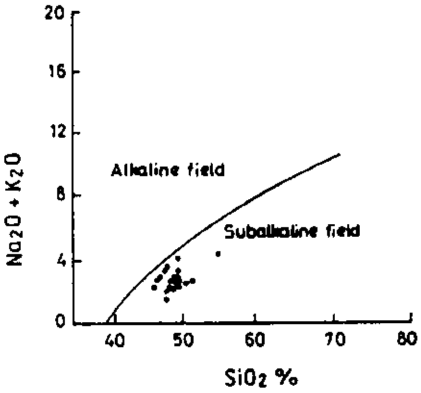

FIG. 6

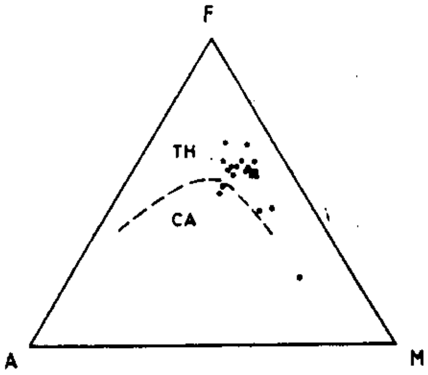

FIG. 7

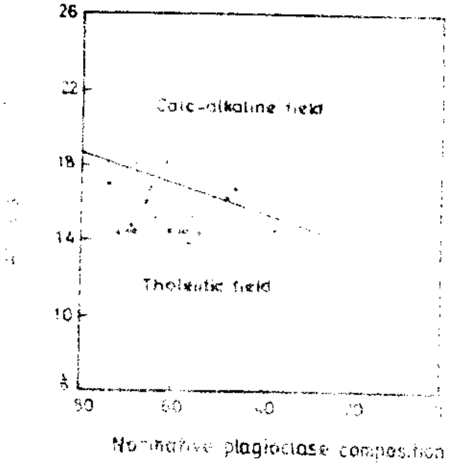

FIG. 8

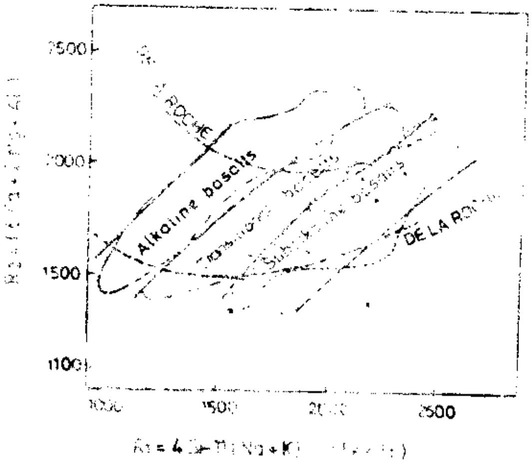

FIG. 9

FIG. 10

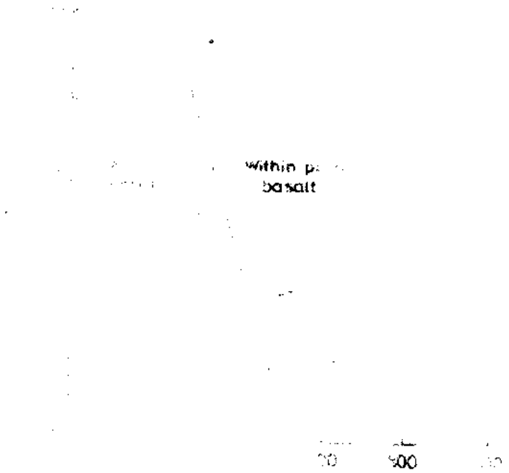

FIG. 11

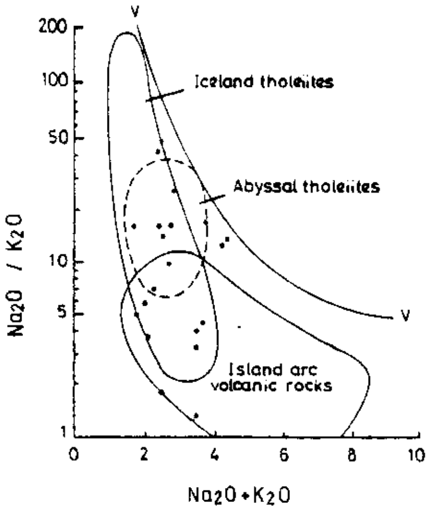

FIG. 12

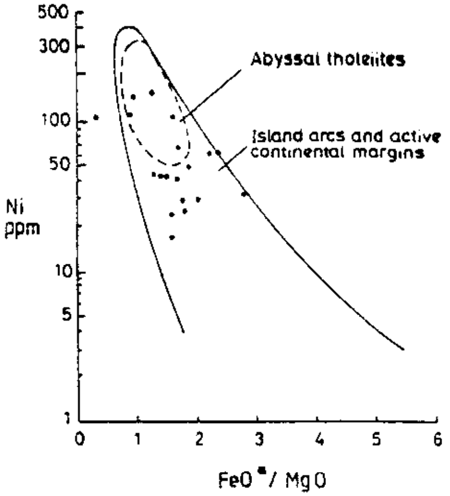

FIG. 13

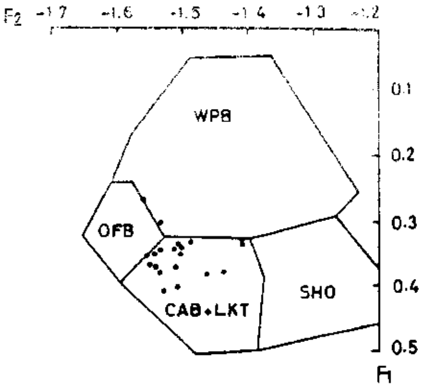

FIG. 14

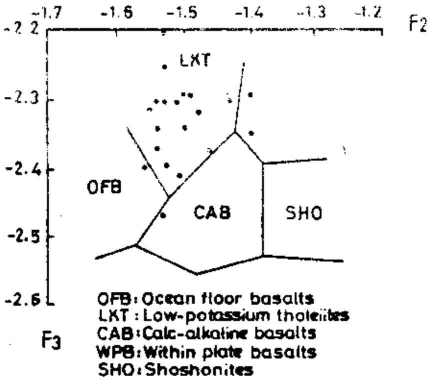

FIG. 15

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بتروكيميائيه قوس بركان البازلت المتحول بين وادى كريم - وادى غنصبيه ؛ الصحراء الشرقيه ؛ مصر

سمير محمد على ؛ محمد فواد غنيم ؛ عبد السلام رشاد أبو العلا
محمد متولى أبو عنبر ؛ جعفر بحريه
قسم الجيولوجيا - جامعة طنطا

تم دراسة الصخور البركانيه المتحوله والتى تشغل مساحه ٣١٥ كم^{٢} وتمثل سبعة تواجدات منفصله والتى تبدو فى الأصل مستمره ، وقد نوقش بتروجرافية وبتروكيميائية هذه الصخور ، ويمثل البازلت المتحول أهم الأنواع البتروجرافيه ، وقد تم تحليل العناصر الأساسيه والثانويه فى عشرون عينه ، وتتكون الصخور كلية من بازلت ثولييتى تحت قلوى وتظهر إتجاه تفارق مجماتى لثوليت فقير فى البوتاسيوم ، الوضع التكتونى القديم لتلك الصخور هو قوس جزر غير ناضج ،