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CHEMICAL DISCRIMINATION, CLASSIFICATION AND PETROGENESIS OF WADI KABB EL RAKAB-GEBEL MIRIER METAVOLCANICS, CENTRAL EASTERN DESERT, EGYPT

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ABSTRACT

The chemical classification of Kab El Rakab metavolcanics has been presented following two approaches of classification and making use of 22 new chemical analyses of dolerites and metabasalts, metarhyodacits, metarhyolites and pyroclastic rocks. The first approach using chemical parameters of major elements and Irvine and Baragar's (1971), Church's (1975) and Middlemost's (1980) diagram are applied. The second approach of classification uses Le Maitr's (1976), Winchester and Floyed's (1976), on the basis of CIPW norm and combination of major and immobile or stable elements. It is proposed to plot normative composition in the QAPF diagram of Strecheisen (1967) whith Q = Qtz, A = Orxt, P = Anxt and F = Ne + Lc + Kp where T = (Or +An + Ab)/(Or + An). The use of immobile elements as proposed by Winchester and Floyd (1977) is more quite satisfactory, for further classification, to avoid the problem of using the changeable immobile elements.

The present study suggests that Kab El Rakab metavolcanic rock suite were formed from seperate partial melts of common sources; i.e. bimodal volcanic rocks representing the second record for this type of volcanicity in the Egyptian Shield (El Ramly, et al., 1982).

INTRODUCTION

The metavolcanic rocks of Kab El Rakab area are located in the eastern margin of the basement complex of Egypt (Fig. 1). They are one of the widely distributed metavolcanic units in the Egyptian Shield, the so-called Shadli metavolcanics. The Shadli metavolcanics are of Late Proterozoic age (700-1100 m.y.) and cover about 12 % of the basement of the Eastern Desert (Stern, 1979). Kab El Rakab metavolcanic assaciations occur in the form of successive sheets and plugs represented by lava flows and intercalations of pyroclastic rocks. The lava flows are mainly basaltic and dacitic with minor andesitic basalt and rhyolitic flow. Pure andestic rock types are rare or lack. The pyroclastics are represented by rhyolitic and dacitic tuffs.

The present work is based on the chemical analyses data of 22 different rock samples, (for both major and trace elements), representing the main types of the studied metavolcanics. The present paper deals mainly with the classification and differentiation nature of Kab El Rakab metavolcanics. The characteristic features of the geochemistry of the studied rocks are presented elsewhere (El Rahmany et al., this volume).

It is worthy that the classification of igneous rocks, especially the volcanics, is a problem. The modal anlysis is commonly profitable and helpfull for the clasification of the plutonic rocks (Sabine, 1974) and (Streckeisen, 1976 b). On the other hand, the modal contents, in most cases, cannot be determined accurately because of the micro-or cryptocrystalline or even glassy texture of their matrix. To obtain an accurate chemical analysis of a rock, as it is much easier in these days of automated X-ray equipment, than an accurate modal analysis, many chemical classification of volcanic rocks have been presented followed mainly two approaches using parameters which are not directly related to mineral contents (oxides and function oxides, molecular values, ratios, etc.). The first approach using chemical parameters of major elements. The second approach using norm claculations for the projection of the chemical data into mineralogical classifications and using combinations of major and trace elements data.

1) Chemical classification of Kab El Rakab Metavolcanics:

For an exact characterization of the investigated rocks, the two approaches of chemical classification are followed. Church's (1975), Irvine and Baragar's (1971) and Middlemost's (1980) classifications are based on chemical parameters following the first approach of classification. while Le Maitre's (1976) and Winchester and Floyed's (1977) classificaions follow the seocnd one. On the bases of chemical analyses (Table 1) CIPW norms and trace element abundances (Tables 2 & 3) of Kab El Rakab metavolcanics.

The methods and diagrams adopted, in the present study, will be discussed as follows:

1. Irvine and Baragar's (1971) Classifications:

Irvine and Baragar (1971) proposed a chemical classification, based on the framework which was set by Kennedy (1933) and Tilley (1950), for the common volcanic rocks into: (a) subalkaline (including both clac-alkaline and tholeiitic basalt series); (b) alkaline; and (c) Peralkaline rocks. Various diagrams were employed by Irvine and Baragar (1971), some of these diagrams are used for the classification of Kab El Rakab metavolcanics as follows:

a. Alalies - Sillica Diagram:

Many workers have several attempts to calssify the volcanic rocks on the basis of the total alalies (Na_2O + K_2O) and silica (in wt. %). This daigram has been estabilshed as an effective means of distinguishing alkaline and subalkaline volcanics, as illustrated by MacDonald's (1968) dividing line (dashed) in (Fig. 2).

The representative points of Kab El Rakab metavolcanics fall below the boundary line (i.e., within the field of subalkaline rocks with the exception of six samples are falling in the field of alkaline rocks. Accordingly they are of subalkaline composition with tendency of some to the alkaline composition.

b. Normative Colour Index (NCI) Versus Normative Plagioclase Composition:

For further classification, Irvine and Baragar (1971) have proposed as sum of the following normative minerals as NC1 = Ol + (Fo+Fa) + Opex (En+Fs) + Cpx (Di+Hy) + Ht + II + Mt.

The calculated normative colour index is plotted against the normative plagioclase composition for the Kab El Rakab metavolcanics. (Fig. 3) shows clearly that the metadacitic rocks fall in the field of dacite, whereas the meta-andesetic basaltic rocks plot in the fields of basalts and andesite. Metarhyolitic rocks plot int he field of andesite showing their higher NCI than the average given by Irvine and Baragar. Basaltic rocks fall in their corresponding field.

c. AFM Diagram:

AFM diagram with total Fe as FeO is used for separation of tholeiitic and calc-alaline rocks. In (Fig. 4) the line separating tholeiitic and cal-alkaline suit is shown. The analysed samples of Kab El Rakab-Gebel Mirier metavolcanics show clearly that they follow the line presented by Irvine and Baragar (1971) for calc-alkaline suites with the exception of one sample falling in the tholeiitic fiels.

2. Middlemost's (1980) Diagram:

A simple satisfacrtory classification using the major elements depending on silica and total alkalies content was attempted by Middlemost (1980), (Fig. 5). This diagram could successfully discriminate the examined metavolcanics into their types confirming typically petrographical classification (El Rahmany et al. this volume).

4. Church's (1975) Variation Diagram:

Church (1975) designated a simple quantitative method for illustrating the composition and comparing the main volcanic rocks. This method is based on using a three orthogonal plot of $Na_2O + K_2O$ versus $Fe_2O_3 + Fe_2O_3 + 1/2$ (MgO + CaO) versue AL_2O_3 / SiO_2 (Fig. 6). The studied metavolcanics plot in their corresponding fields, except the metarhyolitic rocks falling outside the rhyolitic field. This slight deviation of the metarhyolitic samples showing their higher basieity index than the range given by Church. It is perhaps due to secondary carbonatization which is often observed as minute veinlets.

b. Le Maitr's (1976) Classification:

Le Maitre (1976) used another new approch, based on some multivariate statistical methods, to the classification of igneous rocks. He used the analyses of basalts (2906), andesites (2342), dacites (526) rhyolites (557), selected from CLAIR master file which consists of 26271 puplished analyses of igneous rocks from allover the world (Le Maitre, 1973). In his study, Le Maitre has shown that the areas occupied by the four rock groups on a Or-Ar-An triangle (Streckeisen, 1976 b) are highly overlapped. A better separation of their fields is attained if the normative contents of the basalts, andesites, dacites and rhyolites are plotted on the QAPF diagram of Streckeisen (1967) with Q = Qtz, A = Or X T and P = An X T, where T = (Or + Ab + An)/(Or + An) and F = Ne + Lc + Kp. The value T was proposed by Le Maitre (1976) to recalculate the Or, Ab and An to alkali feldspar and plagioclase. Worthy of remark, that the distribution of the feldspar molecules over potash feldspar and plagioclase was tentatively renounced by Streckeisen (1976, a, p. 3).

The Or, Ab and An contents of Kab El Rakab metavolcanics recalculated to alkali feldspar and plagioclase following Le Maitre's (1976) recommendations. Fig. (7) shows the plot of the examined metavolcanics on the QAPF diagram. The examined rocks fall in their corresponding fields except rhyolitic rocks which plot outside the rhyolitic field towards Q apex due to their higher content of normative quartz. Also, one basaltic sample plot outside the basaltic field towards F apex, due to its higher normative Ne value.

2. Winchester and Floyed's (1977) Classification:

Winchester and Floyed (1977) introduced simple diagrams using the immobile element concentrations in volcanic rocks to recognize their original rock type. Worthy of nomark that the chemical criteria commonly used to classify fresh or slightly altered volcanic rocks, all use elements known to be mobile during metamorphism. Thus, they avoided that by using immobile elements as Zr/TiO_2 ratio against SiO_2 as a mean of discrimination between different rock types (Fig. 8). The different types of Kab El Rakab metavolcanics plot in their corresponding fileds.

II. DIFFERENTIATION OF KAB EL RAKAB METAVOLCANICS:

The differentiation nature of Kab El Rakab metavolcanics could be revealed by adopting the results of the chemical analysis. The follwoing methods and diagrams are used:

1. Thronton and Tuttle Differentiation Index:

Thronton and Tuttle (1960) proposed the differentiation (D.I.) as the sum of the weight percentages of normative quartz + albite + orthoclase.

The differentitation index, is a measure of lecuocoratic nature of the rock.

Fig. (9). shows a differentiation trend similar to that recognized in many worldwide studies of volcanic rocks. SiO_2, Na_2O and K_2O show positive trends with increasing D.I. AI_2O_3, femic oxides (sum of Fe_2O_3 + Fe_2O_3 + MnO + MgO) and CaO decrease with increasing D.I. index.

From the figure, it is noticed that a distinct gap exists, ranging between 44.33 and 66.14, i.e. it is formed between the acidic and basic rocks of the studied metavolcanics. This gap could be not by itself rule out the possibility that more silicic rocks are formed by fractional crystallization from the basaltic magmas (Brayan, 1964).

A variation diagram for trace elements abundances plotted against the D.I., to reveal the trend of evolution of Kab El Rakab metavolcanics is also shown in Fig. (10). From the diagram, it is abvious that the differentiation trend of Kab El Rakab metavolcanics is consistant with many worldwide studies of volcanic rocks. Generally, Ba, Zr, Be, Sn and Mo increase with icnreasing D.I., while V, Cr, Co, Cu and Ni are of negative correlation with D.I. Sr contents are of no characteristic order of differentiation.

2. Simpson's Graphic Representation:

To reveal the magmatic differentiation of the igneous rocks Simpson (1954) had designated a graphic representation for the felsic and mafic indices of igneous rocts.

As shown in the diagram, the Felsic indxe(M)=

$$\frac{Na_2O + K_2O}{CaO + Na_2O + K_2O} \times 100$$ is plotted against the

$$\text{Mafic index (F)} = \frac{FeO + Fe_2O_3}{MgO + FeO + Fe_2O_3} \times 100 \text{ (Fig. 11).}$$

The general trend for Nockold's (1954) average trend is also shown in the diagram. The mafic index (M) and felsic index (F) are computed for the studied metavolcanics. The Kab El Kabab metavolcanics fall in the field of intermediate differentiate.

III. REMARKS ON PETROGENESIS

To idnetify the specific magmatic character of Wadi Kab El Rakab-Gebel Mirier metavolcanics, few attempts have been centered on the general field studies, compositional range and chemical character of some rock types on relation to ridge enironment or the main phase of folding (Sabet, 1961; Awadallah and Shaalan, 1979; and Noweir, 1983). From the chemical data reviewed above the Kab El Rakab-Gebel Mirier metavolcanics are characterized by a number of significant features both in space and time.

1. Nature of volcanism. (a) Typical of Kab El Rakab-Gebel Mirier metavolcanics is a bimodal basic-acid pre-orogenic volcanism (basalts-association) with basaltic composition predominating. (b). The area is more vairable with either (i) pre-orogenic bimodal volcanism associated with basic/ultrabasic rocks and syn-orogenic granitoid plutonism and (ii) a Late-orogenic acid dominated granitoid plutonism.

2. Chemical variations. The increase in incompatible element abundances from basic to acidic varieties with time may reflect either (i) decrease of partial melting of a uniform source with time, possibly warning geothermal

gradient. Or (ii) the melting of incompatible element enriched mantle that was later produced by progressive metasomatism during the scond orogeny.

3. It has been suggested that hydrous large ion lithophile elements enriched fluids derived from a dehydrating subducted slab may metasomatize the mantle wedge above and produce magams typical of island arc. This opinion is in harmony with that suggested by Floyd (1982) for the Hercynian volcanic zones, SW England.

CONCLUSION

In conclusion, the previous sutdy permits to conclude that the chemical classification of the examined metavolcanics and their evolutionary trends according to their chemical parameters are valid. The convenient method for the classification of metavolcanics by plotting their normative composition onto mineralogical classification, appear to b:

1. A distribution of the fledspar molecules between potash fledspars and plagioclase following Le Maitre's (1976) recommendations.

2. A plotting of normative composition on the QAPF diagram of Streckeisen (1967) with Q = Qtz, A = OR X T, P = An X T and F = Ne + Lc + Kp, where T = (Or + Ab

+ An)/(Or + Ab). The fields designated by Le Maitre (1976) are quite satisfactory.

3. For further classification to avoid the problems of using the changeable mobile elements, the use of immobile elements by Winchester and Floyd (1977) is more quite satisfactory.

4. A continuous chemical evolutionary trend from the most basic volcanics (basalts) to the most acidic components (rhyolites) may suggest a genetic relationship.

5. The lack of pure andesitic rock and the presence of geochemical gap as shown by their chemical discrimination parameters and evolutionary trnds points out the possibility melts of common sources, i.e. biomdal volcanicity for Kab El Rakab metavolcanic rock suite.

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