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PALEOZOIC IGNEOUS ACTIVITY IN EGYPT

By

M.Y. MENEISY*
Department of Geology, Faculty of Science, University of Qatar
Doha, Qatar

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ABSTRACT

Based on available isotopic age data, including a few K/Ar ages obtained by the writer, a geochronological sequence of the main phases of igneous activity in Egypt during the Paleozoic is presented. Five main phases at around 550-500 Ma, 400 Ma, 350 Ma, 290 Ma and 230 Ma are identified. An attempt is made to relate these phases with tectonic events. It appears that Paleozoic igneous activity in Egypt was more widespread than has previously been recognised.

INTRODUCTION

Igneous activity repeatedly occurred in Egypt during the Phanerozoic, mainly related to the fracture system which originated in the late Precambrian. Periodical reactivation of these older fracture zones gave way to different types of plutonic and volcanic rock assemblages. It is noted that while several published works dealt with the Mesozoic and Cenozoic igneous activity in Egypt, yet, information concerning the Paleozoic is realtively limited.

This paper is part of a detailed geochronological study of Phanerozoic magmatism recently carried out by the present writer.

Compared with those of the Mesozoic and Cenozoic, the Paleozoic igneous rocks are more diversified in their chemical characteristics, size and mode of occurrence. The main petrological aspects of these rocks are also indicated herein.

ISOTOPIC AGE DATA

Available isotopic age data are compiled and carefully examined. Some thirty five 'reliable' ages, including K/Ar ages obtained by the writer are presented in Table 1.

*Present address: Department of Geology, Faculty of Science, University of Ain Shams, Cairo, Egypt.

Table 1.
Isotopic Determinations Yielding Paleozoic Ages

No.	Locality	Age(Ma)	Method*	Rock	Reference
1.	W.Dib N.ED	553±11 558±11 551±11	K/Ar(b) " "	Qz-syenite umptekite umptekite	Serencsits *et al.* 1979
2.	N.Qena- Safaga Rd Um Rus, C.ED	527 521 488 480 497	K/Ar " " " "	acidic, intermediate & basic dikes	Nairn & Ressetar 1980
3.	W. Gemal C.ED	530	Pb "	allanite- pegmatite	El Ramly 1963
4.	W.Hafafit	495	K/Ar	pegmatite	El Ramly 1963
5.	Um Kroosh S.ED	500±30 480±15	Rb/Sr "	andesite andesite	El Shazly 1977
6.	G.Abu Durba	485±23	K/Ar	rhyolite	Steen 1982
7.	G.Babein S.WD	489±12	K/Ar	microgranite	Hunting 1974 (recalculated)
8.	G.Kamil S.WD	431±33	Rb/Sr (isochron)	granite	Schandelmeir & Darbyshire 1984
9.	Zargat Naam S.ED	404±8	K/Ar(h)	alkaline syenite	Serencsits *et al.* 1979
10.	Sharib Well 1, 8205 ft N.WD	395±16	K/Ar	basalt	McKenzie 1971
11.	Tarbite N S.ED	351±7	K/Ar(h)	nordmarkite	Serencsits *et al.* 1979
12.	G.Mishbeh S.ED	305±20	Rb/Sr	Ne-syenite	Serencsits *et al.* 1979
13.	Um El Khors C.ED	302±15	Rb/Sr (isochron)	trachyte	El Shazly 1977

Table 1 Contd.

No.	Locality	Age(Ma)	Method*	Rock	Reference
14.	W. Kareim S.ED	300±15	Rb/Sr	bostonite	Sayyah *et al.* 1978
15.	Hafafit Mine S.ED	300	K/Ar	camptonite	El Ramly 1963
16.	Rabat Well 1 N.WD	293±12	K/Ar	olivine basalt	El Shazly 1977
17.	G. Um Kibash S.ED	290	K/Ar	bostonite	El Ramly 1963
18.	El-Atshan	273±20	Rb/Sr	bostonite	El Ramly 1963
19.	Um Shaghir C.ED	273±15	Rb/Sr (isochron)	trachyte	El Shazly 1977
20.	Nasb El Qash C.ED	245±15	Rb/Sr (isochron)	trachyte	El Shazly 1977
21.	Farsh El-Azraq, W.C. Sinai	238±3 233±3	K/Ar " "	olivine basalt	Meneisy (This work)
22.	G.Zargat Naam, S.ED	247±13	Rb/Sr	syenite	Hashad & El-Reedy 1979
23.	Uweinat area, S.WD	235±5	K/Ar	basaltic dike	klerx & Rundle 1976
24.	El-Gezira S.ED	229±5	K/Ar(b)	gabbro	Serencsits *et al.* 1979
25.	G.Bir Um Hebal, S.ED	223±9	Rb/Sr	granosyen-ite	Hashad & El-Reedy 1979
26.	G.Silaia S.ED	221±12	Rb/Sr	granite	Hashad & El-Reedy 1979
27.	G.El-Naga S.ED	220±20	Rb/Sr	Ne-syenite	El Shazly 1977

Abbreviations:

G. gebel
W. Wadi
WD Western Desert
ED Eastern Desert

*Whole rock, unless otherwise specified
b: biotite
h: hornblende

DISCUSSION

The earliest Phanerozoic igneous activity in Egypt was that associated with or closely related to the Pan-African tectono-thermal event. Despite current controversy as to the nature and time span of this important event (e. g. Fleck et al, 1976; Gass, 1977; Rogers *et al,* 1978; Engel *et al,* 1980) it is generally accepted that the last phases of this event persisted through earliest Paleozoic times. It is with these late Pan-African phases that we are concerned here.

The sequence of principal Pan-African magmatic events - especially in the north Eastern Desert - has recently been outlined by Stern *et al* (1984). According to his sequence, the final Pan-African phase of igneous activity took place roughly around 550-500 Ma. This is in close agreement with what was proposed by Fleck *et al* (1976) for the Arabian Shield. They report ages indicating two Late Pan-African thermal pulses or maxima. The first, between 610 and 580 Ma, is associated with the major igneous activity which took place in the region at the end of the Precambrian (Late Proterozoic). The second, between 540 and 510 Ma (Cambrian), was relatively less pronounced in terms of temperature and igneous activity, but was accompanied by faulting and fracturing.

Early Paleozoic (Pan-African) Magmatism (550-500 Ma):

The earliest Paleozoic igneous activity reflects the emplacement of minor alkaline intrusions and granites (mainly alkali to peralkaline-G3-granites of Hussein *et al,* 1982) as well as "dike swarms" common within basement rocks. Examples are Locations 1, 2, 3, 4 and 5 given in Table 1.

The alkaline ring intrusions are characteristic of the Red Sea Rift zone of Egypt and Sudan with the oldest yielding Pan-African "Eocambrian" ages around 570-540 Ma (Razvalyayev and Shakhov, 1976). The oldest known alkaline intrusion in the Eastern Desert is that of Wadi Dib with an average age of 554 Ma (Serenscits *et al,* 1979). This age places the Wadi Dib complex among the group of Pan-African Younger Granites with an alkaline affinity (El Ramly *et al,* 1982). This complex is silica over-saturated and relatively low in alkalies (as compared with the younger complexes). Structurally, it is associated with the northwest trending Najd transcurrent fault system developed at about the same time span 580-530 Ma BP (Fleck *et al,* 1976).

In Sinai, a ring dike complex with a central volcanic pile of alkaline rocks is reported by Shimron (1980) as associated with the "Catherina cycle" of volcanicity roughly dated at 550±50 Ma.

It is interesting to note that ring complexes in northeast Sudan yield ages in the same range. Vail (1976) reports K/Ar ages for Sabaloka granite between 476 and 540 Ma, and for Salala syenites and gabbros (411-550 Ma).

Several periods of alkaline magmatism are now known to have occurred in Egypt during the Phanerozoic and will be consecutively dealt with in this chapter.

The "Dike Swarms"

The basement terrains in Egypt, especially in the Eastern Desert and Sinai, are of the most intensely dike-intruded regions known. Commonly referred to as dike swarms, these post-tectonic intrusions vary widely in composition from acidic, intermediate, basic and alkaline, and were intruded over a lengthy period of time.

The dikes are narrow, steeply dipping bodies, a few metres thick and several kilometres in length. As mapping has progressed, the distribution of these dikes has become more accurately known. Most of the dikes post-date the folding and metamorphism of the basement complex and the batholithic granites and some pre-date ring complexes.

In some areas, where paleomagnetic and isotopic age studies were carried out, the age of the dike swarms could be ascertained. K/Ar ages in the range 530-480 Ma were obtained for dike swarms located north of the Qena-Safaga Road and Um Rus area, central Eastern Desert (Nairn *et al,* 1980). These ages, however, should be considered as minimum ages in view of the possible argon loss due to alterations suffered by some of the dated samples. In many areas in the Nubian Shield, acidic dikes, pegmatites and aplite veins genetically and spacially related to the "Younger Granites" are reported by El Ramly (1963) in the range of 530-495 Ma (Locations 3 and 4; Table 1). A brief review of relevant information concerning the age of the dike swarms in Egypt is recently given by Schurmann (1984).

It is important to point out here that detailed systematic studies and geochronological investigations of the dike suites in the Eastern Desert and Sinai are, as yet, insufficient.

Post Pan-African magmatic activity intermittently took place during the early Paleozoic. A number of intrusions and extrusions yielding Ordovician-Devonian ages are shown in Table 1.

In other areas, where age data is lacking, early Paleozoic ages are assigned to various subalkaline, intermediate and basic dike swarms (El Shazly *et al,* 1965). Rhyolite flows in Gebel Uweinat area, south Western Desert, are also assigned to this period.

Two periods of alkaline magmatism (404 and 351 Ma) are indicated by the isotopic ages obtained for Zargat Naam and Tarbtie North ring complexes corresponding to the Silurian and Devonian. The age of Zargat Naam is of particular significance since it intrudes Nubian Sandstones; a Paleozoic age is thus assigned to the latter.

Late Paleozoic Magmatism

A number of alkaline and subalkaline volcanic rocks occur as plugs, sheets and cones as well as swarms of sills and dikes invading Precambrian formations mainly in the central and southern parts of the Eastern Desert. These volcanics are most probably related in age and genesis to the alkaline ring complexes. Based on the major chemistry statistics, these rocks include seven main types; namely, trachytes, bostonites, nepheline syenites, latites, spessartites, camptonites and keratophyres.

Numerous age determinations (Table 1) reflect three main volcanic episodes in the Late Carboniferous, Permian, and Permo-Triassic. The rocks in the first two episodes are mainly trachytes, bostonites and nepheline syenites but also include camptonites and olivine basalts. They are widely intruded as ring complexes, sills, dikes, plugs, sheets and flows into the basement of the Eastern Desert and the sedimentary column of the Western Desert.

In the central Eastern Desert, the peralkaline volcanics of the greater Wadi Kareim area give an average Rb/Sr isochron age of 290±15 Ma (Sayyah *et al,* 1978). This includes the age of El Atshan volcanics known for their radioactive mineralization. One isochron on Nasb El Qash trachytes gives a slightly younger age of 245±15 Ma. The Wadi Kareim volcanics occur as sills, dikes and plugs of variable dimension but of limited lithological variation. Trachytes and bostonites are the main types. The isotopic ages place these volcanics between late Carboniferous and early Permian. Their average initial Sr^{78}/Sr^{86} ratios show that they fall within the range typical for continental acidic volcanics (Hashad *et al,* 1981).

Permo-Triassic (230+10 Ma) Magmatism

Related to the initial break-up of Pangea and the closure of the Tethys, this period is characterized by rapid polar wandering (Gass *et al,* 1978). Records of volcanicity related to the uplift of the Aswan-Uweinat massif exist (Locations 118, 19, 20, 21 and 22, Table 1).

In the late Permian/early Triassic, the area between Gebel Uweinat and Bir Safsaf, South Western Desert, was uplifted along zones of pre-existing crustal weaknesses and these reactivated fractures gave way to the intrusion of basaltic dikes around 235 Ma as well as rhyolitic subvolcanics around 216 Ma (Schandelmeier and Darbyshire, 1984). A group of K/Ar ages falling in the range 230±15 Ma is reported from northeast Sudan (Vail, 1976).

During this period the massifs of Zargat Naam (partly), Bir Um Hebal and Gebel Silaia were emplaced. The granosyenite masses of Gebel Silaia and Gebel Zargat Naam fall along a major transform fault that runs approximately N 60° E, while Bir Um Hebal complex is located along a parallel transform fault somewhat to the north. The intersection of these transform faults with the northwestern faults seems to have controlled the location of the complexes. In Sinai, a major unconformity between the dominantly clastic Upper Carboniferous and Triassic deposits was detected in several wells, indicating a major movement in the Late Paleozoic (Said, 1962). Recently, Meneisy has obtained a Permo-Triassic K/Ar age (238 Ma) for an olivine basaltic sheet from Farsh El Azraq volcanics, west central Sinai. This sheet (about 70 m thick) overlies the Upper Carboniferous rocks and is locally covered by Cretaceous Nubian Sandstone. These basaltic rocks subareally erupted along deep-seated faults and were derived from an olivine tholeiitic magma.

In a recent study of the Paleozoic rocks of Egypt. Issawi and Jux (1982) report major breaks within the Paleozoic succession especially in the south Western Desert. The breaks reflect uplift and subsidence of Arabo-Nubian Craton, echoing worldwide crustal disturbances during the Caledonian and Hercynian orogenies.

Also, in the Gulf of Suez area, Cherif (1977) concludes that most of the Carboniferous and Permian stages seem to have been subjected to the major movements of the Hercynian orogenesis, but were less strongly affected than most European and North African countries. The phases are indicated in the Gulf of Suez region by mild epirogenic movements.

Table 2
Main phases of Paleozoic igneous activity related to tectonic events.

MESOZOIC		Magmatic phases			Tectonic event
Palecozoic		230+10		Hercynian	
	Permian	290+10	— Ring complexes — Dikes, sheets.		Overall compression and subduction of Paleo-Tethys north of Afro-Arabia.
	Carboniferous	350+10	— Dikes of varied composition		
	Dovonian		— Ring complexes		Initial break-up of Pangea
	Silurian	400+10			
	Ordovician		— Ring complex — Dikes		
	Cambrian	550-500	— Post-granite dikes — granites — Ring complex		Pan-African final phases of tectonism and magnatism.
Proterozoic		×	× × ×	×	× × ×

To sum up, the Late Carboniferous, Permian and Permo-Triassic volcanicity is a reflection of land emergence and diastrophism occurring between the Paleozoic and the Mesozoic (Hercynian). Late Paleozoic volcanicity in Egypt appears to have been more widespread than has previously been recognized. Table 2 summarizes the main magmatic phases.

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النشـاط النـــاري خلال حقب الحياة القديمة (الباليوزوي) في مصـــــــر

محمـــد يســـري منـــيسي

إستناداً إلى نتائج تعيين أعمار الصخور النارية المختلفة بطرق النظائر المشعة ـ يقدم هذا البحث تتابعاً زمنياً يوضح المراحل الرئيسية للنشاط الناري في مصر خلال حقب الحياة القديمة (الباليوزوي) ـ والمراحل الرئيسية التي تم تحديدها هي :

٥٥٠ _ ٥٠٠ مليون سنة ، ٤٠٠ مليون سنة ، ٣٥٠ مليون سنة ، ٢٩٠ مليون سنة ، ٢٣٠ مليون سنة .

ويتضح من هذه الدراسة أن النشاط الناري في الباليوزوي هو أكثر انتشاراً عما كان معروفاً عنه من قبل .