Basement rocks

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الفرقة الرابعة جميع الشعب

اعداد

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(محاضرة 2)

2.1 *Pre-Pan-African rocks (infrastructure)*

The presence of pre-Pan-African rocks is a point of contention among geologists studying the Eastern Desert of Egypt. In the context of this description of the basement, it is assumed that pre-Pan-African rocks do exist in the form of the gneiss domes of the Eastern Desert. They are thought to represent a lower structural level that, although reworked by the Pan-African orogeny, is part of the older East Sahara craton exposed farther to the west in the Gebel Uweinat area.

Medium- to high-grade schist, gneiss, and granite gneiss, together with their mylonitized products, cover mappable areas:

1. along the northwestern coast of the Gulf of Aqaba (Fjord gneiss),
2. at Wadi Feiran, southwestern Sinai,
3. along the Qena-Safaga road (Barud gneiss),
4. at Gebel Meatiq,
5. at Gebel El Sibai,
6. at Gebel El Shalul,
7. at Hafafit area,
8. at Wadi Khuda and on St John's Island,
9. at Aswan, and
10. at several scattered localities to the east and

southeast of Aswan (Fig. 10/1). The gneiss occurrences of Wadi Feiran, Gebel Meatiq, and Migif-Hafafit area are well researched and described (e.g. Akaad & Shazly 1972, El Ramly et al. 1983).

The rocks of the old continental crust in the Eastern Desert and Sinai were incorporated in the Pan-African orogeny. The effects of the orogeny varied according to the prevailing temperatures. At low temperature and shallow levels, the rocks of the old continental crust were subjected to plastic deformation leading to the formation of quartzo-feldspathic mylonites and blastomylonites – the 'acid gneiss' of Hume (1934). This situation can be observed at the Meatiq, Sibai and El Shalul areas where mylonites and blastomylonites enclosing relics of the original rocks constitute a carapace surrounding a less deformed kernel of gneissic granite.

At higher temperature and deeper levels, the older rocks were remobilized and mostly transformed into migmatite and granitic gneiss, commonly associated with autochthonous to parauthochthonous synorogenic granitoids of tonalitic to monzogranitic composition (G1 of Hussein et al. 1982). This situation is well displayed at Wadi Feiran in Sinai, along the Qena-Safaga road, and around Aswan in the Eastern Desert.

The spacious Hafafit culmination offers a rather complete cross-section of the infrastructural rocks. On the eastern flank of this domal structure, mica schist is diaphthorized along many small, listric thrust faults underneath a serpentinite-metagabbro thrust sheet; variably deformed gneissic granite occurs at Wadi Sikait and at the upper reaches of Wadi Nugrus within the 'psammitic gneiss' of Akaad & El Ramly (1960). Along the western bank of Wadi Nugrus, fine-grained hornblende gneiss grades westward, that is downward, into medium- to coarse-grained banded and homogenized hornblende gneiss which is intruded by parautochthonous granitoids occupying the core of this swell. On the western side of the culmination, the Wadi Shait granite is deformed and mylonitized along several major shear zones trending nearly northwest-southeast (El Gaby & El Aref 1977).

The identification and mapping of the pre-Pan-African rocks was based on structural and petrographic considerations. The infrastructural rocks comprise, as stated above.

– medium to high-grade metamorphic rocks and granites that have been deformed and diaphthorized, and

– other rocks that have been migmatized during the Pan-African orogeny.

2.2 *Pan-African rock assemblage*

The Pan-African thermo-tectonic event (Kennedy 1964) that took place toward the end of the Proterozoic, between 550 and 650 Ma ago (Clifford 1970), strongly affected the old cratonic margin. Ophiolites and one or several island arcs were accreted to and obducted over the continental mass and mixed with foreland-derived sedimentary, pyroclastic, and volcanic rocks. Prolific intrusions of a granite series (Read 1955) with corresponding thermal metamorphism took place, accompanied by calc-alkali volcanism and the deposition of molasse-type sediments. This Pan-African rock assemblage dominates the basement of the Eastern Desert and Sinai.

2.2.1 *Ophiolites and island-arc association*

Ophiolites and rocks pertaining to an island arc association constitute a highly deformed sequence of low-grade, regionally metamorphosed serpentinites, gabbros, volcanics and volcaniclastics. These rocks cover large areas in the central Eastern Desert and are preserved in synfolds between gneiss swells in the south Eastern Desert. They occupy narrow stretches in the north Eastern Desert but are entirely lacking in Sinai. In part they are equivalent to the 'eugeosynclinal filling' of Akaad & Noweir (1969), the 'ophiolitic mélange' of Shackleton et al. (1980), and the 'greenschist assembly' of Vail (1983). The whole succession is dissected by many listric thrust faults causing repetitions and tectonic mixing. Nevertheless, it can be differentiated into a lower ophiolite sequence and an upper island arc association.

Ophiolites. In general the basic to ultrabasic rocks of the Arabian-Nubian shield are currently interpreted within the framework of plate tectonics as remnants of obducted oceanic crust. The major occurrences of

In the present work, the authors support the view that those rocks that were previously classified as serpentinite, metagabbro, metavolcanics, and metasediments are, at least in part, components of an ophiolitic mélange in a purely descriptive sense. Formerly, the mafic and ultramafic rocks of Egypt were interpreted as geosynclinal submarine flows (Rittmann 1958) and as intrusive bodies emplaced into eugeosynclinal metasediments and metavolcanics (El Ramly & Akaad 1960, El Shazly 1964, Sabet 1961, 1972, El Ramly 1972, Akaad 1972, Akaad & Noweir 1980). An interpretation of the serpentinites and related rocks as ophiolitic suites is first given by Garson & Shalaby (1976).

Several ophiolite suites are reported from the Eastern Desert, e.g. from the Wadi Zeidun area (Dixon 1979), the Qift-Quseir road (Nasseef et al. 1980, Stern 1981), from the Idfu-Marsa Alam area (Shackleton et al. 1980, Ries et al. 1983), the Gebel Mohagara-Ghadir area (Takla et al. 1982), the El Rubshi area (Khudeir 1983), and from Wadi Bitan, Wadi Rahaba and Wadi Naam (Ashmawy 1987). Ophiolites always occur as allochthonous and commonly incoherent basic to ultrabasic bodies. The most complete ophiolite sequence is described from Wadi Ghadir (El Sharkawy & El Bayoumi 1979).

The ideal section is composed as follows, starting from the top:

from the top:

5. Thinly bedded metasediments of deep facies, 100 to 200 m thick at Wadi Ghadir, are generally quite rare. They are essentially formed of pelites intercalated by thin chert and calcareous bands.
4. Low-potash tholeiitic basalt sheets, several hundred meters thick, are sometimes pillowed, and the pillows are always right-up (Stern 1981). Alkali basalts are rare.
3. Massive diabase and sheeted-dyke complexes, 100 to 200 m thick, also of tholeiitic composition are common.
2. Metagabbro of tholeiitic composition is formed at the base of cumulate pyroxenite and gabbro, followed upward by isotropic gabbro and hornblende gabbro, frequently enclosing small dioritic bodies or being cut by appinites. Primary hornblende, when present, is of olive-brown color. Olivine,

fresh or altered, has never been recorded, so cumulate dunites cannot have developed. The contact between the metagabbro and the underlying serpentinite is always occupied by a thrust fault. Mesoscopic layering reported by El Sharkawy & El Bayoumi (1979) and Kröner (1985) is believed to be of secondary origin; it is observed in the sheared lower parts along sole-thrust planes. The thickness of the gabbro layer is about 1 km, at Fawakhir, and 2 km at Gebel El Rubshi.

1. Serpentinites, essentially after harzburgite and to a lesser extent after dunite and lherzolite, are frequently transformed into talc-carbonates, particularly along thrust faults and shear zones. They sometimes enclose boudinaged chromite lenses (El Sharkawy & El Bayoumi 1979; Khudeir 1983) and may contain enstatite, diopside, and sometimes olivine relics. They are characterized by

The ophiolites are commonly dismembered and even the large serpentinite masses are frequently intercalated by thin, highly foliated pelitic layers (Shackleton et al. 1980, Khudeir 1983) marking minor thrust faults. The ophiolites are believed to have developed in back-arc basins (Stern 1981) and later obducted from the east over the old continental margin (El Gaby et al. 1984, Kröner 1985).

The ophiolites are commonly located along major thrust faults, and particularly along the decollement surface between the obducted Pan-African ophiolites and island arc rocks (= suprastructure) and the underlying old continental margin (= infrastructure; El Gaby 1983, El Gaby et al, 1984). This would explain

Island-arc association. The ophiolites are overlain and tectonically mixed with another series of weakly metamorphosed, calc-alkaline intermediate to acid volcanics essentially formed of andesite, dacite, and other volcaniclastics of comparable composition. Basalt, rhyolite and rhyodacite are subordinate. The tuff and volcanogenic graywacke is often banded, with graded bedding indicating submarine deposition. These rocks are frequently intercalated with metamorphosed iron-ore layers, particularly in the northern part of the central Eastern Desert. Farther to the

On previous maps, the volcaniclastics were generally mapped as metasediments. This volcanic association is referred to as 'younger metavolcanics' (YMV) to differentiate it from the 'older metavolcanics' (OMV) of the ophiolite association (Stern 1979, 1981). The volcanic rocks around Sheikh Shadli (Shukri & Mansour 1980), the type-locality for the 'geosynclinal metavolcanics' (El Ramly 1972), are formed of island-arc volcanics and volcaniclastics, which means that they belong to the YMV. Due to severe tectonics and tectonic mixing, it was not always possible to separate the island-arc association (YMV) from the ophiolitic metavolcanics (OMV) on the new geologic map. Nevertheless, they constitute

In the north Eastern Desert, the YMV are locally preserved in narrow belts bounded by faults within the major Qena-Safaga shear zone. They display the common lithologic features of the island arc association and are intercalated at Gebel Um Anab by the characteristic iron ore bands (Sabet et al. 1972).

In Sinai, the YMV appear to be entirely absent. The volcanics of the Wadi Kid and Wadi Sa'al areas, southeast Sinai, are metaphorphosed and locally deformed and sheared. Petrologically, they range from andesite to rhyolite, with the acid members prevailing; ignimbrite is quite abundant. These are the characteristic petrologic features of the calc-alkaline, Andean-type Dokhan volcanics. Moreover, the associated sediments at Wadi Sa'al are of molasse facies (Shimron 1984) akin to that of the Hammamat clastics. Bentor (1985) reported that the sediments at Wadi Sa'al are largely clastic and consist mainly of thick units of conglomerates composed of boulders and pebbles of dioritic and granitic gneiss. The presence of gneiss pebbles speaks for deposition in intracontinental basins (i.e. molasse-type Hammamat clastics) rather than in an island-arc environment.

The reported isochron age of 734 ± 17 Ma (Bielski 1982) from the metamorphosed Sa'al volcanics must be considered cautiously, particularly if one takes into account that granite-gneiss boulders from the Sa'al conglomerates yielded a Rb-Sr isochron age of 641 ± 25 Ma (Bielski 1982). Similarly, abnormally old Rb/Sr apparent ages are sometimes obtained from Dokhan volcanics (Stern & Hedge 1985).

Plutonic rocks belonging to the island-arc association are least recognized and studied in the Egyptian basement. They might include subduction-related diorite and tonalite, the plutonic equivalents of island arc andesite and dacite, as well as mantle-derived gabbro. The sheared tonalite of Gebel El-Mayit (s.l.). It was difficult to separate island-arc metagabbro from ophiolitic metagabbro which are petrographically almost identical. Therefore intensive field work is required for this distinction since island-arc metagabbros are intrusive and are composed to a considerable extent of metadiorite. Metagabbro to metadiorite occurs in relatively small bodies intruded into the YMV in the Sheikh Shadli region. Metagabbro/metadiorite complexes occupy wide areas between Marsa Alam and Wadi Mubarak (Hassan & Essawy 1977); two metagabbro/metadiorite intrusions in this area can be recognized on the Landsat-MSS imagery. These plutonic rocks are expected to be intimately associated with and are likely to be intrusive into the YMV, and they are likely to be metamorphosed and deformed.