A Comparative Study on the Metallogenic Provinces in the Ophiolite Belts and Ring Complexes in Both Egypt and Saudi Arabia (between Latitude 22° N—24° N)

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Summary

The ophiolite belts in both Egypt and Saudi Arabia between Latitude 22° N and 24° N, having approximately the same direction of extension, NNW or N—S.

The ophiolite belts are folded, the fold axes trending NW to E—W in Egypt, while NE—SW is the main trend in Saudi Arabia. The shear zones of E—W strike are mineralized (Cu, Zn, Pb minerals) in the Egyptian side, while N—S or NE—SW shears are mineralized in Saudi Arabia (Cu minerals in Umm ad Damar and J. Sumran). The tension faults play a role for gold mineralization in both Egypt and Saudi Arabia. The directions and magnitudes of folds and faults in Egypt and Saudi Arabia are different, probably that is due to the difference in directions and magnitude of the forces and stresses on both sides of the Red Sea. The sulfides in the ophiolites have to be taken to represent typical "Cyprus type" volcanic exhalative mineralization during sea floor spreading. Later on some of these sulfides were remobilized by epigenetic hydrothermal solutions to be localized along pre-existing shears.

In Egypt, the ring complexes zone is located west to the main ophiolitic suite; that let the present writer to be tempted to say, the ring complexes are probably existing in a zone east of the western ophiolitei mass of Southern Hijaz Quadrangle, but now is covered by Tertiary basaltic and andesitic lavas.

Introduction

This study is a partial contribution towards the establishment of a compiled metallogenic map for the Eastern Desert of Egypt and Western Part of Saudi Arabia.

After the establishment of this compiled map, the correlation of ore provinces in both countries, separated by continental drift could be executed successfully.

The present study and the accompanied metallogenic map scale 1 : 1,000,000 are based on the data available about the South Eastern Desert of Egypt and the Southern Hijaz Quadrangle, between latitudes 22° N and 24° N.

The photogeological map of South Eastern Desert, scale 1 : 500,000 by HUNTING (1967); the compiled map of the basement rocks in the Eastern Desert of Egypt, scale 1 : 1,000,000 by EL RAMLY (1972); the mineral resources map of Egypt, scale 1 : 2,000,000 by KOCHIN (1967); the geological map of Southern Hijaz Quadrangle scale 1 : 500,000 by BROWN and others (1962); the mineral resources map of Southern Hijaz 1 : 500,000 by the Directorate General of Mineral Resources, Saudi Arabia (1968); and several references were used in this study.

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The sequence of the sedimentary and volcanic rocks of the Precambrian age in the Southern Hijaz Sector is very general (GOLDSMITH 1971), not studied on details and the stratigraphic position of some units is not clear, GOLDSMITH (1971) did not specify the ophiolites in this sector of Saudi Arabia. The concept of ophiolitic rocks in Egypt is a new one and very few authors have described them even briefly. It is therefore difficult to outline true extent of the ophiolitic belt in Egypt (GARSON et al. 1974). Now there is an attempt to solve this problem in the Aswan sector between latitude 22° N and 25° N.

Depending on the available data the present writer could outline the extent of the ophiolite belts in the two sectors.

The ophiolite belts in Egypt and Saudi Arabia between Latitude 22° N and 24° N

THE OPHIOLITE BELT IN EGYPT:

The ophiolite belt of Precambrian age in South Eastern Desert of Egypt extends NNW—SSE in the area between Latitude 22° N and 24° N.

This belt represents a deep seated tectonic zone. It consists of metavolcanics, serpentinites and metagabbro.

The metavolcanics are distributed through the whole area and they are represented by metabasalt, metadolorite, metaandesite, metarhyolite and metadacite. They occur as sheets and sills interbedding and intruding the metasediments.

Recently pillowed metaspilitic lavas have been recognized at several localities including Muweilih (AKAAD and NOWEIR, 1972), North Aswan area (HUNTING, 1967).

The serpentinites and related rocks are of very limited distribution. They are represented by antigorite and talc carbonates formed after ultrabasic intrusions and sheets. The association of serpentinites with the almost metavolcanic formation may favour the possibility of fractional crystallisation of peridotitic "magma" from basaltic melts (AKAAD and NOWEIR, 1972).

The metagabbroic rocks are represented by metamorphosed gabbros.

The ophiolite belt exhibits conspicious folding, the metavolcanics are folded into a number of normal anticlines and synclines, the axes or which trend in a roughly North West—South East to East—West directions.

GARSON and SHALABY (1974) described briefly the ophiolite belts in Egypt, mentioning that these NNW trending belts are offset by an important series of N 60° E trending deep-seated fracture zones recognized on geophysical evidence.

These fractures which locally are intruded by layered ultramafic assemblages may be related to transverse tectonic structures similar to those developed at occeanic ridges. Some of the isolated ultramafites and associated volcanics in the Abu Swayel area may fall into the diapiric class emplaced partly in continental crust, but age determinations suggest that they belong to the oldest ophiolitic belt in Egypt.

The fault pattern in the ophiolite belt in the area between Latitude 22° and 24° N, is dominated by main faults trending NW—SE and NE—SW as well as E—W.

MINERALIZATION ASSOCIATED WITH THE OPHIOLITIC BELTS:

The mineralization in the ophiolite belt includes zinc, lead, copper, nickel, cobalt, gold, chronite, asbestos and talc.

Zinc-lead-copper mineralization:

The zinc-lead-copper deposits are found in shear zones cutting the metavolcanics in Darhib area. ABDEL TAWAB (1960) reported that the Darhib area consists of metaandesite around the Darhib talc mine. A shear zone of approximately E—W direction cuts the metavolcanic for a distance of about 400 m. Along this shear zone, amphibolite, chlorite schist, tremolite and talc are found. Minerals of zinc, lead and copper occur in the shear zone. The sulfides of these minerals in the sulfide zone are sphalerite, galena, chalcopyrite and pyrite in small lenses. The sulfide zone is overlain by oxidized zone of about 30 m thick. The minerals of the oxidized zone are malachite with patches of azurite, Smithonite and anglesite.

The zinc and copper elements do not exceed 12%, 1.5% respectively, but the lead is not more than 2%.

Copper-nickel mineralization:

Copper-nickel sulfides at Abou Swayel area are confined to a lens of amphibolite (probably metagabbro). GARSON and SHALABY (1974) considered the isolated ultramafites and associated volcanics in the Abou Swayel area of diapiric type, and belonging to the oldest ophiolitic belt in Egypt. The sulfide ore body is generally lenticular and shows irregular mineralization of magmatic segregation (GARSON et al. 1974 after EL GORESY 1964). The impregnated and massive sulfide ores consist of pyrhotite, chalcopyrite pentlandite, of average Cu and Ni contents 4.11% and 1.7% respectively (BASSYONI, 1960).

Nickel mineralization:

Nickel occurence is in St. John's island, where the nickel is represented by garnierite in two parallel veins cutting ultrabasic rocks (serpentinized peridotite). The veins strike NW—SE outcropping on surface for a distance about 50 m (HUME 1937).

GARSON and SHALABY (1974) reported that it is not clear if the peridotite forms part of the ancient ophiolite belt caught up in a transverse tectonic structure, or if the peridotite is a much younger intrusion developed in this structure during the Red Sea ocean floor spreading episode (Tertiary—Recent).

Analysis shows:

Ni 4.86%	Cu 0.25%	Fe 12.25%
Au 0.19g/t	Pt 0.93g/t	Ag 0.62g/t

Copper-nickel-cobalt mineralization:

Copper-nickel-cobalt sulfides of Gabbro Akarm area are of magmatic segregation origin.

SHALABY (1974) described the gabbro as elongated intrusive rocks, trending ENE. Drilling operation had been done in the area and to show the richest section is from 100.5 m to 138.35 m with copper ranging from 0.34% to 1.52% (average 0.70%); nickel ranges from 0.22% to 2.44% (average

0.70%); nickel ranges from 0.22% to 2.44% (average 0.74%), cobalt ranges from 0.018% to 0.136% (average 0.053%).

GARSON et al. (1974) believes that this type of mineralization is related to layered ultramafic complexes within transverse tectonic structures.

Gold mineralization:

The distribution of the primary gold deposits and occurences is structurally controlled. Ore bodies are confined to fault planes or highly fractured zones.

Gold in the ophiolite belt is confined to quartz veins of ranging dimensions and directions cutting the metavolcanics and serpentinites.

HUME (1937) gave three generations for the quartz intrusion, the first is barren, the second is mineralized with gold, and the third carries sulfides.

Some gold deposits contain appreciable amounts of sulfide minerals such as pyrite, galena, arsenopyrite, chalcopyrite and sphalerite. The average thickness of the gold bearing veins does not exceed 0.6—1.5 m. The gold content of the veins may reach in average 11—29 g/ton.

Karbiai is the most important gold occurence in the area. The gold bearing veins as a mixture of quartz and calcite are cutting serpentine with schist and diorite in close association. The principal vein has a general NW—SE trend and dips steeply southward.

There are other minor gold occurences between Latitude 22° 19′ and 23° 37′ namely Romit, Betan and Ourga.

Chromite-asbestos and talc mineralization:

The chromite is found in serpentinite as lense like bodies up to 25 m long by 2 m wide at Gabal Abou Dahr. Sometimes the serpentinite are cut by structural planes along which magnesite, asbestos and talc bodies are developed.

The talc is mainly found along shear zones cutting serpentinites or metavolcanics (Gabal Darhib).

Just to the north of the area of the present study there is an ilmenite occurence at Wadi Abou Ghalaga (Lat. 24° 21′ 20″).

ABDEL TAWAB (1974) reported that this ilmenite was deposited from a titaniferous gabbroic magma rich in volatiles and fluxes.

The mineralizers and fugitives played a role in partial retardation of a crystallization of the deposit and to give pegmatitic texture to the gabbroic rocks overlying the ore deposit. The ilmenite body is found in two horizons, the upper is oxidized and brownish in color and the lower is non-oxidized and black in color. The TiO_2 content is higher in the lower horizon to reach 40%. Due to later granitic intrusion, a hydrothermal solution had thermal effects on the gabbro especially along the structural planes. These solutions were accompanied with sulfide minerals as pyrite and chalcopyrite. The sulfides were deposited along cracks and fissures in the ilmenite mass. Probably by detailed prospection the ilmenite could be found in Southern Hijaz Quadrangle.

THE OPHIOLITE BELT IN SAUDI ARABIA:

According to the geologists of Bureau Recherches Geologiques Minière (1973), the ophiolite in Saudi Arabia consists of serpentinite, gabbro and greenstone. GOLDSMITH (1971) assumed thath the greenstone is probably equivalent to a part of the Halaban Andesite. GLEN F. BROWN and others (Geological map 1—210 A, 1962) identified the Halaban Andesite as fine grained andesite and felsite, subordinate dacite, trachyte and rhyolite breccia and agglomerate in extrusive phase; epidiorite, diabase microdiorite, gabbro and serpentinite in later intrusive phase.

GOLDSMITH (1971) stated that there are an older and younger suite of volcanic rocks in Mahd adh Dhahab, Umm ad Damar area, but the two suites could not consistently be identified as distinct mappable units. He added that the metavolcanic rocks interpreted as older than the volcanic rocks associated with Mahd adh Dhahab series are tentatively correlated with Halaban Andesite of the type area but they may represent an older series.

Due to what previously mentioned the present writer lumps together the Halaban Andesite and the green stone sequences, overlying the schist series, as a group of metavolcanic rocks. He also considers some of the schists underlying the metavolcanics as metasediments could be correlated with the metasediments in Egypt. The metasediments in some places contain schists after basic and ultrabasic rocks.

The serpentine and metagabbro in the Southern Hijaz are of very limited extension.

The ophiolite belt trending NNW—SSE contains several folds, the axial planes tend to follow the strike of the belt. The metavolcanis are folded in Jabal Sumran area. The strike of major fold axes is to the northeast and there can be demonstrated minor scale recumbent folding and overthrusting. The minor axes having the same strike as the major fold axes. InMahd adh Dhahab and Umm ad Damar area, there are some folds trending NE—SW.

The faults of NW trend appear to cut the Precambrian and Paleozoic rocks. Tensial faults are oriented North—South. The fault pattern in the belt is dominated by three major sets, NE trending set of faults with subordinate NW trending faults and in between them there are North—South trending faults.

MINERALIZATION ASSOCIATED WITH THE OPHIOLITIC BELT:

The mineralization in the ophiolite belt includes copper, silver, gold, zinc, lead and talc. No chromite or nickel bearing minerals were observed in the ophiolite belt.

Wadi samples of materials from serpentinite at Jabal Thrarwah contain anomalous amounts of chromium and nickel which are probably normal for this kind of rock (GOLDSMITH 1971).

Copper mineralization:

The principal copper bearing mines are in the Madh adh Dhahab (average copper 0.8%) — Jabal Lahouf (Cu up to 2.60%) — Umm ad Damar (Cu up to 2.95%) — Jabal Sumran (Cu up to 2%).

A few small copper bearing prospects are scattered elsewhere in the ophiolite belt, but these are of little signifance.

The most common type of copper deposit is characterized by the presence of disseminated primary pyrite and chalcopyrite in metavolcanics (GOLDSMITH, 1971).

On the surface, secondary copper minerals coat shear planes, cleavage planes and fracture surfaces. Quartz veins may or may not be present.

GOLDSMITH (1971) stated that the workings at Umm ad Damar for copper are along sheared and altered zones of north direction (Cu up to 2%), in metavolcanics. At Jabal Sumran visible evidence for mineralization consists of malachite and chrysocolla concentrations in shears in metavolcanics. The main zone of apparent mineralization trends North 10° West. The mineralized deposits at Madh adh Dhahab were sulfides (chalcopyrite, pyrite, bornite and galena) are associated with quartz veins, which are probably a variant of the disseminated sulfide type of deposit, in which there has been a stage of major introduction of silica. In this mine, sulfides occur only in the immediate area of the quartz.

Copper is very low in the serpentine mass at Jabal Tharwah, copper indication around zhe marble mass at Jabal Farsan was recognized (GOLDSMITH, 1971).

In Jabal Rayan the fractures in andesite are filled with malachite (Cu up to 7.2%).

By drilling operation in the copper occurrences one could reach to this summary:

- A sulfide bearing zone was found at depth in Lahuf mine.
- A sulfide bearing zones were found in Umm ad Damar mine. The richest zone was a 4.2 m interval that cuts a replacement vein at a depth of more than 61 m (Umm ad Damar South). Also massive sulfide of about 1,5 m thick was found in a central zone, copper averages 4.9%, silver 1.2 ounces per ton, zinc o.7% and gold negligible. In Umm ad Damar North, a disseminated sulfide zone of 16 m wide was found, (Cu 1.35%).

Silver mineralization:

The silver is found in Umm ad Damar North where the silver content reaches 1.2 ounces per ton. Slightly anomalous amounts of silver are reported in Wadi samples from places scattered through the ophiolite belt.

Gold mineralization:

Madh ad Dhahab district is still the richest gold deposit in the Quadrangle (Au 0.30 oz/ton at Jabal Rayan). The area of Hawara has gold in average 0.09 oz/ton and in Sumran the percentage of gold ins 0.06 oz/ton in average.

At Madh ad Dhahab the gold mineralization is associated with quartz veins and associated quartz sealed breccia, most of which trend north in the mine area but a few trend east-northeast and are the most mineralized. The quartz veins appear to have been emplaced along tensional openings related to folding and faulting in the metavolcanics. The best grade material was not in large veins, but in sheared selvages on the flanks on the veins. Greatest ore values recorded were from the richest ore shoots in the host agglomerate (GOLDSMITH, 1971). Gold values decreased on the lower levels.

GOLDSMITH, 1971 gave three generations of quartz veins, one is barren, the second is gold bearing and the third carries sulfides but has little gold.

Zinc mineralization:

Anomalous amount of zinc in wadi samples show up in Madh ad Dhahab area only around the mines (above 2000 ppm near the mine, the median is 200 ppm). At Wadi Hawara is about 1.0% zinc and probably present the same at Jabal Sumran.

Lead mineralization:

The lead is subordinate element in most of the ancient mines and prospects. Lead is negligible at Lahuf mine. Anomalous lead (concentration of 15—20 ppm) occurs in wadi area eastnortheast of Madh ad Dhahab.

The talc occurs in small amounts as an alteration product. It was seen only as minor amounts associated with serpentinite masses at J. Thawah, more detailed investigation of these masses may reveal significant quantities of talc.

The Ring Complexes in Egypt and Probability to find their Equivalents in Saudi Arabia between Latitude 22° N and 24° N

The ring complexes in Egypt:

El Ramly, Budanow and Hussein (1971), reached to a conclusion that the ring complexes were formed by Late Mesozoic igneous activity, mainly south latitude 25°.

The majority of the ring complexes in Egypt and in other parts of Africa, are developed under rift tension conditions.

In Gebel Nigrub El Fogani, the alkaline rocks forming the ring complex include alkaline soda granite passing gradually into normal granite. The ring complexes lie along two main directions NW direction (Zarget Naam, Nugrub El Tahtani, Nugrub el Fogani ring complexes) and NE direction (G. Mansouria—El Naga—Mishbah ring complexes).

Gebel Zarget Naam Complex:

The complex was formed as an ultraacid volcanic cone, later on alkali syenites and alkali granites were intruded along an incomplete ring fault. Later radial alkali granite and felsite dykes were intruded. (El Ramly et al, 1971).

Gebel Nigrub El Tahtani Complex:

A small volcanic cone composed of trachytic, rhyolitic lavas and agglomerate gave rise to this alkaline complex. Later there was an intrusion of alkaline syenites along an incomplete ring fault. Finally a system of radial dykes of alkaline syenites and incomplete ring fault. Finally a system of radial dykes of alkaline syenites an incomplete ring dykes were intruded.

Gebel Nigrub el Fogani Complex:

This complex is formed of an outer incomplete ring of alkaline granites, an inner ring of alkaline gabbro and a central stock of various nepheline syenites (Hussein, 1973). Samples collected from this complex yielded the following results (ppm):

	Pb	W	Be	Mo	Nb	Zr	Zn	U	Th
up to	300	200	1000	500	1000	Maj.	550	130	1420

Gebel Mashbah Complex:

It is a volcano of flat covering type and represented mainly by trachytes, latites and their pyroclastic equivalent. Alkaline syenites by later faulting action were intruded.

Gebel El Naga Complex:

This is formed of two successive rings and a central stock. The outer ring is of porphyroblastic gneiss. The inner ring is built up of nepheline poor syenites. The nepheline syenites form mainly the central stock.

The samples collected gave the following results on analysis (Hussein, 1973):

	Pb	W	Nb	Ta	Zr	Y	Zn	U	Th
up to	200	800	Maj.	1000	Maj.	2000	450	510	8400

Gebel El Gizera Complex:

The ring complex is found in metavolcanics which are highly tectonized altered and occasionally pass into green schists (El Ramly et al. 1971).

The complex consists of a volcanic cone composed of lavas and agglomerates of trachybasalts which form the outer ring, followed by gabbroic intrusion. The inner ring is composed of syenite. Ring faults played a role in the formation of the complex. The analysis of the samples showed the following results:

	Ni	Co	Mo	Nb	U
up to	100	200	100	1000	1000

Gebel El Masouri Complex:

This complex is of simple structure with a hardly recognizable ring nature, weak differentiation of its rocks and showed the absence of nepheline syenites.

The ring complexes are usually of great interest for the occurence of some specific mineralizations such as Nb and rare earths (Hussein, 1973).

Probability to find Ring Complexes in SaudiArabia:

No alkaline ring compexes of volcanic origin were recorded in Saudi Arabia in Southern Hijaz between Latitude 22° N and 24° N.

Goldsmith, 1971, described rounded to subrounded plutons of alkalic to peralkalic granite, that locally forms ring structures. Isotopic ages on a few of these plutons indicate an age of about 550 million years, which could make them early Paleozoic in age.

It is recognizable that the ring complexes in Egypt are occuring in a zone mainly west to the major ophiolite belt. This mentioned zone was an area of tension during the Red Sea rift formation. Possibly this type of events was prevailing in the area to the east of the main ophiolite belt in Saudi Arabia.

Conclusion

The ophiolite belts in both in Egypt and Saudi Arabia between Latitude 22° N and 24° N, having approximately the same direction of extension, NNW or N—S.

In the Egyptian sector the ophiolite belt is divided into two; one major suite lies near the Red Sea Coast and a minor one west to it. The major suite contains Darhib mine with Cu, Zn, Pb associations; the gold mine of Korbiai plus small gold occurences of Romite, Betan and Ourga.

The minor mass contains Abou Swayel Cu, Ni occurrence.

The two masses are separated by gneiss, metasediments, syntectonic granite and younger granitoids.

In the Saudi Arabian sector the ophiolite belt is divided, too into two masses of different trends, one mass contains the mineralized areas of Madh ad Dhahab and J. Sumran striking NE—SW, and the other, bigger and poor in mineralization trends NNW—SSE.

These belts on the both sides of the Red Sea, are folded, the axes of folds are different; in Egypt trending NW to E—W (GARSON and SHALABY, 1974); while in Saudi Arabia the axes trend NE in J. Sumran and Madh ad Dhahab (GOLDSMITH, 1971).

The significant faults in Egypt and Saudi Arabia are different, in Egypt the major faults are of NW direction, while in Saudi Arabia the faults of this trend are subordinate, but the faults trending NE are predominate.

The shear zones of E—W strike are mineralized (Cu, Zn, Pb minerals) in the Egyptian side, while N—S or NE—SW shears are mineralized in Saudi Arabia (Cu minerals in Umm ad Damar and J. Sumran).

The tension faults play a role for gold mineralization in both Egypt and Saudi Arabia. The gold quartz veins occupying the tension faults in Madh ad Dhahab mine are trending N—S or NE—NW, while in Korbiai mine of Egypt they are trending NW—SE.

It is quite clear that the directions and magnitudes of folds and faults in Egypt and Saudi Arabia are different, probably that is due to the difference in directions and magnitude of the forces and stresses on both sides of the Red Sea.

The isotopic data indicate that the metavolcanics of the ophiolite belts are older than the plutonites of 900—1000 my (BROWN and others 1962; SHAZLY and others 1973).

There is a similarity between the mode of occurences of polymetallic sulfides (Cu, Zn, Pb) in the ophiolite belts. The polymetallic sulfides are found as massive sulfides or disseminated in metavolcanics or along shear zones.

On the surface the secondary minerals of Cu, Zn, Pb coat the shear zones. The oxidized zone in Egypt is of about 30 m thick, but in Saudi Arabia reaches to 60 m thick.

The massive sulfides in Egypt (probably the same in Saudi Arabia) are banded showing sedimentary lamination and slump folds which are indicative of initial sedimentary deposition. These sulfides have to be taken to represent typical "Cyprus type" volcanic exhalative mineralization during sea floor spreading.

Later on some of these sulfides were remobilized by epigenetic hydrothermal solutions to be localized along pre-existing shears (the same genesis like in Betts Cove-Newfoundland; UPADHYAY and STRONG, 1973).

The nickel—copper mineralization of magmatic segregation origin in the Egyptian sector is well developed in Abu Swayel, Gabbro Akarm areas. But in the Saudi sector no nickel bearing minerals were observed, probably because the ultramafic rocks are very rare in this sector.

There is a great similarity between gold mineralization in both sectors. The quartz veins are cutting metavolcanics and serpentinites, and were formed during three generations, the first is barren the second is gold bearing and the third carries sulfides with little gold (HUME, 1937 and GOLDSMITH, 1971). The gold values decreased pn lower levels.

The chromite lenses are scattered in the serpentine masses in Abou Darh area (Egypt), while no chromite occurences in Saudi sector, are known but probably will be found by further exploration.

The ring complexes in Egypt and other parts of Africa are developed under the Red Sea rift tension condition by late Mesozoic igneous activity.

In Egypt the ring complexes zone is located west to the main ophiolitic suite, that let the present writer to be tempted to say, the ring complexes are probably existing in a zone east of the western ophiolitic mass of Southern Hijaz Quadrangle, but now is covered by Tertiary basaltic and andesitic lavas.

The geothermal deposits resulted by the Red Sea rift like the manganese veins in Halaib (Egypt) and the manganese-barium deposit of Afar (Ethopia) (Bonatti et al, 1972); are proposed to be dealt in future comparative studies with similar occurences in Sudan and Saudi Arabia.

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