Mineralogical Studies Associated with Meta Volcano Sedimentary Sequence, in Sinkat Area - Sudan

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ABSTRACT

Sinkat area is located in the southern part of the Red Sea State- Sudan. It dominated by the late Proterozoic Pan-African meta volcano-sedimentary green stones and Syn-late and post orogenic igneous intrusive complex. Data obtained during this work indicated that the meta volcano-sedimentary sequence is transitional to low-K tholeiitic and calc-alkaline meta volcanics and the associated plutonic rocks are more evolved and comprised a low- K calc -alkaline series, more the less major mineralized zones associated with this sequence. The objective of this study is to identify the mineralization zones associated with the rock unit in Sinkat area. This is because it is rich in many economic minerals such as (Mn, Fe, Cu) and did not receive adequate geological studies to confirm existence of many types of mineralized rocks. Field observations with chemical analysis for samples showed clearly there are mineralization of Mn-Fe bearing minerals in Jebel- Almashgog North of Gebiet and Cu minerals in Jebel -Lambat West of Sinkat. All these minerals are in low-to-medium grade. In addition to that there is a good reserve of marble rocks that be quarried in Summite village west of Sinkat area.

Keywords: Volcano, Proterozoic, Mineralization.

Introduction

The Red Sea Hills occur in the north eastern Sudan form part of the Nubian- Arabian shield (Vail 1979). These hills constitute a semi desert dissected plateau. Physiographically the area of the Red Sea state can be divided into three parts; the coastal plain, the Red Sea Hills and the western slope. Sinkat-Gebiet area is known for its complicated structure within the regional geology of the Red Sea Hills located approximately 140 km south west of Port Sudan town in Red Sea State, north eastern Sudan. The area is bounded by the coordinates: longitudes: 36° 40-37° 10 E and latitudes: 18° 40-19° 8 N (Fig 1). The area is situated within the physiographic limits of the Red Sea Hills and it can be divided into four topographic regions: Mountainous massif, plateau, ridges and open Pedi plain terrains.

The drainage system is variable starting from sub parallel narrow, steep, sided gorges and tributaries in the high lands to semi-dendritic, slightly meandering flat and wide, valleys (Khors). The trends of these khors are, in general structurally controlled; they follow faults, joints or fractures e.g. k. Gebiet Al-Ashraf. The region of the Red Sea Hills lies within the desert to semi desert climatic belt. But the weather in Sinkat and Gebiet station is different and good compared to the other areas in Sudan and Red Sea Hills. This is due to the high altitudes and enjoys winter and summer rainy seasons.

Material and Methods of investigation

The methodology adapted to the different aspects of geological studies and to identify mineralization in the study area is divided into two parts field work and laboratorial methods. In the field work sampling was conducted by collecting representative rock units and some mineralized zone e.g. quartz vein in J-Almashgog, shear zones in J-Lambat in the study area. About 60 samples were collected for explore mineralization taken from the secondary hallo in the study area. In laboratory work there are microscopic studies and mineralogy studies about 30 thin-section were chosen and prepared from various rocks units and have been studied to determine mineralogical composition and mineral assemblages. In mineralogy studies rock samples were subjected to analysis by X-ray Fluorescence Analysis (XRF) and X-ray Diffraction Analysis (XRD), so as to determine the major oxides and trace elements.

Geologic Setting

New concept of stratigraphy of the Red Sea Hills allied to island arc, plate tectonic models and the evolution of the Nubian Arabian Shield, is summarized in the following (Abu Fatima,1992):
Cainozoic volcanic Activities                           Post - Pan African
Phanerozoic Sedimentary covers                       Mainly Mesozoic
An orogenic Intrusions                                Pan African
Post orogenic Intrusions                             Orogenic
Syn orogenic Intrusions                              Sequences
Ophiolites                                            1200- 500
Meta volcano- sedimentary sequence                   Pre Pan African
Older gneisses                                       1200 m

Fig1: Location Map of the study area (modified after (Abu Fatima, 1992))
The study area is located at the collision zone of the mobile belts of Haya and Gebiet terrain. Geologically, Sinkat area is made of granite, granodiorite and diorite. The igneous rocks types in the area are mainly Syn-tectonic and post tectonic intrusions composed of granite, granodiorite and diorite. The lithostratigraphic classification for the study area can be correlated with that for the Red Sea Hills and divided into four geological units.

1. Meta volcano sedimentary complex & metamorphic complex
2. Batholithic complex.
3. Intrusive massive.
4. Dykes (older and younger) dykes.

Meta Volcano-sedimentary complex & Metamorphic Complexes

The rocks of this sequence mostly consist of greenstone schist faces and metamorphose basalt, flow banded rhyolite, volcano clastic tuffs, marble and quartzite. The metamorphic rocks composed of dark amphibole schist, banded amphibolites, rare biotite, sillimanite schist’s and quartzite’s with volcanic lenses and calc silicate bands (Plate 1-3).

The Meta volcano-sedimentary sequence forms high rugged topography with deep narrow gorges in the study area. Few primary contacts are exposed between the various lithological units of this sequence; nevertheless this sequence can be grouped into two main lithostratigraphic sub units in the study area which is:-

Basic intermediate meta volcanic

These are the dominant rock types in the area. They underlie the acid meta volcanic’s and form highly elongated ridges as well as the outcropping as lenses and small hilllocks. These units can be represent the oldest rock assemblage in the area and includes strongly differentiated sequences ranging from basaltic through andesitic and dacitic to rhyodacitic volcanic and composed mainly of meta basalt, basaltic andesite, andesite, microdiorite and porphyritic andesite alternating with tuffs, grey wackes and some limestone’s. Eastern J. Adar Hindar these volcanic rocks are intermixed comprising variety of bands of tuffs and andisite intruded by late-tectonic granitoid and are variably deformed, faulted and contain disseminated mineralization of sulphides.

There is ranged in color from deep yellow to brown dark red, this is due to hydration of iron oxides which can be as a criteria for prospecting for poly metallic sulphides mineralization.

Acid Meta volcanic

The acidic meta volcanic unites as minor bands interlayered with the basic intermediate volcanic rocks are occurrence. These rocks are strongly foliated and highly altered. Similar rocks were observed around Khor Abo Shidda.

Granitoidal Batholith

The whole area has been extensively intruded by large Syn-to late tectonic batholithic granitoitd which were emplaced during the deformation of volcano-sedimentary sequences of greenschist facies. This unit is made up of intrusive rocks of granitiodal composition, with oriented texture and affected by major tectonic phase which cover the study area (Plate 2). The batholithic rocks vary in composition from gabbroic, dioritic to granitic but mostly granodioritic and can be divided into two groups according to field criteria:-

*Syn tectonic gabbro diorites *and Syn–tectonic granodiorite granites.

Post-tectonic intrusions

These rocks are exposed in the form of more or less extensive massifs, distributed over many parts in the study zone. These intrusions were intruded during the late Pan-African event. They are considered to be the youngest Precambrian magmatic rocks (Abu Fatime 1992). These are usually unfoliated and unmetamorphosed. Lithologically they range from ultrabasic to acidic composition including pyroxenites, gabbro, quartz diorite, pink granite and hornblendites.

Dykes

Dykes vary in thickness form a half to four meters. Mainly basic dykes are prominent feature in the Sinkat area. They trended NE, NW, NNE and normally are sub vertical, although gently dipping sills and inclined folded sheets.

The composition of these dykes is essentially basic (gabbros) dolerites, basalts and some dyke comprises of andesite rocks. Many of these dykes are genetically associated with the late portoroezic - post igneous complex. In the study area there are two type of dykes :-

Older dykes

These dykes have been deformed, highly foliated and altered within the host rocks for these reasons they are considered to be the oldest dyke family in the area (Plate 3).

Younger dyke

In the Sinkat area these types of dykes, trend E-W and less common they cut the previous ones which trend NE / SW. The younger dykes are mainly basaltic to inter mediate in composition and occur south and west of Sinkat and Summit. They form high ridges extending from 50 meters to several kilometers and sometimes have thickness up to 30 meters.

Fig 2: Geological Map of Sinkat area.

Plate 1: Photomicrograph of acid meta volcanic

Plate 2: Photomicrograph of granodiorite rock from Gebiet village showing plagioclase represent the dominate phase

Mineralogical Studies

Metallic minerals

Manganese Mineralization

Minerals in Sinkat area are manganese deposits consisting mainly of oxides occurring in green, hard, well foliated hornblende and chloritic schist associated with some marble bands.(Plate 4). During weathering conditions they in general behave similarly to iron minerals. They are closely related chemically. Manganese deposits accompany iron minerals but in smaller amounts. Their oxides resist solution and accumulate as a result of weathering of manganese - bearing rocks to form extensive residual deposits which are the most important type next to sedimentary deposit. The source materials are generally similar to those of iron, namely altered igneous rocks (schist). This mineralization occurs in Sinkat area. The nature and genesis of manganese deposit in Jebel-Almashgog East of Gebiet village is found as crystalline textured variety frequently with a fibrous and radiate structure.

Generally Sinkat area the manganese deposits are found filling fractures in the country rocks of pre Cambrian age controlled by the fracture zone and weathering zone in the schist rock consist the oxidation zone. They are believed to be supergene in origin. There are five localities in Sinkat area which are considered to be manganese mineralization (See table 1). The grade of manganese ore in Sinkat area is classed as medium to low grade.

Table 1: The manganese content in rock samples from Sinkat area.

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Manganese values in (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta sediment</td>
<td>2006</td>
</tr>
<tr>
<td>Gabbro in syn- tectonic granite</td>
<td>1537</td>
</tr>
<tr>
<td>Basic &amp; Ultrabasic</td>
<td>1347</td>
</tr>
<tr>
<td>Andesite</td>
<td>1362</td>
</tr>
<tr>
<td>Post -tectonic granite</td>
<td>1415</td>
</tr>
</tbody>
</table>

Iron mineralization

Iron mineralization in Sinkat-Gebiet area occurs in the oxidation and alteration zones of igneous rocks. Examples of such localities are associated with gabbro and porphyritic gabbro in North East Gebiet, some dykes of andesite and basalt, East Sinkat and in Jebel-Almashgog North of Gebiet.

Through oxidation the minerals are mostly altered and the structure is largely obliterated. The metallic substances for most parts are leached or are altered to new compounds that require quite different metallurgical treatment for the extraction of their metals from that employed for the unoxidized ores (Plate 5). Iron mineralization in Sinkat area is fine in brown to red color due to the oxidation and alteration zone.

In Jebel-Almashgog there are some geological factors which controlled the iron deposit such as andesite and basalt dykes because the movement of these dykes consist brecciation and some alteration in the host or country rocks (meta sediment) and crystalline anew minerals due to the replacement and the mobility of the minerals, for that the iron mineralization is localized within andesite foliated near altered gabbro rocks and among this foliation there are intensive foliated.

The intensive foliation and oxidization zone were affected by a fine impregnation with iron. Chemical analysis of the rock samples shows that the grade of iron minerals is high to medium grade (Table 2) and (Fig 3).
### Table 2: Iron content in rock samples from Sinkat area

<table>
<thead>
<tr>
<th>Rock type sample</th>
<th>Content of Fe (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta sediment</td>
<td>73790</td>
</tr>
<tr>
<td>Gabbro in syn- tectonic granite</td>
<td>62311</td>
</tr>
<tr>
<td>Basic &amp; Ultrabasic</td>
<td>69259</td>
</tr>
<tr>
<td>Meta volcano</td>
<td>54246</td>
</tr>
<tr>
<td>Post-tectonic granite</td>
<td>45690</td>
</tr>
</tbody>
</table>

#### Copper Mineralization

Copper mineralization in the study area occurs in Jebel-Lambat, Jebel-Hoshoribab and near Khor Mikeri in the form of sulphides deposits with minerals such as chalcosite and chalcopyrite but in Khor-Mikeri East of Gebiet Cu mineralization occurs in spotted Shale-Jebel-Lambat Cu mineralization is structurally controlled by fault related structure by the mylonite and breccias. The area is characterized by a brecciated quartz and calcite. This factor indicates hydrothermal alteration with an increasing content of Cu, Zn and Pb (poly metallic sulphides).

Along Khor-Mikeri East Gebiet there is showings of Cu mineralization occur in spotted shale with abundant opaque minerals and large grains of quartz with iron oxide.

In Jebel-Hoshotriba also there is Cu mineralization which occurs in basalt and gabbro rocks penetrating the diorite complex. The chemical analysis of some samples shows the Cu mineralization to be of low grade of mineralization (Table 3) but if the grade may be increase with depth (Fig 4) In the chemical analysis (Table 4) Zn and Pb values higher associated with the cu minerals in the basic or ultrabasic rocks. This indicates that the poly metallic sulphides were form by hydrothermal solution but there are also some structural factors which controlled the concentration of these minerals such as faults and weathering of foliated rocks Fig 5.
### Table 3: Show the Cu, Zn and Pb values in some samples from Sinkat area

<table>
<thead>
<tr>
<th>Rock type sample</th>
<th>Cu content (ppm)</th>
<th>Zn content (ppm)</th>
<th>Pb content (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meta sediment</td>
<td>18.9</td>
<td>56</td>
<td>42.3</td>
</tr>
<tr>
<td>Gabbro in syn-tectonic granite</td>
<td>12.2</td>
<td>109.5</td>
<td>37.1</td>
</tr>
<tr>
<td>Basic &amp; Ultrabasic</td>
<td>13.7</td>
<td>55.9</td>
<td>42.1</td>
</tr>
<tr>
<td>Meta volcano</td>
<td>13.8</td>
<td>112</td>
<td>36</td>
</tr>
<tr>
<td>Post-tectonic granite</td>
<td>10.7</td>
<td>106</td>
<td>44.2</td>
</tr>
</tbody>
</table>

### Building Materials

Building materials in the study area contain of marble and granite which can be useful for chemical industry and construction purpose.

**Marble**

Marble occur in the study area in the meta volcano sedimentary sequences it is the oldest sequence in the Sinkat-Gebiet area. Marble is situated within amphibole genesis of meta volcano sedimentary sequence.

Summit marble belt is banded and consists of alternative bands of light brown and grey color (Plate 6); on the other hand there is some bands of pink and dark color varieties.

The bands strike 35° and dip 60° to SE. They are 40-45m thick and extend for 200m. The thickness of the marble becomes less to the north and reaches 2m at its end.

The chemical analysis of marble is showing the high grade of Cao and the other minerals is trace, the transportation and nearness of water supply and accessibility all this factors make the marble of Summit economic for chemical industrial purposes.

### Table 4: The chemical analysis for marble rocks in Summit area

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cao²</th>
<th>MgCO³</th>
<th>Trace Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>97.7%</td>
<td>0.1</td>
<td>2.2%</td>
</tr>
<tr>
<td>2</td>
<td>85.5%</td>
<td>4.5%</td>
<td>10%</td>
</tr>
</tbody>
</table>

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Granite rocks (dimension stone)

They occupied more than 60% of the exposed area in the northern Red Sea Hills. The mode of occurrence of these grinitioid complexes are dykes, sills, plutons with composition comprise mainly of granodiorits to adamellite and quartz diorite. These are intruded mainly into volcanic rocks.

South of Sinkat in Der Haepe station there is outcrop of younger granite which elevating up to 735m compose of potash feldspar, quartz and biotite. This locality can form a good quarry for decorative granite because the granite form a large bolder and the minerals composition in porphyritic texture this make it beauty (Plate 7).

Conclusions

The geology of the study area has been subdivided into meta volcano sedimentary sequences layering unconformably of the older metamorphic complexes. All of these lithological had been invaded by syn- and post tectonic intrusions. The meta volcanic group of mainly banded rhyolites, volcaniclastic tuffs, basalts and locally rhyodacitic, daicetes, andesite and intermediate and basic metavolcanics.

The whole area has been extensively intruded by large Syn-to late tectonic batholithic gnoitoids which were emplaced during the deformation of volcano -sedimentary sequences of greenschist facies. The batholithic rocks are varying in lithology from gabbro diorites to granite and granodioritic.

Copper showing in the study area occurs in some localities such as Jebel-Lambat, Jebel- Hoshoriba and near Khor Mikeri in the form of sulphides deposits such as (chalcosite and chalcopyrite) except in Khor-Mikeri East of Gebiet where Cu occurs spotted in shales in low grade. Manganese and iron mineralization have been represented in Jebel-Lambat South West of Sinkat, Jebel-Almashgog North Gebiet village (Fig 6).

Chemical analysis of the samples of iron mineralization shows medium to high grade.

Generally all mineral deposits that have been explored in the study area are in low to medium grade, because all the study samples were taken from primary dispersion haloes and surface of mineralized zones. So more advanced geological studies need to be carried out in Sinkat area such as drilled trenches and pits. Marble occur in the study area in the meta volcano sedimentary sequence in a number of localities (5) in Sinkat-Gebiet-Summit area. The largest marble deposits is located ½ Km west of Summit station in the south west part of Sinkat area in three major outcrops of relatively high relief as well as in other small low outcrops.

Granite rocks there are a number of localities of granites and similarly outcrops in the area which can be used as dimension stone for both decorative and construction e.g. The best of these outcrops are these of Der Hape station 40 Km south of Sinkat and in Sinkat town itself 1km south of Tawi Dam.

![Mineralization map of the study area.](image.png)

**Fig 6:** Mineralization map of the study area.

**References**


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