Economic Geology of Prospecting Areas of Moein Abad, Qaen, South Khorasan, East of Iran

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ABSTRACT

The prospecting area of Moein Abad is located in the east of Iran in South Khorasan province. Generally, the purpose of Moein Abad project is to explore and prospect mineral materials such as gold, copper, iron, molybdenum and tungsten. The main rock units that appeared in the study area are composed of metavolcanic rocks (metv), metamorphosed limestone (mb), metagabbro-diorite as well as some intrusive bodies (granite to granodiorite). The mineralization is mainly observed in the form of veins, veinlets, and dissemination of copper and iron sulfides and oxides which have occurred at contact of metavolcanic rocks and the metamorphosed limestone. According to our investigation, the mineralization is of skarn type. Because of intrusive granite mass in to limestone and metamorphosing these limestone in the result of reactions between solutions of magmatic-hydrothermal solutions and limestone of mineralizations of Moein Abad area in the border of metamorphosed limestone and volcanic rocks (metv) and skarn zone. This skarn that occurred in the contact place of metavolcanic with metamorphosed limestone all over the area is seen as a relatively narrow strip with thickness from several meters to tens of meters in an approximant trend of north western–south eastern. The total mineral of this skarn includes quartz, calcite, grossular, augite and gypsum. The skarn’s host stone is the unit of metamorphosed limestone and therefore calcium rich garnets are formed. Mineralization most of the time is in the form of copper sulfite (like Chalcopyrite) and sometimes in the form of magnetite. Therefore, we can state that because of intrusion of granite mass to late cretaceous age inside limestone mb unit and metamorphosing these limestone because of reaction between magmatic-hydrothermal solutions and limestone, mineralization in the Moein Abad area in the border of metamorphosed limestone and volcanic stones and Zone Skarn. As garnet and Pyroxene in the area are rich in calcium and such minerals are found highly in the area; therefore, the mineralization type in Moein Abad area is a calcic skarn copper.

INTRODUCTION

The exploratory area of Moein Abad is the east of Iran in South Khorasan (170 km to south east of Qaen-figure 1). This area is located in the north west of 1:250000 sheets of Shahraht and 1:100000 of Ahangaran. The studied area with north-south trend covered a part of topography sheet 1:50000 of Ardcole (Gomenj). For having access to Moein Abad area one can use the road of Qaen- Esfeshad- Esfeden passing a distance about 150 km, after passing from Degh Bala (about 5km from Haji Abad village) and after passing from Bashiran village (in the south eastern corner of the area).

The project of exploration of mineral materials in the Moein Abad area (Qaen) is performed by consultation engineers of Zarnab Company aiming at searching and exploration of mineral metal materials. According to the previous studies the presence of anomalies elements such as gold, copper, Iron, Molybdenum and tungsten are approved and this subject specified the necessity of doing more exploratory studies. In this article, shortly it is tried to represent exploratory activities in the Qaen city around Moein Abad.
Fig. 1: Geographical position and access areas to understudied area.

1.1. Literature review:
In the Ahangaran area different geological studies were performed with different purposes that most of these studies performed by Ministry of Industries and Mines (Industries and Mines organization of South Khorasan), geology organization and mineral exploratory of the country and companies like consultation engineers of Zarnab Company and connection consulter of Madan Ara were done during tens of years. the oldest of these studies were performed in 1978 by geology organization and mineral exploratory of the country and the newest of such studies performed in 2007 by consultation engineers of Zarnab Company. Below, some of these activities are represented:
A: geology sheet 1:250000 Shahrakht (Geological quadrangle map of Iran –B.R.G.M Orleans(France) and under supervision of Dr. Mansour Alavi nacini.
B: Exploratory design of gold and orpiment in the east of Qaen (geochemical of stream sediments, 1:20000) the connection consulter of Madan Ara Company in 2001 performed project in an area about 80 km². On the basis of conclusions from reports, this area is rich in mineralization of Fe, Cu, Au and As, and geochemical abnormalities and heavy minerals have conformity. Four prone areas in the 2 km distance from Dezak Village, the 3 km diagonal of Hosain Abad Village, 3 km to the south east of Ali Abad until Souround Village and one km from Manavand Village to Dezak were introduced for exploratory activities.
C: The gold semi-detailed exploratory of gold and orpiment in the east of Naein (Lito-geochemical exploration 1:5000) connection consulter of Madan Ara Company in 2003 performed this project in an area with 10 km³. Geographically, the area of the project is located in the northern areas of Manavand village to the south east of Moein Abad that is centralized in line with Skarn outcrop. On the basis of conclusion, generally mineralization is formed in the lower strip of limestone and in its border with meta-volcanic unit and one skarni environment.
D: Geochemical and geological exploratory in the Manavand area of the scale 1:10000 by consultation engineers of Zarnab Company, in the year 2006, this project was performed in an approximate area 99.5 km³ that covers 24.6 km³ of the studying area. Economically in this area there are indexes of Cu, Fe, Mn, and Cr and observations for exploitation of Cu and Fe were specified.

2. Methodology:
The project of exploring mineral materials in the Qaen city (Moein Abad Area) during several stages was discovered by consultation engineers of Zarnab Company for exploring, primary exploitation and detailed exploitation. Some of these activities included preparing of geology-mineral map with scale 1:5000 in the two east and west area of Moein Abad with 22.5 km and preparing geological-mineral map 1:1000 in the 300 hectare space , geophysical exploratory operation using IP-RS methods and measuring the agmatic by picking from 1360 points of measuring magnetics and 1358 points of IP and different sampling. During the performance of preparing geological-mineral map in western and eastern Moein Abad mineralization zones were introduced and were selected. In the next stage on important zones with more importance respecting mineralization totally 305 M³ in the form of 12 chis in the east and western areas were excavated. While geological studies in the three areas of the map of mineral geology (figure 2), the eastern area of Moein Abad with 8 km² and the western area of Moein Abad with 14.5 km³ were geologically studies in the 1:5000 scale. Also, in an area as wide as 300 hectare in the 1:1000 scales the geological-mineral and topography was depicted. Area 1: 1000 is located inside area 1: 5000 east of Moein Abad, that after preparing the geographical map 1:5000 are performed for studying and more precise analysis.
3: Analysis and Discussion:

3.1: Geology of the studied area:

The stone units that are found in this area are as follow [2]:

The oldest rocks of Proterozoic period are composed by metg units (metagabro-diorite). On this unit mb and metv units are composed of limestone (crystal limestone), and metalava-amphibolite schist. Meantime gd intrusive bodies with Hornblende granodiorite to monzonite permeated between meta-gabbro and limestone. This unit in most of the points is situated on other units by fault contact. Outcrop of units belonging to Proterozoic are seen in the western parts of understudied area. Generally the unit of limestone as the host rock of mineralization of copper and iron played the role in this area. The principal parts of north-north eastern parts of the area are composed by previous cretaceous units. This category from old to new respectively are Ksl (Asparayt sandstone and shale), Kcl (red sandstone and conglomerate), Kll (Massive limestone with Orbitolina and Rodsite), kfl (shale and cutting of limestone), meantime the unit of kll has the most of permeate and it is highly tachtonized. Stones belonging to the late cretaceous from the old to the newest includes Kgd2 (tonalite) and Kg2 (weathered granite). The unit of Kg2 that is seen in the form of contacted with orbitolina limestone units and separated from north western part to south eastern part and has a fault contact, these rocks generally are outcropped in the center of understudied area. The unit of kgd2 (tonalite) are outcropped in the center, North west and west of the area that are situated on the Amphibolite and amphibolite schist. The unit of Kg2 permeated in the north western part of the area into the late cretaceous limestone. The rocks belonging to Cenozoic period (Paleocene-Eocene) are PEL, PEc, and PEms units that include bioasparaite, red conglomerate horizons, red conglomerate horizons, and sandstone, and also in the south of the area and in neighboring with tonalite units are outcropped. Also from units belonging to quaternary we can refer to the following rock stone units: OP1cg unit (conglomerate and sandstone), Qt1 and Qt2 unit (old and new traces in the area), Qal unit (Alluvial deposits).
4. Structural geology and tectonics:

The tectonic position of Ahangaran area (Qhaen) is so that situated between the two main and great faults of Nehmandan in the west and Harirood in the east. The entire geological structures in this area are affected by these two faults. Understudied area with respect to structural geology is located in the north western block of the map 1:100000 of Ahangaran and on northern tails of Nehbandan fault [1].

The general trend of the area faults is north west-south east and a number of small secondary faults in a low number with different trends are seen in the north west of the area.

In a greater scale the line of structures is NNW – SSE and WNW – ESE that is affected from movement of Nehbandan fault. In the view of structural geology the most important structures of the area is Rastalghaz with compressive component that in most of the contact points of the units (mb) with other neighboring units. The borders of units are generally faulting and in the border of permeating units such as craterous granite (kgr) with craterous limestone the performance of the fault is specified and no metamorphosed are seen, and most of mineralization is done in the border between metamorphosed limestone units and meta-volcanic unit. This issue represents relationship between performance of faults and mineralization in the area (figure3).
According to the desert observations and the prepared map the faults in the area can be divided as follow:

**Faults with NNW-SSE direction:**
This fault are more observable in the south eastern tail of the area and follow the main trends of Nehbandan fault and their length is between several hundreds of meters to mostly two KMs of oscillation. The principle movements of these faults are in the form of Rastalghaz, rightward and compressive component.

**B: The fault with WNW-ESE trend:**
These faults are mostly seen in the northern part of the area and their length is around several hundreds of meters. The movement of these faults is mostly in the time in reversal direction along with the component of Rastalghaz right ward. Of the impacts of these faults that forms the connection of the metamorphosed limestone (mb) and limestone (KI) in the north of the area that provides necessary ground for permeation of fluids and mineralization [3]. Figure 4 shows a look of performance of this group of faults.

In the figure (5) the diagram of the red soil (rose diagram) is depicted for faults in the Moein Abad area. As seen in this rose diagram, the trends of faults in the area has a great deal of verity, therefore, processes of NW-SE and NE-SW benefit more relative importance (figure 3).
4. **Mineralization:**

Mineralization in the exploratory area (eastern and western) of Moein Abad is formed of sheets and zones of silica that includes the copper and iron sulfite minerals. Also, these sheets includes some amounts of gold, zinc, tungsten and molybdenum.

Most of the separable sheets that have a great length have outcropped in the north western part of the area (figure 7). Such cases of mineralization in the ground level by experienced miners (the current century and before) were exploited. Such sheets have the trend of north—north eastern and thickness of 2-4 meter and have a length from 20 to 25 meter. These sheets are developed in the eastern part of Moein Abad and have little development in the western Moein Abad area. Such sheets mostly are rich in silica, carbonate, and silica—carbonate (figure 7). According to the depth of the opening and the volume of exploited depots from the old wells it seems that in some of the areas to several meters of the land sheets are exploited (figure 6). Mineralization in the Moein Abad area occurred in the contact points of limestone metamorphosed with metavolcanic units or granodiorite. The studied mineralization with respect to the host rock is divided into two groups: the first group is mineralization in which their host rock is meta-volcanic units (metv) and the second host group is metamorphosed limestone (mb).

The general process of this mineralization follows intrusion units so that in the northern part of area it has an eastern-western process, but from the center of the area toward south until the east of Moein Abad village the process is from north west-south east. In the east of Moein Abad the impact of the old holes is seen more than other parts. The copper mineralization in this part is of malachite and azurite type, while mineralization with eastern-western trend includes iron mineralization with magnetite type. Mineralization in this section is performed inside metamorphosed limestone. Result of studies of the polished section and the element analysis using ICP-OES method from harvested cases from the sheets with mineralization represents this issue that the average copper grade is about 0.9%, and tungsten, molybdenum and gold respectively are about 180, 59, 0.35 g/t. In some points such as a point with coordinate (233173, 3691344) is based on UTM of silica sheets are seen brightly that despite thickness and appropriate outcrop lack mineralization. The stated sheet with observable length about 5 meters is in the extension of 150 with thickness of about 20 meters in the granite unit (figure 7). To analyze the type and the method of mineralization, 27 cases aiming at element analysis using ICP-OES method were harvested from the place of depo of the old works that the elicited results with respect to elements of gold, arsenic, copper, molybdenum, cadmium, tungsten and zinc are observed (table 1).
Fig. 7: A close view of the silica sheet in the area.

Totally, 10 cases of aiming at chemical analysis using ICP-MS methodology were harvested from the current sheets in the area that result of this analysis is indicated in the table (2).

Table 1: The result of analysis ICP-OES of depo cases of the old works including mineralization

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Table 2: The result of ICP-MS analysis from harvested cases of existent sheets in the Moein Abad area

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The result of harvested cases of analysis during the recent studies and previous ones shows that some of the sheets have a considerable amount of gold. These results show that paragenesis of mineralization of chalcopyrite, pyrite, malachite, azurite, garnet and magnetite occurred. But most of the observed minerals in the hand specimens are malachite and magnetite. The 2 cases from one mineralized sheet include mineralization of malachite, magnetite and epidote that has a thickness about 2.5 meter and length of 22 meters and extended in line with N70E degree and steep of 85degree in line with the limestone layer. According to the result of the element analysis of the first hand sample using ICP-MS method around 0.4% of copper and 8.1% iron is reported along with a little amount of tungsten. The study of the polished area of the second sample showed presence of magnetite and chalcopyrite in the Cong silica set (figure 8).

Fig. 8: Right: a view of mineralized sheet with mineralization of copper from the place of the first sample, and Left: is a view of the microscopic section of the second sample Cp = Chalcopyrite, Mag = Magnetite

Fig. 9: The map of separation of mineral indices, mineralized sheets and geographical works in the north, center and south of the area

The study of polished sections of the area from the sheets and silica zones shows that mineralization of chalcopyrite, pyrite, malachite, azurite, garnet and magnetite occurred. In the hand specimens also malachite and magnetite are seen (figure 10).
The superficial mineralization are mostly oxidized in the surface and in the study of the sections a great volume of metamorphosed sulfite minerals are seen, so that healthy chalcopyrite is seen in the form of remaining among oxides and iron hydroxides and they are dissolved to secondary minerals of chalcocite and covellite (figure 11).

**Fig. 10:** Right: is a microscopic section of the harvested sample from mineralization sheets, and left: the copper mineralization in the form of malachite and azurite in the hand specimen (Mal = Malachite, Mag = Magnetite)

4.1. Skarn:

All over the skarn area in the form of a narrow strip with thicknesses of several meters to several of 10 meters are seen in an approximate trend of North West –southeast. This skarn occurred in the contact place of meta-volcanic unit with metamorphosed limestone unit that is seen all over the area. The sets of minerals of this skarn include quartz, calcite, grossular, augite, and gypsum. The host rock of that unit was metamorphosed limestone unit and therefore the calcium garnets are composed. The result of the harvested samples from this skarn for analysis of XRD shows presence of these minerals (table 3, 4).

In the ZMT – 336 samples that is harvested from Zone Skarn are mineral garnet, plagioclase, epidote along with diopside in the background of rock in the strip form of diopside and epidote minerals. Their stretching mode can be a sign of stress on the rock the tangible quartzite sheets also cut the rock. The sample ZMT – 372 is also one Garnet, epidote, diopside calc-silicate with similar conditions (figure 12).

**Fig. 11:** Is a microscopic section of the sample (Bor = Bornite, Cc = Chalcocite, Cov = Covellite)ZMP-288

**Fig. 12:** A view of microscopic section of the sample ZMT – 336 and ZMT – 372
5. Alternation:

Generally studies of alternation (including desert observations, petrography studies and harvested samples for XRD analysis-table 3,4)in the Moein Abad area specifically specified epidotic- chlorite and iron oxide. These alternations most of the time is observed in the meta-volcanic rocky units and border of this unit with metamorphosed limes. The argillic alternation in lower width is seen in the granite units that seems mostly they are effected by atmosphere solutions and also considering this issue that most of the existent alternations in the region in the view of mineralization are useless, therefore we conclude that there is no relationship between alternations and mineralization, description of these alternations are presented below:

5.1: Epidoty-chlorite:

Epidoty-chlorite alternation from the center-west of the area and to some extent occurs from south to center. Epidote, chlorite, calcite and quartz minerals composed these alternations.

Epidoty alternation in the meta-volcanic units (metv) occurred beside tactionized and metamorphosed limestone. In a microscopic study of the sample ZMT–375 that is removed from this zone plagioclases of the rock became sosority and changed to the set of epidote and albite. In the chlorite rock it is observed to a great extent, because actino is not formed in this stone and we can conclude that the rock still is not reached at the green sheet mass (figure 13).

5.2: Average Argillic:

Average argillic alternation in the west of the area is developed by a relatively low width. The host rock of these alternations is outcrops of granite to granodiorite unit (gr-gd). It seems that this alternation that is influenced by atmosphere solutions and with respects to mineralization it has no value.

6: Conclusion:

Because of intrusion of the granite masses to the late cretaceous age into limestone unit mb and metamorphosing these limes and because of reaction between magmatic-hydrothermal solutions and limestone mineralization is formed in the Moein Abad area in the border of metamorphosed limes and volcanic rocks and...
zone skarn that in this zone grossular, diopside, magnetite, epidote, malachite, chalcopyrite, pyrite, galena, hematite minerals are constituted. Studies showed that these minerals with respect to elements such as copper, iron, gold, tungsten and molybdenum are important. We can indicate that a good space is formed for intrusive and injection of hydrothermal solutions in the Moein Abad area by means of faults and existent breaks in the border of the two metamorphosed rock unit of (mb) and meta-volcanic (metv) and as the mineralized host rock is the unit of metamorphosed limestone; therefore, calcium-rich garnets are formed [4], in this way considering this subject that garnet and existent pyroxene in the area arch rich in calcium and minerals rich and such minerals are found highly in the area; therefore, the type of mineralization in the Moein Abad area is a calcic skarn copper type.

REFERENCES