# Physico Chemical condition of Mazreah Skarn North of Ahar ,North West of

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## Abstract
*Principal Skarn deposits along the northern margin of the Ahar batholith from west to east include Mazraeh, Vine and Gowdoul skarn deposits. Among these skarn deposits, the Mazraeh Cu-Fe Skarn deposit is the most typical skarn deposit in the NW Iran. The main mineral constituents of the skarns are garnet, magnetite, calcite, chalcopyrite, epidote, hematite and pyroxene, accompanied by quartz, pyrite, bornite, coevalite, chalcocite, plagioclase and chlorite.This investigation presents and interprets fluid inclusion data of different lithological units of the copper skarn deposits in the north of Ahar NW Iran. The results provide an assessment of the P-T conditions and mineral-fluid .Various fluid inclusions present in Mazraeh show homogenization to different phases. The overall homogenization of inclusions with daughter-bearing fluid inclusions ranges from 157$^o$ to 520$^o$C. The total salinity of salt bearing inclusions varies from 31.4 to 63.0 wt.% NaCl equiv. The salinity of biphase inclusions, based on their final ice melting temperature in different samples, vary between 10. 2 to 20.8 wt.% NaCl equiv. The inclusions formed at low pressure. $T_h$ vs. salinity plots of Mazraeh inclusions show that the salinity of the fluids correlates positively with temperature.*

**Key words:***physico chemical condition , Skarn deposit, Fluid inclusions, Azarbayjan, Iran,*

## Introduction
In the Alborz unit, Precambrian basement rocks are of Gondwanan affinity. Tectonic movements in the Late Precambrian caused significant uplift in Azarbaijan and locally formed angular disconformities .A thick Triassic to Upper Cretaceous sedimentary- volcanic sequence was subsequently folded during Late Cretaceous-Early Tertiary orogenic movement (Eftekharnezhad, 1975). The late Eocene-Oligocene plutonic activity of northern Iran (the Gharah Dagh - Tarom plutonic belt) has a NW–SE trend (Pourhosseini, 1981). Late Eocene-Oligocene (mainly Oligocene) plutonic activity was reported by Khain (1975) from the Lesser Caucasus to northern Azarbaijan (Stockline and Eftekharnezhad, 1969; Pourhosseini, 1981).
Fluid inclusion studies have become vital to understanding the genesis and exploration of ores. Several workers have studied skarn deposits as well as those linked with granites to understand fluid evolution that resulted in ore deposition (Einaudi and Burt 1982; Ahmad and Rose, 1980; Sato, 1980; Kwak, 1986; Meinert, 1992; Mollai, 1993; 1996; and Calagari, 2004). This investigation presents fluid inclusion data for different lithological units of the Mazraeh copper deposits. Our results were used to the exploration parameters and for an assessment of the P-T conditions for mineral-fluid evolution.

### The Ahar Batholith
This Ahar batholith extends E–W for about 30 km and is 3–10 km wide (Fig.1). In general, the rock is fresh except at few places. The pronounced structure of the granodiorite body is cross jointing striking NNE-SSW and NNW-SSE with spacing of joints from a few centimeters to a meter. In some places, veins of aplite, pegmatite and quartz fill the joints and some joint planes are coated by malachite. The granodiorite pluton has intruded Cretaceous subvolcanic and sedimentary rocks along a plunging antiformal structure. In the host rocks, skarn

deposits are developed, as well as silicification, recrystallization of limestone, and production of spotted schist and hornfels. From west to east, the following are the principal skarn deposits:

**Geological and Minera logy of copper skarn deposit**

Major rock types of the copper skarn deposit include metasedimentary and metavolcanic country rocks, and intruding plutonic rocks that have developed a metasomatic zone at the contacts with Cretaceous limestone. The whole structural set up of the Mazraeh mine is in an elliptical shape with the major axis striking E-W for a strike length of about 1.5 km and the minor axis lies in N-S direction with a width of almost 1 km. The whole meta-volcanic sedimentary sequence occurs as a mega-enclave within the granodiorite The country rock is nearly pure recrystallized limestone interbedded with the aluminosilicate layers. This argillaceous limestone consists of angular calcite, subordinate biotite, feldspar and quartz exhibiting low-grade regional metamorphism and metasomatism. To the north of the copper mines, hornfels have developed after the metasomatism of cataclastic rocks. They are very fine-grained, hard and usually black in colour. The southern periphery of the elliptical body comprises siliceous recrystallized limestone layers, which have a sharp contact with skarn whereas the contact between limestone and pelitic rocks is transitional. The main skarn zone varies in width from 2 to 50 meters. The Mazraeh iron-copper skarn deposit can be classified on the basis of petrology into endoskarn, exoskarn and ore skarn. Each of these types can be further divided on the basis of predominant primary skarn minerals assemblage, as follows:

I. Endoskarn, II. Exoskarn ,:III. Ore skarn

## Physico- Chemical Condition of Skarn Deposit

**Method of study**

Doubly polished plates (0.05-0.1 mm thick) were prepared for microthermometric measurements. These sections were scanned microscopically for inclusions and small chips ($0.5cm^2$) containing inclusions were broken of mounting in the heating/freezing stage. Photographs were taken from each microscope field for re-identification of individual inclusions. Fluid inclusions were examined using a petrographic microscope to determine the size, shape, abundance, distribution and type of inclusion present in the rock samples before commencing the freezing/heating experiments. In addition to ice melting temperatue ($T_m$) and homogenization temperature ($T_h$), individual inclusions were studied for their approximate size and the relative phase volumes using the spherical approximation (Roedder, 1984)

**Fluid inclusion types and petrography**

Characteristics of fluid inclusions in different minerals from the Mazraeh skarn deposit are shown in Fig. 3. Five inclusion types can be classified on the basis of observable phase at room temperature and their paragenesis. The important of inclusions have been observed in the studied samples are as follow:-

**Type A inclusions**: These are multiphase inclusions (Fig.3A ) that essentially consist of a liquid, a vapor phase and at least two daughter crystals.**Type B inclusions:** Type B inclusions are primary liquid–vapour inclusions containing one or two fine-grained daughter crystals (Fig.3 B). They are similar to Type A inclusions in shape, size and distribution. The gas / liquid ratio varies with liquid from 50–60 vol% and the vapor bubble from 30–50 vol%. They exhibit subhedral to equant grains shapes.**Type C inclusions**: These are liquid-rich biphase inclusions that may include solid crystals and an opaque mineral (Fig. 3C). Their liquid-vapor ratio is usually 8:2. The size of these inclusions ranges from 15 to 30 μm. They are isolated subrounded to irregular in shape with an average population density of 30 to 40 inclusions per square cm. **Type D inclusions**: These are gas-rich biphase inclusions with about 80 vol % to > 90 vol % vapor phase . They usually vary from 5 to 15 μm in size, are irregular in shape, and occur in trails.

### Microthermometry

A summary of fluid inclusion data is shown in Tables 1-3. Freezing and heating experiments were also restricted to the primary fluid inclusions of types A-D. Stretching of inclusions as described by Bodnar and Bethke (1984) and Singoyi and Khin Zaw (2001) was noted during heating of large fluid inclusions in garnet and quartz from mineralized quartz veins, but smaller inclusions(<2 μm) provide reproducible homogenization temperatures. In such samples homogenization temperature ranges from 369 -420$^o$C (n=10). Various inclusions present in the Mazraeh show homogenization at a) halite melting temperature b) vapour disappearance temperature and c) liquid disappearance temperature. These results in homogenization of different fluid inclusions to liquid as well as to vapour phase. The sylvite melting temperature is from 157$^o$ to 190$^o$C and the halite dissolution temperature ranges from 200$^o$ to 520$^o$C**.** Of these temperatures, the highest values are recorded in the mineralized veins followed by the skarn and the lowest in the granodiorite. Barren veins do not have any solid crystals as inclusions.

## Conclusions

Various fluid inclusions present at the Mazraeh deposit show homogenization by (a) halite melting, (b) gas disappearance and (c) liquid disappearance. Sylvite melting temperature vary from 157$^o$ to 190$^o$C. The homogenization range of salt bearing inclusions in mineralized quartz veins varies from 295$^o$ to 520$^o$C. The total salinity of salt bearing inclusions varies from 31.4 to 63.0 wt.% NaCl equiv. The salinity of biphase inclusions, based on their final ice melting temperature, varies between 10. 2 to 20.8 wt.% NaCl equiv., whereas the salinity of fluid in barren quartz veins varies from 10.2 to 17.9 wt.% NaCl equiv.

The early stage ore fluid was produced at the late to post granitic stage under low pressure and at temperatures < 500$^0$C, below the granite crystallization temperature of 698 to 754$^0$C. $T_h$ *vs* salinity plots show that most inclusions positioned above NaCl saturation curve are from mineralized vein quartz. The salinity of the fluids and the temperature values are positively correlated. Early highly saline, high temperature fluids were late to post granitic as they are not only abundant in ore veins intruding granite but also present in the granite itself. It is interpreted that the mineralization occurred at temperatures above 350$^o$C, before mixing of the fluids.

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**Table.1. Fluid Inclusion data of Mazraeh samples**

| | Mineralized Veins | Skarn | Granodiorite |
|---|---|---|---|
| Temp. of sylvite diss. ( $^{o}$C) | 155 to 190 | 162 to 185 | 155 to 182 |
| Temp. of halite diss. ($^{o}$C) | 260 to 520 | 240 to 385 | 200 to 370 |
| Homogen. temp.of Type A inclusions ($^{o}$C) | 312 to 520 | 325 to 460 | 230 to 495 |
| Homogen. temp of Type B inclusions ($^{o}$C) | 274 to 470 | 400 to 460 | 340 to 465 inclusions ($^{o}$C) |
| $T_h$ of type C&D | 172 to 370 | 200 to 395 | 180 to 490 |
| Final melting temp. of biphase inclusion ($^{o}$C) | -5.2 to -18.0 | -4.0 to -17.0 | -4.2 to -18.0 |
| Salinity range | 11.0 to 63.0 | 10.2 to 59.1 | 10.4 to 58.7 (wt.% NaCl equiv.) |
| Homogenization phase | Both liquid & gas(mostly liquid) | Both liquid & gas(mostly liquid) | Both liquid & gas(mostly liquid) |

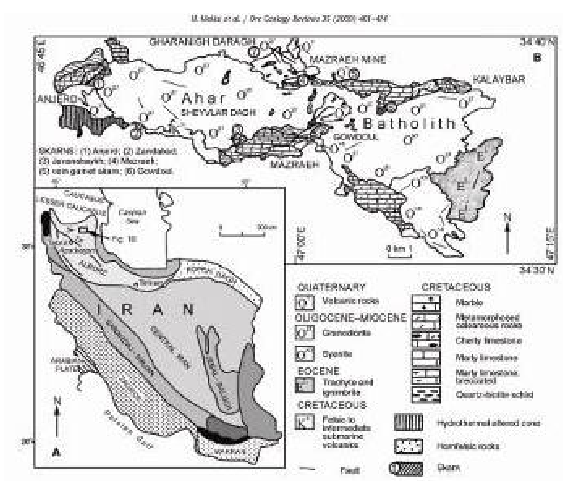


**Fig. 1. Regional tectonic map of Iran (after Nabavi 1976) showing location of area under study. and Geological map of Ahar batholith (Modified after Mollai 1993).**

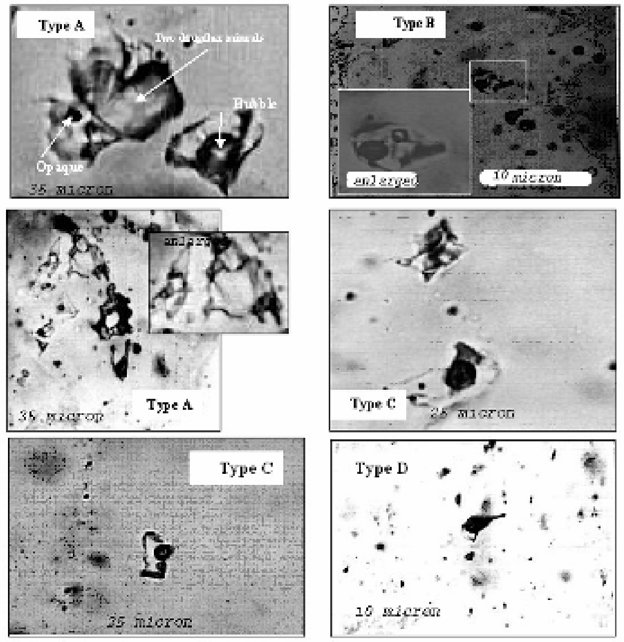


**Fig.2- Microphotographs of different types of fluid inclusions observed in the Mazraeh samples**