FROM FLUID INCLUSION STUDY TO GENESIS OF THE ANGURAN ZN-PB DEPOSIT, NW IRAN

Mahmood SADEGHI BOJD,
Birjand University, Birjand, Iran and postdoctoral student in Sweden, Mardtorps gatan3, 584 32, Linkoping, Sweden. E-mail: Sadeghi_bojd@yahoo.com and sadeghi_bojd@comhem.se

Abstract: The Anguran Zn-Pb deposit is located within the Urumiah-Dokhtar zone, 120 Km west of Zanjan City (47º 20´ E, 36º 40´ N). It is one of the largest and highest-grade non-sulfide zinc deposits in the world. The data obtained from geothermometric studies of Sphalerite and flourite associated with Zinc-Lead mineralisation at the Anguran mine are compatible with a structurally controlled, Sedimentary-hydrothermal origin. Hemogenization and last ice melting temperature of primary fluid inclusion indicate that mineralization taken place over a temperature range 155-165°C and salinities of inclusion fluids range 18.63 to 22.38 wt.% TDS. Finally According to field geology, mineralogy, Geochemistry and fluid inclusion study Anguran deposit is related to the subsurface activity and the same of Irish – Type Zn-Pb deposits.

Geology

The Angouran Zn-Pb deposit is situated in the Zanjan Province, NW Iran, approximately 450 km from Tehran. It is one of the largest and highest-grade non-sulfide zinc deposits in the world, and additionally hosts a very high grade sulfide ore body. The resources in 1999 were estimated at 13.5 Mt of non-sulfide ore with 26.4% Zn and 4.5% Pb, and 3.2 Mt of sulfide ore at 37.0% Zn and 2.32% Pb, plus 2.0 Mt of mixed sulfide-carbonate ore at 31.2% Zn and 4.1% Pb. The carbonate ores are currently exploited in an open pit around 2700 m above sea level.

Angouran is located within a metamorphic complex in the central Sanandaj-Sirjan Zone of the Zagros collisional belt close to the Urumieh-Dokhtar magmatic arc. The metamorphic rocks comprise a series of amphibolites, micaschists, and marbles of supposed Precambrian (to Cambrian) age and greenschist to amphibolite facies conditions. The crystalline complex shows internal thrusting and is thrusted onto Tertiary sediments at its western margin. The basement rocks are unconformably overlain by Miocene intermediate to acidic pyroclastic and
intrusive igneous rocks, and by a succession of sedimentary deposits. The latter consist mainly of shallow marine limestones of the Aquitanian Qom Formation and evaporite-bearing, red marls and sandstones of the Upper Red Formation. Quaternary travertine terraces complete the stratigraphic section. (Glig et al, 2003)

**Fluid inclusion study**

Considering the fact that fluorite is one of transparent ore minerals in the Anguran deposit, all fluid inclusion microthermometric measurements were carried out on this mineral and Sphalerite. It is also assumed that deposition of the coexisting (cogenetic?) galena and sphalerite has taken place within the temperature range of fluorite deposition. Doubly polished wafers were prepared from the collected samples using mount resin and thin-section methods (Craig, 1981; Roedder, 1984).

Using the classifications of Nash and Theodor (1971) and Roedder (1984), Anguran fluid inclusions can morphologically divided into three distinct types:

1) Monophase liquid inclusions
2) Two phase liquid-vapour inclusions
3) Three phase liquid-vapour-daughter mineral inclusions

The second and Third type represents the most and least abundant types, respectively. The degree of filling of inclusions also varies from 100% for the first type to 70% for the second and Third types. However, the degree of filling of the majority of inclusions ranges between 85-90%. The inclusions appear in various sizes and shapes including lath-shape, bar shape, negative crystal-shape and irregular. The largest observed fluid inclusion measures 150 microns in size and the smallest one just over 5 microns. Some inclusions display evidence of necking down. Figure 1 represents some of the inclusions encountered in crystals at Anguran deposit.

**Fig 1:** Different type of the Anguran fluid inclusion: A, B, and C are lath-shape, rounded and inclusion with negative crystal shapes respectively, D and E is a trail of pseudo secondary and secondary inclusions and F is a necked –down inclusion (magnification for all inclusion is 500)
Frequency histograms for homogenization and last ice melting temperatures of about 300 primary and pseudo secondary inclusions from Anguran deposit are depicted in figure 2. Homogenization was mostly to a liquid phase. The reported homogenization temperatures are uncorrected for pressure, as the morphology of the inclusions and the open space nature of mineralization indicate that mineralization took place at rather shallow depths where pressure correction can not change the measured homogenization temperatures significantly and hence was considered negligible.

Figure 2 show that mineralization has taken place in a temperature range of 125 to 255°C with a conspicuous peak at 165°C. The last ice melting temperatures of the liquid phase range from between-16 to -20°C with -17°C being the most frequent. This melting range corresponds to a salinity of 18.63 to 22.38 equivalent weight percent NaCl. Eutectic point temperature for CaCl₂-H₂O-NaCl aqueous system is -52°C (Crawford, 1981). The colour of ice during the freezing in Samples of fluorite in Anguran deposit was Brown, indicate that composition of fluid is CaCl₂-H₂O-NaCl. Low first (-45°C), hydrohalite (-35°C) and ice melting (-24 to -26°C) temperatures indicate Ca-Na-Cl brines with high salinity (18-23 wt.% TDS) and Ca dominance. Preliminary crush-leach analyses show very high and variable Br/Cl ratios suggesting fluid mixing and probably the participation of highly evaporated sea water.

![Fig2: Homogenization and last ice melting temperature of fluid inclusions in Anguran ore deposit.](image)

Although it is difficult to generalise about the properties of fluid inclusions that occur in different type of ore deposit, a number of parameters are consistent enough to be worth summarising. The most obvious and simplest way of characterising the fluid inclusions present in mineralized system is in terms of homogenization temperature and NaCl equivalent salinity. Whilst these properties are not direct functions of fluid temperature and fluid salinity. The general relationship which exist and the natural variability of these two parameters in hydrothermal system make them useful for comparative purposes.
Fig 3 represents a compilation of Th and salinity information from different zinc deposit types, drawing significantly on the summaries of Roedder (1984) together with a wide range of published data (Willkinson, 2001). The main classes of ore deposits occupy broad fields in Th-Salinity space which reflect the basic properties of the fluid involved in their formation and are broadly constrained between the halite saturation curve and the critical curve for pure NaCl solutions. For instance, epithermal deposits are primarily formed from modified, surface-derived fluids that have circulated to a range of depths within the brittle regime of the crust, often in areas of elevated crustal permeability and heat flow. They are therefore typified by low salinity fluids and a range of homogenization temperature that, because of the generally low trapping pressure involved, serve as an approximation of trapping temperature, spanning the typical epithermal range of < 100°C to 300°C. It should be emphasized that such fields are not sharply determined and that examples exist which do not fall into the defined ranges; such information should solely be used as a guide and provides for the inexperienced worker a feel for the type of data characteristic of different mineralizing systems. However, the data of fluid inclusions in Anuran deposit shows that the deposit is the same of Irish type Zn deposit.

**Fluid density**

Homogenization temperature information when coupled with fluid salinity data defines the density of the fluid, irrespective of fluid trapping conditions. Variation in fluid density is particularly important with respect to mechanisms of fluid flow process. A particularly useful diagram in this respect is a conventional Th-Salinity plot but contoured with lines of constant fluid density (Fig 4, Bodnar, 1983). Fluid inclusion data can be plotted on such a diagram and density variations considered. Fluid inclusion data at Anguran deposits plotted in Fig 4.
Fig 4.- Th-Salinity plot showing densities g cm\(^{-3}\) of vapour- saturated NaCl - H\(_2\)O solutions. Data of fluid inclusions of the Anguran deposit plotted in the diagram.

Conclusion

Homogenization and last ice melting temperature of primary fluid inclusion indicate that mineralization taken place over a temperature range 155-165°C and salinities of inclusion fluids range 18.63 to 22.38. Although it is difficult to generalise about the properties of fluid inclusions that occur in different type of ore deposit, a number of parameters are consistent enough to be worth summarising. The most obvious and simplest way of characterising the fluid inclusions present in mineralized system is in terms of homogenization temperature and NaCl equivalent salinity. Whilst these properties are not direct functions of fluid temperature and fluid salinity, the general relationship which exist and the natural variability of these two parameters in hydrothermal system make them useful for comparative purposes. Finally, according to field geology, mineralogy, and fluid inclusion study, Anguran deposit is related to the subsurface activity and the same of Irish – Type Zn-Pb deposits.

References