Characterization of fluids in the transition from deep porphyry Cu to shallow high-sulfidation epithermal mineralization at Red Mountain, AZ

Pilar Lecumberri-Sanchez[1*], Robert J. Kamilli[2], Robert J. Bodnar[1]

[1]Virginia Tech, Blacksburg, USA, pilar@vt.edu*
[2]U.S. Geological Survey, Tucson, USA, bkamilli@usgs.gov

In recent years, significant efforts have been made to better understand the genetic relationship between deeper porphyry and shallower epithermal ore-forming systems [1,2,3]. Advanced argillic alteration is frequently associated with high-sulfidation epithermal systems and is typically absent in porphyry copper systems from the southwestern US. However, Red Mountain (AZ) has experienced relatively little erosion, leading to the occurrence of a well-preserved transition between a deep porphyry and a shallow high-sulfidation epithermal system. Hypogene mineralization at Red Mountain occurs as chalcopyrite-bornite ore at depth and transitions gradually to shallow chalcocite-enargite mineralization.

Early fluids in the deep part of the system are represented by chalcopyrite-bearing fluid inclusions that typically homogenize to liquid at 350-380 °C and have salinities of 2-5 equivalent wt% NaCl. For this range of salinity and Th the slope of the isochore is about 6 bar/°C so that the trapping temperature may be significantly greater than Th depending on the pressure of entrapment.

Later fluids in the deep part of the system are represented by halite+chalcopyrite-bearing fluid inclusions with consistent Th but variable halite dissolution temperatures of 350-420 °C within fluid inclusion assamblages. The consistent Th and variable Tm indicates that, unless necking down occurred after halite precipitation and before bubble nucleation, the fluid entrapped by this inclusions was halite saturated and therefore provides a constraint on the pressure and temperature of entrapment. The halite-bearing fluid inclusions are in secondary trails with chalcopyrite blebs. Therefore, these inclusions represent the mineralizing fluid and the trapping conditions represent the mineralization conditions.

Towards the surface and the high sulfidation epithermal system, the fluid inclusions are generally less saline and evidence of boiling is more frequent. Fluid inclusions spatially related to enargite-chalcocite mineralization have homogenization temperatures above 480 °C.

[1] Hedenquist, Arribas & Reynolds (1998) *Economic Geology* **93**, 373-404 [2] Pudack et al. (2009) *Economic geology* **104**, 449-477 [3] Muntean & Einaudi (2001) *Economic geology* **96**, 743-772

How to recognize and use primary cherts for studying Archean seawater?

Morgane Ledevin[1*], Nicholas Arndt[2] and Alexandre Simionovici[3]

[1*]ISTerre, OSUG, Grenoble, France, morgane.ledevin@ujf-grenoble.fr (* presenting author)
[2] ISTerre, OSUG, Grenoble, France, nicholas.arndt@ujf-grenoble.fr
[3] ISTerre, OSUG, Grenoble, France, Alexandre.Simionovici@ujf-grenoble.fr

Archean cherts are a powerful tool for studying physico-chemical conditions at the seafloor during the early history of the Earth. Numerous studies use geochemistry to infer the characteristics of Archean seawater (e.g. temperature, salinity, composition), but surprisingly few use rigorous petrological and field observations which are critical to understand the origin of analyzed cherts, their environmental context of emplacement, and their diagenetic history.

We sampled four sites in the Archean (3.5 – 3.2 Ga) Barberton Greenstone Belt in South Africa and identified three types of chert. Primary cherts are directly precipitated on the seafloor, secondary cherts come from the silicification of any kind of protolith, and fracture-filling cherts are precipitated from fluids circulating through the crust. Using field and petrological observations, we define reliable criteria to identify primary cherts, which are most likely to represent Archean seawater geochemistry.

Our field observations focus on the depositional environment and particularly on evidence of direct deposition on the seafloor. Several criteria are defined: (1) First, primary cherts are homogeneous and translucent, concordant with surrounding sedimentary rocks and they lack well-developed internal sedimentary structures (i.e. layering). (2) They contain recurrent undulating surfaces with troughs filled by the overlying sediment (i.e. load casts). (3) The presence of microbial mats on bedding surfaces indicates shallow-water deposition. (4) Slab conglomerates are interpreted as tempestites composed of angular fragments of reworked chert representing material that was precipitated and indurated on the sea floor.

When those criteria are absent, we use petrological observations to distinguish primary and secondary cherts. We show that primary cherts are exclusively made of microcrystalline quartz (<200μm in size), with little porosity (<1%) and without any internal sedimentary-like structures (i.e. layering). This homogeneity is inherited from early chert deposition as a colloidal silica phase. Cathodoluminescence and X-ray microfluorescence mapping confirm the homogeneity of primary chert which are composed also entirely of silica and contain extremely low concentrations of other elements. The very good preservation of Barberton samples is shown by an absence of major recrystallization and lack of metamorphic and/or alteration minerals.

Finally, we tested the validity of geochemical criteria to identify the primary oceanic signature in cherts. We show that such proxies are extremely dependent on the environmental context of deposition, and that no conclusions can be made without careful field and petrologic studies.