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THE PORPHYRY TO EPITHERMAL TRANSITION IN A MAGMATIC-HYDROTHERMAL SYSTEM: VALEA MORII COPPER-GOLD DEPOSIT, APUSENI MTS, ROMANIA

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ABSTRACT

Porphyry Cu-Au mineralisation with associated potassic and phyllic alteration and low-sulphidation epithermal quartz-sulphide-gold-carbonate veins, are telescoped within a vertical interval of >400 m in the Valea Morii deposit, Romania. The deposit is located in the eastern part of the Barza magmatic structure – the richest gold-bearing magmatic-hydrothermal system of the South Apuseni Mountains Miocene metallogenic district. It consists of a steeply dipping intrusion of quartz diorite crosscut by a younger quartz microdiorite subvolcanic body. The field observations and time relationships between the porphyry and epithermal styles of mineralisation and host rocks in both intrusions give evidence for successive development of alternating porphyry-style veining and igneous breccias, followed by several porphyry and epithermal stage hydrothermal breccias. Detailed petrographic study allowed reconstruction of the complex scenario of magmatic and hydrothermal events. EMP and LA-ICPMS analyses of magmatic and hydrothermal minerals, isotopic magmatic geochemistry and tracing, and microthermometric together with LA-ICPMS analyses of fluid and melt inclusions, are currently in progress in order to constrain the chemical, spatial and temporal evolution of the magmatic-hydrothermal system in Valea Morii and to trace the porphyry to epithermal transition

***Keywords*:** porphyry copper, epithermal, gold, fluid and melt inclusions, LA-ICPMS, Valea Morii, Apuseni

INTRODUCTION

Numerous examples of spatially associated porphyry-type and epithermal ore deposits exist (e.g., Hedenquist et al. 1998, Müller et al. 2002). Such a spatial association is ubiquitous in the southern part of the famous Apuseni Mountains Neogene ore district in Romania, also known as "Gold Quadrangle" (Ghitulescu & Socolescu 1941; Udubasa et al. 2001). At the Valea Morii Cu-Au deposit, the porphyry mineralisation is associated with potassic and phyllic alteration and low-sulphidation epithermal quartz-sulphide-gold-carbonate veins. They are telescoped within a vertical interval of >400 m provide an excellent opportunity to study the genetic connection between these two mineralisation styles in the context of the evolution of the magmatic-hydrothermal system of Barza structure.

Detailed fieldwork and petrographic study form the basis to reconstruct the chemical, spatial and temporal evolution of the system using different analytical techniques such as EMP and LA-ICPMS analyses, microthermometry, isotopic magmatic geochemistry and tracing.

REGIONAL SETTING

The Gold Quadrangle is historically the most productive gold district in Europe mined and explored since Roman times. The South Apuseni Mountains district, which represents an internal part of the Carpatho-Pannonian Cenozoic calc-alkaline belt, is also one of the Europe's most important porphyry Cu-Au provinces. The district covers an area of about 900 km^2 and includes numerous porphyry-type Au-rich (e.g. Rosia Poeni, in the northern part; Deva – in the southern part, Bostinescu 1984; Ivascanu et al. 2003) and low- to intermediate sulphidation epithermal Au deposits (Udubasa et al. 2001). Mineralisation is associated with calc-alkaline Neogene igneous rocks that were intruded through pre-Mesozoic low-grade metamorphics, Mesozoic volcanics and sediments, and Neogene sedimentary rocks (Ianovici et al. 1976). The Neogene magmatic activity and related hydrothermal mineralisations are controlled by strike-slip fault system forming pull-apart basins (Rosu et al. 2000; Drew & Berger 2001).

GEOLOGY OF THE VALEA MORII DEPOSIT

The Valea Morii deposit (0,26 % Cu and 0,49 g/t Au; André-Mayer et al. 2001) is located in the eastern part of the Barza magmatic structure (ca. lat 46°05' N and long 22°51' E) that takes up the northwestern sector of the Brad-Sacaramb Neogene basin (Ghitulescu et al. 1970). The local geology is characterised by the presence of Mesozoic basalts, Miocene sedimentary and volcano-sedimentary rocks (Badenian) and andesitic volcanics with Sarmatian-Panonian age (Nedelcu et al. 2001). The Neogene volcanics consist mainly of lava flows and pyroclastics of Barza type andesites (Borcos et al. 1977).

The deposit itself is associated with a steeply dipping shallow intrusion of quartz diorite crosscut by a younger quartz microdiorite subvolcanic body (Fig. 1). Both intrusive bodies are younger than the first effusive to subvolcanic quartz andesite, according to the terminology of Borcos et al. (1977).

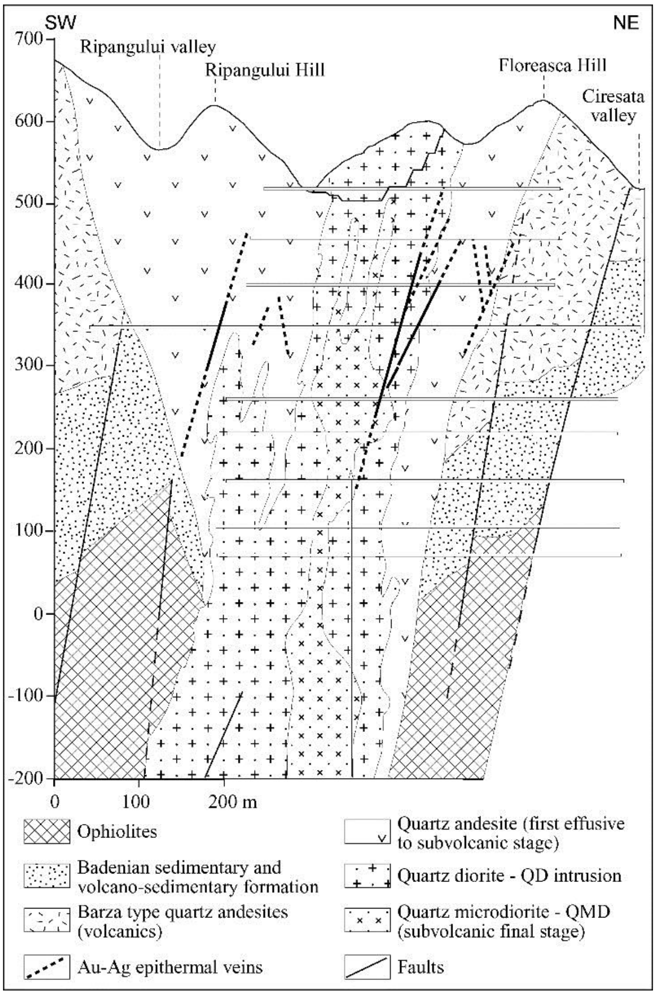

Figure 1. Geological cross section through the Valea Morii deposit showing both the underground levels and the open pit; open pit outline as of 2002 (modified from Borcos et al. 1977).

The early quartz diorite (QD) porphyry has a medium- to coarse-grained, equigranular to strongly porphyritic texture and is composed of plagioclase, amphibole up to 1 cm in size, and minor quartz in the matrix (Fig. 2a). The quartz microdiorite (QMD) porphyry has an equigranular fine-grained texture. On the lowermost level (+505) of the open pit we observed irregular bodies of igneous breccia with a strongly magnetite-K feldspar altered QMD matrix and clasts of QD, affected by propylitic alteration and porphyry style mineralisation (Figs. 2b, c). The intrusive contact between the two porphyries also crosscut previously formed porphyry-type veins within the QD intrusion (Fig. 2a). These facts allow discrimination of magmatic breccia event affecting the early quartz diorite porphyry and separating two porphyry-style veining events.

MINERALISATION STYLES

The porphyry stage mineralisation forms a network of ~1 cm to <1mm veins and veinlets and impregnations in the rock. Five generations of porphyry style veins have been recognised: (1) Qtz-Mt-Cp-Ep veins associated with propylitic alteration (defined as first porphyry stage and corresponding to the porphyry mineralisation affecting the QD before the emplacement of QMD), (2) Mt-Qtz veins with week K-silicate alteration, (3) barren Qtz veins with propylitic alteration, (4) Qtz-Mt-Cp-Py veins with propyllitisation and chloritisation, and (5) Qtz-Py veins with sericitic alteration halo (Fig. 3). Porphyry stage hydrothermal breccia (Fig. 2d) was formed on the transition between the barren Qtz stage and the Qtz-Mt-Cp-Py stage.

Two epithermal stage hydrothermal breccias (up to 15 m in diameter), crosscutting the mineralised QD porphyry (Fig. 2e) have been mapped. Epithermal veins have sericitic ± adularia to argillic alteration halo (Fig. 2f). Field and petrographic observations define five stages of epithermal veining, as summarised on Figure 3. The presence of sulphate minerals (barite and anhydrite) indicates the relatively oxidised character of some fluid stages during the epithermal mineralisation.

PRELIMINARY LFUID INCLUSION STUDY

Microthermometric results combined with Raman microspectrometric analyses of fluid inclusions from the Valea Morii deposit were reported by André-Mayer et al. (2001).

We performed some preliminary fluid inclusion microthermometric measurements as a basis for the LA-ICPMS analyses of the fluids, associated with the porphyry and the epithermal stages of mineralisation in Valea Morii. Two types of fluid inclusions have been observed in the porphyry style veins - low density vapour coexisting with high-salinity (48 to 61 wt

% eq. NaCl) polyphase brine inclusions. Brine inclusions show final homogenisation temperatures up to 512 °C.

In epithermal veins we recognised four types of primary fluid inclusions: low- and high-density vapour inclusions, liquid-rich two-phase inclusions, liquid-rich sericite-bearing inclusions and halite-saturated (NaCl-L-V±sulphate minerals) inclusions. High-density vapour inclusions and liquid-rich two-phase and sericite-bearing inclusions have low salinities (< 2 wt % eq. NaCl). Homogenisation temperatures for liquid-rich inclusions are of the order of 245-276 °C. Halite-saturated inclusions show salinities between 27 and 30 wt % eq. NaCl, and homogenisation temperatures in the range 180-231 °C.

Limited measurements on primary liquid-rich and vapour-rich inclusions coexisting along growth zones in quartz give similar homogenisation temperatures, suggesting trapping in boiling conditions. Sericite, which is observed in some liquid-rich inclusions, is not a daughter crystal, but results from accidental heterogeneous trapping.

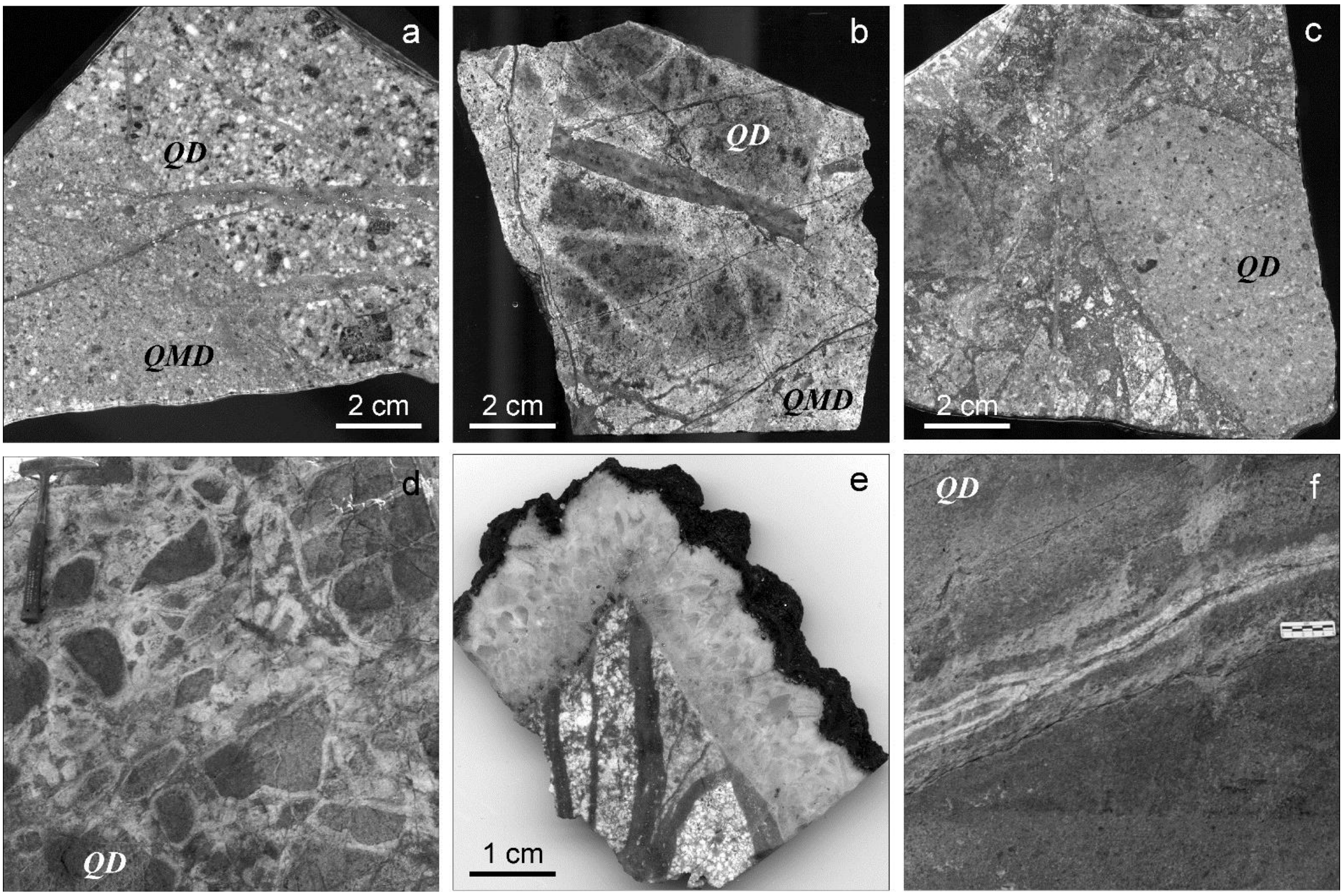

Figure 2. Macroscopic features of the host rocks, main breccia types and porphyry and epithermal veining in the Valea Morii deposit: **a**) Intrusive contact between the quartz diorite (QD) and the subvolcanic quartz microdiorite (QMD). Note the porphyry veins crosscutting QD and stopping at the intrusive contact, as well as the thin porphyry veinlet crosscutting both intrusions; **b**) Clast of QD crosscut by quartz-chalcopyrite-epidote porphyry vein in a matrix of QMD; **c**) Magmatic breccia. Clasts of QD in a matrix of QMD, affected by intense K-feldspar-magnetite-quartz alteration; **d**) Porphyry stage (quartz ± magnetite-chalcopyrite-pyrite) hydrothermal breccia; **e**) Epithermal stage hydrothermal breccia - quartz-pyrite-secondary Mn oxides epithermal vein crosscutting the porphyry style mineralised QD intrusion; **f**) Quartz-chalcopyrite-carbonate epithermal vein with a halo of sericitic alteration.

CONLUSIONS AND PERSPECTIVES

Excellent exposure relationships at the Miocene Valea Morii Cu-Au deposit, South Apuseni Mountains district, Romania, provides good opportunity to study the transition between porphyry and epithermal stages of the development of a complex magmatic-hydrothermal system.

Based on detailed fieldwork, petrographic observations and the reconstruction of successive magmatic and hydrothermal events, LA-ICPMS analyses of individual fluid inclusions from the porphyry and the epithermal parts of the system are in progress. They will be combined with EMP and LA-ICP analyses of melt inclusions, magmatic phenocrysts and hydrothermal minerals, radiogenic isotope tracing, as well as high-precision (U-Pb and Ar-Ar) dating of the different magmatic and hydrothermal events in order to obtain a complete picture of the chemical, spatial and temporal evolution of the system. The petrochemical and melt inclusion study will be of primary interest in understanding the magmatic factors, controlling the mineralisation in a magmatic complex as Barza, where the mineralised central part of the structure is surrounded by coeval barren intrusions (Grancea et al. 2001).

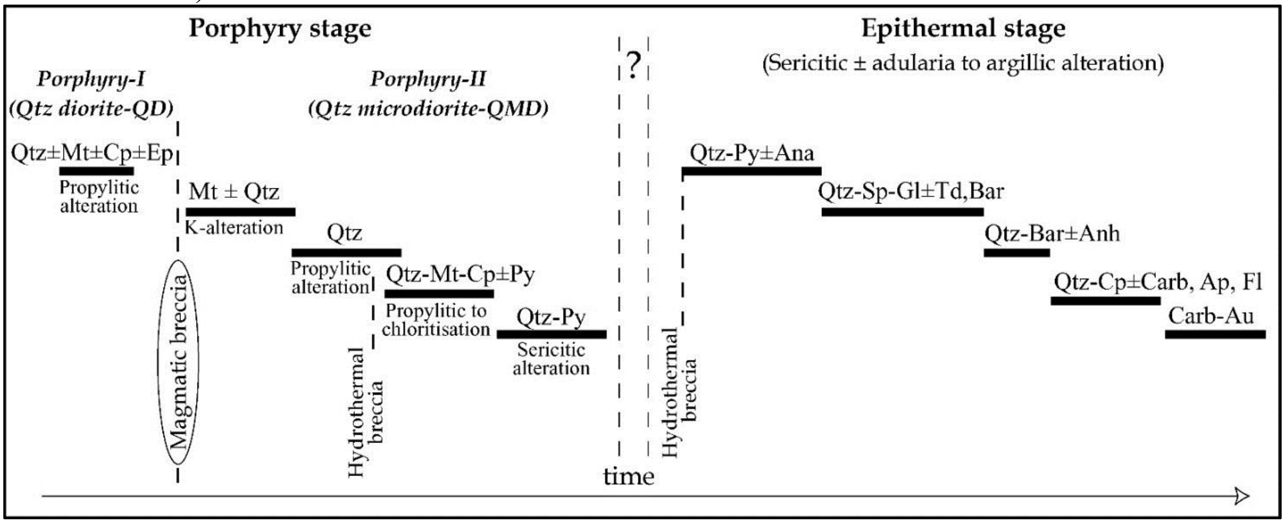

Figure 3. Time relationship between main porphyry and epithermal ore stages, hydrothermal veining and alterations in the Valea Morii deposit. Abbreviations: Qtz = quartz, Mt = magnetite, Cp = chalcopyrite, Ep = epidote, Py = pyrite, Ana = anatase, Sp = sphalerite, Gl = galena, Td = tetrahedrite, Bar = barite, Anh = anhydrite, Carb = carbonates, Ap = apatite, Fl = fluorite, Au = gold.

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