Diversity of epithermal gold ore formation events in southeastern Europe: a record of a protracted 60 m.y.-long geodynamic and metallogenic evolution of the Tethyan arc

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The Bulgarian Late Cretaceous Srednogorie belt and the adjoining Tertiary Rhodope massif to the south record a sequence of tectonic, magmatic and metallogenic events during a protracted, ~60 m.y. long geological evolution. A diversity of epithermal gold deposits is associated with this geological environment, which reflects changing regional tectonic and magmatic conditions over time of this segment of the Tethyan metallogenic belt, in combination with local variations of structural and lithological controls, and variable evolutionary trends of the ore-forming fluids.

The Late Cretaceous Srednogorie belt is an Andean-style, calk-alkaline magmatic arc, with dominantly andesitic-dacitic rocks, where the Panagyurishte district is the main Cu and Au producing center, with spatially associated porphyry-Cu and high-sulfidation Cu-Au epithermal deposits. Ore formation was located along belt-parallel pull-apart basins, and occurred during changes in principal stress axe orientations. Many studies were focused on the world-class high-sulfidation epithermal Chelopech deposit, which is located in the northern, more fertile part of the Panagyurishte district. These studies reveal both structural and lithological controls during or formation. Combined isotope data (O-H-S-Sr-Pb) indicate a magmatic origin for the epithermal deposits, which are roughly coeval with spatially associated porphyry-Cu deposits. Fluid inclusion salinities are mostly below 5 wt% NaCl throughout the paragenetic evolution for all epithermal deposits from the Panagyurishte district, including enargite from the main ore forming stage, and are compatible with a vapor-transport model of Au and Cu. Post-ore basin sedimentation and tectonics, and different erosion levels explain variable preservation states of the Late Cretaceous ore deposits. Preliminary fluid inclusion studies at the Breznik prospect, Western Srednogorie, suggest that local drastic changes of pressure conditions (due to volcanic collapse structures?) may locally explain porphyry-epithermal transitions, and the juxtaposition of apparently different styles of ore forming conditions (high- vs low-sulfidation fluid states).

With progressive plate convergence and collision, the ore forming activity moved southward into the Rhodope massif. Renewed, major gold deposition took place during Late Eocene-Oligocene extension of the Rhodope massif, and was related to metamorphic core complex exhumation. New and published $^{40}Ar/^{39}Ar$ age data (Stremtsi, Ada Tepe, Rosino pospects) reveal that sedimentary rock-hosted, low-sulfidation epithermal deposits were formed between 37.5 and 35 Ma, and pre-date local magmatism. Textural, fluid inclusion and isotope data indicate that gold deposition was related to different processes, including boiling, fluid mixing and/or fluid-rock interaction. The dominant sulfur isotopic composition of sulfides, between –6 and +4 ‰ in all prospects, reveals a similar ore fluid in the different localities. Based on oxygen isotope data, the fluids were dominated by meteoric water, partly reequilibrated with metamorphic and magmatic basement rocks. The origin of the dilute ore-forming fluids, with salinities mostly below 2.2 wt%, and rarely as high as 5 wt%, is still open to question. The sedimentary-rock hosted gold event, was followed at 32-29 Ma by the formation of magmatic-associated Pb-Zn±Cu deposits with subsidiary Ag and/or Au in the Bulgarian part of the Rhodopes (e.g. Madan and Madjarovo districts), and by porphyry and epithermal Cu-Au occurrences in the Greek Eastern Rhodopes, with transitional high- to intermediate sulfidation states of the epithermal fluids based on previous studies.