A review of age constraints of epithermal precious and base metal deposits of the Tertiary Eastern Rhodopes: coincidence with late Eocene-early Oligocene tectonic plate reorganization along the Tethys

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The Tertiary Eastern Rhodopes are a major ore province within the Tethyan metallogenic belt. $^{40}Ar/^{39}Ar$ age data obtained in the past ten years are overviewed and discussed. It allows us to address some of the open questions and shed some new light on the sequence of ore-forming, magmatic and tectonic processes throughout the Eastern Rhodopes. Small to moderately sized ore deposits and prospects in the Rhodope Massif are hosted by high-grade metamorphic, continental sedimentary and igneous rocks. Sedimentary rock-hosted gold epithermal prospects are the earliest hydrothermal systems, hosted by Maastrichtian-Paleocene clastic rocks. Their $^{40}Ar/^{39}Ar$ ages vary between 37.55 ± 0.44 Ma and 34.71 ± 0.16 Ma, with the waning hydrothermal activity overlapping with the start of the oldest volcanism in the Eastern Rhodopes yielding $^{40}Ar/^{39}Ar$ ages ranging between 34.62 ± 0.46 Ma and 32.97 ± 0.23 Ma. Within a very short time between 32.13 ± 0.20 and 31.2 ± 0.4, Pb-Zn-dominated and Cu-Au-dominated epithermal prospects, respectively in the northern and the southern parts, were formed, and coincide with rhyolitic dikes emplaced at about 31.5 Ma. The Late Eocene-Early Oligocene post-orogenic magmatic and ore-forming evolution of the Eastern Rhodopes coincides with the time of collision at about 30-35 Ma of the African and Eurasian plates in the Caucasus and the Rif-Betic belts, when a dominantly subduction-dominated tectonic regime changed to a collision-dominated system, and the northward motion of the African plate slowed down, accompanied by an increasing southward slab retreat velocity in the Aegean Sea.

Remnant mineral assemblages in the garnet porphyroblasts from the Rebra Group micaschist used for establish metamorphic PT path (Rodna Mountains, East Carpathians)

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The Rebra Group terrane from the Rodna Mountains is part of the Rodna Variscan nappe which was remobilized during Alpine cycle (Austrian phase). Its rocks are polymetamorphic and polydeformed, which mainly consist of: micaschist and gneisses (with garnet, ± kyanite, ± fibrolite), marbles (± tremolite, ± fucshit, ± diopside), amfibolites (± garnet, ± epidot), pegmatites (± garnet, ± turmaline) and Nichitas granitoid. The rocks are S and L-S tectonits with 3 main foliations, the last (S3) being of crenulation type due to retrogression and S1 was transposed after S2 by isoclinal folding. The penetrative lineations are trending NW-SE. The metamorphic peak was attained under amphibolite facies (medium pressure), and corresponds to the staurolite – almandine and kyanite – almandine – muscovite subfacies, retrogressive mineral assemblages are indicative of greenschist facies, particularly of quartz – albite – biotite – muscovite – chlorite, and locally, quartz – albite – epidote – almandine subfacies conditions. To understand the complex PT path of this group, we used the petrographic microscopy combined with microprobe analyses of some mineral pairs and geothermobarometrical calculations. The data presented in this paper set new petrological constraints for the interpretation of the tectono-metamorphic history of the Rebra Group. The garnets of the Rebra Group rocks display a large dimensional variation (submillimetric to centimetric sizes) and they have a prevalently almandinic composition. The garnets from Rebra Group could grow in three main phases. The first generation garnets grow prekinematical (68-77% almandine, 10-20% grossular) in relation to the penetrative S2, enclosing relic isoclinal fold-marking trails of quartz and ilmenite grains, followed by syn-kinematic second generation garnets(55-75% almandine, 15-25% grossular), which overgrew, partly simultaneously with Fe-Mg chloritoid, epidote core and tourmaline grains. More or less before the garnet overgrowth, could been active a boron and sodium rich solution transport with dravit- schorl series tourmaline grains genesis. The garnet 3 blasthesis was postkinematic in relation to S2 and was observed on corroded rims of earlier ones.The centrimetric sized garnet porphyroblast from micaschists may preserve some remnant minerals from the prograde phase and peak conditions, which are missing in the rock matrix. Such minerals are: chloritoid, REE- rich epidote, Cr-spinel.

Using garnet – biotite geothermometry for Rebra Group rocks temperatures of 425 – 550 °C were calculated. Calcite – dolomite solvus geothermometry indicated 350–430 °C (retrogressive conditions), while amphibole – garnet geothermometry and phengite geobarometry for the Rebra Group amphibolite yielded temperatures between 550 and 630°C (peak conditions). Using Ca-amphibole – plagioclase geothermometry for the same samples 550 °C and 7 ± 1 kbar were calculated. The garnet porphyroblast of metapelites are the most indicative for PT path evolution and their matrix minerals (fengit, ilmenite, albitised oligoclase, zoned epidote group minerals with La, Cr, Y, chlorite, and apatite), because may contains beside the quartz inclusion trails, some other minerals such as: ilmenite, ilmenite-magnetite intergrowth, Cr spinel, apatite, tourmaline (dravit- schorl series), fengite, epidote group minerals and chloritoid (the first record of it in this metamorphic group garnets). Geothermobarometric calculations using microprobe data on centimetric sized garnets and its inclusions from Valea Blazna Gallery micaschists samples evidenced: by garnet- ilmenite geothermometry 678 ± 30 ºC and phengite geobarometry 7 kbar for the metamorphic peak conditions; the garnet-tourmaline, tourmaline-muscovite thermometry evidenced a prograde phase temperature of 450 ºC and a minimum pressure of 4Kb (phengite geobarometry). The garnet rim-ilmenite (matrix) pair outlined 498 ± 30 ºC, and plagioclase- muscovite pair data 422 ºC and 3.5 kbar pressure for retrogression conditions.

High-precision P-T estimates for retrogressed kyanite eclogites from Thermes, central Rhodope (Greece)

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The Rhodope massif in northern Greece and southern Bulgaria constitutes the hinterland of the Hellenide orogen. It exposes low- and high-grade metamorphic rocks and their sedimentary cover. Kyanite eclogites from Thermes-Rhodope (northern Greece) belonging to the structurally upper unit were studied in order to constrain their metamorphic conditions. The kyanite eclogites are boudins enclosed in quartzofelspathic gneisses. They experienced a polyphase metamorphic history involving equilibration at granulite-, amphibolite- and greenschist-facies conditions successively. Textural relations reveal the successive equilibrium mineral assemblages and provide constraints that very local, domainal equilibria were attained during metamorphic evolution. Omphacite formed symplectites of