Timing of polymetallic Pb-Zn mineralisation in the Laki district, southern Bulgaria – constraints from $^{40}Ar/^{39}Ar$ dates

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Abstract

The Central Rhodopean Dome (CRD), in southern Bulgaria and northern Greece, is composed of high-T, low-P gneisses and marbles which were exhumed along detachment faults during post-collisional extension, resulting in widespread magmatisation and local anatexis. Peak metamorphic temperatures are recorded at 35.9 ± 0.2 Ma (Ovtcharova et al. 2003), whereas cooling below ~300 ºC occurred between 36 and 34 Ma (Kaiser-Rohrmeier et al. 2013). Regional acid magmatism (~33-30 Ma; Ovtcharova et al. 2001), occurring throughout the CRD as dykes and sub-volcanic bodies, cross-cuts detachment faults and sedimentary basins, and is commonly spatially associated with polymetallic Pb-Zn veins and metasomatic replacement bodies.

The CRD hosts six Oligocene Pb-Zn mining districts: Laki, Davidkovo, Ardino, Enyovche, Madan and Thermes (from north to south), all of which display similar mineralisation styles (polymetallic veins and metasomatic replacement bodies) and are all located proximal to the Middle Rhodopean detachment fault. Despite these similarities, previous studies, based on ^{40}Ar-^{39}Ar dating of sericite indicate a significant age difference between the Laki (~29.5 Ma) and the Madan (~30-30.5 Ma) districts, which suggests an overall younging of mineralisation towards the north (Kaiser-Rohrmeier et al. 2004).

This study applies high-precision $^{40}Ar/^{39}Ar$ thermochronology to hydrothermal and metamorphic K-feldspar from the Laki mining district. In order to better constrain the timing of mineralisation, K-feldspar separates were dated from vein selvages and a mineralised polymictic volcanic breccia containing intergrown hydrothermal K-feldspar and sulfides. Hydrothermal K-feldspar from non-mineralised sub-volcanic bodies were also dated to establish the extent of the hydrothermal activity in the Laki district, while metamorphic K-feldspar from gneiss spatially unrelated to mineralisation was dated to constrain the upper age limit of metamorphic K-feldspar in the vein selvages.

Our data obtained from hydrothermal and metamorphic K-feldspar reveal three stages: (1) ~33.5-33 Ma, pre-mineralisation metamorphic K-feldspar; (2) ~32-30 Ma, K-feldspar from vein selvages and mineralised polymictic breccia; and (3) ~29.5-27 Ma, post-mineralisation hydrothermal K-feldspar from non-mineralised sub-volcanic bodies. $^{40}Ar/^{39}Ar$ dates from stage (1) closely match U-Pb zircon dates from sub-volcanic bodies in the Laki district, which form part of the Borovitsa volcanic zone (~33 Ma; Ovtcharova et al. 2001), and therefore can be interpreted as being thermally reset by magmatism. The range of $^{40}Ar/^{39}Ar$ dates displayed during stage (2) is indicative of partial to complete resetting of metamorphic K-feldspar by the hydrothermal, mineralising fluid. Consistent minimum dates of ~30 Ma from the vein selvages and corresponding hydrothermal K-feldspar dates obtained from a mineralised polymictic breccia from the Chetroka mine, as well as fluid temperatures of 300-350 °C recorded during the main stage of mineralisation in the Djurkovo mine, suggest that mineralisation in the Laki district ceased at ~30 Ma, and was coeval with hydrothermal activity in the Madan district to the south. Post-mineralisation hydrothermal fluid circulation (at temperatures <200 °C) during stage (3) resulted in the precipitation of hydrothermal K-feldspar within the previously altered sub-volcanic bodies from 29.5-27 Ma, possibly corresponding to previously published $^{40}Ar/^{39}Ar$ sericite dates from the Laki district.

References

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