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Space and Time Evolution of Ore Deposits in the Eastern Mediterranean Region During the Last 100 Myrs: A Matter of Subduction Dynamics

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Active subduction zones generate major economic interest in terms of mineral resources, mainly with copper and gold deposits, but also lead and zinc concentrations. While many studies emphasize ore-forming mechanisms, the control of large-scale geodynamic processes on such metal deposition remains poorly understood, especially considering fast-evolving three-dimensional (3D) subduction zones. Identifying subduction-related mantle and crustal processes which control ore genesis is, however, fundamental for large-scale prospection. In this work, we study the effects of changing subduction dynamics on the typology and distribution of ore deposits since the Late Cretaceous in the eastern Mediterranean region, which is part of the western Tethyan margin.

Starting with a new kinematic reconstruction model of the region, we superimposed the distribution of magmatic products and mineralization in space and time. Two metallogenic periods are thus revealed: (1) In the Late Cretaceous-early Paleocene, Cu-rich deposits associated with calc-alkaline magmatism emplaced along the Balkans and the Pontides. The active margin was then similar to the present-day Andean Cordillera with the Tethyan oceanic lithosphere subducting along a long and linear trench. (2) In the Oligocene-Miocene, Pb-Zn–rich deposits, then Au-rich deposits and related K-rich magmatism, emplaced in the Rhodopes, Aegean, and western Anatolian extensional domains, in response to fast slab retreat and hot asthenosphere upwelling. In this back-arc basin, rising of the isotherms induced (1) metamorphism and partial melting of continental crust, mobilizing metals with crustal affinity (Pb and Zn), and (2) partial melting of metasomatized lithospheric mantle where Au was previously stored. The emplacement at shallow levels of this mineralization was then largely controlled by crustal-scale structures that drained fluids, such as in the Cyclades (Aegean domain), where field studies show that Au-rich deposits are synextensional and spatially related to detachment systems. Besides a general southward migration of this magmatic-hydrothermal activity since the Late Cretaceous, a secondary westward migration is observed during the Miocene from the Menderes massif (western Anatolian domain) to the Cyclades. We propose that this secondary migration is related to the slab-tearing event below western Anatolia. We tested the effects of slab roll-back and tearing on the flow and temperature field within the mantle, by means of 3D high-resolution thermomechanical numerical models. Results suggest that the asthenospheric flow induced by the retreat of a torn slab affects the distribution of potentially fertile magmas in the upper crust. Our results clearly show that slab retreat and tearing and related asthenospheric flow are responsible for the evolving distribution

and typology of ore resources in the eastern Mediterranean region. A good comprehension of the 3D large-scale geodynamics may thus provide interesting regional guidelines for mineral prospection.