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Timing of Uralian orogenic gold mineralization at Kochkar in the evolution of the East Uralian granite-gneiss terrane

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Abstract Gold mineralization at Kochkar (Urals, Russia) is hosted mainly by quartz lodes, which developed at lithological contacts between mafic dikes and granitoids of the Plast massif during late Carboniferous to early Permian, regional E–W compression in the East Uralian Zone (EUZ). The alteration mineralogy in mafic dikes comprises biotite, actinolite, albite, K-feldspar, quartz, epidote, tourmaline, sericite, pyrite, arsenopyrite, chalcopyrite, sphalerite, fahlores, galena, bismuthinite, and gold, and in Plast granitoids quartz, sericite, calcite, epidote, and ore minerals. Geochemically, an enrichment of Si, K, Rb, Ba, S, base metals, W, and Au can be observed. The ore fluid had $\delta^{18}\text{O}$ values between 8.2‰ and 9.5‰ typical for metamorphic or deep magmatic fluids. The tectonometamorphic evolution of the EUZ is marked by peak metamorphic conditions at $635 \pm 40^\circ\text{C}$ and 5–6 kbar through $500 \pm 20^\circ\text{C}$ during gold mineralization, and $300\text{--}350^\circ\text{C}$ and 2–3 kbar. The last event was dated on a late, barren quartz vein formed during

greenschist facies metamorphism at 265 ± 3 Ma by the Rb–Sr method. Fluids related to this overprint had a $\delta^{18}\text{O}$ value of 5.2‰ and an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.70685 indicating that they are largely equilibrated with metamorphic lithologies of the EUZ. The Plast granitoids and the adjacent Borisov granite, which was dated at 358 ± 23 Ma (U–Pb zircon age), have an adakitic character. This, together with the arc-signature of the mafic dikes, supports the setting of the EUZ within the Valerianovsky continental arc. Eastward subduction of the Uralian Ocean below this arc began during the late Devonian to early Carboniferous. Between 320 and 265 Ma, the oblique closure of the ocean resulted in doming of granitoid massifs in a sinistral transpressional regime, subsequent retrograde gold mineralization during E–W compression and a later greenschist facies overprint. This long-lasting retrograde evolution of the EUZ was caused by the lack of postcollisional collapse. Heat for a “deep-later” type of metamorphism and triggering the auriferous fluid system was supplied by radiogenic heating of an overthickened crust. The greenschist facies overprint at Kochkar and coeval crustal melting in the EUZ was additionally initiated by local external heating of the terrane. This could have been caused by syn- to postcollisional slab rollback or delamination resulting in magmatic underplating of the EUZ, which postdates orogenic gold mineralization at Kochkar. The tectonic interpretation of the EUZ indicates that gold mineralization at Kochkar formed in a mid-crustal environment of a continental magmatic arc at the cessation of active subduction predating post orogenic plutonism.

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Introduction

Historical gold mining in the late-Paleozoic Uralides started 250 years ago with about 400 t gold produced to