The Onset of the Crustal Gold Cycle

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Summary

Comparison of conglomerate-hosted, Witwatersrand-type gold deposits/occurrences worldwide reveals that this deposit type is by no means unique to the Kaapvaal Craton but common to most Archean/Paleoproterozoic cratons. The age of the variably mineralized fluvial to fluvio-deltaic conglomerates ranges from 3.1 to 1.9 Ga. They were deposited in tectonic settings ranging from continental rifts to passive margins and syn-orogenic foreland basins, and all of them are paleoplacers. Although several of them show evidence of local mobilization of ore components by post-depositional hydrothermal fluids, purely epigenetic hydrothermal models fail to explain the geometry of the ore bodies as well as available lithogeochemical, mineral chemical, and isotope data. Conglomerates older than 2.4 Ga are characterized by an abundance of detrital (and secondary) pyrite, and in most cases also detrital uraninite, whereas most of the younger examples (<2.2 Ga) contain Fe-oxides instead. A common denominator of Witwatersrand-type deposits is the stratigraphic position above erosional unconformities adjacent to an Archean to Paleoproterozoic hinterland. The Witwatersrand deposits themselves differ from all other examples of this type by a gold endowment that is two to three orders of magnitude greater, an abundance of gold-rich “carbon” seams that reflect former microbial mats, a scarcity of gold nuggets, and orders of magnitude higher Os contents in the gold.

For the Witwatersrand gold, a genetic model is proposed that involves the following requirements: (i) an anomalous mantle domain as the ultimate source, strongly enriched in siderophile elements, caused by inhomogeneous mixing with cosmic material that was added during intense meteorite bombardment of the Hadean to Paleoarchean Earth, plume-like ascent of relics from inefficient core formation, or plumes from the core-mantle boundary; (ii) elevated gold extraction into juvenile crust when mantle temperature reached its maximum in the Mesoarchean; (iii) several orders of magnitude higher run-off of gold from the Mesoarchean land surface due to intense weathering under an aggressive, reducing atmosphere and high gold solubility in coeval river water; (iv) trapping of gold from river water on the surface of local photosynthesizing microbial (cyanobacterial) mats; and (v)reworking of these mats into erosion channels during flooding events (and by eolian deflation) and redeposition of gold as placer particles. Post-depositional hydrothermal/metamorphic overprints explain why much of the gold is now located in texturally late positions but had little significance on the macro-scale distribution of the gold. Elsewhere in the world, a less fertile hinterland and/or less reworking of older sediments led to correspondingly lower gold endowment. Most of the Archean sedimentary rocks were affected by crustal reworking in the course of later tectonic overprints. The multitude of fluids and melts involved in these reworking processes gave rise to the great variety of gold deposit types known in post-Archean crustal sections.

The probability of discovering a new supergiant cluster of Witwatersrand-type deposits is considered very low. However, considerable potential exists for finding new smaller economic deposits of this type in Mesoarchean to Palaoproterozoic fluvial to fluvio-deltaic basal conglomerates, deposited especially in foreland basins next to Mesoarchean hinterland and/or auriferous sediment successions that could be reworked.

Publications

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