American Mineralogist, Volume 97, pages 1013–1042, 2012

Mercury (Hg) mineral evolution: A mineralogical record of supercontinent assembly, changing ocean geochemistry, and the emerging terrestrial biosphere

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Abstract

Analyses of the temporal and geographic distribution of earliest recorded appearances of the 88 IMA-approved mercury minerals plus two potentially valid species exemplify principles of mineral evolution. Metacinnabar (HgS) and native Hg are the only two species reported from meteorites, specifically, the primitive H3 Tieschitz chondrite with an age of 4550 Ma. Since the first terrestrial appearance of cinnabar more than 3 billion years ago, mercury minerals have been present continuously at or near Earth's surface.

Mercury mineral evolution is characterized by episodic deposition and diversification, perhaps associated with the supercontinent cycle. We observe statistically significant increases in the number of reported Hg mineral localities and new Hg species at ~2.8–2.6, ~1.9–1.8, and ~0.43–0.25 Ga—intervals that correlate with episodes of presumed supercontinent assembly and associated orogenies of Kenorland (Superia), Columbia (Nuna), and Pangea, respectively. In constrast, few Hg deposits or new species of mercury minerals are reported from the intervals of supercontinent stability and breakup at ~2.5–1.9, ~1.8–1.2, and 1.1–0.8 Ga. The interval of Pangean supercontinent stability and breakup (~250–65 Ma) is also marked by a significant decline in reported mercury mineralization; however, rocks of the last 65 million years, during which Pangea has continued to diverge, is characterized by numerous ephemeral near-surface Hg deposits.

The period ~1.2–1.0 Ga, during the assembly of the Rodinian supercontinent, is an exception because of the absence of new Hg minerals or deposits from this period. Episodes of Hg mineralization reflect metamorphism of Hg-enriched marine black shales at zones of continental convergence. We suggest that Hg was effectively sequestered as insoluble nanoparticles of cinnabar (HgS) or tiemannite (HgSe) during the period of the sulfidic "intermediate ocean" (~1.85–0.85 Ga); consequently, few Hg deposits formed during the aggregation of Rodinia, whereas several deposits date from 800–600 Ma, a period that overlaps with the rifting and breakup of Rodinia.

Nearly all Hg mineral species (87 of 90 known), as well as all major economic Hg deposits, are known to occur in formations ≤400 million years old. This relatively recent diversification arises, in part, from the ephemeral nature of many Hg minerals. In addition, mercury mineralization is strongly enhanced by interactions with organic matter, so the relatively recent pulse of new Hg minerals may reflect the rise of a terrestrial biosphere at ~400 Ma.

Keywords: Ocean geochemistry, cinnabar, tiemannite, biosphere, supercontinent cycle, mercury (Hg) isotopes