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The Padaeng Supergene Nonsulfide Zinc Deposit, Mae Sod, Thailand

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Abstract

The Padaeng deposit near Mae Sod in western Thailand was the first supergene nonsulfide zinc deposit in the world to be developed as a large modern mining operation. The mine and associated zinc smelter, operated by Padaeng Industry Public Company Ltd. since 1984, went into production with reserves of 4.59 Mt at a grade of 28.9 percent zinc with a 10 percent zinc cutoff. Current resources are 5.14 Mt at a grade of 12.0 percent zinc with a 3 percent zinc cutoff.

The Padaeng deposit is hosted by a mixed carbonate-clastic sequence of Middle Jurassic age. The deposit occurs in the hanging wall of the Padaeng fault, a major northwest-trending structure that was active through Cretaceous and Tertiary tectonism and uplift. Nonsulfide zinc ore comprises dominant hemimorphite with minor smithsonite and hydrozincite. Strata-bound ore zones occur within a northwest-dipping, deeply weathered, dolomitic sandstone; steeply dipping and irregular karstic zones in underlying massive, silty dolomite are controlled by north-trending fracture zones.

Sulfide zinc-lead mineralization of Mississippi Valley type occured extensively in the vicinity of the Padaeng mine, most notably the small resources at Pha De and Hua Lon. Mineral deposits are typically sphalerite rich with minor galena and pyrite, forming small-scale open-space fillings, veins, and replacements within hydrothermal dolomite. Mineralization is dominantly strata bound within a horizon of intense hydrothermal dolomitization that forms the stratigraphic hanging wall to the nonsulfide ore zones at Padaeng. The only significant sulfide at the Padaeng mine is within this unit. Only trace sulfide occurs peripheral to, or down dip of, strata-bound or steeply dipping, nonsulfide orebodies.

Sulfide mineralization is believed to have accompanied Cretaceous uplift and deformation, related to the onset of oblique subduction beneath the western margin of the Shan-Thai terrane. The nonsulfide deposit is believed to have formed when a substantial body of sulfide ore was uplifted on the margin of the Mae Sod Tertiary intermontane basin, commencing in the middle to late Miocene. Zinc-bearing acidic supergene fluids, generated by oxidation of the precursor sulfide body, reacted with carbonate in the underlying stratigraphic section to precipitate hemimorphite and smithsonite. Fluids were channeled by permeable dolomitic sandstones and by steep fracture and fault zones. Acidic fluids promoted deep weathering and karst formation, allowing mineralization to extend down dip in sandstone units for at least 150 m and vertically for a similar distance in steep structural zones. Transport of zinc out of the precursor sulfide body was facilitated by a falling water table, owing to uplift of the Padaeng fault block and a change from wet tropical to monsoonal or semiarid climatic conditions. There is no evidence for significant in situ replacement of sulfide deposits, and the leached remnants of the precursor sulfide body have been removed by erosion.

The supergene process of dissolution and reprecipitation of zinc in the host rocks increased zinc grades and separation of zinc from lead, producing an economically attractive deposit. Successful exploration for this type of deposit requires a good understanding of the controls on primary sulfide mineralization and a good knowledge of local neotectonism, uplift history, hydrogeology, climatic evolution, and weathering history.

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