

Understanding Bismuth as Critical Mineral: From Source to Sink

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Bismuth has been identified as a critical metal in several countries due to its significant role in the transition to green energy and the economy. Despite its importance, the behavior of bismuth within the geological cycle remains poorly understood. This study offers a comprehensive review of bismuth, covering its origin, mineralogical characteristics, evolution within the Earth system, and enrichment during ore-forming processes. Bismuth is primarily concentrated in the continental crust and associated with felsic rocks, occurring in various mineral deposits. Currently, there are 240 recognized bismuth-containing mineral species, predominantly sulfides and sulfosalts. Besides sulfide ores, bismuth can be sourced from residual materials and industrial and mining waste. The primary method of bismuth production is pyrometallurgy, though efforts are being made to develop more environmentally friendly separation technologies. The complex mineralogy of bismuth presents significant challenges in its processing and refining. Bismuth has substantial potential in mineral exploration, as demonstrated by its historical and ongoing use as a pathfinder element for other commodities. A significant risk to bismuth supply is the concentration of 70% of global production in a single country. Despite bismuth enrichment being reported in various deposits worldwide, many exploration programs and resource calculations do not account for bismuth grades. Reporting bismuth grades for all known bismuth-bearing deposits could alleviate future supply risks. Recent technological advancements are important for extracting bismuth from secondary sources, meeting the criteria of being economically viable and scalable, with minimal environmental impact.