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Quantitative Relationships among Giant Deposits of Metals

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Abstract

Metallogenic studies that try to identify the geochemical fluxes of metals in the lithosphere leading to ore formation have a higher sensitivity when the traditional mining data, based on grades and tonnages, are normalized to crustal element abundances, and derivative units such as clarke of concentration and tonnage accumulation index are used. This technique has been applied to the world-class deposits of all industrial metals, i.e., to 34 metals plus the rare earth elements and platinoid groups. The lower magnitude limits for inclusion in the giant and supergiant categories (ore metal content in a deposit/metal clarke $>1X10^{11}$ metric tons (t) and 10^{12} t of average crustal material, respectively) have been established for each metal. There are, presently, 486 giant and 61 supergiant metal accumulations of the various metals in 446 deposits and districts. A single deposit and/or district, such as the Olympic Dam Cu-U-Au-REE-Fe deposit, could be the site of a giant accumulation of more than one metal. Cu with 103 giant accumulations followed by Au (99), Pb (55), Mo (41), Sb (24), and Sn (22) are the most superaccumulated metals, whereas 11 metals entirely lack giant deposits. Although this is partly influenced by economic factors, such as low demand and price, the main cause is the geochemical behavior of metals, especially the trace metals compatibilities at the various stages of crustal evolution.

Porphyry Cu-Mo deposits have the greatest number of giant accumulations among the popular ore deposit types (90), followed by sedimentary exhalative Zn-Pb-Ag (23), volcanogenic massive sulfides (22), stockwork Mo (17), epithermal Au-Ag veins (13), and Broken Hill-type Pb-Zn-Ag (12). In terms of origin, the greatest number of giant deposits is among the mesothermal Cu deposits (67), which reflect the porphyry Cu-Mo preeminence, followed by mesothermal Au (61), mesothermal Mo (39), mesothermal Sb (22), mesothermal Pb (19), and sediment-hosted Cu deposits at redox interfaces (19). As a class, the mesothermal epigenetic deposits account for 271 giant metal accumulations, which represents 52 percent of the entire database. Hydrothermal deposits including exhalative and epithermal deposits possess 333 giant representatives, or 63.5 percent. Other genetic families of ore deposits, including precipitates from less than 150°C hot hydrous fluids (59 giant deposits), orthomagmatic deposits (40), sedimentary deposits (39), and weathering-generated deposits (14), are less significant. An astonishing 446 giant metal accumulations (92.5%) thus relied on water as the principal agent of formation.

Of the giant deposits genetically associated with magmatism, the metaluminous granodiorite-quartz monzonite suite at subductive margins is related to most giant deposits (98, or 19%). Second in importance is the high potassium granite suite (23 giant deposits). Carbonatites, with only about 350 occurrences known worldwide, are the most striking rare magmatic hosts to giant deposits. Five carbonatites host giant or supergiant deposits and an additional 1 carbonatites host large deposits (i.e., tonnage accumulation index $> 1X10^{10}$ t), so there is a 4.5 percent chance that any newly discovered carbonatite will host a large or giant deposit. The major period of preserved giant deposit accumulation occurred during lower-middle Tertiary (103 giant deposits or 20% of the total), followed by middle-upper Tertiary (59 giant deposits), Jurassic (39 giant deposits), Carboniferous (37 giant deposits), and Paleoproterozoic (33 giant deposits). The predominantly young age of mineralization indicates that shallow crustal depths or subsiding subaqueous and subaerial depositories provide the most favorable milieu for superaccumulation of many metals but, on the other had, are vulnerable to removal by erosion.