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Triggers for the formation of porphyry deposits in magmatic arcs

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Porphyry ore deposits source much of the copper, molybdenum, gold and silver utilized by humankind. They typically form in magmatic arcs above subduction zones via a series of linked processes, beginning with magma generation in the mantle and ending with the precipitation of metals from hydrous fluids in the shallow crust. In this review, a hierarchy of four key "triggers" involved in the formation of porphyry deposits is outlined. Trigger 1 (100-1000 km scale) is a process of cyclic refertilization and enrichment of magmas in metals and volatiles in deep crustal sills trapped for long time periods in compressional tectonic settings. Trigger 2 (10 to 100 km scale) is the process of sulphide saturation in magmas that can both enhance and destroy ore-forming potential by stripping chalcophile metals from silicate melts, but also, in this way, pre-concentrating them. Trigger 3 (1-10 km scale) relates to the efficient transfer of metals into hydrothermal fluids exsolving from porphyry magmas, in particular the potential role of melt reduction in enhancing melt-volatile partitioning. Trigger 4 (1-5 km scale) identifies processes that are currently thought to be critical for the efficient precipitation of ore minerals in the deposit environment. Although all processes are required to a greater or lesser degree, it is argued that trigger 2, as an over-riding mechanism, can best explain the restriction of large porphyry deposits, highly enriched in chalcophile metals and sulphur, to specific arc segments and time periods. Consequently, recognition of the fingerprint of sulphide saturation in igneous rocks may help mineral exploration companies to identify parts of magmatic arcs particularly predisposed to porphyry ore formation.