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Metamorphic fluids and varieties of orogenic mineralisation

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In Archean and Phanerozoic metamorphic belts, dehydration of chlorite, and in some cases muscovite, produces large volumes of low salinity, moderately reduced, H_2S- and CO_2-bearing fluid. The orogenic gold deposits that form from these metamorphic fluids are typically low in base metals, likely because gold can be transported in low salinity fluids as hydrosulfide complexes, whereas base metals tend to be transported as chloride complexes, so their transport is inhibited by the low salinity conditions. Most Archean and Phanerozoic orogenic belts with greenschist to amphibolite facies metamorphic rocks contain orogenic gold deposits. However, there are some metamorphic belts that contain large numbers of mineral deposits, including gold-bearing deposits, but little or no typical orogenic gold mineralisation. Instead, there are numerous Cu-Au occurrences (some are iron-oxide Cu-Au mineralisation style, others are iron-sulfide Cu-Au; IOCG and ISCG) and a broad variety of other deposit types. Fluid inclusion studies have demonstrated that the Cu-Au deposits formed from highly saline fluids. A defining feature of these distinctly different metamorphic belts is that they contain thick sequences of scapolitic calc-silicate metasedimentary rocks. We have found that the presence of widespread Cl- and variably SO_4-rich scapolite creates a system where metamorphic fluids are continuously buffered to oxidised and highly saline conditions. High salinity and elevated oxygen fugacity increases the solubility of base metals and gold, as well as other metal-complexing ligands such as sulfur, fluorine and phosphorus, and thus dramatically expands the range of metals that can be carried in the fluid. In this way, metamorphic belts with large volumes of evaporitic material are ideal for generating a broad spectrum of syn-orogenic hydrothermal ore deposit types, including IOCG, ISCG, Mo-Re and U-REE, but lacking Au-only. Unlike regions hosting traditional orogenic gold deposits, belts containing evaporitic sequences retain Cl-rich minerals to high metamorphic grades, allowing them to remain active as ore forming systems for prolonged periods. Supercontinent breakup, notably in the Mesoproterozoic, formed large, intracontinental basins well suited to the development of widespread evaporitic sequences. This, in combination with overprinting orogenesis and high temperature magmatism, provided the ingredients for distinct periods of global scale ore deposit formation.