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Formation of Archean Orogenic Gold Deposits: Insight From Phase-equilibrium Modeling

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Metamorphic devolatilization is the most accepted process to form orogenic gold deposits. Recent models suggest auriferous fluids can be released at ~700 °C without partial melting; however, the specific mineralogical controls remain poorly constrained. Here, we use phase-equilibrium modeling across different geothermal gradients and basaltic compositions relevant to the Archean to identify P-T silicate-hydrous mineral equilibria. In addition, we integrated mass balance calculations coupled with Monte Carlo simulations to estimate Au concentrations in the fluid release.

During metamorphism of water-saturated basalts, chlorite breakdown occurs between 460–500 °C, releasing ~60% of the initial Au content. Our models show a release of ~1.75 wt.% H₂O, yielding a cumulative Au concentration of 50 ± 40 ppb in the fluid before reaching the solidus (~675 °C). By contrast, in water-unsaturated metabasalts, amphibole (60–80 vol.%) is the dominant phase. Here, only ~5% of initial Au is released during chlorite breakdown (when stable) at 475–525 °C or epidote/biotite breakdown above 540 °C. The released fluid contains lower Au (30 ± 30 ppb) due to a maximum H₂O release of ~0.5 wt.%.

Our preliminary results show that Au mobilization is highly efficient during chlorite breakdown. Moreover, we found that if the system is water-undersaturated, Au release decreases drastically.