Inverted geotherms within accretionary complexes: implications for the metamorphic orogenic gold deposit model

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There is considerable evidence for a metamorphic origin for lode gold deposits, although the fluid isotopic signature, episodic nature of fluid expulsion, and gold solubility considerations are problematic. The oxygen isotopic signature of quartz and carbonate within the vein systems are typically between 15‰ and 10‰, which between 350° and 250°C is associated with fluids between 10‰ and 1‰. This range of fluid compositions typically falls on the isotopically light end and even outside of the D-O metamorphic water box. However, high-T dehydration reactions of sedimentary and even low-T, seawater-altered mafic volcanic rocks at depth should typically yield fluids of heavier isotopic composition. Given a normal metamorphic gradients, these infiltrating fluids should subsequently deposit quartz and carbonates at lower T's within greenschist-grade shear zones; the oxygen isotopic composition of quartz and carbonate should then be higher than is typically observed. Magmatic and meteoric fluids have been used to explain the relatively light oxygen isotopic values inferred for the mineralizing fluid; these models invoke hydrothermal circulation systems with magmatic heat sources driving isotopically light fluid convection. This, however, is generally inconsistent with the permeability structure and syndeformational prograde metamorphic assemblages present.

An alternate model involves progressive dehydration reactions within a region of inverted geotherms to account for the light oxygen isotopic signatures of the infiltrating early metamorphic fluid. Within large (old) accretionary wedge complexes, internal radioactive heating, magmatic heating across the buttress, and mid-wedge level frictional heating occurs (Barrovian-like). The continuous subduction of hydrated ocean crust (old, cold) with fore-arc and trench sediments undergoing progressive dehydration during underplating provides a continual source of isotopically light, low salinity, low-T fluids that are heated during upward egression through the deforming wedge complex. Even with these high fluid/rock, heterogeneous isotopic re-equilibration is typical and chemical modifications are common as most of the fluid flux would be focused along fabrics and shear zones, possibly forming gold mineralization near the brittle-ductile transition (upper part of wedge), if the fluid fluxes were high. The lower T's involved in the lower wedge would enhance gold-bisulphide complexing and would be consistent with the low pH alteration and retrogression to greenschist-grades typically seen within shear zones. Lastly, the evolution of the accretionary complex to a terminal collisional orogen (possibly with slab rollback) would result in dehydration reactions related a normal thermal gradient being established. These later metamorphic fluids would also be focused along reactivated shear zones within the exhuming orogen.