Gold Metallogeny During Subduction Initiation and a Source Rock Control on Proto-Arc VMS Endowment

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Intraoceanic subduction intiation marks the transition between the mature divergent and convergent stages of the Wilson cycle, each with its distinct and relatively well understood metallogeny. The metallogenic systematics of the transition, however, are less clear, with uncertainties regarding controls on Au endowment in proto-arc volcanogenic massive sulfide (VMS) deposits and the potential for magmatic-hydrothermal ore formation. The lavas of the Samail ophiolite (Oman) formed during Tethyan subduction initiation and host VMS deposits with Au/Cu ratios that increase up through the volcanostratigraphy. Our new analyses of volcanic glasses reveal this increase is closely paralleled by Au/Cu ratios in the footwall lavas, implying a footwall source compositional control on proto-arc VMS Au endowment.

Supporting trace element analyses and magmatic modelling indicate that Au enrichment of the boninites was enabled by sulfide-undersaturated fractionation. This occurred due to remelting of mantle that had already lost most of its sulfide during production of MORB-like melts earlier in the subduction initiation seqeuence. The early melting left a refractory residue with only small amounts of Au-enriched sulfide, which was completely extracted during the later remelting to produce Au-rich but S-poor boninites. Despite H_2O enrichment in the boninites, low S contents may have suppressed efficient magmatic-hydrothermal extraction and transport of Au and Cu, thereby limiting magmatic-hydrothermal input to the VMS deposits. Subduction maturation and the refertilization of the wedge with S and metals by mantle corner flow would then have been necessary to produce melts capable of forming magmatic-hydrothermal ore deposits. This stage was not reached prior to detachment of the Samail lithosphere, but was by many other well-endowed Tethyan and circum-Pacific intra-oceanic arcs. The Samail ophiolite thus provides a record of both evolving metallogeny during subduction initiation and the limitations on the onset of porphyry-type mineralization in nascent arcs.