SEG 2024 Conference: Sustainable Mineral Exploration and Development

The Role of Carbonate Melts in the Transport and Concentration of Metal-Rich Magmatic Sulfides

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Sulfur and metal mobilization during mantle metasomatism and magmatic transport of dense, metal-rich sulfide liquid have been intractable problems for decades. A better understanding of how these processes operate at multiple scales may provide insights into the genesis of critical resources such as nickel, copper, and platinum group elements. We investigated experimentally the role of incipient carbonate melts in mobilizing sulfur and metals at mantle conditions. Results show that carbonate melts can sequester sulfur in its oxidized form as sulfate, as well as base and precious metals from mantle lithologies as sulfide. Accordingly, incipient carbonate sulfur-rich melts may play a first-order role in the metallogenic enhancement of localized lithospheric domains.

We subsequently addressed the problem of sulfide transport in magmas derived from partial melting of variably metasomatized mantle domains. Whereas recent studies emphasize adherence of volatiles to sulfide liquids to lower their densities and favor transport across extensive magmatic plumbing networks, we show that the presence of volatiles alone cannot generate the mineral assemblages documented in natural rocks. Experimental results indicate that carbonate melt wrapping around sulfide globules is an alternative process to the previously proposed gas bubble to aid dense sulfide liquid on its journey across the lithosphere.

We conclude that carbonate melts act as effective agents to dissolve, redistribute, and concentrate metals within discrete domains of the mantle and into shallower regions of the Earth, where dynamic physicochemical processes can lead to ore genesis at various crustal depths. The recognition of a greater role for carbonate in enhancing physical processes in the transport and concentration of metal-rich sulfide liquid may lead to a paradigm change in exploration for magmatic sulfide deposits, as a series of targeting proxies related for example to crustal contamination that we currently utilize may not be essential in ore genesis.