

The Skaergaard Intrusion: Using Petrography to Characterize an Exsolved Magmatic Volatile Phase

B.W. Wernette^{1†} and A.E. Boudreau¹

¹Division of Earth and Ocean Sciences, Duke University, Durham, N.C., 27705, USA

[†]Corresponding email: benjamin.wernette@duke.edu

The 55 Ma Skaergaard Intrusion of southeast Greenland is one of the most well studied layered mafic intrusions (LMI) in the world. The Intrusion is thought to represent one pulse of magma and consequently, has proven to be a wonderful locality for the study a number of processes including fractional crystallization and magma chamber dynamics. Notably, the Intrusion is host to the metalliferous Platinova Reef, a diffuse stratigraphic horizon anomalously enriched in Cu, Au, and PGEs. Extensive research by others has allowed for superb understanding of the stratigraphic distribution of metals and their host minerals within the Reef. What remains unclear however, is whether exsolved magmatic volatiles generated, or significantly modified, the Platinova Reef. Some have argued anomalously high Cu/S values are well explained by the degassing and loss of S prior to crystallization and/or later loss from the Skaergaard cumulate pile, while others have argued Cu/S values are merely representative of the Skaergaard source region.

To better understand the role magmatic volatiles play in modifying the Skaergaard metal budget, we use the Cameca CAMEBAX microprobe at Duke University to characterize sulfide assemblages and accessory phases throughout the Skaergaard stratigraphy. We find that sulfides below the Platinova Reef are readily replaced by low-Ti magnetite; in thin section [\sum low-Ti magnetite area / \sum sulfide area] reaches a maximum at the stratigraphic level of the Platinova Reef. Sulfide assemblages below the Reef are accompanied by trace clinopyroxene, orthopyroxene, biotite, apatite, and calcite. Notably, we discovered native Ag, commonly accompanied by trace amounts of Cl, both in and below the Platinova Reef. Evidence of coexisting precious metal + brine assemblages is observed where native metals are accompanied by sylvite \pm halite and Ag is accompanied by proximal Ag-halides. Ag occurrences in the Platinova Reef are of irregular morphology with trace Cl \pm calcite \pm sulfur. Further evidence is observed where a Ag + quartz assemblage is found in an apparent fluid inclusion consisting of Na, K, Ca, and Cl.

Numerical modelling suggests that Ag can be effectively mobilized by an exsolved volatile phase in a sulfide-free system at variable chlorine molarities. Residual Ag concentrations and concentrations in the exsolved phase are most affected at higher Cl concentrations. In a sulfide bearing system, residual Ag concentrations and concentrations in the exsolved phase are most affected at the point where sulfide is entirely lost to the exsolved volatile phase. We propose that fractional crystallization produced the enrichment of Ag in the interstitial liquid. As this interstitial liquid evolved, Ag was lost to an exsolved volatile phase of high salinity and migrated upward along grain boundaries and fluid pathways. We imagine that a similar process occurred for Au, ultimately supporting observations made by other workers as well as our own.