

AN EXPERIMENTAL INVESTIGATION OF POTENTIAL SULPHIDE MAGMA EVOLUTION MECHANISMS RELEVANT TO THE MERENSKY REEF IN THE BUSHVELD COMPLEX

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PGE mineralization in the Rustenburg Layered Suite of the Bushveld Complex (BC) is strikingly focused on chromite bearing horizons in the Merensky and UG2 reefs. The mechanisms by which this association is achieved are not completely clear, however it is argued that sulphide melt had an important role to play considering that other PGE mineralized reefs in the Bushveld, e.g. Platreef, contain almost no chromite (Cawthorne, 1999). Current BC mineralization models struggle to address the details of the role played by sulphide magma in generating the ore deposits. For example, if PGE's have been concentrated in chromitite layers by immiscible sulphide liquids, why are the PGE concentrations in the reefs apparently too high to be reconciled with their current sulphide contents (Godel et al, 2007)? This has prompted several authors to argue that the reef horizons have lost sulphur or sulphide (Naldrett & Lehmann, 1988). In this work, the concept proposed by Godel et al (2007), that chromitite layers may have acted as a physical barrier to denser downwards percolating sulphide melts is investigated experimentally. Experiments were performed at 1Atm between 1250 to 850 °C, to constrain phase relations in a Merensky Reef sulphide proxy [Cu (4.69 Wt%), Ni (11.79 Wt%), Fe (45.7 Wt%), S (36.9 Wt%) + 100 ppm Pt]. The liquidus was bracketed between 1100 and 1050 °C, where the first Mss (mono-sulphide solid solution, $(Fe, Ni)_{1-x}S$) crystals were noted; mss exists in equilibrium with melt until 850 °C, where the melt fraction is so low that melt only exists as inclusions in larger Mss grains. Chromite-sulphide melt interaction was investigated by allowing sulphide melt, in the temperature interval 1050 to 900 °C at 4 kbar, to move downwards through two layers of partially melted pyroxenite that were separated by a narrow (2mm) thick layer of chromite. Image analysis on BSE images demonstrate that the median sulphide melt–chromite dihedral angle is extremely low, $\sim 11^\circ$ compared to $\sim 33^\circ$ for silicate minerals. These angles are far lower than the percolation threshold (60°) for natural systems, however instead of percolating through the chromitite layer, the sulphide melt became trapped within the chromite layer by virtue of strong capillary forces (“sponge” effect) that hold the melt in the chromite layer. In contrast, within the silicate layer, sulphide melt coalesces promoting vertical movement. Additionally, sulphide melt existing above 950 °C preferentially leaches Fe^{2+} from chromite causing Mss to crystallize within the chromitite layer. This lowers the S cation ratio of the sulphide magma, lowering Pt solubility which results in the crystallization of Pt alloys within chromitite. Evidence suggests that sulphide melt percolating through the silicate cumulate potentially crystallized a significant volume of Mss in the silicate hanging wall overlying the reefs. This is supported by sulphide compositional trends which indicate bulk sulphides in the Merensky chromitites represent a fractionated Pt-Ni-Cu rich sulphide melt. Preferential partitioning of Pt ($D=0.013$; at 1000°C) into this melt caused the high concentrations of Pt. In conclusion, experimental evidence indicates that chromitites likely acted as trap for evolved Pt-Cu-Ni rich sulphide melts, and that secondary process, including the leaching of Fe^{2+} from chromite caused large amounts of Pt alloys to precipitate in chromitites. By considering these fractionation mechanisms, a sulphide magma containing sufficient Pt, could easily account for the extremely high Pt/S ratios observed in chromitite reefs.

Reference list:

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