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High temperature (>800°C) brine and sulfide melt interaction during the formation of Northern Bushveld magmatic sulfide Cu-Ni-PGE deposits.

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The role of volatiles in the development of layered intrusion-hosted magmatic sulfide deposits is still poorly understood. We present petrological and fluid inclusion evidence that an aqueous brine phase was present during the formation of Ni-Cu-PGE mineralisation throughout the northern Bushveld Complex, which hosts some of the largest and most valuable Ni-Cu-PGE orebodies on Earth. This brine phase was present while the system was at least partially molten and we present direct evidence of brine – sulfide melt interaction.

Fluid inclusions were identified in cumulate magmatic silicates (feldspar, olivine, and pyroxene) in the Aurora, Waterberg PTM, Troctolite Unit and Platreef deposits. These comprise brine and vapour inclusions which do not crosscut crystal boundaries. Optical microscopy and confocal Raman spectroscopy show that the brine inclusions contain multiple daughter minerals (including halite and carbonates), 10-15% vapour and 15-25% liquid water; whereas vapour inclusions contain CH_4 and N_2. Microthermometry shows that brine inclusions homogenise to liquid by vapour disappearance between 819 – 1000°C in the Aurora deposit (n=281), between 877 – 994°C in Waterberg (n=256), between 860 – 942°C in the Troctolite Unit (n=428) and between 829 - 988°C in the Platreef (n=227). Halite dissolves between 521 – 697°C, giving salinities of 61-87 wt.% NaCl equivalent.

Examples of co-eval interaction and entrapment of brine and Cu-rich sulfide melt are observed in all deposits, implying this was a common factor during their development. The PGE in the Aurora project and the T zone at Waterberg are hosted in platinum group minerals (PGM) that are spatially removed from magmatic sulfides and hosted in late silicates such as quartz, suggesting PGE remobilisation by hydrothermal processes. The petrological similarity between inclusions in all Northern Limb deposits suggests the high temperature fluids had a similar origin, either from late magmatic degassing or possibly from volatiles released from assimilated dolomite country rock.