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Mineralogical and geochemical variations in the UG2 reef at Booysendal and Zondereinde mines, with implications for beneficiation of PGM

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The layered intrusion of the Bushveld Complex, South Africa hosts the world's largest concentration of platinum group elements (PGE), which are principally mined from three mineralised horizons namely, the Merensky reef, the Upper Group Two (UG2) reef and the Platreef. The PGE contents of these horizons are conventionally beneficiated via comminution, froth flotation and smelting techniques. The performance of the above-mentioned techniques are directly related to the mineralogical and geochemical characteristics of the platiniferous reefs, and any variations thereof. In particular, the chromite-rich UG2 reef presents a variety of complications; for example ore/gangue relationships, mineral chemistry and textural characteristics, which can impact upon its beneficiation potential. This study is primarily aimed at evaluating, constraining and comparing the mineralogical and geochemical characteristics of two UG2 reef mining cuts from Booysendal Mine (eastern Bushveld Complex) and Zondereinde Mine (western Bushveld Complex). The results of comprehensive petrographic (2-D and 3-D), compositional and geochemical investigations are placed within the context of milling and flotation in order to assess the impact that any variability might have during beneficiation of the PGE contents. In addition to these aims, the validity of results obtained from 3-D microfocus Computed Tomography (μXCT) were assessed within the context of this study.

In this study it was found that the main ore zone from each UG2 reef sample is characterised by cumulate chromite grains with variable characteristics depending on grain size, composition, degree of compaction and grain shape. The Zondereinde UG2 reef, in particular, was interpreted as having experienced a significant degree of compaction, based on relative paucity of intercumulate silicate phases. All mineral phases within both UG2 reef sample sets exhibit variable alteration features, due to the replacement of primary silicates by hydrous silicate minerals. PGE grade, which is commonly distributed with a top- and bottom-loaded profile in the main chromitite layers, manifests as platinum group minerals (PGM) with average grain sizes of less than 3 μm, associated predominantly with nickel and copper sulphide minerals. The Booysendal UG2 reef is dominated by a PGE-sulphide assemblage whereas Zondereinde is dominated by PGE-alloys.

The mineralogical and geochemical characteristics described in this study can be utilised to refine the milling regime and flotation parameters in order to maximise plant efficiencies. It is suggested that the Booysendal UG2 reef's lesser degree of compaction within the chromitite horizons and predominance of PGE-sulphide mineral compositions may yield better liberation and faster recoveries of PGM contents when compared to the Zondereinde UG2 reef. In the case of the Zondereinde UG2 reef, the

homogeneity of chromite textures might serve to simplify the refinement of milling regimes so as to not over- or under-grind the reef contents. This, coupled with a strong association of PGM with comparably higher sulphide mineral proportions, will assist the beneficiation process. The interpretation of results obtained from 3-D μXCT proved the technique to be a powerful tool in terms of the broad-scale characterisation of chromite textures and PGM distribution. The technique however suffers from resolution limitations when attempting to accurately discern individual PGM grains, this is interpreted to be an artefact of the typically small grain size of PGM from the UG2 reef.