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In situ Sr isotope evidence for plagioclase mingling in the UG2 layer of the Bushveld complex (South Africa)

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The Rustenberg Layered Suite (RLS) hosts the mafic-ultramafic components of the Bushveld igneous complex in South Africa and is further subdivided into a Marginal, Lower, Critical, Main and Upper zone. Within the Critical Zone three sets of chromitite layers are observed that are the Lower Group (LG) 1-6, Middle Group (MG) 1-4 and Upper Group (UG) 1-3 layers. Especially the UG2 layer is of great economic importance and exploited throughout the Bushveld complex. In this study a drillcore through the UG2 unit derived from the Two Rivers Platinum Mine located in the Eastern Lobe close to Steelport has been analysed. The UG2 unit in that area is comprised of five melanoritic layers and two chromitite seams that are from bottom to top: Lower pegmatoid, Main seam with intercalated Lower split, Upper split, Leader seam, Upper pegmatoid and Upper distal unit [1].

Chromite formation is not well understood and different models are debated. The groundbraking work of Irvine [2] who showed that mixing of silicate melts into a hybrid melt can lead to chromite as sole cumulus phase promoted the so-called in situ cumulate models. This process, however, cannot explain the amount of chromite (~7-10 m in total) observed as silicate melts can only host up to 2-3 wt% Cr_2O_3. A different approach to explain chromite formation is used by the intrusive models. These argue for an intrusive origin of the chromitite layers and circumvent the “missing silicate” problem through formation of chromite in structural traps beneath the main magma chamber. Within these traps chromite forms as cumulate phase by (traversing) hybrid silicate melts and accumulates with time. These trapped chromites are later remobilised and transferred into the magma chamber to spread laterally forming layers.

Both approaches have in common that mixing of melts is proposed either in or below the main magma chamber, which would demand a homogenous mineral chemistry of cumulus plagioclase throughout one magmatic cycle. To test this hypothesis, we analysed the plagioclase composition and its initial Sr isotope signatures through the different layers comprising the UG2 unit. Anorthite contents of cumulus plagioclase grains show values between 70 and 80 mol%, which is typical for the upper Critical Zone. Plagioclase grains hosted in the Upper Pegmatoid and Upper Split layers show evidence for later hydrothermal alteration with highly variable Anorthite contents (55 to 90 mol%). Interestingly, initial $^{87}Sr/^{86}Sr$ ratios show typical upper Critical Zone signatures of ca. 0.7065 for all but one unit and are unrelated to obtained Anorthite contents. The Upper Distal layer shows significantly more radiogenic initial Sr isotopic signatures of 0.7075. This value is considered typical for the Main Zone [3]. Close to the contact between Upper Critical and Main Zone mineral mingling has already been proposed based on Sr isotope signatures of plagioclase in contrast to mixing of melts [3]. We speculate here that at least one melanoritic unit (the Upper Distal pyroxenite) that is now part of the UG2 unit is originally derived from Main Zone magmas and thus evidences mineral mingling over larger scales than has been previously shown.

References:

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