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Concentrations of Te, As, Bi, Sb (TABS) and Se in the Marginal Zone of the Bushveld Complex: evidence for crustal contamination and the nature of the magma that formed the Merensky Reef

Eduardo Mansur[1] and Sarah-Jane Barnes[2]
[1]Sciences de la Terre, Université du Québec à Chicoutimi, Canada (etmansur@gmail.com)
[2]Sciences de la Terre, Université du Québec à Chicoutimi, Canada (sjbarnes@uqac.ca)

The association of platinum-group elements (PGE) and the chalcophile elements Te, As, Bi, Sb and Sn (TABS) has been documented in several magmatic sulfide deposits. These groups of elements are either hosted within sulfide minerals, or combine to form discrete platinum-group minerals (PGM) associated with sulfide minerals. However, the concentration of TABS in parental magmas from which magmatic sulfide deposits formed was still missing. This study presents the distribution of TABS and Se in B-1, B-2 and B-3 rocks of the Marginal Zone of the Bushveld Complex. These rocks have been proposed as representative of the parental liquids from which the Bushveld Complex crystallized, thus allowing us to assess the concentration of Se and TABS in the liquids from which some of the largest PGE deposits in the world have formed. Concentrations of As and Sb in the initial Bushveld liquid (B-1) are significantly higher than in primary magmas, whereas the Se and TABS of later magmas (B-2 and B-3) are similar to primary magmas. We attribute the difference due upper crustal contamination of the B-1 magma, whereas the B-2 and B-3 magmas were most likely contaminated with a plagioclase-rich residuum formed upon the partial melting of the upper crust. Moreover, we modeled the concentrations of the TABS in the Merensky Reef using a mixture of two of the magma types present in the Marginal Zone (the B-1 and B-2) as the initial silicate liquid. The modeled concentrations closely resemble the measured values obtained for a section across the Merensky Reef at the Impala mine. This supports the B-1 and B-2 mixture as an appropriate initial liquid for the crystallization of the Merensky Reef. The modeling also shows that the distributions of Se, Te and Bi across the Merensky Reef are controlled by the sulfide liquid component. In contrast, As and Sb distributions are influenced both by the amount of silicate melt component in the cumulates and the sulfide liquid component. This is because Se, Te and Bi are moderately to strongly chalcophile elements, but As and Sb are only slightly chalcophile elements. Consequently, the effect of crustal contamination for elements with high partition coefficients between sulfide and silicate liquid (Te, Bi and Se) is obscured by the interaction of sulfides with a large volume of silicate magma. Therefore, the concentrations of these elements are higher in samples with greater proportions of sulfide minerals. In contrast, for elements with lower partition coefficients (As and Sb), the whole-rock concentrations are not upgraded by the presence of sulfide minerals, and thus the effect of crustal contamination can be more readily assessed.