A case study of chromite and associated minerals as indicators of diamonds in the Botswanan Orapa kimberlite cluster

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Kimberlites are deep mantle magmas and the primary source of diamonds. Ilmenite, perovskite, rutile, titanite, and spinel group minerals are commonly found in matrices of kimberlites. Prior research shows that changes in temperature, volatile content, oxygen fugacity, and degrees of country rock assimilation influence what minerals are formed and the textures which are created. Similarly, these processes influence diamond preservation. Therefore, understanding the stability and reactions occurring in these minerals has implications on the features of diamond populations in kimberlites.

Two kimberlite bodies positioned in the Botswanan Orapa kimberlite cluster were examined. The first consists of a single coherent kimberlite pipe, AK-15. BK-1, the second and more complex body is composed of two coherent facies, CK-A and CK-B, and the volcanoclastic MVK facies. Sixty-seven samples, made up of the 4 kimberlite facies, were investigated using optical microscopy to observe the textures, zoning, and phases present in each sample. Twelve thin sections, three from each facies, were examined using a scanning electron microscope (SEM) with Back Scatter Electron imaging, X-ray mapping, and Energy Dispersive Spectroscopic analysis to confirm the presence and relationship between the minerals of interest. CK-A showed altered ilmenite with exsolution textures and reaction products made up of Ti-magnetite, rutile, and titanite indicating high fluid content which fluctuated during crystallization. Minor chromite was present which also showed exsolution textures and was rimmed by titanite. Perovskite was not observed, implying high silica activity. CK-B contained ilmenite displaying exsolution lamella and was rimmed by perovskite and Ti-magnetite. Titanite was often found rimmed by perovskite. Abundant perovskite in the groundmass indicates much lower silica activity than in CK-A as well as a much lower fluid content. In MVK ilmenite showed exsolution textures and was rimmed by intergrown Ti-magnetite, rutile and titanite. Minor amounts of chromite was found, altered and rimmed by titanite. This indicates volatile exsolution and high silica activity possibly due to assimilation of crustal material. AK-15 contained ilmenite typically rimmed by titanite and Timagnetite. Chromite was found throughout with alteration textures and Ti-magnetite intergrowths. Rutile, perovskite, and titanite were also found throughout. The observed difference in groundmass mineralogy between the four studied kimberlite lithologies could be a result of differences in assimilation of crustal material, which would rise silica activity and trigger CO_2 degassing with exsolution of fluid. Absence of fluid in CK-B would explain the corrosive surface features and high degree of kimberlitic resorption on CK-B diamonds.

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