THE GEOLOGY, MINERALOGY AND PETROLOGY OF THE PREMIER MINE KIMBERLITE PIPE

By

C. Frick
Geological Survey, South Africa.

The geology of Premier Mine is discussed and it is shown that the Premier Mine kimberlite formed as a consequence of four intrusions. The first intrusion, a heterolitic kimberlite breccia is heavily contaminated by wall rock xenoliths (Fig. 1) as it had to drill a vent through the overlying rocks. The succeeding two intrusions of autolitic kimberlite breccias caused the eastern and western bulges to form, and brought ultramafic xenoliths to the surface. The igneous activity terminated with the emplacement of the dykes of massive kimberlite (Fig. 2).

According to the textural and mineralogical data, the constituents of the kimberlite breccias can be classified into primary phenocrystal phases, a carbonate matrix, and wall rock inclusions. The massive kimberlites only consist of secondary phenocrystal phases and matrix, and are thus considered as the 'carbonate' (Wyllie, 1966) kimberlite magma. The primary phenocrystal phases are mostly resorbed and altered, and were not in equilibrium with the kimberlite magma in which they are enclosed. They also show mineralogical, petrographical and petrochemical characteristics similar to those mineral phases in the ultramafic xenoliths, and are considered to represent crystallates from the 'silicate' (Wyllie, 1966) kimberlite magma.

The secondary phenocrystal phases are mostly euhedral in shape, only slightly altered, and appear to be in equilibrium with the kimberlite magma in which they were enclosed. The textural and mineralogical data thus suggest that the secondary phenocrystal phases crystallized intratellurically from the 'carbonate' kimberlite magma below the thermal devide in the CaO-CO_2-H_2O-SiO_2-MgO system (Wyllie, 1966 and 1963).

The effects of the autometamorphism (formation of minerals such as serpentine, bastite, sphene, and phlogopite) of the Premier Mine kimberlites could be distinguished from those of the pyrometamorphism (formation of minerals such as brucite, hydrogrossular, biotite, diopside, tremolite, enstatite and olivine) caused by the intrusive tholeiite sill. It appears that the autometamorphism was accompanied by a very water-rich volatile phase which was absent during the pyrometamorphism. Except for the immediate upper contact of the tholeiite sill with the kimberlite, the contact metamorphism occurred in the hornblende hornfels facies.

According to the petrochemistry of the kimberlites and ultramafic rocks from Premier Mine, it appears that fractional crystallization of the constituents of the ultramafic xenoliths within their solid solution series, and ilmenite would be able to explain the derivation of the carbonate kimberlite magma from an alkali peridotite (King, 1965) or picrite (O'Hara, 1970) primary silicate kimberlite magma. The evidence suggests that extreme fractionation, the formation of a volatile phase, and liquid immicibility caused the formation of the carbonate kimberlite magma from the silicate kimberlite magma.

It is proposed that the sudden release in pressure which coincides with the explosive eruption of the volcano enhanced the exsolution of the carbonate magma from the residual silicate magma, and that this carbonate magma, by virtue of its lower density, and higher vapour content, is largely instrumental in bringing the ultramafic constituents to the surface. Slow cooling of the kimberlite magma after the last kimberlite breccia has been emplaced, could result in an accumulation of some of the exsolved carbonate magma, which would emplace as dykes if the vapour pressure becomes sufficiently high.

References

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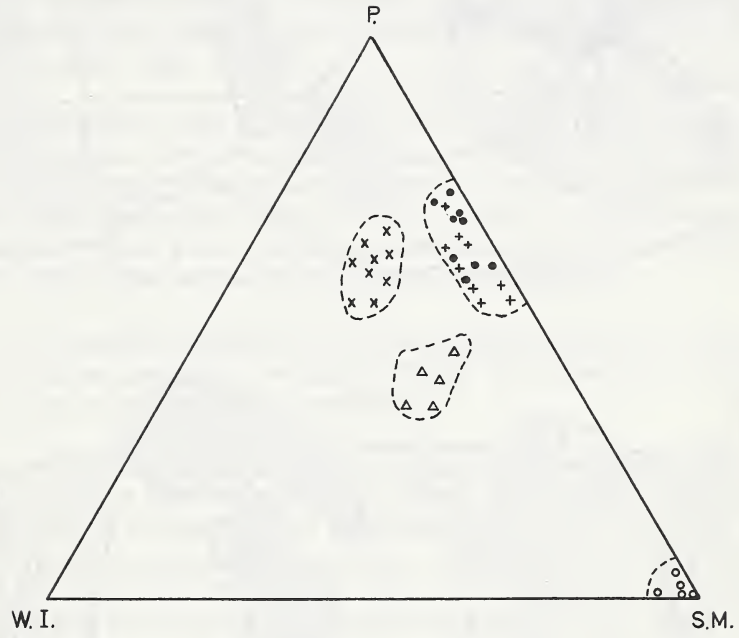

Figure 1. The distribution of primary phenocrystal phase inclusions (P), secondary phenocrystal phases and matrix (S.M.), and country rock inclusions (W.I.) in the heterolitic (x), eastern autolitic and western autolitic (• and + respectively) kimberlite breccias. The symbols △ and ○ represent the carbonated western kimberlite and the massive kimberlite respectively.

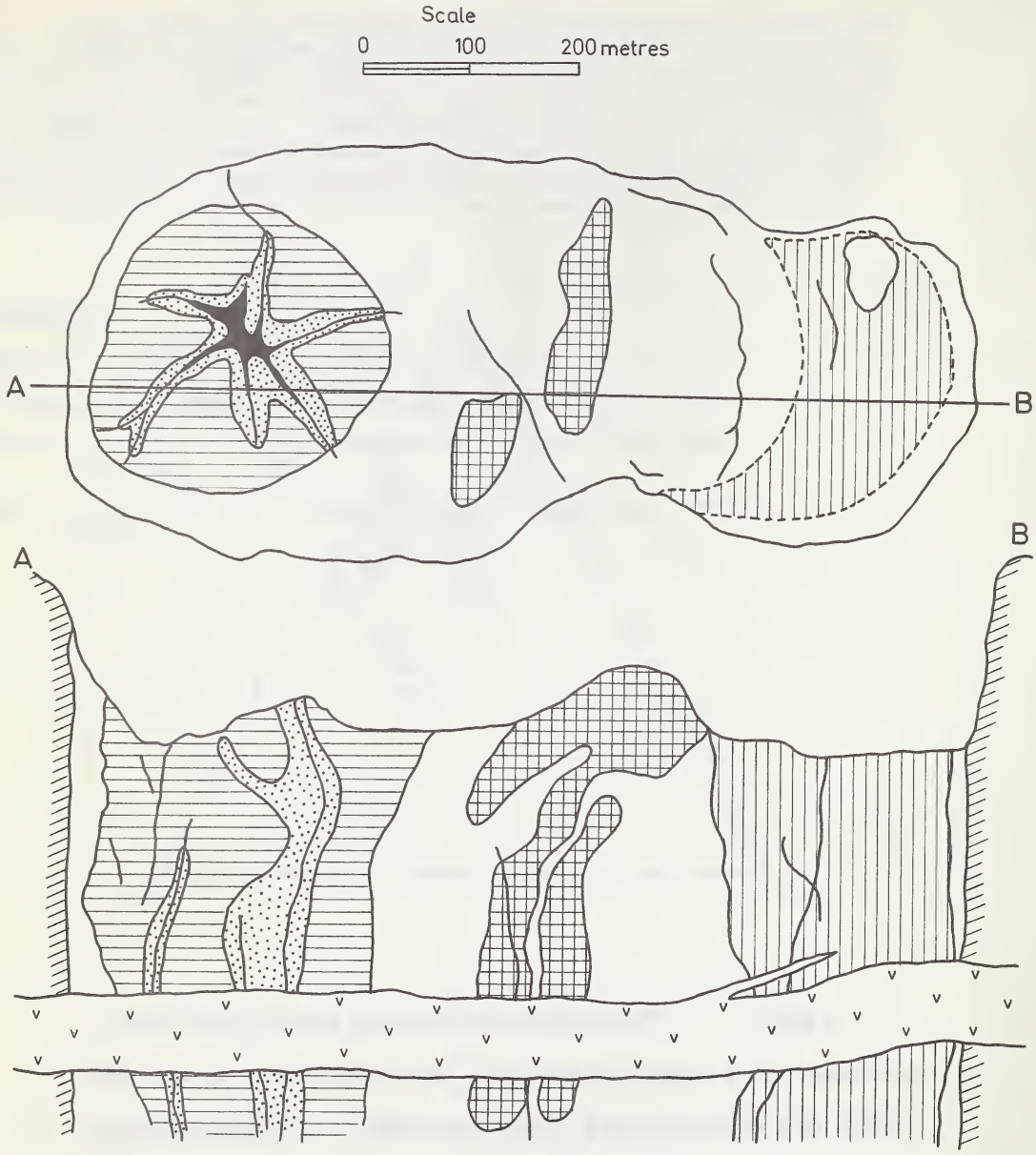

Figure 2. The distribution of the heterolitic kimberlite breccia, the western kimberlite, the eastern kimberlite, the massive kimberlite, and the carbonated western kimberlite in Premier Mine.