RECENT ADVANCES IN THE GEOLOGY OF KOFFIEFONTEIN MINE, FREE STATE PROVINCE, SOUTH AFRICA

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INTRODUCTION

Koffiefontein Mine is a low-grade diamond producer located in the south-western part of the Free State province of South Africa. The Koffiefontein pipe is the largest and most economic of a cluster of 3 kimberlites in the area viz. Koffiefontein, Ebenhaezer and Klipfontein. The pipes lie on a SE-NW structure and are thought to be linked by a single dyke at depth (Wagner, 1914).

The pipe was emplaced in basement granite gneiss and a sequence of Karoo shales, dolerites, sediments and (?)lavas 80Ma ago. The authors have not conclusively proved the presence of Stormberg basalt. The present thickness of these Karoo units varies from 250-260m. A substantial thickness of Karoo lavas, sediments and the upper portions of the pipe are believed to have been removed by post emplacement erosion. The Koffiefontein pipe has an area of 11.1ha at the present day erosion surface. The pipe narrows down to 7.8ha at the present production level 490m below surface (49 Level).

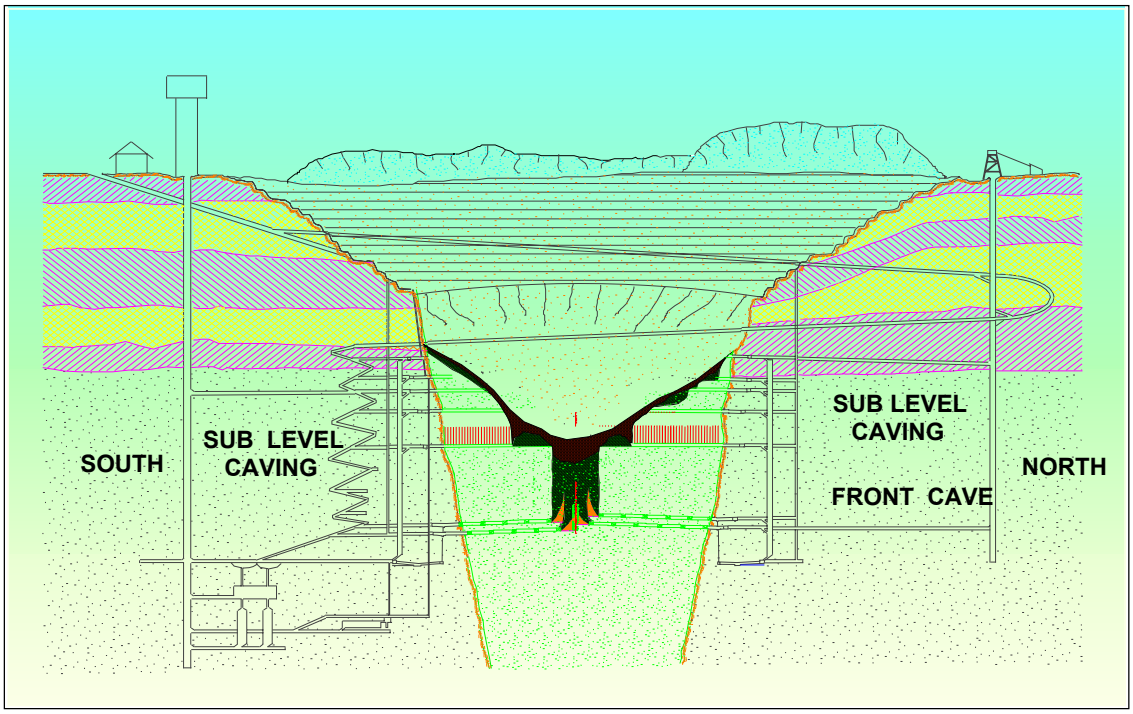

Figure 1. Schematic section of Koffiefontein pipe showing Karoo stratigraphy and existing underground development.

Mining commenced with open pit operations, but changed to underground operations in 1988. Currently mining is carried out using the sub-level caving method in the upper levels and by the front cave method, a modified block cave, at lower levels. The mine has opened and closed several times in its history due to the impact of prevailing economic conditions

The internal geology of the pipe has contributed to the marginal nature of the mine. Key to this is the presence of a large zone dominated by down-rafted Karoo sediment dolerite and crater facies material. Prior to 2000, the grade plans for the orebody were based on inferred geological boundaries due to the lack of detailed geological knowledge. An intensive programme commenced recently to further investigate the internal geology of the pipe.

A tunnel sampling campaign was undertaken at closely spaced intervals to ensure detailed coverage of waste rock distribution and petrographic data. This was supplemented by an underground drilling programme.

As a result of this investigation it is clear that the kimberlite pipe at Koffiefontein consists of pre-cursor dykes (the West and East Fissures), and the main pipe in which two main eruptive phases have been recognised.

The two "fissure" systems that preceded the main eruptive events are geologically distinct. The West Fissure exhibits less internal complexity than the East Fissure and is largely comprised of melilite-bearing diatreme facies kimberlite (classification after Clement and Skinner, (1985)).

The East Fissure exhibits a transitional internal geology, ranging in cross-section from segregationary-textured macrocrystic phlogopite-monticellite kimberlite, through a variety of transitional features to a narrow zone of diatreme facies kimberlite in the middle, before passing back into a segregationary-textured hypabyssal kimberlite breccia.

Both main eruptive phases within the pipe viz. the Speckled TKB west (KF1) and the Speckled TKB East (KF10) comprise diatreme facies kimberlite. Altered melilite and monticellite dominate the magmaclast groundmass of both these intrusions. They are separated by a large irregular mass of kimberlite that has been highly diluted in places by varying amounts of Karoo mudstone and dolerite, as well as probable bedded crater facies fragments. A single, small hypabyssal plug intrudes the speckled TKB west. Late stage dykes, characterised by a phlogopite and altered melilite-rich groundmass, also occur.

Groundmass spinel compositions have been used to provide a chemical fingerprint of each lithology (see Figure 2). Crosscutting contact relationships suggest that the emplacement sequence was as follows: West and East Fissures> Speckled TKB East> Speckled TKB West> Hypabyssal plug> Late dykes.

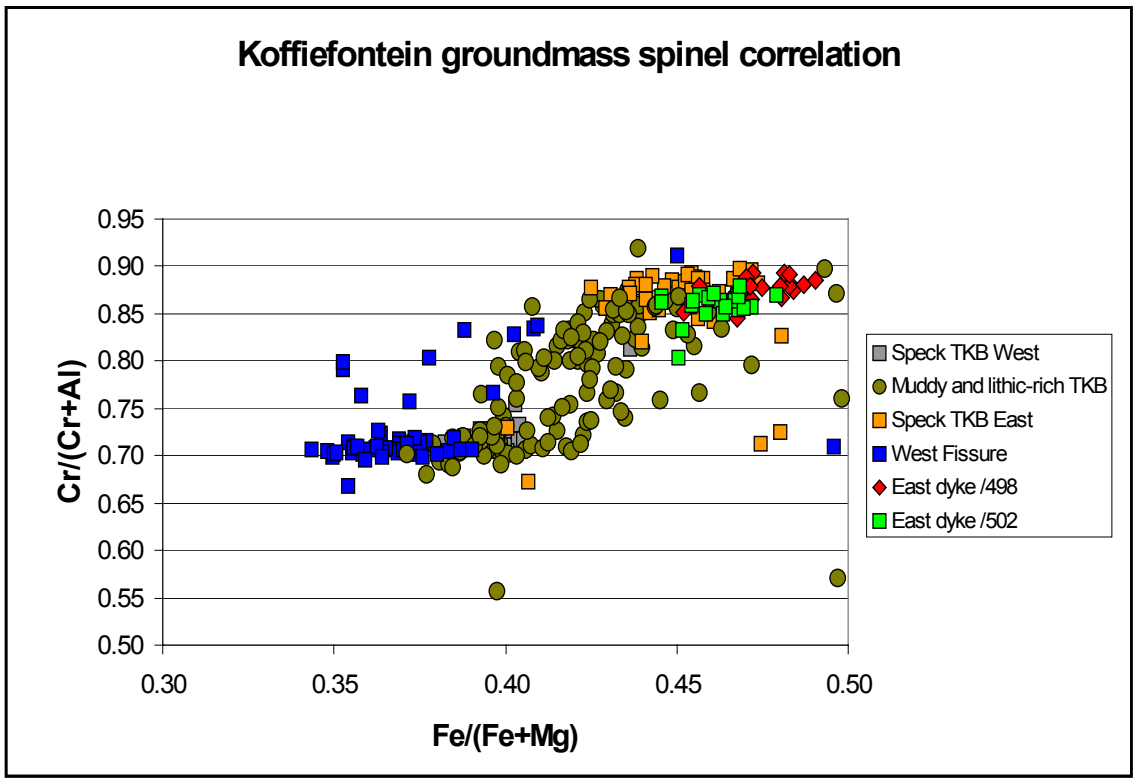

Figure 2: Spinel compositions of the main geological units at Koffiefontein represented in Fe/(Fe+Mg) vs Cr/(Cr+Al) compositional space. The bulk of the spinels from the Speckled TKB West are poorly visible amongst the Muddy and lithic-rich TKB data points, but exhibit compositions within a field very similar to those of the latter. The two East dyke samples were collected from different geological units within the East Fissure, one hypabyssal (/498) and the other diatreme facies (/502).

The characterisation of the different internal geological units permitted the development of a three dimensional model of the pipe (refer to Figure 3).

The Koffiefontein pipe again demonstrates the complexity that may occur within such geological structures. In this case there is evidence for at least three magma batches, each with its own chemical signature.

Proper geological control is crucial in determining future mining below 49 Level at Koffiefontein Mine due to the presence of the large zones of diluted ore that also pose geotechnical challenges.

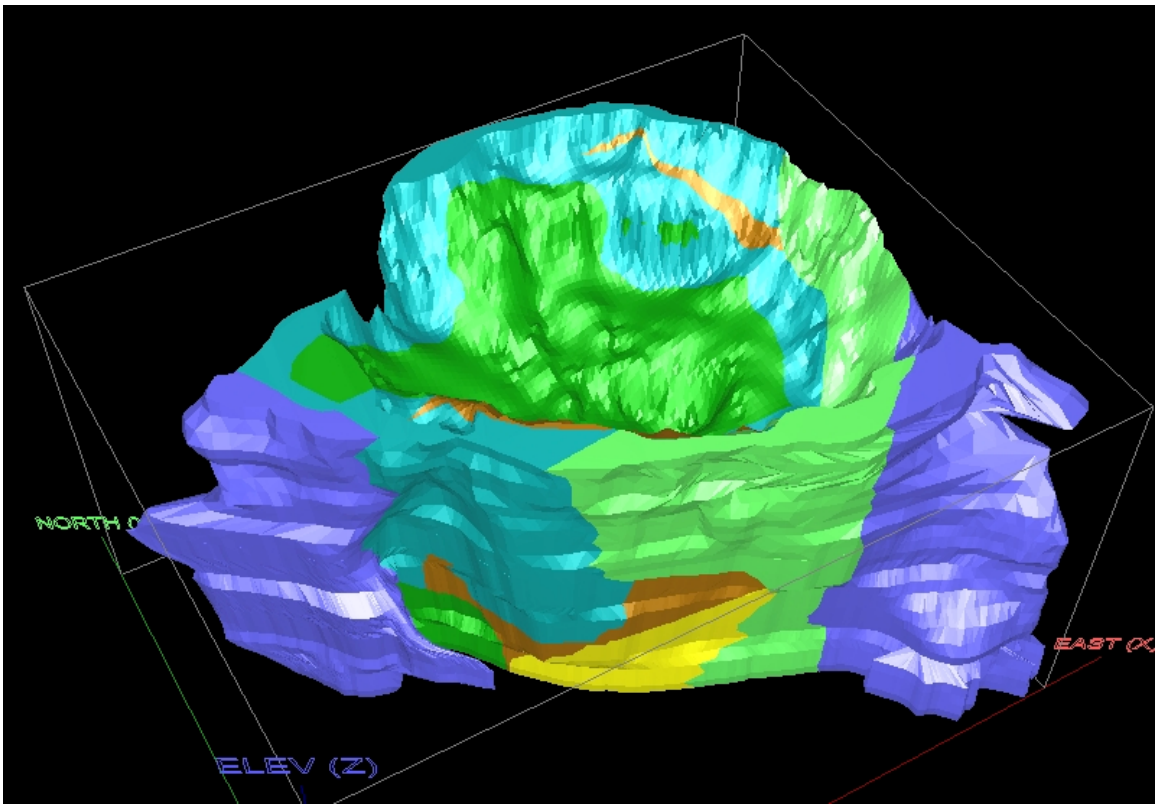

Figure 3: GEMCOM image of Koffiefontein kimberlites showing the pipe outline on 24 level and the mined out area as at December 2001.
Key: dark blue = East Fissure and West Fissure , green = Speckled TKB West,
light blue = diluted Speckled TKB West, brown = muddy and lithic Speckled TKB,
yellow = diluted Speckled TKB East, light green = Speckled TKB East.

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