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A step forward in understanding 3D magmatic structures and ore deposits

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Potholes are spectacular features that disrupt the layering of the Bushveld Complex (Fig. 1) and provide key insights into the processes through which the layering, and the critical metals it hosts (PGE, Cr & V), developed. Despite detailed studies on the potholes over the last ~70 years there is very little consensus as to how they formed. Recent studies are based on typical geological techniques including fieldwork and geochemical analyses, however these have not yet provided a widely accepted model of the magma chamber processes that led to the development of potholes.

This study presents an analysis of pothole structures within the Bushveld Complex, using a combination of traditional geological techniques with geophysical (aeromagnetic and 3D seismic) studies. Fieldwork arguably remains one the best primary techniques for understanding magmatic processes, but is limited to the available outcrop, therefore provides a limited view of 3D structures such as potholes. High-resolution aeromagnetic and 3D seismic data can provide detailed information on 3D structures at a scale of a few metres, but is less informative of the detailed geology. Thus this study represents a novel approach to understanding magmatic processes and the ore deposits they host through the integration of these techniques.

Potholes have a complex 3D structure and vary greatly in size and depth. Although they typically have an elliptical shape, this becomes greatly elongated orthogonal to regional-scale fault structures. Potholes typically do not display symmetry, having a relatively steep up-dip slope compared to the down-dip (Fig. 1) and also steepen in one direction along strike. The lithology is highly variable throughout pothole structures, with the layer that forms coevally with the pothole often thinning and cutting back underneath itself in an 'overturn'. The ore minerals are often concentrated in spatially restricted locations, either in the steepest dipping portions of the pothole, or in the footwall ~0.5 m below the base of the pothole.

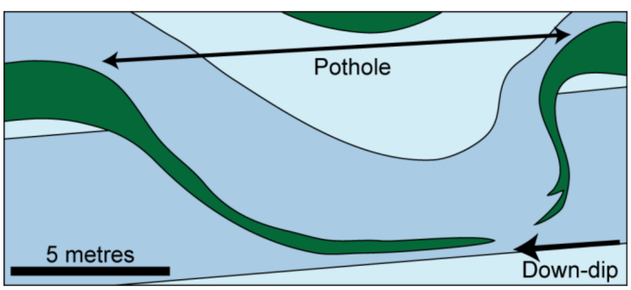

Figure 1: Typical pothole features in cross-section.

Both datasets indicate that potholes have a complex 3D structure, relating to interactions of multiple magma chamber processes. Thus combining analytical techniques is key to understanding the large-scale magma chamber dynamics during the development of potholes; the crystallisation of the Critical Zone; and the economic resources it hosts. It also emphasises the need for exploration models to draw on many sources of expertise in understanding the genesis of mineralisation and predicting economic deposits.