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ARTICLE

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Shape and distribution analysis of Merensky Reef potholing, Northam Platinum Mine, western Bushveld Complex: implications for pothole formation and growth

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Abstract Syn-magmatic removal of the cumulate pile during the formation of the Bushveld Complex resulted in "potholes". Erosion progressed downward in the cumulate pile, resulting in a series of steep, transgressive contacts between locally conformable potholed reefs in the regional pothole sub-facies of the Swartklip Facies in the western limb of the Bushveld Complex. The deepest of these potholes, "third-order" or "FWP2" potholing, occurs where the base of the Merensky Cyclic Unit transgresses the Upper Pseudo-Reef Chromitite marker horizon. The base of a FWP2 pothole on Northam Platinum Mine consists of an unconformable stringer Merensky Chromitite overlain by a medium-grained, poikilitic orthopyroxenite and underlain by either a pegmatitic harzburgite or the medium-grained Lower Pseudo-Reef Anorthosite. Detailed shape and distribution analysis of FWP2 potholes reveals underlying patterns in their shape and distribution which, in turn, suggest a structural control. The ratio between pothole short vs long axes is 0.624 (N=1,385), although the ratio increases from 0.48 to 0.61 in the long axis range 10 to 60 m, then decreases from 0.61 to 0.57 from 61 to 100 m, increasing again from 0.57 to 0.61 from 101 to 400 m, suggesting that there is not a simple relationship between pothole shape and size. Shape (circularity, eccentricity, and dendricity) analysis of a subset of 638 potholes indicates that potholes with long axes <100 m have an elliptical, average normalized shape, elongate on a 120–150° orientation. Potholes with long axis lengths >100 m have an average normalized shape that is bilobate and elongate on a 120° orientation. The average aspect ratio (short axis length divided by long axis length) of potholes is highest for potholes with long axis lengths >100 m and lowest for potholes with long axis lengths between 35 and 60 m. The most common long axis orientation for potholes with long axis lengths <100 m is 150° but 120° for long axis lengths >100 m. Fractal analysis indicates that the distribution of pothole centers is controlled neither by a single nor several interacting fractal dimensions. Autocorrelation (Fry) analysis of the distribution of pothole centers shows recurring pothole distribution trends at 038, 070, and 110° for potholes over the full range of long axis lengths, while the trends of 008 and 152° occur in potholes with long axes lengths between 60 and 100 m. Chi-squared (X^2) analysis of the locations of pothole centers suggests that the distribution of small potholes is highly non-uniform but becomes exponentially more uniform with increasing pothole size. The model which best fits the observed shape and distribution analysis is a combination of protracted independent growth and "nearest neighbor" merging along specific orientations. For instance, the clustered distribution of original pothole centers resulted in merged potholes with long axes lengths of up to 60 m, exhibiting short vs long axes ratios of 0.61, preferred orientations of 150°, and alignment along 010 and 150° trends. Further independent growth allowed for merging of similar-sized (and smaller) neighboring potholes, generating potholes with long axes of up to 100 m in length, a preferred long axis orientation of 150°, and alignment along 010, 040, 075, and 150°. Subsequent preferential merging occurred along a 120° trend, thereby preserving a bilobate form. This implies that while pothole initiation and enlargement may be driven by a "top-down" (i.e., possibly thermomechanical) process, an underlying linear or structural catalyst/control is revealed in changes in pothole shape during enlargement and, furthermore, in the preferred trends along which potholes merged over a

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