THE 144 MA MOROKWENG IMPACT STRUCTURE, SOUTH AFRICA: EVIDENCE FOR A ~240 KM CRATER.

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Introduction: The ~144 Ma Morokweng impact crater, buried by shallow Late Cretaceous to Cenozoic Kalahari sediments, contains a ≥870 m melt sheet highly enriched in siderophile elements and in clasts of pristine and partly recrystallized, boulder-size chondrite fragments [1, 2]. However, the one aspect that remains unclear about the structure is its size, with estimates ranging from <80 km [3, 4] to ~320 km [5, 6]. In this abstract we present geophysical and borehole data to re-evaluate the crater diameter.

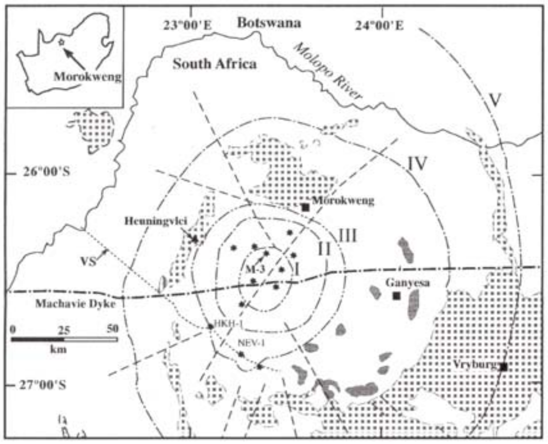

Figure 1. Generalized geological map of the Morokweng impact structure, modified after [2] showing: dark stippled, Archaean granite; light stippled, supracrustal rocks; blank, Kalahari Cenozoic Cover; broken lines, observed and interpreted faults; stars, location of boreholes; VS, trace of Vibroseis seismic profile [7]; Rings I to V: see text. The inset shows the location of the Morokweng structure.

Methods and Results: Given the extensive Cover across the Morokweng area (Figure 1), the size and structure of the Morokweng crater may only be assessed by integrating processed images of the gravity and airborne magnetic fields (Figures 2, 3) with the diamond drill/percussion borehole record (Figure 1). The geophysical and Pre-Kalahari topographic data were obtained mainly from open files of the South African Council for Geoscience, whereas the diamond-drill borehole data had been obtained from prospecting companies and from the former Pophuthatswana Geol. Survey. Valuable information was also provided from the study of basement fragments recovered from groundwater boreholes .

Bouguer gravity image. The more obvious features discernible in Figure 2 are four concentric rings labelled A to D. A and B (Radii [R] ~18 and ~30 km) are closer to the centre of a regional gravity low, whereas C and D (R ~75 and ~100 km) define its edge. Further away, an arc concentric to the inner rings may be observed close to the eastern edge of Figure 2 (R ~ 120). The innermost ring broadly follows the extent of the melt sheet (Ring I, Figure 1) [4], whereas the regional gravity low (dark blue in Figure 2) is caused by Archaean granite rimmed by Precambrian cover rocks (Ring IV, Figure 1) [8].

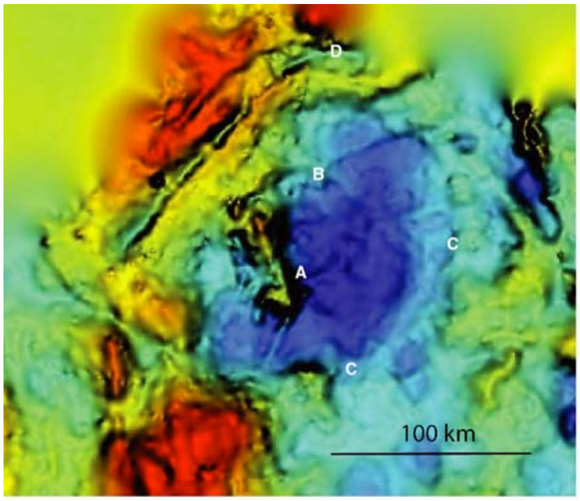

Figure 2. Edge-enhanced image of the Bouguer gravity of the Morokweng area (gravity data supplied by the Council for Geoscience). Rings A-D, see text.

Airborne magnetic image. This image (Figure 3) emphasizes a ~120° arc (E) with a radius of ~140 km, concentric to the impact melt (at A) and caused by Archaean BIFs outcrops north of Vryburg (Ring V, Figure 1).

Digital palaeo-topographic model. Concentric features are also observed in a digital terrain model of the pre-Kalahari unconformity (Figure 4) compiled with data from hundreds of groundwater boreholes. This image shows that the topographically elevated core of the Morokweng structure (i.e. the melt sheet) is surrounded by two horse shoe-shaped moats (R ~34 and ~93 km). Geomorphologic and stratigraphic evidence indicates that these moats were filled by Late Cretaceous lacustrine deposits [9, 10].

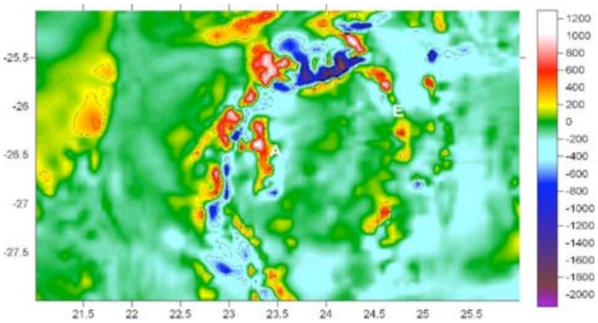

Figure 3. Airborne magnetic image over the Morokweng structure (source: Council for Geoscience of South Africa; scale: 1° E-W ~100 km). A, E: see text.

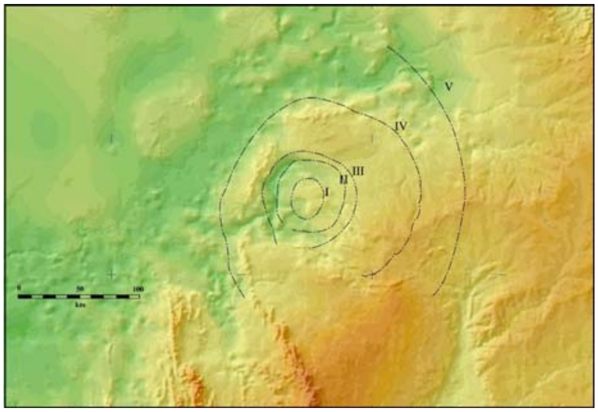

Figure 4. Sub-Kalahari topographical map of the Morokweng impact structure merged with a digital terrain model (DTM) for areas of exposed pre-Mesozoic basement [9]. Rings I–V: see Figure 1 and text.

Borehole data. All the boreholes drilled within **Ring I** (R ~12 km) intersect the melt sheet, whereas at least three boreholes within **Ring II** (R ~33 km) intersect melt rock or shocked (i.e. PDF-bearing) breccia and suevite in varying combination ([2], M Andreoli, unpublished data). Boreholes within **Ring III** (R ~38 km) show localized shock metamorphism, major structural disruption and brecciation of the cover rocks. In addition, polymict suevitic impact breccia in borehole HKH-1 and brecciated dolomite in borehole NEV-1 record localized shock metamorphism up to 40 km from the centre (Figure 1) [2, 11]. Tectonic disturbance was also recorded along the Vibroseis seismic profile up to 40 km from the centre (Figure 1) [7]. **Ring IV** (R ~70 ± 10 km) is defined in the SE quadrant of the structure by the contact between basement granite and its Late Archaean Cover. Borehole and Vibroseis seismic data suggest that this contact probably continues under the Kalahari cover and may represent an impact-related tectonic feature [7, 9, 11]. PDFs-bearing quartz is largely absent within this ring, having been reported only near Heuningvlei, ~40 km from the centre [3]. Finally, **Ring V** (D ~ 280 km) has no surface expression other than an arc of BIFs outcrops north of Vryburg (Figure 1).

Conclusions: the Morokweng impact stands out as a set of concentric rings and arches in the Bouguer gravity and magnetic images (Figures 2, 3). This structure is also easily recognizable on satellite imagery [11], including GoogleEarth. Various formulas {13, 14], used to calculate the diameter of the final crater in impact structures, indicate that the diameter of Morokweng may range between 190 and 240 km [11]. These values were obtained assuming a shock metamorphosed central uplift with a ~80 km diameter, and are consistent with the exceptional volume of the melt sheet [1, 2, 6].

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