

**SETLAGOLE MEGABRECCIA, SOUTH AFRICA: CLUES TO A POSSIBLE MESOARCHAEAN IMPACT EVENT AND AEROMAGNETIC RECOGNITION OF A C. 30 KM CONCENTRIC MULTIPLE RING STRUCTURE.** C.R. Anhaeusser<sup>1</sup>, E. Stettler<sup>2</sup>, G.R. J. Cooper<sup>3</sup>, and R.L. Gibson<sup>4</sup>, <sup>1</sup>Economic Geology Research Institute, School of Geosciences, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa, e-mail: [carl.anhaeusser@wits.ac.za](mailto:carl.anhaeusser@wits.ac.za) <sup>2</sup>Thani Dubai Mining Ltd., P.O.Box 88188 Dubai, UAE, e-mail: [estettler@thani.ae](mailto:estettler@thani.ae) <sup>3</sup>Department of Geophysics, School of Geosciences, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa, e-mail: [gordon.cooper@wits.ac.za](mailto:gordon.cooper@wits.ac.za) <sup>4</sup>Impact Cratering Research Group, School of Geosciences, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa, e-mail: [roger.gibson@wits.ac.za](mailto:roger.gibson@wits.ac.za)

**Introduction:** The Kraaipan Archaean granite-greenstone terrane of the North West Province, South Africa has revealed a spectacular megabreccia (Fig. 1) which crops out in a river bed near Setlagole village in the west-central region of the Kaapvaal Craton some 300 km west of Johannesburg [1], [2]. Kalahari sand and calcrete covers much of the Archaean basement in this area where only sporadic exposures of banded iron-formation and amphibolite occur as xenoliths in a variety of massive and gneissic granitoid rocks ranging in age from about 3160 to 2790 Ma [3], [4]. The megabreccia, exposed in the Setlagole river approximately midway between Mafikeng and Vryburg, was first noted by A.L. du Toit [5], who described the breccia as marking a major thrust fault. This interpretation could not be verified and instead it is now speculated that it may be of meteorite impact origin.

**Field Observations:** The megabreccia is exposed in two meanders of the Setlagole river, roughly 2 km apart. Despite poor exposure, the region south of the megabreccia consists of granitic terrane, which can be followed intermittently for over 18 km to the village of Madibogo. No further breccia was recorded, but the granitic rocks are fractured, jointed and mylonitised, and in places show highly altered fracture fillings. The Setlagole megabreccia consists of countless rock fragments with angular and rounded shapes of various sizes in a dark, fine-grained matrix containing small to microscopic fragments and particles of predominantly granitic material. The lithic fragments in the megabreccia consist predominantly of granite and gneiss with rare clasts of banded iron formation, amphibolite, chert and calc-silicate rocks, all of which occur in the vicinity. The largest granitic fragment measured 6.5m x 3.5m in size. A crude gently-dipping layering is seen locally within more sandy, clast-poorer, regions. A single granite clast containing pseudotachylite in a brittle-ductile shear zone was found. Flattened irregular dark grey masses up to decimeters in length are locally deformed around the clasts. These were tentatively described as altered melt clasts, but the low-grade metamorphism has obscured any original fea-

tures, and they may be metamorphosed argillaceous clasts.

**Microscopic Observations:** The breccia matrix comprises decussate to radiating fine-grained chlorite masses that enclose highly angular mineral clasts (predominantly quartz, plagioclase and K-feldspar, with biotite, amphibole, epidote and zircon) that are derived from the same medium- to high-grade granite-greenstone source as the lithic clasts. Analysis of 62 thin sections has failed to provide conclusive evidence of shock metamorphism – quartz grains contain a variety of undulose and mosaic extinction features, deformation bands, subgrains and fluid inclusion trails whereas feldspars show twinning and undulose extinction. No planar features were found in zircon, but epidote contains sets of planar fractures. Alteration of the feldspars is variable. Biotite grains are commonly bent, rather than kinked, and variably chloritised. The chloritisation indicates that the megabreccia experienced a lower greenschist metamorphism, which has obscured the original nature of the matrix.

**Geophysical Evidence:** High density aeromagnetic data from the Council for Geoscience of the region south of the Setlagole outcrops, available on 200m line spacing flown in the late 1980s, shows a fairly faint magnetic signature, but a 7 km central core can be clearly identified, together with curved semi-concentric magnetic lineaments. Filtering techniques involving fractional derivative and circular-shaded relief algorithms have been applied to enhance the magnetic signatures (Fig. 2). The surrounding collar is not symmetrical around the core, but exhibits semi-concentric magnetic lineaments. The exact dimensions of the structure have yet to be determined, but the outer perimeter of the collar is more than 20 km in diameter and appears as an oblate ring of strong magnetic anomalies. Preliminary estimates suggest a structure of between 25-30 km diameter.

**Age Relationships:** No direct age dating of the megabreccia or the circular structure have yet been attempted. Indirect lines of evidence suggest the structure may be of Mesoarchaeon age. Firstly, the megabreccia comprises rock fragments derived from the

Archaean Kraaipan granite-greenstone basement on which it lies. Although Ventersdorp (c. 2700 Ma) [6] and Transvaal (2642-2224 Ma) [7] Supergroup rocks occur in the region, there are no fragments of these rocks in the megabreccia, suggesting that these formations had not yet been deposited at the time of impact. Secondly, the megabreccia experienced a low-grade metamorphic event not recorded in the Ventersdorp and Transvaal successions, but which is not as high as the upper amphibolite facies metamorphism seen in the greenstone fragments. Thirdly, geophysical evidence suggests that the Setlagole ring structure is cut by at least three dyke events, which show up clearly on the aeromagnetic images. Some of the dykes, which are not exposed in the Setlagole area, may be feeders to the Ventersdorp volcanic succession, while the youngest set, probably of Karoo (c.180 Ma) age, appears to have been disrupted by the 145 Ma Morokweng impact structure located 135 km to the west [8],[9],[10]. An east-west-trending dyke (Machavie dyke [8]), which cuts through the centre of the Morokweng structure, is representative of the youngest dyke event in the North West Province and is possibly of Cretaceous age (c. 142-65 Ma).

**Conclusions:** An impressive megabreccia near Setlagole pointed the way to the discovery of a sizeable ring structure, which we speculate could represent remnants of a meteorite impact structure. The age of the structure remains uncertain, but is, at the very least, older than the 145 Ma Morokweng impact structure and the 180 Ma Karoo-aged magmatic dyke event. Support for a much older age for the structure lies in the fact that the NNE-SSW-trending dykes that cut across it (Fig. 2) and the Kaapvaal Craton appear to be terminated by the c. 2060 Ma Bushveld Complex in the east, and by the c. 1890-1928 Ma Olifantshoek Supergroup rocks to the west. If this is correct these dykes may be at least pre-Bushveld in age. However, the possibility exists, on the basis of the nature of the megabreccia and its subsequent metamorphism, that the structure may have formed even earlier, in pre-Transvaal or pre-Ventersdorp times. This suggests the structure may post-date the granitoid rocks of the 2790-3160 Ma Mesoarchaean to Neoarchaean basement complex. The precise diameter of the structure is also unknown, but recent suggestions that the Morokweng impact crater may be up to 240 km in diameter [10] may imply that the outer effects of this structure overlap with those of the Setlagole structure. The origin of the megabreccia remains enigmatic. If linked to the ring structure, its location beyond the limits of the latter would suggest some form of debris flow.

**References:** [1] Anhaeusser C.R. (2007) *GSSA Geobulletin*, 50 (2), 7-9. [2] Anhaeusser C.R. et al. (2007) *GSSA*

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Fig.1 Setlagole megabreccia showing a large block (3.6m x 1.5 m) of gneissic granite in a mass of rock fragments and finer-grained chloritized matrix.

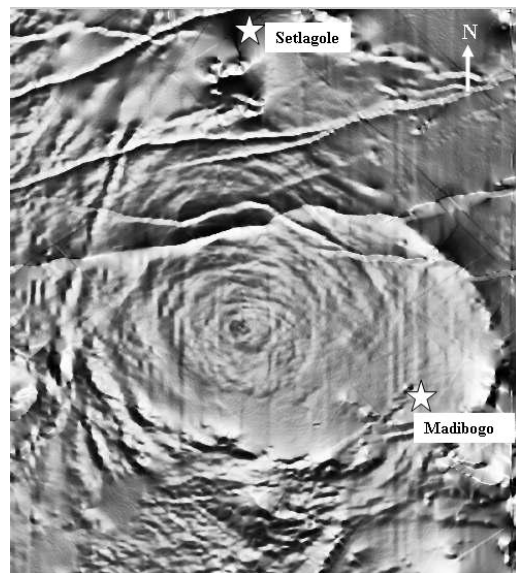


Fig. 2 Aeromagnetic image (filtered) of the Setlagole impact structure showing a central uplift, concentric rings and a variety of cross-cutting, pre-impact structure, mafic dykes. The distance between Setlagole and Madibogo is 18 km.