IMPORTANCE OF PSEUDOTACHYLITIC BRECCIA ZONES FOR UNDERSTANDING THE FORMATION OF CENTRAL UPLIFT STRUCTURES: FIELD EVIDENCE FROM THE VREDEFORT DOME, SOUTH AFRICA. D. Lieger[1], U. Riller[1], W. U. Reimold[1], R. L. Gibson[2], [1]Museum für Naturkunde Berlin, Invalidenstrasse 43, 10115 Berlin, Germany, daniel.lieger@museum.hu-berlin.de, [2]School of Geosciences, University of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa.

Objectives: Target rocks underlying the central portions of large terrestrial impact craters, such as Sudbury and Vredefort, are characterized by the pervasive presence of pseudotachylitic breccia zones, often up to hundreds of meters in width and many kilometers in length at surface. Uncertainty regarding the origin of prominent breccia zones exists in particular with regard to melt generation (i.e., friction- vs. shock-induced), melt mobility, geometry of zones, fragmentation process and timing of breccia formation with respect to the evolution of central uplift structures. Collectively, this is paramount for assessing the kinematics and mechanics of rock deformation during formation of central uplift structures in large impact structures, a major focus of numerical models. We address these issues with field-based structural analysis of pseudotachylitic breccia bodies in the Vredefort Dome, the central uplift structure of the ca. 2 Ga Vredefort impact structure.

Observations: Our structural analysis focusses on mapping the geometry, orientation, brecciation intensity, and possible indicators of melt flow in pseudotachylitic breccia zones as well as orientation of pre-impact fabrics in the outer core of the Vredefort Dome (made up of Archaean metagranitoid and gneissic rock). The breccia zones range from mm- to cm-wide veins and dm- to m-wide dikes to irregular zones of network breccias tens of meters wide.

Large breccia zones are mostly disposed radially and concentrically with respect to the centre of the Vredefort Dome, often regardless of pre-impact mineral fabric orientation. By contrast, thin pseudotachylitic veins are arranged in multiple sets, orthogonal to each other, whereby one set is often found to be concordant to pre-impact mineral fabrics. Where three-dimensional exposure permitted judgement, such as in quarries, prominent breccia zones approximate planar geometry and were found to be horizontal and vertical.

Brecciation intensity was estimated visually by taking into account breccia zone thickness, fragment-matrix ratios as well as density and shape of fragments. Outcrops characterized by high brecciation intensity seem to connect to radial and concentric zones on the scale of the crystalline core. The trend of these zones coincides with the strike of prominent breccia zones.

The geometry of breccia zone margins indicates that breccia zones are essentially fragment- and melt-filled fractures formed by dilation, i.e., volume increase. This is supported by the fact that strike separation of pre-impact mineral fabrics at the zones is generally less than a few centimetres. Therefore, breccia zones formed as tension gashes or minor hybrid shear faults. Where pseudotachylitic breccia veins overstep each other, their respective tips are curved toward the neighbouring vein, thereby isolating elliptical host rock fragments. This underscores the formation of breccia zones in terms of fracture mechanics known from upper-crustal tectonic regimes. Recognition of the pre-impact fit of marker points across pseudotachylitic veins allowed us to determine the components of maximum dilation vectors at a given outcrop surface. Measurement of the component vectors throughout the outer core of the Vredefort Dome indicates either radial or concentric stretching of material, regardless of breccia zone orientation.

Pre-impact configuration of fragments in large breccia zones and the paucity of fragments that are exotic with respect to the immediate host rock indicates that generally fragments were not transported distances larger than tens of meters. However, this may not apply for the pseudotachylitic matrix, i.e., former melt.

Conclusions: Our field observations indicate that the geometry and distribution of pseudotachylitic breccia zones is rather systematic across the outer core of the Vredefort Dome. In particular, the orientation of prominent zones and components of maximum dilation agrees with a strain field characterized by radial and concentric stretching of rock. Such a strain field is compatible with the terminal stages of central uplift formation inferred from numerical modelling, i.e., gravitational collapse of the central uplift. Thus, transport of melt and its pooling in (low-pressure) dilation zones seems to have been controlled by the overall strain field. By contrast, the geometry of minor sets of pseudotachylite veins and their geometric relationship to pre-impact mineral fabrics may be explained in terms of decompression of rock upon rapid uplift and removal of overburden. The dilational nature of melt-filled dislocations seems to exclude generation of melt by frictional sliding on these dislocations.