Formation of fragment-rich pseudotachylite zones during central uplift formation in the Vredefort Impact Structure, South Africa. D. Lieger[1], U. Riller[2], W. U. Reimold[1], R. L. Gibson[3], [1]Museum for Natural History (Mineralogy), Humboldt University, Invalidenstrasse 43, 10115 Berlin, Germany (daniel.lieger@museum.HU-Berlin.de), [2] School of Geography and Earth Sciences, McMaster University, Hamilton, Canada, [3]Impact Cratering Research Group, School of Geosciences, University of the Witwatersrand, Private Bag 3, P.O. Wits 2050, Johannesburg, South Africa.

Introduction: Target rocks underlying the central portions of large terrestrial impact craters are characterized by the pervasive presence of fragment-rich pseudotachylite bodies. Debates regarding the formation of these bodies include the origin of pseudotachylitic melts, i.e., friction- versus shock-induced melting, melt mobility, causes of target rock fragmentation, as well as timing of fragmentation and melt emplacement with respect to stages of cratering. In order to better understand these processes, we conducted a detailed analysis of pre-impact mineral fabric orientation and pseudotachylite bodies in the core of the Vredefort Dome, the relic of the central upift of the 2.02 Ga Vredefort impact structure.

Results: Our field-based structural analysis focussed on mapping of pre-impact planar mineral fabrics and structural properties of fragment-rich pseudotachylite zones, such as geometry, orientation, brecciation intensity of the zones (Fig. 1). Trajectories of inclined mineral fabrics show that NW-SE striking fabrics prevail in the core centre, whereas circumferential fabric strike is found close to the core-collar boundary. The fabric symmetry is consistent with vertical stretching and uplift of the inner core and outward rotation and dilation in the outer core zone as is predicted by numeric modelling at the erosion level [1].

The geometry of pseudotachylite zone margins and fragments indicates that the zones are essentially fragment- and melt-filled fractures formed by dilation, i.e., volume increase of target rock in the central uplift. This is supported by the fact that strike separation of pre-impact markers at the zone boundaries is generally less than a few centimetres. Thus, the zones formed as tension gashes or hybrid shear faults. Where pseudotachylitic veins overstep each other, their respective tips are curved toward the neighbouring vein, thereby isolating elliptical host rock fragments. This underscores the formation of pseudotachylite zones in terms of fracture mechanics known from brittle deformation.

Fragments in pseudotachylite zones are almost exclusively derived from the immediate host rock, generally display jigsaw geometry, vary greatly in size and are angular to well-rounded. Generally, fragments are more angular and elliptical near zone margins and more rounded and circular in the interior of zones. The traces of pre-impact mineral fabrics on outcrop surfaces suggest that the fragments underwent limited but progressive rotation with increasing distance to zone boundaries. This can be accounted for by rotation of fragments in a viscous medium, such as melt.

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 indicate 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.

Interpretation: The well-developed centro-symmetric patterns of distribution, geometry, brecciation intensity (Fig. 1) and maximum dilation directions of pseudotachylite bodies correspond kinematically to the variation in total strain predicted by numerical modelling [1]. Structural properties of the bodies suggest that pseudotachylitic melt is allochthonous and was emplaced at an advanced stage of cratering into tensional fracture zones within the crater floor. Both, concentration of bending strains imparted on target rocks during central uplift formation and thermal stresses induced by the emplacement of allochthonous melt led to fragmentation of target rock. Tensional fracture zones opened in an overall dilational strain field towards the end of cratering and formed low pressure zones, into which melt was likely forcefully drawn. Melt may have been drained from the overlying impact melt sheet or from sites within the crater floor and transported into fragment-rich dilation zones. Our field-based analysis failed to identify the presence of shear faults that could potentially have generated *in situ* frictional melts and fragments. Rather, target rock fragmentation and melt generation that resulted in fragment-rich pseudotachylite bodies are processes separated in space and time during cratering.

References: [1] Ivanov, B. A. (2005) *Sol. Syst. Res., 39*, 381-409.

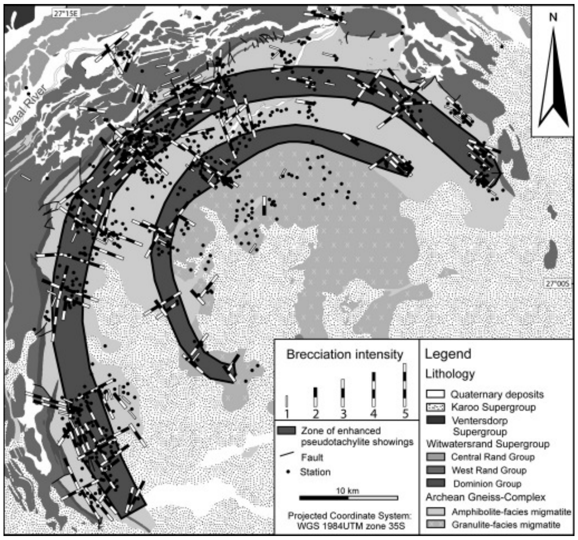

Fig.1: Geological map of Vredefort Dome showing the centro-symmetric distribution and brecciation intensity of fragment-rich pseudotachylite zones.