THREE-DIMENSIONAL MODELING OF GROUND-TRUTH DATA - A NEW APPROACH FOR UNDERSTANDING THE SIGNIFICANCE OF PROMINENT DISCONTINUITIES DURING FORMATION OF THE VREDEFORT CENTRAL UPLIFT, SOUTH AFRICA. A. Jahn1, U. Riller2 and W. U. Reimold3; 1Museum for Natural History (Mineralogy), Humboldt University, Invalidenstrasse 43, D-10115 Berlin, Germany (Andreas.Jahn@museum.hu-berlin.de), 2McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4K1, Canada.

Introduction: In order to investigate the subsurface structure of the Vredefort dome, the central uplift of the 2.02 Ga Vredefort impact structure, structural, petrological and geophysical work [1, 2, 3], as well as numerical modeling [4], have been conducted. Based on these studies and new ground data, we constructed a 3D structural model for the upper parts of the central uplift. In particular, we present a new interpretation of a fault system in the northern collar that has been proposed to be a pre-impact half-graben [5]. Our modeling results are more consistent with an impact-induced suite of normal and reverse faults in this area.

The Vredefort Dome is the eroded remnant of the collapsed central uplift structure [1]. The inner core of the Dome is approximately 40 km in diameter and consists mainly of Archean (> 3.1 Ga) granitoids and minor mafic intrusions. It is surrounded by the collar, an assembly of steeply dipping and overturned sedimentary and volcanic strata of Paleoproterozoic (3.07 - 2.1 Ga) age. To the north and west, the collar rocks are well exposed and form a series of concentric, morphologically prominent quartzite ridges, and valleys along less resistant shale horizons, wrapping around the crystalline core. To the east and the south, the central uplift is largely covered by the Phanerozoic Karoo Supergroup and Quaternary deposits.

Methods: In a field campaign in 2007 we collected structural data, mostly in the northwestern collar region, and created a detailed map of bedding plane orientations and faults identifiable in outcrop. Combining surface structural data with seismic data and information from drill holes we used the software ArcGIS and GOCAD to construct a 3D model of the respective collar strata. For the visualization of the rock orientations we chose prominent lithological interfaces within the Archean sediments (West Rand and Central Rand Group) as marker surfaces. We also included a number of major faults known from previous field studies [6] and geophysical imaging. In order to test the plausibility of our results, we compared them to those of predicted by numerical models [3].

The construction of a 3D multi-surface model characterized by impact-induced faults allowed us to identify coherent rock domains and their possible displacement during collapse of the central uplift. The model is limited by the exposure of pre-impact rocks and, therefore, to the northwestern quadrant of the central uplift.

Results: The dips of inclined to steeply dipping, overturned sedimentary strata in the collar region increase from < 60° to 70-90° at a depth of 2 to 3 km (Fig.1). Hence, the current erosion surface is situated within the hinge zone between the steeply dipping strata and the overturned parts in the roof of the collapsed central uplift [4]. This observation agrees with erosion of 6 to 8 km. The dip of bedding planes also varies with the individual domains defined by faults. Generally, the bedding planes display maximal rotations in the northwest, but this may be blurred by differential rotation between adjacent domains (Fig.2).

On the km-scale, a significant number of faults is exposed in the collar. Most of them are either concentric or radial faults with respect to the centre of the Vredefort Dome. Concentric faults strike parallel to the outcrop lines of strata, but intersect the strata. Thus, thicknesses of strata are reduced by movements on concentric faults. Radial faults, however, are more curved at surface, listric in geometry and displace concentric faults.

Conclusions: Our field structural analysis revealed the existence of a set of faults with variable orientations and truncation relationships. The observed fault geometry does not support the hypothesis of a simple pre-impact normal fault system that led to the formation of a half-graben.

Rather, the geometry and geometric relationship of bedding and fault surfaces point to impact-induced deformation. The shape and orientation of the faults with respect to orientation of bedding planes excludes an origin of the faults in their current orientation. Concentric faults formed likely by reverse sense of slip toward the crater centre and appear to be younger than the collapse of the central uplift. By contrast concentric faults are displaced by radial ones, which were tilted later. Consequently, the concentric faults must have formed during an early stage of crater modification.

Back rotation of the collar strata to their pre-impact orientation leads us to the following kinematic model of faulting during central uplift formation.
Back rotation of the concentric faults by the same rotation magnitude as bedding planes, suggests an origin of these faults as normal faults. Thus, concentric faults are likely relics of discontinuities accomplishing terracing of the rim of the transient cavity. The geometry of concentric faults was subsequently modified by radial faults which formed as reverse or thrust faults. Overall, the fault kinematics point to a constrictional rock flow, which is compatible with the formation of the central uplift by crater-inward mass flow. As a consequence of convergent rock flow toward the crater centre, the strata and faults were uplifted and rotated as well as displaced outwards with respect to the crater centre. This kinematic model does not require pre-impact normal faulting to account for the observed fault geometry and seems crudely to account also for other sectors of the collar.

**Figure 1:** Three-dimensional model of the complex fault pattern. Displayed are the top (yellow) and base (orange) of the Central Rand Group that is cut by concentric and radial faults (transparent green). The vertical extent of this section of the model is 3km below the surface.

**Figure 2:** Maps of the study area. (A) Detailed structural map of the Witwatersrand Supergroup in the northern collar. The dashed lines indicate the extent of the bedding planes in the model, the full lines show the modeled faults. (B) Inset shows the extent of the map area within the Witwatersrand Basin region.