STRUCTURAL INVESTIGATIONS IN THE CENTRAL UPLIFT OF THE UPHEAVAL DOME IMPACT CRATER, UTAH.

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Introduction: The Upheaval Dome structure is a morphological expression of variously deformed sedimentary rocks in the otherwise relatively flat lying rocks of the Colorado Plateau in SE Utah. It has been identified to be an impact structure by early workers such as Shoemaker et al. in 1983 [1]. Even though Jackson et al. [2] proposed a concurring genetic theory of salt tectonics, geological [3] and geophysical [4] contributions as well as recent rock mechanical evidence [5] provides us with the impact-theory as the most favorable starting point for a kinematic model of the structure's genesis. Using geological and structural features, which were mapped during a field campaign in the innermost part, comprising of layered Triassic rocks (Chinle & Moenkopi formations), we generated a 3D-model using ArcGIS and the 3D-Analyst by ESRI. In addition to the mapping, several samples of the outcropping lithologies were taken to compare their microstructure with respect to those of undeformed samples in later work. By combining field observations with the visualization benefits of a 3D-model, important structural elements, their lateral development and relevance for uplifting material shall provide helpful insights on the formation of a central uplift in a layered target. The spatial distribution of the dipping strata, faults, folds and cataclastically deformed rocks were used for imposing constraints on the kinematics of central uplift formation during crater collapse. The work is in progress and displayed are the results so far. Further processing of the data shall result in a structure-map of marker horizons, the 3D-visualization of faults and eventually a balanced restoration of movements during crater collapse.

Structure and Deformation: The mapped units mainly consist of terrigenous clastic lithologies and are dominated by sand- and siltstones. Their deformational behavior range over a large scale though aren't everywhere visible due to distributed faulting and weathering. Close spaced fracturing is abundant over the entire structure and even though only small individual offsets (mm-cm) can be observed (Fig. 1), their accumulation might result in remarkably strain on a macroscale. On a dm- to m-scale, intraformational thrusting in a ramp-flat-geometry is common in stratified units such as the Jurassic Kayenta Formation or the Chinle and Moenkopi Formations. While concentric shortening, bound to reverse faults or folding, is well localized at the perimeter, the fault pattern gets more complex and diffuse towards the center. Anyhow, several major thrust faults are traceable from the margin of the mapped area towards the center and allow to distinguish blocks of relatively less internal deformation. Their radial arrangement [6], likewise reported from the Spider Impact Structure [7] in an iris-like fashion, appears to allow the accommodation of vertical displacement by stacking of inward flowing material. The amount of displacement increases centerward and is sometimes seen to develop from a radial striking fold, eventually indicating thrust direction by its vergency.

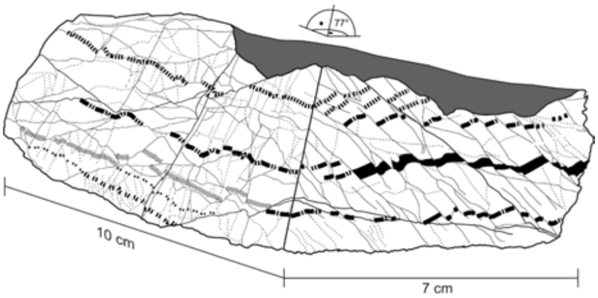

Fig. 1: Blockview of Church Rock sample (Chinle Fm)

Clastic dikes [2,3] of different lithologies occur throughout the structure but concentrate in the center, where the White Rim Sandstone (Permian), as the lowermost outcropping unit, forms a complex dike network [7]. It's proximity to the overlying Hoskinnini Member suggests short transport distances. Other dike occurrences are generally smaller and the determination of their protoliths is future work, but can on first sight by means of color and mineralogy be restricted to high-porosity sandstones. In several locations, sandstones of various lithologies, though not displaced as dikes, display thickening with a massive appearance and the loss of sedimentary structures.

Rock masses within Wingate Sandstone (~100 m thick unit overlying the Triassic formations mentioned above) that outcrop at the perimeter of the inner depression appear to have undergone some ductile deformation similar to the dike rocks. Besides folding, due to convergent material flow, in some places the rock became displaced into the hanging wall unit with dike-like crosscutting relationships. The downward displacement of these rock masses apparently affected the internal geometry of the central uplift during its formation as seen from a normal fault overprint of a reverse fault structure.

3D-Model and data processing: The GIS-database (Fig. 2) consists of a DTM (A), polygons (e.g. outcropping units, B), lines (e.g. faults, C) and points (e.g. dips, D). The result is a DTM covered with geological signatures (E). Besides our own mapping of the innermost part, further information was taken from the works of [2] and [3].

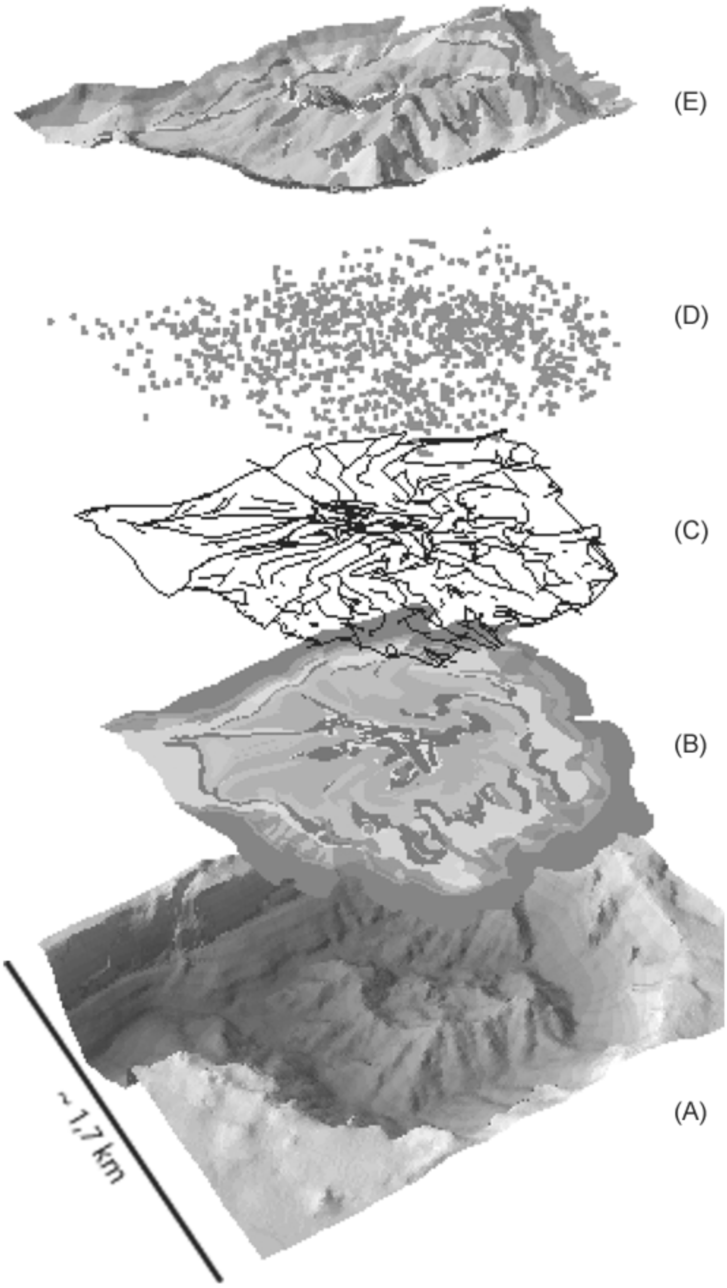

Fig. 2: Components of 3D-geological model.

Using spatial analytical tools, such as geostatistical interpolation for generating surface data from point information, we processed the data, generating thematic maps. Fig. 3 shows a dip-map (interpolation via kriging), that lines out the spatial variance of dip angles. Since the Kayenta Formation, just inside of the ring syncline, is a well stratified (and traceable) unit, distributed intraformational faulting, makes for strong varying dip-angles that reach high values, and results in thickening of the unit [6]. Even though a canyon cuts through the WNW' perimeter of the structure, there seems to be some symmetry with low dip-angle sectors in the WNW and ESE, since comparing dip-angles with topographic height showed no significant trend. This spatial variation might reflect an oblique impact scenario as proposed earlier [6], striking WNW-ESE.

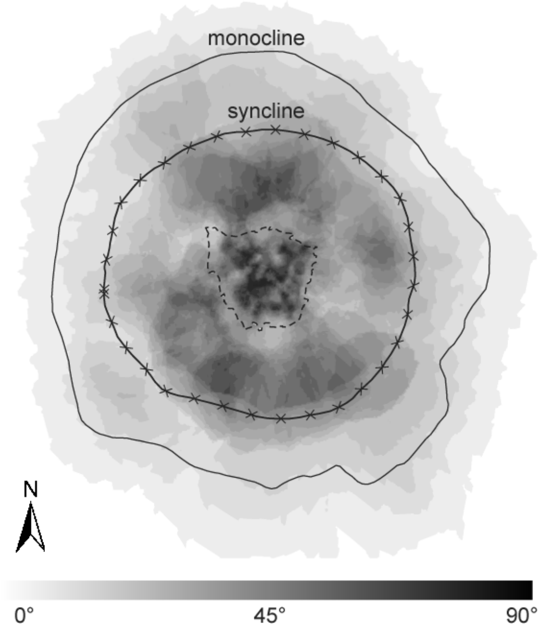

Fig. 3: Dip-map. Inner polygon is the mapped area.

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