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Constraining the timing and geometry of shock features, polyphase folding and faulting in the Vredefort central uplift, South Africa

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The formation of central uplifts in complex impact craters remains one of the most poorly understood aspects of cratering mechanics. Numerical modelling is able to explain the varying gross morphologies of central uplifts but not the internal complexities that arise from the heterogeneities within layered targets. In the Vredefort Dome – the 90 km wide, deeply exhumed, central uplift of the world's largest impact structure –the crystalline basement core is surrounded by a 25 km wide collar of layered supracrustal and intrusive rocks that show complex macroscopic deformation features. This study examines the geometry and sequence of formation of complex fold, fault and microstructural deformation features induced by the impact in metasedimentary rocks of the lower Witwatersrand Supergroup located ∼22 km from the centre of the dome in the WNW collar. The principal findings are: (1) a pair of pervasive, cm-spaced, orthogonal shatter cleavages, marked by strong grain size reduction in quartzite, lie with a bisector rotated 18° counterclockwise from the centre of the dome; these are attributed to passage of the shock wave; (2) polyphase macroscopic folding on a scale of hundreds of metres comprises a set of overturned, centrifugally-verging folds with moderately steeply centripetally dipping axial planes and horizontal tangential hinges that show some fault displacement, and a set with upright axial planes trending oblique to the strike of the collar; (3) a network of pseudotachylite-bearing faults with oblique- to normal-slip displacements of up to a few tens of metres that are oriented oblique to the strike of the collar and that show some preferred orientation parallel to the upright fold set. The folds and faults identified in this study do not conform to the radially-trending, centripetally-plunging folds and strike-slip faults previously identified in the dome as related to constriction during initial rise of the central uplift. Their orientation and origin is best explained by slightly later outward collapse of the central uplift. These results suggest that detailed structural mapping of the layered target rocks in central uplifts can help discriminate between different stages in the formation of central uplifts, with the Vredefort Dome presenting information for both giant craters and deep levels (∼10 km below surface).