# Variations in shock features among country rock and lithic clasts in granophyre at the Vredefort impact structure, South Africa

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The Vredefort Granophyre represents impact melt injected downward into fractures in the floor of the Vredefort impact structure, the largest and oldest terrestrial impact structure documented (Therriault et al., 1996; Gibson and Reimold, 2001). Rock fragments from a variety of depths were included in this impact melt. These lithic clasts include metasedimentary rocks from relatively shallow stratigraphic units (e.g., the Transvaal Supergroup) and Archean granitoids from deeper levels. During the 2 by since impact, the structure was eroded by 8-10 km and the shallow units were removed (Gibson et al., 1998).

Planar deformation features (PDFs) in quartz are one of the few features that unambiguously indicate shock metamorphism due to hypervelocity impact (e.g., French, 1998). These features form at shock pressures of 8-30 GPa and are parallel to important crystallographic orientations in quartz (e.g., Stoffler, 1971). At the Vredefort Dome, the deeply eroded central uplift of this complex impact structure, PDFs occur in quartz in the Archean granitoids and the overlying metasedimentary rocks of the Witwatersrand System (Grieve et al., 1990; Leroux et al., 1994). Orientations of PDFs from these country rocks are predominantly parallel to the quartz basal plane (Grieve et al., 1990; Leroux et al., 1994). Grieve et al. (1990) suggested that other orientations were originally present, but were largely destroyed by post-impact metamorphism. Quartz grains with PDFs also occur in the Vredefort Granophyre in rare lithic clasts of moderately metamorphosed sedimentary rocks, which probably were derived from shallower supracrustal sequences (Transvaal and Witwatersrand supergroups). Orientations of these PDFs are similar to those reported from other impact structures with a predominance of omega orientations and significant proportions of pi, s, and rho orientations.

There was a relatively steep gradient in shock pressure and post-shock temperature from the center of the dome to the outer parts and, hence, the Archean granitoids and overlying Witwatersrand metasediments were exposed to varying degrees of post-shock metamorphism (Gibson and Reimold, 2001). However, both lithic clasts from the Vredefort Granophyre and immediately adjacent country rocks in the center of the structure were at similar post-impact depths and experienced similar levels of post-impact metamorphism. Hence, the anomalous basal orientations of PDFs in quartz from the country rocks might not caused by preferential destruction of other orientations by metamorphism. Another possible interpretation is that these orientations are the result of differences in the mechanisms by which PDFs are formed in quartz by high shock pressures under conditions of high temperature and/or confining pressure compared to low temperature and/or confining pressure. These results have significant implications for the formation of shock features in a variety of planetary environments, including large impact craters on other planets (e.g., Mars) and asteroids (e.g., 4 Vesta).

References: French (1998) Traces of catastrophe. LPI Contribution 954, Houston, Texas, 130pp. Gibson et al. (1998) Geology 26, 787-790. Gibson and Reimold (2001) Memoir 92, Council for Geoscience, Pretoria, 111pp. Grieve et al. (1990) Tectonophysics 171, 185-200. Leroux et al. (1994) Tectonophysics 230, 223-239. Stoffler (1971) J. Geophys. Res. 76, 5541. Therriault et al. (1996) S. Afr. J. Geol. 99, 1-21.