Distinguishing shock-related microstructures in gneisses from the Vredefort impact structure, South Africa. F. Dellefant[1], C. A. Trepmann[1], S. A. Gilder[1], I. Sleptsova[1], M. Kaliwoda[2], and B. P. Weiss[3], [1] Department of Earth and Environmental Sciences, Ludwig-Maximilians-University, [2]Mineralogical State Collection Munich, Ludwig-Maximilians-University, [3]Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology

Abstract: Shocked gneiss (~8 GPa) from the Vredefort impact structure (South Africa) contains planar fractures in quartz decorated by magnetite and ilmenite, which are commonly attributed to the impact event. However, the surface at Vredefort is riddled by lightning strikes that also produce rapid pressure-temperature pulses that can modify the microstructure and the magnetic properties of the rocks [1], [2]. To understand the differences between lightning and impact-related shock effects, we investigated samples from two, 10 m-deep drill cores (-26°97'S, 27°24'E) [2] by Raman spectroscopy, polarized light microscopy/U-stage and electron microscopy/electron backscatter diffraction techniques. Magnetite and ilmenite within planar fractures in quartz occur at all depths (Fig. 1). Therefore, they cannot be correlated to the rock magnetic lightning effects limited to the top 100 cm of the cores [2] and are intrinsic to the impact event, independent of lightning.

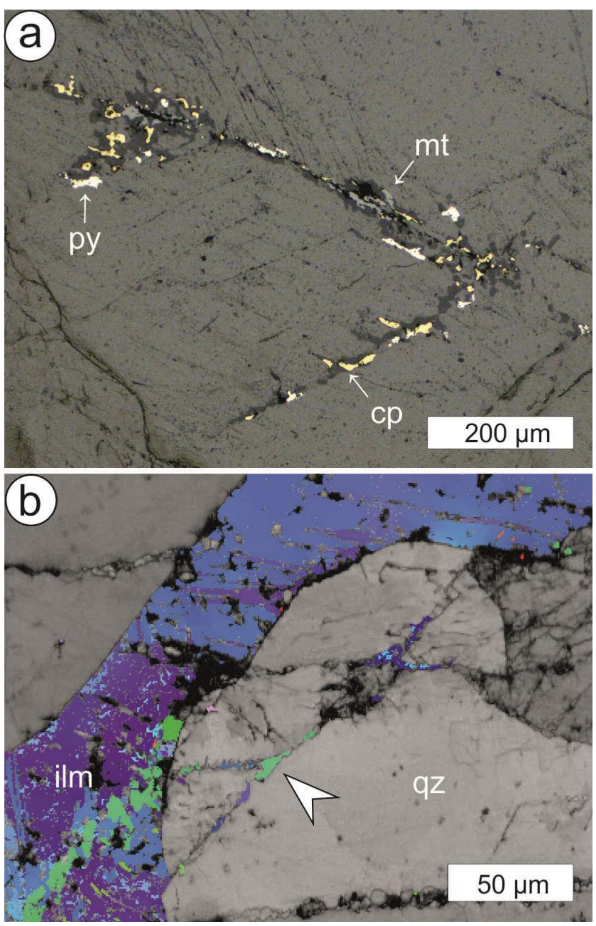

Fig. 1. Meteorite impact shock effects in iron-bearing minerals in the drill core samples. a) Magnetite (mt), pyrite (py), and chalcopyrite (cp) along planar fractures in quartz. Photomicrograph taken with reflected light of sample V2 4.2 (33 cm depth). b) Electron back scatter diffraction map displaying the crystallographic orientations of an ilmenite host grain (ilm) and ilmenite along planar fractures in quartz (qz), indicated by the white arrow. Sample V3 2.1 (5 cm depth).

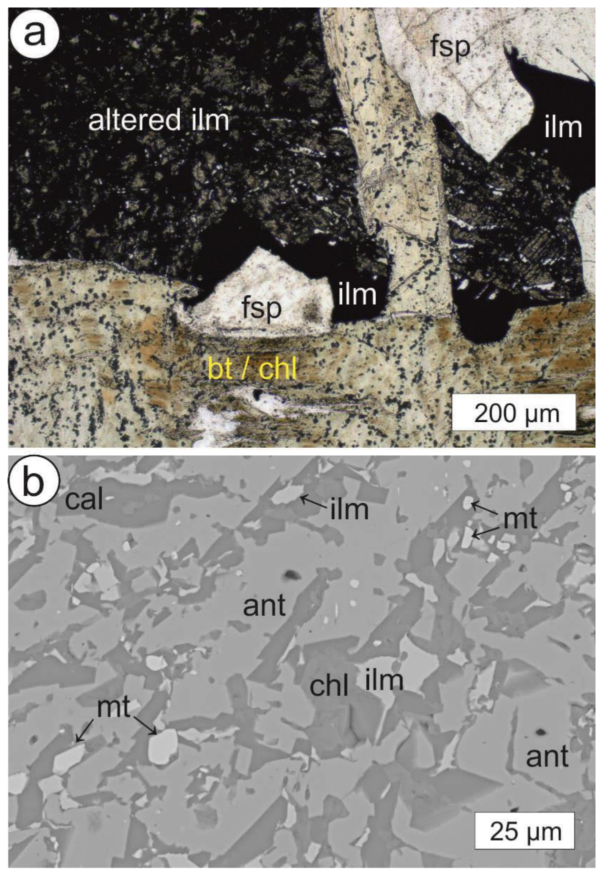

Fig. 2. Lightning effects in iron-bearing minerals in samples within 80 cm of the surface. a) Altered ilmenite in contact to biotite, which is partly replaced by chlorite (bt / chl). Note the not altered ilmenite in contact to feldspar (fsp). Photomicrograph taken with polarized light, sample V3 2.1 (5 cm depth). b) Ilmenite alteration microfabric, which consists of anatase (ant), chlorite (chl), calcite (cal), and residual ilmenite fragments (ilm). Magnetite grains (mt) with smoothly curved boundaries. Back scattered electron image, sample V3 3.16 (26 cm depth).

Primary iron-bearing minerals were locally heated by the generation of shear fractures in neighboring minerals, leading to micrometer-scale melt intruding into nearby fractures (Fig. 1). Frictional heating and rapid quenching of feldspar and quartz is indicated by localized, fine-grained aggregates along intragranular planar fractures as well as transgranular pseudotachylytic veins. On the other hand, altered ilmenite grains with exsolved magnetite occur only in gneisses from the uppermost 80 cm of both drill cores (Fig. 2). When in contact with biotite (Fig. 2a), the ilmenite-magnetite boundaries are altered to chlorite and the ilmenite is partly transformed to anatase (Fig. 2b). These alteration products contain fine-grained magnetite. It appears that lightning strikes altered the existing ilmenite-magnetite in the Vredefort samples to produce smaller, more single-domain like magnetite grains, consistent with the observed high remanent coercivity and the high- and low-temperature Verwey transitions of the samples [2].

References: [1] Carporzen, L. et al. (2006) *Earth Planet. Sci. Lett.*, 251, 305–317. [2] Carporzen L. et al. (2012) *J. Geophys. Res.*, 117, 1–17.