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Distinguishing shock-related microstructures in gneisses from the Vredefort impact structure, South Africa

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Shocked gneiss (~8 GPa) from the Vredefort impact structure (South Africa) contain 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, which also produce rapid pressure-temperature pulses that can modify the microstructure and the magnetic properties of the rocks. To understand the differences between lightning and impact-related shock effects, we investigated samples from two, 10 m-deep drill cores 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, and are therefore intrinsic to the impact event, independent of lightning. Primary iron-bearing minerals were locally heated by the generation of shear fractures in neighboring quartz, leading to small volumes (micrometer scales) of melt intruding into nearby fractures. 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. When in contact with biotite, the ilmenite-magnetite boundaries are altered to chlorite, and the ilmenite is partly transformed to anatase. 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 magnetic properties of the samples