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Tectonic vs impact zircon deformation: from the Vredefort impact structure to the Moon tectonics, a possible key to understand different geological processes

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Impact-produced pseudotachylites are abundant in the core of the Vredefort impact structure, affecting all pre-impact lithologies [1,2]. However, pre-impact tectonic pseudotachylites might also occur in the same rocks [1]. In the absence of convenient and robust distinguishing criteria, all pseudotachylites found within the Vredefort impact structure are commonly assumed to be impact-related [3].

A sample from metamorphosed granitic basement, collected in approx. 13 km NW from the Inlandsee – the geographical center of the crater, contains two pseudotachylitic veins. Vein 1 is parallel to the metamorphic foliation, has consistent thickness and locally is folded. It contains a moderate amount of relatively undeformed and rounded clasts, and reveals a high re-crystallization degree. In contrast, Vein 2 cuts the foliation at sharp angles, is undeformed and shows variable thickness and geometry at cm scale. Vein 2 contains multiple angular mosaic clasts, is cryptocrystalline and crosscuts Vein 1. Crosscutting relationships and the different degree of deformation and re-crystallization point to an earlier crystallization of Vein 1. Moreover, the irregular geometry and thickness of Vein 2, and a large amount of highly strained clasts, suggest a different mechanism of Vein 2 formation.

Deformed zircon is present in both veins. Vein 1 hosts zircon with a lower degree of internal strain compared to either Vein 2 or host rock. However, zircon from Vein 1 reveals planar deformation bands (PDBs), which are evidence of seismicity, as they were found in zircon from co-seismic zones [4,5,6]. Zircon from Vein 2 is highly-strained and contains abundant shock microtwins, which represent a robust evidence of shock deformation [7,8]. This suggests that Vein 1 originated from pre-impact tectonics, whereas Vein 2 is unambiguously impact-related.

The association of specific deformation microstructures in zircon with particular deformational settings provides hints on the hosting pseudotachylite origin. Moreover, internal microstructures in zircon could be the origin key for grains that have been removed from their geological context. A possible implication of our finding is that the deformation histories of some reported zircon grains might need revision. The deformation features associated with zircon from Apollo 17 breccia 72215, "The Oldest Zircon" [9,10], are PDBs rather than shock microtwins, and, therefore, are not directly linkable with impact processes. Even though this does not necessarily imply tectonic activity on the early Moon, as tectonic-like processes can also occur during the modification stage of impact cratering, our finding suggests that the interpretation of deformation features in zircon should be reconsidered and supported by experimental work.

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