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Global warming after the Snowball Earth glaciation: The search for an extraterrestrial component

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The so-called Snowball Earth hypothesis states that the Sturtian ($\sim$ 710 Ma) and Marinoan glaciations ($\sim$ 635 Ma) were of global extent and may have lasted for several million years [1]. Neoproterozoic glacial deposits often lie beneath cap dolostones that have been linked to a sudden warming at the termination of the proposed "Snowball Earth" glaciations. Bodiselitsch et al. [2] measured an Ir anomaly in sediments just below the cap dolostones, which was explained as an accumulation of meteoritic material on the ice sheets due to low sedimentation rates over millions of years and the subsequent deposition of Ir-enriched sediments when the ice melted. However, it is also possible that the Ir anomaly was due to a large bolide impact and, if so, this may have triggered the end-Snowball Earth warming. A thorough analysis of the transition layers from glaciogenic diamictites to postglacial cap carbonate sediments is needed if one looks for evidence of a possible meteorite impact, such as shock metamorphism. Here we present the results of preliminary investigations into a Snowball Earth meteorite impact hypothesis.

Our samples were collected from the glaciogenic Chuos (Sturtian) and Ghaub (Marinoan) formations of the Neoproterozoic Otavi Group in NW-Namibia. All the samples are so-called cap dolostones, showing different colour ranges from pale gray to red and black (depending on their iron content). A variety of petrographic and geochemical analyses have been conducted to search for potential evidence of a meteorite impact event at the onset of deglaciation. The sedimentary structures and petrography of thin sections were studied with optical microscopy. Micro-Raman spectroscopy was utilized to study crystal defects and determine the composition of detrital feldspars. Geochemical analyses were conducted with INAA and XRF. The cathodoluminescence (CL)microscope was used to detect carbonate cement structures and detrital minerals. Mineral phases were identified in sample powders using XRD. Representative parts of our samples were dissolved with formic acid to estimate their carbonate content and conduct mineral separations.

In petrographic thin sections the mineral composition consist of mostly carbonates (80-100%), with very low abundance of detrital minerals (0-5%).The carbonate cement shows mainly block- and stalactite-cement structures surrounded by brighter CL rims. Several synsedimentary structures, such as convolution, microfolds, listric faults, and stylolites occur in the samples.

Detrital mineral separation is needed to confirm the possible presence of shock metamorphic effects. Therefore, the carbonates have to be dissolved before the separation procedure.

The quartz has mostly diagenetic origin (no CL-color), which occur as cement, or fracture-filling material. A few detrital quartz grains contain PFs -but no PDFs- but this is insufficient to confirm shock metamorphic origin. On the other hand a few calcite grains show a dense lamellae system which might be due to dislocations according to Langenhorst [3], therefore a TEM-study is required for decision.

Heavy minerals are concentrated in the fine-grained fractions of the samples, which show bright yellow (zircon) and pink (spinel) CL-color. The feldspar compositions are microcline and albite. According to our preliminary trace element analyses of the bulk samples, the Fe/Ni, Ni/Cr, Co/Cr ratios are all together near or below normal crustal ratios.

Although some detrital minerals from transition layers contain crystal lattice defects, in our opinion this is not a clear evidence of an meteorite impact. At this time, no definitive impact signatures have been found in our Namibia samples. Before abandoning the impact hypothesis, additional analyses are planned to look for impact evidence in the Snowball Earth cap carbonates. These include the search for shocked quartz grains among detrital minerals and for geochemical anomalies in our trace element measurements of the separated silt fraction.

Literature:

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