



A Siderian Snowball Earth? Multiscale and interdisciplinary Analyses of the Makganyene Formation, South Africa

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Snowball Earth events, or at least intense glaciations, belong to one of the most important types of events in Earth's Deep Time climate record. The Siderian (2.45–2.22 Ga) contained several such events, during which a diamictite-dominated succession named the Makganyene Formation was deposited in the Griqualand West Basin, South Africa. By comparison to their younger cousins in the Cryogenian, Siderian diamictites have been subject to comparatively less sedimentological investigation, although they have much potential in terms of reconstructing aspects of paleoclimate and former ice-sheet behaviour. In this study, multiscale and interdisciplinary analyses of both field and core data provide new insights into the sedimentology and deposition of the Makganyene and thereby aspects of its associated glaciation in the Siderian. Outcrop and core descriptions were supplemented by polarised light microscopic and scanning electron microscopic analyses, including element distribution maps for Al, Ca, Fe, Mg, Si and Ti. We propose that the deposits are the record of grounding zone wedge (GZW) deposition at the ice margin, with a contribution of iceberg-rain out, subglacial deposition and localised mass flow deposition playing a role. We show how interdisciplinary perspectives enrich the overall picture and allow a more accurate interpretation of the Makganyene Formation as a glaciogenic sediment.