



Microbialite recovery in the aftermath of the Sturtian glaciation: Insights from the Rasthof Formation, Namibia



Erwan Le Ber^{a,*}, Daniel P. Le Heron^a, Gerd Winterleitner^a, Dan W.J. Bosence^a, Bernie A. Vining^{a,b}, Fred Kamona^c

^a Earth Sciences Department, Queen's Building, Royal Holloway University of London, Egham, Surrey TW20 0EX, UK

^b Baker Hughes, Bentley Hall, Blacknest, Alton, Hampshire GU34 4PU, UK

^c Geology Department, University of Namibia, Windhoek, Namibia

ARTICLE INFO

Article history:

Received 6 February 2013

Received in revised form 1 May 2013

Accepted 8 May 2013

Available online 16 May 2013

Editor: B. Jones

Keywords:

Cap carbonate

Stromatolites

Cryogenian

ABSTRACT

Ice sheet meltback in the aftermath of the Sturtian (mid Cryogenian) glaciation was accompanied or followed by deposition of thick carbonate successions. In northern Namibia, the Rasthof Formation is a 200–400 m thick cap carbonate sequence divided into (1) a basal cap dolostone, (2) a microbial member and (3) an epiclastic member. This subdivision applies for > 100 km along strike at the southern and western edges of the Owambo Basin. In this paper we focus essentially on macrofacies of the cap dolostone and the microbial member. Cap dolostones are commonly interpreted as subtidal to deep water deposits, with delicate mm thick laminae. We describe well-preserved, ungraded hummocky cross-stratification in the cap dolostone, expected to occur no deeper than the offshore transition zone. The overlying microbial member contains thickly laminated microbialites with folded and contorted intervals interpreted as soft-sediment deformation structures. The thickly laminated microbialites are followed by more thinly laminated microbialites, with “roll-up” structures and more unusual individual, vertical stromatolite morphologies. We interpret the vertical growths in the microbial member as a direct response to the changing environment. The new observations and interpretations presented in this paper contrast with previous work on the Rasthof Formation. We recognise a relatively shallower setting associated with a trend in the geometries of the microbial member.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

The style and intensity of glaciation, together with the nature of post-glacial climatic recovery, from the Sturtian icehouse event remain vigorously debated (e.g. Eyles and Januszczak, 2004, 2007; Fairchild and Kennedy, 2007; Allen and Etienne, 2008; Eyles, 2008; Le Heron et al., 2011; Le Heron, 2012). At least two glacial events punctuated the Neoproterozoic, the older Sturtian (750 Ma) and the younger Marinoan (635 Ma) event, sediments from which are preserved worldwide, including northern Namibia. The glaciogenic sediments are sharply overlain by a ~10 m cap dolostone unit, with mm thick laminae (Hoffman and Schrag, 2002; Shields, 2005; Hoffman et al., 2007). The cap dolostones deposited after the Marinoan glacial event have unusual features such as sheet-crack cements, low angle cross stratification, tube structures, tepee-like structures, giant wave ripples and seafloor crystal fans (Corsetti and Grotzinger, 2005; Corkeron, 2007; Hoffman et al., 2007; Hoffman and MacDonald, 2010; Rose and Maloof, 2010). They are more widely studied than the post Sturtian cap dolostones, in which these features are absent. Cap dolostones represent a real challenge in terms of interpreting

sedimentation processes, timing of deposition and paleoenvironment interpretation (Hoffman et al., 2007; Loyd and Corsetti, 2010; Rose and Maloof, 2010; Kennedy and Christie-Blick, 2011). The cap dolostones often represent the base of what is termed the “cap carbonate sequence” (Hoffman and Schrag, 2002); sediments overlying the cap dolostone can include massive carbonates, transgressive shales or siltstones (Shields, 2005). In this study, we describe and interpret a cap carbonate sequence – the Rasthof Formation – preserved above a Sturtian glacial succession in Namibia. The scope of our study includes both the cap dolostone and its overlying microbialites.

Several recent studies focused on the Rasthof Formation in north-west Namibia with observations made on the cap dolostone and the microbialites. Publications cover several disciplines, encompassing outcrop studies (Hedberg, 1979; Hoffman and Halverson, 2008; Pruss et al., 2010), isotopic analyses (Yoshioka et al., 2003; Tojo et al., 2007; Pruss et al., 2010) and microscopic investigation (Pruss et al., 2010; Bosak et al., 2011, 2012). The Rasthof Formation was initially named the Rasthof Member (Hedberg, 1979). It is interpreted as a shoaling-upward succession, with the cap dolostone deposited in the deepest environment followed by sublittoral stromatolites (Halverson et al., 2005). An abundance of soft sediment deformation structures has been described (Hoffman and Halverson, 2008; Pruss et al., 2010), creating a chaotic aspect despite continuous laminae. Most recently the

* Corresponding author.

E-mail addresses: e.leber@es.rhul.ac.uk, leber.erwan@gmail.com (E. Le Ber).

microbial member has been interpreted as a deep-water microbial ecosystem in the Warmquelle–Okaaru area (Fig. 1A) (Pruss et al., 2010), on account of the lack of bedforms, scour marks and intraclasts. Petrographic studies have revealed the occurrence of possible early agglutinated foraminifera in the microbial member (Bosak et al., 2012; Dalton et al., 2013). The aim of the present paper is to describe the Rasthof Formation at the Rasthof Farm locality. New sedimentological observations from the type area are presented, they suggest that the cap carbonate was deposited in substantially shallower water than suggested elsewhere. This interpretation has major implications both for facies models on the post-Sturtian carbonate platform and, potentially, for the interpreted magnitude of postglacial sea level rise.

2. Study area and stratigraphy

The Rasthof Formation was deposited on the Northern Platform and is well exposed along the edges of the Kamanjab Inlier, north-west Namibia (Fig. 1A). A regional model suggests that the Kamanjab Inlier is a basement high that created ridges separating platform facies to the north from slope facies to the south (Hoffman and Halverson, 2008). This paper presents data from the type section at Rasthof Farm, north of the Kamanjab Inlier and, therefore, on the platform.

Detailed previous studies of the platform were focused more than 50–100 km to the north-west and west. The cap dolostone and/or the

microbial member were examined in the vicinity of Warmquelle, Okaaru and Ongongo localities (Yoshioka et al., 2003; Tojo et al., 2007; Hoffman and Halverson, 2008; Pruss et al., 2010; Bosak et al., 2011, 2012; Dalton et al., 2013). Hoffman and Halverson, 2008 also described the Rasthof Formation in the Northern Margin Zone, south of the Kamanjab Inlier. The type area of the unit (“Rasthof Member”: Hedberg, 1979) in Rasthof Farm has, surprisingly, not been subject to detailed investigations.

In northern Namibia the Otavi Group (Fig. 1B) was deposited after the break-up of Rodinia (recorded by syn-rift sediments of the Nosib Group) and prior to the Pan African Orogen (recorded by molasse deposits of the Mulden Group) (Frimmel et al., 2011). The Otavi Group accumulated on an extensive carbonate platform lining the southern edge of the Congo Craton. It starts with the Ombombo Subgroup, consisting of mixed carbonate and siliciclastic sediments. These deposits are overlain by glacial sediments of the Chuos Formation, which are in turn followed by the Rasthof, Gruis and Ombaatjie formations; forming the Abenab Subgroup. A second glacial succession, the Ghaub Formation, is overlain by carbonate sediments, forming the Tsumeb Subgroup (Hoffmann and Prave, 1996).

On the Northern Platform, the Chuos Formation bears evidence of direct ice contact (subglacial shear zones, dropstones, ice-contact fans) with two glacial cycles preserved (Le Heron et al., 2013). The overlying 200–400 m thick Rasthof Formation rests in sharp contact,

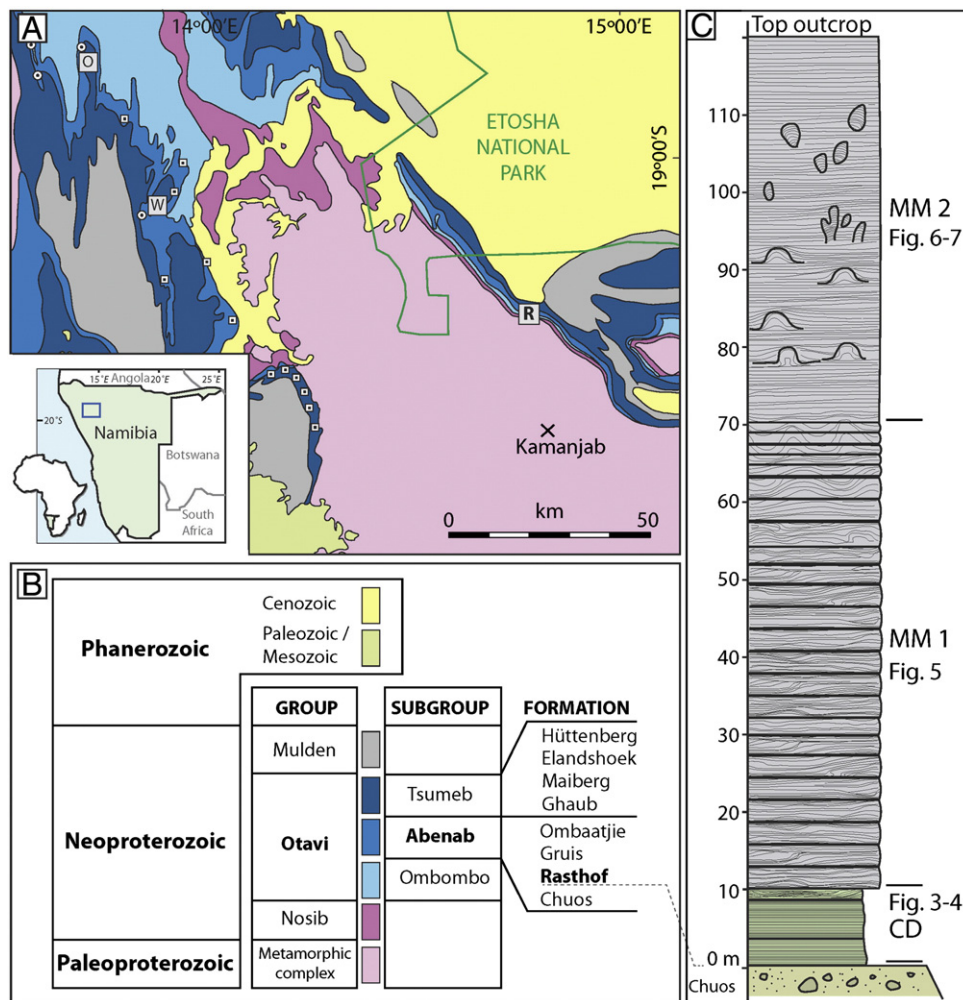


Fig. 1. Outcrop location and lithostratigraphy of the Otavi Group. A. Simplified geological map of the area (modified from Hoffman and Halverson, 2008), “R” is the location of the Rasthof Farm, □ are the sections described by Hoffman and Halverson, 2008, ○ are sections described by Pruss et al. (2010). “O” and “W” indicate Okaaru and Warmquelle areas. B. Stratigraphy of the Otavi Group, from Hoffman and Halverson, 2008. C. Idealized log of the section at Rasthof Farm, with references to others figures: Figs. 3–4 (deformation and hummocky cross-stratification, top cap dolostone); Fig. 5 (facies of MM1); and Figs. 6 and 7 (facies of MM2).

Download English Version:

<https://daneshyari.com/en/article/6433190>

Download Persian Version:

<https://daneshyari.com/article/6433190>

[Daneshyari.com](https://daneshyari.com)