New Discoveries in the late Neoproterozoic of Namibia: New Material-New Analysis

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INTRODUCTION

Over the past 15 years UNESCO Projects IGCP493 /587 have concentrated efforts by a consortium of researchers from around the world on the detailed field documentation and exploration of the Nama Group in southern Namibia, an important sequence recording how life so changed from 600 to 530 million years ago – across the Precambrian-Cambrian boundary. An impressive collection of material from the area around Aus has increased the up until then known fossil material [1] many fold in those years [2-7]. New scanning and analytic techniques, involving facilities such as the Australian synchrotron, and in depth reconstruction art and use of new graphic programs, along with a detailed sedimentology of deposits preserving these new discoveries have led to a marked improvement in the understanding of both the morphology and relationships of the organisms, the environments they inhabited and the effects imposed by how they were preserved .

FARM AAR – GEOLOGIC SETTING

Studies carried out by participants in UNESCO IGCP493/587 from 2003 to present have concentrated on one of the four areas in the southern Nama Basin, in particular in the region to the east of Aus, on Farm Aar, an area that has been studied paleontologically since the beginning of Ediacaran research and field work in the 1930s. These strata are richly fossiliferous, with Ediacaran shelly fossils (mainly *Cloudina*) present in the carbonates and iconic representatives of the Ediacara-type soft-bodied megafossils *Pteridinium, Rangea*, and *Ernietta* in the siliciclastics. Farm Aar stands out as the

most significant single site in all of Africa for these ancient organisms, and it has been designated and preserved as a National Heritage Site and National Geopark by the Namibian Government.

Nama Group strata on Farm Aar are represented by the lower part of the Kuibis Group, an early foreland basin succession comprising mainly shallow-water fine siliciclastics and carbonates. Four sequences (K1 to K4) have been recognized in the Kuibis Subgroup, two of which are relevant to this poster and a Pre-conference field trip to the IGC, K1 and K2. **Sequence K1** comprises the lower part of Dabis Formation, which nonconformably overlies crystalline basement. K1 consists of a basal unit of coarse, tabular-bedded sandstones (Kanies Member)) overlain by fine-grained, irregularly laminated dolostone and limestone (Zenana and Mara members). Sequence K1 is extremely thin on Farm Aar, but is considerably thicker on Farm Pockenbank to the south of Aar.

Sequence K2 consists of the Kliphoek and Aar (Hall *et al.,* 2013) members of the the Dabis Formation and the overlying Mooifontein Limestone of the Zaris Formation.

The **Kliphoek Sandstone** is made up of lowstand deposits consisting of mainly thick-bedded, coarse-grained quartzarenites with abundant meter-scale trough cross-bedding. Deposition may have occurred in a sandy braided fluvial or high energy nearshore or deltaic setting. The upper 70 cm of the continuous sandstone within the lower part of the Kliphoek Member consists mainly of fine-grained quartzarenite with syneresis cracks and/or sandstone injection structures, current and combined-flow-ripplemarks and hummocky cross-stratification.

The overlying **Aar Member** represents sediment accumulation during the transition from a braided, sandy, fluvial environment (Kliphoek Sandstone) to a fully marine, clear water environment, which eventually facilitated carbonate deposition (Mooifontein Member). The Aar Member consists of transgressive gray-green shale and siltstone with sporadic interbeds of very fine- to fine-grained, centimeter-scale sandstone event beds that are laterally discontinuous over decameter scales. Sandstone event beds are erosionally-based. The lower part of each event bed consists of parallel-laminated sandstone reflecting upper-flow regime plane beds, which is overtopped by sandstone exhibiting hummocky cross-stratification, wave ripples, or combined-flow ripples. Centimeter-scale rip-up clasts of shale and/or microbialite also occur commonly in the upper half of these event beds. These features are diagnostic of storm beds modified by wave processes during the waning flow stage, and imply deposition slightly below fairweather wave-base on a muddy.

Shallow-water limestones with hummocky and swaley cross-stratification, intraclastic textures, and microbial textures first appear abundantly near the top of the Aar Member. Laminated carbonates, locally containing cross-bedded ooids and the shelly fossil *Cloudina*, dominate the overlying **Mooifontein Member** and imply shallow-water deposition during highstand conditions to the top of the K2 sequence. The Mooifontein Member is part of an extensive carbonate platform that thickens northward toward the Damara Belt and reaches a maximum thickness of 500 m along the Zebra River in the northern Nama sub-basin.

Fig. 1, 2 placed here

NEW MATERIAL OF *RANGEA* AND *ERNIETTA* EITHER IN SITU OR NEAR ORIGINAL HABITAT

The contact between the Kliphoek Sandstone and the overlying Aar Member at Farm Aar *locale Road Quarry 2.3* showcases a remarkable occurrence of complete, three-dimensional specimens of *Rangea* preserved 35-40 cm above this contact. *Rangea* was the first complex Ediacaran fossils named and defined anywhere by Gürich in 1930, and it has become both an iconic image of the Ediacara biota that has been figured in nearly every Ediacaran diorama – the type genus for the Rangeomorpha, a major clade in Ediacaran life. Prior to 2004, a total of less than 25 specimens of *Rangea* had been described worldwide, none of them collected from outcrop by a paleontologist. Discovery of more than 100 *in situ* specimens in gutter casts from the basal Aar Member on Farm Aar (Vickers Rich *et al*., 2013) significantly enhanced the global dataset and also provided the first 3-dimensionally preserved specimens for this taxon (Hall *et al*. (2013) and Vickers-Rich *et al*. (2013)).

Fig. 3 here

The fine stuctural details of the *Rangea* specimens are preserved in the mineral jarosite, a complex hydrous sulfate of potassium and iron with a chemical formula of $KFe^{3+}_3(OH)_6(SO_4)_2$, which appears as a yellow mineral coating the *Rangea* fossils. It seems likely that the original coating mineral was pyrite, with later oxidation to jarosite by acidic groundwater; the addition of potassium probably caming from the subarkosic sandstones in which the fossils are preserved. These jarosite coatings are key to the three-dimensional preservation of these specimens and to the techniques that were used to elucidate it (Vickers-Rich *et al*., 2013).

Fig. 4 here

The internal structures of *Rangea* consist of a basal, hexaradial axial bulb that passes into an axial stalk which extends to the distal end of the specimen. This axial structure is the foundation for six vanes arranged radially around the axis, with each vane consisting of a bilaminar sheet composed of a repetitive pattern of elements exhibiting at least three orders of the self-similar (rangeomorph) branching. The basal part of the axial bulb is typically partly filled with sediment, with the dorsal end of the stalk typically preserved as an empty, cylindrical cone. This probably served as a 'weight belt' to keep the organism in an upright positon sitting on the sediment surface in life, with later transport to form the fossil accumulations in the gutter cast

Fig. 5-7 here

A large collection of *Ernietta* bases preserved on a deflation surface were discovered in 2004 at the appropriately named *Ernietta* Hill and have been subsequently described by **Elliott *et al*. (2016, in press**). An even more significant find is the discovery of the first-known specimens of *Ernietta* anywhere in the world that are in place. Despite the many scores of specimens illustrated by several authors in the past (Pflug , Jenkins *et al*., Vickers-Rich & Komarower, Seilacher & Gishlick , Elliott *et al.*), all known specimens were from float and incomplete, consisting only of the basal part of the organism or basal and part of the more dorsal section. This led to considerable variation in the three-dimensional reconstructions of *Ernietta* and in interpretations of its lifestyle, which ranged from fully endobenthic to semiendobenthic to epibenthic (see Fedonkin, *et al.,* 2007 for a summary).

Figure 8 here

And and even more spectacular discovery was made by Andrey Ivantsov 2014 m- more than 100 specimens of *Ernietta* were found in a small gutter-cast located near the top of the Aar Member! As summarized from Ivantsov *et al.* (2015) specimens within the mass-flow deposits in the gutter cast ranged through a continuous series from short, vertically oriented specimens indistinguishable from the type specimens of *Ernietta*, althrough longer, obliquely oriented specimens, to a few fully horizontal (procline) specimens that reveal the complete, three-dimensional shape of *Ernietta*). These specimens collectively show that the classic specimens of *Ernietta* represent only a basal, sand-filled anchor that in complete specimens passes distally into a trunk that is crowned by two facing fans that extended into the overlying water column. In contrast to these differences in shape in different parts of the complete Ernietta organism, the architecture of *Ernietta* everywhere consists of a longitudinal palisade of morphologically similar tubes. These tubes could be modified to fill all of the functional needs of *Ernietta* – ranging from sand-filled tubes that helped to anchor the buried base of the organism in the seafloor, to the support function fulfilled by fluid-filled tubes in the mid-trunk region, to the tubes in its distal fan that may have performed feeding and/or respiratory functions.

References

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Figures 1-8. 1-2, Stratigraphy and location of new material; 3, preservations style common in Nama Group; 4, first complete Ernietta *description; 5-6, internal structure determined by micro-CT scanning of new* Rangea*; 7, new* Rangea *material; 8, Channel, which yielded abundant new material.*

See also Vickers-Rich, et al., 2016, The Nama Group of southern Namibia. The End Game of the first Large, Complex Organisms on Earth, the Ediacarans [IGCP493/587]. Pre-conference Field Guide, 35th International Geological Congress, ExSA=Pre2).