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The 'string of beads' fossil (*Horodyskia*) in the mid-Proterozoic of Tasmania

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ABSTRACT

Horodyskia has been found at a single Tasmanian locality, in the Cassiterite Creek Quartzite (ca. 1300–800 Ma), part of a thick Proterozoic, mildly deformed, low greenschist facies, marine shelfal siliciclastic succession known as the Rocky Cape Group. The rock hosting the fossils is thinly interbedded and interlaminated dark grey slaty shale and quartzose siltstone. The sharp-based, graded siltstone layers are interpreted as distal storm surge deposits on an outer marine shelf. The 'strings of beads' are mostly preserved at the base of the siltstone layers, in concave hyporelief (external moulds) on the soles of the event beds, and as convex epirelief (casts) on the tops of the underlying shale beds. The casts comprise shale identical to the underlying bed. The beads average 1.7 mm in diameter, and the gap between the borders of adjacent beads tends to be approximately equal to the bead diameter. Occasionally, the fossils are preserved within shale, as wholly flattened beads delineated by a subtle darkened halo. The Tasmanian 'strings of beads' have most of the morphological attributes of previously described *Horodyskia*, including regularity of size and spacing of beads in any one string, lack of branching, and in some instances, 'haloes' and casts with apical depressions. The strings on at least one bedding plane have a strong N–S preferred orientation of unknown origin. Tectonic deformation has resulted in 30% shortening in a SW–NE direction. The morphologic similarity, but differing mode of preservation of the Tasmanian *Horodyskia* to the two previously described Mesoproterozoic species is strong evidence for a biologic origin for the string of beads phenomenon. After morphological and morphometric comparisons with other species of *Horodyskia*, the Tasmanian specimens are assigned to *Horodyskia williamsii*.

1. Introduction

Horodyski (1982) was the first to describe a distinctive variety of serial bedding plane markings in Mesoproterozoic sedimentary rocks from Montana. The features, aptly named 'strings of beads', were considered by him to be of problematic origin. The markings exhibited a striking regularity within a string, both of bead dimensions and the distance between adjacent beads. Similar structures were described from the late Mesoproterozoic Bangemall Supergroup of Western Australia by Grey and Williams (1990). Yochelson and Fedonkin (2000) applied Linnaean nomenclature (*Horodyskia moniliformis*) to the examples from Montana, and further detailed description of this material was given by Fedonkin and Yochelson (2002). The Western Australian examples are named *Horodyskia williamsii* by Grey et al. (2010), and details of their taphonomy and depositional environment were given by Martin (2004). A third species, *Horodyskia minor*, was described from the upper Ediacaran of South China by Dong et al. (2008). This species is unusual in being preserved three-dimensionally in chert, and in its much smaller size and younger age than the two previously described forms.

A biogenic origin for the 'string of beads' is now generally accepted, although biological affinities are still a matter of conjecture (Knoll et al., 2006). Grey and Williams (1990) concluded the strings were most likely to be fossil phaeophytes (brown algae). Fedonkin and Yochelson (2002) suggested they were multicellular, tissue-grade, colonial eukaryotes, probably autotrophic. A spongal affinity was suggested by Hofmann (2001), while Dong et al. (2008) suggested a comparison with uniseriate agglutinated foraminifers. The biogenicity and affinities of *Horodyskia* have been extensively discussed by Grey et al. (2010) and previous workers, and will not be further treated here.

The history of discovery of the Tasmanian *Horodyskia* began in the mid 1990s when one of the authors (M. Laan) collected some slabs of Proterozoic slate with intriguing bedding plane impressions that he featured as flagstones in a concrete floor. On learning of the 'strings of beads' fossils in discussions with Tasmanian government geologists in early 2006, he sent photographs of the flagstones to C.R. Calver who recognised the fossils, having been shown the West

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Australian *Horodyskia* by K. Grey the previous year. The identification was confirmed by Grey, and Laan and Calver then relocated the source of the fossiliferous slabs and collected additional material, described here.

In this paper, the Tasmanian examples are described and compared with the three previously named species. The Tasmanian 'strings of beads' are morphologically similar to *H. williamsii* and *H. moniliformis*, although their mode of preservation is somewhat different. They may be of similar age to *H. williamsii*, but are younger than *H. moniliformis*. We tentatively assign them to *H. williamsii*. Only one Tasmanian locality is so far known, although the fossils are found in great profusion on some bedding planes. We used GIS (Geographic Information Systems) software to spatially analyse the Tasmanian material, which has undergone a slight tectonic distortion.

Figured specimens, numbered Z3701–Z3706, are lodged at the Tasmanian Museum and Art Gallery, Hobart.

2. Geological setting and age

The single Tasmanian *Horodyskia* locality is in the Cassiterite Creek Quartzite, a formation in the Balfour Subgroup, in the lower part of the Rocky Cape Group, the oldest known succession in northwest Tasmania (Figs. 1 and 2). The Rocky Cape Group consists almost entirely of siltstone, mudstone and quartzarenite, in total over 10 km thick, deposited in shelfal environments ranging from tidal flat to offshore below wavebase (Fig. 2; Gee, 1968; Everard et al., 2007). It is moderately deformed and weakly metamorphosed (lower greenschist facies). Age constraints are poor. The Rocky Cape Group is thought to be younger than the Surprise Bay Formation (ca. 1300 Ma) of King Island, although no stratigraphic contact is known between the two units (Black et al., 2004). The Rocky Cape Group is unconformably overlain by the Cryogenian to lower Cambrian Togari Group (Calver, 1998; Everard et al., 2007). The lowermost part of the Togari Group consists of a probable equivalent of the

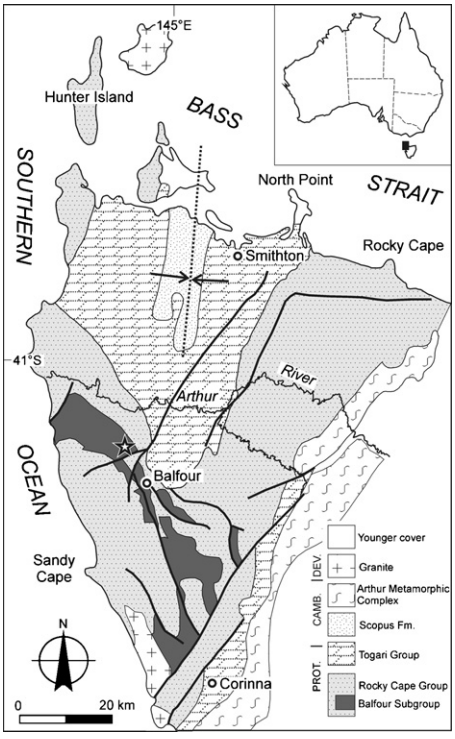

Fig. 1. Generalised geology of north-west Tasmania, with 'string of beads' locality shown (star).

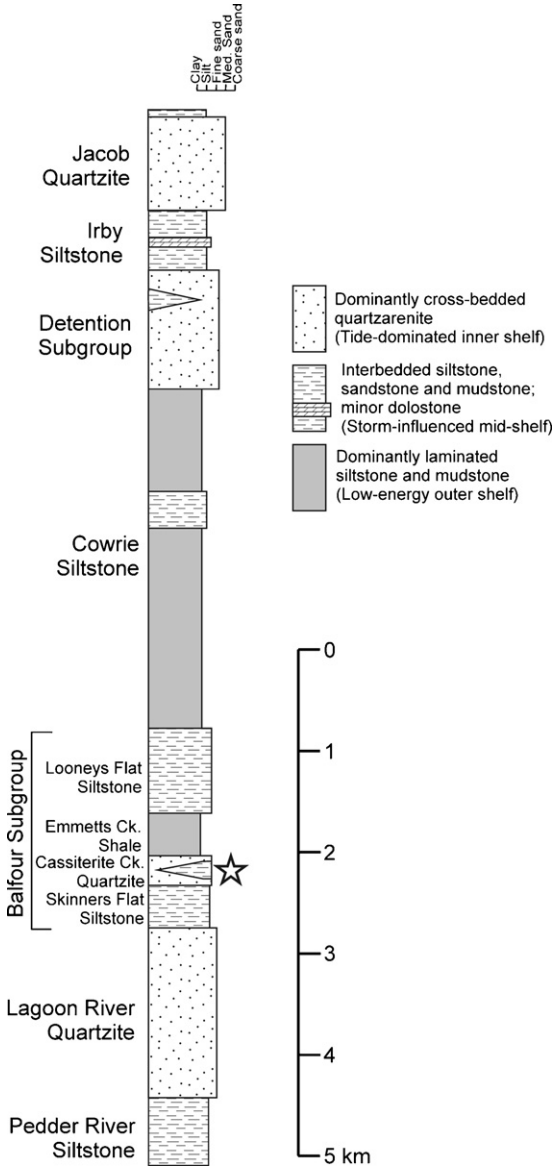

Fig. 2. Generalised stratigraphic column and palaeoenvironments of the Rocky Cape Group. Star indicates stratigraphic position of *Horodyskia*.

Burra Group of South Australia (ca. 800–700 Ma: Calver, 1998; Hill and Walter, 2000). The youngest detrital zircon population in the Jacob Quartzite (the youngest formation in the Rocky Cape Group) is 1000 Ma, so this unit is early Neoproterozoic (1000–ca. 800 Ma: Black et al., 2004). However, the Cassiterite Creek Quartzite could be significantly older, given the great stratigraphic thickness separating it from the Jacob Quartzite (Fig. 2). Current age constraints therefore suggest that the Tasmanian *Horodyskia* – bearing horizon is late Mesoproterozoic to early Neoproterozoic (1300–800 Ma).

The Cassiterite Creek Quartzite, in its type section near Balfour, is described as interbedded quartzarenite, laminated siltstone and carbonaceous shale, about 350 m thick. The formation thickens and incorporates a greater proportion of siltstone, and less quartzarenite, north of the type section (Everard et al., 2007).

The Blackwater Road Quarry, where *Horodyskia* is found 10 km north-west of Balfour, exposes some 50 m stratigraphic thickness of fresh (unweathered), thinly interbedded and interlaminated, quartz siltstone and dark grey, slaty shale, mapped as Cassiterite Creek Quartzite (Everard et al., 2003). Bedding dips and faces con-