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Cottons Breccia of King Island, Tasmania: Glacial or non-glacial, Cryogenian or Ediacaran?

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ABSTRACT

The Cottons Breccia of King Island, Tasmania, is a 100-m-thick carbonate-clast diamictite traditionally interpreted as the product of a Cryogenian or Ediacaran glaciation. It was recently reinterpreted as a mass-flow deposit, unrelated to glaciation, within an active rift basin. We reaffirm the glacial–periglacial interpretation on the basis of sedimentary facies, internal facies relations, clast lithology and isotopic composition, clast fabric analysis, and consistent stratigraphic position beneath a typical post-glacial cap dolostone. The Cumberland Creek Dolostone closely resembles basal Ediacaran cap dolostones world-wide in terms of colour, texture, sedimentary structures and isotopic characteristics. Because it was deposited above storm wave-base, differences in $\delta^{13}C$ between closely adjacent sections suggest diachronous deposition during post-glacial marine transgression of a basin with steep local topography. This is compatible with an active rift basin in which glacigenic diamictites of the end-Cryogenian (Marinoan) pan-glacial episode were lodged.

1. Introduction

Palaeogeographic reconstructions of Neoproterozoic glacial epochs depend on reliable identification and interpretation of glacigenic deposits (e.g., Howchin, 1908; Coleman, 1926; Crowell, 1964; Harland, 1964; Schwarzbach, 1964b; Schermerhorn, 1974; Deynoux, 1985; Brookfield, 1994). As glaciomarine deposits are more likely than their terrestrial counterparts to be preserved in the geological record (Carey and Ahmad, 1961), the rapid increase in knowledge of glaciomarine sedimentation over the past 25 years is a welcome development (e.g., Molnia, 1983; Dowdeswell and Scourse, 1990; Anderson and Ashley, 1991; Hambrey, 1994; Menzies, 1995; Benn and Evans, 1998; Anderson, 1999; Dowdeswell and O'Cofaigh, 2002).

The Cottons Breccia (Jago, 1974) of King Island, Tasmania (Fig. 1), has long been regarded as a glacial or glaciomarine deposit (Waterhouse, 1916; Carey, 1947; Spry, 1962; Harland, 1964; Schwarzbach, 1964a; Solomon, 1969; Calver and Walter, 2000; Calver et al., 2004), but doubt has recently been cast on its glacial origin by Direen and Jago (2008), who interpret it as a product of mass-flows in an active rift basin. Here, we present new field and isotopic evidence supporting a glacial and periglacial origin, and correlation with terminal Cryogenian glaciations world-wide.

2. Previous work

A lithified "glacial till" was first recognized on the southeast coast of King Island, Tasmania, by Waterhouse (1916), who tentatively assigned it to the base of the Permo-Carboniferous system, although "there are no fossils to enable the age to be positively fixed" (Waterhouse, 1916).

Carey (1947) supported the glacial interpretation and noted that the "tillite" is conformably overlain by a unit of laminated dolomite. He inferred a Neoproterozoic or Cambrian age for the glaciation and suggested a possible correlation with the "Adelaide series glacial horizon" (Sturtian) of South Australia (Carey, 1947).

Jago (1974) introduced the name "Cottons Breccia" after measuring 10 stratigraphic sections along its east-dipping, 8-km long, outcrop belt (Fig. 1). Its average thickness is ~100 m and non-stratified, matrix-supported diamictite is the predominant lithology. He noted the preponderance of angular to subrounded sedimentary clasts – carbonates (some oolitic), quartzites and siltstones – along with minor clasts of red jasper and basic lava. He was circumspect about the origin of the Breccia, citing evidence both for

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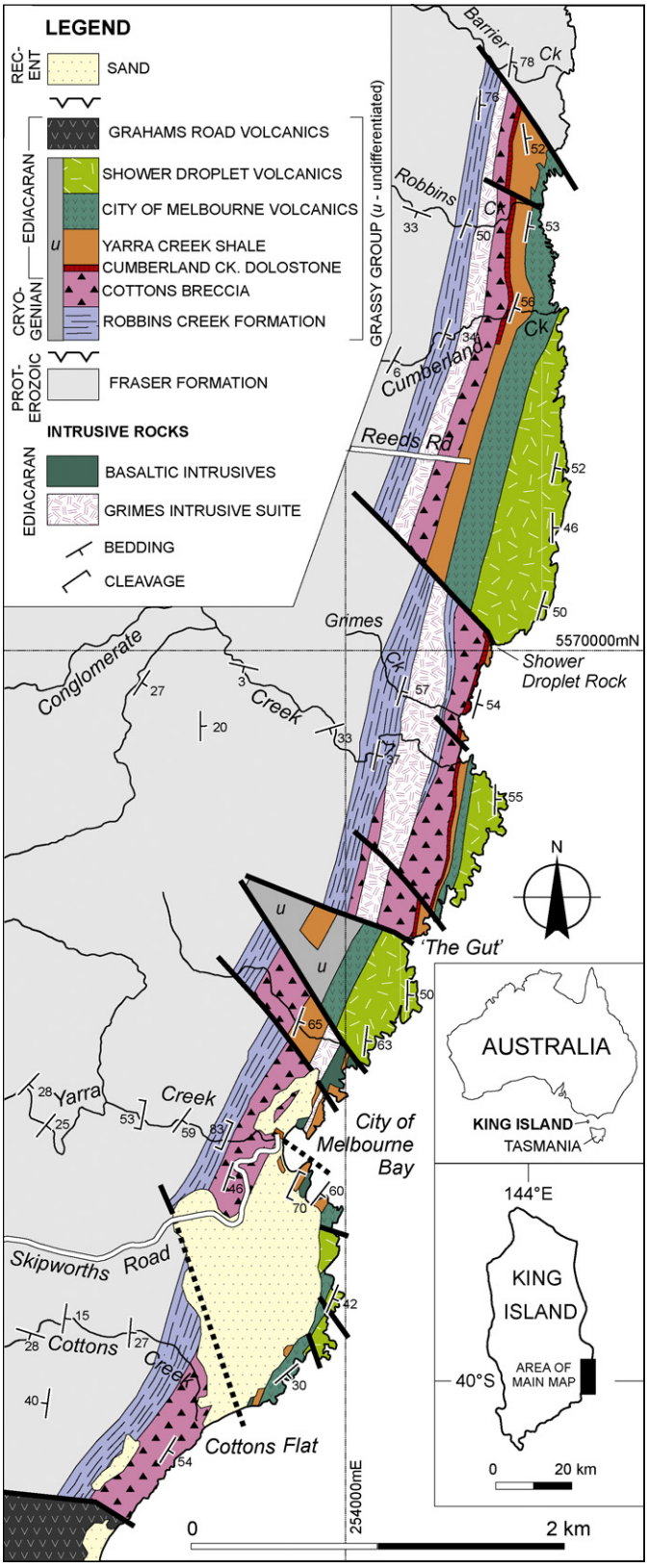

Fig. 1. Geological map of the Grassy Group on the southeast coast of King Island, Tasmania.

(e.g., presence of possible dropstones) and against (e.g., absence of extrabasinal debris) glaciation (Jago, 1974, 1981).

Coats and Preiss (1987) noted the lithological similarity of the "cap dolomite" overlying the Cottons Breccia (Fig. 1) with the Nuccaleena Formation above the younger Adelaidean (Marinoan) glacials in South Australia. This theme was amplified by Calver and Walter (2000), who remarked on the presence in both areas as well as presumed correlatives in central Australia of identical "sharp-crested intrastratal anticlines" that "resemble tepee structures but lack cavity-filling cements" (e.g., Plummer, 1979; Kennedy, 1996). The "pale grey to pale pinkish-grey, fine-grained, laminated dolostone that weathers to a pale yellow-brown" on King Island contains "scattered rounded micritic peloids 0.1–0.25 mm in diameter, and irregular microfenestrae concentrated along particular horizons" (Calver and Walter, 2000). They noted similar gradations upwards into shales, which on King Island and in central Australia contain thin beds of micritic grey limestone. Above these, in all three regions, are "impersistent but widespread developments of black shales comprised of remnant benthic microbial mats" (Calver and Walter, 2000), which isotopic and chemical data suggest were composed of non-photosynthetic, sulfide-oxidizing bacteria (Logan et al., 1999). A six-point $\delta^{13}C_{carb}$ profile from King Island (Calver and Walter, 2000) decreases monotonically up-section from −2‰ to −5‰ (VPDB), similar to the Nuccaleena Formation and basal Ediacaran cap dolostones globally (Kennedy et al., 1998).

With respect to the Cottons Breccia itself, Calver and Walter (2000) favoured a glacial or periglacial origin, pointing to the presence of "diffusely bounded clumps of diamictite, 50–100 mm wide, that are probably till clasts", as well as lonestones, in sandstone intervals bounded by diamictite. They also noted that "common carbonates and rarer chert, red mudstone and jasper" clasts within the Breccia "appear to be foreign to the area", contrary to the argument of Jago (1974) that extrabasinal debris was absent. They remarked on the presence of "partly silicified clasts of oolite with large (3 mm) ooids". Comparing the respective Neoproterozoic successions as a whole, Calver and Walter (2000) postulated that western Tasmania and King Island originated between mainland Australia and northwest Laurentia, and that western Tasmania rifted apart from mainland Australia after the older (Sturtian) glaciation (Calver, 1998). Rifting of King Island occurred after the younger (Marinoan) glaciation, coincident with voluminous subaqueous tholeiitic and picritic volcanism of the upper Grassy Group (Meffre et al., 2004). King Island preserves a volcanic rifted margin that arguably never fully separated from the Australian segment of Gondwanaland (Direen and Crawford, 2003; Meffre et al., 2004; Direen and Jago, 2008).

Direct and indirect age constraints on the Cottons Breccia were provided by Meffre et al. (2004) and Calver et al. (2004). The former authors presented a Sm–Nd isochron age of 579 ± 16 Ma with an initial εNd of +4.1 (579 Ma) for volcanic rocks of the upper Grassy Group (Fig. 1). The isochron is defined by four data points from the middle picrite unit (Shower Droplet Volcanics) and a single data point from the upper tholeiites (Grahams Road Volcanics) on which the slope (age) of the isochron heavily depends. Data points from the lower tholeiites (City of Melbourne Volcanics) and related intrusive sills (Grimes Intrusive Suite) fall well off the isochron and were not included in the age calculation (Meffre et al., 2004).

Calver et al. (2004) presented U–Pb (sensitive high-resolution ion microprobe) zircon ages of 574.7 ± 3.0 Ma from the Grimes Intrusive Suite, where it intrudes the Cottons Breccia, and 582.1 ± 4.1 Ma from a rhyodacite eruptive stratigraphically beneath the Croles Hill Diamictite on the mainland of northwest Tasmania, approximately 150 km southeast of King Island. Calver and Walter (2000) and Calver et al. (2004) correlated the Croles Hill Diamictite with the Cottons Breccia. Accordingly, they considered the 582-Ma