

Neoproterozoic Reef at Arkaroola

Item: A well preserved outcrop section through a Cryogenian (650 Ma) barrier reef system

Location: Kingsmill Canyon on Paralana Springs Rd, 5 km ESE of Arkaroola Tourist Village, northeastern Flinders Ranges, South Australia

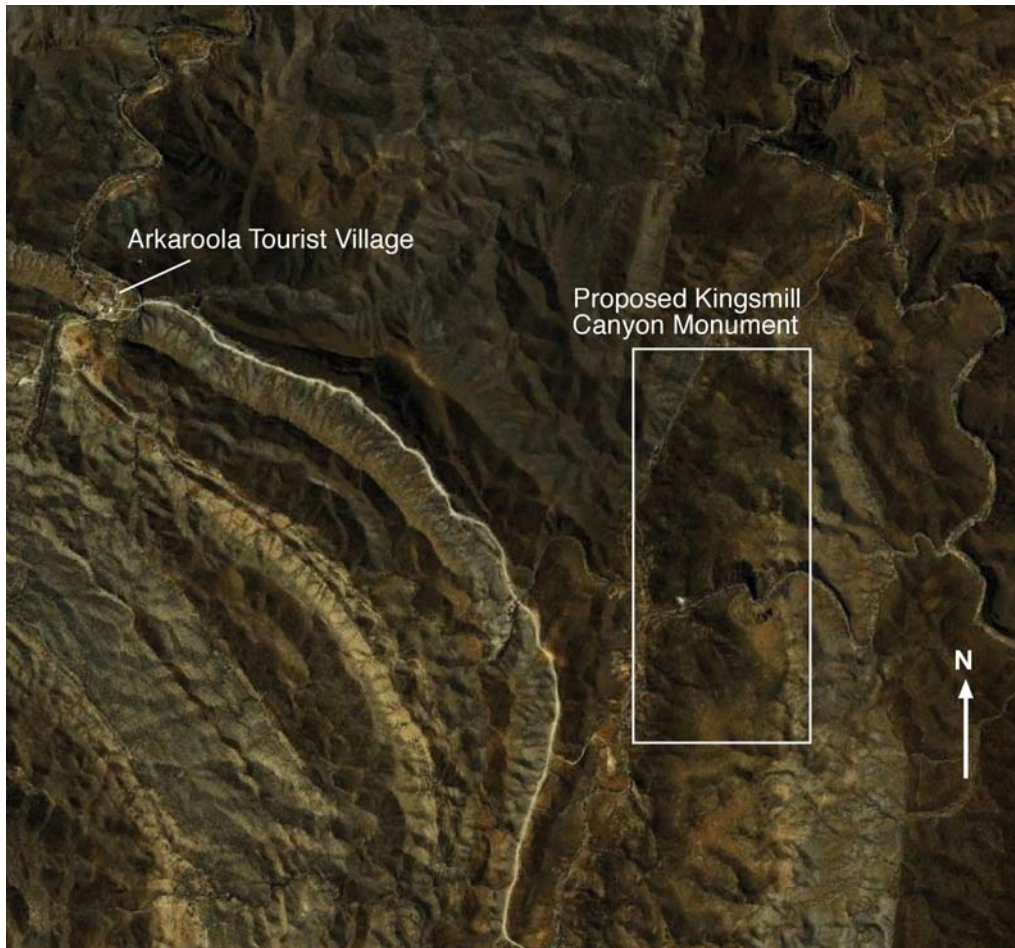


Figure 1. Location map of proposed geological monument based around Kingsmill Canyon.

Size of area: See Figure 1 above. Total area 4.8 square kilometres.

Precise location: See Figure 1 above. Western edge of gorge is at: **30 degrees 19' 54.31" S, 139 degrees 22' 54.57" E**

Ownership: Arkaroola Wilderness Sanctuary, Doug and Margaret Sprigg

Access: Kingsmill Canyon-Tillite Gorge walk on Paralana Springs Road, Arkaroola. A scenic walk is already signposted (courtesy of Arkaroola

Wilderness Sanctuary). Access is relatively easy down the gorge and is available to anyone who is fit enough to walk a kilometre or so.

General description

The barrier reef system at Arkaroola is hosted by the Balcanoona Formation which consists of buff-weathering dolomite. The dolomites of the Balcanoona Formation produce prominent strike ridges with considerable elevation and a distinctive flora. At Kingsmill Canyon, the stream has cut a spectacular gorge through the Balcanoona Formation. The Balcanoona Formation strikes roughly north-south and dips steeply west. The gorge is oriented roughly east-west and so is perpendicular to strike, thus exposing a complete stratigraphic section through the Balcanoona Formation reef and the underlying Tapley Hill Formation shales.

The reef has a prograding (advancing) geometry overall, so Kingsmill Canyon exposes a section from oldest to youngest (east to west) that includes:

1. The underlying slope sediments (Tapley Hill Formation).
2. The lower reef framework facies (Lower Balcanoona Formation)
3. Upper reef framework facies (Mid Balcanoona Formation)
4. Platform or backreef facies (Upper Balcanoona Formation)

Slope sediments of the Tapley Hill Formation are calcareous shales. In the uppermost parts of the unit, transported blocks of the reef are visible in outcrop. The **lower reef framework** of the basal Balcanoona Formation consists of an organic framework with enigmatic chambered organisms of unknown affinity. The **upper reef framework** consists of stromatolites. Overlying the stromatolites are ooidal dolomites of the uppermost Balcanoona Formation.

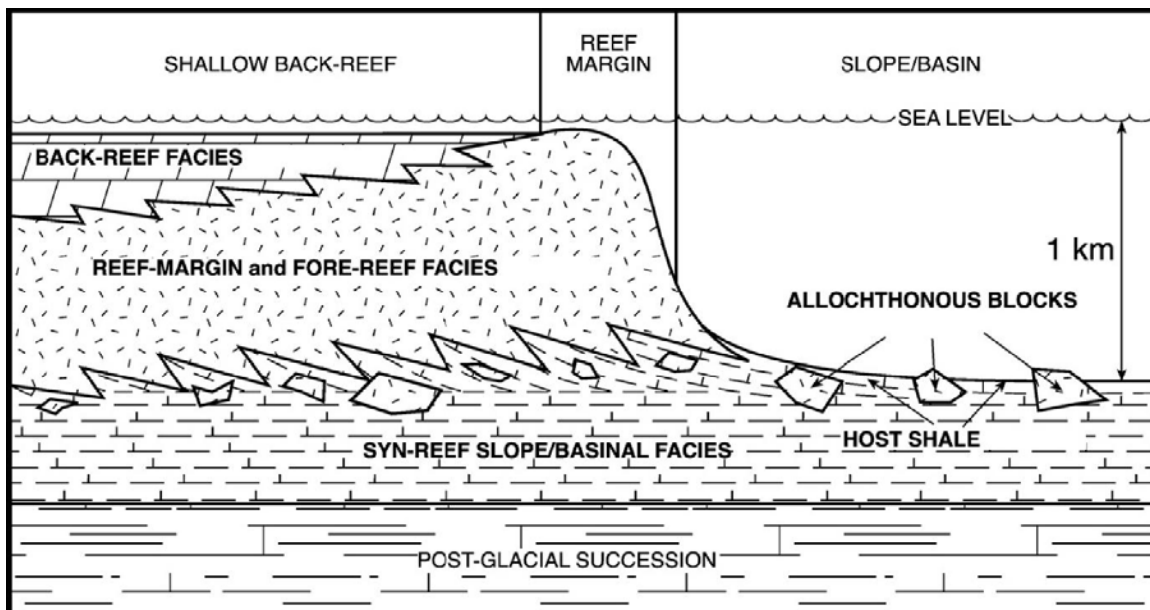


Figure 2 General geometry and environment of the Arkaroola Reef. The reef (Balcanoona Formation) is strongly prograding and grows over the Tapley Hill

Formation Shales. Kingsmill Canyon exposes a stratigraphic section of the entire reef and underlying slope shales.



Figure 3. Eastern side of Kingsmill Canyon.

Geological interest and significance

Two Cryogenian reef complexes have recently been discovered in the northeastern portion of the Adelaide Geosyncline: the Oodnaminta Reef and the Arkaroola Reef (Fig. 1). The Oodnaminta Reef is protected within the Gammon Ranges National Park. The Arkaroola reef does not have this protection. These reefs are of tremendous scientific importance because the reef framework contains calcified organisms that probably represent the remains of the oldest animals on Earth. We can find no described ancient or modern organisms that resemble those from the reef complexes. The degree of complexity and overall size (often at centimetre scale) of the fossils certainly does make it difficult to rule out a multicellular origin. Regardless of the exact origins of these

complex calcified fossils (multicellular, or microbial), their evolutionary position as possible precursor steps towards Ediacaran animals makes them hugely significant.

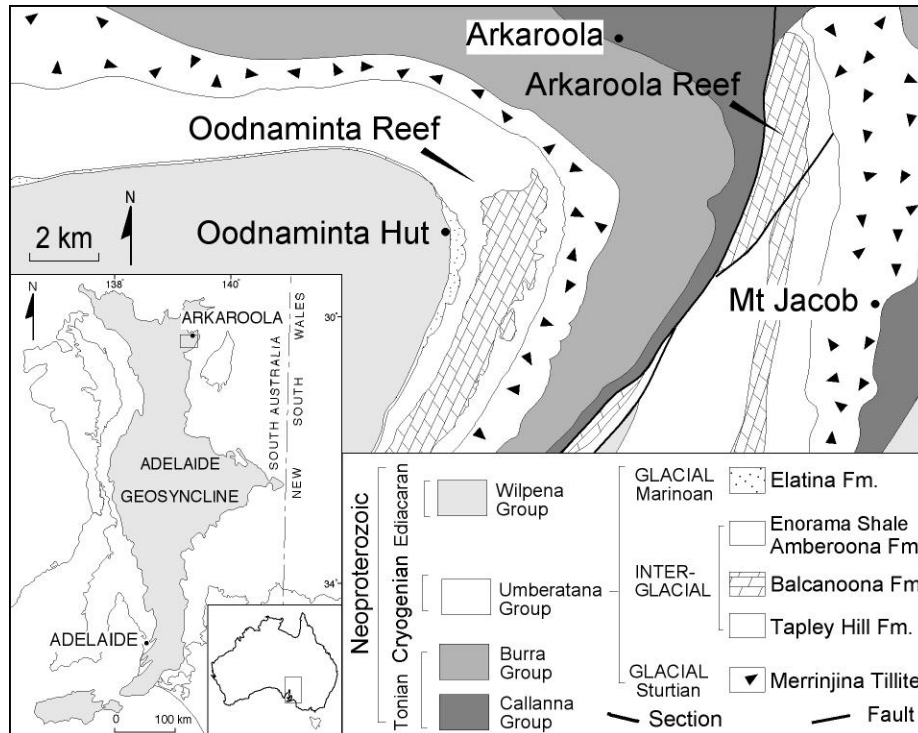


Figure 3. Location of newly discovered reef complexes, Flinders Ranges, SA (modified from Giddings and Wallace, 2009).

The reef complexes themselves are also of great importance as there have been no other comparable reefs of that age yet discovered anywhere on Earth. In fact the entire Tonian, Cryogenian and Ediacaran record is remarkably depauperate in reef complexes. Reefs allow a rare window into the foundations of organic calcification and skeletonization by providing an ideal environment for the calcification of organisms. The latest Ediacaran (~543-548 million years before present) Nama Group reefs, for example, host calcified metazoans (e.g. *Namacalathus*) and microbes that predate the base of the Cambrian (Grotzinger et al 2000). However, the record of Neoproterozoic reefs is extremely sparse, with the remarkable Little Dal reefs (1100-780 Ma) in arctic Canada representing the only other examples of large-scale Neoproterozoic reefs (Aitken, 1989; Batten et al, 2004).

Geological Setting

The reef complexes occur within the Umberatana Group in the northern Adelaide Geosyncline of South Australia. The reefs are of late Sturtian to early Marinoan age (late Cryogenian), overlying Sturtian diamictites and underlying Marinoan glacigene sediments. The platforms consist of dolomite of the Balcanoona Formation that is laterally equivalent to the basinal Tapley Hill Formation calcareous and dolomitic shales (Giddings and Wallace, 2009). The reef complexes (platform, reef margin and slope) consist entirely of dolomite. The dolomite has mimetically replaced the primary calcium carbonate sediments and much of the sedimentary microstructure is preserved. In

contrast, allocthonous blocks and megabreccias preserved in the basinal shales consist of undolomitized and dolomitized limestone. The undolomitized allocthonous material of the basin generally better preserves the primary depositional fabrics of the reef (and proves the reefs were originally precipitated as calcium carbonate rather than dolomite).

State of preservation and condition of item: Almost pristine condition at the moment. Threats to the area include mineral exploration and development activities.

Recommendations for protection: I suggest that the entire outcropping reef (see fig 1) be designated as a geological monument. There are other geologically significant sites within this area.

Relevant publications

Giddings, J.A, and Wallace, M.W., 2009, Facies-dependent $\delta^{13}C$ variation from a Cryogenian platform margin, South Australia: Evidence for stratified Neoproterozoic oceans? v. 271, p. 196-214.

Giddings, J.A., Wallace, M.W. and Woon, E.M.S., 2009 Interglacial carbonates of the Cryogenian Umberatana Group, northern Flinders Ranges, South Australia. Australian Journal of Earth Sciences. v. 56, p. 907 — 925

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