Insights into revised stratigraphy and structure: Updates from regional mapping in the eastern Amadeus Basin

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Introduction

The Amadeus Basin (**Figure 1**) has significant potential for hydrocarbon, helium, and hydrogen resources (Munson 2014, Schmid *et al* 2016), as well uranium and sediment-hosted copper mineralisation. The majority of the basin lies within the Northern Territory, with a section extending into Western Australia, and covers a total area of ~170 000 km^2 (Edgoose 2013). Sedimentation was active within the basin during the Neoproterozoic to the late Palaeozoic (ca 800–354 Ma) and is dominated by shallow marine successions with some fluvial, aeolian, and glacial deposits (Normington and Donnellan 2020). Lithologies include conglomerate, sandstone, siltstone, carbonate, and evaporite (Edgoose 2013). These sedimentary rocks are estimated to have a maximum thickness of 14 km (Munroe *et al* 2004) and have undergone two major intracratonic orogenic episodes (Wells *et al* 1970). First, the north-directed Petermann Orogeny at 570–530 Ma (Aitken *et al* 2009, Weisheit 2021b), followed by the south-directed Alice Springs Orogeny at 450–300 Ma (Haines *et al* 2001, Weisheit 2021b).

Mapping of the Amadeus Basin (**Figure 1**) at 1:100 000 and 1:250 000 scales was carried out from the 1950s to early 1970s by the Bureau of Mineral Resources, and by the Northern Territory Geological Survey (NTGS) during the mid to late 1990s in the southwest part of the basin. After an almost two decade hiatus, renewed mapping in the Amadeus Basin by NTGS began in the central part of the basin in HENBURY[3] (Donnellan *et al* 2023a, Donnellan *et al* 2023b), continued westward to LAKE AMADEUS and BLOODS RANGE (Verdel *et al* 2021), and is now focused in the east in RODINGA. In addition, a 1:500 000-scale interpreted geology map of the West Amadeus Basin was released in 2021 (Weisheit 2021a, b). The mapping in RODINGA will update the first edition geological map that was published in 1968 (Ranford *et al* 1968). Findings from this recent mapping have led to a number of stratigraphic and structural updates.

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3 Names of 1:250 000 mapsheets are shown in capital letters, eg HENBURY

Stratigraphic updates

Modifications to the Ediacaran and early Cambrian stratigraphy formalised in the central and western parts of the basin are being established in RODINGA. For example, the former Winnall beds, originally defined by Ranford *et al* (1965), were promoted by Donnellan *et al* (2023b) to the Winnall Group during mapping of HENBURY in the central part of the basin, and was extended into the western part of the basin by further work (Verdel *et al* 2021). This revision introduced five new formations to the group: the Breaden, Liddle, Froud, Gloaming and Puna Kura Kura formations (**Figure 2**).

RODINGA is a critical area for understanding the relationships and correlations of the Ediacaran stratigraphy of the Amadeus Basin. Here the Liddle, Froud, and Gloaming formations of the Winnall Group of the central and western basin have been identified in the western part of the mapping area. The former Winnall beds have not been identified in the eastern Amadeus Basin (including RODINGA). Instead, large areas of outcrop were originally mapped as the temporally correlative Pertatataka Formation (**Figure 2**), which comprises siltstone with lenses of conglomerate, sandstone, and carbonate (Prichard and Quinlan 1962, Ranford *et al* 1968). Results from the current mapping indicate that these areas shown as Pertatataka Formation actually comprise a wide range of Neoproterozoic to early Palaeozoic stratigraphy, which, apart from true Pertatataka Formation, includes units

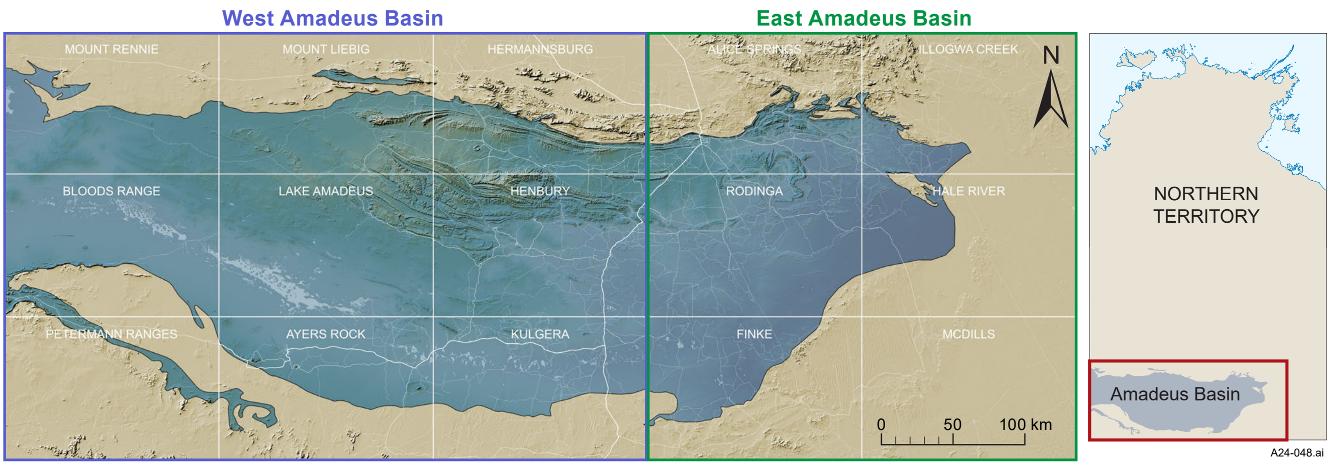

Figure 1. Shaded relief map highlighting the extent of the Amadeus Basin (in blue) within the Northern Territory. White grid and labels indicate the location of Northern Territory Geological Survey 1:250 000 map sheets. West Amadeus Basin and HENBURY released, BLOODS RANGE and LAKE AMADEUS in final edit, East Amadeus Basin and RODINGA in progress.

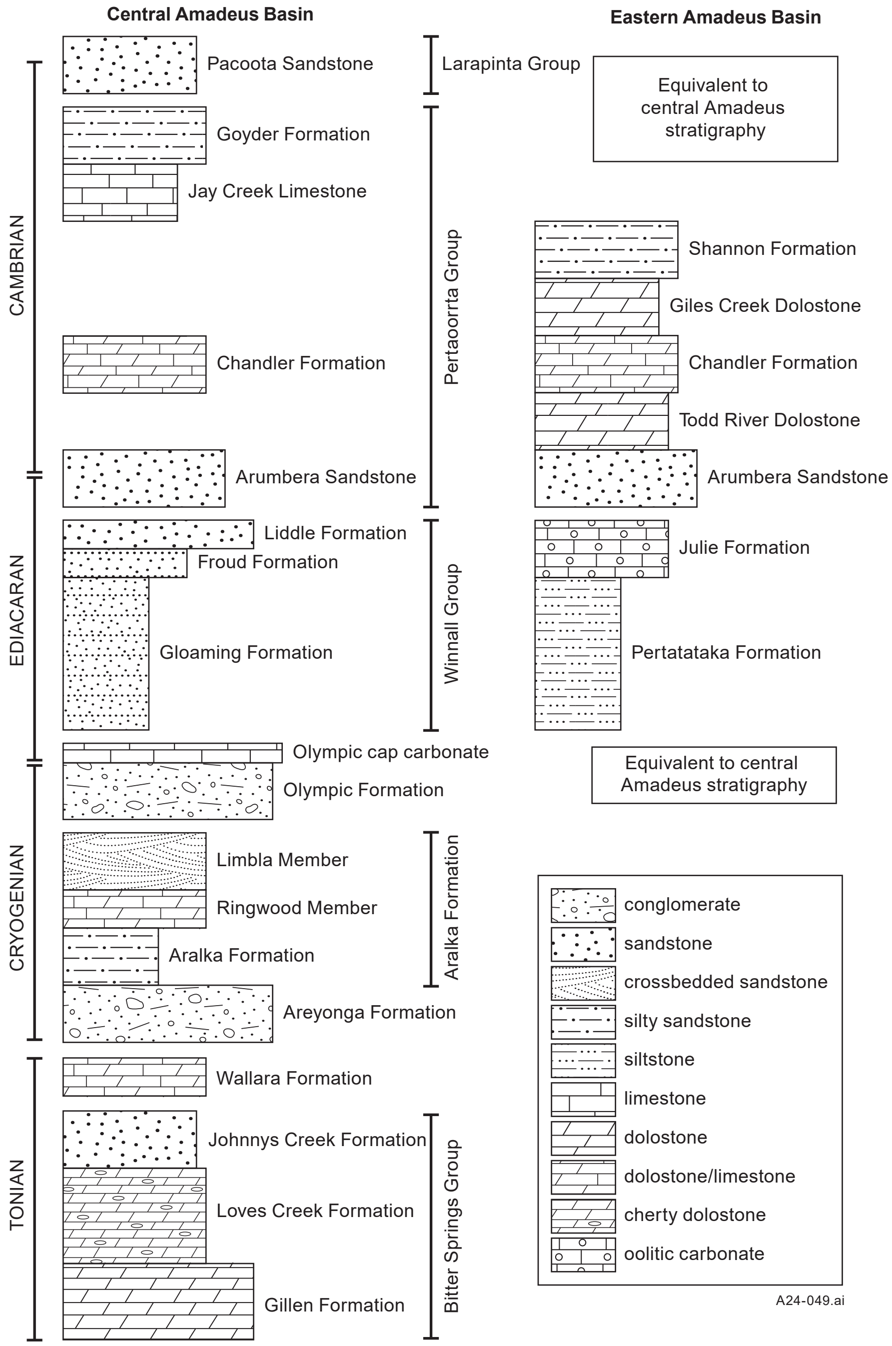

Figure 2. Simplified stratigraphic columns of the central and eastern Amadeus Basin. Note the discrepancy between the Ediacaran and early Cambrian formations across the basin.

that range in age from stromatolitic carbonates of the Tonian-aged Bitter Springs Group up to middle Cambrian units. In addition, preliminary results suggest that a more detailed correlation between the Pertatataka Formation and one or more of the formations of the Winnall Group is likely as mapping progresses.

An example of the complexity of the Neoproterozoic stratigraphy is demonstrated in a series of prominent east–west striking conglomerate ridges preserved in an anticline at Mount Burrell in the central region of RODINGA. Previously, these ridges were mapped as an informal unit of conglomeratic sandstone belonging to the Pertatataka Formation, and possibly a lateral equivalent of the former Olympic Member (Cook 1969, Ranford *et al* 1968), now named the Olympic Formation. A new interpretation, based on data collected during NTGS fieldwork, is that these conglomerate ridges and the intervening carbonates are a continuous stratigraphic succession and not a repeated one. The upper conglomerate is likely the Olympic Formation, and the lower one is likely the older Areyonga Formation (**Figure 2**). This has implications for the interpretation of the structural architecture of the eastern Amadeus Basin and will be tested with additional fieldwork.

Structural updates

The stratigraphic updates discussed above have major implications for the current understanding of the deformational history of the eastern Amadeus Basin. They suggest a simpler interplay of faulting and folding and a significant reduction in the amount of horizontal shortening compared to the existing models. An example is the Mount Burrell Anticline described above (**Figure 3**). This structure was first interpreted by Wells *et al* (1970) to be a top-to-

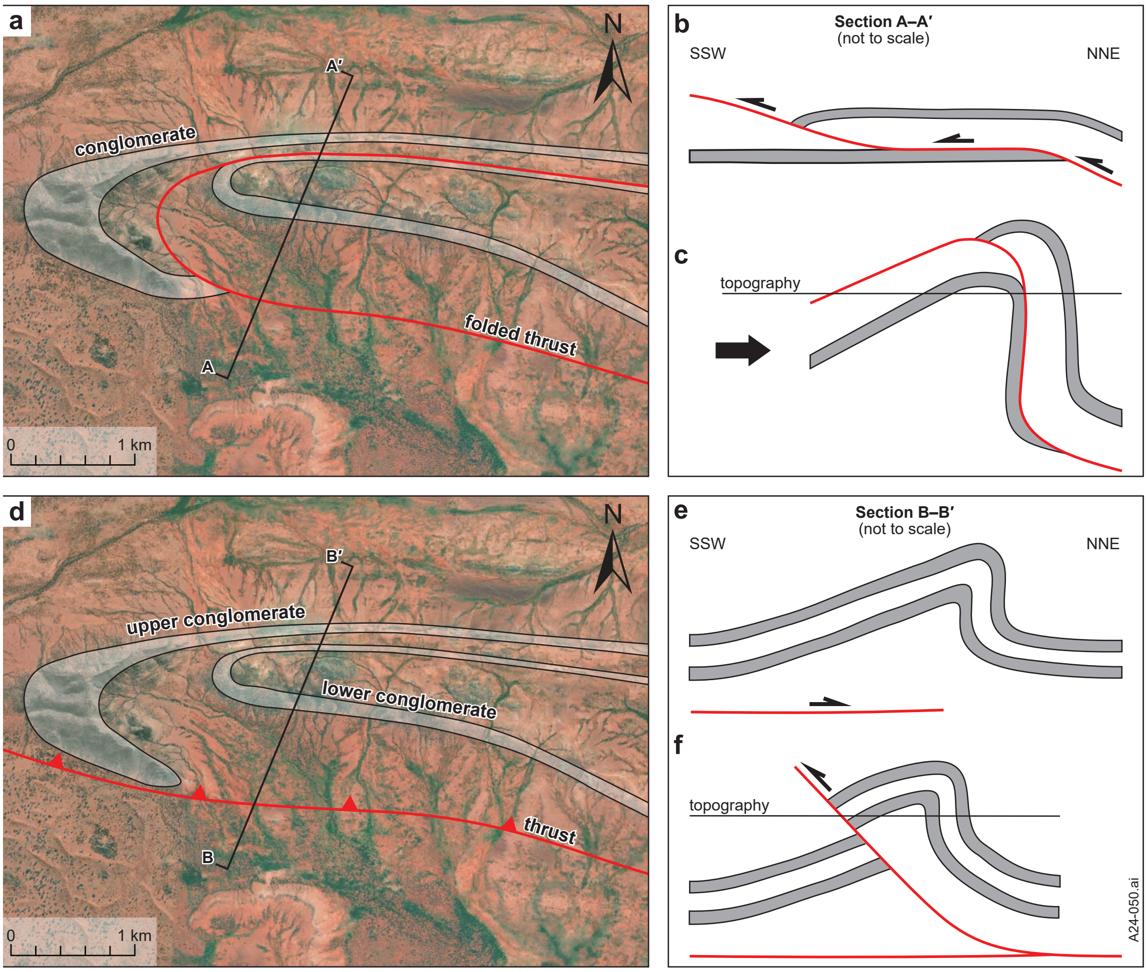

Figure 3. Two interpretations of the Mount Burrell Anticline. (**a**) Map view showing a single conglomerate that is repeated by a thrust that is then folded (interpretation from Wells *et al* 1970). (**b**) Cross-section of the single conglomerate model, initiating with a top-to-the-south thrust, followed by (**c**), top-to-the-north asymmetric folding. (**d**) Map showing the two conglomerate model. Deformation begins with (**e**), top-to-the-north detachment folding followed by (**f**), a top-to-the-south backthrust, or a distinctly younger top-to-the-south thrust. Satellite imagery from Google, ©2024 CNES / Airbus.

the-south structure that repeated a single conglomerate layer that was subsequently folded (**Figure 3a–c**). However, if the conglomerate ridges are not repeated and there is an upper conglomerate (Olympic Formation) and a lower conglomerate (Areyonga Formation) as interpreted by our work and described above, then the structural evolution is also significantly revised. In the case of two conglomerates, an initial folding event created the north-verging asymmetric fold, which was then cut by a top-to-the-south thrust (**Figure 3d–f**). Direct field evidence of folded thrusts is difficult to find; instead, evidence of major faults cutting folds is common, as can be seen by the truncation of the upper conglomerate (**Figure 3d**). This supports our new interpretation that there are two conglomerates in the stratigraphic succession, and, as noted above, this has implications for the tectonic evolution and timing of horizontal shortening in the Amadeus Basin.

Future work

Geological mapping will continue in RODINGA in 2024. Fieldwork will focus on further assessment of the Mount Burrell area, as well as similar structures to the east, with the aim of confirming and updating the currently proposed model for deformation in this part of the Amadeus Basin. The completion of mapping in RODINGA will unify the Ediacaran stratigraphy of the northeastern Amadeus Basin with that of the central and western Amadeus Basin. This work will be integrated into a new 1:500 000 scale interpreted geology of the East Amadeus Basin that is currently underway. New insights into the style of structural deformation will be useful for future mineral and energy exploration activities in the eastern Amadeus Basin.

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