

## **A revised Permian–Triassic stratigraphic framework for the northeastern Galilee Basin, Queensland, Australia, and definition of a new Middle–Upper Triassic sedimentary unit**

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### **SUPPLEMENTAL DATA**

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### **Supplementary paper**

Appendix 1. Definition of the Porcupine Gorge Formation.

Appendix 2. Definition of the Galah Tuff Bed.

Appendix 3. Raw detrital zircon data. (excel spreadsheet)

## Appendix 1. Definition of the Porcupine Gorge Formation

### Derivation of name

A previously unrecognised stratigraphic unit discovered in this study is here defined as the Porcupine Gorge Formation. The name for the unit is derived from the Porcupine Gorge in which the unit was discovered, and in which the type section is described.

### Type and reference sections

The type locality is defined as an 18.4 m thick interval of sedimentary rock, accessible on the eastern cliff-face ~1.8 km north of the base of the Pyramid Trail, itself 300 m north of the Pyramid, in Porcupine Gorge National Park, ~63 km northeast of the town of Hughenden in northern Queensland, Australia (WGS84 20°20'6.91"S 144°28'8.48"E). An additional 18.2 m thick interval of the Porcupine Gorge Formation was observed in the GSQ Hughenden 6 stratigraphic drill core (~184.6–202.8 m), which is housed in the Department of Minerals and Energy Exploration Data Centre in Zillmere, Brisbane, Queensland.

### Lithology

The 18.4 m thick formation consists of four main lithologies. The basal 2.9 m (15.8% of the formation) contains a yellow to red, poorly to moderately sorted, polymictic pebble conglomerate, with sub-rounded to rounded clasts. Clast types are dominated by quartz and rhyolite with lesser intraformational mudstones and cherts. Above the conglomerate is a 2.2 m covered interval where lithology is indeterminable. This is followed by a 3.8 m thick very pale yellow quartzose, cross-bedded sandstone (20.7% of the formation). The sandstone fines upwards from medium- to fine-grained, is typically subangular to subrounded and moderately to well sorted. Overlying this unit is 2.2 m of localised bluish grey carbonaceous siltstone interbedded with minor claystones and fine-grained sandstone (12.0%). The siltstone is typically thinly laminated but may also contain small ripple cross-stratification. Carbonaceous leaf and wood fragments are common within the laminations, with less abundant conchostracan and *Planolites* trace fossils occurring. Capping the formation is a distinctive, 6.7 m thick, mottled paleosol succession, with minor interbedded fine-grained sandstones and numerous slickensides (40%). A very thin sandstone (<10 cm) is interbedded with the paleosol at the very top.

### Distribution

The Porcupine Gorge Formation replaces 18 m of strata that had been previously assigned to the overlying Warang Sandstone. However, the distinct lithology of this unit, coupled with the erosional unconformity above and the distinct difference in mean paleocurrent vectors (southwest for Porcupine Gorge Formation, south for Warang Sandstone), is sufficient to determine it as a separate lithostratigraphic unit. The Porcupine Gorge Formation is confined in its extent to Porcupine Gorge and to the GSQ Hughenden 6 stratigraphic drill core, located ~1.2 km west of the gorge. The Warang Sandstone is poorly preserved in GSQ Hughenden 5 and so it is not possible to ascertain whether the Porcupine Gorge Formation extends to this bore location.

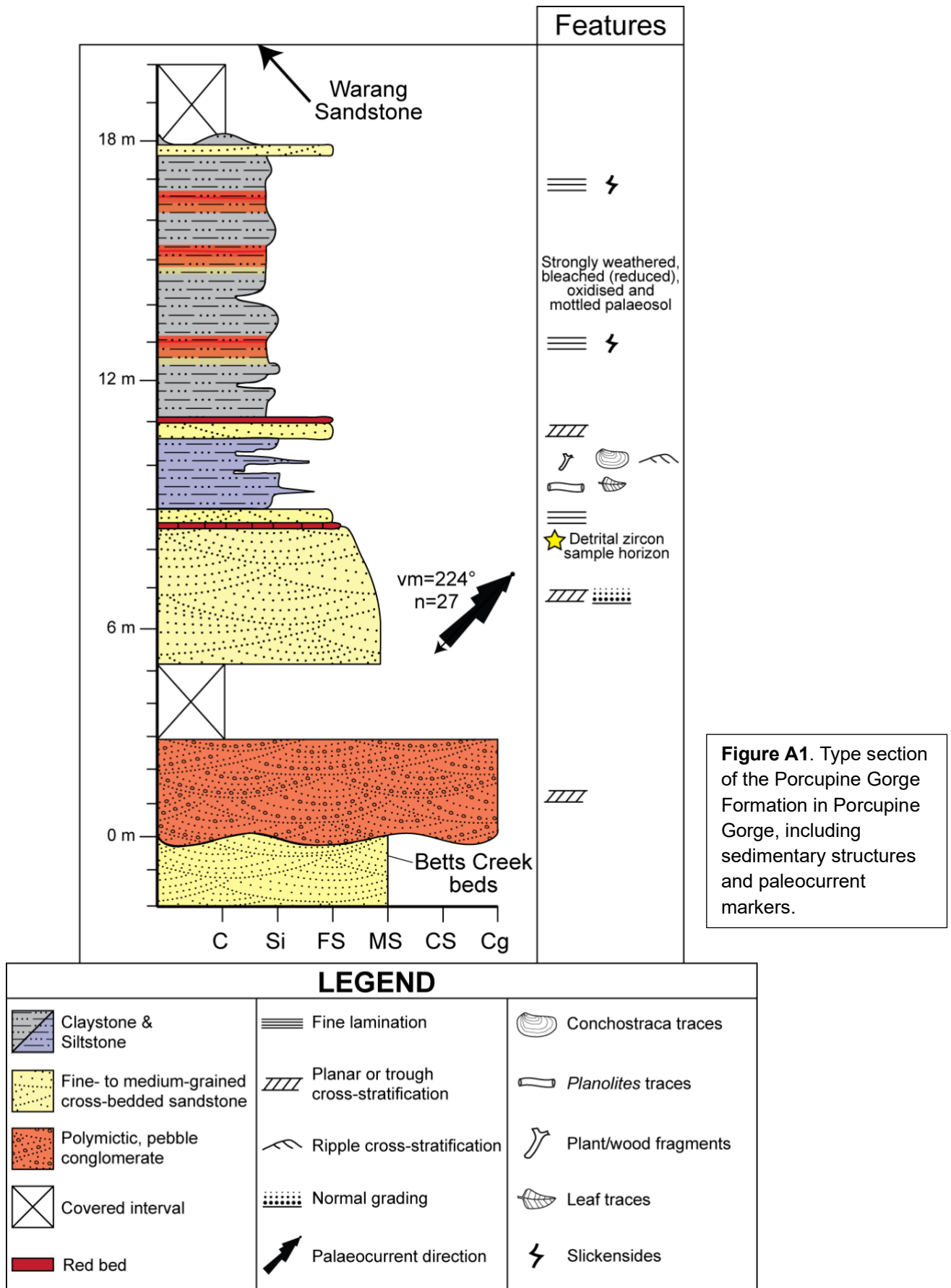
### Stratigraphic relationships

In the type section in Porcupine Gorge, the Porcupine Gorge Formation overlies the medium-to very coarse-grained sandstones of the Betts Creek beds at a disconformable surface. The white, medium-grained, cross-bedded sandstone Warang Sandstone then overlies the paleosol of the Porcupine Gorge Formation at a paraconformity. These same relationships are observed in the GSQ Hughenden 6 drill core.

### Age

Using U–Pb detrital zircon geochronology through LA-ICP-MS, a robust maximum depositional age of the Porcupine Gorge Formation was determined at  $238.7 \pm 3$  Ma from the core. A second age was calculated from outcrop at  $229.4 \pm 3.6$  Ma from outcrop and is considered to have been taken higher in the unit (see main text for discussion). This indicates that deposition of the Porcupine Gorge Formation occurred from the Ladinian until at least the late Carnian. Palynology conducted on the mudstone unit returned an Anisian to Carnian age for the unit, which is consistent with the detrital zircon ages. Further, based on this age, this unit cannot be either the Rewan or Clematis group, which

overlie the Betts Creek beds in more southerly exposures of the Galilee Basin.



**Figure A1.** Type section of the Porcupine Gorge Formation in Porcupine Gorge, including sedimentary structures and paleocurrent markers.

## Appendix 2. Definition of the Galah Tuff Bed

### Derivation of name

This distinctive tuff horizon in the Betts Creek beds is named for the parish of Galah, which covers the northern section of Porcupine Gorge where the type section is located.

### Type and reference sections

The type section is recognised within a 10 m thick succession of medium- to very coarse-grained quartzose sandstone in the uppermost exposures of the Betts Creek beds, ~2 km NNE of the base of the Pyramid Trail, approximately 300 m north of the Pyramid in Porcupine Gorge National Park, ~63 km northeast of the town of Hughenden, North Queensland, Australia (WGS84 20°19'58.22"S 144°28'15.45"E).

### Lithology

The Galah Tuff Bed is white, porphyritic, and typically internally massive. It contains rounded phenocrysts of coarse-grained quartz clasts and clay clasts that range in size from 0.2–3.0 mm but are generally <1 mm. These phenocrysts constitute ~5–10% of the tuff and are evenly distributed within a very fine-grained matrix. The clay clasts are likely the result of feldspar weathering and give a soapy feel to the rocks. Based on this grain size and distribution, the Galah Tuff Bed is classified as a volcanic ash-fall tuff.

### Distribution

The Galah Tuff Bed is confined to outcrop exposures in Porcupine Gorge National Park in North Queensland, observable in lateral extent for ~80 m in the cliff face. While a similar stratigraphic interval was intercepted in drill core GSQ Hughenden 6, no tuff horizon was recorded. However, it is notable that ~3 m of core was not recovered from this bore traversing the boundary between the Betts Creek beds and Porcupine Gorge Formation, and this may have contained the Galah Tuff Bed.

### Thickness

In the type section, the Galah Tuff Bed attains a maximum thickness of 1.5 m but averages 0.5 m.

### Age

LA-ICP-MS zircon geochronology provided an age of  $251.9 \pm 3.0$  Ma (latest Permian–earliest Triassic) for the Galah Tuff Bed. This confirms the late Permian assignment of the Betts Creek beds and provides a robust stratigraphic marker for the overlying Triassic strata.

### Stratigraphic relationships

The Galah Tuff Bed is highly limited in extent in Porcupine Gorge, where it is situated ~5 m below the top of the Betts Creek beds. Based on the age assignment of  $251.9 \pm 3$  Ma, the Galah Tuff Bed is roughly equivalent in age to the Gibraltar Ignimbrite ( $251.6 \pm 3.2$  Ma; Campbell *et al.*, 2015), as well as the Yarrabee Tuff ( $252.54 \pm 0.04$  Ma –  $253.07 \pm 0.22$  Ma; Phillips *et al.*, 2018).

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