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Browse LNG Precinct




Browse Liquefied Natural Gas Precinct
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Preliminary Report upon the Palaeontology (including Dinosaur Footprints) of the Broome Sandstone in the James Price Point Area

Browse LNG SEA

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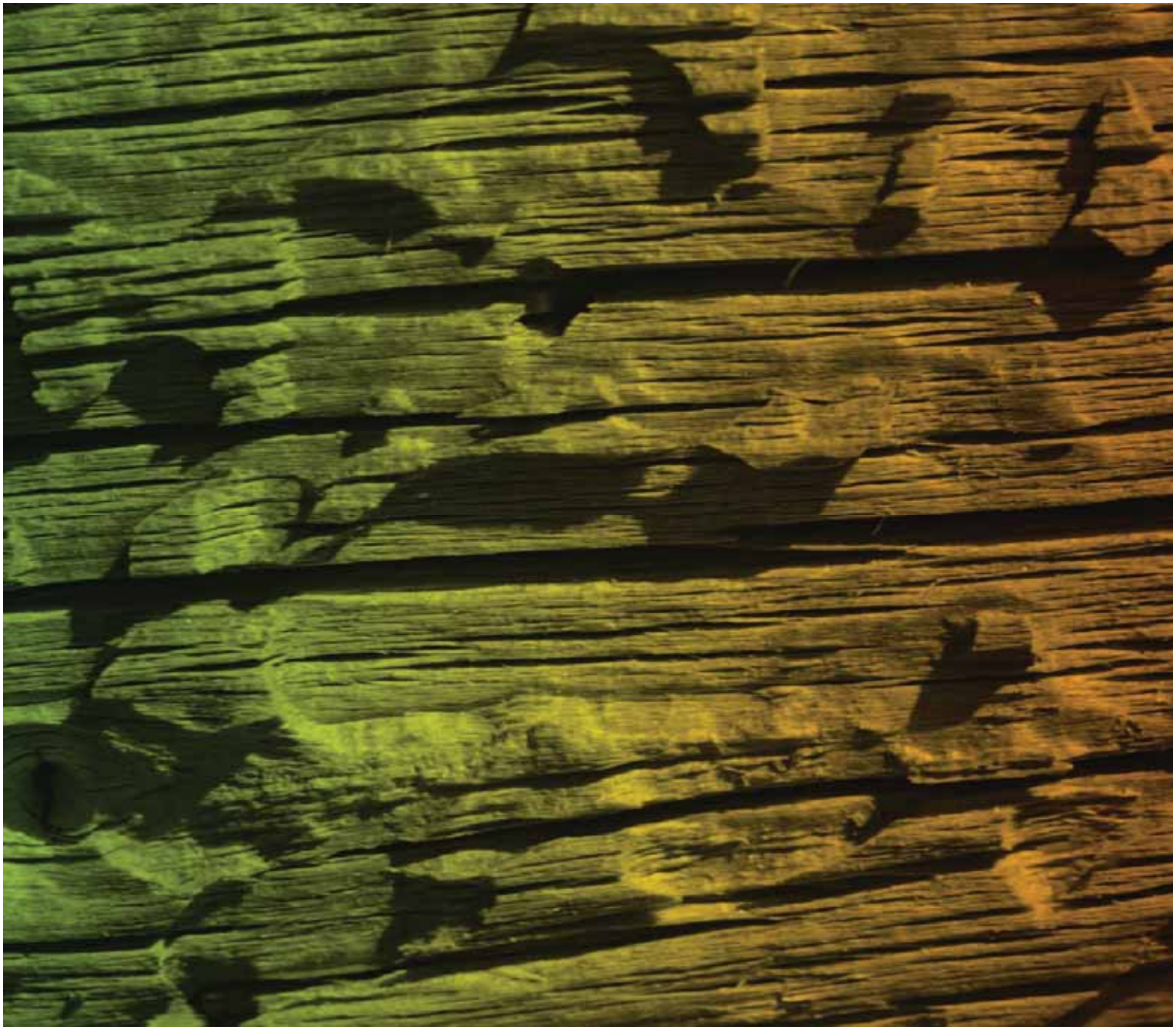

Preliminary Report upon the Palaeontology (including Dinosaur Footprints) of the Broome Sandstone in the James Price Point Area, Western Australia

Prepared for

Department of State Development

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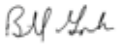
1	27-Jan-2010	For Issue	Bill Gorham Project Manager	

Table of Contents

List of Figures

Executive Summary

Intertidal outcrops of the Broome Sandstone were examined on 3, 4, and 5 November 2009 at low tide along a 4.2 kilometre (km) stretch of coastline, between 3 km south and 1.2 km northeast of James Price Point. Suboptimal spring tides prevented examination of the lowermost 1 metre (m) of vertical outcrop within the total intertidal zone. These may or may not yield museum-grade trackways.

Relatively abundant (approximately 1/200 m² on average), sub-circular structures interpreted as degraded sauropod underprints (see end of this report for a definition of the term 'underprint'[i]) were found in two beds (almost all in the lower bed) in the lowermost third of the intertidal zone (within a 280 m long and 30 m wide area), approximately 2 km south of James Price Point.

The Broome Sandstone exposed in cliff sections and within the intertidal zone between 2 km south of James Price Point and 1.2 km north of the point, did not yield any dinosaur footprints.

The intertidal zone between 1.2 km and 4.5 km north of James Price Point was not surveyed but is largely covered by sand.

The site selected for the LNG plant covers the section of the intertidal zone yielding the sauropod underprints. This is likely to result in the complete destruction of dinosaur trace fossils unless they are removed.

The quality of the sauropod trackways at James Price Point is very poor compared to spectacularly well-preserved examples recorded by Dr Thulborn and colleagues at undisclosed sites further south along the coastline between Broome and James Price Point.

1.0 Introduction and Background

As part of the Strategic Assessment for the Browse LNG Precinct, the Western Australian Museum (WAM) was contracted to undertake an assessment of the fossil content in intertidal exposures of the Lower Cretaceous Broome Sandstone in the James Price Point area. The Broome Sandstone is well known for its dinosaur trackways and footprints (Glauert, 1953, Colbert and Merilees, 1967; Playford *et al*., 1975; Thulborn *et al*., 1994; Long 1998), and special emphasis was placed on recording dinosaur footprints occurring along a stretch of shoreline located between 3.0 km south to 1.2 km north of James Price Point.

In the James Price Point area, the Broome Sandstone is exposed intermittently **(Figure 1)** within the intertidal zone and in cliff sections **(Figure 2)** north of the point. The unit is overlain by the Pleistocene 'Pindan' sandstone/siltstone deposits that form bright red cliff sections around the point **(Figure 3)**.

In the first published account of dinosaur footprints and trackways near Gantheaume Point, Glauert (1952) recognised that the local Traditional Owners were very familiar with trackways of 'giant birds' in the Broome Sandstone. Their reference to the trackways as enormous bird tracks has proved rather accurate given that most current vertebrate palaeontologists regard birds as of dinosaur lineage. The local Aboriginal name for these trackways is 'warragunna'.

Conversations with a member of the Jabirr Jabirr people, who kindly and efficiently guided the survey team on site, indicate that James Price Point is visited on a more-or-less regular basis by camping family groups, especially at spring tides.

2.0 Methodology

The survey was carried out by a field crew from the Western Australian Museum comprising the officer in charge, Dr Siversson, a technical officer and two volunteers. The area intended for the five days of survey included the intertidal zone between 3 km south and 4 km north of James Price Point. Because of weather limitations, surveys were conducted over only three days and limited to the intertidal zone between 3 km south and 1·2 km northeast of James Price Point **(Figure 4)**.

Mapping of footprints involved measuring the maximum diameter of sauropod underprints, recording their position with a hand held GPS device (Garmin eTrex, horizontal accuracy 15 m) and photographing some of the footprints and incomplete trackways. All specific locality data was stored by Dr Siversson.

The very limited time available for this type of mapping and the nature of the outcrops did not permit the use of a grid. Most of the underprints were discovered on Tuesday 3 November, between 3 and 5pm. The lowest tide on that day was 1.79m (Broome datum) around 5pm.

3.0 Results

The Broome Sandstone is up to 286 m thick in the Broome area (Playford *et al.*, 1975). It comprises several lithofacies around James Price Point, including massive sandstones, cross-bedded sandstones **(Figure 5)**, laminated siltstones **(Figure 6)**, flaser bedding, and conglomerates **(Figure 7)**. Ripple marks were encountered in places **(Figure 8)** and some of the sandstone beds are visibly bioturbated by worms and possibly crustaceans. Numerous bedding planes preserve sections of desiccated mud flats **(Figure 9)**. Plant fossils, relatively abundant in the Broome Sandstone around Broome itself, are absent or very rare.

Sub-circular structures interpreted as degraded sauropod underprints **(Figure 8, Figure 10, and Figure 11)** were identified within two sandstone beds south of James Price Point. The specific locations and related information are available from Dr. Siversson but can only be provided to people authorised by the Department of State Development or the Traditional Owners.

A presumed tridactyl footprint **(Figure 12)** was discovered in the uppermost part of the intertidal zone, approximately 1 km south of the point. A closer examination indicates that the specimen is a 'pseudo-fossil', superficially resembling a tridactyl (three-toed) dinosaur foot print **(Figure 13)** as the individual 'digits' are demarcated by different sediment layers (not apparent in **Figure 12** as the middle and right 'digit impressions' are partly filled with water).

Intertidal outcrops of the Broome Sandstone between 1·2 km and 4·5 km north of James Price Point are poorly exposed during low to mid-tide. The intertidal zone immediately north-east of James Price Point is much degraded and contains no recognisable footprint (with the possible exception of the lowermost part, accessible only during extreme spring tides). Farther north the intertidal zone is largely covered by sand **(Figure 14)**; indicating poor potential for further finds (unless cyclonic storm surges temporarily remove the sand cover).

4.0 Discussion

The dinosaur footprints and trackways within the intertidal zone of the Broome Sandstone are, by far, the most diverse in Australia and compare favourably with the most diverse assemblages known from anywhere in the world (Thulborn *et al.*, 1994). The area includes the only known sauropod trackways in Australia. The quality of some of the sauropod trackways is outstanding (Long, 1998, p. 129) and some of the individual sauropod footprints are larger than dinosaur footprints found on other continents. The distribution of sauropods in the Cretaceous period of Gondwana and the identity of recently described skeletal remains from sauropods in the Albian-Cenomanian Winton Formation in Queensland, infer that many, if not all, sauropod trackways in the Broome Sandstone can be assigned to titanosaurs. This group of sauropods includes the largest known land animals, such as *Argentinasaurus*, estimated to have reached a weight of 60-70 tonnes.

The dinosaur footprint assemblage identified by the WAM field crew at James Price Point comprises sub-circular structures identified as degraded underprints of sauropods. The quality of the trackways and individual footprints is not as spectacular as that of some of the material described by Thulborn *et al.*, (1994). The footprint-bearing bed does not form a well-preserved bedding plane but comprises isolated, often rounded boulders of sandstone. As with any type of fossils, dinosaur footprints in general range in preservation from spectacularly well preserved trackways (which do occur further south in the Broome Sandstone) to severely degraded, almost unrecognisable isolated imprints. The sauropod underprints identified within a 280 metres long and 30 metres wide area, approximately 2 km south of James Price Point are not of museum-grade quality. Given that exceptionally well-preserved dinosaur trackway assemblages occur at several locations further south of James Price Point (see Thulborn *et al.*, 1994), the footprints found during the survey are of moderate scientific importance from the Western Australian Museum's viewpoint but may have significant heritage value to the Traditional Owners.

The lack of fossil plant material, abundant flaser bedding, desiccation surfaces, and intervals with fine-grained laminated sediments indicate tidal and lagoonal palaeoenvironments in the James Price Point area. In their preliminary report on sauropod trackways from the Dampier Peninsula, Thulborn *et al.* (1994) reported relatively abundant sauropod underprints and rare footprints of large theropods (carnivorous species) and ornithopods (group of 'bird-hipped', plant-eating dinosaurs) from the tidal/lagoonal facies of the Broome Sandstone. Terrestrial strata with plant fossils, indicating a swamp/forest setting, yielded well-preserved true tracks (as opposed to the subsurface prints characterising tidal/lagoonal facies) of a whole variety of small to large dinosaurs, including sauropods.

Presumed fossilised footprints are some of the most common 'fossils' brought in to the Western Australian Museum for identification by the public. In almost all cases, they turn out to represent weathering features of non-biological origin. It is therefore justifiable to approach unpublished/unverified reports of dinosaur footprints around James Price Point with some scepticism. The author of this report has examined a number of photographs depicting alleged dinosaur footprints and even dinosaur remains from the James Price Point area. All of them depict various weathering features of the Broome Sandstone.

5.0 Assessment of possible impacts

Dinosaur trackways and isolated footprints occur in the Broome Sandstone between Broome itself and James Price Point (Thulborn et al., 1994, fig. 1). Virtually all imprints are exposed within the intertidal zone.The dinosaur ichno fossils range in state of preservation from 'world-class' assemblages of extraordinary scientific importance (assuming they will eventually be described in peer-reviewed scientific journals) to severely degraded, barely recognisable underprints. In 1997, Thulborn and colleagues flew over the intertidal zone at low tide and recorded numerous trackway sites, many of which had just been exposed after cyclonic storm surges. The sites were subsequently visited from the ground. Some of the sites yielded trackways even better preserved than the high-quality examples illustrated by Thulborn *et al.*, 1994 and Long, 1998. The results of the 1997 expedition have not been published in a scientific journal. In the absence of a formal description of the spectacular trackways discovered in 1997, comparisons of the trackways/footprints in the James Price Point area with those in other parts of the Broome Sandstone (for example the intertidal zone 3 km south of James Price Point to Broome), depend on the few illustrations in Thulborn *et al.,* (1994) and Long (1998), depicting spectacular, museum-grade trackways from undisclosed sites along the coast between Broome and James Price Point.

The dinosaur trackways/footprints found during the survey of the James Price Point area are near the bottom end of the preservation scale of these ichnofossils in the Broome Sandstone of the Dampier Peninsula. Outcrops of the Broome Sandstone within the accessed part of the intertidal zone are predominantly rubbly, especially around James Price Point itself. The degraded condition of the outcrops renders identification of possible footprints difficult, at best, in most areas.

The exact location for the proposed Browse LNG precinct indicates a direct impact on the sauropod underprints. Their removal or destruction is regrettable but the overall impact on the entire dinosaur trackway assemblage of the Broome Sandstone is negligible considering the vastly superior quality of trackways found further south along the coast.

The proposed development of a LNG plant at James Price Point would require significant and possibly ongoing dredging of one or more channels and the construction of groynes and bulkheads. Both groynes and breakwater structures cause a re-distribution of sand transported by longshore currents. The net impact on dinosaur footprints in the area is unpredictable, but currently exposed sauropod footprints may well become buried under sand whereas areas within the intertidal zone currently covered by sand could be exposed, potentially revealing better preserved trackways and footprints.

6.0 References

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Figure 1 **Bedding plane with numerous potholes, exposed at low tide south of the point. The more-or-less circular depressions resemble sauropod footprints. However the small diameter of the depressions (~30 cm) and their seemingly random distribution indicate that they are not footprints.**

Figure 2 **Outcrop of Broome Sandstone with heavy mineral sand at its base, approximately 1 km north of James Price Point.**

Figure 3 The Pleistocene 'Pindan' sandstone/siltstone, overlying the Lower Cretaceous Broome Sandstone at James Price Point

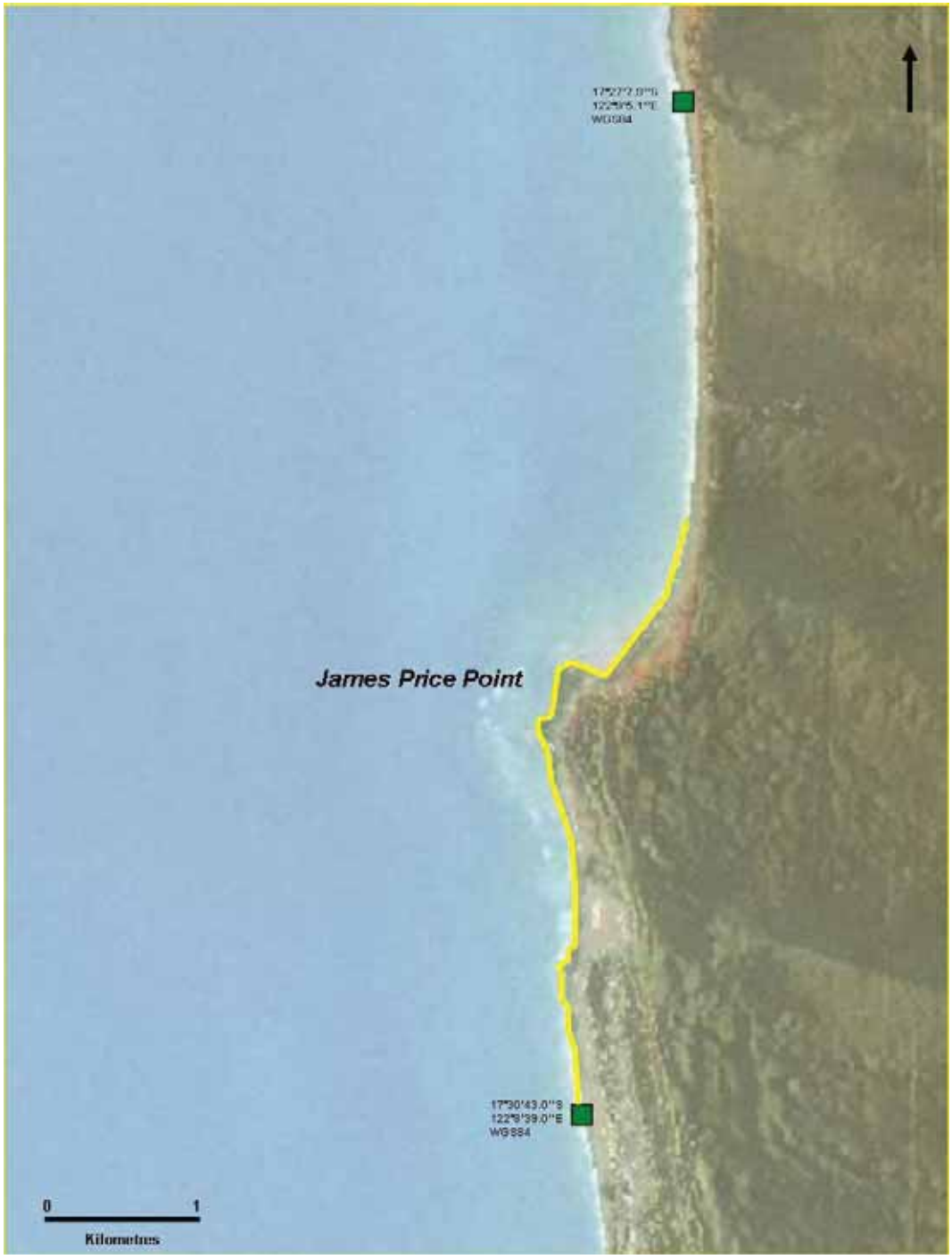

Figure 4 **Map showing the southern and northern boundaries (green boxes) of the proposed survey area and the actual area surveyed (yellow line).**

Figure 5 Cross-bedded Broome Sandstone, exposed in cliff-sections a few hundred metres north of James Price Point.

Figure 6 Erosional contact between laminated lagoonal silt/mud-stone and overlying coarse sandstone.

Figure 7 Conglomerate, overlying cross-bedded sandstone.

Figure 8 Sauropod underprint with a more weathering resistant core. Note surrounding ripple marks.

Figure 9 Fossilised desiccation cracks.

Figure 10 Relatively large (~70 cm in diameter) sauropod underprint with positive relief, south of James Price Point.

Figure 11 Two degraded sauropod underprints, south of James Price Point.

Figure 12 A 'footprint' of non-biological origin, convincing with the right lighting.

Figure 13 Another photograph of the same specimen showing a horizontal, undisturbed stratum overlying the 'heel' area and the following bed forming the outer edge of one of the 'digits'.

Figure 14 The area north of James Price Point at low tide. Note the sand-covered intertidal zone in the background.

[i] Underprint is a term applied to the horizontal cross-section of the deformed sedimentary layers directly underlying the bed or beds forming the walls of the actual footprint. The shockwave from the foot of the sauropod making contact with the sediment formed dish-like structures in underlying sediment layers down to a depth of up to 70 cm (Thulborn *et al.*, 1994). Deeply formed underprints do naturally not preserve any impressions of individual digits of the pes (hind foot) and manus (front foot). Towards the base of the deformed stack of strata impacted by the sauropod foot, the underprints take on a progressively more circular outline with little detail. The horizontal cross-section of an underprint commonly resembles that of an onion with several concentric laminations, each representing an individual, deformed sediment layer. Typically, sauropod footprints would form in a fine-grained muddy sediment (e.g., a tidal mudflat) and subsequently become covered with a coarser sand, preserving the original impression. The backfill sand is sometimes preserved as a central dome-shaped structure within the underprint **(Figure 8)**. The vast majority of sauropod underprints preserved in the Broome Sandstone are pes imprints. This indicates that most of the weight of the sauropod was supported by the hips, resulting in deeper penetration of the pes. Sauropod tracks in the forest/swamp facies of Thulborn (*ibid.*)et al., (1994) tend to preserve both the subcircular pes imprint and the often kidney-shaped manus imprint (Anonymous, 2009, fig. 3).