



# Erosion rates and weathering history of rock surfaces associated with Aboriginal rock art engravings (petroglyphs) on Burrup Peninsula, Western Australia, from cosmogenic nuclide measurements

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## ABSTRACT

The Burrup Peninsula and surrounding Dampier Archipelago, in Western Australia, contain the world's largest known gallery of rock art engravings (petroglyphs), estimated to number up to 1 million images. The peninsula is also the site of major industrial development and there are concerns that industrial emissions may adversely affect the stability and longevity of the rock art. We have studied the natural processes and rates of weathering and erosion, including the effects of fire, that affect the stability of rock surfaces and hence the longevity of the rock art, using cosmogenic nuclides. The concentration of  $^{10}\text{Be}$  in quartz yields erosion rates in the range 0.15–0.48 mm/1000 years on horizontal rock surfaces and 0.34–2.30 mm/1000 years on vertical rock faces. The former, largely caused by mm-scale surface flaking, are amongst the lowest erosion rates measured by cosmogenic nuclides anywhere in the world. The latter are inferred to represent a combination of mm-scale flaking and very rare centimetre- to metre-scale block falls, controlled by failure along joint planes. Such low erosion rates result from a combination of resistant rocks, low relief and low rainfall, favouring long-term preservation of the petroglyphs – long enough to encompass the known period of human settlement in Australia.

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## 1. Introduction

The Burrup Peninsula and surrounding Dampier Archipelago, near Karratha, in the Pilbara region of Western Australia, contain the world's largest known gallery of rock art engravings (petroglyphs), estimated to number up to 1 million images (Bird and Hallam, 2006). Archeological studies on the Burrup Peninsula indicate human occupation at least during the last 7000 years (Bradshaw, 1995), and perhaps up to 18,000 years (Lorblanchet, 1992), while sites in the inland Pilbara have yielded occupation ages up to 35,000 years (Law et al. 2010). Lorblanchet (1992) reported radiocarbon ages of up to 3700 BP for sediments containing rock art fragments, thus providing a minimum age for some of the rock art. Mulvaney (2011) has argued that, based on stylistic and weathering patterns of the rock art, it may span up to  $25,000 \pm 5000$  years. However, whether the age of the rock art on Burrup Peninsula spans the known range of human occupation in the region remains unknown.

The peninsula is also the site of major industrial development, associated with the port of Dampier, which has resulted in destruction of many archeological sites and thousands of petroglyphs in the industrial precinct. Approximately 15% of the Burrup Peninsula has undergone industrial development, but in 2007 the remaining parts of the peninsula and the other islands of the archipelago were placed on National Heritage Register of Australia (McDonald and Veth, 2009). There have also been concerns (e.g. Bednarik, 2002) that industrial emissions may adversely affect the stability and longevity of the rock art over a wider area.

In this study, we report long-term erosion rates on rock surfaces associated with the rock art, using cosmogenic nuclide measurements. Our data represent 'natural' rates of rock surface erosion averaged over timescales of thousands of years, against which modern (post-industrial) erosion rates can be assessed and which will be reported in a subsequent paper.

## 2. Field setting

The Dampier Archipelago, on the northwest coast of Western Australia, some 1500 km north of Perth, consists of 42 islands of which Dampier Island is the largest (Fig. 1). Dampier Island is now

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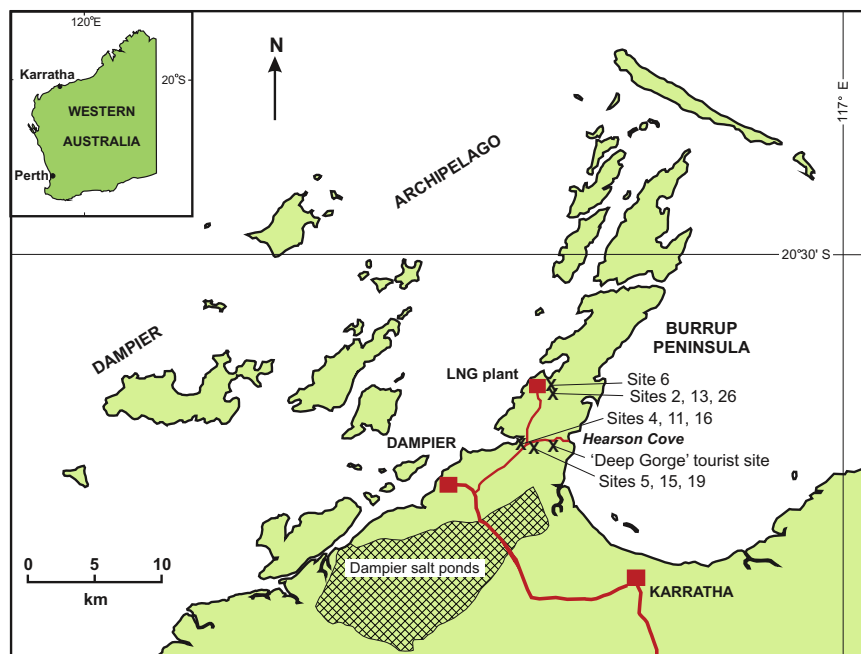


Fig. 1. Location of study area and sample sites on Burrup Peninsula, Western Australia.

an artificial peninsula, known as 'Burrup Peninsula', joined to the mainland by a causeway that links the nearby city of Karratha with the port of Dampier. Major industrial activity includes the Rio Tinto iron ore loading facility at Dampier, and the Woodside liquefied

natural gas (LNG) plant some 10 km to the north, as well as salt mining and local quarrying.

Burrup Peninsula, about 30 km long and 5 km wide, is characterised by boulder-covered ridges and rocky hills up to 128 m high



Fig. 2. General view of boulder-covered hills and ridges, looking northwest to the Woodside LNG plant, Burrup Peninsula.

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