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The influence of tropical cyclones on long-term riverine flooding; examples from tropical Australia

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ABSTRACT

Luminescence chronologies for two new slackwater flood deposit (SWD) sites (Broken River northeast Queensland and Ord River northwestern Western Australia) are presented and these along with other SWD chronologies from the same regions are compared with recently developed high resolution, isotope tropical cyclones (TC) records. Heightened TC activity occurred between 1400 and 1850 CE in Queensland and between 1500 and 1850 CE in Western Australia. A distinct clustering of flood events in northwest Western Australia during the period of enhanced TC activity suggests the two may be related. The SWD records in northeast Queensland do not cluster specifically during the period of heightened TC activity however several major floods do occur during this time suggesting that TCs may have been involved.

1. Introduction

The link between palaeoflood records and climate is often tenuous despite the fact that phases of enhanced flooding in a record can be suggestive of a wetter climate and an absence of such phases the opposite (Kale and Baker, 2006). In tropical regions palaeoflood deposits are also sometimes suggested to be due to the rainfall and floods generated during tropical cyclones (TCs) and these palaeoflood records are taken as a type of proxy for these storms (Deniston et al., 2015; Rouillard et al., 2016). An assumption is made here however that such high magnitude floods are caused by TCs as opposed to other rain bearing systems such as upper troughs and monsoonal low pressure systems. Historically, TCs do appear to produce many of the largest floods in some catchments such as the Barron River catchment in northeast Queensland (Leonard and Nott, 2016) and also the Kimberley region (Deniston et al., 2015). It would stand to reason therefore that palaeoflood records would also reflect palaeo-TC activity but to date no independent verification has been made to assess whether this is the case. The recent development of high resolution isotope records of TCs within limestone stalagmites and the development of the Cyclone Activity Index (Nott et al., 2007; Haig et al., 2014) offers scope in this regard. Comparisons are made here between these types of long-term high resolution TC records from Western Australia and northeast Queensland and previously published slackwater deposits (SWD) along with two new SWD sequences. Slackwater deposits are defined here as fine-grained sedimentary units deposited during high magnitude floods in areas of relatively calm water away from the zone of higher velocity flow. The two new SWD records presented in this study are from the Broken River in northeast Queensland and the Ord River in northwest Western Australia. These along with existing SWD records from the Burdekin and Herbet Rivers in northeast Queensland and the Margaret, Fitzroy and Leonard Rivers in northwest Western Australia are compared with the high resolution multi-century Cyclone Activity Index (CAI) records from Cape Range, Western Australia and Chillagoe, northeast Queensland. The aim of these comparisons was to examine whether there were any clear associations between periods of heightened palaeoflood activity and TC activity in these tropical regions.

2. Geological and geographical settings

All of the palaeoflood sites discussed here are influenced by the Austral monsoon between November and April each year. Average annual rainfall however varies substantially between sites. The Burdekin and Herbet River catchments in northeast Queensland receive between 600 and 1500 mm annually. The Broken River catchment receives between 600 and 1000 mm annually. Likewise, the Ord River in northwest Western Australia receives between 600 and 1000 mm annually whereas the Fitzroy, Margaret and Leonard Rivers receive between 400 and 600 mm annually (BoM, 2016).

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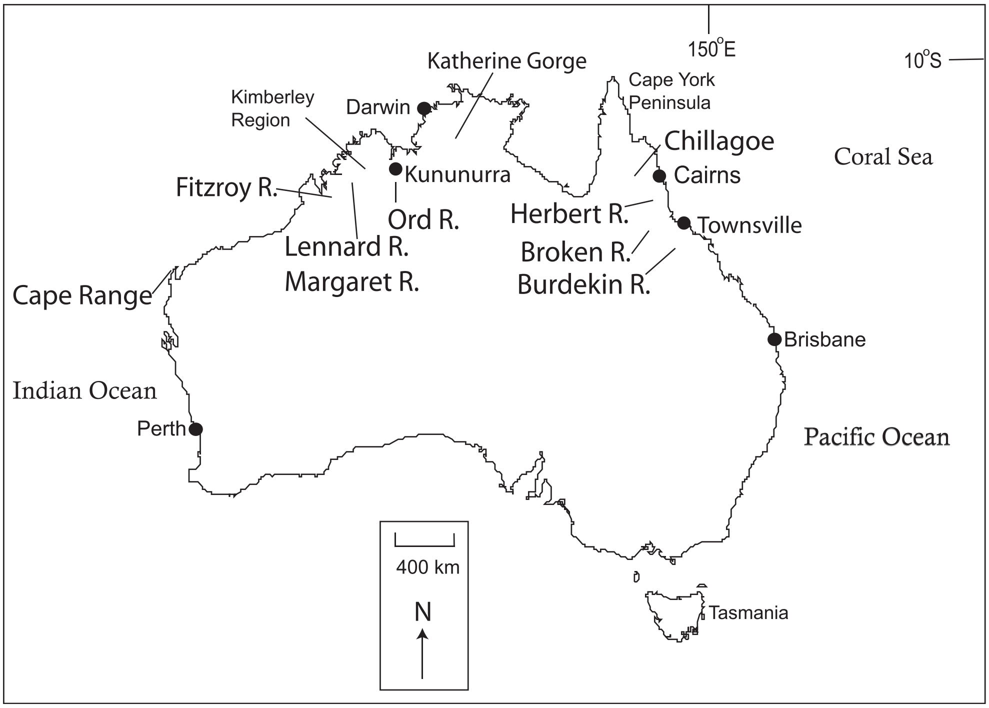

Fig. 1. Locations mentioned in text.

Tropical cyclones produce rainfall in all of these catchments at various times. The percentage of annual rainfall from TCs however is relatively low. In Western Australia annual rainfall totals from TCs vary between 20 and 40% with the inland parts of catchments receiving approximately 20%. Along the east coast of Australia annual percentage contributions from TCs can be as low as 10% (Dare et al., 2012).

Each of the palaeoflood deposit sites contain SWD and all but two have been documented previously (Herbet and Burdekin Rivers – Wohl, 1992a,b; Fitzroy and Margaret Rivers – Wohl et al., 1994; Lennard River – Gillieson et al., 1991). The two new sites presented here are Broken River in north Queensland and the Ord River in northwest Western Australia (Figs. 1–4). Slackwater deposits have also been documented in the Katherine River by Baker and Pickup (1987) but these have not been included in the analyses as there is no nearby site record of TCs (long-term) for this area of the Northern Territory.

2.1. *Broken River, North Queensland*

Broken River is a tributary of the upper Burdekin River which flows to the Coral Sea south of Townsville (Figs. 1–3). Broken River flows through late Palaeozoic fold belt strata and has a catchment area of approximately 120 sq. km., 280 km southwest of Cairns. The river forms a small gorge as it traverses a narrow belt of Silurian limestone. The mechanical strength and hence erosional resistance of the limestone has caused a significant narrowing of the river valley and as a consequence, flood-waters back up at the upstream end of the limestone gorge. Here, slackwater sediments consisting predominantly of fine-grained sands and silts (Fig. 4) have been deposited within the channel of a northern tributary which flows into Broken River along the junction of the limestone and adjacent fold belt rock. The slackwater sediments in the tributary stream valley are approximately 12 m thick. The sediments have been deposited against the valley walls of the tributary channel, one of which is the edge of the limestone outcrop.

2.2. *Ord River, Western Australia*

The Ord River rises in the Carr Boyd Range, near Kununurra in the East Kimberley region of northwest Western Australia. The river flows northward for most of its 120 km length and enters the Timor Sea at Cambridge Gulf (Figs. 1 and 5). The river is dammed in two locations. The upstream dammed section of the river forms Lake Argyle, downstream of here the river has carved a gorge, up to 40–50 m deep and several hundred metres wide. The second dam occurs downstream of the gorged section near Kununurra. The gorge is carved into Proterozoic sandstones. It does not maintain a uniform width along its length; in places the gorge width decreases from about 300 m to 200 m. Sedimentary terraces/benches occur immediately upstream of these gorge constrictions in at least 5 separate locations. The terraces stand up 8 m high above the normal dry season river level and extend along the stream for several hundred metres (Fig. 6). They are flat topped and usually about 30–40 m wide and abut the gorge walls. They could be likened in morphology to a lateral bar. They are composed of well-sorted fine-grained sands and silts (Fig. 4) and show no distinct variation in colour, texture or degree of weathering down profile. Indeed for the most part, the sediments have a relatively fresh appearance as they contain well-preserved micas, which are normally easily weathered and removed from sedimentary units in tropical Australia after only a few thousand years. The units also have sedimentary structures preserved. These ‘drape like’ structures appear to be bedding planes developed from the deposition of suspended sediments in relatively still water for they have high dip angles (>30°) and drape over irregularities along the contact with the underlying strata.

3. Methods

Two auger holes (JG3 and JG4) were sunk into the SWD deposit at Broken River and two of the SWD/terraces in the Ord River was also augered. The auger holes were drilled to a depth of 4 m in each