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A 100 ka record of fluvial activity in the Fitzroy River Basin, tropical northeastern Australia

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ABSTRACT

This study reports the nature and timing of Quaternary fluvial activity in the Fitzroy River basin, which drains a diverse 143,000 km^2 area in northeastern Queensland, before discharging into the Great Barrier Reef Marine Park. The catchment consists of an extensive array of channel and floodplain types that we show have undergone large-scale fluvial adjustment in-channel planform, geometry and sinuosity. Optically stimulated luminescence (OSL) dating of quartz sediments from fifteen (3–18 m) floodplain cores throughout the basin indicates several discrete phases of active bedload activity: at ~105–85 ka in Marine Isotope Stage (MIS) 5, at ~50–40 ka (MIS 3), and at ~30–10 ka (MIS 3/2). The overall timing of late Quaternary fluvial activity correlates well with previous accounts from across Australia with rivers being primarily active during interstadials. Fluvial activity, however, does not appear to have been synchronous throughout the basin's major sub-catchments. Fluvial activity throughout MIS 2 (i.e. across the Last Glacial Maximum) in the meandering channels of the Fitzroy correlates well with regional data in tropical northeastern Queensland, and casts new light on the river response to reduced rainfall and vegetation cover suggested by regional palaeoclimate indicators. Moreover, the absence of a strong Holocene signal is at odds with previous accounts from elsewhere throughout Australia. The latitudinal position of the Fitzroy across the Tropic of Capricorn places this catchment at a key location for elucidating the main hydrological drivers of Quaternary fluvial activity in northeastern Australia, and especially for determining tropical moisture sources feeding into the headwaters of Cooper Creek, a major river system of the continental interior.

1. Introduction

The value of reconstructing alluvial sequences for our understanding of global Quaternary climate change and fluvial dynamics is widely acknowledged (Bridgland et al., 2007; Bridgland and Westaway, 2008a, 2008b; Westaway et al., 2009). In Australia, palaeoenvironmental reconstructions of Quaternary fluvial, lacustrine and aeolian activity provide a picture of marked climatic oscillation spanning the last two glacial cycles (Nanson et al., 1992, 1995, 2008; Kershaw and Nanson, 1993; Magee et al., 1995; Magee and Miller, 1998). Nanson et al. (1992) noted the persistence of substantially increased fluvial activity throughout northern, central and southeastern Australia during interglacial periods over the last 300 ka. Magee et al. (2004) provide a continuous moisture record from inland Lake Eyre, which suggests that during the last interglacial the basin was wetter than any other time in the past 150 ka. They also note the failure of the Holocene monsoon to establish a deep-water lake as occurred between 65–60 ka leading to suggestions of altered boundary conditions linked to human activities such as burning (Miller et al., 2005).

Much of this existing work has taken place in two key regions of the continent: the interior arid landscapes of the Lake Eyre Basin (Nanson et al., 1992, 1995; Magee et al., 1995; Croke et al., 1996, 1998), and the extensive meandering river systems of southeastern Australia (Page et al., 1996; Bowler, 1978; Yonge and Hesse, 2009; Kemp and Rhodes, 2010). Fluvial and lacustrine activity in the former has, until recently, been seen to reflect variations in the intensity and landward extension of the Indo-Australian monsoon (Magee et al., 1995, 2004; Croke et al., 1999). Fluvial activity in southeastern Australia, recently

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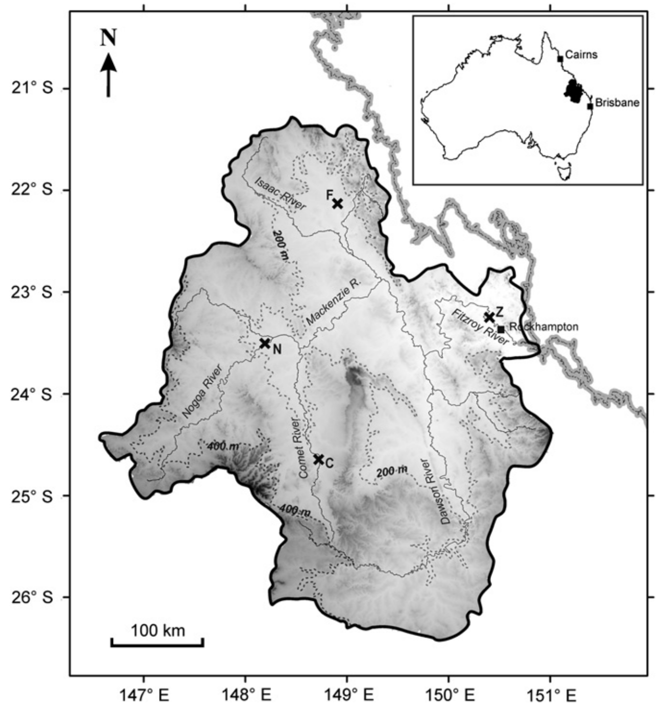

Fig. 1. Location of the Fitzroy River Basin (FRB) in eastern Queensland and location of its six major sub-catchments; Isaacs, Comet, Nogoa, McKenzie, Dawson and Fitzroy. The location of sampled sites in four of these sub-catchments is also identified.

reviewed in Kemp and Rhodes (2010), is considered to be a response to variations in the intensity of the westerly circulation system. Recent palaeoenvironmental reconstruction in the Lachlan River has greatly refined our understanding of Murray-Darling Basin palaeohydrology (Kemp and Spooner, 2007; Kemp and Rhodes, 2010).

Most regions investigated have evidence of enhanced fluvial activity during some period of MIS 5, but important regional differences emerge after this time. In northern Australia higher discharges occurred during the Last Glacial Maximum (LGM) (23–20 ka) and the Holocene climatic optimum (8–5 ka) (Nott et al., 1996; Nanson et al., 2008), but in the southeast, enhanced fluvial activity was split into two phases: 30–25 ka and 20–15 ka, with evidence for a short dry interval around 20–22 ka, preceded and followed by periods of greatly enhanced discharge relative to the present (Page et al., 1991, 1996; Nanson et al., 1992; Nanson et al., 2008; Kemp and Rhodes, 2010).

As a result of this earlier work, research is now moving on from defining broad spatial and temporal patterns to investigating more detailed hypotheses regarding the distribution, intensity and timing of palaeo-precipitation sources. Regional synchroneity between northern and southeastern Australia, for example, is used as key evidence of the likely climatic drivers of fluvial activity across the continent (Nanson et al., 2008). The debate on the relative importance of the Indo-Australian monsoon continues (Miller et al., 2010).

Catchment location has a profound influence on both the length and nature of the alluvial record (Lewin and Macklin, 2003; Lewin et al., 2005). In Australia major differences in the preservation of fluvial units both geographically and over time are evident in the most recent synthesis of luminescence dates of fluvial activity in northern and central Australia (see Nanson et al., 2008). Regional aggregation of fluvial sedimentary records is considered essential, therefore, to ensure that sampling biases can be systematically assessed (Macklin et al., 2010). Key regional gaps exist in the palaeoenvironmental database in Australia. For example, little is known of fluvial systems in the northeast of the continent, which lie in latitudinal positions that may prove relevant to determining the key sources, and variations in the intensity of precipitation both for inland central Australia and systems further south in the Murray-Darling Basin.

The aim of this paper is, firstly, to provide a preliminary Quaternary chronology of fluvial behaviour in one of Australia's largest, coastal catchments: the Fitzroy River Basin (FRB) of eastern Queensland. Little is known of the fluvial geomorphology of subtropical Australia, yet it straddles a key transitional zone influenced by both the southern Trade Winds and tropical moisture sources to the north (Lough, 1997, 2007). The chronology of fluvial activity in the FRB will provide further information on continental and regional differences in river response to Quaternary climate change in Australia. Secondly, the substantial size of this catchment (>140,000 km^2) provides the opportunity to explore intra-catchment variations in fluvial activity. A supplementary aim is to provide a meaningful temporal framework with which to assess perceived rapid environmental changes that are hypothesized to have occurred in the catchment since European settlement (Prosser et al., 2001; McKergow et al., 2005).

2. Regional setting

The FRB, ($\sim$143,000 km^2) is the second largest exoreic catchment in Australia and the main drainage into the Great Barrier Reef lagoon (Fig. 1). The basin contains large areas of low gradients ($\sim$65% of the catchment is <300 m ASL), studded with isolated ranges up to 700 m ASL (Fig. 1).

2.1. Channels and floodplains

The FRB consists of five sub-catchments: Isaac/Connor, Nogoa, Comet, Mackenzie and Dawson (Table 1), and a range of river patterns including anabranching, single-channel meandering and

Table 1
Characteristics of the six sub-catchments within the Fitzroy River Basin.

Attribute	Issac Sub-catchment	Comet Sub-catchment	Dawson Sub-catchment	McKenzie Sub-catchment	Nogoa Sub-catchment	Fitzroy Sub-catchment
Catchment Area (km^2)	22,446	17,253	50,864	13,078	27,989	10,005
Minimum Altitude (m ASL)	72.8	136.6	41.5	41.3	136.7	0
Maximum Altitude (m ASL)	1049.3	1231.3	943.4	943	1156.7	737.8
Mean Annual Discharge (ML)	1,960,000	448,000	1,066,000	4,470,000	614,000	5,160,000
Predominant Contemporary channel pattern	Anabranching	Anabranching	Anabranching	Meandering	Anabranching/meandering	Meandering
Sinuosity[a] (P)	1.07	1.10	n/a	1.5	"-"	1.8
Total Channel Length (km)	13,300	9380	29900	6020	20400	6530
Mean Slope[b] (m/m)	0.031–0.09	0.011	"-"	"-"	0.043	0.0006

ASL = Australian sea level.
[a] Sub-catchment sinuosity estimate is derived from data presented in the National land and Water Resources Audit (NLWRA, 2001).
[b] channel slope estimate is derived from data presented in the National land and Water Resources Audit (NLWRA, 2001).