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A Holocene fluvial archive of the Mulgrave River, Notheastern Australia: Influence of tropical cyclones and sediment delivery to the Great Barrier Reef

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ABSTRACT

The sedimentology, geomorphology and chronology of late Quaternary fluvial landforms and sedimentary sequences within the Mulgrave River catchment in northeast Queensland suggest that episodic stripping or wholesale erosion of Holocene floodplains is a major mode of sediment delivery to the Great Barrier Reef lagoon. The last major phase of Holocene valley sediment removal likely occurred sometime between approximately 1200 and 250 years ago and was possibly associated with a phase of heightened tropical cyclone activity and consequent riverine flooding that occurred between AD1400 and 1800. Since then relative tropical cyclone quiescence may be the cause of a phase of valley aggradation that has been occurring over the past two centuries. The results of this investigation suggest that in this catchment there have been alternating phases of Holocene valley floodplain stripping and subsequent aggradation, with the latter being the current dominant mode. This suggests that at least here, in this relatively confined valley, sediment delivery to the Great Barrier Reef may be relatively low compared to other periods over the past millennium and this may be due to low levels of tropical cyclone activity over the past 200 years.

1. Introduction

The rate and volume of sediment delivery to the Great Barrier Reef (GBR) is a major issue for the preservation of coral reefs, smothering of sea-grass beds and the general health of the inshore marine environment of northeast Australia (Fabricius et al., 2005; Hughes et al., 2010, 2011; Sweatman et al., 2011; Waterhouse et al., 2012). Various estimates have been made of these rates and volumes, with the general conclusion that sediment delivery has increased markedly since European settlement about 140 years ago (Furnas, 2003; McCulloch et al., 2003; McKergow et al., 2005; De'ath and Fabricius, 2010; Brodie et al., 2012; Kroon et al., 2012). However, very little is known about pre-European settlement sediment yields or the nature of sediment delivery and sources within catchments. We make a contribution towards this end by examining the floodplain stratigraphy and chronology of alluvial sedimentary sequences in the middle and lower Mulgrave River catchment near Cairns, northeast Queensland. The Mulgrave River catchment drains a region receiving the highest annual rainfall on the Australian continent. We investigate the geomorphology, stratigraphy, sedimentology and chronology of the Quaternary sedimentary infill of this valley in order to gain insights into the erosional and sedimentation history of this river system. Our results allow us to draw conclusions about the rates and mode of sediment delivery to the GBR and possible controlling or influential factors prior to any European disturbance to this region.

2. Regional setting

The Mulgrave River catchment covers an area of 1315 km^2 in the central eastern section of the Wet Tropics region of northeastern Australia. The river rises in the Bellenden Ker Range and flows north across the escarpment then east down the lower highland slopes. It then flows across the coastal plain and turns abruptly south bordering the Malbon-Thompson Range, after which it joins the Russell River to enter the sea at Russell Heads, 40 km south of Cairns (Fig. 1). The river is 65 km in length and straddles the highest part of the Great Dividing Range, within the Wet Tropics World Heritage Area of Queensland. Coastal lowland tropical forests once covered the floodplain but now only a patchwork mosaic remains due to extensive clearing for agricultural expansion. An extensive Holocene fill extends from the escarpment base to river mouth and is estimated to cover an area of 57.14 km^2, approximately 7% of the total catchment area (Leonard and Nott, 2015a).

The Mulgrave catchment has a mean annual rainfall of 3233 mm, with 60% of this total falling in the summer-wet season. An extreme rainfall event occurred over an 8 day period in 1967 when 3847 mm

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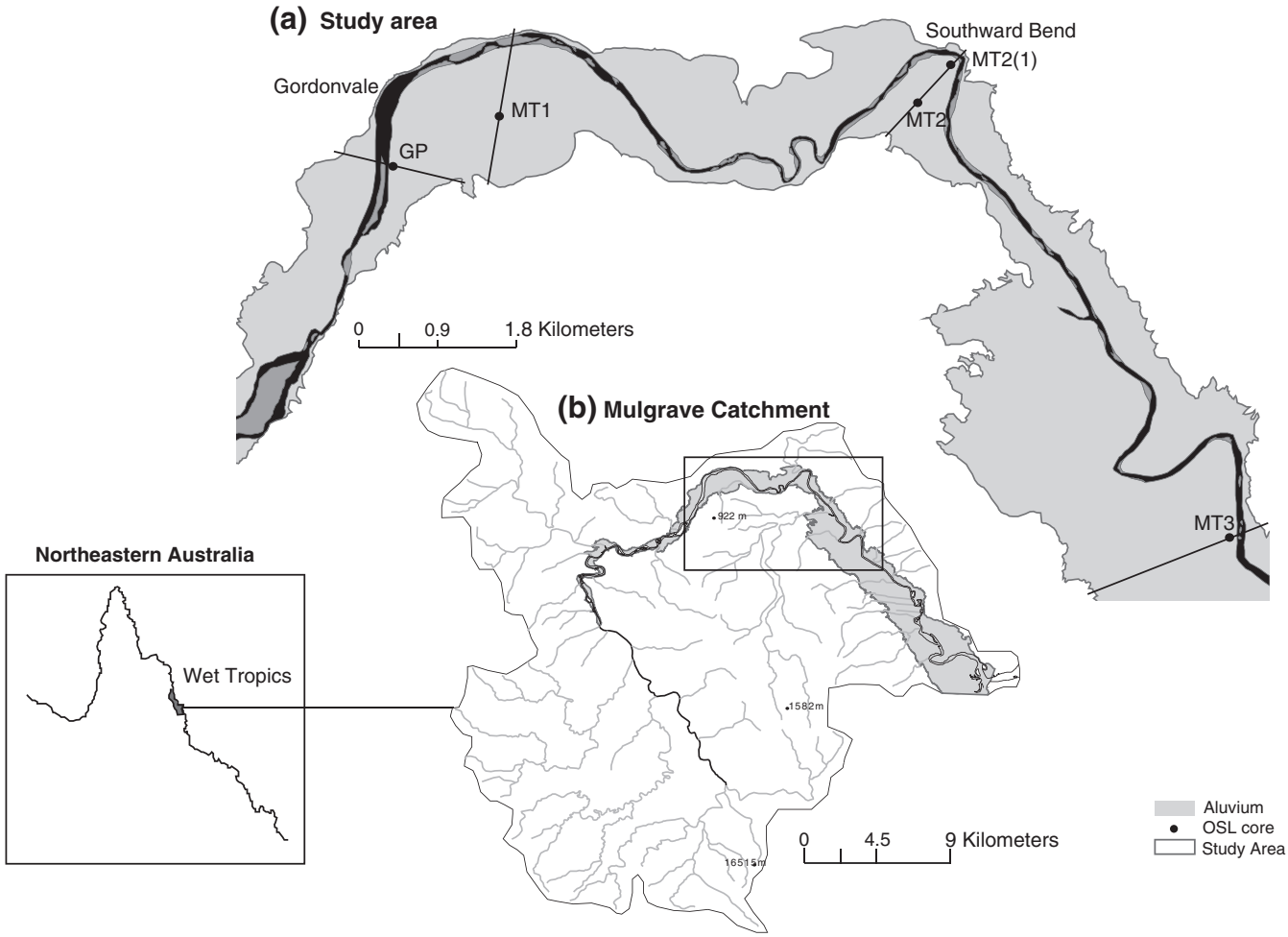

Fig. 1. Map of the Mulgrave River catchment and study sites.

was recorded at Mt Bellenden Ker within the Mulgrave catchment (1140 mm of this fell in 24 hours) (Hausler, 1990). Tributaries in the headwaters of the Mulgrave River drain the eastern edge of the basalt covered Atherton tablelands before the main stream flows through the granites of the Bellenden Ker Range (1615 m at its highest point) and across the metamorphics that dominate the lower reaches of the catchment (Willmott and Stephenson, 1989). The highest recorded maximum instantaneous discharge in the Mulgrave River was 3777 m^3/s in March 1967 at the Fisheries gauge station. Oral histories suggest that the 1911 and 1913 events were substantially larger than the 1967 event but these predated the installation of gauge stations in the catchment.

The channel is characterized by extensive in-channel benches comprised of rounded gravels and course-grained sand. Extensive gravel and sand extraction operations have existed in the middle reaches between Fisheries Crossing and Gordonvale since the early 1970s. These activities have been mostly concentrated at Fisheries Crossing, Fairweathers, Charlton Island and Ross and Lock (Fig. 1). Extraction has occurred on gravel islands, in-channel benches, point bars and the channel bed, in many cases below the low water level. In the lower reaches of the river below Gordonvale sugar cane farming dominates the Mulgrave corridor and has resulted in extensive clearing of remnant vegetation along steep river banks.

The geology of the Mulgrave catchment is dominated by the Palaeozoic Hodgkinson Province metamorphics and the Mareeba Granite. The latter forms the Bellenden Ker massif, including the Malbon-Thompson Range and Mt Bartle Frere (Nott, 2003). These granites intrude the Hodgkinson metamorphics. Quaternary colluvial/alluvial deposits dominate the Mulgrave River corridor and the narrow floodplains of the Little Mulgrave River (Willmott and Stephenson, 1989). A late Pleistocene alluvial fan (Nott et al., 2001) extends from the foothills through the Mulgrave corridor (valley) forming an extensive Pleistocene terrace (Thomas et al., 2007). Nott et al. (2001) and Thomas et al. (2007) dated these sediments between 26,000 BP and 17,000 BP and suggested a relationship between these deposits and late Quaternary climate change. Thomas (2008) suggests that the contemporary floodplain is comprised of Holocene alluvial sediments; however, no age estimates had been made prior to this study. Leonard and Nott (2015a) suggest that the floodplain has formed from both lateral and vertical accretion, with extensive scroll bars evident on meanders and levee development on straight stretches. Considerable lengths of the upper Mulgrave River abut metamorphic outcrops on which soil development is limited. In the middle reaches of the river between Fisheries Crossing and Gordonvale (Fig. 1), the river cuts through the brown and red clay soils of the deeply weathered Atherton basalts forming steep banks of moderately structured soils. These banks are well vegetated and are presently stable but could be susceptible to slumping on steeper banks if cleared in the future.

3. Materials and methods

A variety of methods were used in this study including mapping using LiDAR, sediment collection methods and analysis and optically stimulated luminescence (OSL) dating.