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Nonsynchronous, episodic incision: Evidence of threshold exceedance and complex response as controls of terrace formation

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ABSTRACT

Terrace sequences can represent regional or continental scale factors such as climatic fluctuations, neotectonic activity, and base-level change. However, they can also reflect random incision events brought about by local scale, geomorphic threshold exceedance, and subsequent complex response. This study explores the formative processes of three discontinuous, but adjacent, late Pleistocene to late Holocene step-terrace sequences in southeastern Australia. Correlation of river terrace fills was undertaken by comparing terrace remnants based on topography, morphology, sedimentology, stratigraphy, and chronology. A geomorphic model of floodplain abandonment and terrace formation for this valley setting is presented. Most of southeastern Australia has shown no evidence of tectonic uplift during the late Quaternary. Bedrock bars on the Hunter River isolate the study reach from downstream base-level changes. The nonsynchronous, episodic behavior of incision events in this catchment strongly indicates that climate is not a dominant control on terrace formation. With the exclusion of climatic fluctuations, tectonic uplift and base-level change as causes of incision, catastrophic floods, and the exceedance of geomorphic thresholds emerge as the dominant controls of terrace formation.

1. Introduction

An understanding of fluvial terrace sequence development can provide insights into local and regional landscape evolution and the external factors involved with their formation. However, correlating terrace fills over larger distances as a result of a single external factor must be done with care (Erkens et al., 2009). Climatic, tectonic, and eustatic fluctuations are the most well-established causes of floodplain abandonment and terrace formation (Leopold et al., 1964; Born and Ritter, 1970; Merritts et al., 1994; Bridgland and Westaway, 2008). However, in addition to and in response to these allogenic influences, terraces can also result from the exceedance of geomorphic thresholds and complex response (Schumm, 1973; Young and Nanson, 1982; Erkens et al., 2009). Readjustments of stream grades by meandering and removal of channel obstructions (Hadley, 1960) and natural progressive downcutting (Warner, 1972) are also influences on floodplain abandonment. As such, fluvial terrace sequences can simply reflect random incision events brought about by intrinsic threshold exceedance, despite any correlation with regional or worldwide climatic fluctuations.

Previous studies in the Widden Valley identified three sedimentologically and chronologically distinct terrace sequences: named the Baramul, Widden, and Kewarra sequences (Cheetham et al., 2008b, 2010). The existence of a continuous chronology throughout the Widden Brook terrace sequences and the confinement of each sequence to a different valley setting are indications that localised processes have controlled their formation (Cheetham et al., 2010, in press). This is significant given that climate change is often seen as the primary control on terrace formation elsewhere in southeastern Australia and around the world (Warner, 1972; Bull and Knuepfer, 1987; Bridgland and Westaway, 2008).

Here we examine the processes of floodplain abandonment and terrace formation for the longitudinally correlated river terraces of Widden Brook. By investigating influences on terrace formation in a range of valley settings, we are able to explore the role of geomorphic thresholds and complex response as primary controls on terrace formation. In addition, we present a model of late Quaternary floodplain abandonment and landscape evolution for Widden Valley.

2. Regional setting

Widden Valley is a north-trending valley in the Upper Hunter region of New South Wales, Australia, and is shown in Fig. 1 (253506 E, 6410466 N–253578 E, 6390530 N, UTM). Widden Brook is a terrace and bedrock-confined, low sinuosity, sand bed stream with a 650-km^2 catchment area. The headwaters of Widden Brook and its only major tributary, Blackwater Creek, lie in Wollemi National Park and are incised into Triassic sandstones of the Narrabeen Group, which is

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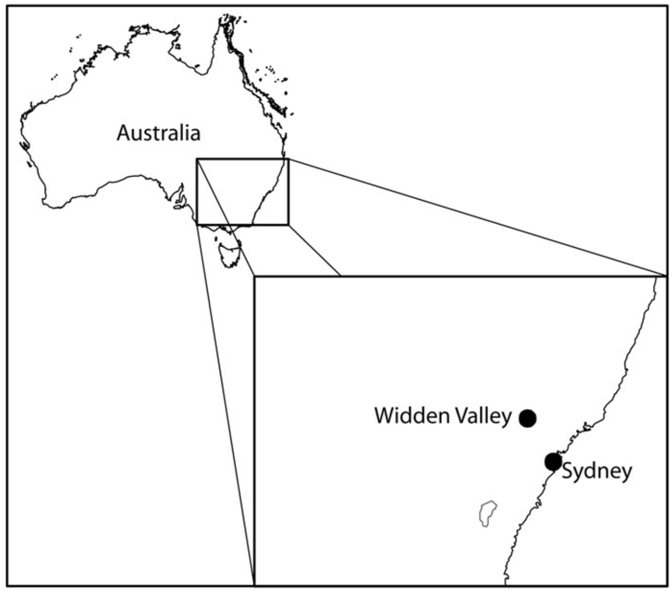

Fig. 1. Location map of Widden Valley, NSW, Australia.

capped by Tertiary basalts (Galloway, 1967) and Permian conglomerate, sandstone, and siltstone (Beckett, 1988). The study reach extends ~26 km upstream of Widden Brook's confluence with the Goulburn River, a tributary of the Hunter River. Three adjacent sedimentologically distinct terrace sequences were identified along the study reach (Cheetham et al., 2010). Each terrace sequence is located in a geomorphologically different valley setting: an upstream constriction (Baramul), a valley expansion (Widden), and a highly constricted downstream section (Kewarra) (Fig. 2).

Bedrock bars on the Hunter River at Scotts Flat (downstream of Singleton) and at Woodlands (downstream of Denman) act as barriers to the effects of base-level changes further upstream at our study location. Thus, despite changes in relative sea level since the last glacial maximum (LGM) (Sloss et al., 2007), base-level change is

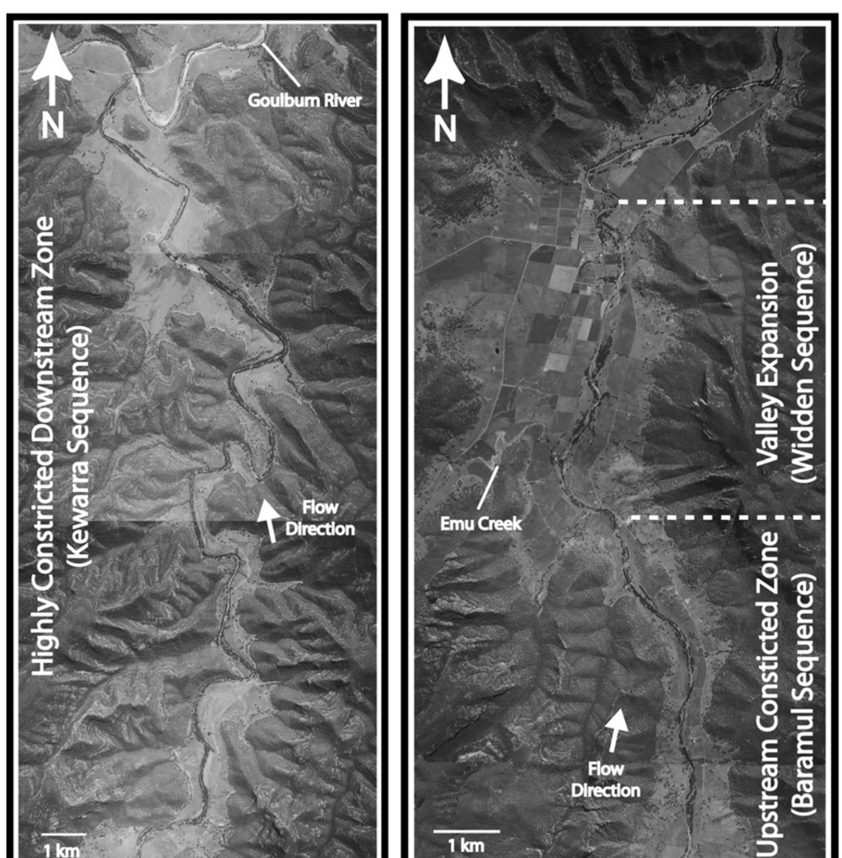

Fig. 2. Study location of Widden Brook, Australia showing the three adjacent but distinct valley settings identified by Cheetham et al. (2010) and examined in this study.