GEOMORPHOMETRY OF THE UMBUM CREEK CATCHMENT, WESTERN LAKE EYRE, CENTRAL AUSTRALIA

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INTRODUCTION

The antiquity of the Australian landscape has been emphasised by several geomorphological studies that consider the Australian continent as tectonically stable (Ollier 1991, Twidale & Campbell 1995). While this may be the case in certain areas, there is growing evidence of the influence of neotectonic activity on landscape evolution within Australia (Hill *et al.* 2003, Sandiford 2003, Tokarev *et al.* 1999).

The Umbum Creek catchment is located in the northeast of South Australia on the western shore of Lake Eyre (Figure 1). It is a dryland catchment characterised by ephemeral streams in a hyper-arid environment (Kotwicki & Isdale 1991). The headwaters of the catchment arise in the Davenport Ranges and flow easterly towards Lake Eyre. The Neales Fan is located between the Neales River and Umbum Creek. This is a fan-shaped feature composed of dominantly fluvial sediments much of which are covered by a colluvial pebble lag. The evolution of the Neales Fan is of interest because the record of climatic variation is preserved in the Quaternary sediments (Croke *et al.* 1996, Croke *et al.* 1998, Croke *et al.* 1999). In order to assess the role of neotectonic activity in the formation of the Neales Fan deposits, studies of longitudinal stream profiles and hypsometrics of the Umbum Creek catchment have been carried out. These show that the underlying geological structure does control geomorphology, however, the relative contributions of neotectonic activity and climate-driven processes remain undefined.

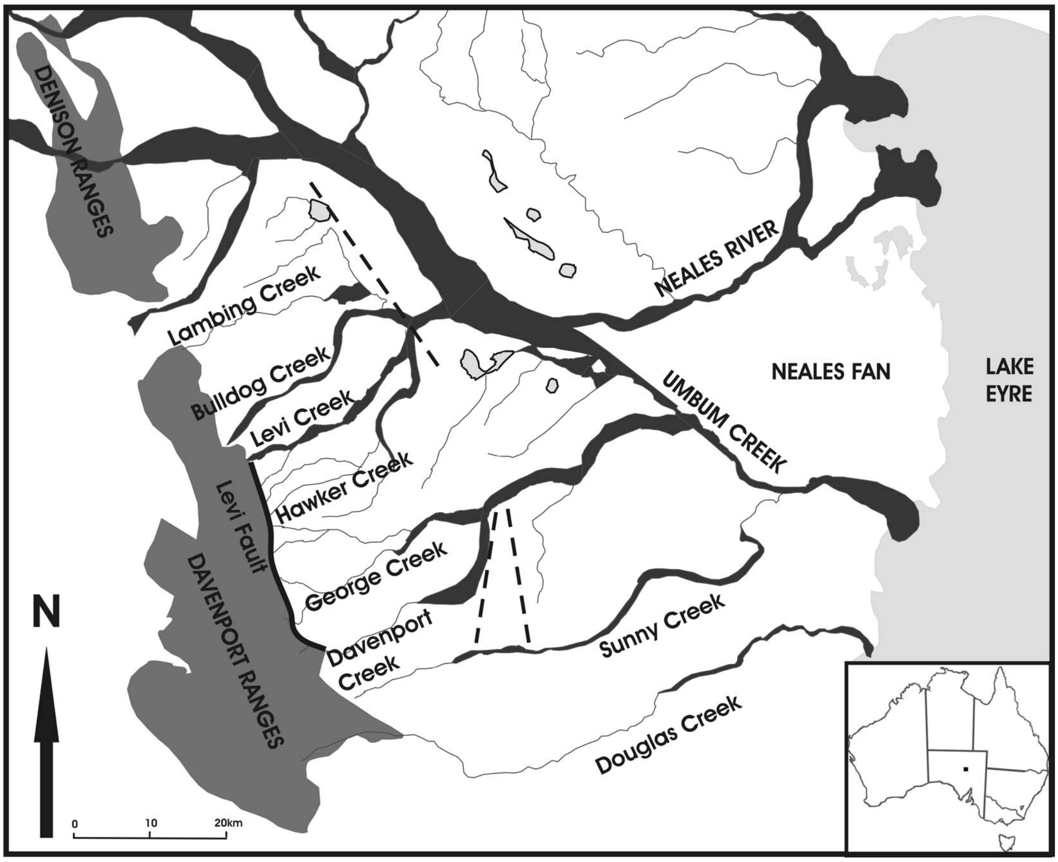

Figure 1: Location Diagram. Dashed lines represent interpreted faults.

LONGITUDINAL STREAM PROFILES

Longitudinal stream profiles were plotted for all major tributaries in the Umbum Creek catchment. The dataset was extracted from the GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 2.1. The data was analysed using MicroDEM freeware and stream pathways defined using GA-Natmap stream vector data. The gridded DEM has an approximate cell size of 250 m. The data within each 250 m cell is represented as the approximate elevation of the centre of the cell; therefore it cannot be assumed that it represents the true depth of the stream profile. An error range of between 7.5 m and 20 m is cited for the DEM-9S dependant on slope (AUSLIG/AGSO 2003). For this reason small-scale perturbations in the longitudinal profile are not examined, it is the general trend of the profiles that is analysed.

The ideal channel of a longitudinal profile is defined here as the exponential line of best fit to the data. Alluvial channels may respond to deformation of longitudinal stream profile by deflection around zones of uplift and into zones of subsidence, and aggradation in back-tilted and degradation in fore-tilted reaches (Holbrook & Schumm 1999).

An examination of the profiles in Figure 2 indicates that Sunny and Douglas Creeks have longitudinal stream profiles that display a positive deviation in the middle of the profile. This is interpreted as a response to relative uplift in the central part of the profile. This tectonic movement is inferred from faults drawn on the Warrina Geological Map Sheet (Rogers & Freeman 1996). The faulting occurs 5-10 km downstream of the start of positive deviation in the longitudinal stream profiles for both Sunny and Douglas Creek.

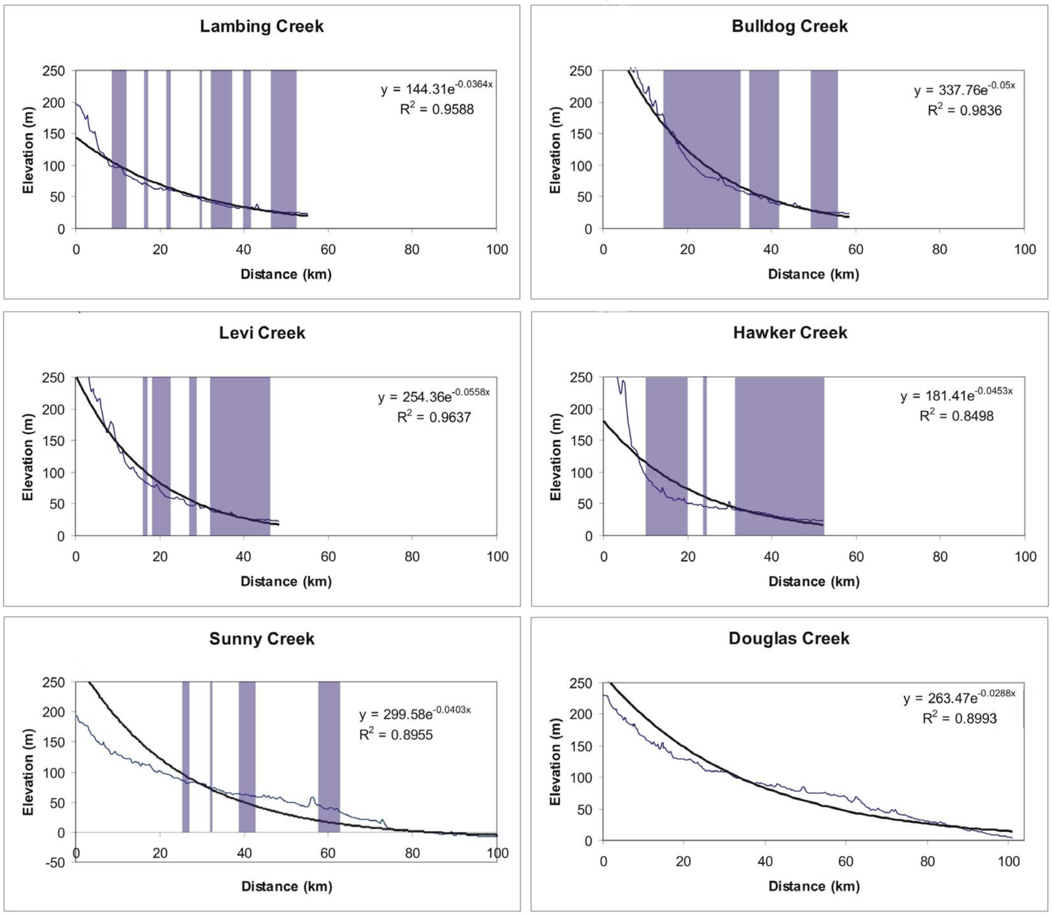

Figure 1: Longitudinal Stream Profiles. The ideal profile is given by the exponential of best fit drawn as a heavy, dark line. The exponential equation is located in the top right corner of each plot. Grey bars represent anastomosing reaches.

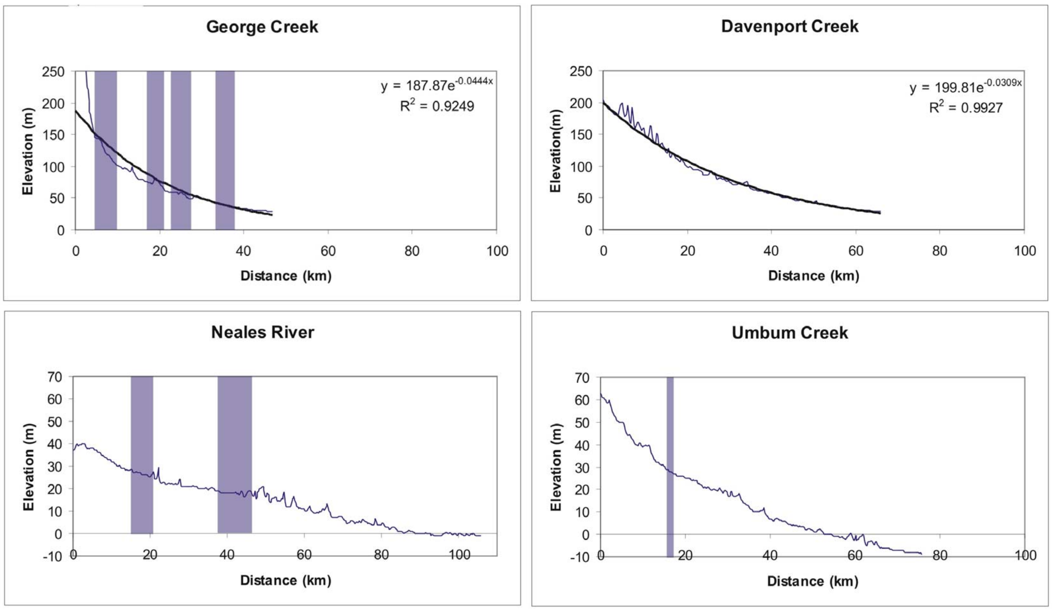

Figure 2 (continued): Longitudinal Stream Profiles. The ideal profile is given by the exponential of best fit drawn as a heavy, dark line. The exponential equation is located in the top right corner of each plot. Grey bars represent anastomosing reaches

The channel profiles from streams with their headwaters in the Davenport Ranges demonstrate a positive deviation from the ideal. This is interpreted as the stream response to the uplift of the Davenport Ranges along the Levi fault during the Early Tertiary (Rogers & Freeman 1993). The headwaters are actively incising into the ranges. Further downstream on these profiles a negative deviation occurs. This corresponds to zones of erosion along the base of the ranges adjacent to Levi Fault.

Lambing, Bulldog, Levi and Hawker Creeks display another positive deviation further downstream. This coincides with a zone of coalescing streams (Figure 1). The channel diversions infer that a zone of uplift has captured them. The forms of the longitudinal stream profiles imply aggradation, consistent with a fault causing a rising of the stream profile resulting in lowering of the channel flow velocity and hence increasing deposition.

It is noted that the boundaries between substrate lithologies plays a role in controlling the behaviour of the longitudinal stream profiles. The extent to which channel incision is controlled by underlying strata as opposed to tectonic movement is unclear as fault boundaries are commonly defined by a change in substrate lithology.

The correlation between channel plan morphology and variation in slope along streams has also been examined. Streams were divided into anastomosing and meandering reaches according to their stream plan morphology. Areas of anastomosing stream morphology were then transferred to the longitudinal stream profiles and displayed as shaded boxes. No clear structural pattern emerges when comparing the location of anastomosing sections across the landscape, however some landform associations are evident. Anastomosing stream sections appear to be associated, to varying degrees, with alluvial fans. The extent to which anastomosing sections respond to changes in channel slope is unclear as other factors may influence channel plan morphology such as sediment grain size or vegetation colonisation.

While the correlation of anastomosing sections between creeks was not strong, the Neales River channel profile does display an association between in-channel slope and channel plan morphology. Of the two reaches along the Neales that are anastomosing, the downstream boundaries coincide with breaks in slope that correspond to observed nick points.

HYPSOMETRIC ANALYSIS

Hypsometric analysis (Figure 3) of drainage basins within the Umbum Creek catchment, to determine the stage of erosion of the catchment area, was carried out utilising Terrain Analysis System (TAS) freeware program applied to the 9 second DEM. A watershed was defined from the DEM calculated stream network

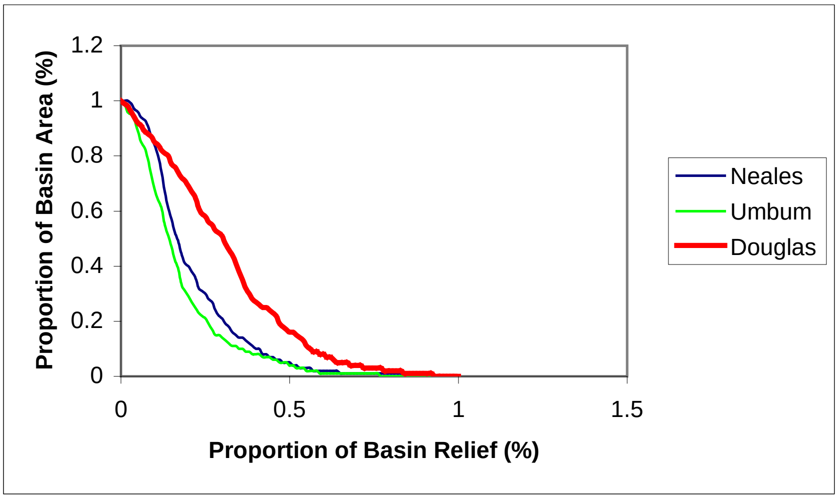

Figure 3: Hypsometric curves.

using the TAS option for calculating catchment area via ADRA (Adjustable Dispersion Routing Algorithm). The watershed analysis divides the drainage into three major sub-catchments: the Neales; the Umbum; and the Douglas. Of the three sub-catchments analysed there is a distinct grouping of curve style associated with the sub-catchment's position in the landscape. The Neales and Umbum sub-catchments display strong concave curves and represent considerably more eroded catchments. The Douglas shows a much less eroded stage (Thornbury 1969).

The hypsometric integral sums up the basin properties into one number (Riquelme *et al.* 2003). The Neales sub-catchment has a value of 21.11%, the Umbum, 17.58% and the Douglas, 31.05%. These are low, as a value of 20 is cited as a general lower limit (Thornbury 1969). All three catchments show a relatively low value reflecting a dissected, eroding landscape, approaching monadnock phase. The dissected landscape has developed in sediments of Pleistocene age and therefore is geologically young; indicating that erosion during the Late Cainozoic has been intense. In the Davisian sense this would be interpreted as a "mature" or "senile" landscape implying a degree of antiquity the landscape does not possess.

CONCLUSIONS

The Umbum Creek catchment can be defined as a catchment in disequilibrium that is dominated by erosional processes, yet it has formed since the Plio-Pleistocene and is geologically young.

An association between anastomosing channels and alluvial fan landforms can be drawn. This association is common on alluvial fans but it has to be pointed out that the braided streams do not form the fans. The braided streams are a secondary process that is reworking today’s fan surfaces (Blair & McPherson 1994).

Longitudinal stream profiles have been used to define faults in areas covered by Quaternary sediment. The style of deviation in the stream profile, along with other field data, allows us to interpret the sense of the fault movement. A zone of uplift to the west of the Neales River is identified from channel diversions and profile deformation. The central part of both Sunny and Douglas Creeks are identified from lithological structure and profile deformation as zones of uplift.

This study has shown that the underlying geological structure has a strong impact on the formation of streams, with faults and substrate lithology playing an important role in the diversion and deformation of river channels in this region.

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