FLUVIAL RESPONSE TO TECTONIC ACTIVITY: THE NEALES RIVER, LAKE EYRE, CENTRAL AUSTRALIA

V.G. Waclawik[1], S.C. Lang[2] & C. Krapf[2]

[1]CRC LEME, Discipline of Geology & Geophysics, University of Adelaide, SA 5005
[2]Australian School of Petroleum, University of Adelaide, L2 Santos Building, Adelaide SA 5005

INTRODUCTION

The Lake Eyre Basin Analogues Research Group is a collaboration between CRC LEME and the Australian School of Petroleum. The aims of this project are to delineate the geometry, provenance and landscape evolution history of the Neales Fan in order to develop an analogue model of clastic dryland fluvial-deltaic petroleum reservoirs.

The Neales Fan is located in the northeast of South Australia on the western shore of Lake Eyre, central Australia (Figure 1). It is composed of dominantly fluvial sediments, much of which are covered by a colluvial pebble lag. It is bounded by the Neales River and Umbum Creek in a dryland catchment dominated by ephemeral streams in an arid environment.

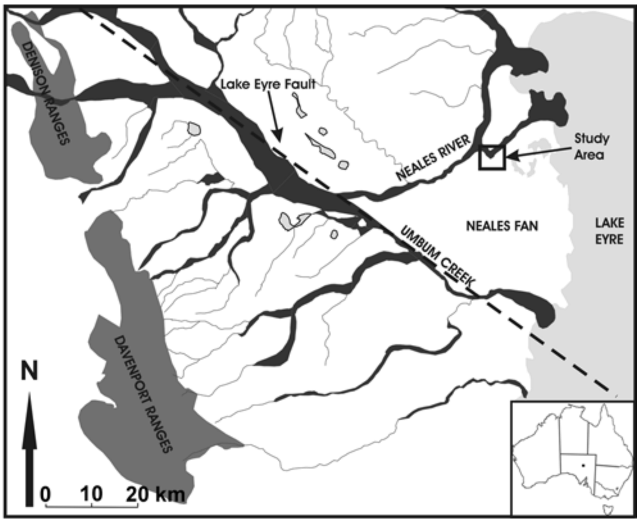

Figure 1: Location diagram showing the position of the Neales Fan bounded by the Neales River to the north and Umbum Creek to the south, with respect to Lake Eyre.

The aim of this research was to examine the possible effects of neotectonic activity on the landscape evolution of the Neales Fan.

ACTIVE SEISMICITY

The South Australian Seismic Register shows a number of earthquake epicentres recorded in the region. When plotted on satellite imagery these epicentres are observed to align with lineaments (Figure 2). These lineaments are interpreted as basement faults and the location of earthquake epicentres on them indicate that these faults are active to some extent. Are the effects of this active seismicity observed in modern sediments?

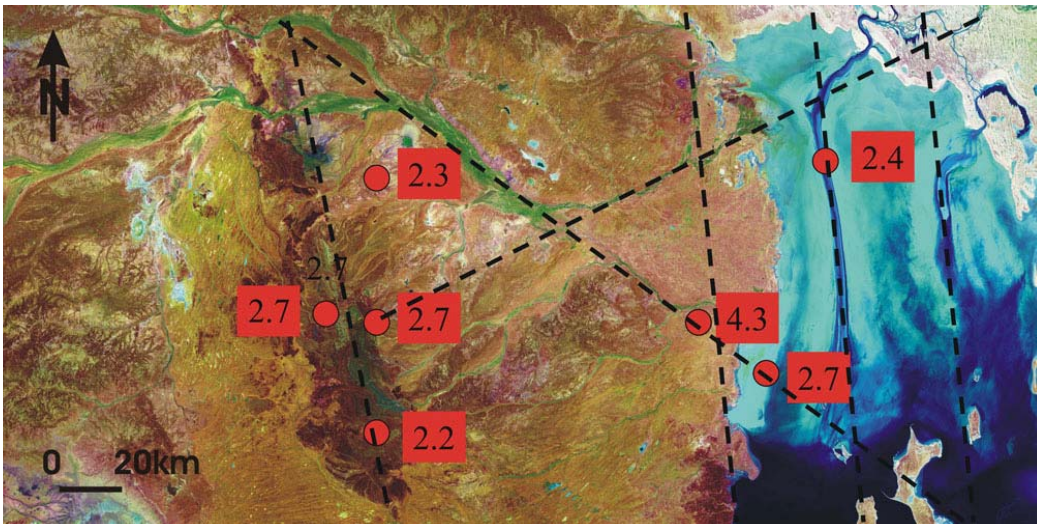

Figure 2: Interpreted basement faults in the Lake Eyre region showing the spatial correlation with earthquake epicentres. The number of stations that record the event and the location of these stations influence epicentre location. For the South Australian seismic network spatial error is likely to be within 25-50 km radius. Seismic stations are located to the south and southeast of this region and thus the error is likely to plot in a north to northeasterly direction.

CHANNEL DIVERSIONS AND STREAM PLANFORM

A lineament is observed to cross the centre of the Neales Fan (Figure 3). It is associated with a sudden change in stream planform from relatively straight channels to a highly sinuous meander present on both the Neales River and Umbum Creek. In addition, the Neales Overflow is seen to diverge from the main Neales River channel at precisely this location and run parallel to this lineament. Since similar north-south trending lineaments are interpreted as faults elsewhere it would be expected that a fault underlies this area and acts as a control on stream directions. Where the Neales River crosses this fault a steepening of the stream longitudinal profile should occur. This steepening would result in the formation of a meander as the stream attempts to expend the extra energy it has gained by lengthening its flow-path (Holbrook & Schumm 1999) (Figure 4). It is noted that channel plan may also alter in response to changes in flood peak, mean discharge and type of sediment load.

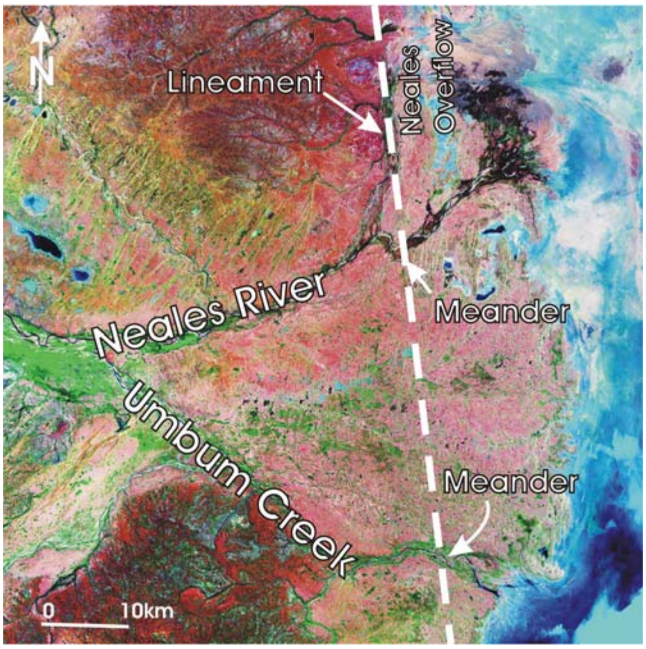

Figure 3: Satellite image of the Neales Fan showing the position of a suspected basement fault and associated meanders in the Neales River and Umbum Creek. Note that the Neales Overflow follows the same trend.

The thalweg profile of the Neales River was constructed from data collected using a Differential Geographical Positioning System (DGPS). Results from this survey demonstrate that the trend of the thalweg profile actually decreases in slope at the point where the channel crosses the observed lineament (Figure 5). Since no tributary streams provide input upstream of this location, sediment load remains the same and mean discharge appears unlikely to change along this reach, the lithology of the substrate must play a controlling factor.

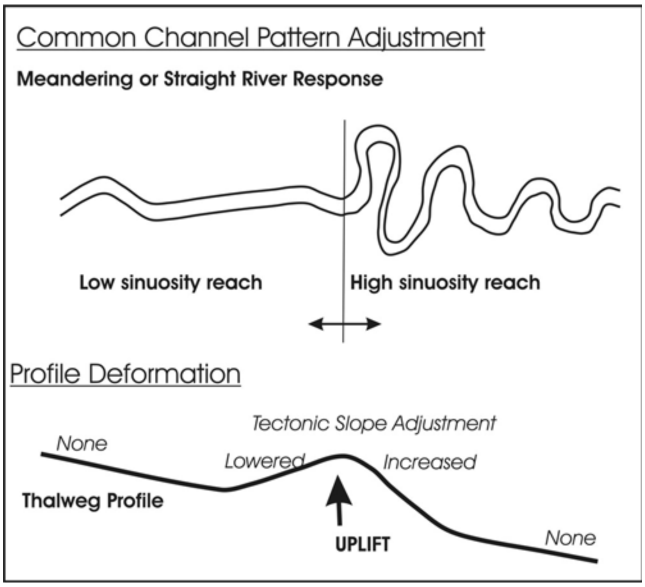

Figure 4: Common channel adjustments in response to channel profile deformation showing the increase in sinuosity caused by tectonically-induced increase in channel slope.

STRATIGRAPHY

At the large meander on the Neales River the channel is incised in excess of ten metres. This exposes Quaternary and Miocene sediments in the walls of the cliff. The exposed sequence is composed of partially silicified dolomitic Miocene lacustrine clay (Etadunna Formation) at the base that is unconformably overlain by Pleistocene fluvial sands (Warmakidyaboo Beds) with interbeds of lacustrine shale (Ghost Yard Beds).

Within the Miocene lacustrine clay there is strong evidence of neotectonic disruption. Marker beds display small thrust duplexes consistent with a compressional zone that is supported by the presence of shear-band deformation and fracturing. This is unconformably overlain by relatively flat-lying Pleistocene fluvial and lacustrine sediments. However, given the lineament may be active over a relatively small geological timeframe it would be expected that flat lying sediments, such as the Pleistocene lacustrine shale (Ghost Yard Beds) preserved in the sequence may display either mild warping or subtle tilting that would not be visible to the naked eye. A survey utilising a total station theodolite was conducted to measure the deformation observed in the Miocene clay (Etadunna Formation) and the Pleistocene shale (Ghost Yard Beds).

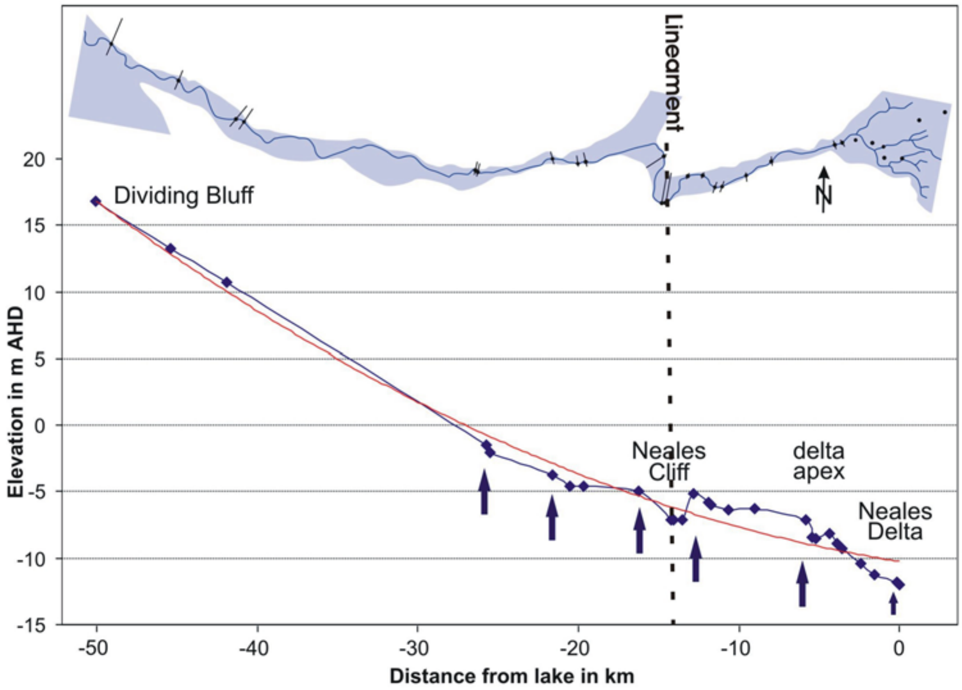

Figure 5: Thalweg profile of the Neales River derived from DGPS data showing a decrease in the gradient of the profile trend where the river crosses the observed lineament and the meanders begin to form. Arrows indicate nick-points in the stream profile.

SURVEY RESULTS

The Miocene Etadunna Formation is deformed at outcrop scale. This is reflected in the survey results (Figure 6) that show a monocline preserved in a marker horizon of the Etadunna Formation. The Pleistocene Ghost Yard Beds display some irregularity in thickness. If this were folding in the shale the thickness of the unit would be maintained equally across the length of the unit. Instead we see there is a fluctuation in the thickness of the shale that is attributed to sedimentary draping of underlying fluvial sedimentary structures. The Ghost Yard Beds do not show any signs of tilting. Over some 400 m the elevation of this unit is maintained at approximately 2 m AHD. These observations indicate that the Pleistocene sediment has not been subject to neotectonic deformation. This period of tectonic quiescence can be constrained to the Late Pleistocene as this cliff section has been dated via thermoluminescence (Croke *et al.* 1998). This dating places the lowest Pleistocene stratigraphic unit as being deposited at approximately 177 ka B.P.

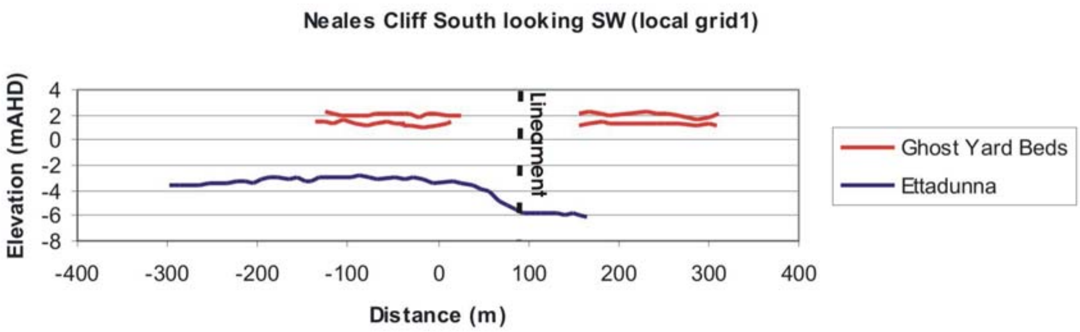

Figure 6: Total station survey of sediments exposed in the Neales River bank showing deformation of Miocene sediments and no detectable deformation of Pleistocene sediments.

LITHOLOGICAL CONTROL

What then causes the meander to form in the Neales River? The only observed change in the system is the lithology of the channel substrate. The Miocene Etadunna Formation is a lacustrine unit that extends to a position roughly coincident with the observed lineament that crosses the Neales Fan (Figure 3). Upstream from this the outcrop lithology consists of fluvial sandstones of the Eocene Eyre Formation. These are considerably more friable than the silicified clays of the Etadunna Formation and as a result are more readily eroded. It is postulated that the change in induration of the substrate across this contact causes the stream to meander as it expends energy as lateral erosion rather than incision (Figure 7).

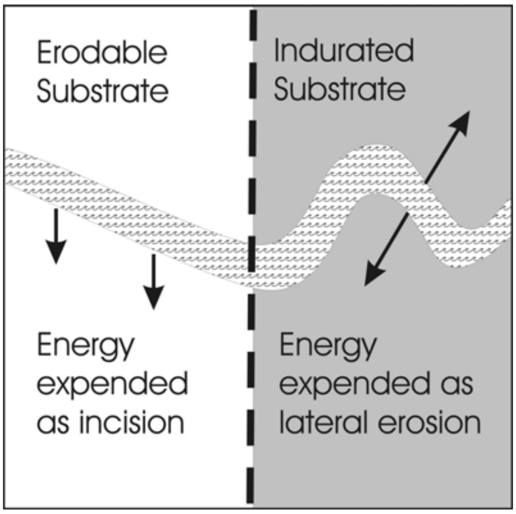

Figure 7: Model of lithological control on stream planform showing energy expended as incision over erodable substrate but energy expended as latera erosion of indurated substrate.

SUMMARY AND CONCLUSIONS

The deformation of Miocene-age sediments clearly demonstrates that neotectonic activity has occurred. This can however be constrained between the Miocene deposition of the Etadunna Formation and the Late Pleistocene deposition of the Warmakidyaboo Beds. This gives a Plio-Pleistocene age for neotectonism in the Lake Eyre region.

In terms of the evolution of the Neales River it is likely that climate change 50 ka ago decreased the base level in the region causing the ancestral Neales River to incise (Croke *et al.* 1998). When this incision reached the Etadunna Formation the partially silicified substrate proved more resistant to weathering than the Eocene sandstone substrate upstream. A meander formed as the stream attempted to dissipate excess energy as a result in the change of the channel profile.

FURTHER WORK

In order to better delineate the geological controls on faulting and the response of fluvial systems to these controls a more detailed geological model is required. There is limited data available from boreholes in the region and a comprehensive shallow drilling program is recommended to provide good geological constraints on the Quaternary geology and fluvial depositional system.

REFERENCES

CROKE J.C., MAGEE J.W. & PRICE D.M. 1998. Stratigraphy and sedimentology of the lower Neales River, West Lake Eyre, Central Australia: from Palaeocene to Holocene. *Palaeogeography, Palaeoclimatology, Palaeoecology* 144, 331-350.

HOLBROOK J. & SCHUMM S.A. 1999. Geomorphic and sedimentary response of rivers to tectonic deformation: a brief review and critique of a tool for recognising subtle epeirogenic deformation in modern and ancient settings. *Tectonophysics* **305**, 287-306.