NEO-TECTONISM AND LAKE EYRE

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INTRODUCTION

The Lake Eyre Sequence Stratigraphy Project is a joint venture between CRC LEME and the Australian School of Petroleum (formerly the National Centre for Petroleum Geology & Geophysics). The aims of the project are to clearly delineate the geometry, provenance and landscape evolution history of Umbum Creek on the western shores of Lake Eyre (Figure 1). This is in order to develop an analogue model of clastic deltaic petroleum reservoirs.

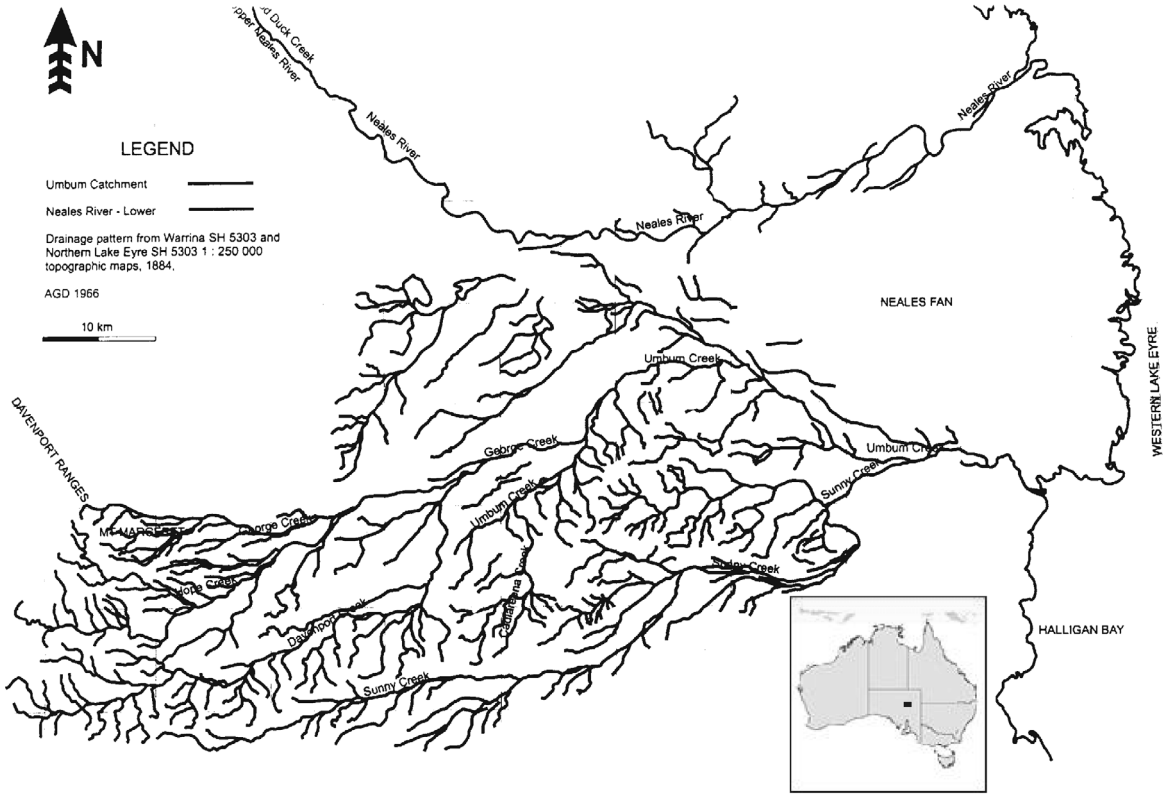

Figure 1: Location map after Lang & Payenberg (2003).

Deltaic reservoirs are complex depositional features that display a range of problems related to connectivity, permeability and variability associated with the distribution of reservoirs, traps and baffles within the deltaic system. As easily accessible reservoirs become depleted, petroleum exploration companies are looking at sourcing more petroleum reserves from these relatively poorly understood systems and a good understanding of their geometry is paramount in the engineering and design of borefields for efficient production.

To understand the development of the geometry of deltaic systems it is necessary to look at the developmental history of the fluvial environment within the context of the surrounding landscape. This raises the question as to whether or not the landscape is still tectonically active and therefore to what degree the modern landscape reflects sedimentary processes responding to ongoing tectonic activity.

Umbum Creek, located in the northeastern corner of South Australia, flows into the western margin of Lake Eyre, which is approximately 1,000 km north of Adelaide. The lake represents the terminal playa of the Lake Eyre Basin, the largest internal drainage basin in Australia, covering one sixth of the Australian continent (>1,300,000 km^2). The lowest point of this playa is presently located at approximately –15 m below present sea level (Australian Height Datum) and represents the lowest point in inland Australia (Nanson & Price 1998).

TECTONIC MODEL

The Lake Eyre depression has been interpreted as a subsiding intercontinental basin that is the result of tectonic post-rift sag following the separation of the Australian and Antarctic continental plates (Drexel *et al.* 1993).

A tectonic model was adopted whereby water entering Lake Eyre would, as a result of its weight, cause tectonic loading on this subsidence-prone area and result in seismic tremors in the surrounding region as the rocks adjusted to accommodate the movement.

Three datasets were considered for comparison, including the state register for seismicity and two sets of hydrologic data: volumetric inflows to Lake Eyre; and lake level measurements. Each of these datasets has different constraints in terms of data consistency and the frequency of measurement.

SOUTH AUSTRALIAN SEISMIC REGISTER

The recording of seismic activity in South Australia since settlement has been sporadic and fraught with the intermittent closure of stations for various periods such that the network of seismic stations varies through time. This, and the location of the bulk of these stations to the south and west of Lake Eyre, results in a loss of spatial resolution due to triangulation errors and the locations of epicenters and foci are unreliable. Measurements of magnitude and occurrence are relatively free of problems of spatial resolution and a period of similar data fidelity was chosen between 1979 and 2001 as representative of seismic activity in the region. The dataset was spatially limited to epicenters listed as occurring in the northeast corner of South Australia north of latitude 30^0 S and east of longitude 134^0E.

VOLUMETRIC INFLOWS TO LAKE EYRE

The volumetric inflow data represents a reconstructed dataset developed by Kotwicki & Isdale (1991) for modeling purposes. This was developed by the use of proxy coral data representing flows in the Burdekin River, a major tributary in a catchment adjacent to Lake Eyre that has been statistically linked to the volumes of Lake Eyre inflows. The dataset is subject to uncertainty but is a good quality estimate of volumetric inflow.

LAKE LEVEL

A reliable method of estimating lake levels was developed by Bob Backway of the Lake Eyre Yacht Club (Backway 2001). Coupling the bathymetry of the lake with Landsat satellite imagery the spatial extent of water in the lake is determined and the lake level calculated. This produces a consistent dataset over the period of time covered by satellite imagery.

METHODOLOGY

Datasets were averaged to annual statistics to account for the differences in measurement timescales. These annual statistics were then analysed using a least squares fit regression and statistical tests were applied to determine the degree of correlation, if any. These tests include the Pearson R, R^2 and ANOVA Tests. Variables of annual average magnitude, annual average frequency and annual average focal depth compared against annual average volumetric inflow and annual average lake depth were included within the seismic data sets.

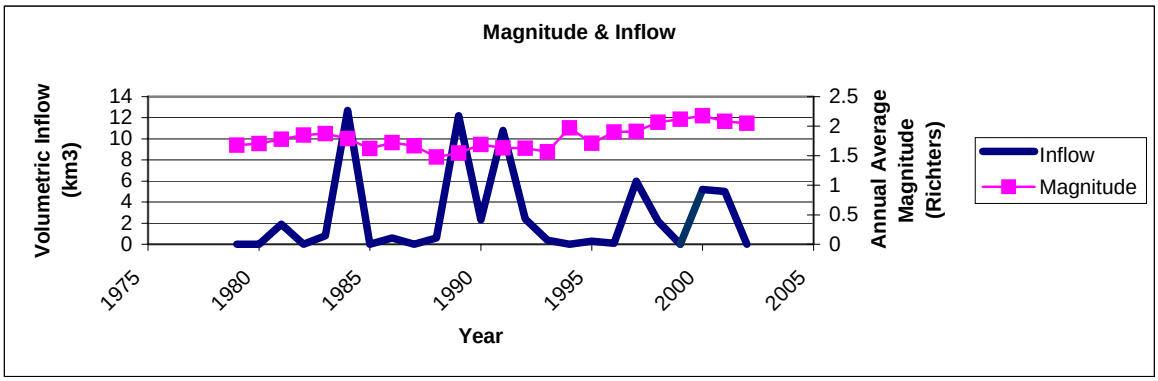

Figure 2: regional earthquake data as compared to volumetric inflows into Lake Eyre through time (1979-2002). Continued next page.

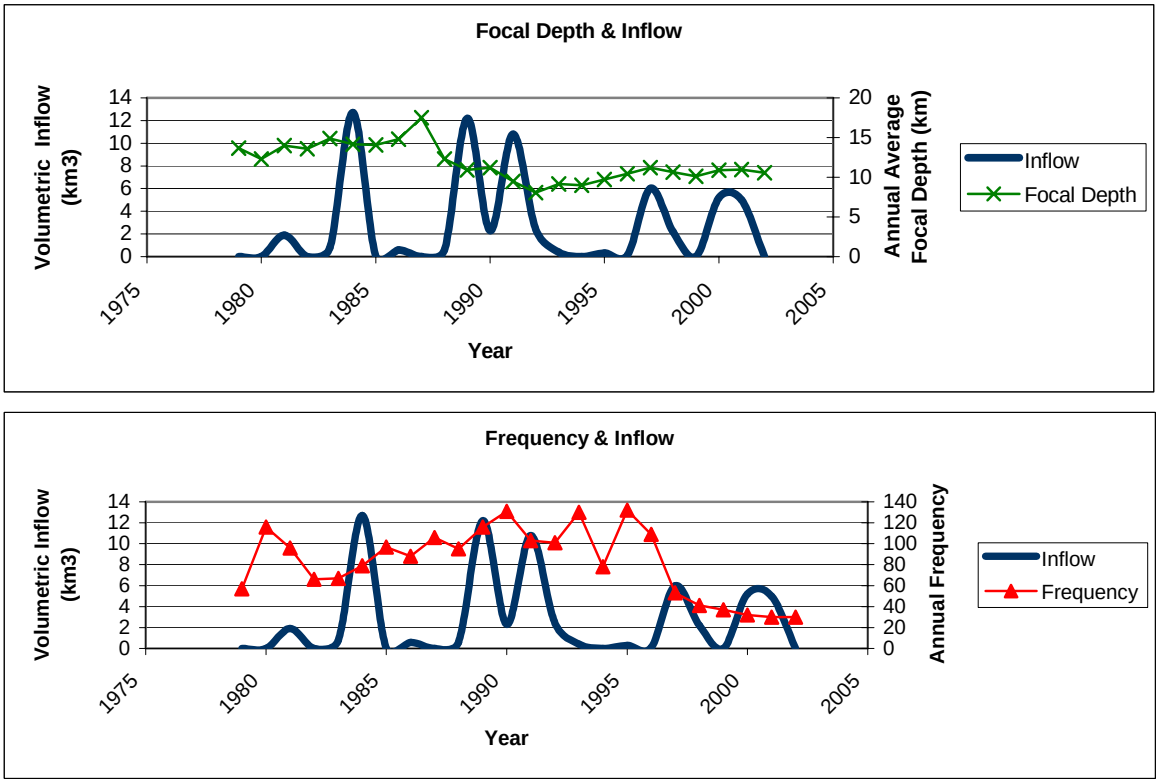

Figure 2 continued: regional earthquake data as compared to volumetric inflows into Lake Eyre through time (1979-2002).

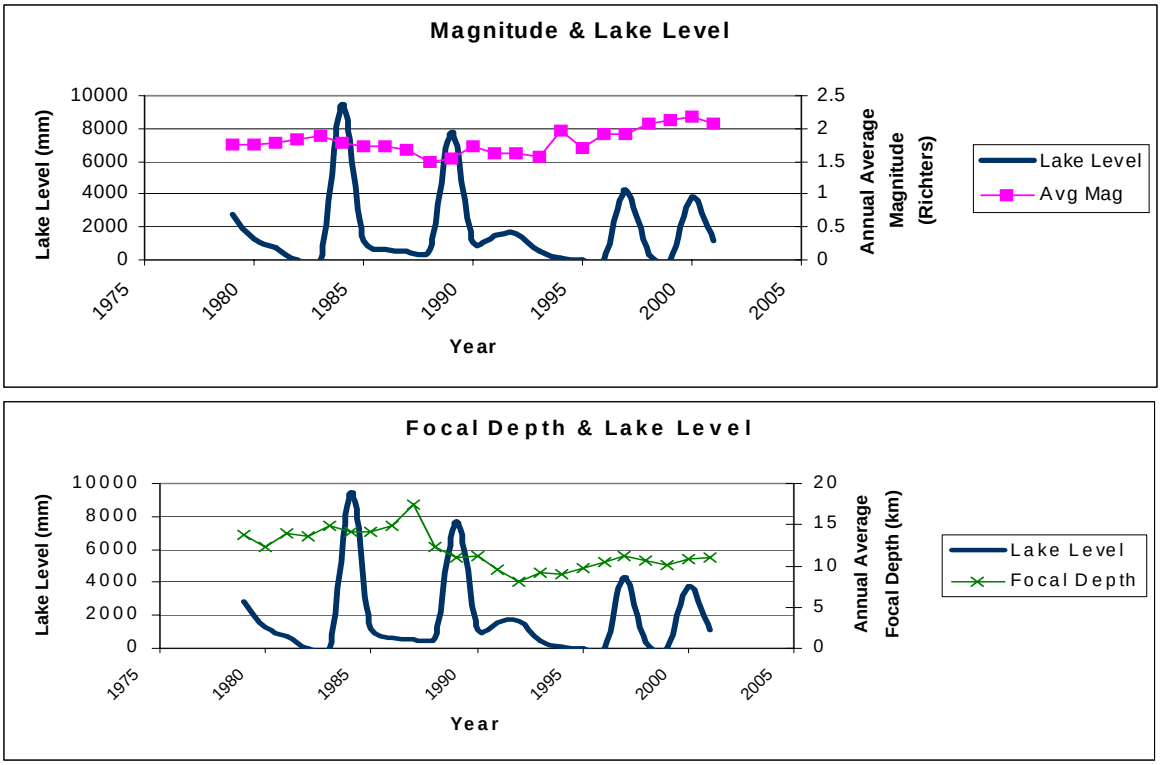

Figure 3: Regional earthquake data as compared to estimated lake levels in Lake Eyre (1979-2002). Continued next page.

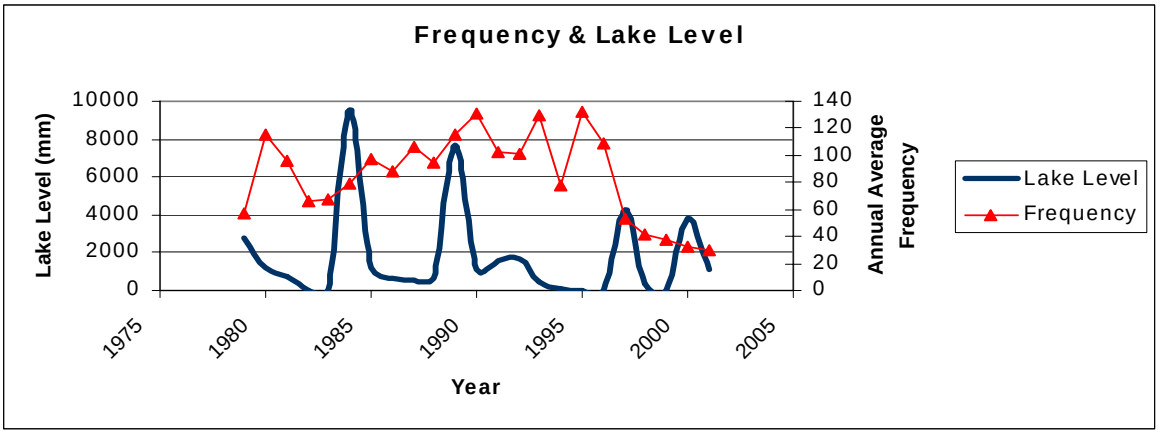

Figure 3 continued: Regional earthquake data as compared to estimated lake levels in Lake Eyre (1979-2002).

RESULTS

Through observational analysis of the plots of raw data there appear to be some suggestions of correlation between the earthquake datasets and the calculated inflows into Lake Eyre. When subjected to statistical analysis, however, these apparent correlations break down to statistically insignificant events.

Each pair of datasets of earthquake and hydrographic data was examined by regression analysis. Further statistical tests were applied to measure the extent, if any, of the correlation between data members. The Pearson Product Moment test, R, produces a result that ranges from -1 to +1and reflects the extent of a linear relationship between the two data sets. A positive result refers to a correlation between datasets where an increase in one is reflected by an increase in the other, and conversely, a decrease in one by a decrease in the other; the two are said to be positively correlated. A negative result refers to the situation where an increase in one data set is reflected by a corresponding decrease in the other and vice versa; this is known as a negative correlation. A result of zero represents a lack of correlation (Statsoft Inc. 2003).

The R^2 Test returns the square of the Pearson product moment correlation coefficient and is interpreted as the proportion of the variance in one dataset attributable to the variance in the other. It can be thought of as representing the strength of the correlation. A value of 1 would represent a complete correlation, that is, no difference between datasets (Statsoft Inc. 2003).

The ANOVA test (Analysis Of Variance) produces a value for “Significance F” which returns the one tailed probability that the variance in one dataset is not significantly different from the other dataset. A high value indicates that there is a high degree of variance between the two datasets. A low value indicates that there is a significant degree of correlation between datasets (Statsoft Inc. 2003).

The results of the statistical tests are recorded in Table 1. Plots of the annual averaged datasets are displayed in Figure 2 and Figure 3 for qualitative analysis. Result shows that most of the dataset correlations display a slightly positive Pearson Product Moment, R. This implies that they are all slightly positively correlated and this can be seen in the plots which suggest hints of statistical agreement. When subjected to the R^2 test, however, the degree of correlation within the groups of data clearly breaks down and small percentages are returned in all cases.

Table 1: Statistical Results.

Magnitude	**Volumetric Inflow**	**Lake Level**
Pearson R	0.078738	0.106003
R squared	0.0062	0.011237
ANOVA	0.71458	0.630244
Focal Depth	**Volumetric Inflow**	**Lake Level**
Pearson R	0.12062	0.065502
R squared	0.014549	0.004291
ANOVA	0.574506	0.766514
Frequency	**Volumetric Inflow**	**Lake Level**
Pearson R	0.005746	0.066648
R squared	3.3E-05	0.004442
ANOVA	0.978742	0.762544

DISCUSSION

Such a poor correlation of results fails to demonstrate that the two events are linked. If the model proposed holds to be true then the weight of the water in the lake should be the driving mechanism for tectonism within the northeastern region of South Australia. The fact that we see little evidence of subsidence corresponding to the emptying and filling cycle of Lake Eyre has

implications for the history of regional landscape evolution.

The landscape in the region consists of mesas, erosional rises and erosional plains covered with a lag deposit of silcrete pebbles, or gibber. These low hills and plains are incised by alluvial systems that are propagating through headward erosion. Sediments in the region display abundant fine grained silts and clays. Under classic fluvial models sediments of this size produce a meandering stream system. When observed in plan view, however, the streams in the western catchment of Lake Eyre display low sinuosity (Figure 1). They are straight channeled, laterally aggrading streams. This lack of sinuosity is indicative of young streams formed as a result of recent tectonic uplift where the stream has not yet adjusted to the new equilibrium conditions and is in the process of forming meanders. The climate, however, has played an important role in stream development.

The ephemeral nature of the modern environment is extremely arid but subject to periods of intense flooding associated with high rainfall events. The drainage system rarely flows for any significant length of time. In this context the amount of time that these ephemeral streams have actually carried water represents only a fraction of the time period that these streams have been resident as geomorphological features. If neotectonic activity were present the interpretation could be made that these streams are newly generated as a result of recent tectonic movement. The evidence presented here suggests otherwise and it is probable that the streams have been landscape features for a significantly longer period of time than might be suspected.

Similarly, along the eastern margins of the Davenport Ranges runs the Mt. Margaret fault. The rate of subsidence of Lake Eyre is likely to influence the activation of faults within the region. At the headwaters of Hope Creek there is displayed a clear juxtaposition of Mesozoic and Proterozoic sediments where there is an absence of alluvial fans suggesting that the fault at this point has remained inactive since the late Cretaceous.

Further north along the same faulted margin there is a succession of low-angle fan deposits composed predominantly of lithic sediments from the Davenport Ranges. These colluvial fans display a high degree of angularity associated with a limited amount of transport and are interpreted as recently deposited sediments overlying Pleistocene land surfaces. Such contradictory evidence suggests that neotectonic movement has occurred along the margins of the Davenport Ranges, indicating that there is a more complex tectonic model than proposed here.

CONCLUSION

A statistical analysis of seismicity data and hydrographical data in the Lake Eyre region has not clearly demonstrated a link between the level of water in the lake and the frequency of tremors in the region. Neotectonic activity may be taking place but the evidence is not strong enough to state this with categorical certainty. Further evidence is required to assess whether or not neotectonic activity impacts upon the contemporary depositional behaviour of the western catchments of Lake Eyre. Results at this stage remain inconclusive.

REFERENCES

BACKWAY B. 2001. Data and graphs (c). *Lake Eyre Yacht Club*, **LakeEyreYC.com.**

CROKE J.C., MAGEE J.W. & PRICE D.M. 1996. Major episodes of Quaternary activity in the lower Neales River, north west of Lake Eyre, Central Australia. *Palaeogeogr., Palaeoclimatol., Palaeoecol.* **124**, 1-15.

DREXEL J.F., PREISS W.V. & PARKER, A.J. 1993. The Geology of South Australia. Vol. 1, The Precambrian. *South Australian Geological Survey Bulletin* **54**, 9-10

KOTWICKI V. & ISDALE P. 1991. Hydrology of Lake Eyre Australia El Niño, *Palaeogeogr., Palaeoclimat., Palaeoecol*. **84**, 87-98.

LANG S.C. & PAYENBERG T.H.D. 2003. *Lake Eyre Fluvial Reservoir Analogues Project*. Field workshop to the Neales River and Umbum Creek, Lake Eyre, South Australia. *Australian School of Petroleum*, unpublished field guide.

NANSON G.C. & PRICE D.M. 1998. Quaternary change in the Lake Eyre Basin of Australia: an introduction. *Palaeogeogr., Palaeoclimatol., Palaeoecol*. **144**, 235-237.

STATSOFT INC. 2003. Electronic Statistics Textbook. Tulsa, OK*: Statsoft*. WEB: http://www.statsoft.com/textbook/stathome.html.