

**“Source to Sink” Sedimentology and Petrology of a Dryland  
Fluvial System, and Implications for Reservoir Quality,  
Lake Eyre Basin, Central Australia.**

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## ABSTRACT

Reservoir quality of subsurface sandstones depends on the composition, texture and grain size of the initial sediments. These factors are a function of hinterland processes: tectonic setting, provenance, climate and depositional environment, and sediment transportation processes. This study focuses on a modern, dryland, fluvial deposition system from source-to-sink that aims to provide a quantitative dataset analogue to facilitate forward modelling for prediction of subsurface compositions, grain size and textures of reservoir sandstones.

Umbum Creek, in the western Lake Eyre Basin of Central Australia, was selected as a small river network (~ 100km<sup>2</sup>) in order to study source-to-sink sedimentation. The provenance area was analysed using isopach maps derived from a 783 drill-hole dataset, which included stratigraphy and lithology information. Subsequently forty-three samples of different provenance lithotypes from the Umbum Creek catchment were collected for petrographic thin-section analysis. Recent sediments were then sampled from 90 strategically located stream confluences along Umbum Creek and tributaries (proximal, medial and distal subsets). A quantitative textural and compositional dataset was subsequently generated from 34 selected samples. With half-phi sieve analysis (4mm to 32 microns), and an associated petrographic description recognising 72 categories of grain composition was undertaken for each sample.

The provenance analysis using isopach maps demonstrated that Palaeozoic and Mesozoic sedimentary basin evolution in the study area was controlled by northeast and northwest-trending structural elements. The regional uplift of the Peake and Denison Inliers that occurred during the Cenozoic had a significant impact on the evolution of the Lake Eyre Basin, causing changes in the provenance of Late Neogene sedimentation and on through to the present. The sink area represents a shallow intracratonic basin whereby a thin veneer of fluvial/lacustrine sediments is accumulating adjacent to a basement uplift.

This study has highlighted the importance of multiple sediment provenances. Five different provenance lithotype grains were identified in the Umbum Creek modern sediments: the Gawler Craton plutonic / basement provenance (recycled) the Peake and Denison Inliers Proterozoic

volcanic provenance (recycled), the Davenport Ranges metamorphic provenance, the Mesozoic sedimentary provenance and the Cenozoic sedimentary provenance. Whereas a downstream fining of grain size was expected, a general trend of downstream coarsening of grain size was noted being the result of aeolian deflation of fines and intra-basinal coarse-grained sediment contributions.

In the sink area, modern sediments from the terminal splay complex comprise 70-80% quartz, 10-20% lithic fragments (of which ~ 7% are ductile lithic grains), < 3% feldspar, and clay (<2%). Grains are sub-angular to well-rounded and moderately well sorted. The compositional and textural maturity of the terminal splay sediments is attributed to reworked plutonic quartz grains, the dissolution and disintegration of feldspar and carbonate grains during transportation, along with the breakdown of lithic fragments due to fluvio-aeolian interactions and subsequent mechanical/chemical weathering processes. These data were used to build a predictive forward model for modal sandstone analysis that achieved a fair to good correlation between predicted and observed grain lithotypes and provenance categories. These results illustrate that the character of sands in the Umbum Creek catchment are governed by a multiplicity of controls such as tectonic setting, provenance lithotype analysis, climate, regional topographic gradient, hinterland transport distance, basin subsidence rate and depositional environment.

The fluvio-aeolian depositional environment along with the current arid to semi-arid playa climatic conditions of Umbum Creek catchment facilitate the growth of clay coatings, however accounts for a low clay matrix within the deposits. In addition, the playa environment also facilitates the alteration of infiltrated detrital clay to kaolinite, the formation of evaporites (gypsum, halite and anhydrite) and the formation of authigenic clays. These factors are all significant in determining the ultimate reservoir quality of reservoir sandstones, emphasising the importance of this study as an analogue for modelling 'buried' dryland depositional systems.

## DECLARATION

The work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institutions and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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