Multiple Provenances on Predicting Reservoir Quality*

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Abstract

Reservoir quality of is primarily controlled by a range of parameters, including grain size, sorting, and modification of the original sediment composition through the diagenetic processes of compaction and cementation. The ability to quantifiably predict such diagenetic processes (controlled by lithology, pressure, temperature, pore fluids type, grain size, and amount of fluid flow) is a significant factor in predicting reservoir quality.

The initial sediment composition, texture and grain size are functions of hinterland processes: provenance, tectonic setting, climate, sand evolution and transportation, and the depositional environment. Sands from the modern dryland Umbum Creek, western Lake Eyre Basin, Central Australia reflect the nature of the hinterland region and drainage basin. Evolution of sand composition throughout the river course is mainly related to the changes in the relative proportion of contributing bedrock lithologies. Six petrographic provenances were identified and established in the Umbum Creek drainage basin. Upstream Palaeoproterozoic and Neoproterozoic provenances supply lithic grains and metamorphic minerals to the stream's sand, whereas quartz is mainly sourced from reworked older sedimentary units further downstream. The initial rock compositions (mineralogy, texture and grain size) are the main influence on diagenetic processes such as cementation, quartz overgrowth, mechanical and chemical compaction, grain breakage and pressure solution. In the case of the Umbum Creek sands, the medium to coarse grain size, 88-92% of quartz, less than 2% of feldspar and less than 10% of lithic fragments, together with subrounded to rounded grains, moderately well sorting and very little in clay content, leads to a suitable candidate for good reservoir quality, if buried. A similar analysis of the ‘source to sink’ sedimentation system of a petroleum basin could lead to a better assessment of reservoir quality prior to drilling.

Website Cited

NASA, Earth Observatory, August 2013, Natural Hazards: Website accessed August 26, 2013.
http://earthobservatory.nasa.gov/NaturalHazards

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Chevron

Human Energy®

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Predicting Reservoir Quality
Challenge

The sheer complexity of factors controlling reservoir quality in the subsurface makes prediction challenging because of the unknown

- ***primary depositional composition and texture,***
- post-depositional (subsurface) modifications that occur to the sediment during and after burial.

Presentation Outline

Introduction

Objectives

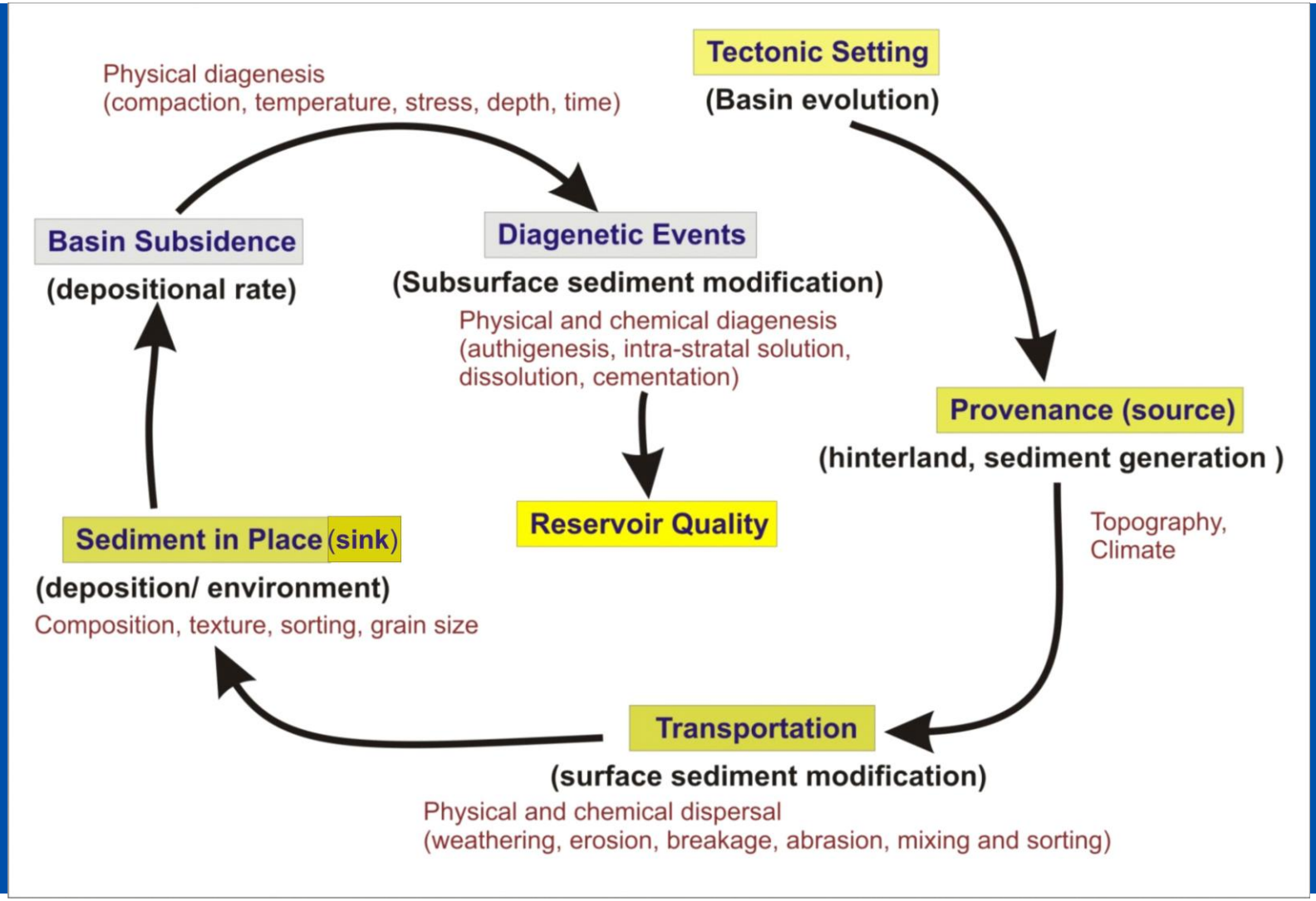
Methodology

Results

Umbum Creek modern sediments implications for Reservoir Quality

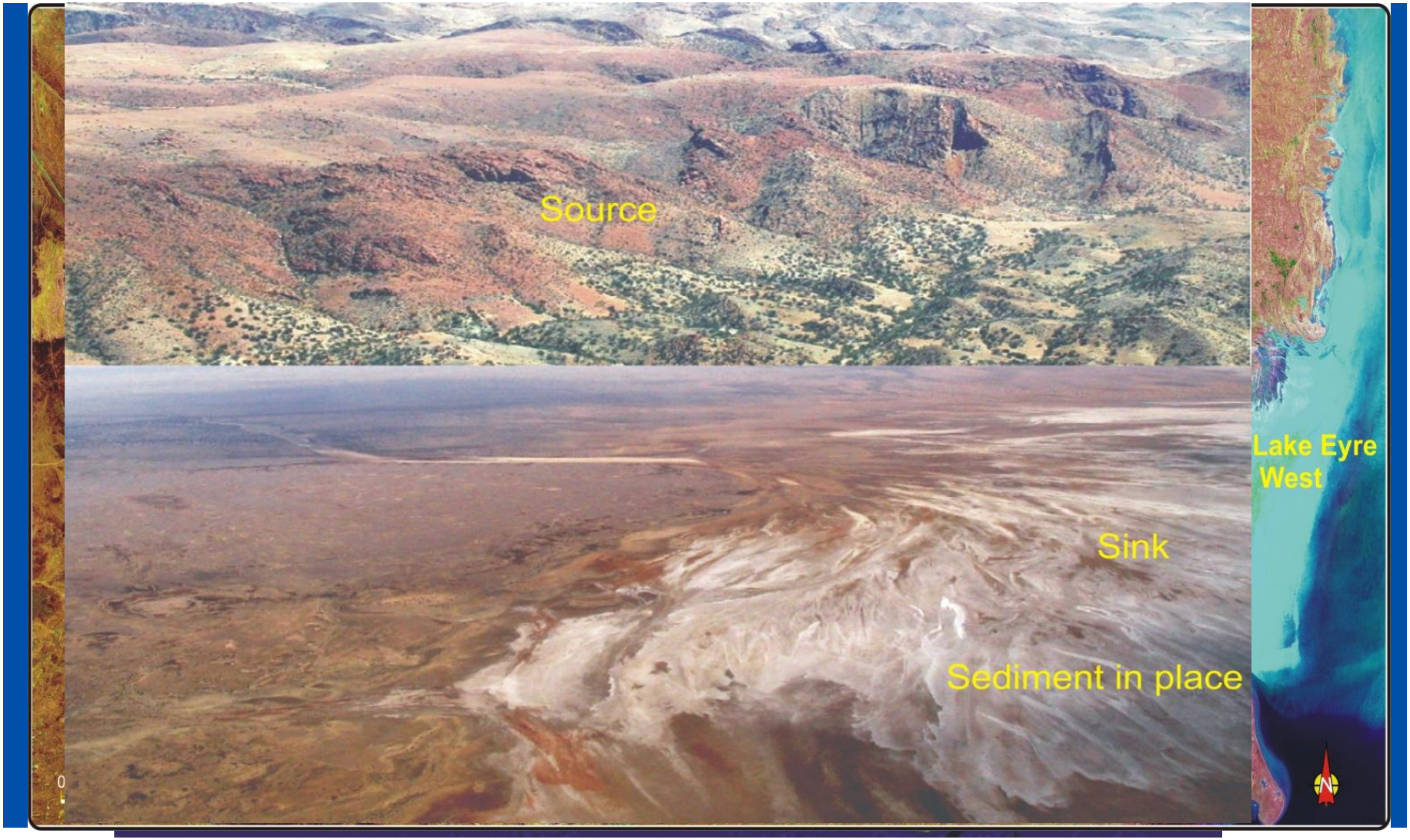
Conclusion

Introduction
Reservoir Quality Prediction



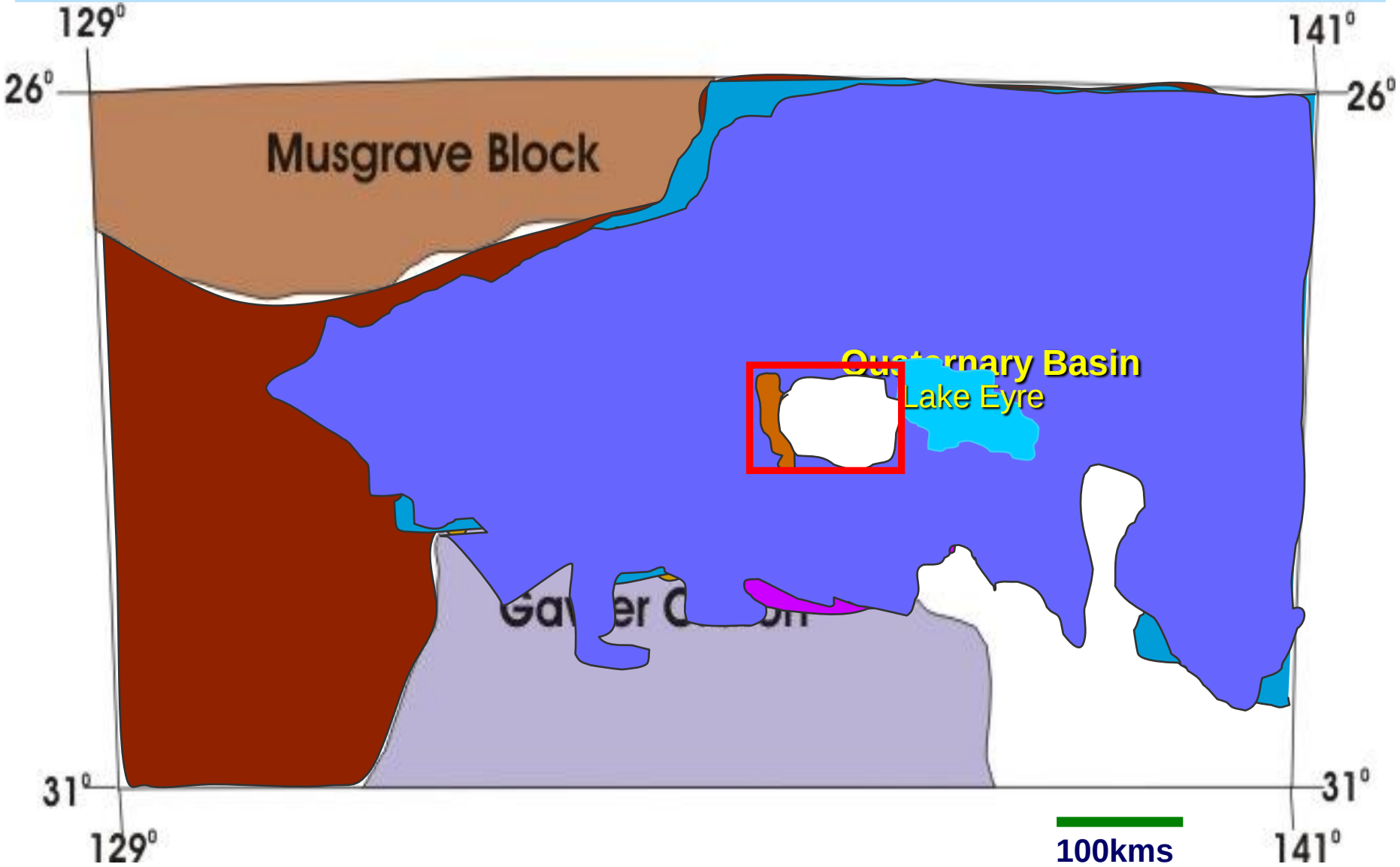
Umbum Creek, Western Lake Eyre Basin, Central Australia

“Source to Sink” sedimentation in a dryland fluvial-aeolian system



Introduction

Sedimentary Basins through time in the Study area



Introduction
Geological setting

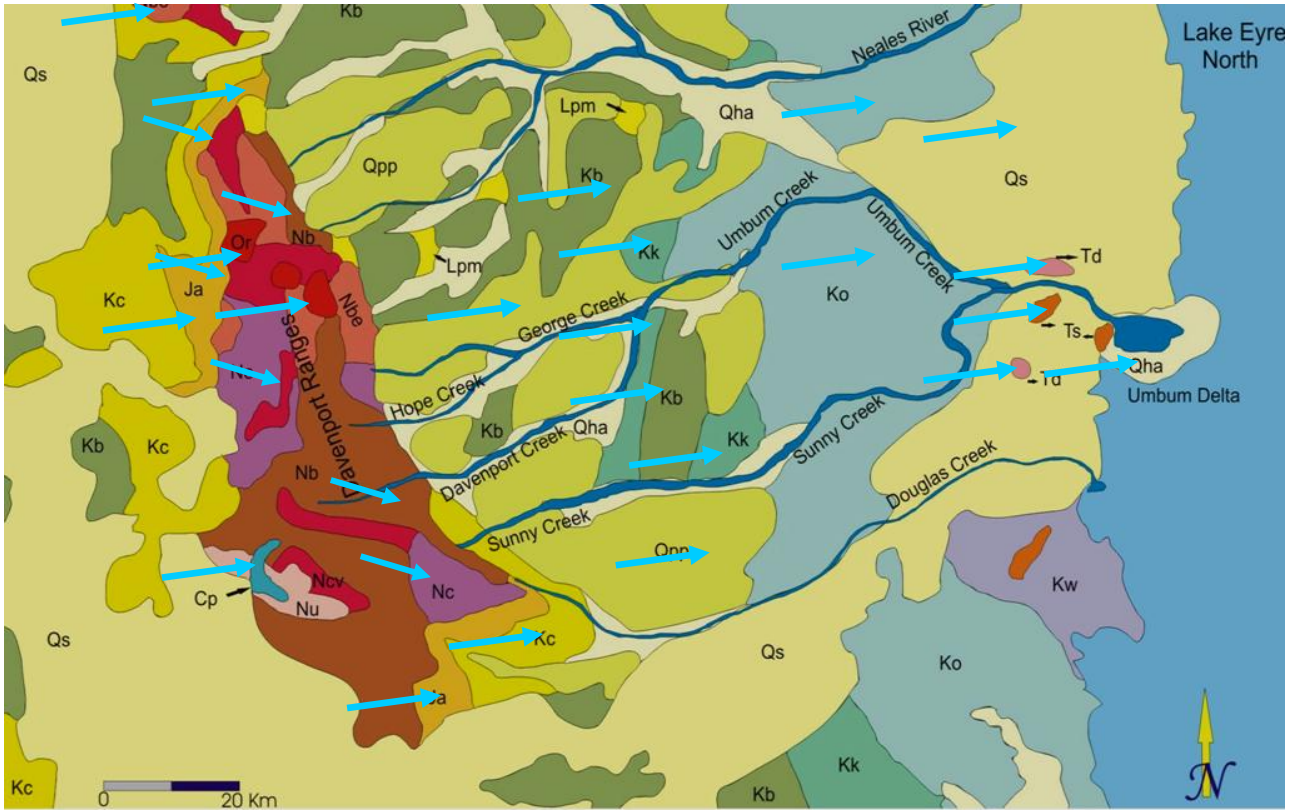
Quaternary- fluvial and aeolian(Qs, Qha, Qpp), m-c grained

Tertiary – *Etadunna* formations(Td)- lacustrine, *Eyre* (Ts) – fluvial and silcrete, m-c grained

Cretaceous – *Oodnadatta* Formation (Ko) Fluvial –Lacustrine, *Coorikiana* sst (Kk)- shallow marine , *Bulldog* shale(Kb)- marine, f *Cadna-owie* formation(Kc)- marginal marine, f-m grained

Jurassic – *Algebuckina* sst (Ja), m-c grained sandstone.

Permian (Cp) – terrestrial – marine sequence, vary grain size

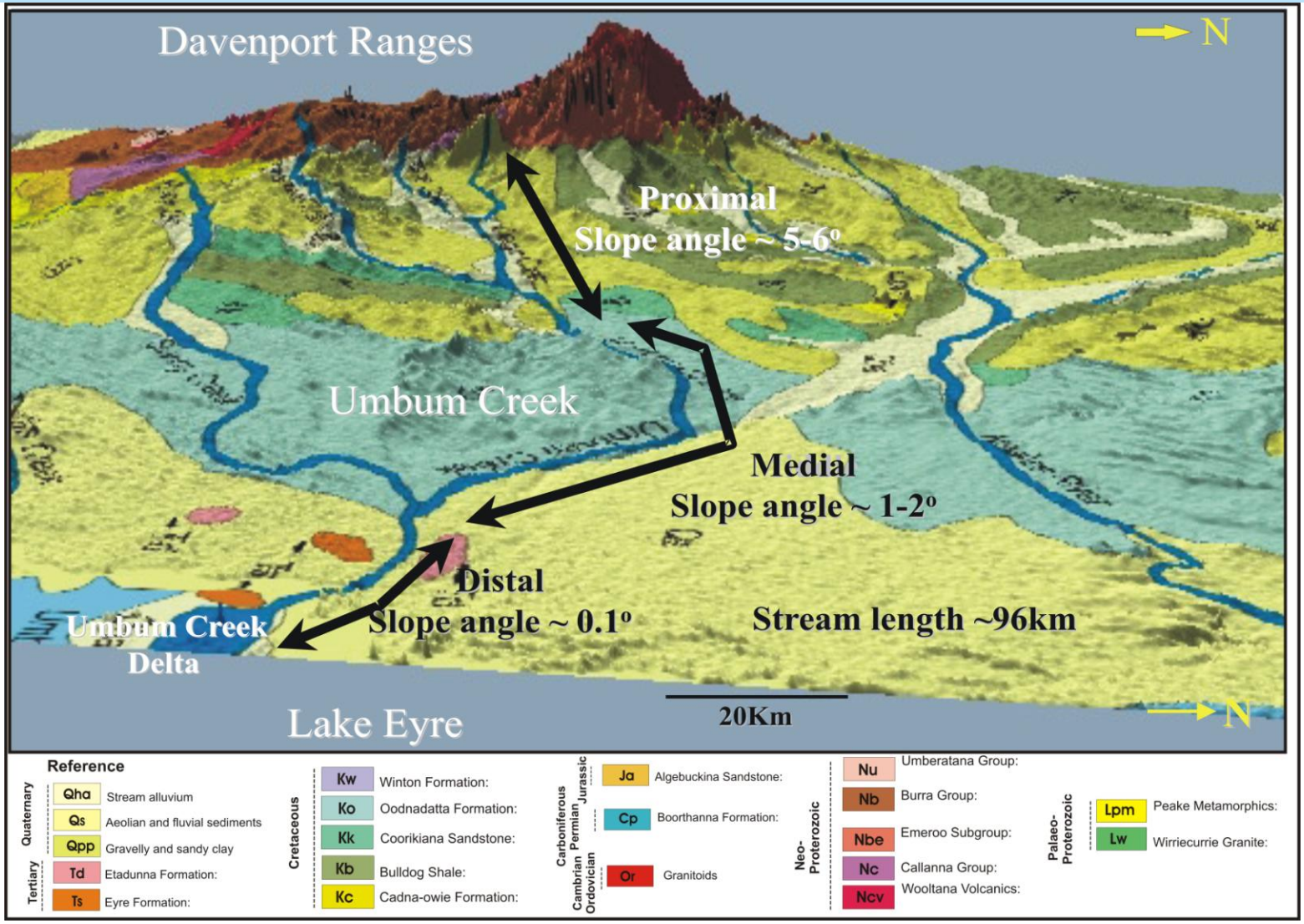


Ordovician-Late Cambrian – 570 – 430 Ma (Or), Officer Basin, Granitoids.

Neo-Proterozoic 1000 – 570 Ma (Ncv, Nc, Nbe, Nb, Nu) – quartzite, dolomitic, siltstone, volcanics, evaporites.

Paleo-Proterozoic 2500 – 1800 Ma (Lw, Lpm) – Peak and Denison inliers, schist, gneiss, granite, quartzite, carbonate rocks

Introduction
Geological setting on 3D-DEM



Objectives

- Assess “Source to Sink” sedimentation in a modern dryland fluvial-aeolian setting within an intracratonic basin to improve prediction of reservoir quality
- Umbum Creek modern sediment analysis and its implications for predicting reservoir quality

Methodology

Source of modern sediments – provenance litho-types

Petrography: modal analyses of 48 rock thin sections from provenance litho-types (72 grain categories, 300 point count)

Modern sediments

Sieve Analysis: 46 modern sediment samples sieved for half phi fraction

Petrography: modal analyses of 34 modern sand thin section (72 grain categories, 300 point count)

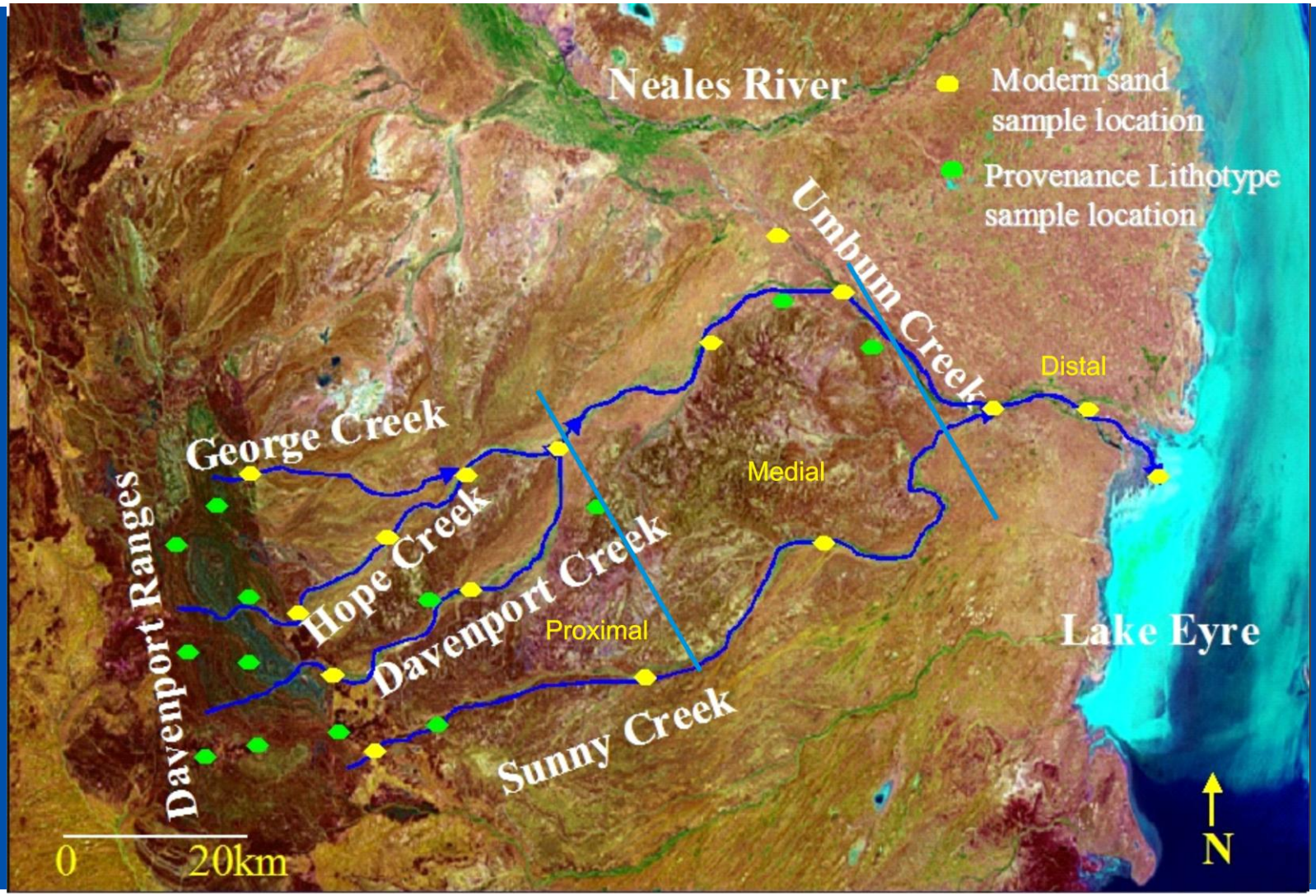
XRD: selected samples from proximal, medial and distal of Umbum Creek

SEM: selected samples from proximal, medial and distal of Umbum Creek

Cathodoluminescence: selected samples from proximal, medial and distal of Umbum Creek

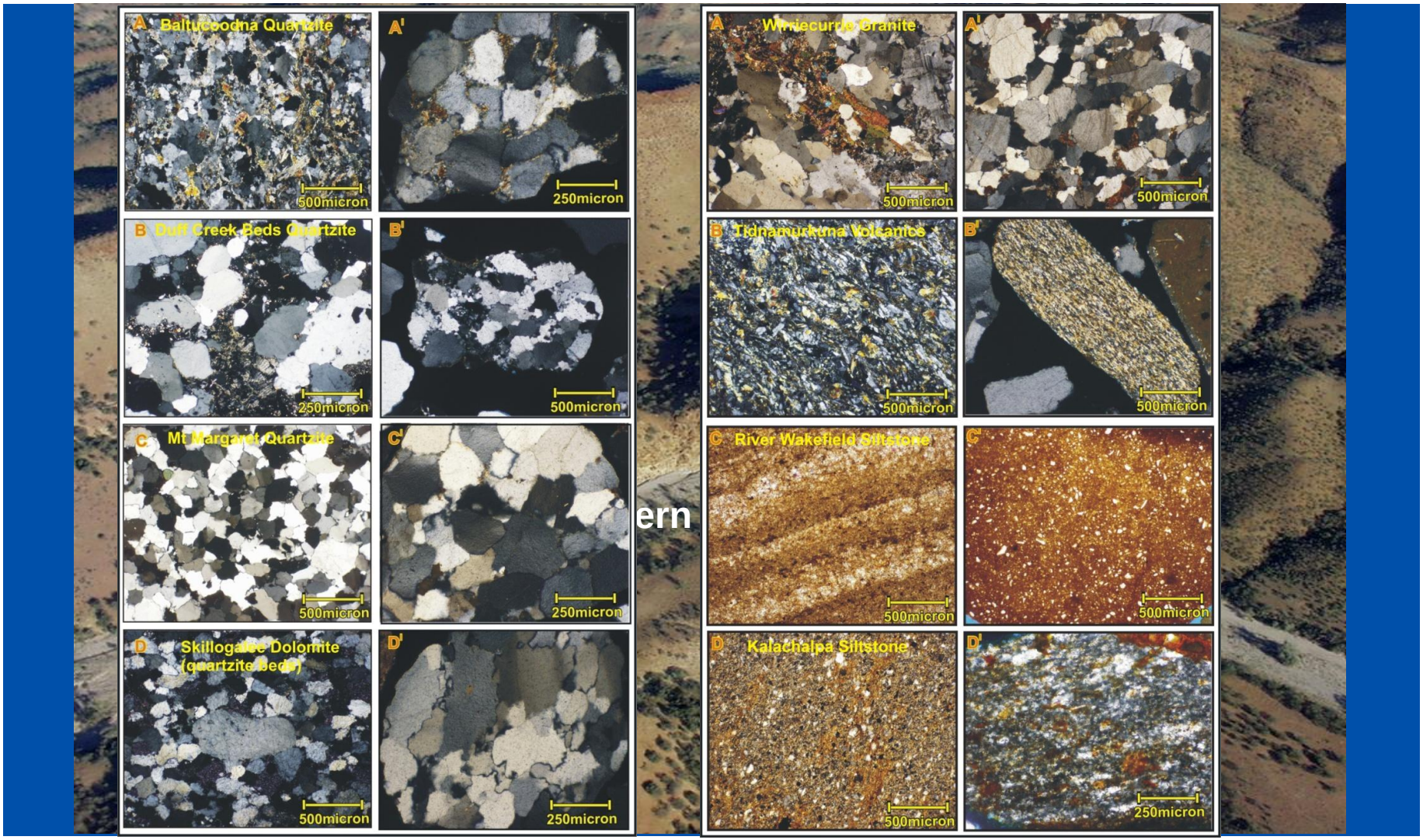
Zoom Stereo Microscope: fluvio-aeolian sand samples

Methodology
Sampling modern sediments



Results - Recognition of modern sand and its provenance

Source for modern sediments – provenance lithotypes



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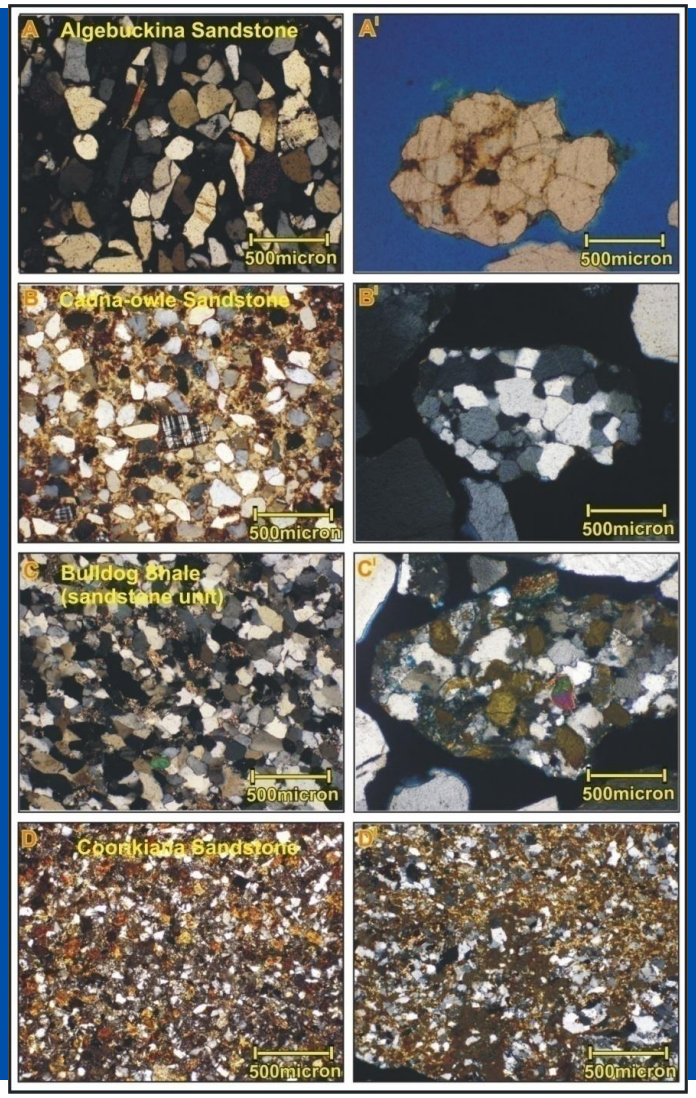
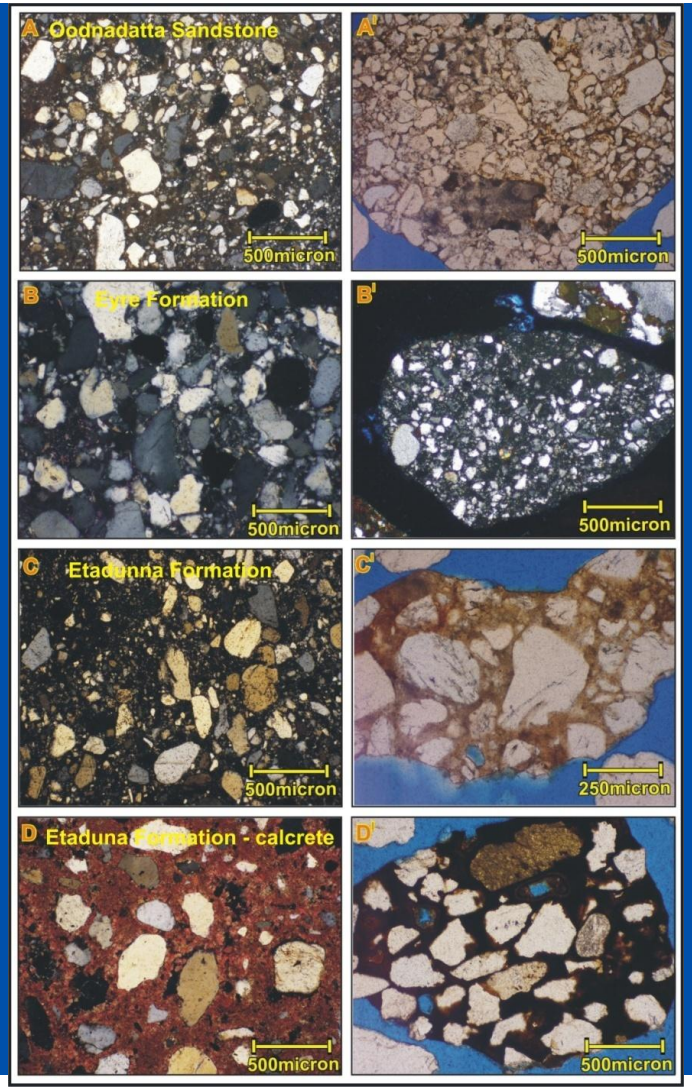
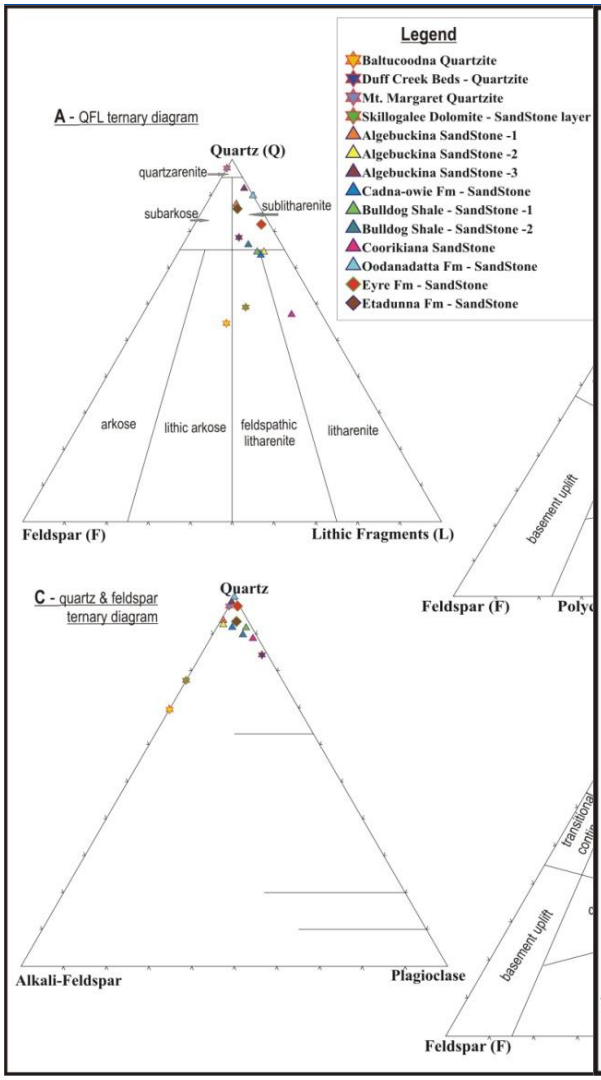
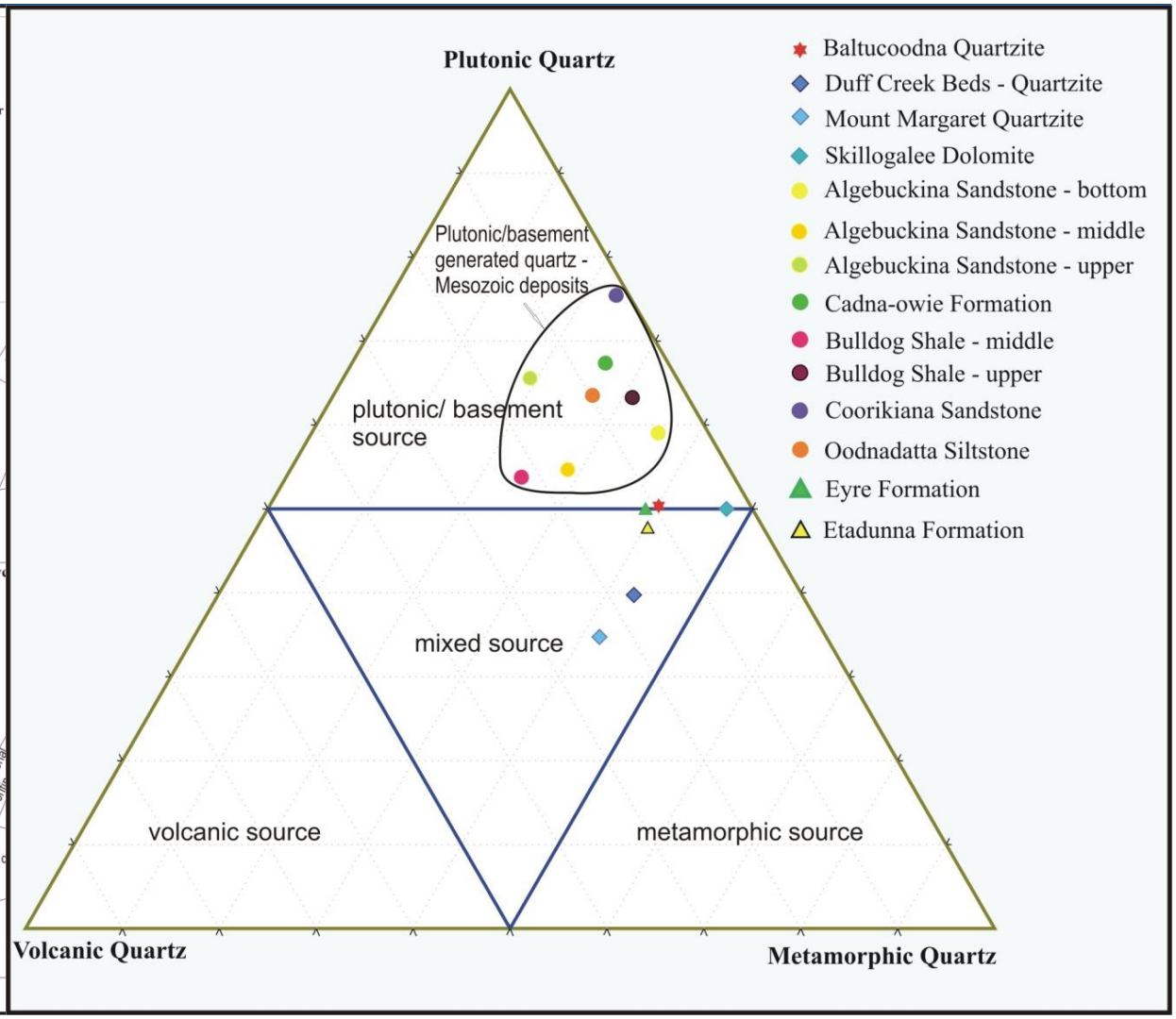




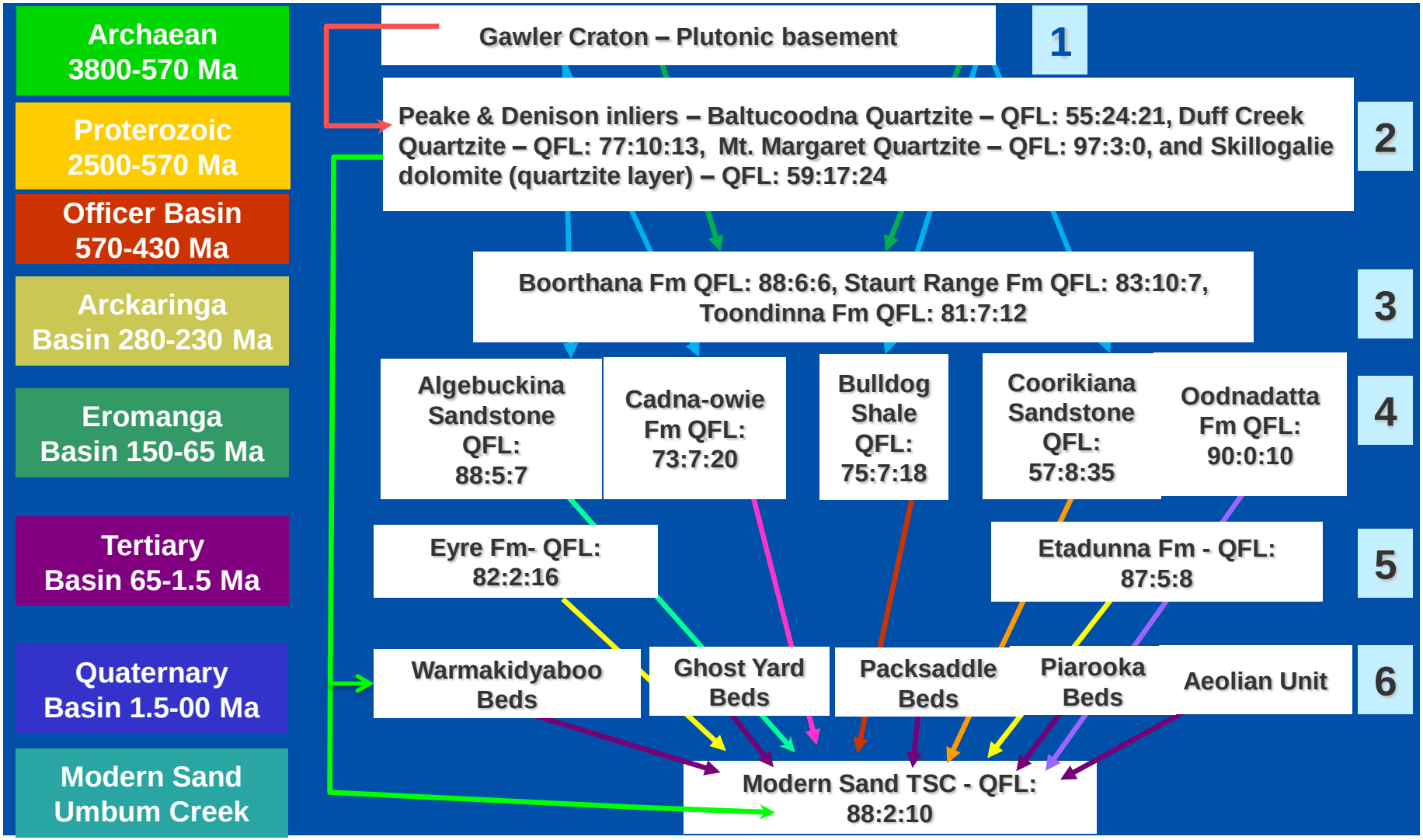
Results – Modal Analyses of Provenance Lithotypes
QFL & Quartz Classification - Source for modern sediments





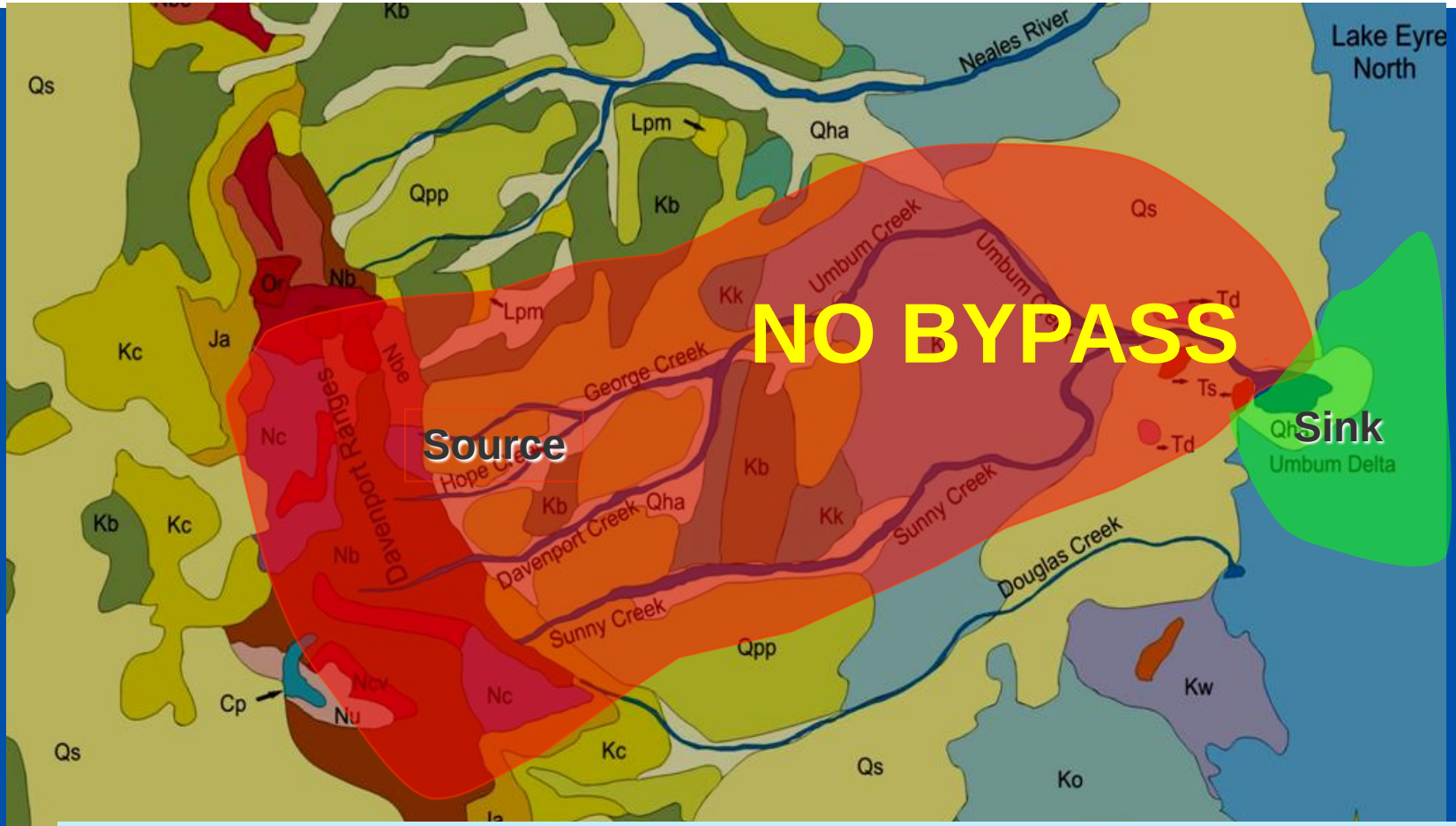
Results - Recognition of modern sand and its provenance

Source for modern sediments – six petrographic provenances



Results - Recognition of modern sand and its provenance

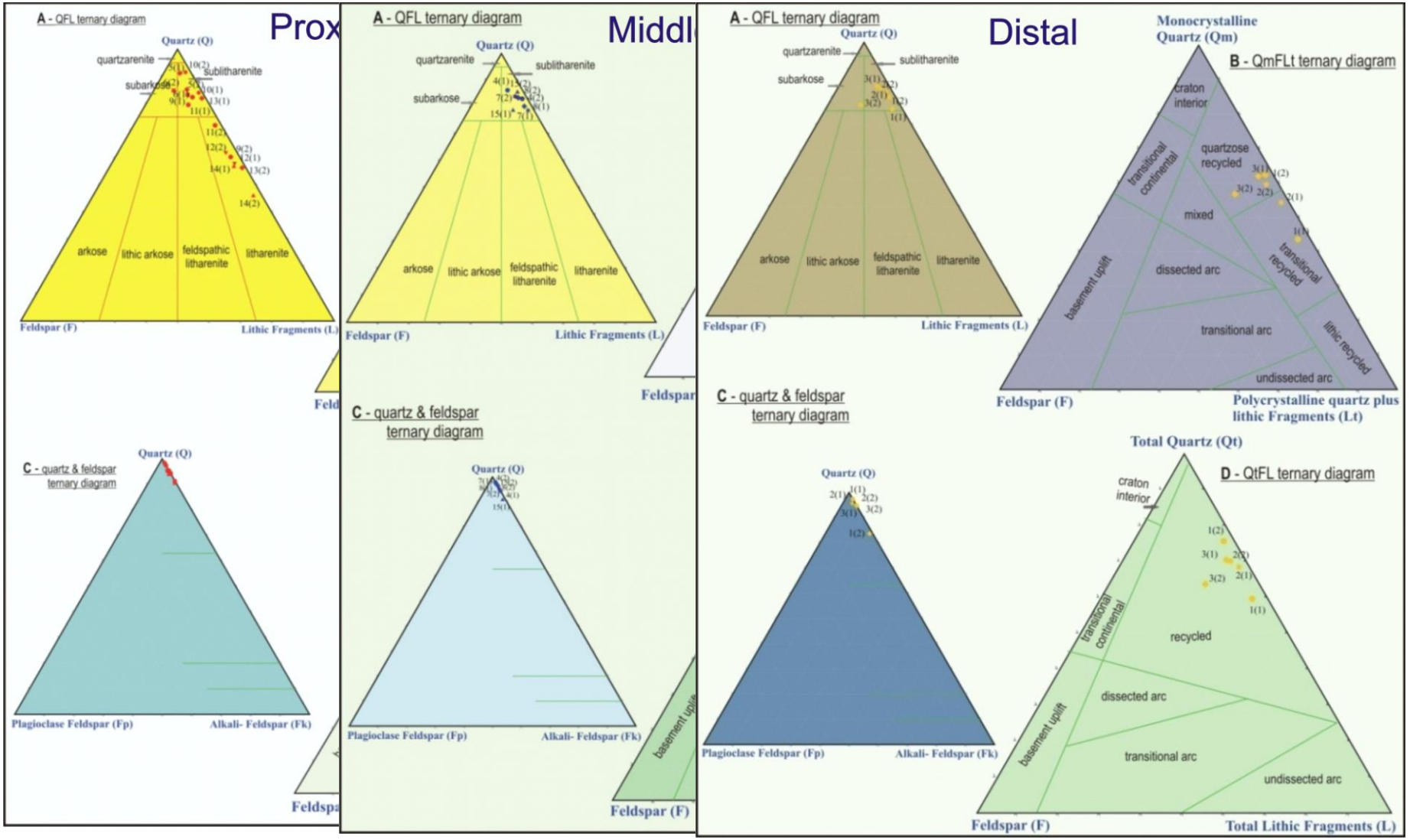
Source for modern sediments – six petrographic provenances



Provenance exerts a significant influence on reservoir quality by controlling the composition of sediments

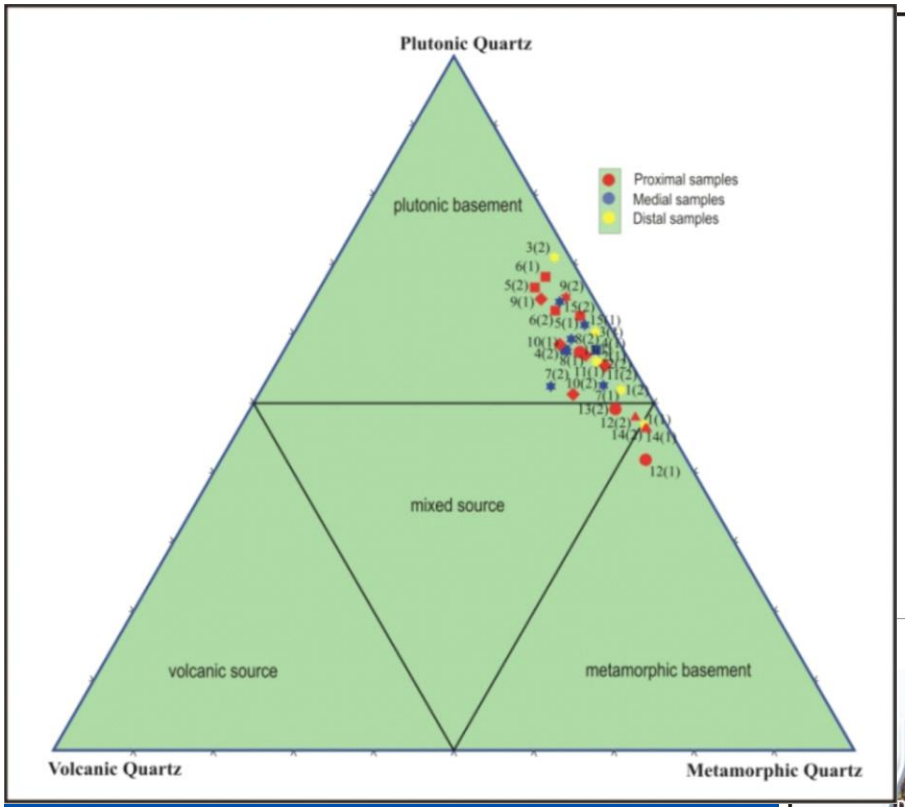
Results - Modal Analyses of Modern Sediment

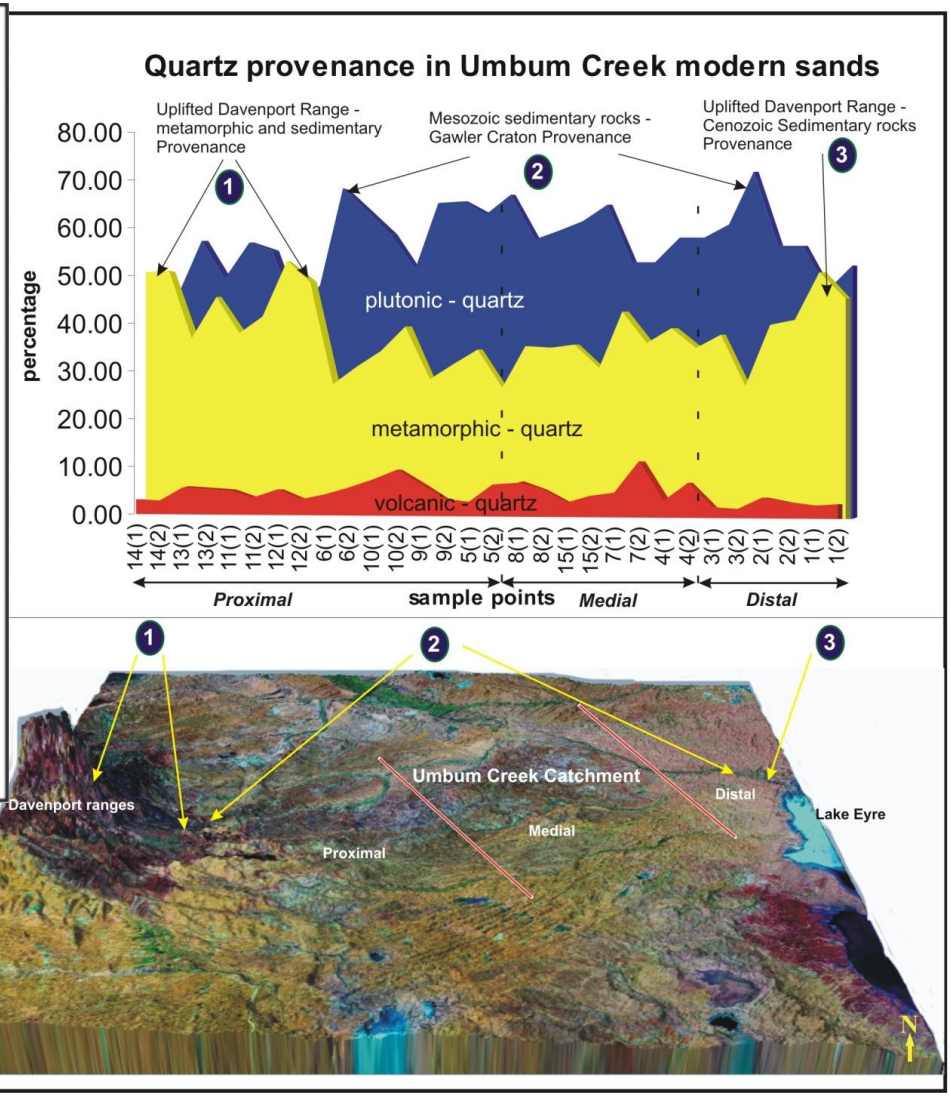
Multiple provenance – QFL Classification



Results – Modal analyses of Quartz Provenance

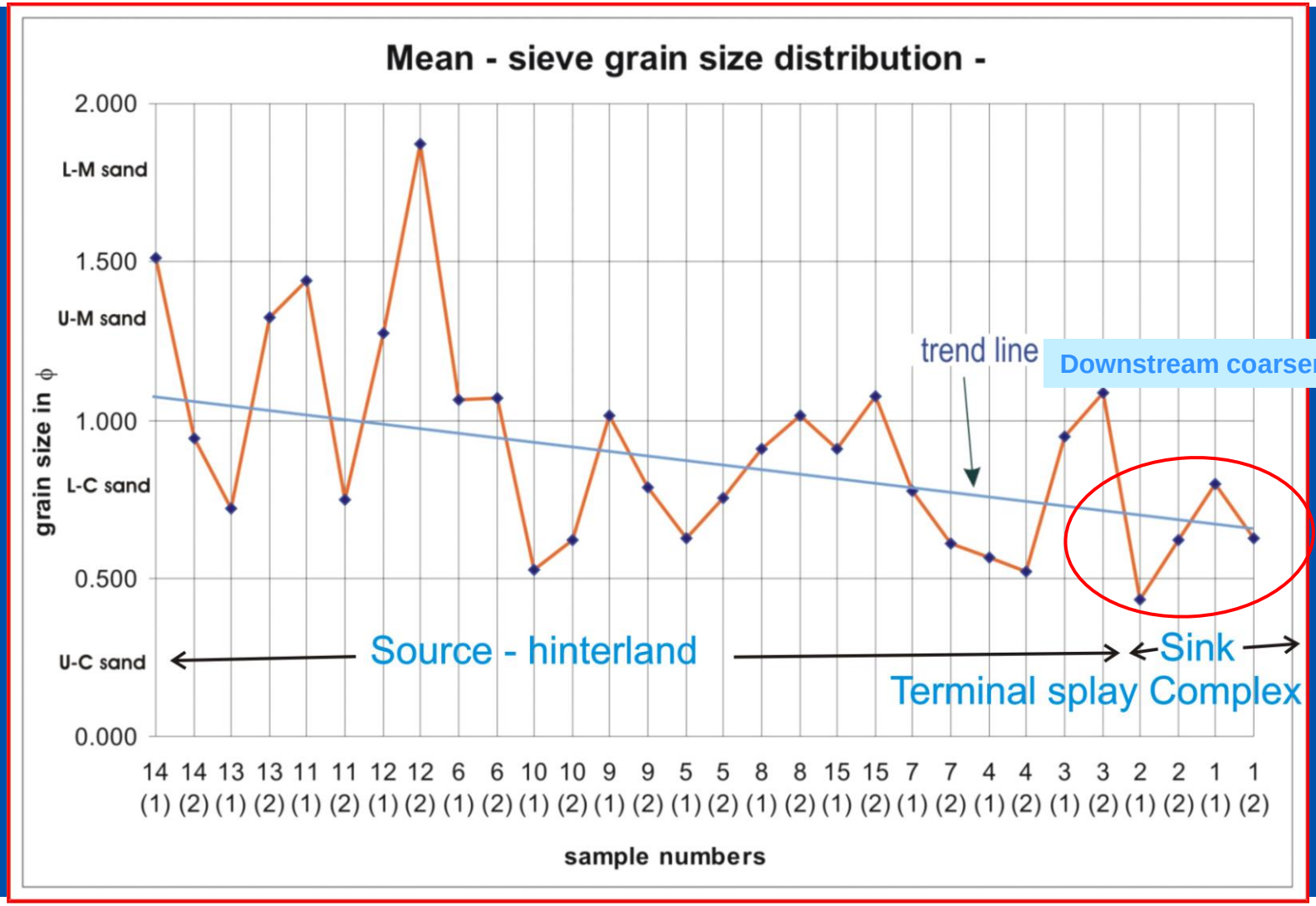
Quartz- Classification - Modern sediments





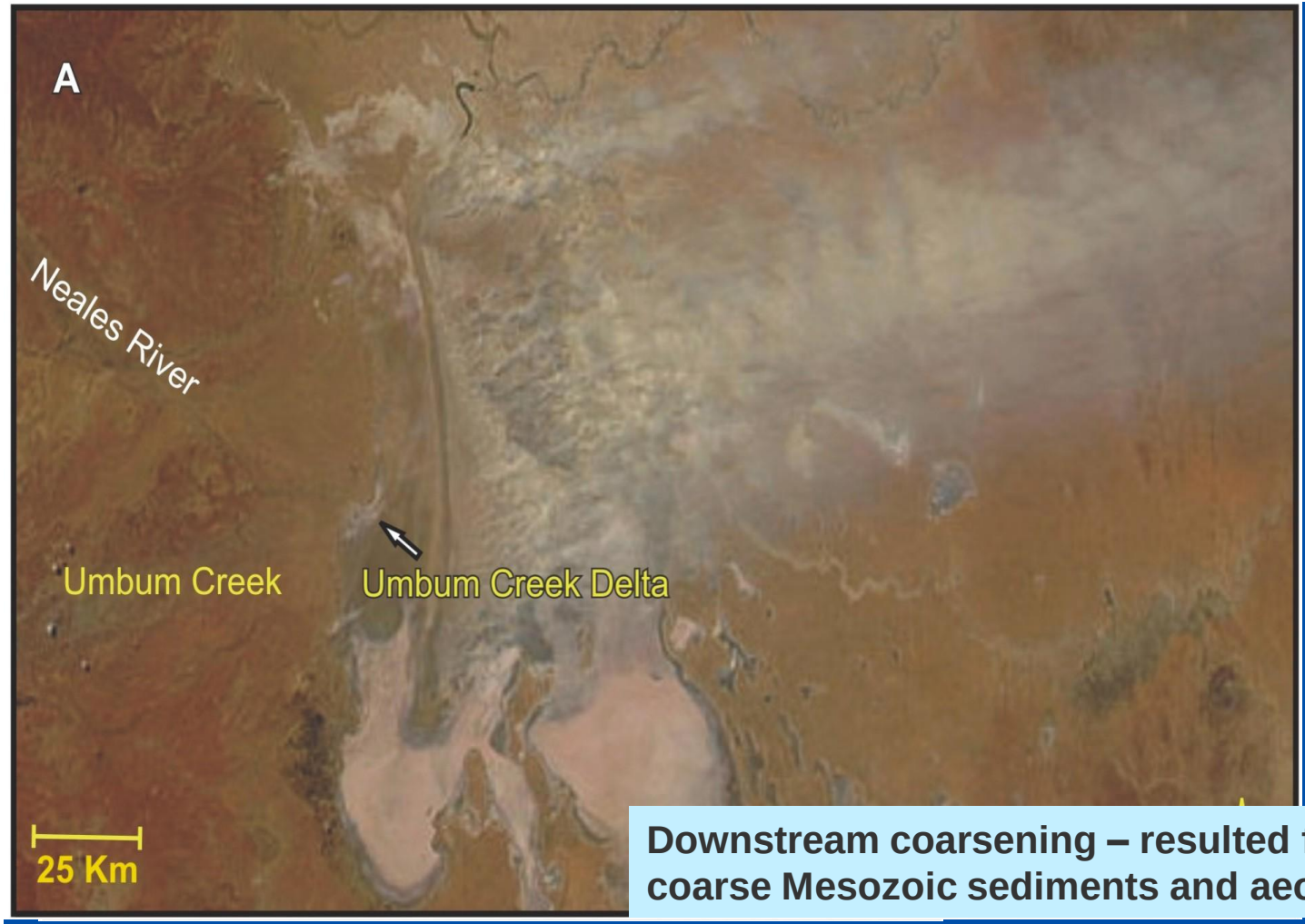
Results – Grain size

Medium to coarse grained sand



Results – Grain size and Clay

Downstream coarsening & low clay content. Why?



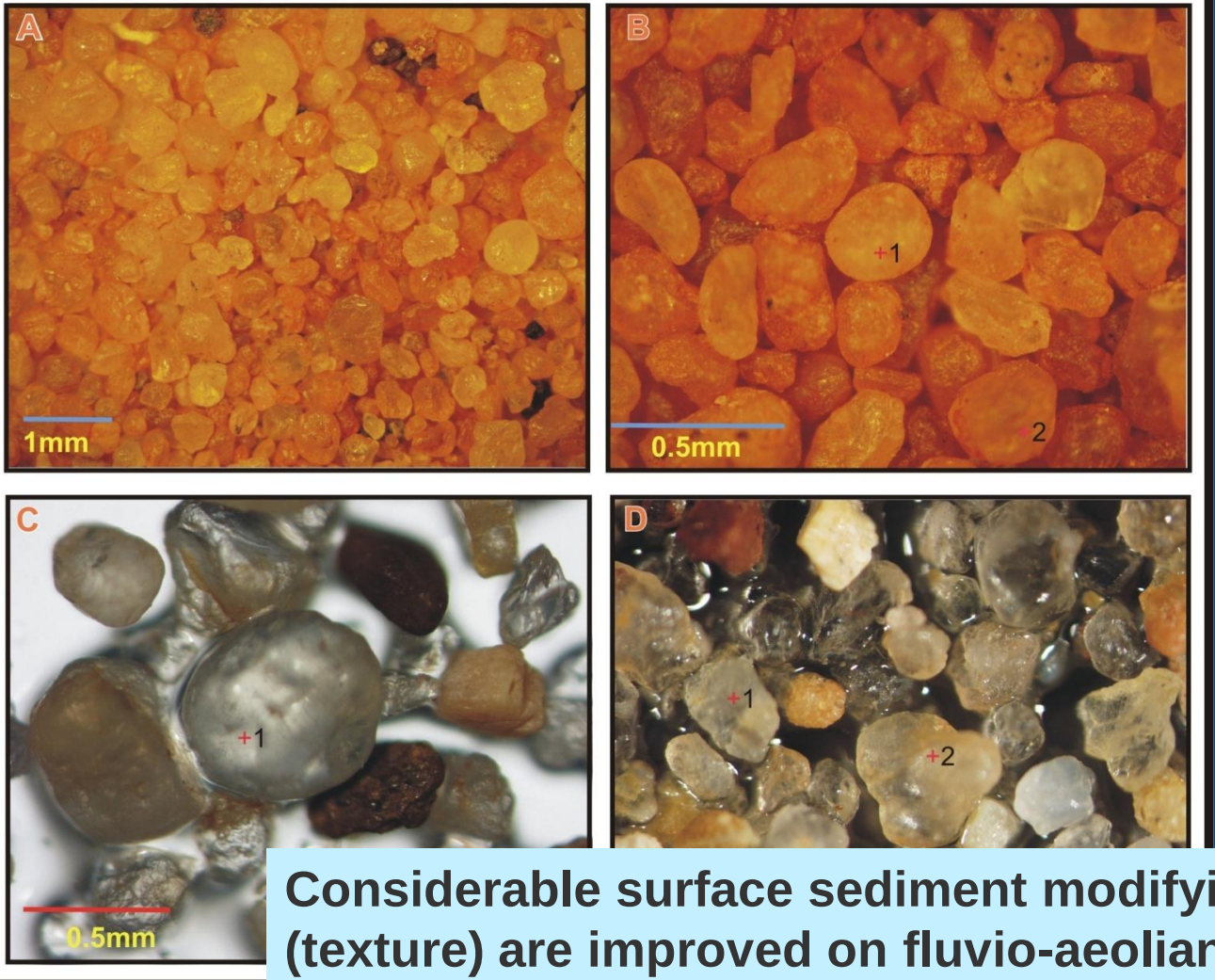
Blowing easterly – October 28, 2003.

Downstream coarsening – resulted from medium to coarse Mesozoic sediments and aeolian interaction

Dust storm causing the deflation in Umbum Creek Terminal splay area. Source: http://earthobservatory.nasa.gov/NaturalHazards

Results – sorting, roundness and coating

moderate to well sort, sub-rounded to well rounded and hematite



Hematite coating (B+1, B+2)

Rounded aeolian grain with grain impact percussion marks (C+1)

Fluvial sub-rounded grain (D+1)

Aeolian rounded grain (D+2)

Considerable surface sediment modifying processes (texture) are improved on fluvio-aeolian interaction.

Umbum Creek modern sediments implications for RQ

QFL: 88:2:10, m-c grained, m-w sorting, sub-well round & low clay

Diagenetic processes	Umbum Creek terminal splay complex sand characteristics	Reservoir quality
3. Cementation		
: early carbonate/ evaporite cements	Low - moderate cementation <1% carbonate lithics, high evaporation rate under playa environment accelerate the gypsum and anhydrite cements	Destroy porosity, however develop the secondary porosity during late diagenesis as dissolution
: quartz cementation	Low - moderate cementation Restrained by early carbonate / evaporite cements, grain coating, and low feldspar content dissolution. Favours by salinity, low temperatures, pressure dissolution at grain contacts in later burial compaction	Preserve porosity in early diagenesis, as well destroy porosity by low rate of quartz cements and in later cements by pressure dissolution.
: grain coating	Low - moderate cementation inhibits cementation by enhanced grain coating of alumino-silicate, microcrystalline quartz and Fe-oxyhydroxides.	Preserve porosity

Conclusion

Umbum Creek modern sediment composed of multiple provenances (six petrographic provenances) of uplifted metasediments from proximal, reworked Mesozoic and Cainozoic sediments from medial and distal respectively (Source) controls the composition, grain size and texture of the sediment.

The significant surface sediment modifying process for redeploying composition, texture, grain size and sorting at the place of deposition (Sink) is by the fluvio-aeolian interaction.

The ability to quantifiably predict diagenetic processes from primary depositional composition and texture with depositional settings is a significant factor in predicting reservoir quality.

Similar study of “Source to Sink” sedimentation and its analysis of a petroleum basin can be of vital importance in the prediction of subsurface reservoir quality of reservoir sandstones prior to drilling.

Takeaway home message:

Umbum Creek: Small Creek, High Diversity!

How diverse is your area?

Thank you