

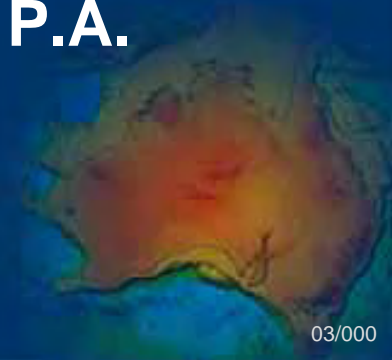


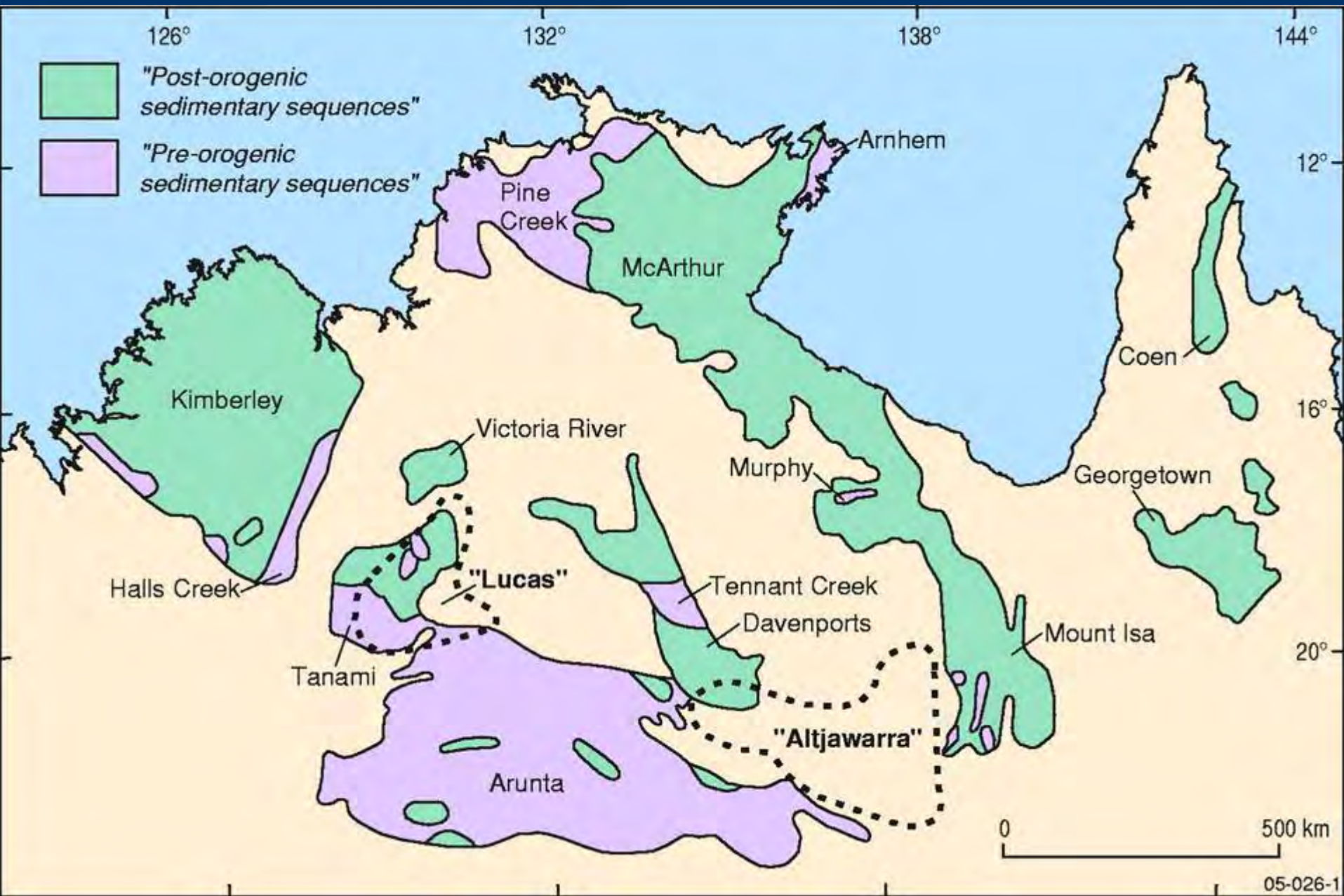
Australian Government

Geoscience Australia

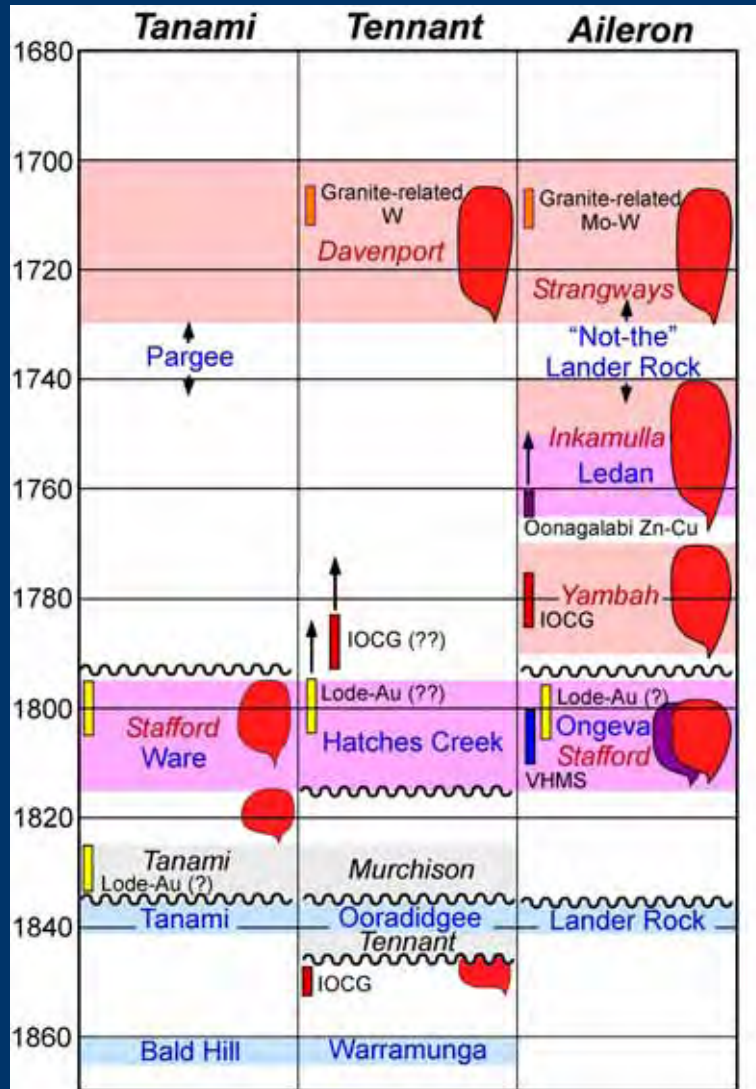
Event-based Chronostratigraphy and Mineralisation: southern McArthur and Mt Isa regions and comparisons with Central Australia

P.N. Southgate, N.L. Neumann, G Gibson and P.A. Polito





Arunta/Tanami Event History



Chewings Event 1590

Leibig Event 1640

Strangways Event
1740-1690

Stafford Event 1800

Tennant Event 1845

Basin - Turbidites

Basin - Turbidites

What impact did the Stafford Event have on the NAC?

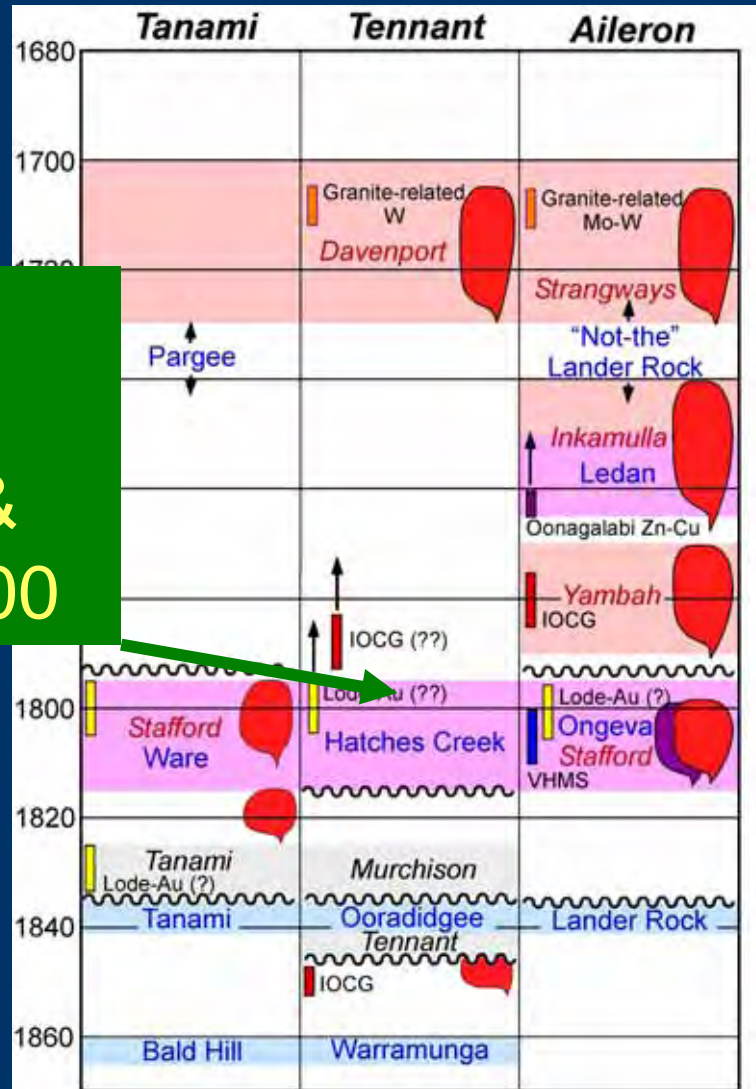




From Basinal Turbidites to Peneplain and Platform



Arunta/Tanami Event History



Chewings Event 1590

Leibig Event 1640

Strangways Event
1740-1690

Stafford Event 1800

Tennant Event 1845

Platform
Birringudu @ 1640

Initiation of
Sedimentary
Basins @ Isa &
McArthur – 1800

Basin - Turbidites

Basin - Turbidites

What expression, if any, do these events have in the Mt Isa and McArthur regions to the east?

What links if any exist between these events and mineralisation?



1800-1575 Ma basin systems host significant Zn-Pb-Ag and U Deposits

World's Premier Zinc Province 116Mt of Pb+Zn metal (Large et al 2002)

Pb/Pb model ages

1575 Ma Century

1640-1575 Ma Lady Loretta, Walford Ck

1640 Ma McArthur Rv

1653 Ma Mount Isa

1665±10 Pegmont, Cannington

Dugald Rv (Carr pers comm)

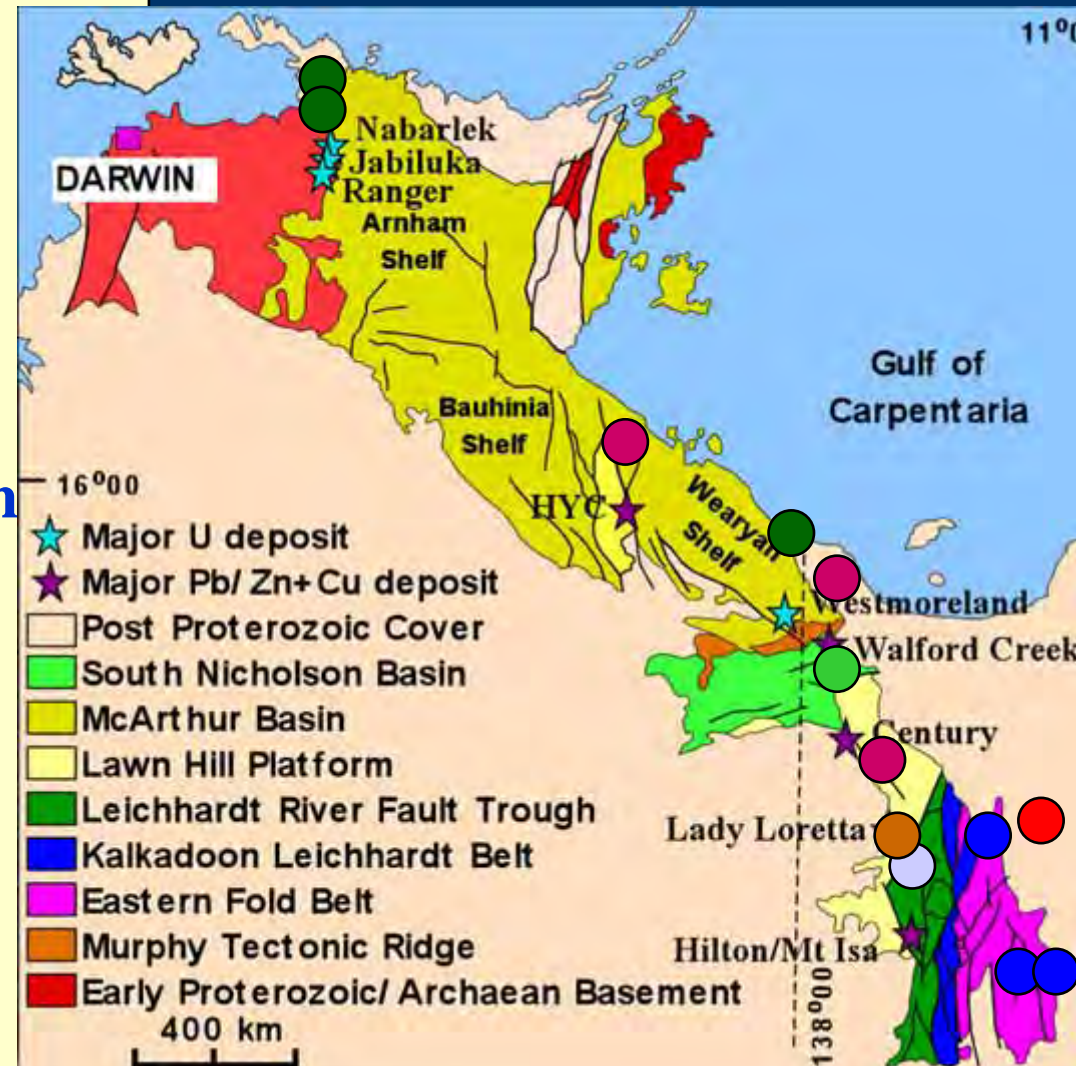
Uranium Deposits

1558 Valhalla & Mt Isa U

1640-1650 Narbalek

Westmoreland, Jabiluka & Ranger

IOCG ~ 1530 Ma.



Each of these resources is associated with a fluid whose evolution involved interaction with the fill of a sedimentary basin.

Hence any understanding of a Pb-Zn-Ag or U minerals system requires:

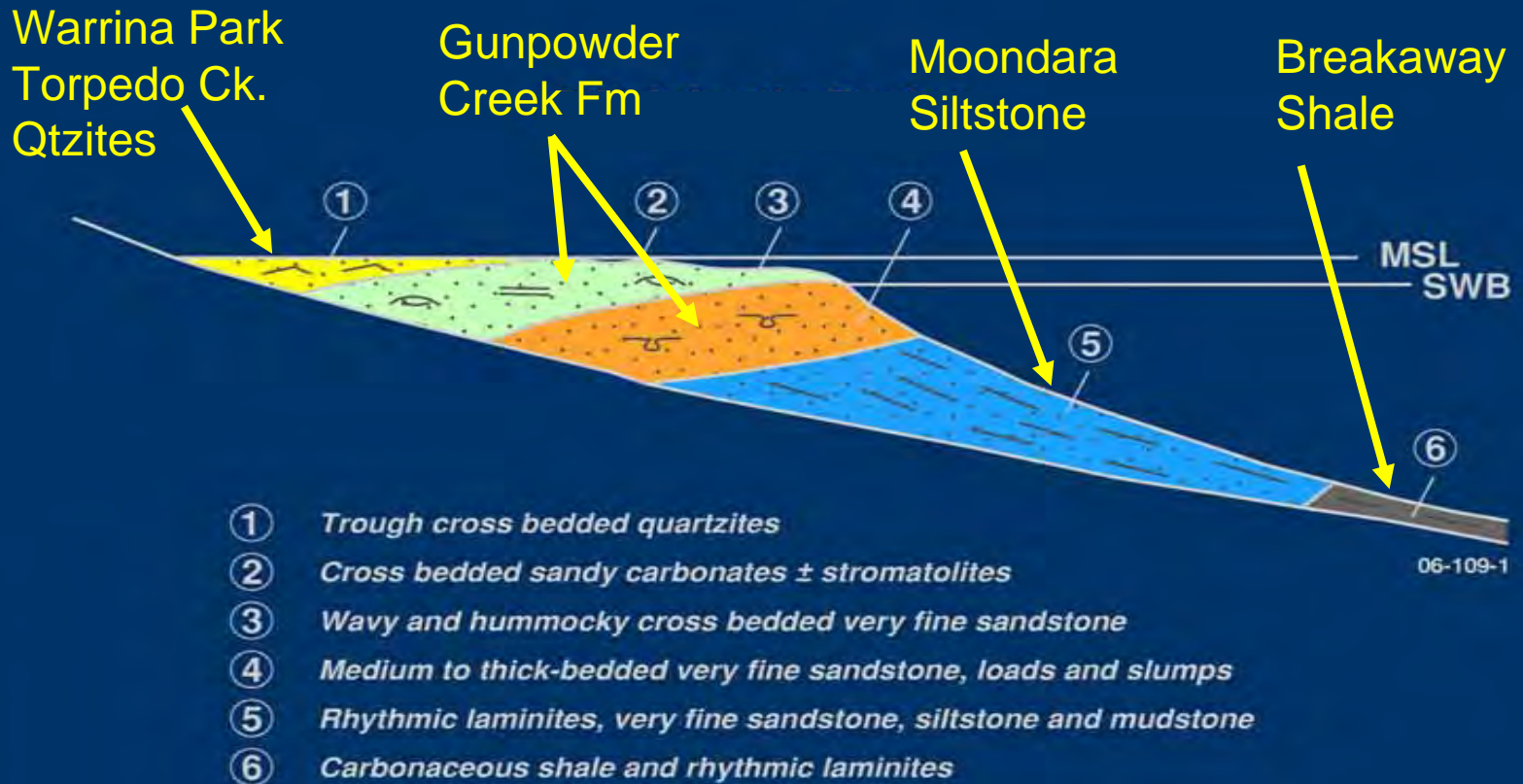
An integrated basin system analysis that involves a time-series predictive framework for fluid evolution in the Paleoproterozoic basins of northern Australia.

How do we construct such a framework?



Siliciclastic Facies Model – Western Succession

Storm-driven processes of sediment transport, dispersal & deposition.



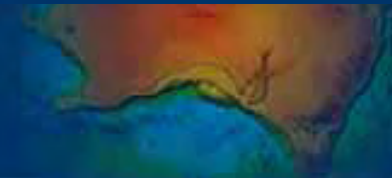
Carbonate Facies Model – Western Succession

Storm-driven processes of sediment transport, dispersal & deposition

Paradise Creek, Esperanza & Lady Loretta Fms



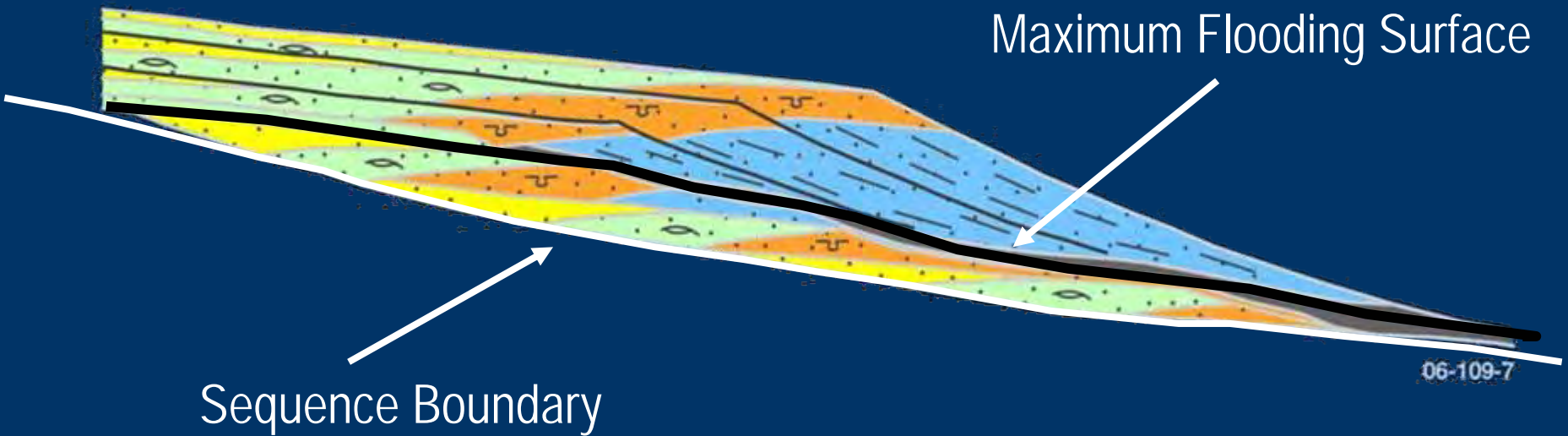
- ① *Shoreface, Cross bedded sandy carbonates*
- ② *Peritidal/ lagoonal cycles, thin to thick bedded units of microbial laminite, intraclast grainstone, dolomudstone quartz peloid grainstone*
- ③ *Domal - columnar stromatolite bioherms*
- ④ *Proximal Tempestites 1-10 m thick shallowing upward cycles, quartz peloid grainstone, dolomudstone, domal stromatolites, intraclasts, HCS and wavy bedded*
- ⑤ *Distal Tempestites Thinly bedded quartz, siltstones, wackstone and mudstone, current ripples*
- ⑥ *Organic - matter rich shales*



Identify Facies Stacking Patterns to determine whether:

Backstepping: implies TRANSGRESSION

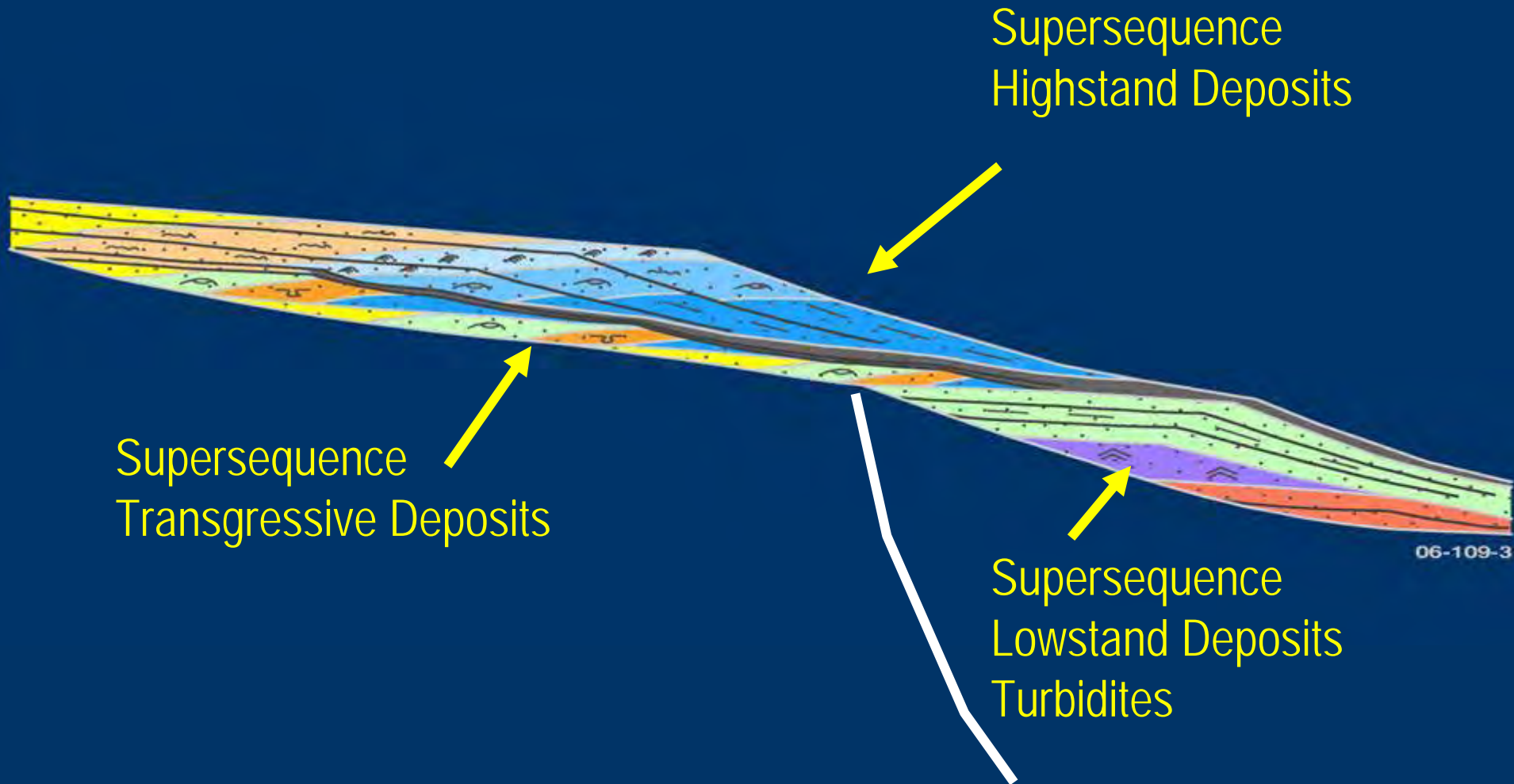
Forestepping or Progradation : implies REGRESSION

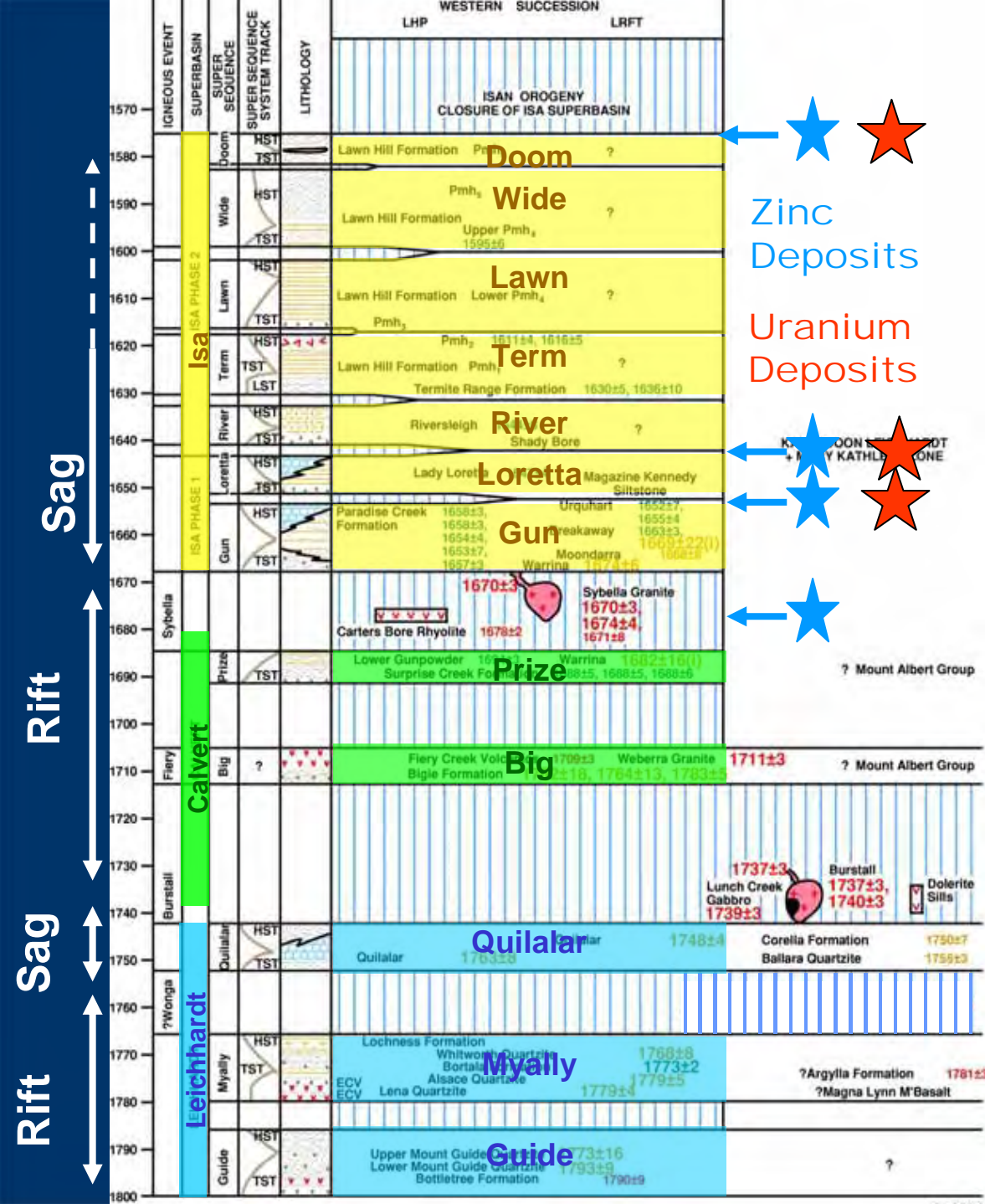


Sediment & Basin Architecture

Platform facies and adjacent basinal turbidites

Platform – Platform Margin - Basin



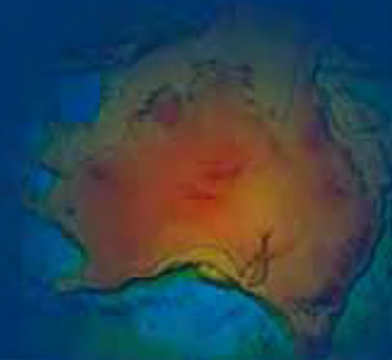


Post 2000 Event Chart Western Succession @ Isa.

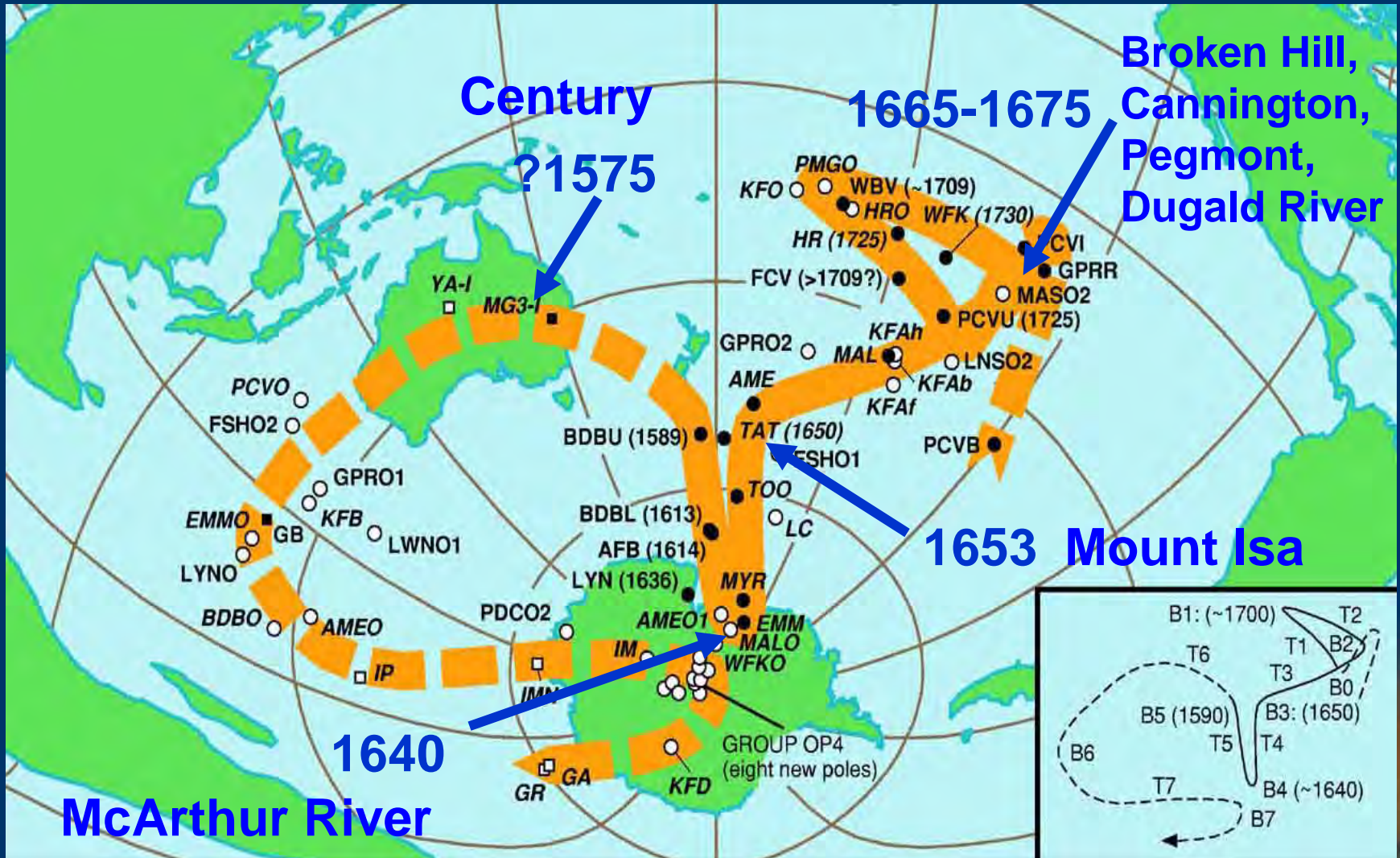
- Integrates ages from:
1. Magmatic intrusives
 2. Volcaniclastic extrusives
 3. Detritals

Sampling takes place within a sequence framework

**What links exist, if any, between
unconformities, accommodation
cycles in the basins
(supersequences), magmatism and
tectonic events?**



Apparent Polar Wander Path Paleomagnetism



Why do we need a chronostratigraphic analysis?

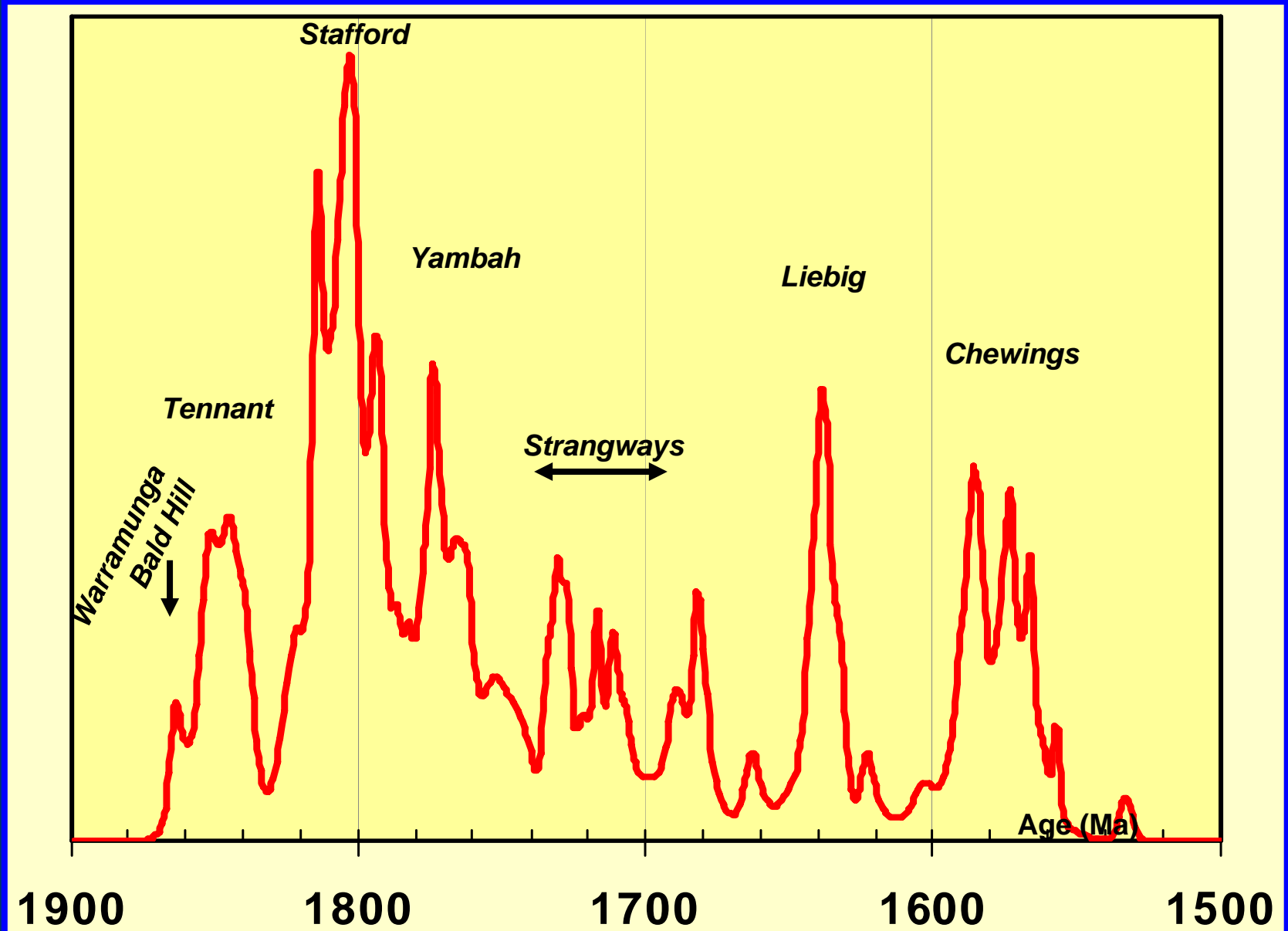
Permits reconstruction of basin shape and an understanding of links between unconformities and intraplate stress

Why is an understanding of event timing important?

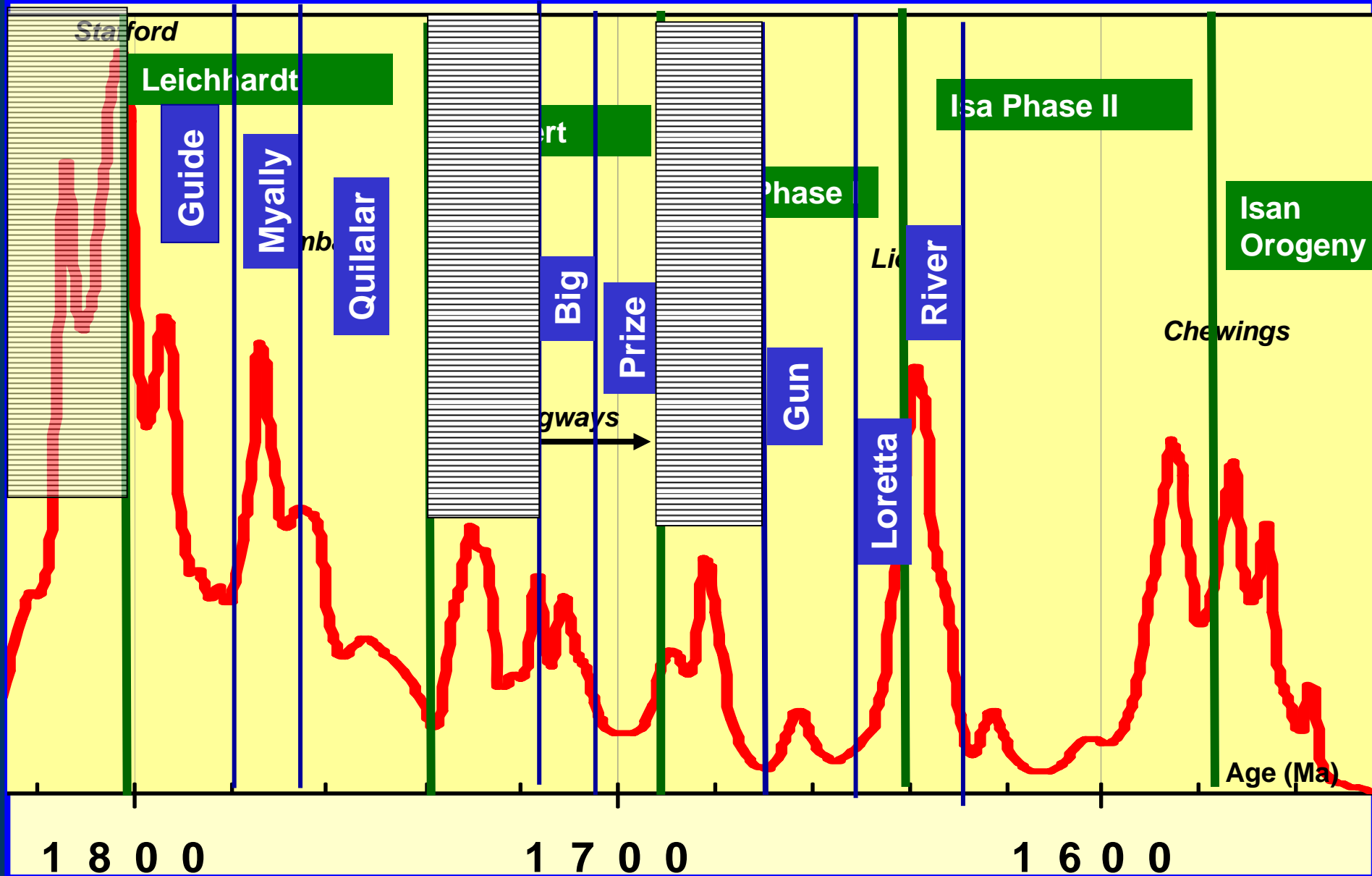
Tectono-thermal events in the Arunta may provide the drivers for fluid migration history in the east @ Isa



Pooled Ages Central Australia



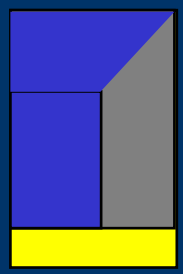
Pooled ages, Supersequences & Superbasins



Isa Superbasin Phase 1
to Phase 2 @ ~ 1640 Ma

Superbasin Evolution – Western Succession

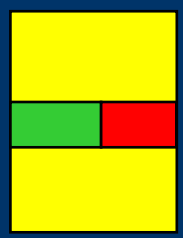
91 @ Isa
~1650-1640



Isa Superbasin
~1665 – 1640 Ma

Drift

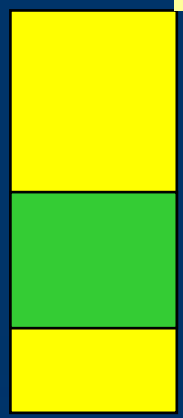
Gun Incision ~ 20 my missing rock record



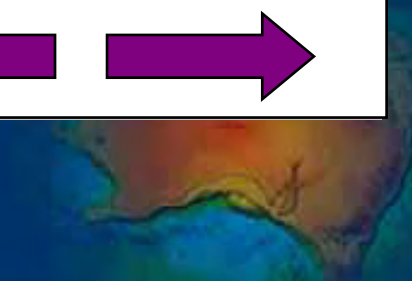
Calvert Superbasin
~1730 – 1685 Ma

Rift

Wonga Event ~20 my missing rock record



Leichhardt Superbasin
~ 1800 – 1745 Ma



From Event-based Chronostratigraphy to Mineral Systems

Fundamental Questions

- **Where are the metal source rocks?**
- **What is the burial depth / temperature necessary to produce a fertile brine?**
- **Where were the fertile brine reservoirs and migration pathways located?**
- **What is the timing of brine expulsion?**



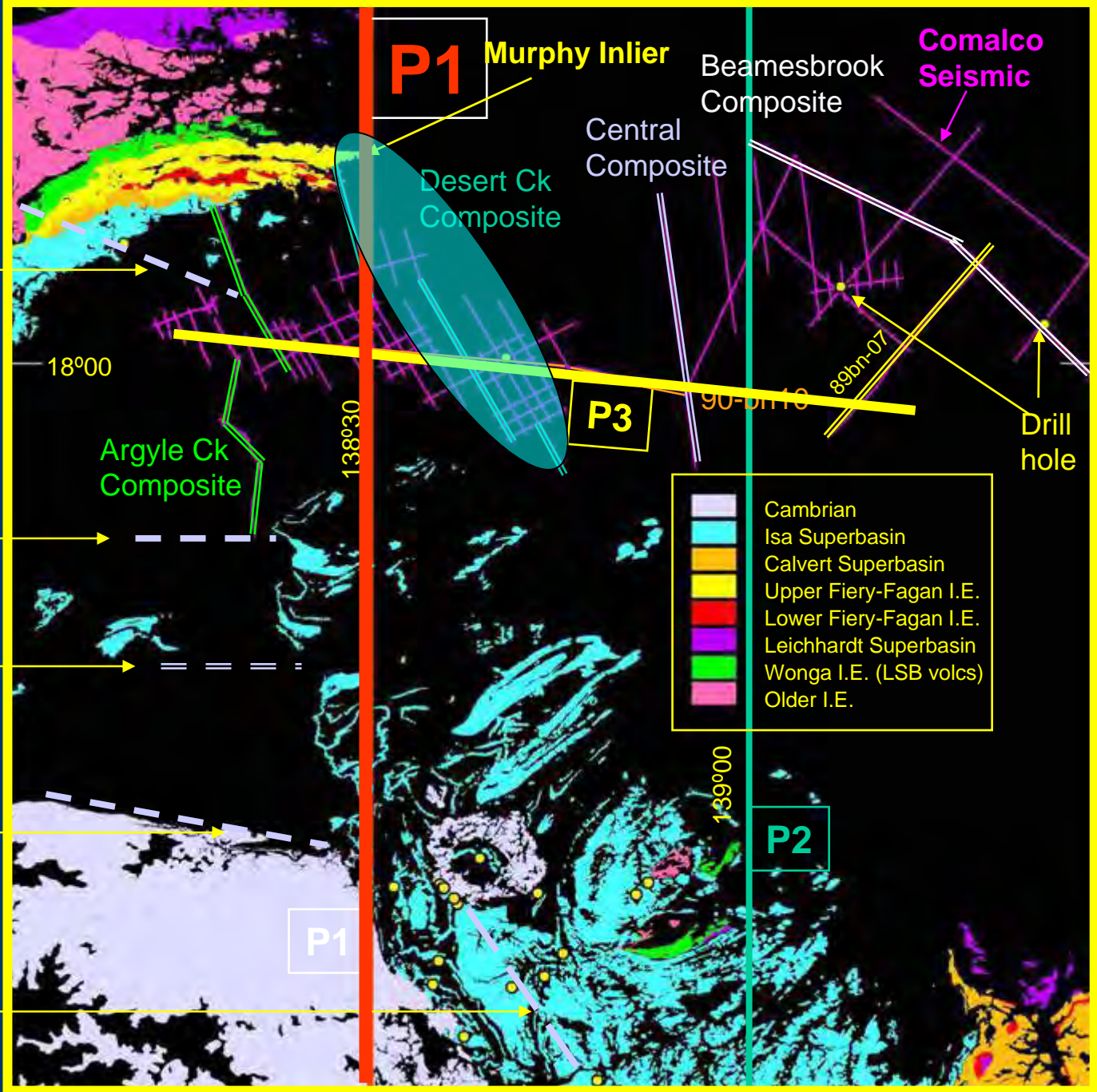
Calvert Fault

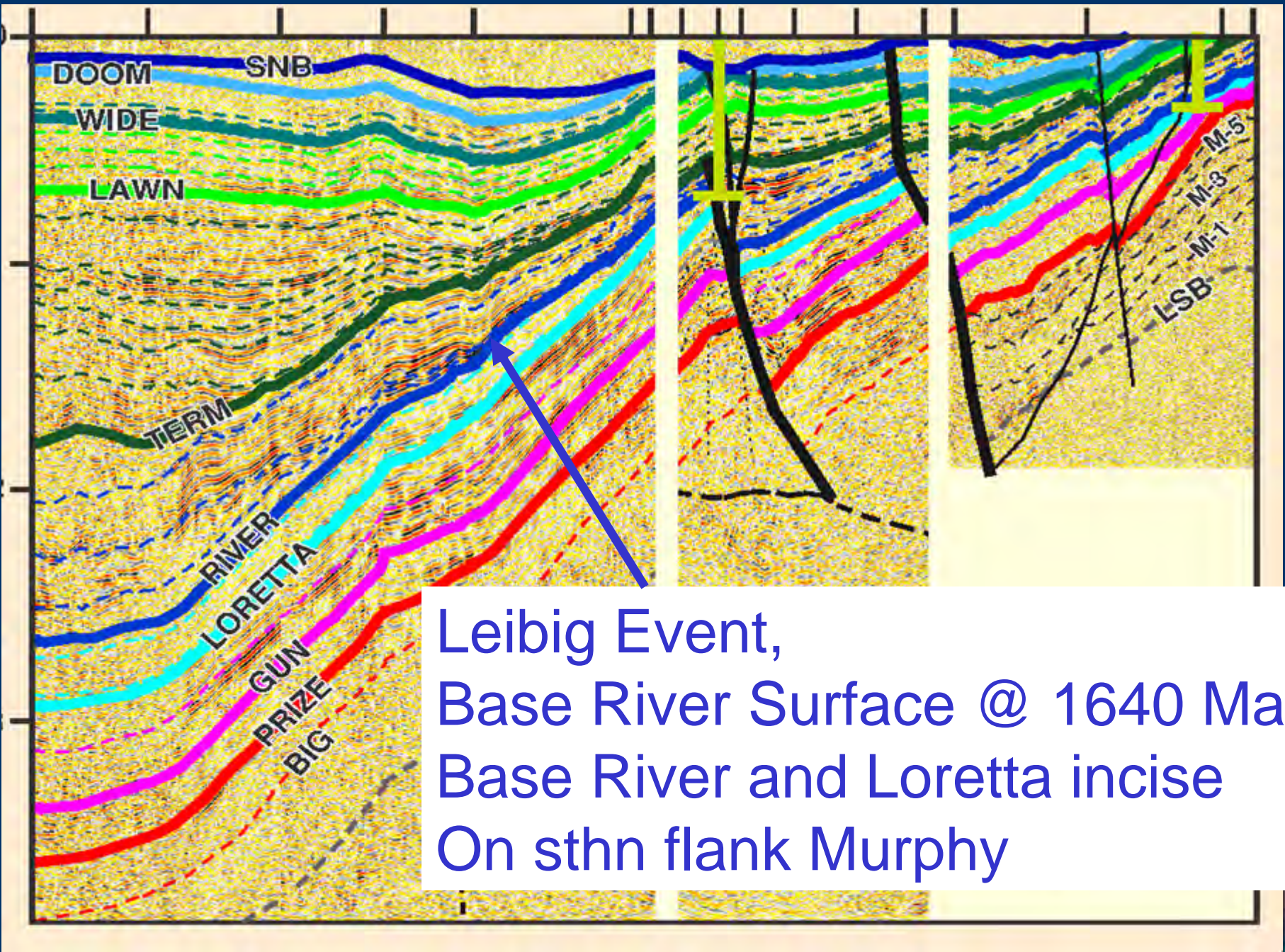
Elizabeth Ck Fault

Unnamed Fault

Little Range Fault

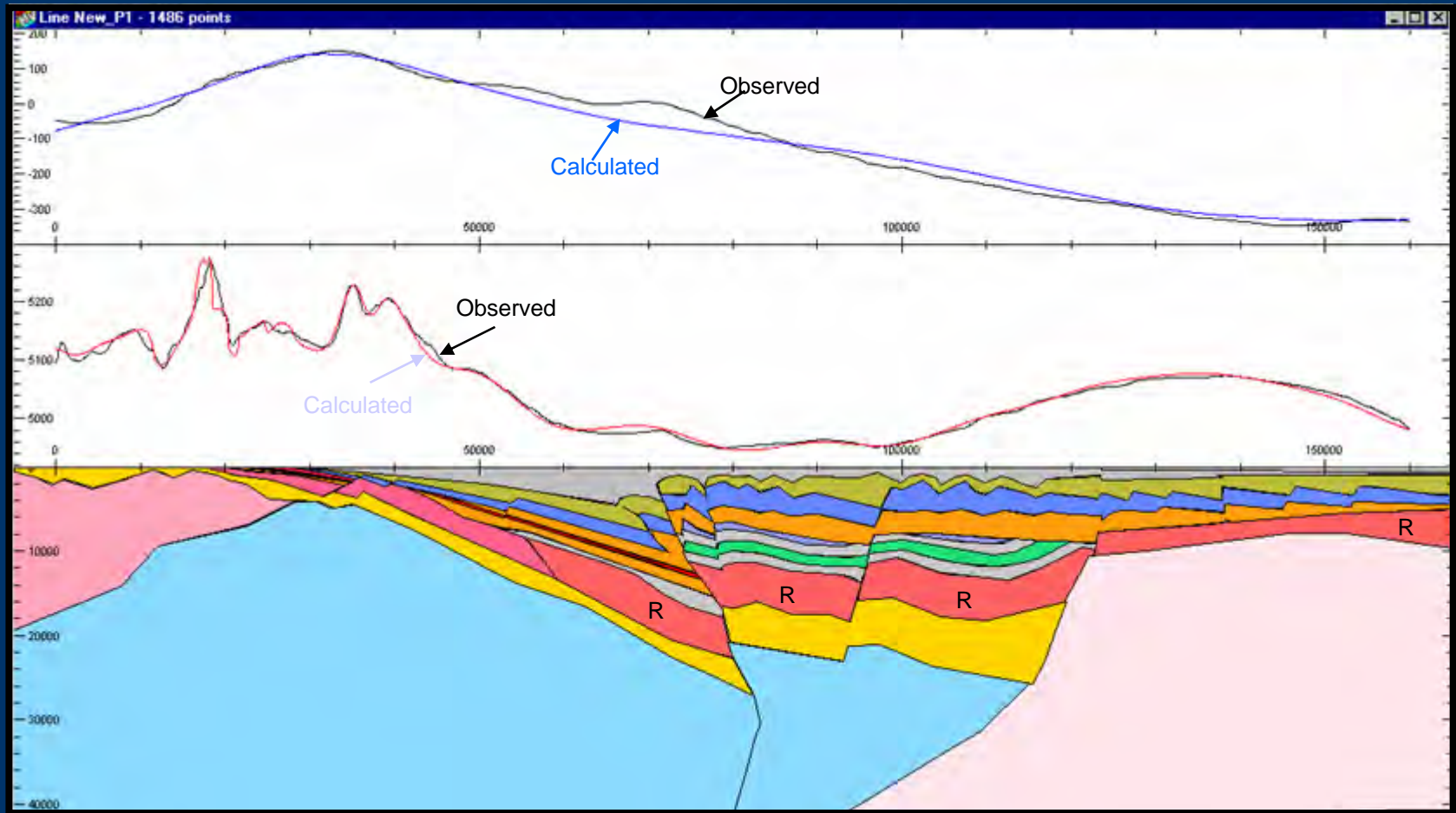
Termite Range Fault





Leibig Event,
Base River Surface @ 1640 Ma
Base River and Loretta incise
On sthn flank Murphy

GEOPHYSICAL FIT OF PRESENT DAY MODEL P1



ISA SB

- Term-Doom
- River
- Gun-Loretta

CALVERT SB

- Prize Big

LEICHHARDT SB

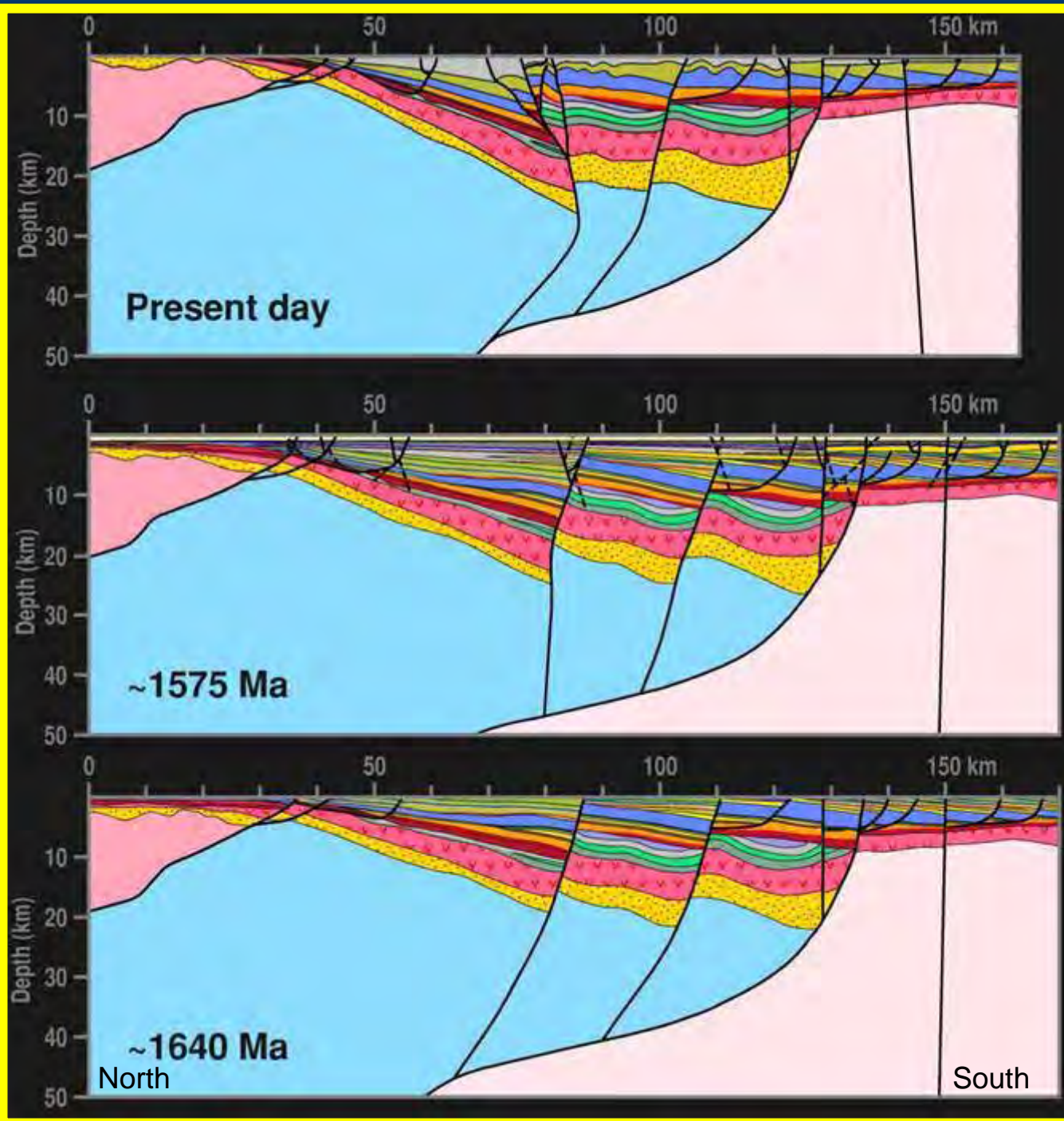
- Upper LSB seds
- LSB volcanics
- Lower LSB seds

BASEMENT

- Cliff/Nich
- Yeldham
- Pre-Barramundi



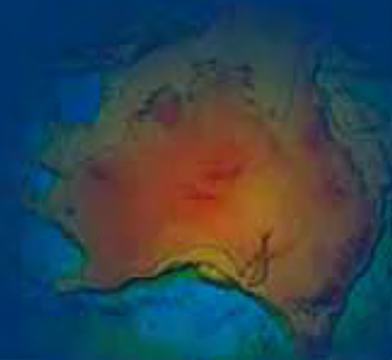
EVOLUTION of P1 PROFILE



Where were the fertile brine reservoirs?

- **Need to examine the sandstones**
 - **Mineral Paragenesis**
 - **Geochemistry**

Identification of Aquifers and Aquitards



AQUIFER: Westmoreland Conglomerate, Kombolgie Fm and Mt Guide Equivalents

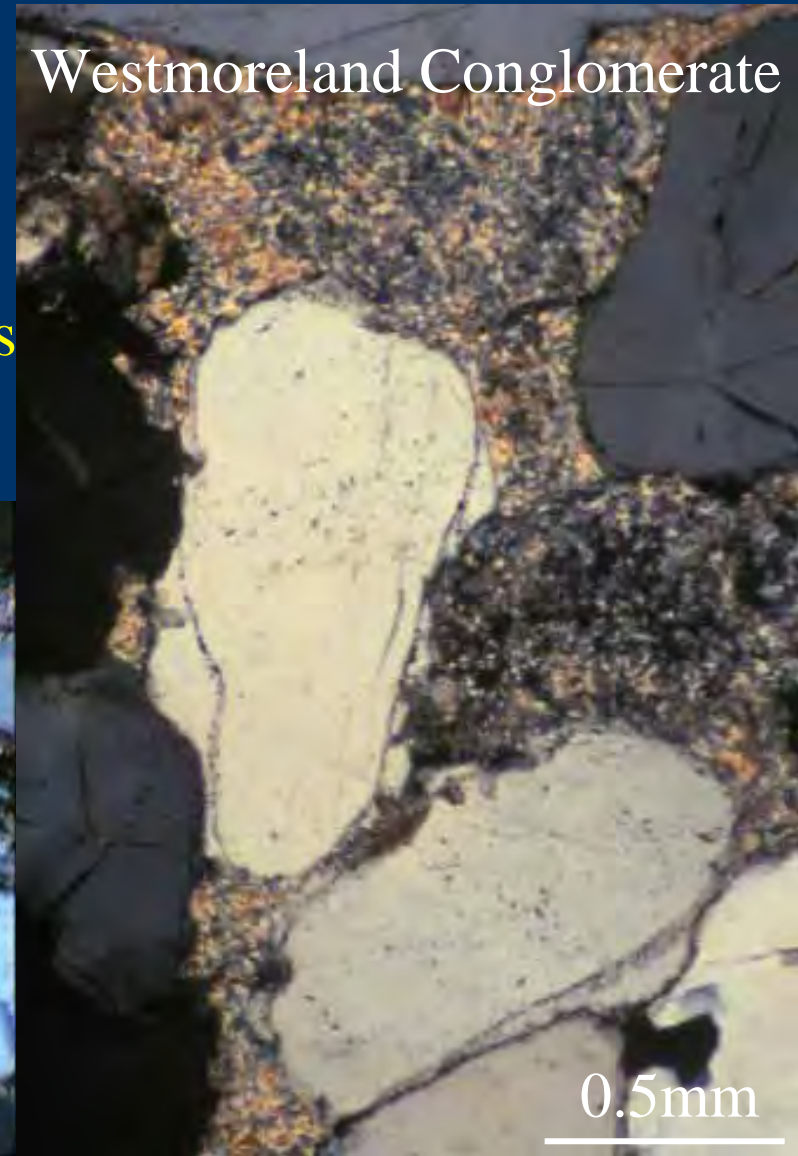
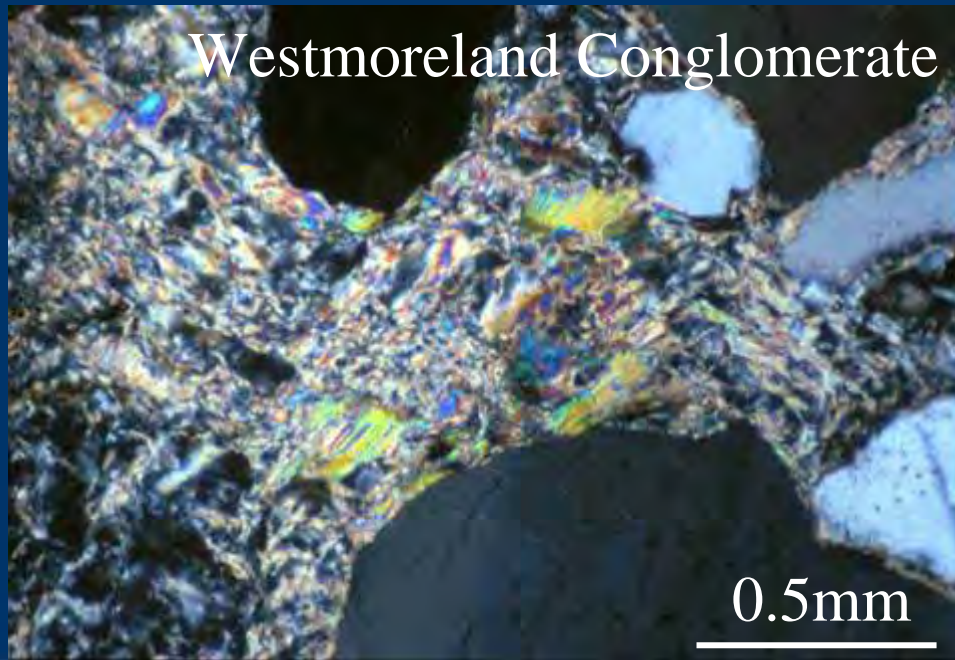
Generation of Secondary Porosity

Quartz O/G's

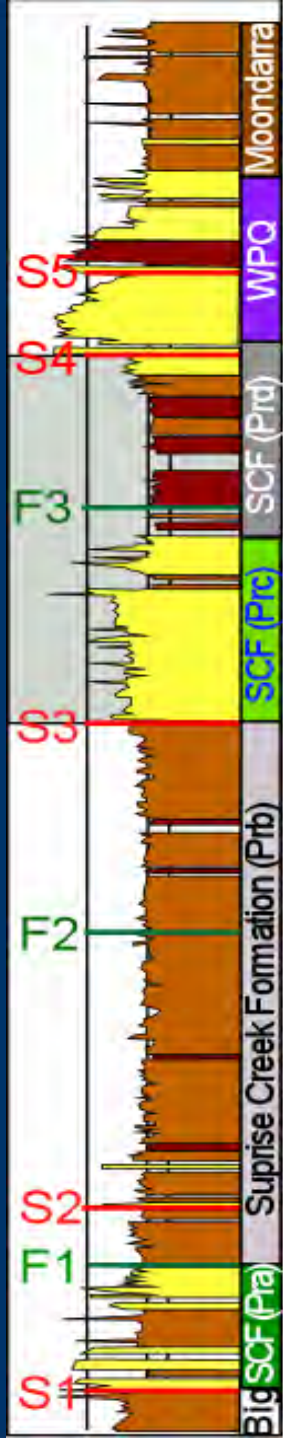
Quartz Dissolution

No feldspars or other detrital phases

Illite +/- chlorite pervasive



Early Diagenetic Aquitards

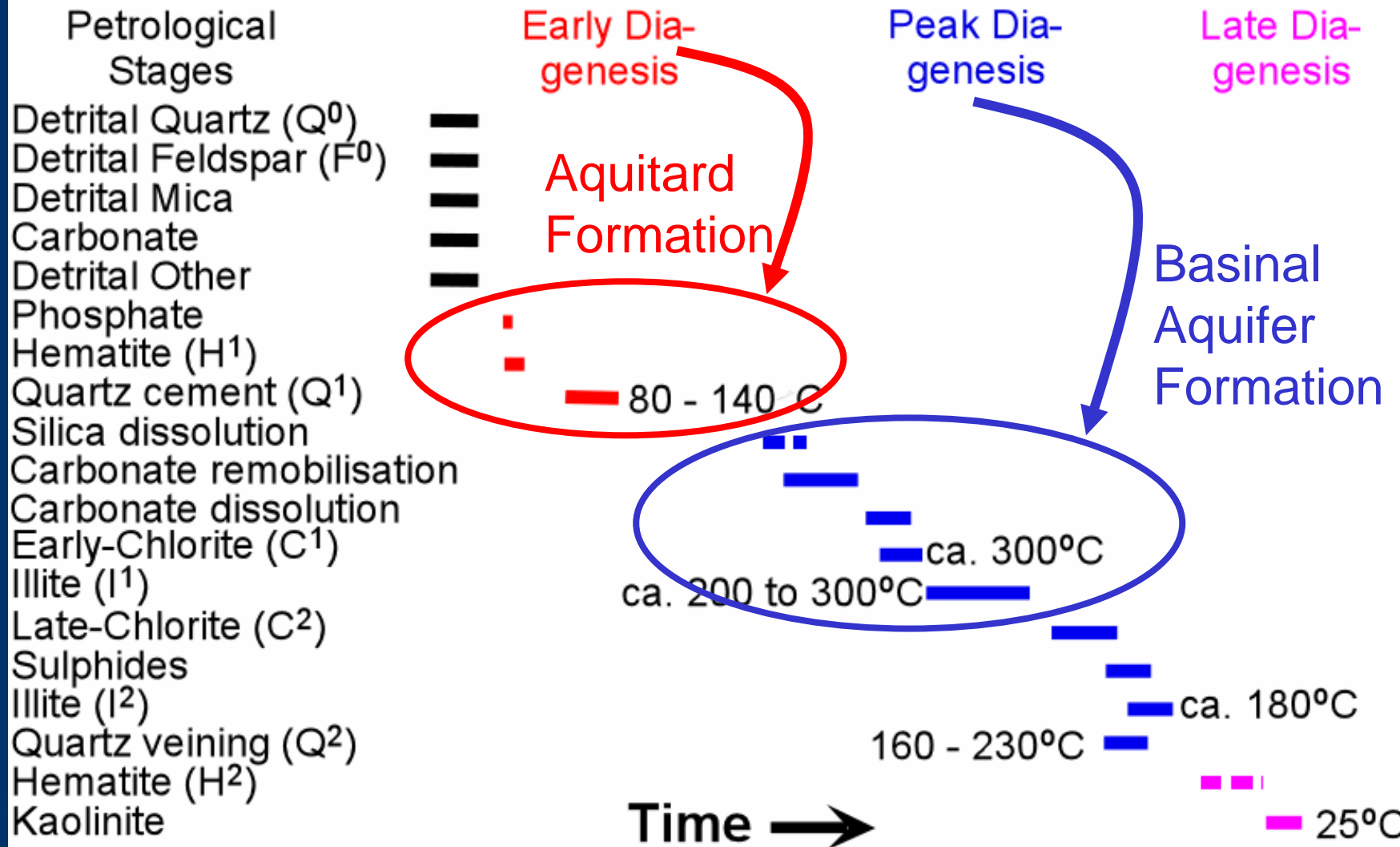


Fine grained marine deposits
Occlusion of High Primary Porosity by Pptn of early Qtz Cements



How does early diagenesis effect basinal fluid development?

Paragenesis of the Leichhardt Superbasin



Where were the fertile brine reservoirs?

- **Proximal fluvial facies**

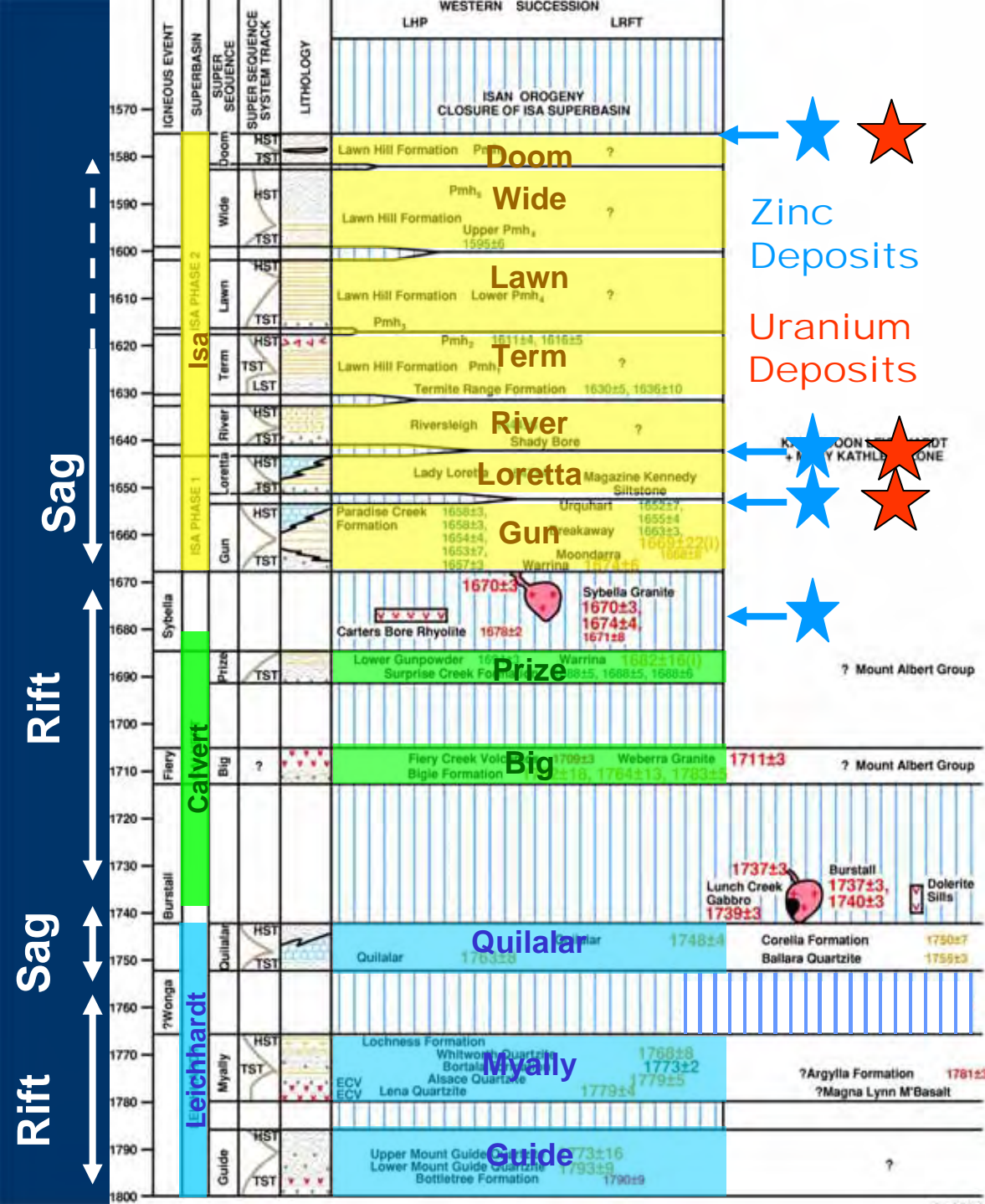
- Regions of high accommodation & sedimentation rates – aquifer charged early & quickly buried
 - **Restricted to basal parts of Superbasin succession eg Lower Mount Guide - Leichhardt SB in LRFT; Southern Kombolgie near Deaf Adder fault**
 - **? Bigie Formation – Calvert SB central & northern LHP.**
- Regions of lower accommodation rates with stacked unconformities
 - **Scattered throughout basin succession above Supersequence boundaries eg McArthur basin and parts of Kombolgie**



Where are the metal source rocks?

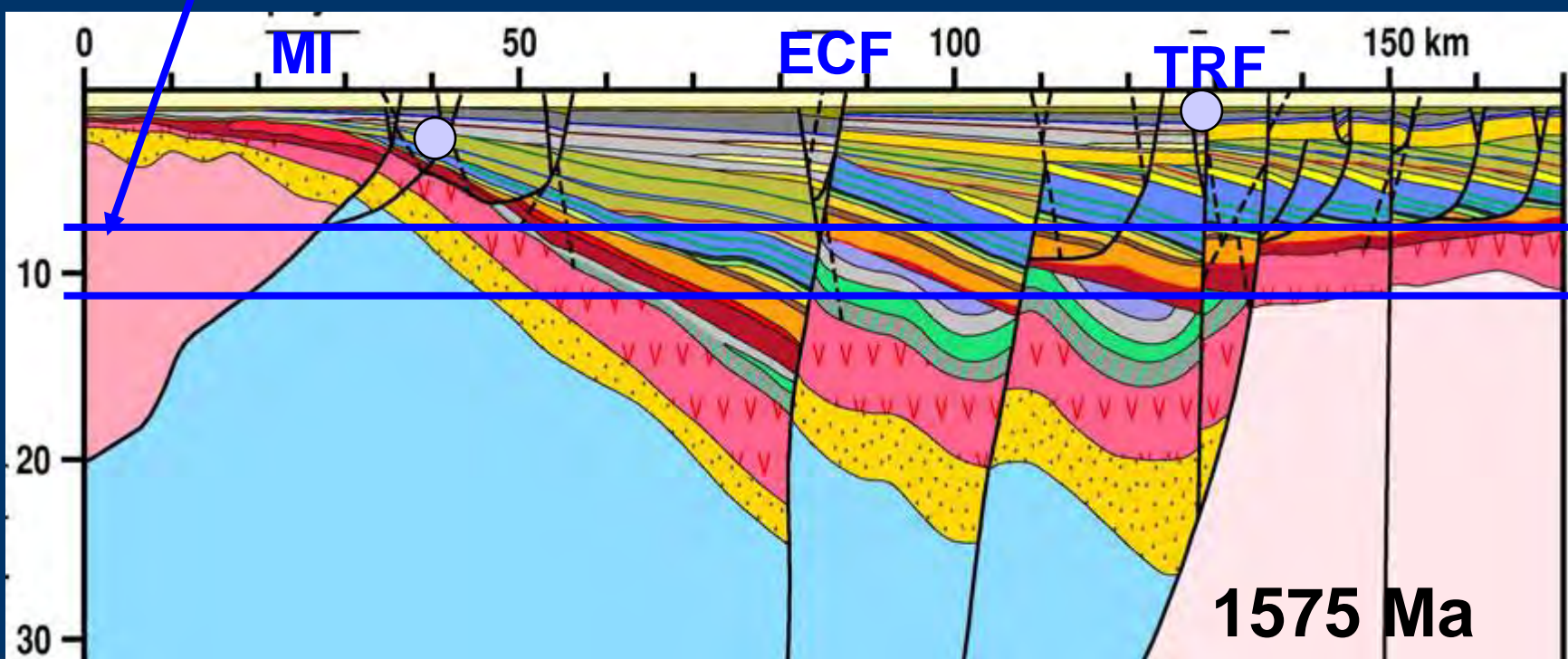
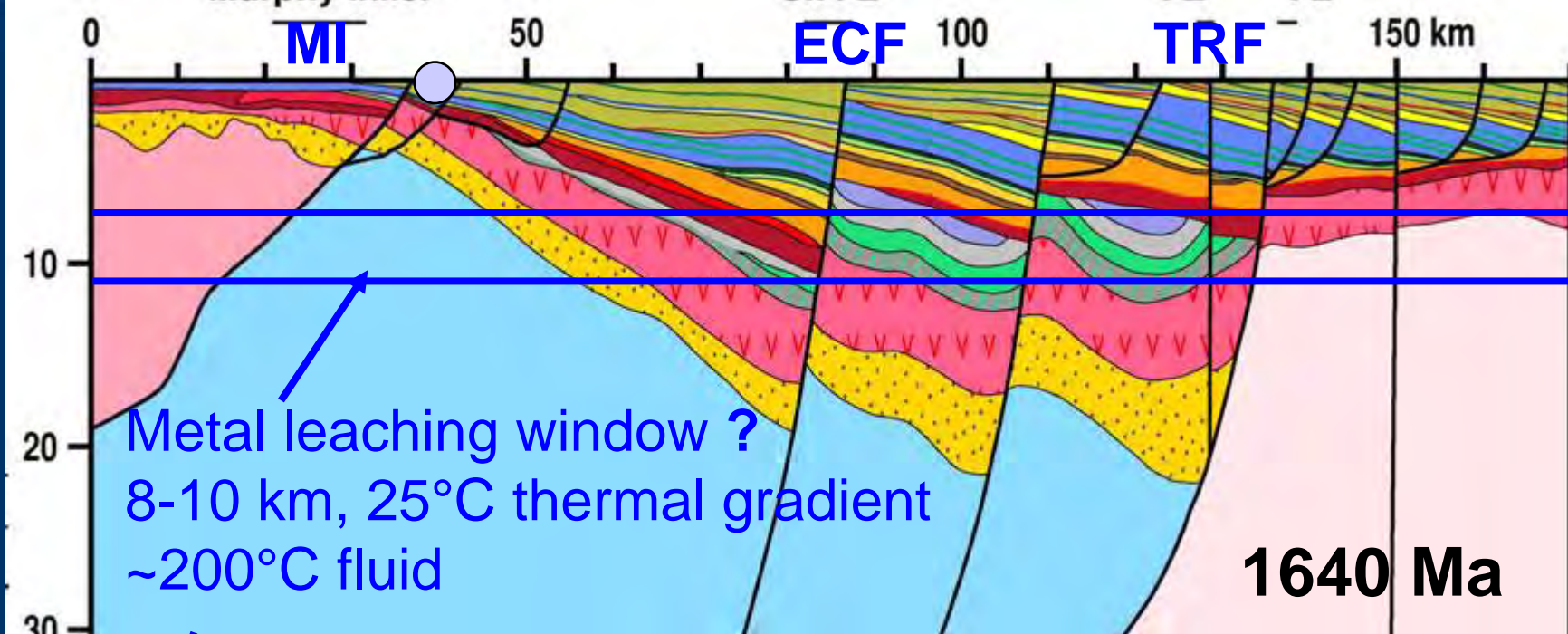
- **Must be in communication with aquifer fluids**
 - **In proximal fluvial sandstones, unstable grains, ie apatites, lithics, feldspars etc.**
 - **Feldspars in felsic igneous rocks & their sandstone derivatives**
- **Mafic volcanics – Cu & ? Zn**
 - **eg Eastern Creek Volcanics – LRFT**
 - **mafic Fiery Creek and Peter Ck Volcanics - LHP**
 - **Siegal & Gold Creek Volcanics - McArthur**

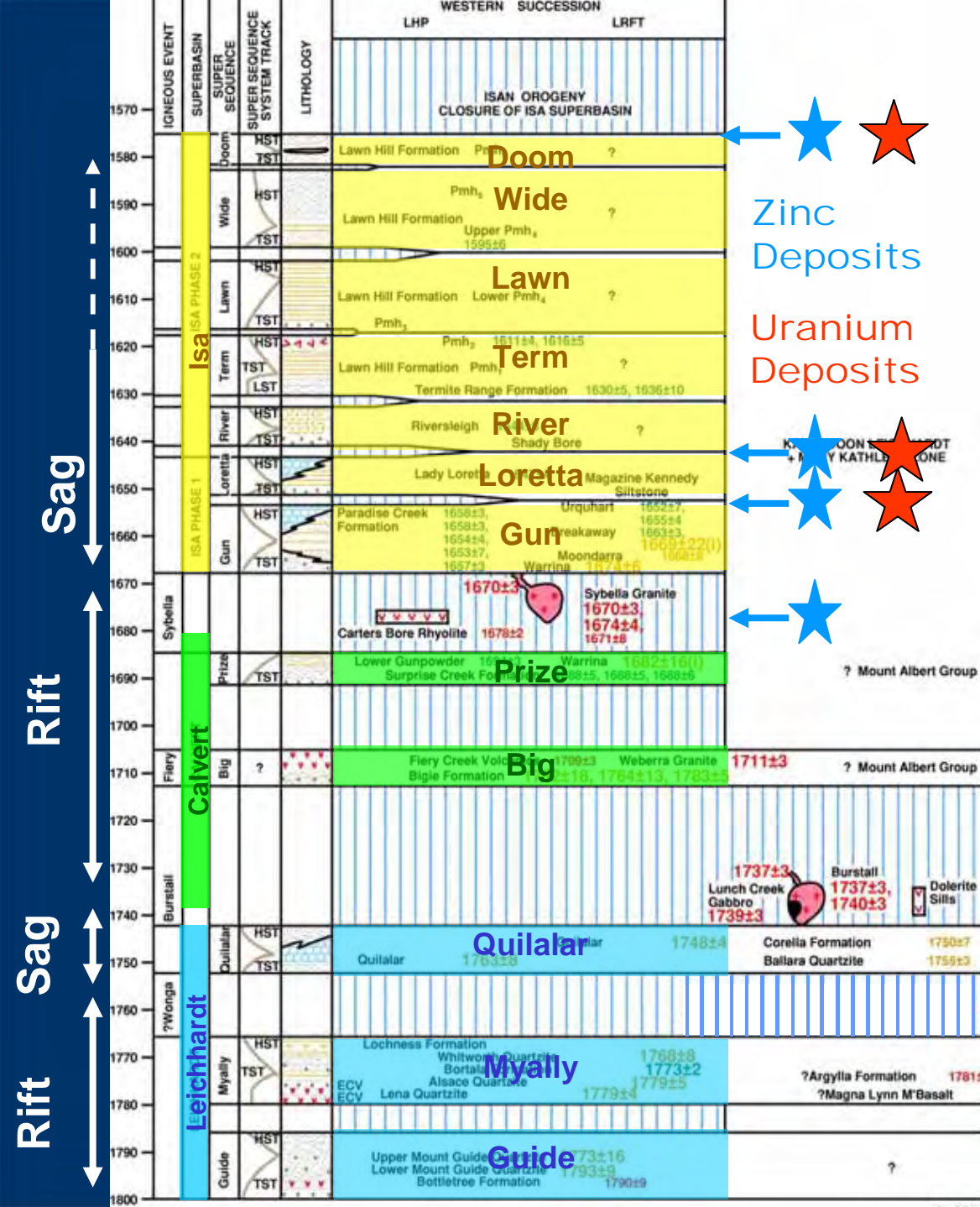




Proximal Fluvial Sandstone Facies in Guide, Big & Prize SS's + altered mafics = Metal Source & Reservoir Packages







Chewings Event

~1590-1570

Leibig Event

~1640

Strangways Event

1740-1690

Yambah Event 1780-1770

Late-Stafford Event





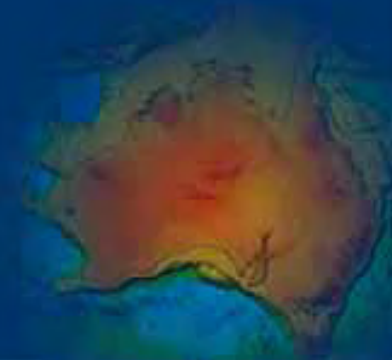
Geochemical Characteristics of Aquifer

- **In aquifer of high accommodation rates and sediment flux (depocentre)**
 - Low δD values (-70) and high $\delta^{18}O$ values (+3-8) indicative of evolved brines with an original meteoric signature
 - eg LRFT and Century + satellite vein deposits
- **In aquifer of lower accommodation rates and sediment flux (basin margin with stacked unconformities).**
 - Aquifers charged with marine waters and evolve to saline brines with high δD values (-40) and high $\delta^{18}O$ values (+3-8). eg Arnhem Land



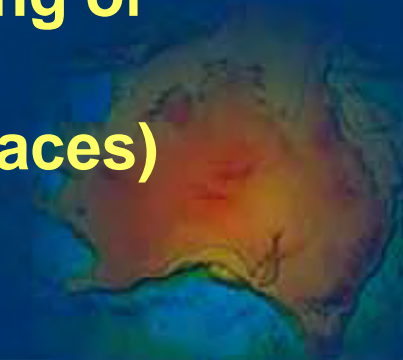
Geochemical Characteristics of Aquifer

- **Salinity**
 - Brine 20wt% NaCl equivalent
- **Sulphates**
 - Sourced from evaporites in
 - Marginal marine facies and/or playas laterally equivalent to proximal fluvial aquifer eg Mount Guide sandstone
 - Enveloping marginal marine facies eg McArthur Basin

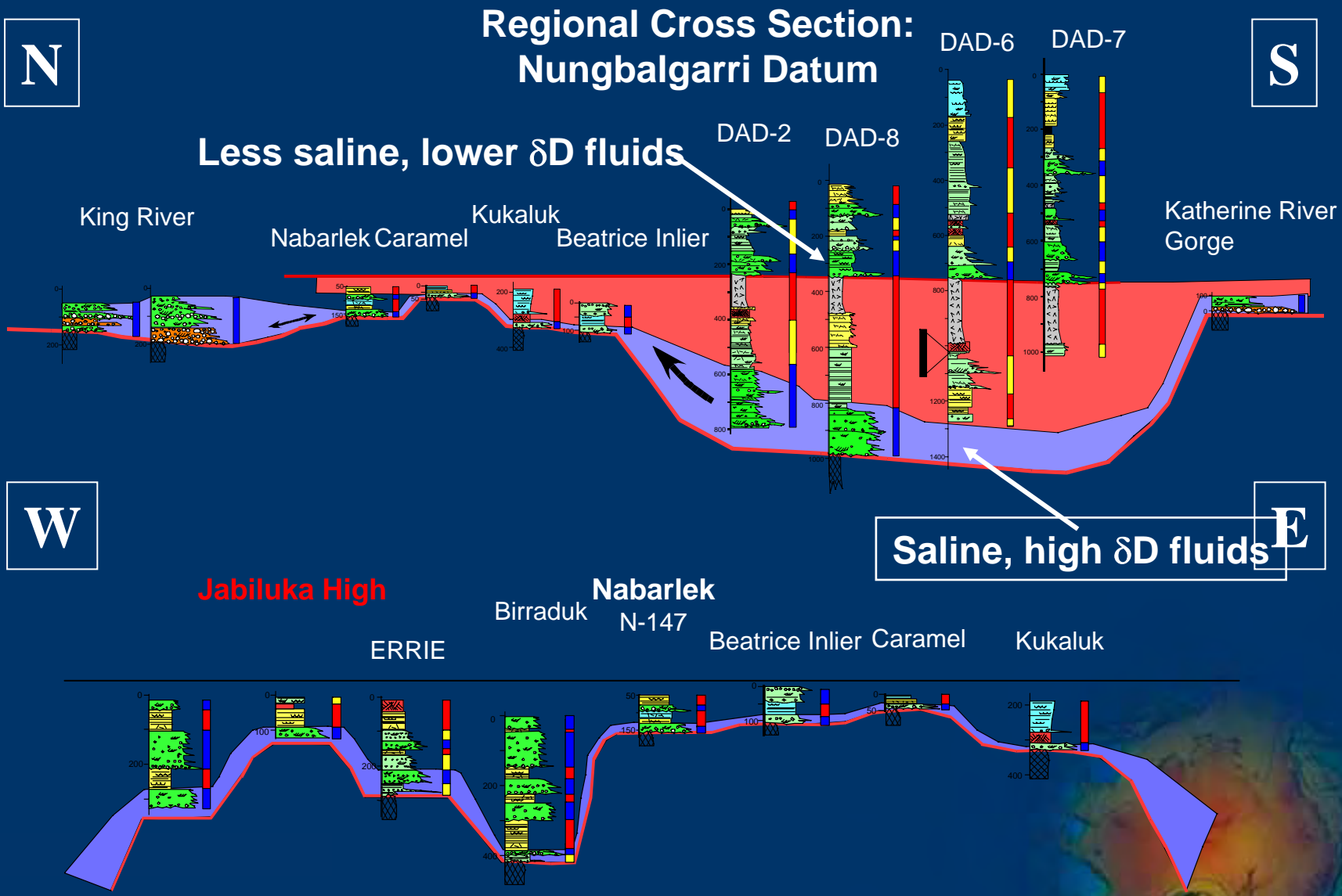


Mineral System Model Requires:

- **Physical Geometric Framework of the container depicting its structure and architecture of the basin fill**
 - Sequence Stratigraphy
 - Structure
 - Magmatism
 - Geophysics
- **Temporal Framework**
 - Isotopic techniques principally U/Pb dating of zircons
 - Sequence Stratigraphy (correlatable surfaces)

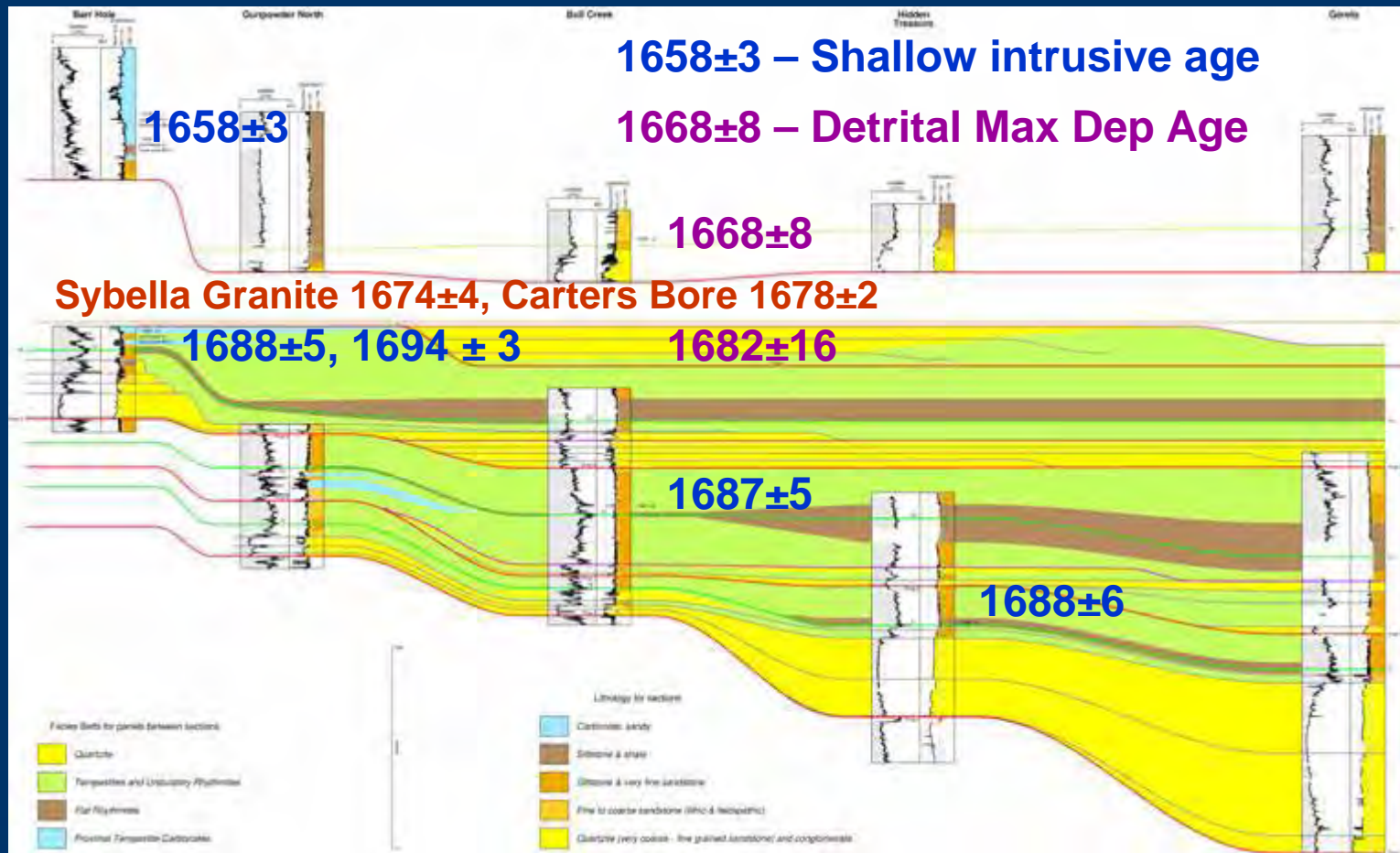


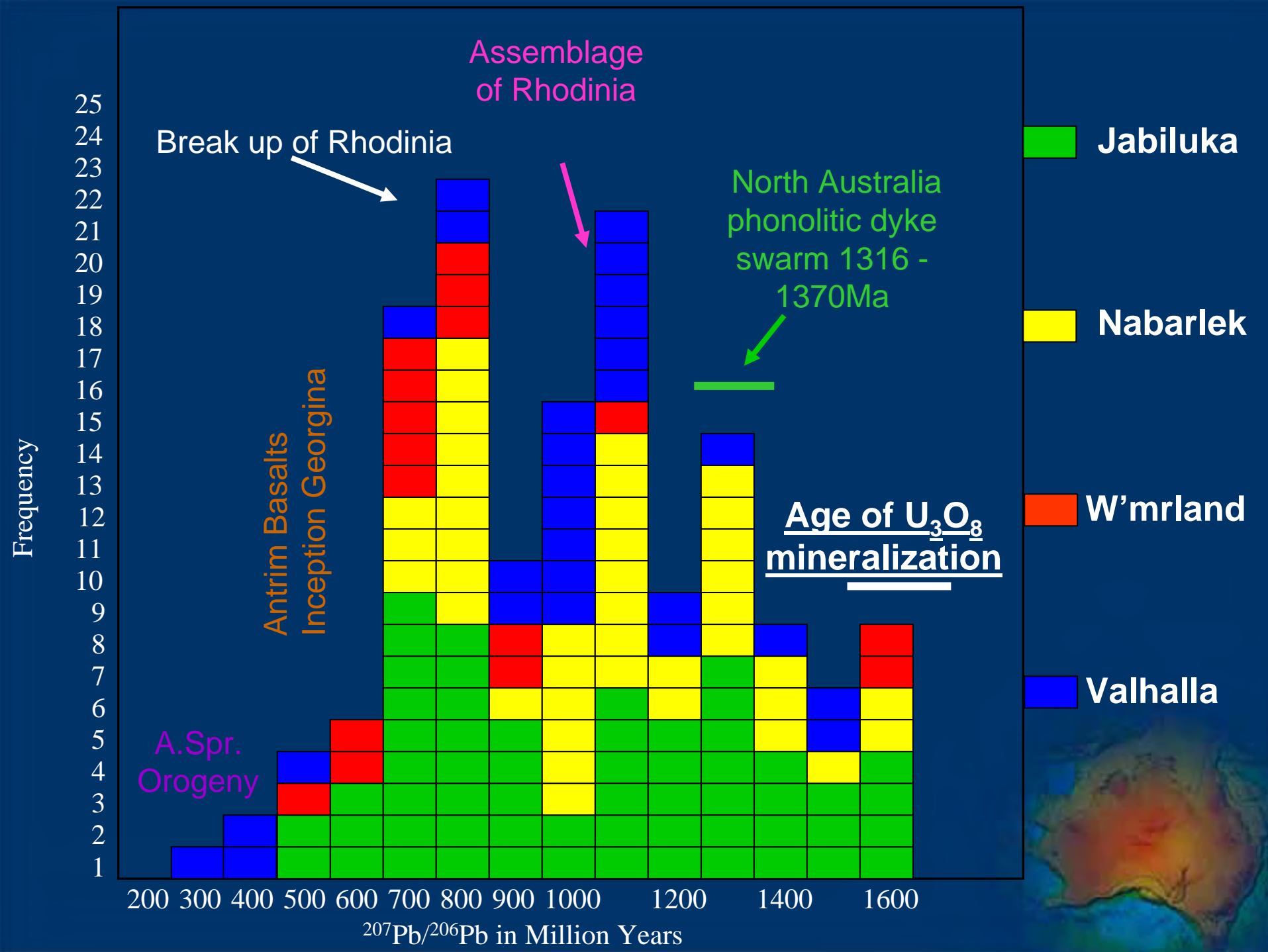
Perched Aquifers



Requires an Understanding of Basin Architecture and an ability to reconstruct basins to times of fluid migration

- Measure sections & determine facies
- Identify cycles
- Correlate using bounding surfaces





What is the relation between field and lab?

Well sorted

Poorly sorted

Marine, aeolian

Proximal fluvial

Early cemented

Diagenetic clays

Aquitard

Aquifer

Resistant outcrop

Recessive

