Mineral Systems

Q1 Architecture

A legacy for mineral exploration science

Key Parameter → Mineral System → Exploration

is reflected in

scale-dependent translation

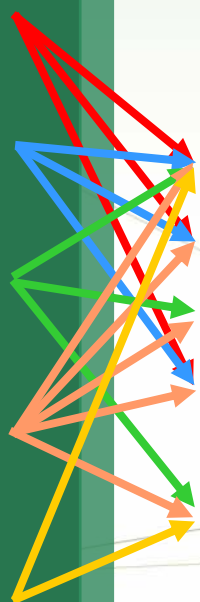
A. Gradient in hydraulic potential

B. Permeability

C. Solubility sensitivity to P, T, C

D. Spatial gradient of P, T, C

E. Time (duration)



5 Questions

1. Geodynamics
2. Architecture
3. Fluid reservoirs
4. Flow drivers & pathways
5. Deposition

Terrain Selection

Area Selection

Drill Targeting

Slide after: A. Barnicoat

Architecture

How big is the system?

Does the system involve the entire crust or just a sedimentary basin within the crust?

What is the stratigraphy ? Strength contrasts, permeabilities at time of mineralisation and chemistry (reduced or oxidised) of the rock units?

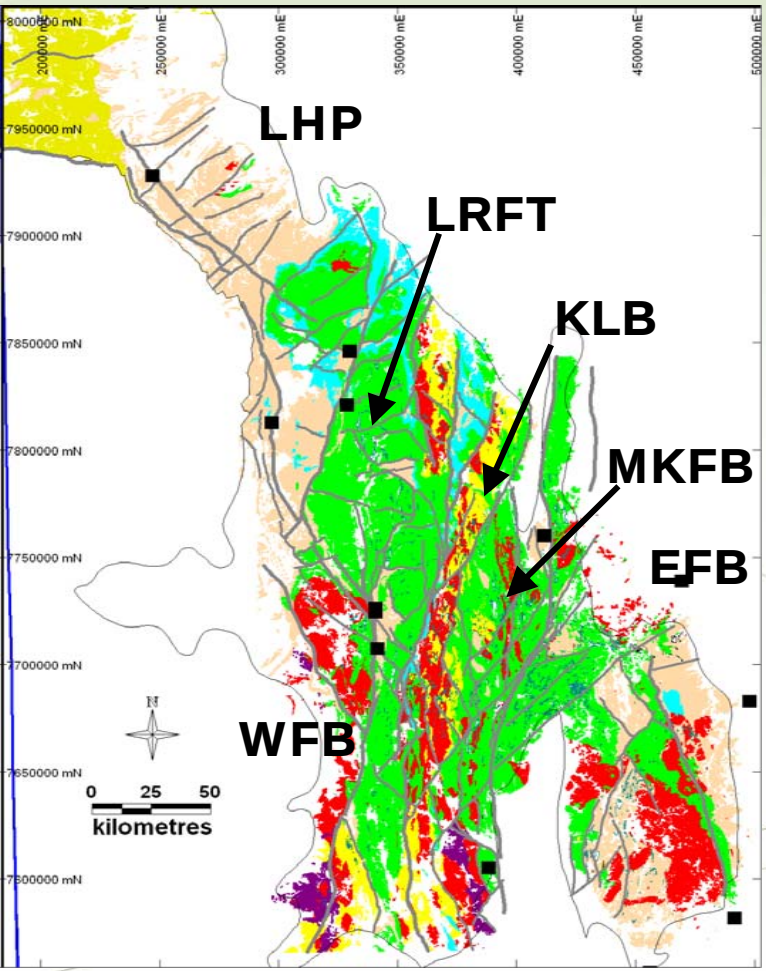
What is the structural geology?

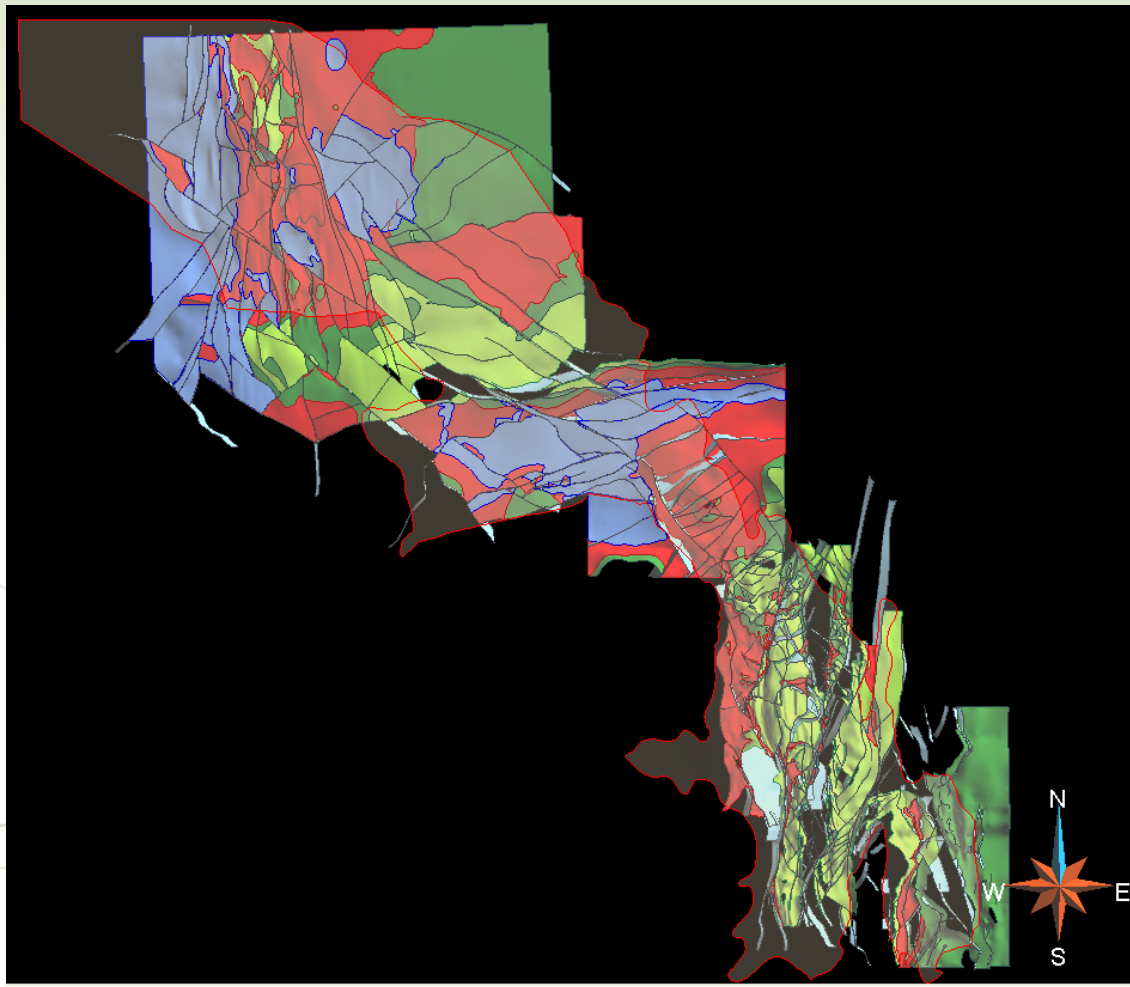
What is the chemistry of igneous intrusions?

Architecture

- lithospheric-scale studies that provide information on the entire craton down to depths in excess of 350 km
- regional-scale studies that provide information at the province scale and down to depths of 30-40 km
- mine- and camp-scale studies providing information on the local-scale down to the top few kilometres of the crust.

Architecture – large scale





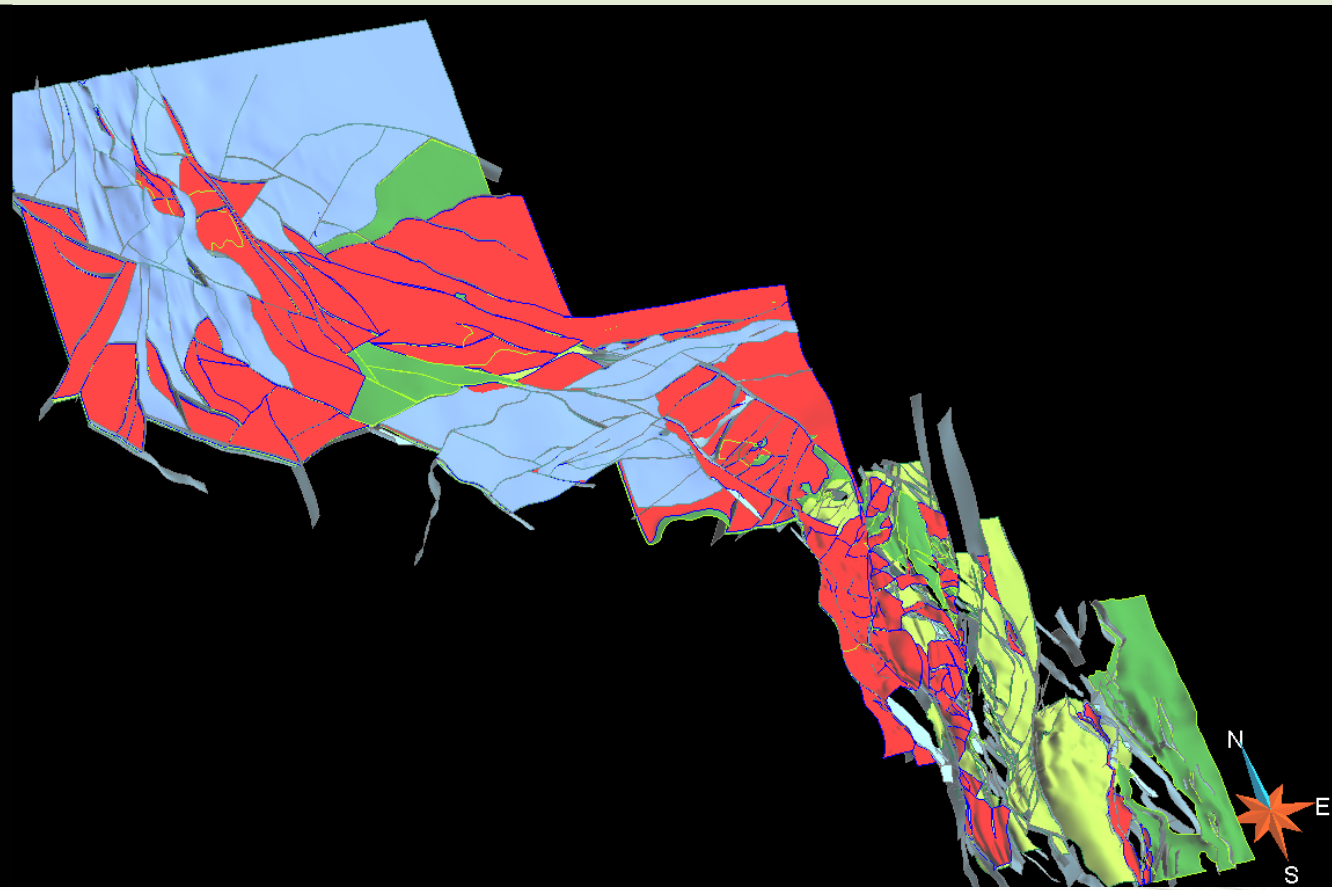
Architecture – stratigraphic

Leichhardt Superbasin (LSB)

Calvert Superbasin (CSB)

Isa Superbasin (ISB)

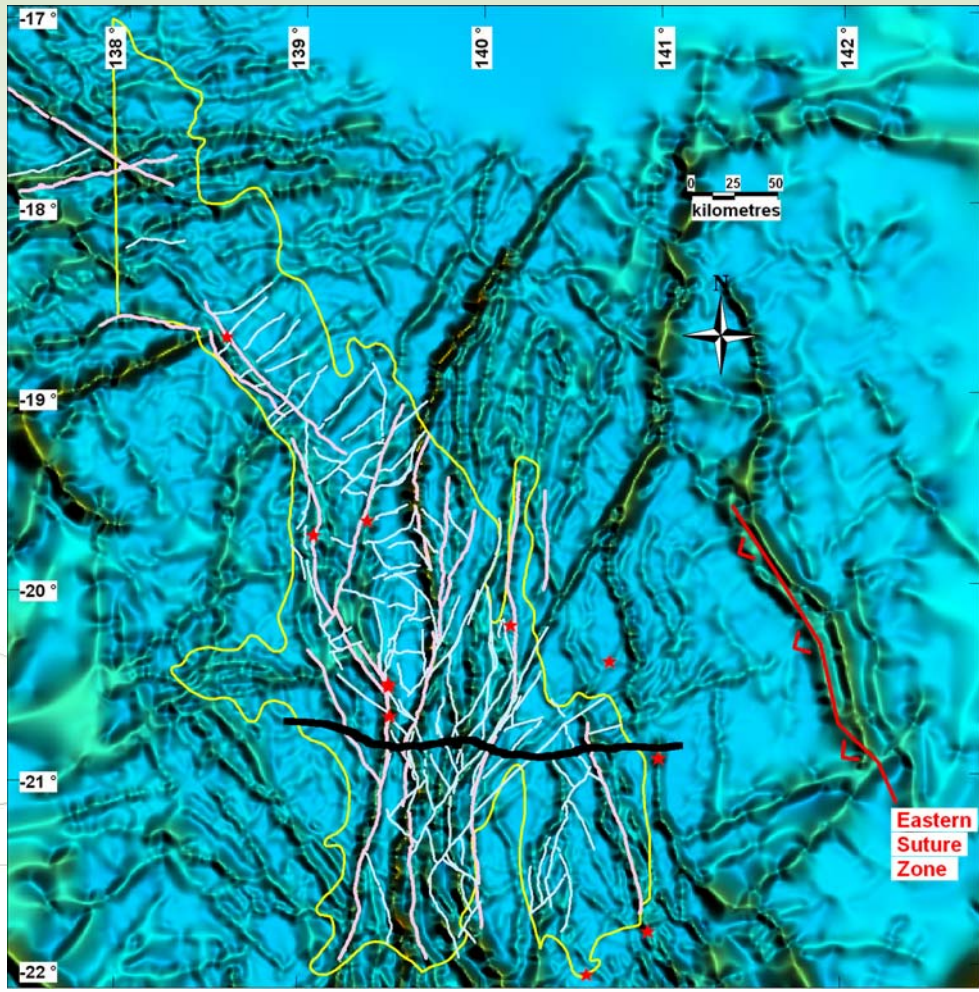
Roper Superbasin (RSB)



Slide after: B. Jupp

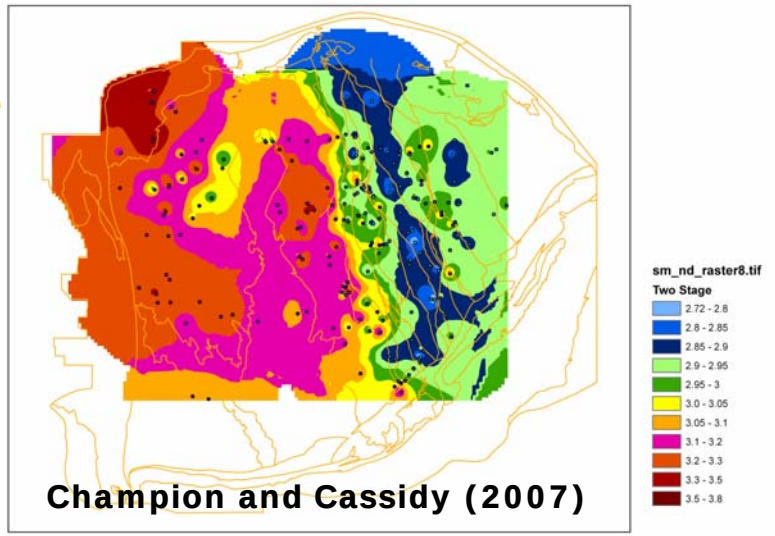
Architecture – Faults

- Major fault trends
- North-south trends are a distinctive feature in the region
- east-west elements and basement trends that dominate in the northern and western regions

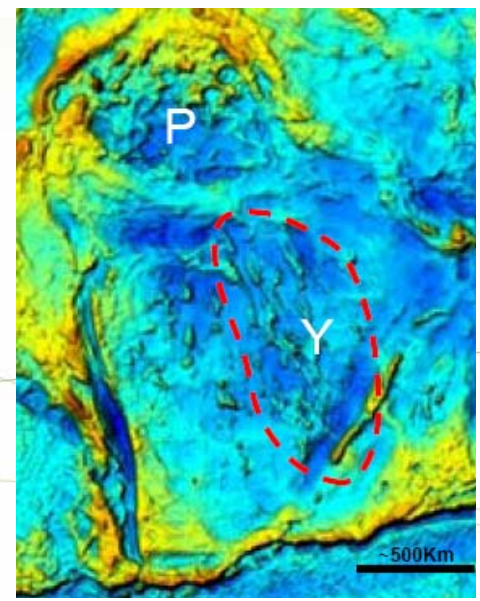


Architecture – large scale

- Target rocks (greenstone belts) 2600-2800Ma
- Large linear fault arrays
- Linear trends in the gravity data (*cf.* non-linear character of P-Pilbara and Y-Yilgarn)
- Sm-Nd model ages indicating linear tectonic belts
- Domes
- Structural complexity

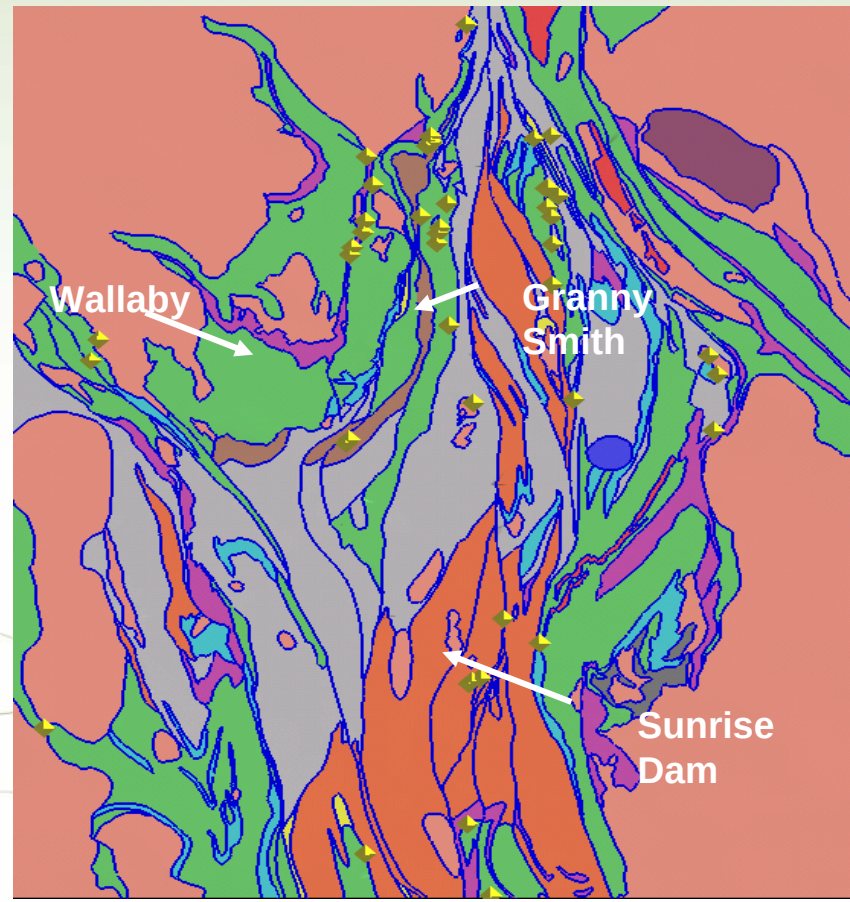


Champion and Cassidy (2007)



Architecture – regional

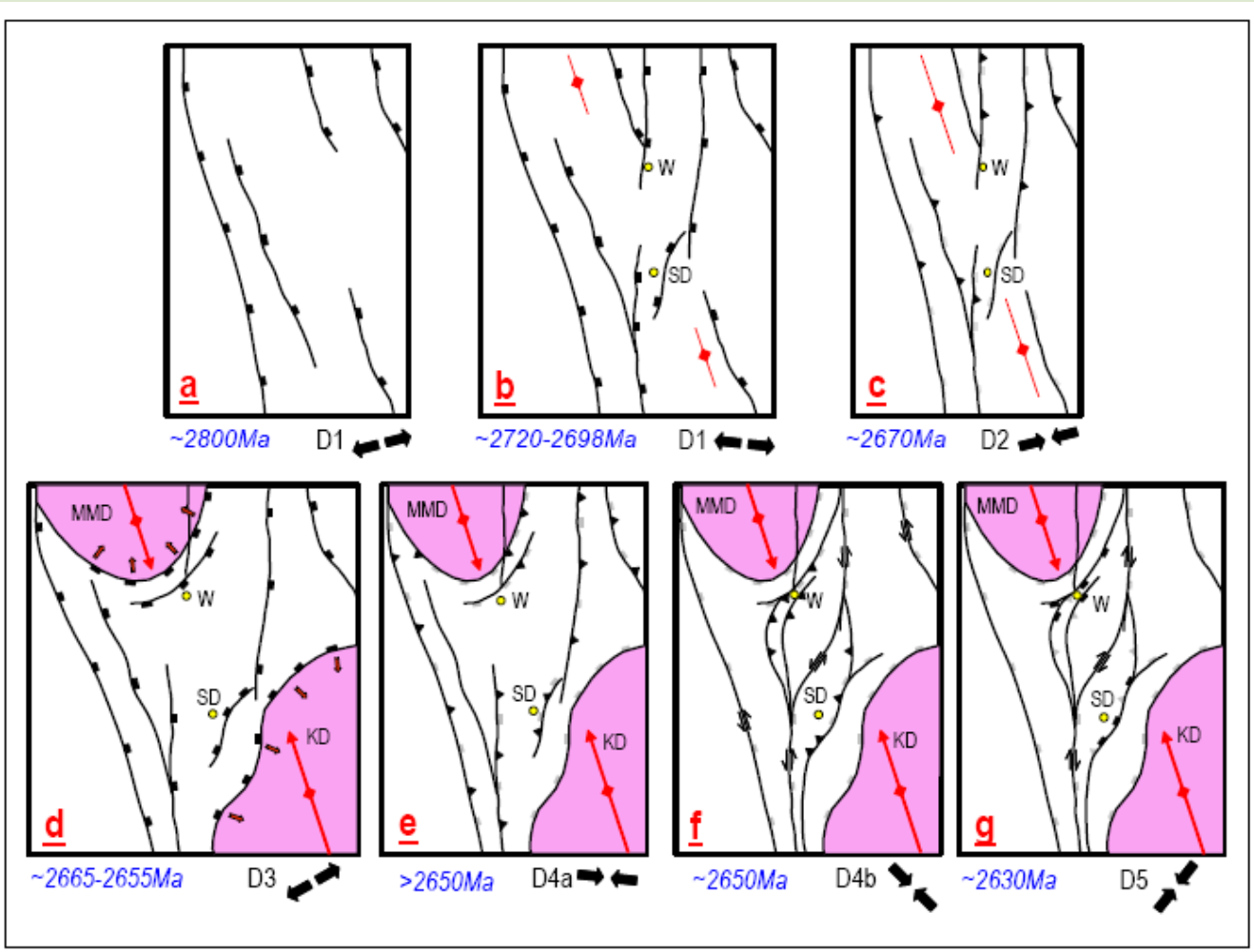
- Links to deep crustal shears
- Domes
- Mantle edges
- Along strike from know mineralisation
- Stratigraphic preservation
- Sm-Nd ages consistent with known mineralisation



Structural History

Blewett & Czarnota 2007			Swager 1997	Blewett *et al.* 2004b	Miller 2006
Minor contraction		D7			
Minor extension		D6	Collapse	Late De	
Dextral transtension		D5	D4	(D3)	D4
Sinistral transpression		D4b	D3	(D3)	D3
		D4a	D2	D2b	D2
Extensional doming	Stage 2 Late Basins	D3b	DE	D2e	
	Stage 1 Late Basins	D3a			
Upright folding and reverse faulting		D2	D2	D2a	D1
Extension with intermittent compression		D1	DE	De, D1, D1e	

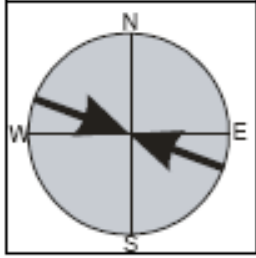
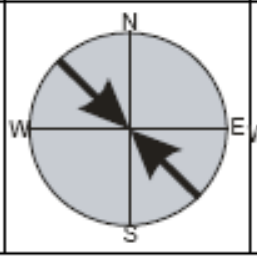
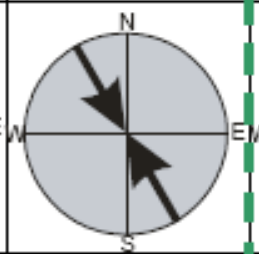
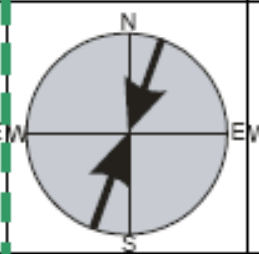
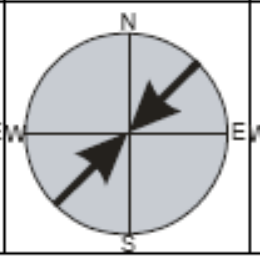
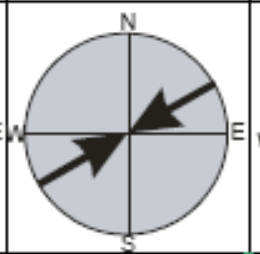
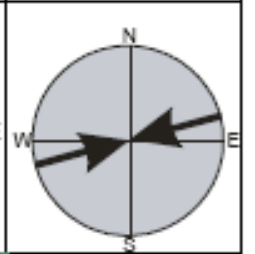
Architecture – regional



Henson et al 2007

Stress switching

Henson et al 2007

NW-SE orientations			NE-SW orientations			
1	2	3	4	5	6	7
WNW-ESE	NW-SE	NNW-SSE	NNE-SSW	NE-SW	ENE-WSW	ENE-WSW
290°-110°	315°-135°	300°-150°	20°-200°	45°-225°	60°-240°	75°-255°
						

Structurally more favourable for Wallaby and, to a less extent for Sunrise

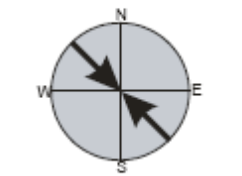
Unfavourable orientations for Wallaby and Sunrise structures

Enhanced at Sunrise
Weakened at Wallaby

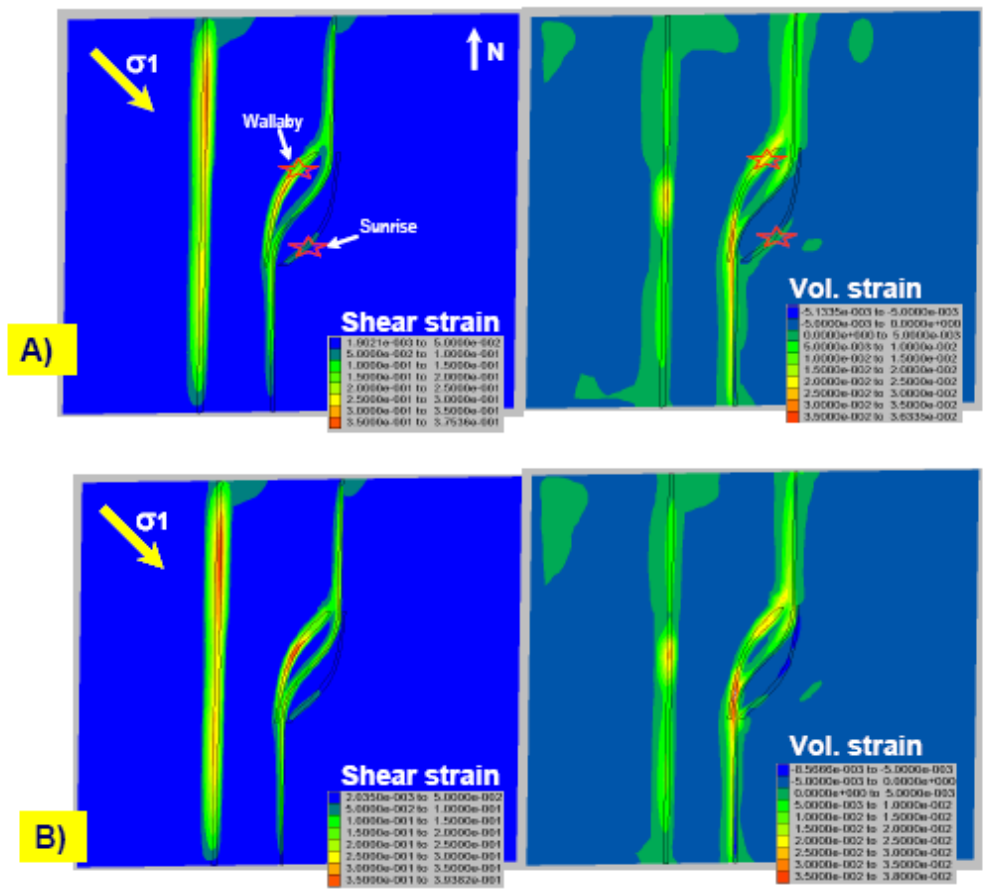
Architecture – regional

Greater shear localization & dilation at Wallaby than at Sunrise

Henson et al 2007



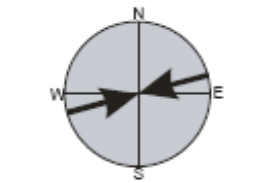
2.8% shortening
(315°-135°, NW-SE)



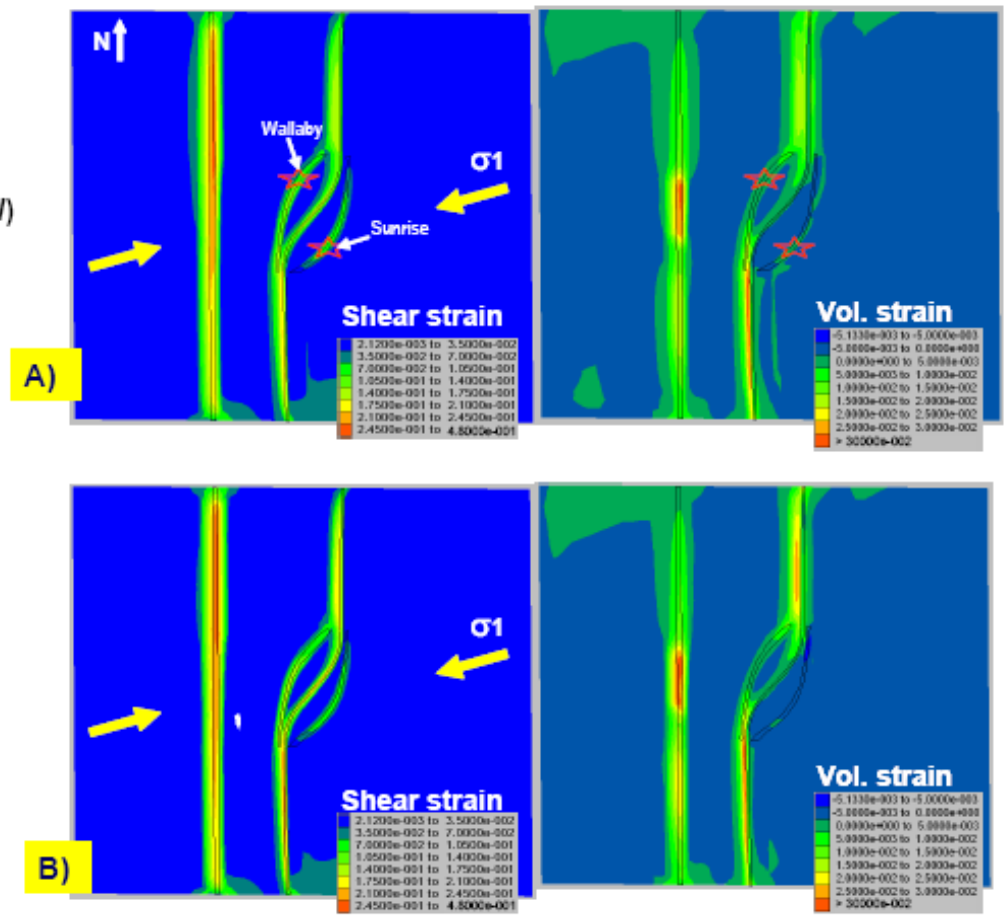
Architecture – regional

Faults show shear Localization and Dilation at both Wallaby and Sunrise

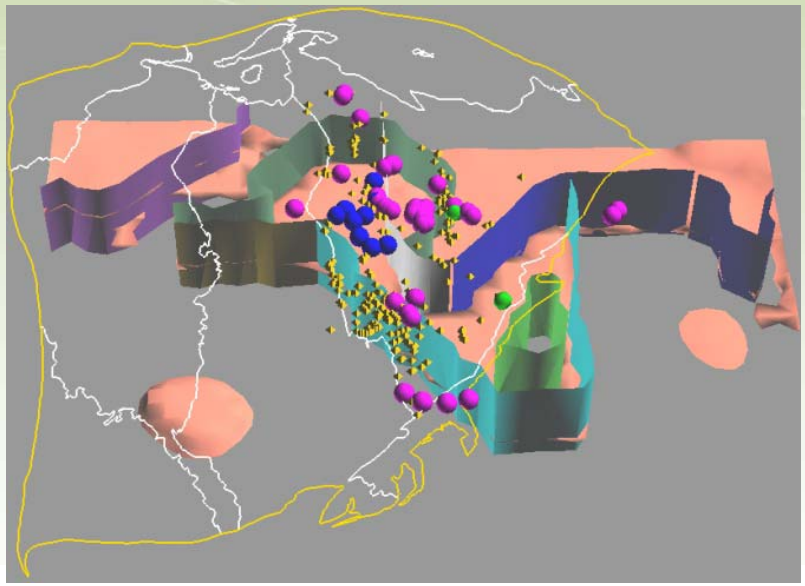
Henson et al 2007

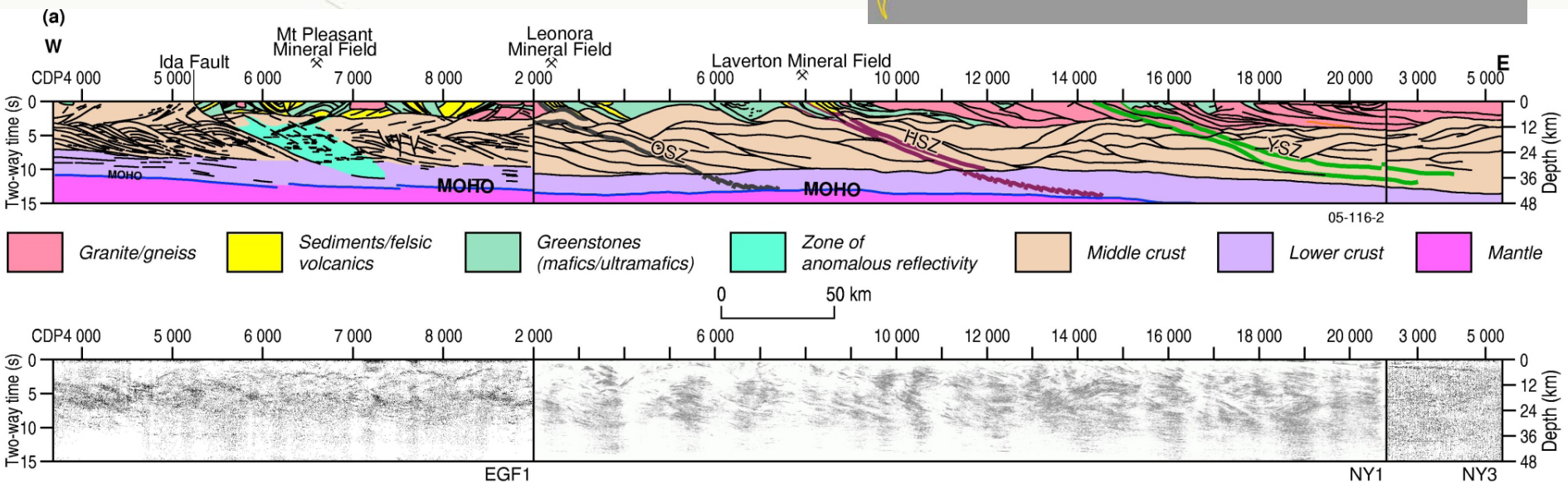


~3% shortening
(75°-255°, ENE-WSW)



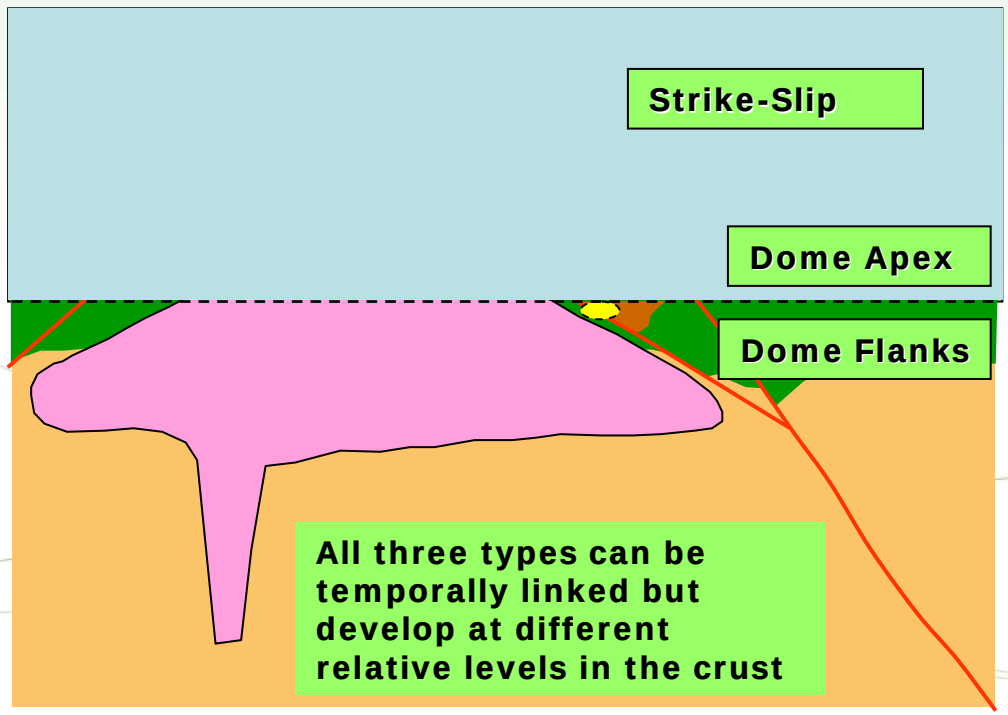
Architecture – regional





Architecture – camp scale

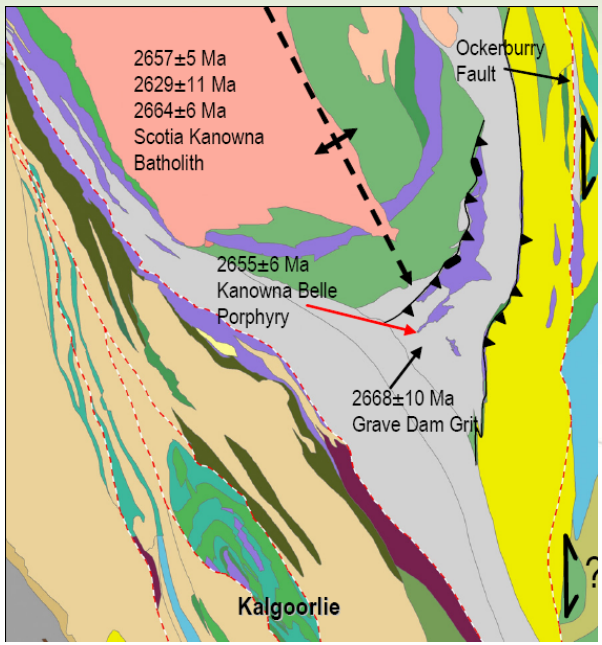
- Proximity to areas with domes and/ or extensional offset
- Identify deposit type: dome flank, dome apex, strike slip
- Proximal to faults on flanks of exposed domes/ batholiths
- Situated above domes
- Proximal to strike-slip reactivated normal faults
- Fault orientations
- Footwall of crustal shears
- Dilation potential
- Structural complexity

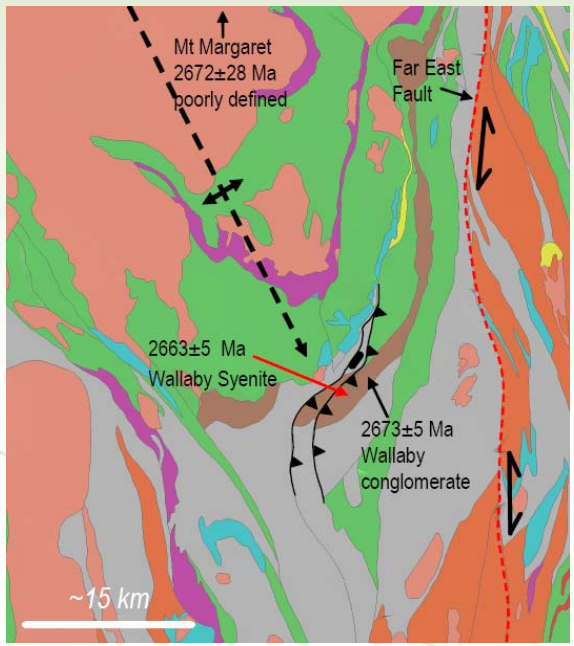


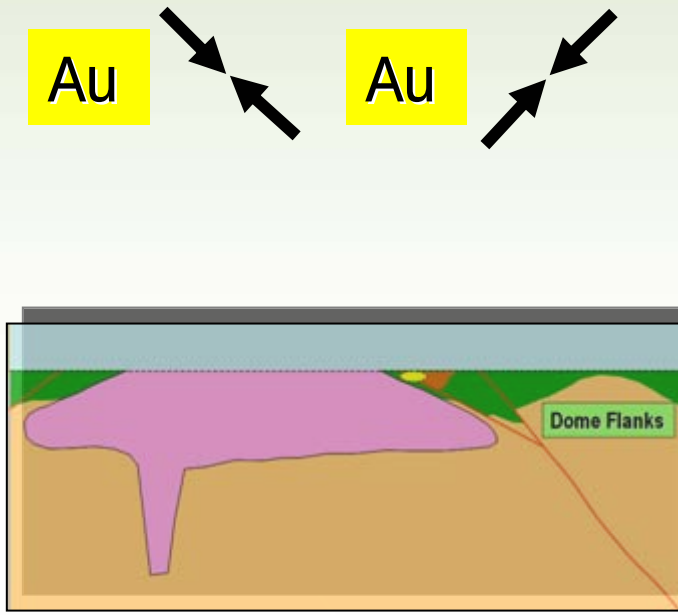
P. Henson

Slide after: P. Henson

Architecture – camp scale

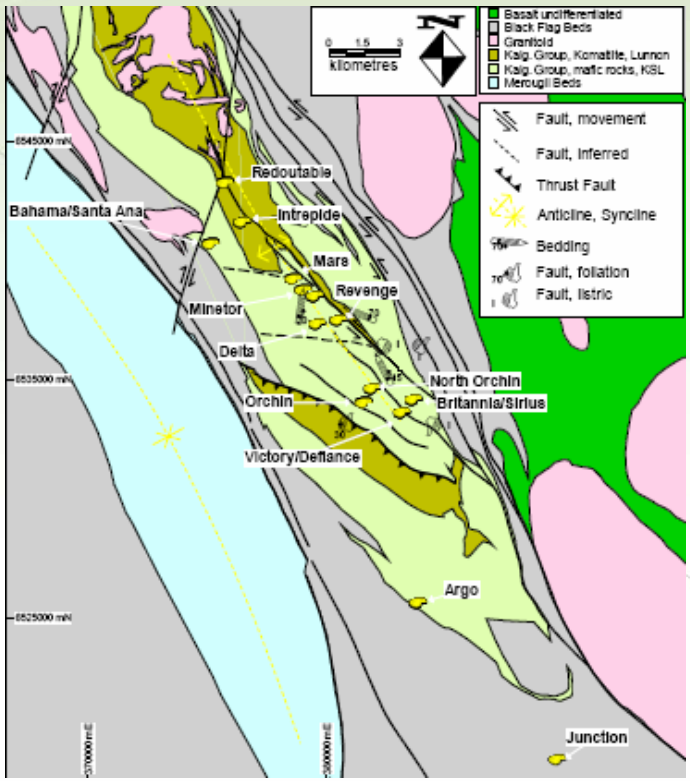


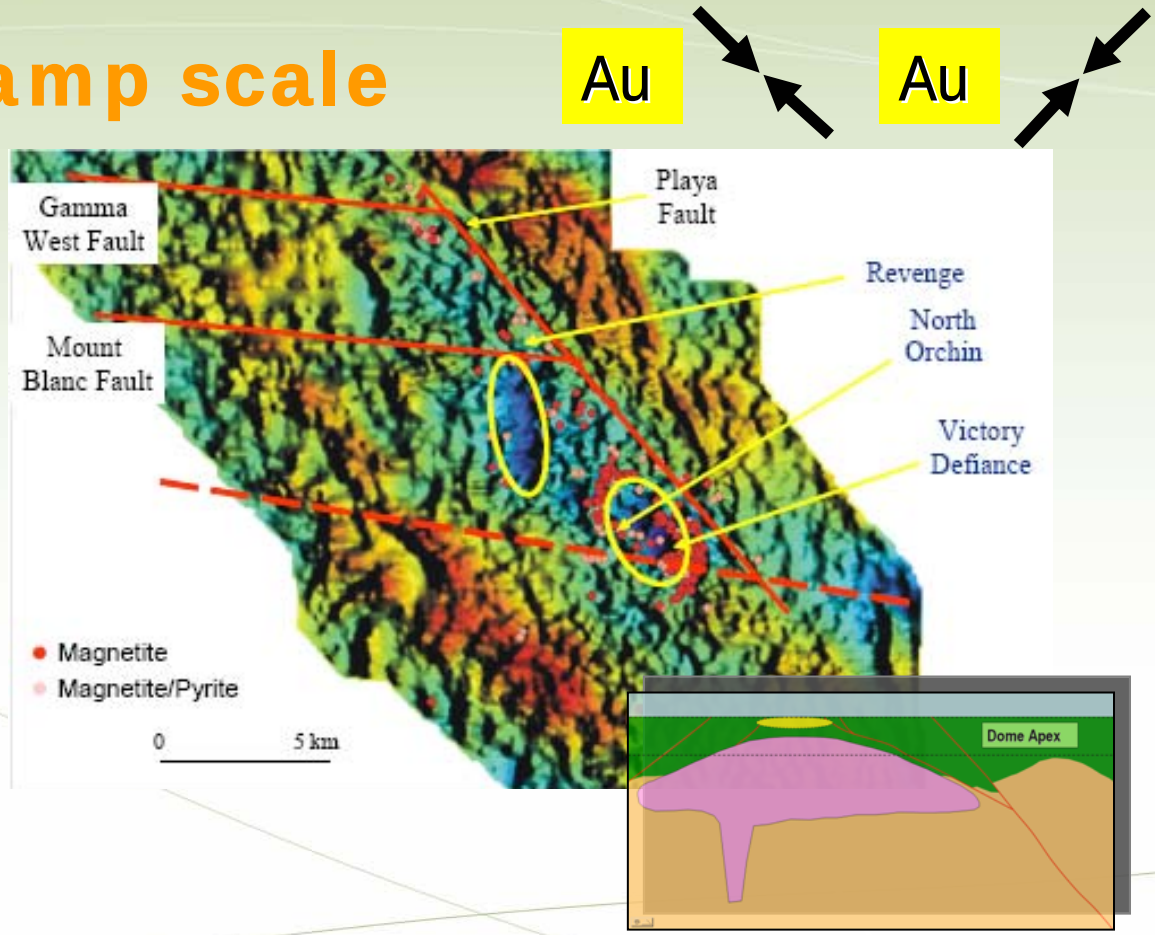




Domes projecting under Kanowna Belle in Kalgoorlie and Wallaby in Laverton focus fluids/ melt into splays off reactivated normal faults

Architecture – camp scale

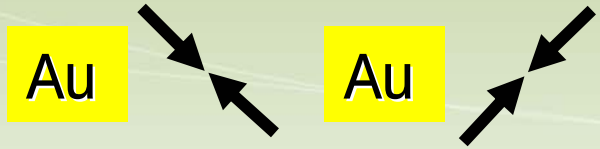


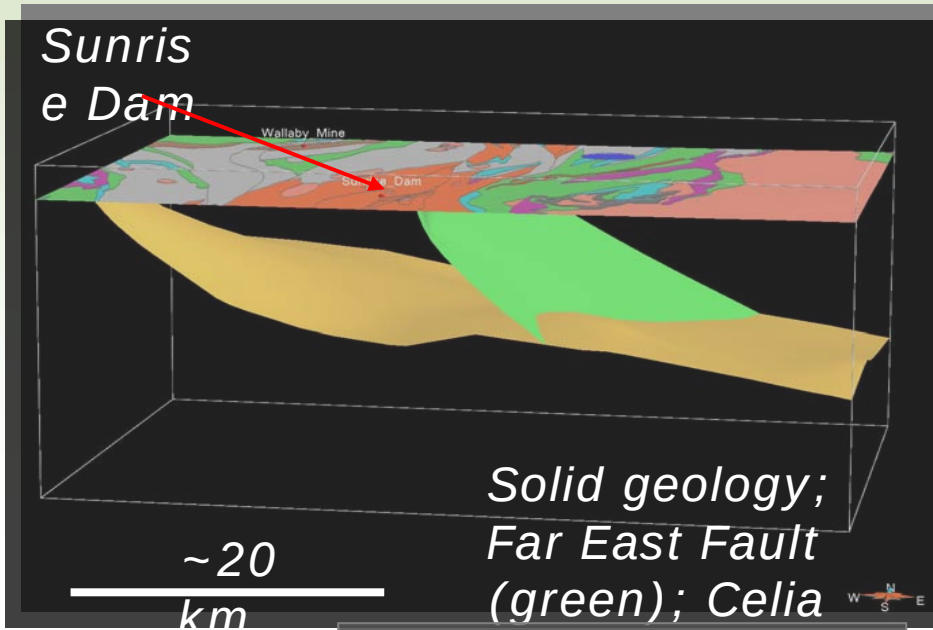


Victory Defiance mine located above a granite dome (focussing fluid / melts) and in the footwall of the strike slip reactivated normal Playa Fault acting as a seal

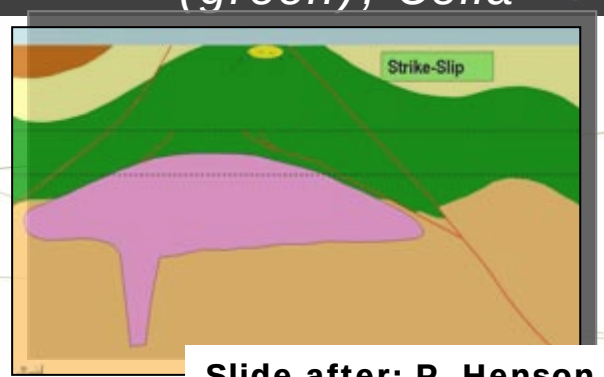
Slide after: P. Henson

Architecture – camp scale





Major deposits (Golden Mile & Sunrise Dam) occur proximal to strike-slip reactivated normal faults determined from lithological distributions and offsets



Slide after: P. Henson

Architecture – Ore scale

Case specific

Structural pathways

Structural complexity

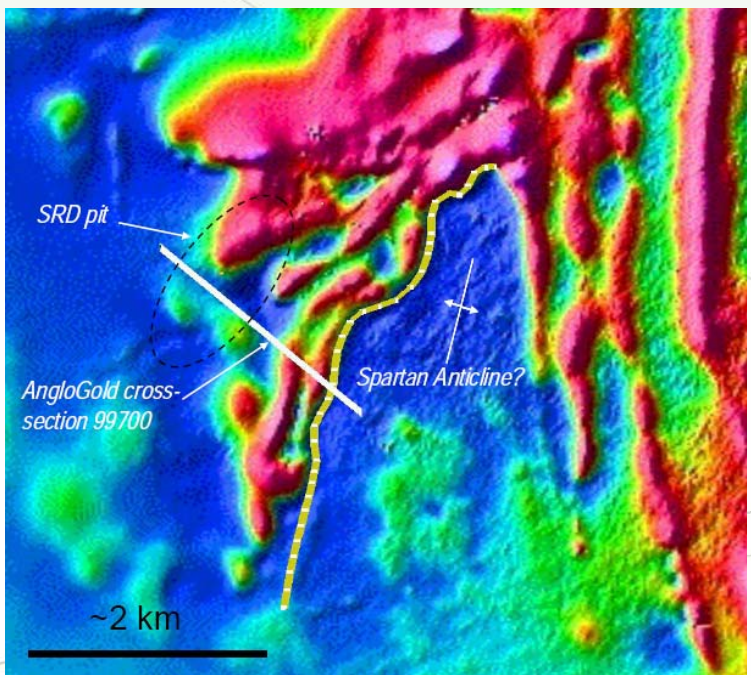
Identify porphyry intrusions/alteration (by detailed gravity)

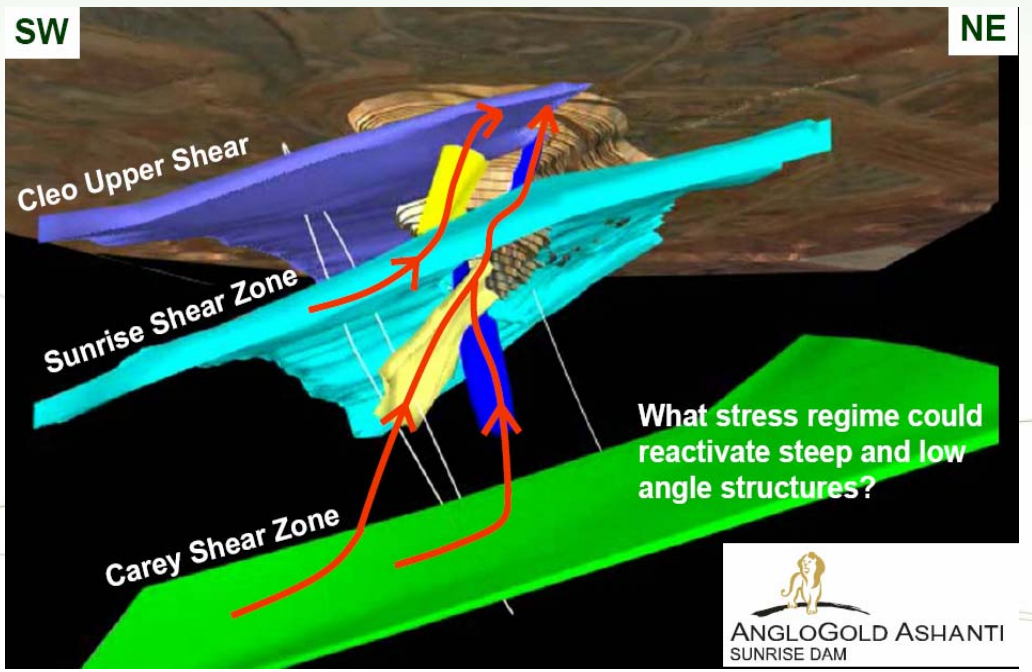
Antiforms or domes focus fluid

Faults act as pathways and/or seals

Architecture – Ore scale

1. Fluid / melt focussing occurs at sites where the folding produces plunging anticlines
2. Shear zones at Sunrise Dam mine act as both fluid pathways and seals during the migration of mineralised fluids. Shear zones interact with local rheology contrasts to influence fluid / migration.





Architecture – Ore scale

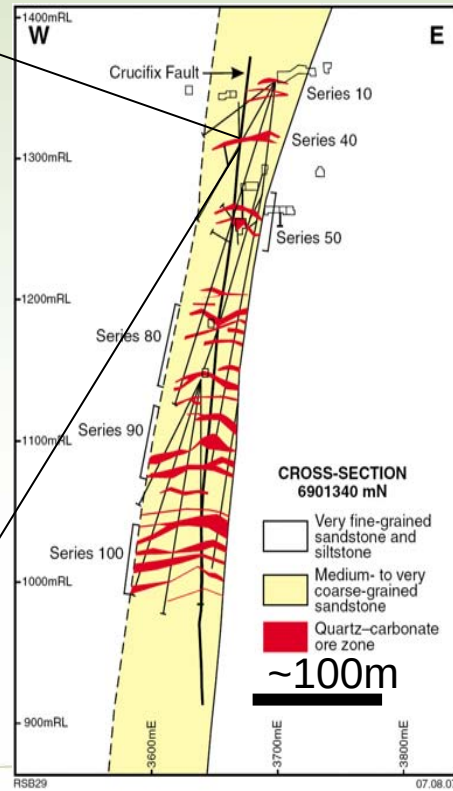
Structural complexity

Favourable fault orientations

Faults that operate as pathways or seals

Proximal to porphyries

Boundary between units with competency contrasts



Rheology contrasts are important controls on dilation / mineralisation at a range of scales within a mine (e.g., New Holland)

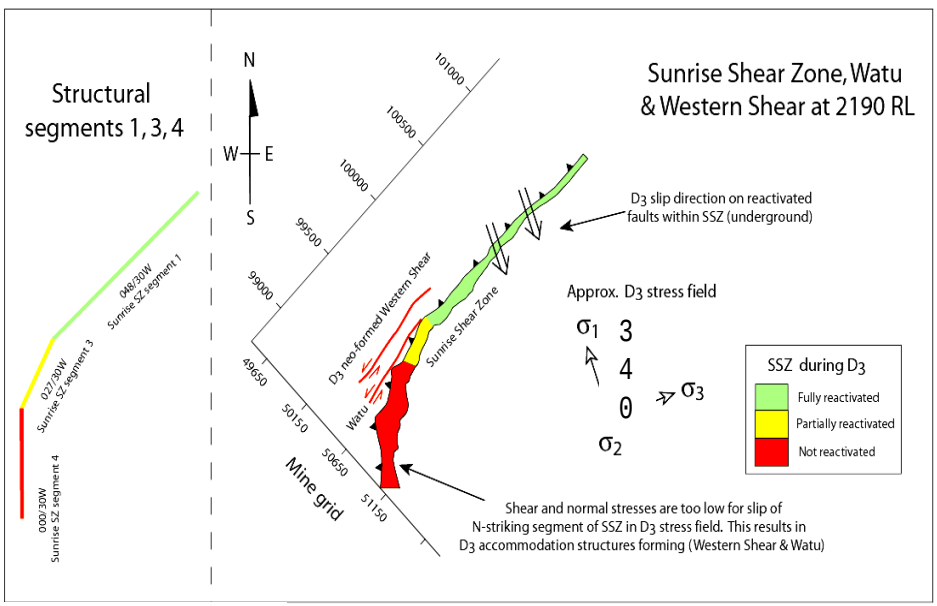
Slide from P. Henson

Architecture – Ore scale

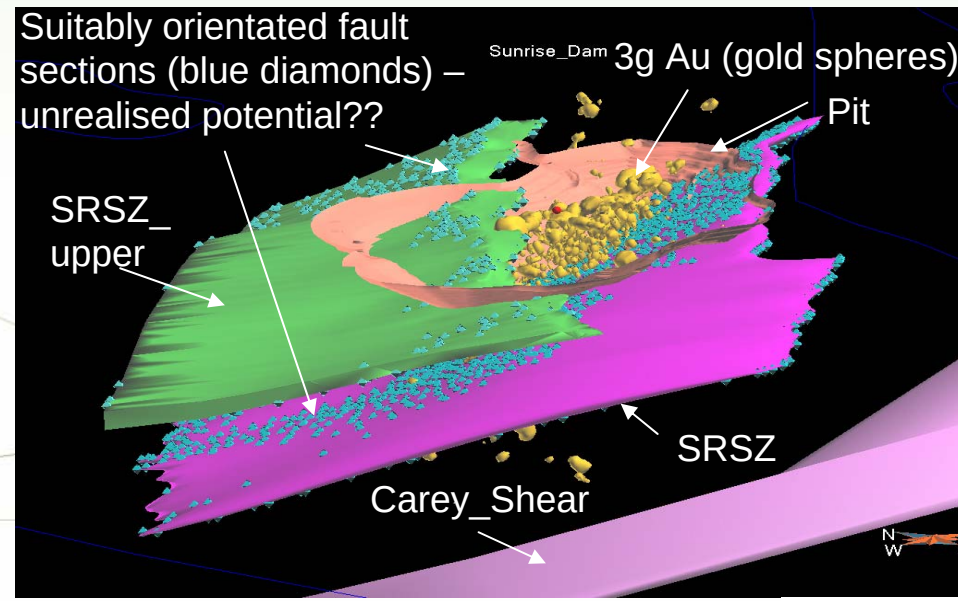
Sunrise Dam

Detailed structural analysis of the Sunrise Dam deposit

Statistical analysis of 3D fault orientations delineates spatial regions that will preferentially reactivate / dilate



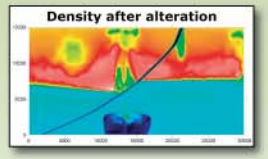
J. Miller 2006

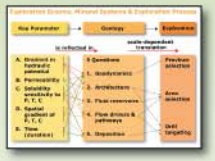


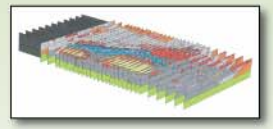
J. Miller

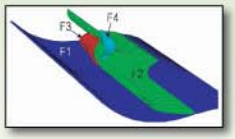
*predictive mineral discovery*Cooperative Research Centre*

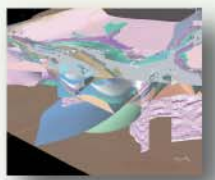
A legacy for mineral exploration science

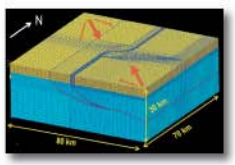


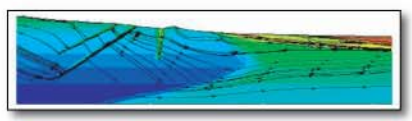


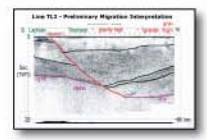












*pmd*CRC* working with industry

*pmd*CRC* research areas

*pmd*CRC* research nodes

*pmd*CRC* working with State/Territory Surveys

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