3D Geoscience at GSWA

Klaus Gessner

3D Geoscience at GSD Mapping Branch

1. Who are we?
2. What are we doing?
3. Why are we going 3D?
4. What are our priorities?
5. What are the challenges?
6. Applications

3D Geoscience: Who?

Klaus Gessner - GSWA

Ruth Murdie – GSWA

Lucy Brisbout – GSWA

Huaiyu Yuan – Macquarie / CET

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3D Geoscience: What?

Aim

- increase the knowledge of Western Australia's subsurface through the integration of geophysical, geological and geochemical data in 3D structural models.

Objectives

- developing the capability to build, manage, analyse and store 3D models according to GSWA quality standards and stakeholder needs
- engaging in collaborative research with leading research institutions that complement GSWA's data collection, analysis and modelling capabilities.

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3D Geoscience: Why?

- Need for integration of surface and ***depth*** data
  - Geology, Geochemistry, Potential Field
  - Active and passive seismic surveys, Magnetotellurics
- ***'The end of the cartoon era'*** – increased level of rigor by geometrical constraints
- Reduced uncertainty and risk
- Effective communication to stakeholders

Why – large scale architecture …

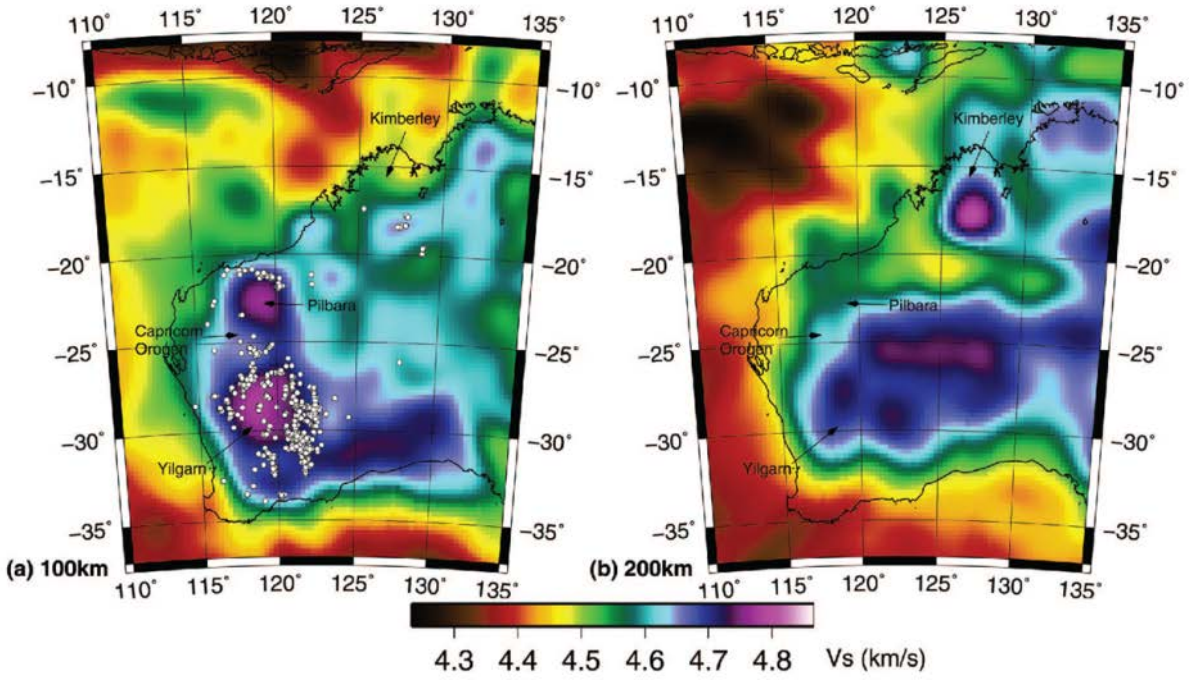
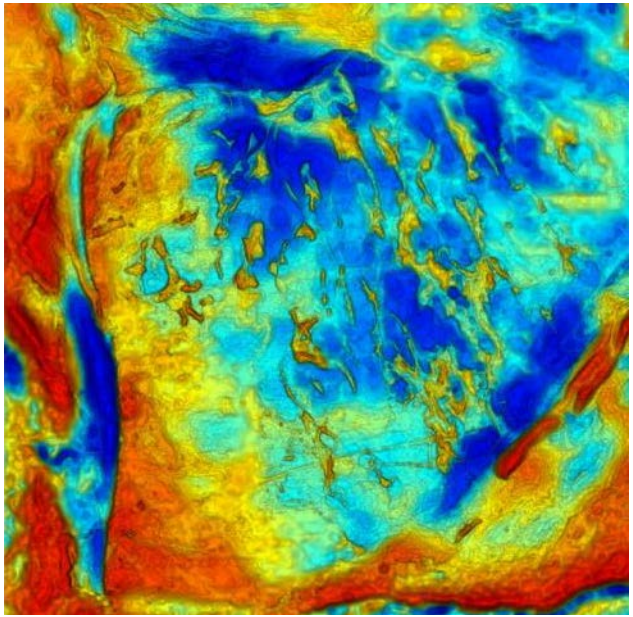


Figure 9 Absolute velocities determined from the surface wave inversion: (a) 100 km; white circles mark the location of all known gold deposits. Locations are taken from the Australian Atlas of mineral resources, mines and processing centres (5 http://www.australianminesatlas.gov.au/ 4); (b) 200 km.

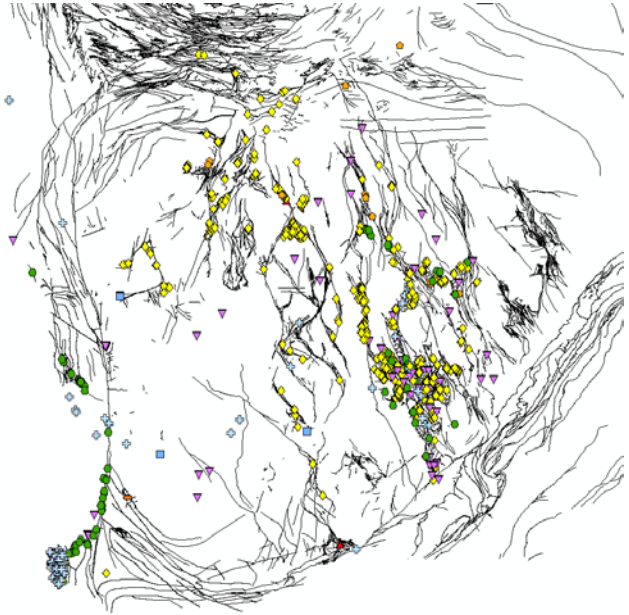
Fishwick & Rawlinson 2012 AJES

Integration: Focus on Yilgarn Craton and its margins

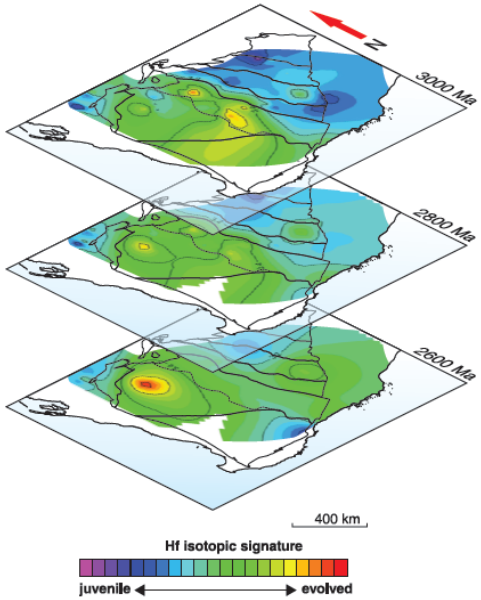
Geophysics



Geology + Resources



Geochemistry



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3D Geoscience Priorities

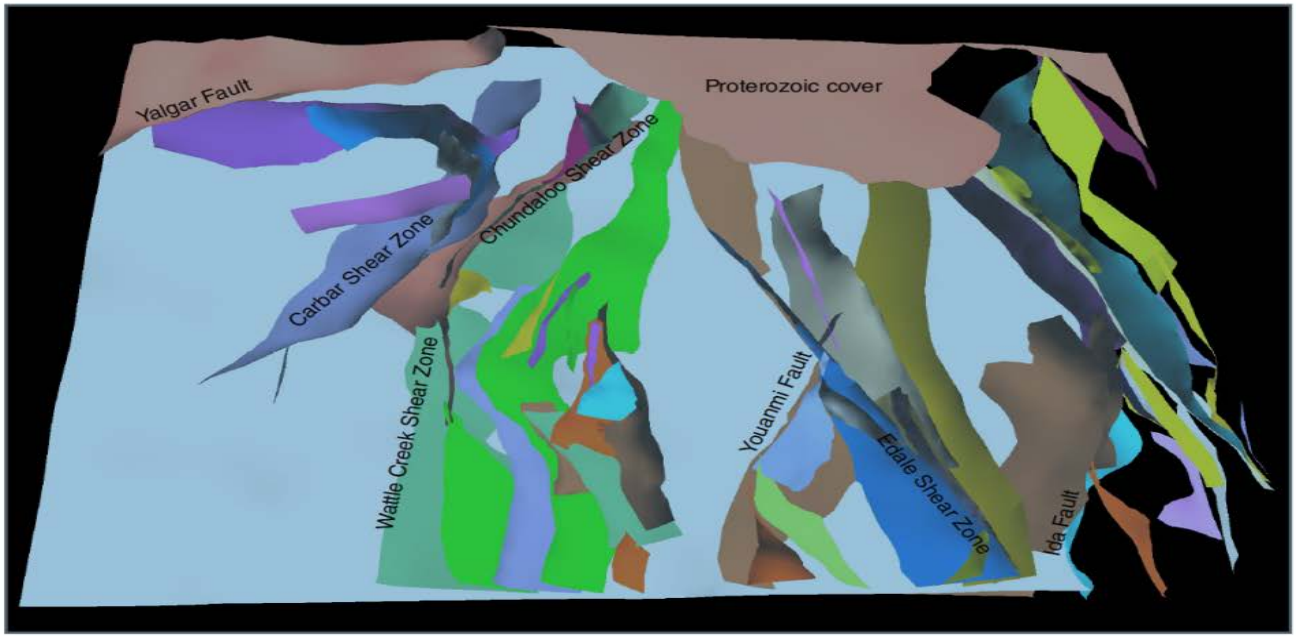
- Field campaigns: passive seismic arrays
- Focus on ***regional scale*** 3D Models (internal/external)
  - Reports
  - Digital package (annually updated)

- Cooperation
  - CET's Integrated Exploration Platform
  - Numerical simulation: Geodynamics (CET) of AFO, Musgraves
  - Imaging / property modelling
    - Gigapixel mosaics
    - Physical properties / CT scans

Regional scale models

YOUANMI 3D MODEL

A focus area of 3D modelling in WA is the Central Yilgarn Craton where the recently shot Youanmi seismic reflection survey will be used together with field mapping, forward models, magnetotelluric profiles and joint inversions to produce a regional 3D model of a crucial part of the WA lithosphere. The seismic data allows us to constrain structures at a much greater depth than can be inferred from geological mapping. The aims of the project are to integrate the data in to 4-dimensional integrated model for the crustal evolution for the Western Yilgarn Craton and to develop a better understanding of the mineralisation processes for this region, how the crust links to underlying lithospheric mantle and what relationships this piece of lithosphere has with the more highly endowed, eastern part of the craton, the Goldfields Superterrane.



Reports and digital package

GSWA

- Windimurra
- Sandstone GB
- Yilgarn Fault Network
- Albany Fraser Orogen

External

- Canning (UWA Centre for Petroleum Resources, about to be released)
- Eastern Goldfields (GA)
- Musgrave Province (UWA, GA)
- Kimberley

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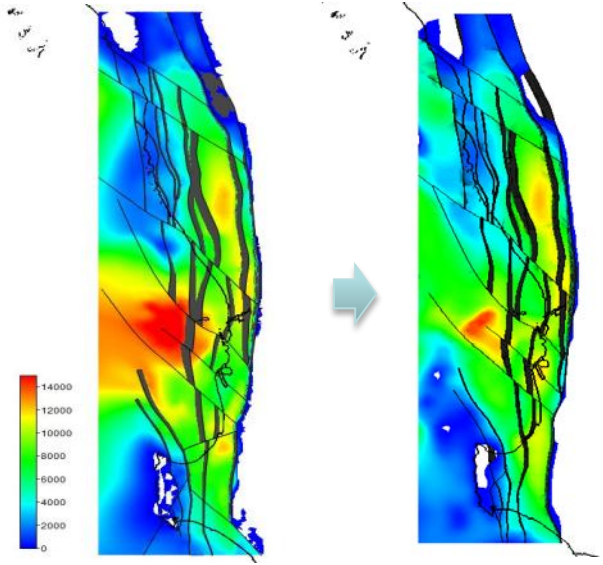
Challenges

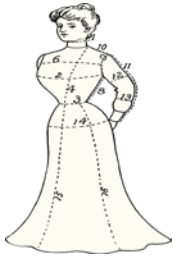
- Collecting / archiving / updating existing models / objects
  - Integration of existing data
  - Corporate style (polygons vs volumes, scale increments, …)
- Products to stakeholders
  - Data vs. models; software platform, 2D vs 3D, 3D-PDF
- Technical framework
  - Style: State surveys, and GA
  - Longevity

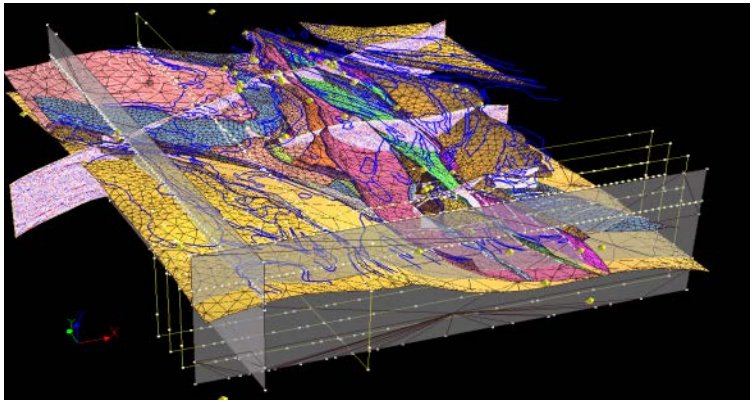
Modelling challenge: Explicit / Implicit

Updateable vs ‘3D sewing’



Wellmann 2012



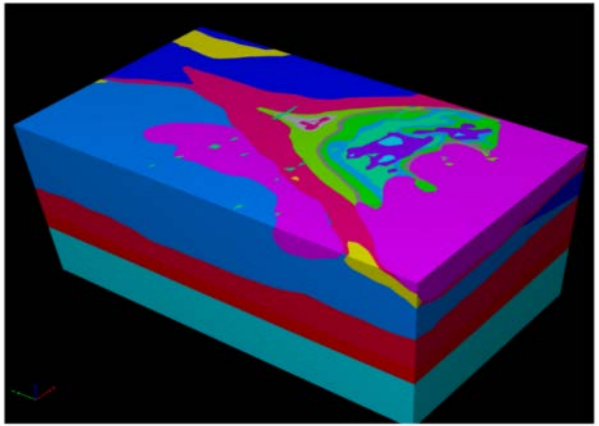


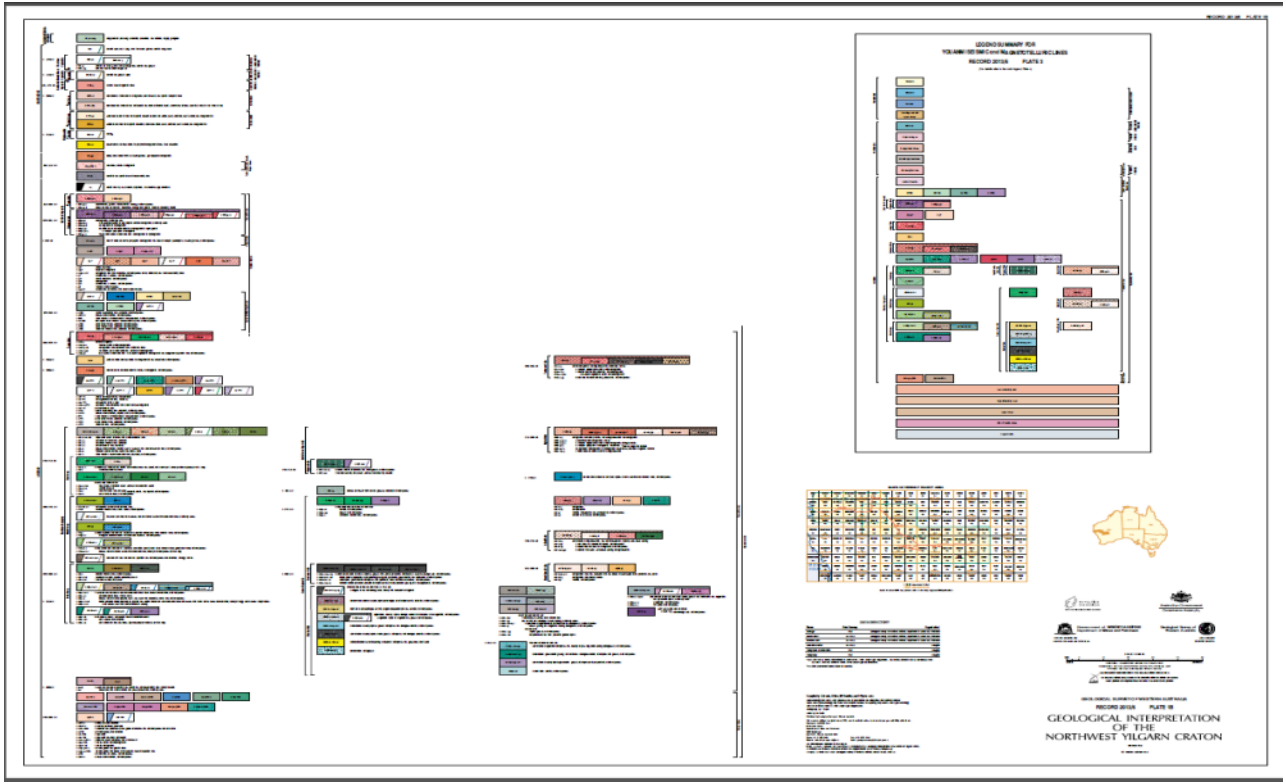
Henson 2006

Data Management Challenge

- Variety of input data
  - Data types / formats
  - Coordinate systems
  - Accuracy across scales (‘mantle to vein’)
- Archive and store
  - 3D database
- Variety of output data
  - Visualisation / Interface (viewers)
  - Data export
  - Selected 2D objects as contoured grids

Production challenge





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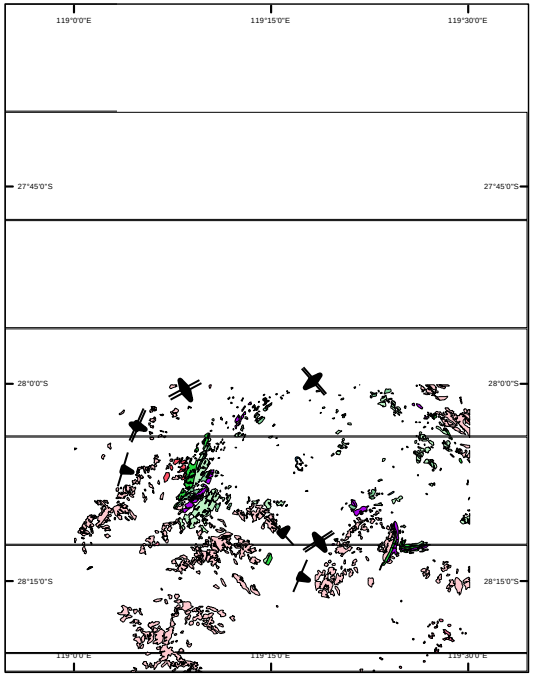
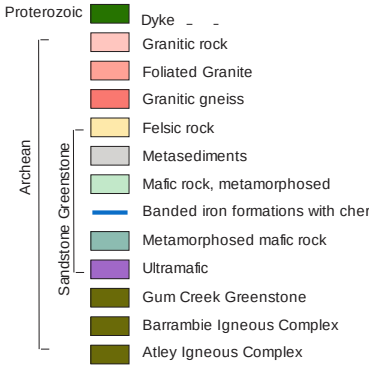
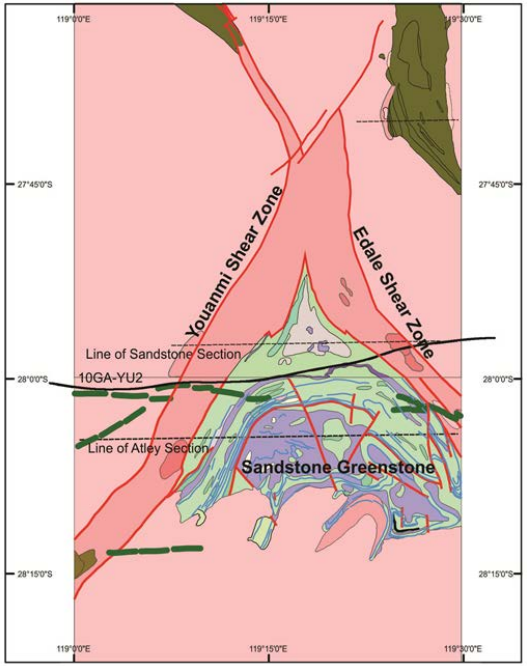
Uncertainty in Geological Data



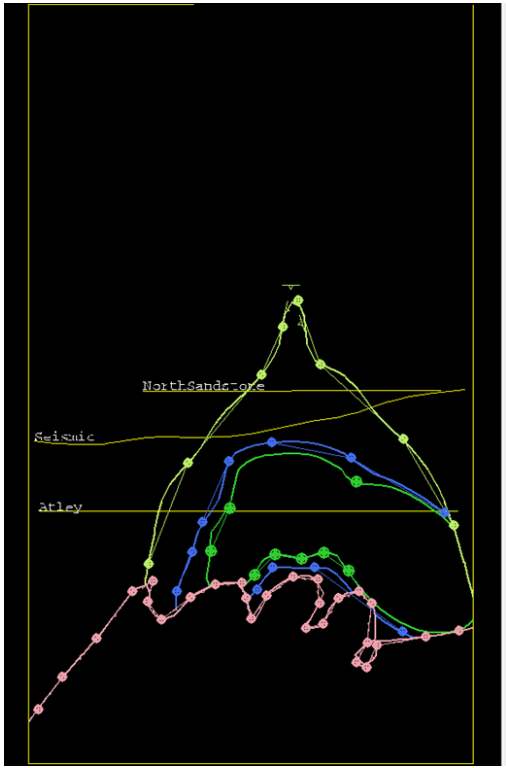
Minimal outcrop
Some structural data

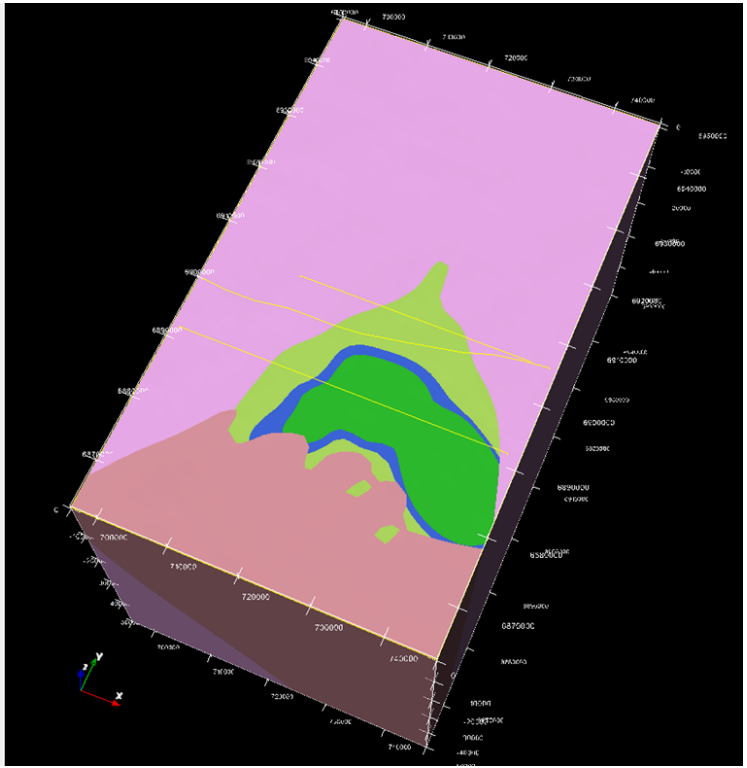




3D model building: Uncertainty

Surface view: constraints

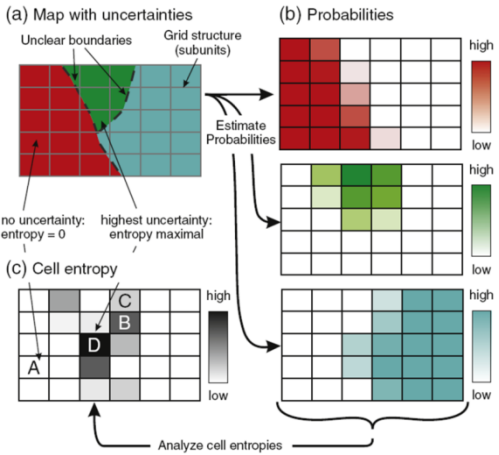




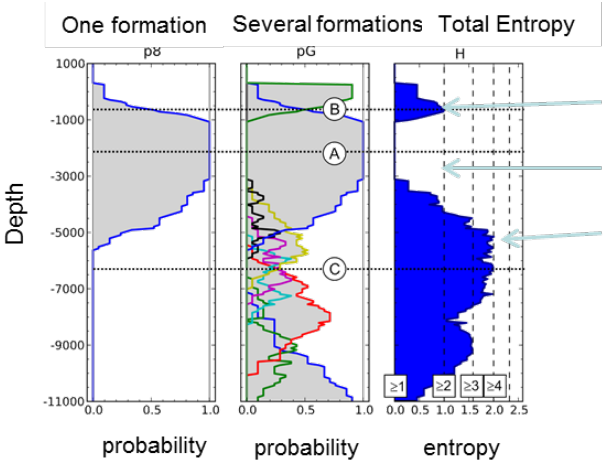
3D view

Information Entropy: Concept, Imaging

Map



Log

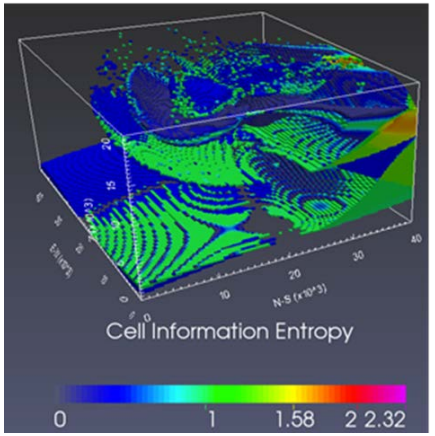


Two outcomes equally probable

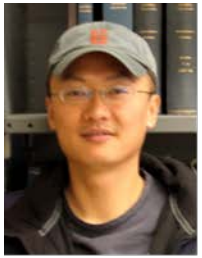
No uncertainty

Generally: more outcomes and more uniform, higher entropy. Max H for n outcomes: $\log_2(n)$

Model

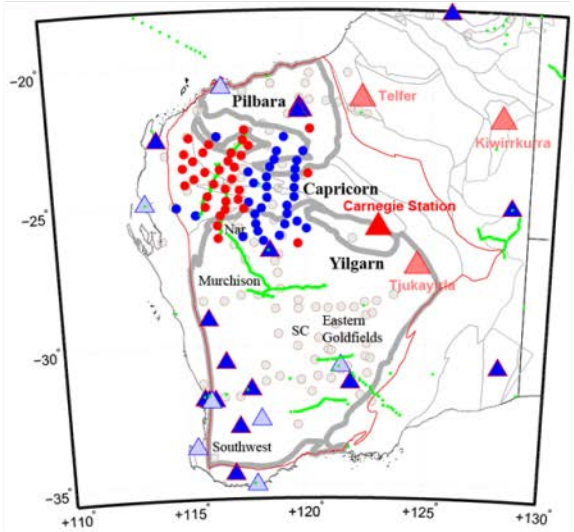


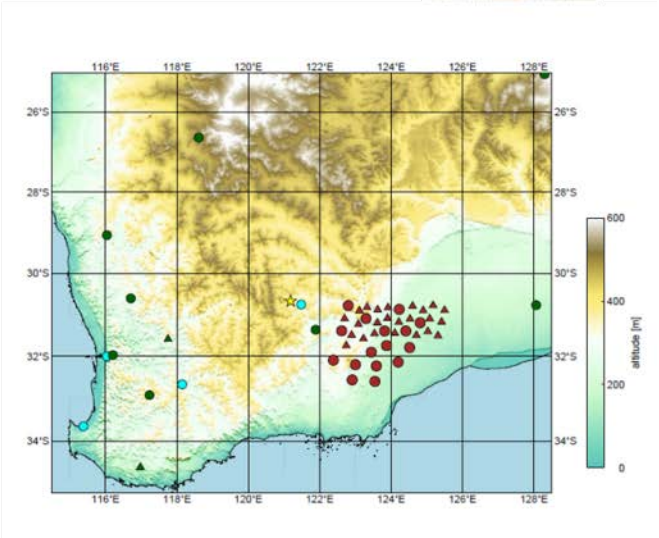
CCFS and ANU Collaboration (ARC CCFS /Linkage)



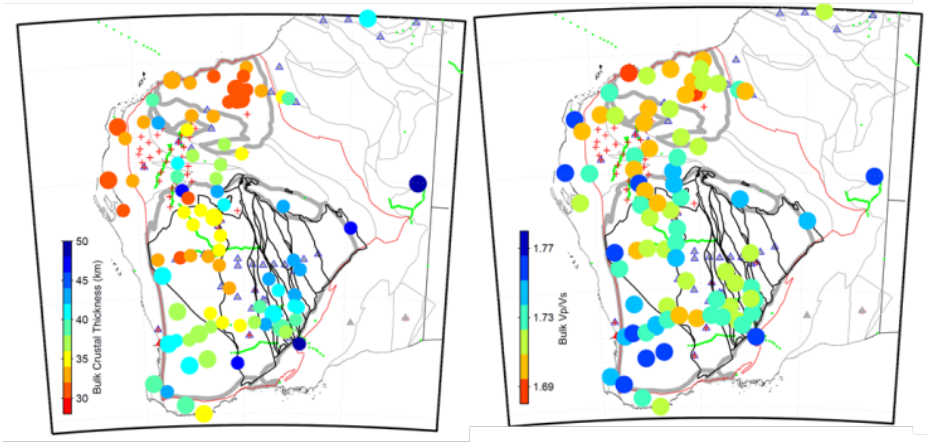
Huaiyu Yuan
CCFS
(CET / Macquarie)

Christian Sippl
ANU RSES

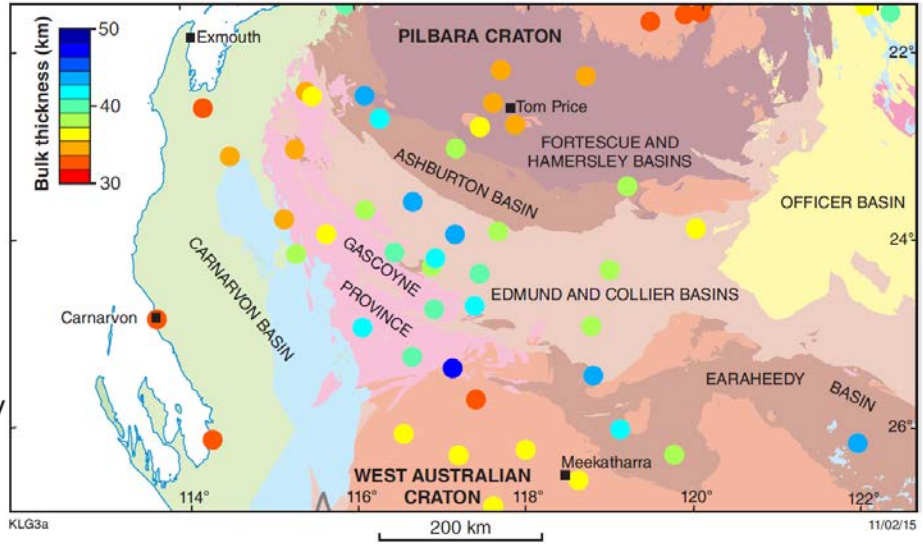




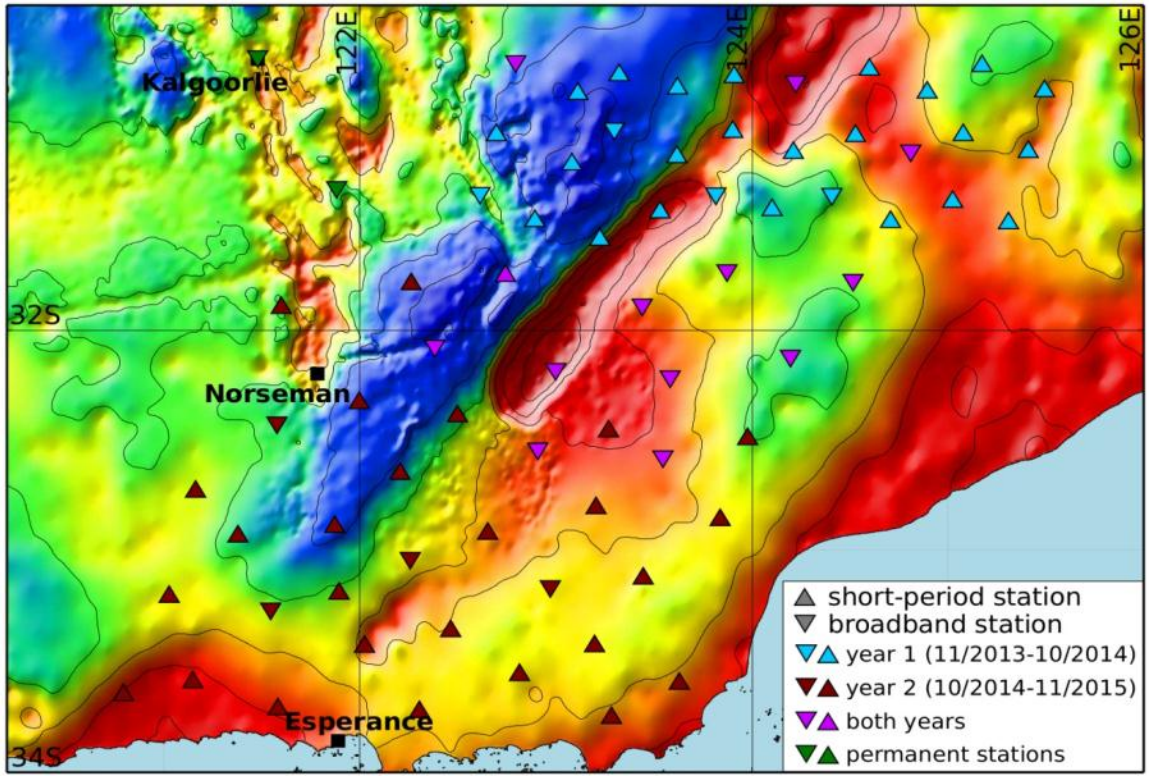
Yuan review of crustal thickness and composition



- Pilbara: thin (29-32km) crust; felsic (1.69-1.72) bulk crustal composition; medium bulk velocity; oldest cratonization age
- Murchison: thin (30-35 km) crust; felsic (1.71-1.73) composition; slow bulk velocity;
- Southwest: thick (>40 km) crust; mafic (>1.75) composition; fast bulk velocity
- Eastern Goldfields: Moho deepens to the north (37-42km); felsic (~1.72) composition; fast velocity; less "flat" Moho observations
- Southern Cross: separating Southwest and Eastern Goldfields

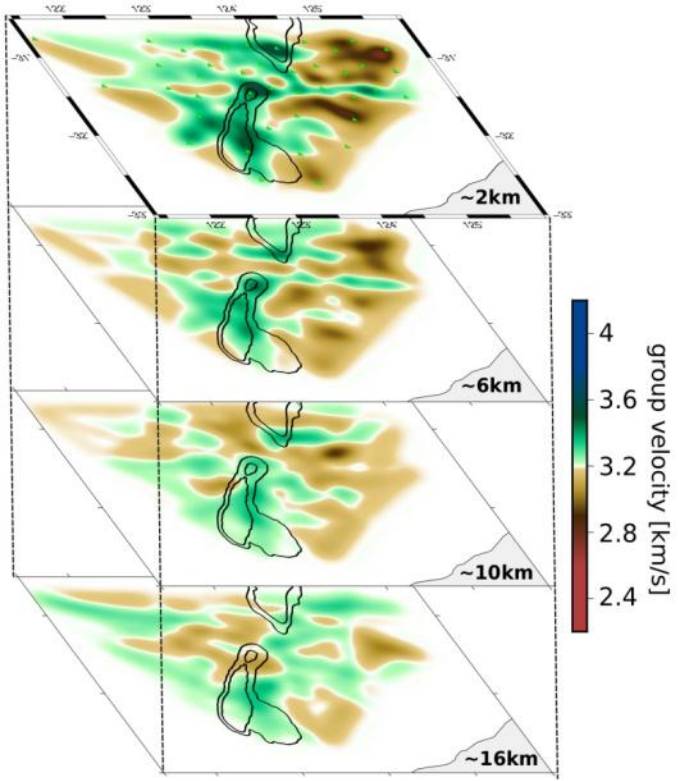


ALFREX array



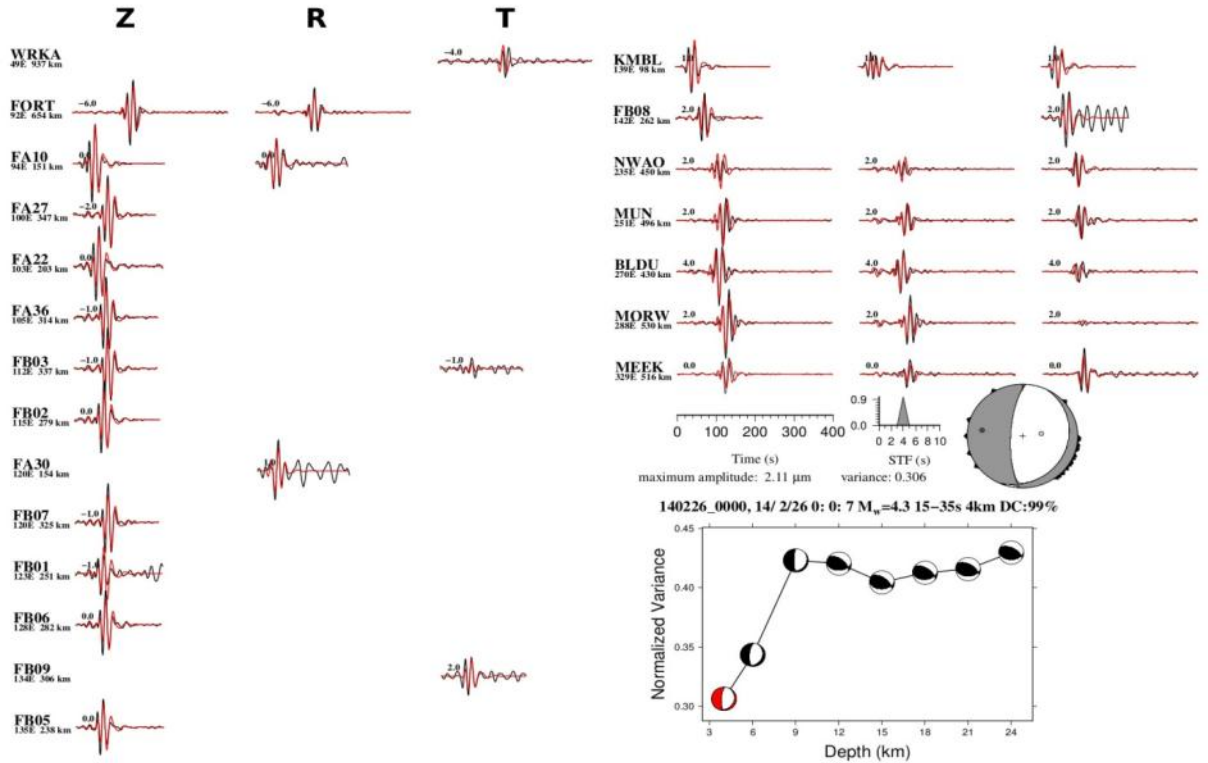
- two-year deployment of 40 seismic stations, array being moved south midterm
- covers all structural domains from Yilgarn craton in the west to Eucla Basin in the east
- “connecting stations” in the center of the array stay for the entire two years

Rayleigh wave group velocities from ambient noise tomography



- uppermost 10 km: first-order contrast between slow velocity beneath the Eucla Basin and faster ones beneath the Yilgarn and Albany-Fraser
- small-scale features still to be validated
- Fraser Zone (indicated by gravity contours) shows highest velocities in shallow crust, not discernible any more at depths >10 km
- lower levels: faster velocities in the east

14 February 2014 Kalgoorlie Earthquake: unexpected result



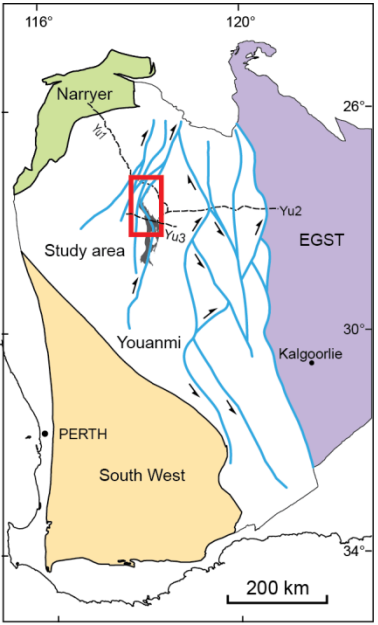
- focal mechanism was east-west extension, in contrast to what is commonly assumed about the regional stress field
- 2010 Boulder yields a comparable mechanism
- observed waveforms can best be explained with two-layered crust of contrasting vp/vs (felsic upper crust, mafic lower crust)

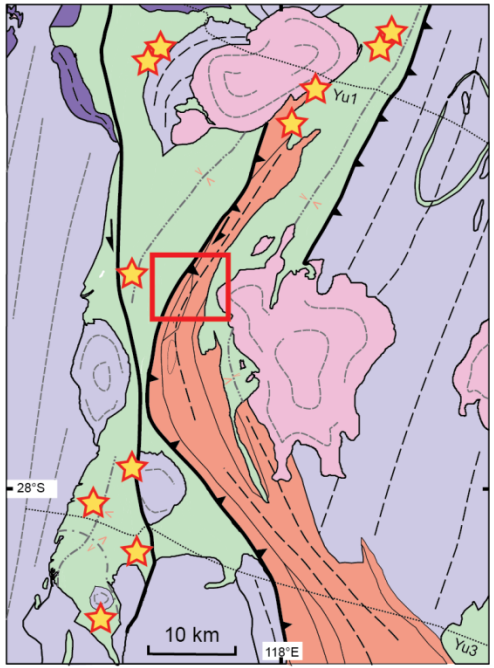
Outcrop scale: Gigapixel images, 3D models

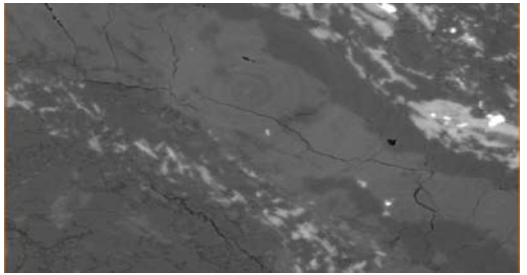
Ivan Zibra, GSWA

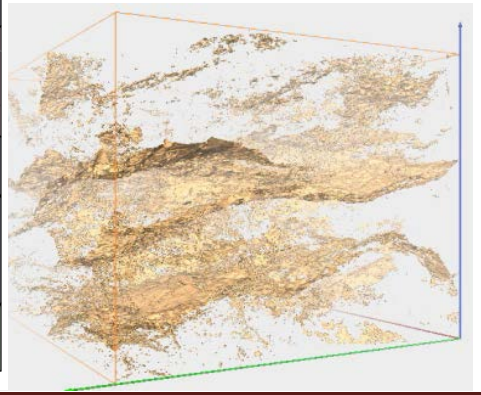
Micro-scale

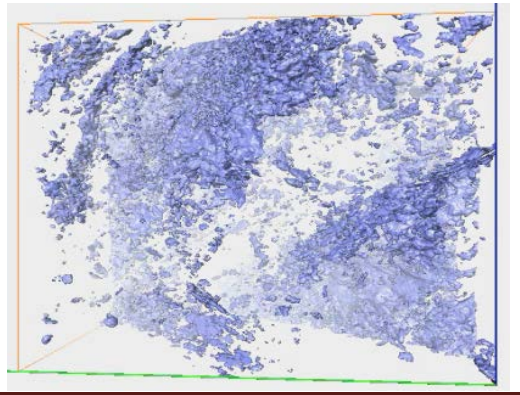
Physical property models based on x-ray tomography; acoustic property measurements (collaboration with Australian Synchrotron, Argonne National Laboratories, UWA, CSIRO)












THANKS !