Central Eastern Fold Belt Solid Geology
Insights from crustal architecture

Karen Connors
DNRME New Discovery Program, Technical Workshop, September 19, 2019
Location and seismic

- Solid Geology interpretation
- Builds on GSQ, Deep Mining Queensland, Ernest Henry, and Southern EFB projects (DNRME and BRC)

Data
- Magnetics – govt and industry
- Gravity, Radiometrics, Hyperspectral, Aster
- Drill hole data – industry and govt
- Seismic
- In progress (confidential 1 year)
- Opportunity to participate
Location and seismic

Approach

• Crustal architecture
• Seismic key in this area
• *Integrated* interpretation

Outline

• Stratigraphy
• Regional seismic
• Evidence for SCG extension / hyperextension
• Seismic in AOI
• Conclusions
Isan Orogeny from ca 1606 Ma (low-P, high-T prograde metamorphism); crustal thickening (E-W shortening) ca 1590-1570 Ma
Key questions

Solid geology from GSQ, DMQ, and SEFB projects

- What forms basement?
- Extent of Staveley?
- Extent of Llewellyn Creek (LCF)?
- Staveley below MNQ / LCF absent??
  - Staveley dips east beneath SCG; but does not appear to resurface
Seismic data
- Different and competing interpretations
- Variable data quality
- Some clear observations can be made
- …. provide fundamental constraints
Numil crust highly reflective and thinner
“Isa” crust – poorly reflective and thicker
Broad west-dipping fault zone
Competent block between Numil and Isa (mod to weak reflections)

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07GA-IG1 Korsch et al., 2012
Regional Seismic

Prominent packages of reflectors (some may be faults of unspecified age)

Steep faults in proximity to interpreted surface trace of Cloncurry and Pilgrim faults

Note that line work highlights a few main features for the purpose of this talk and is not intended as a detailed interpretation
Answer Slate overlies Staveley - Mitakoodi

“complete” section Staveley - SCG

Mount Norna over Staveley

Regional Seismic – DMQ interpretation

Mount Isa Crust
Poorly reflective

Numil Crust underlies SCG east of Cloncurry Fault and extends west at depth

Remarkably similar geometry on 14GA-CF3 to south

Detailed interpretation in upper section from Deep Mining Queensland Project

Note that line work in lower section highlights a few main features for the purpose of this talk and is not intended as a detailed interpretation

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SCG extensional models - intracontinental basin (Ellis and Wyborn, 1984; Williams, 1998; Hattan, 2004; Giles et al., 2006) or back-arc (Gibson et al., 2008; 2016; 2018)

Difficult to quantify crustal thinning

Giles et al. (2006)

Gibson et al. (2018)
Observations
Outcrop – preserved SCG 5-8 km (10-15 km in seismic)
Widespread detachment and pervasive layer parallel fabric – near horizontal and folded
Voluminous mafic magmatism – high Fe tholeiites sourced from mantle
Felsic magmatism
Possible oceanic crust to east (Etheridge Province; Baker et al., 2010)
Seismic – imbrication of crustal slices 5-15 km thick
High geothermal gradient (45°C / km) at start of Isan thin-skinned (1606 Ma; Porteau et al., 2018)

Significant, widespread extension
Implications for geometry of EFB prior to Isan Orogeny
Hyperextension, serpentinisation and detachment faulting

1. As stretching factor increases and crust thins (to ~10 km), the upper and lower crust become coupled and embrittled.

2. Brittle faults extend through entire crust allowing sea water to access mantle.

3. Partial hydration (serpentinisation) of the upper mantle produces a weak zone that forms a detachment – leading to exhumation of mantle.

Range of factors – rate of extension, sedimentary cover thickness, temperature, and mantle magma supply.
1. Zone of greatest thinning corresponds with area where more stratigraphy is missing (youngest units overlie detachment)
2. Syn-extension units have differences in areal extent
3. Older syn-extensional units can be faulted during ongoing extension
Hyperextension

Insights from the geometry of extended margins

Detachment – localised in Staveley carbonates

Detachment – “young over old” with missing stratigraphy

Older unit - Llewellyn Creek Formation – limited extent

Observations consistent with an extensional setting

Possibly involving hyperextension
Seismic DMQ interpretation

Complete strat

Missing New Hope (=MNQ) and Kuridala (=LCF)

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Prominent packages of reflectors 0-2 sec TWT
Prominent packages of reflectors 2-4 sec TWT
Detachment within Staveley
Steep faults disrupting packages of reflectors

Inverted normal faults overlying regional detachment within Staveley

Weatherly Ck syncline
Middle Ck anticline
Snake Ck anticline

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Reflective crust and shallow moho

Faults in proximity to interpreted surface trace of Cloncurry Thrust and steep NE fault

Prominent packages of reflectors (some may be faults of unspecified ages)

Note that line work highlights a few main features for the purpose of this talk and is not intended as a detailed interpretation.

Poorly reflective crust and deeper moho

“Isa”

“Isa or Numil” Competent block

“Numil” Reflective crust and shallow moho

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CRICOS code 00025B
Prominent packages of reflectors (some may be faults of unspecified ages)

Steep faults in proximity to interpreted surface trace of Cloncurry Fault

Note that line work highlights a few main features for the purpose of this talk and is not intended as a detailed interpretation.
Summary

Seismic data is variable quality but provides clear information: crustal architecture, structural evolution, and surface geology

- Reflective crust of “Numil” extends beneath EFB and Soldiers Cap Group
- Buried competent block (07GA-IG1) may extend south (06GA-04)
- Gidyea “suture” – juxtaposition of crustal blocks “separated” during SCG extension
- Numil may represent highly attenuated “Isa” crust or was accreted prior to SCG deposition
• Structure style / geometry of Isan Orogeny controlled by extensional architecture – low angle faults, fault blocks and detachment
• Crust was highly thinned during SCG deposition
• Staveley (and detachment) extends beneath the SCG
• Soldiers Cap Domain represents a large extensional basin(s) inverted during Isan Orogeny (cf Giles et al., 2006)
• Difficult but possible to “see through” Isan Orogeny and start to understand the extensional fault system
Thank you

Assoc Prof Karen Connors | Principal Research Fellow
WH Bryan Mining and Geology Research Centre
Sustainable Minerals Institute
k.connors@uq.edu.au

www.smi.uq.edu.au

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