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Central Eastern Fold Belt Solid Geology

Insights from crustal architecture

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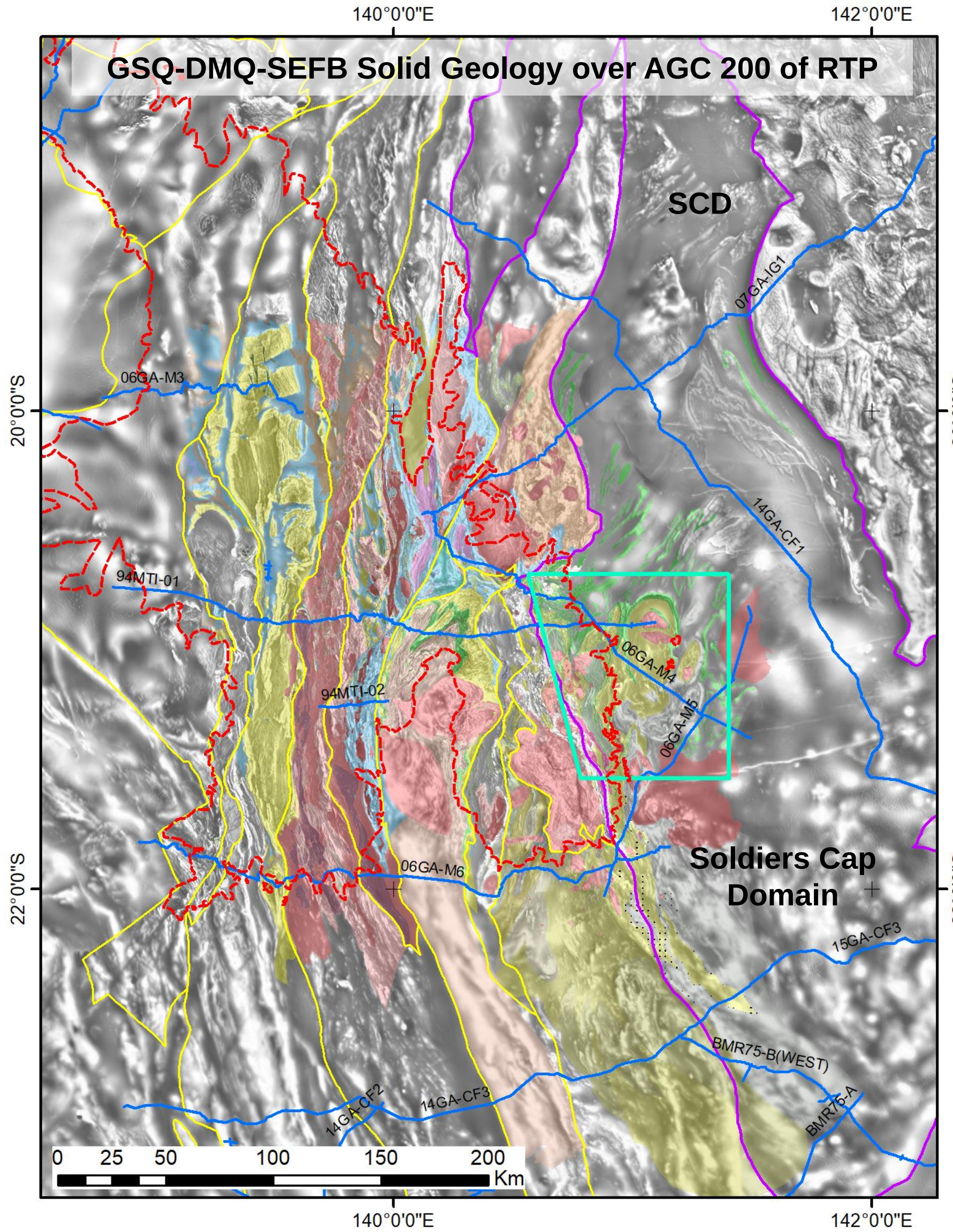
DNRME New Discovery Program, Technical Workshop, September 19, 2019

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



Legend

- Central EFB Project Area
- Mt Isa Inlier Outcrop
- Seismic 2019
- Soldiers Cap Domain
- Mt Isa Domains GSQ / GA

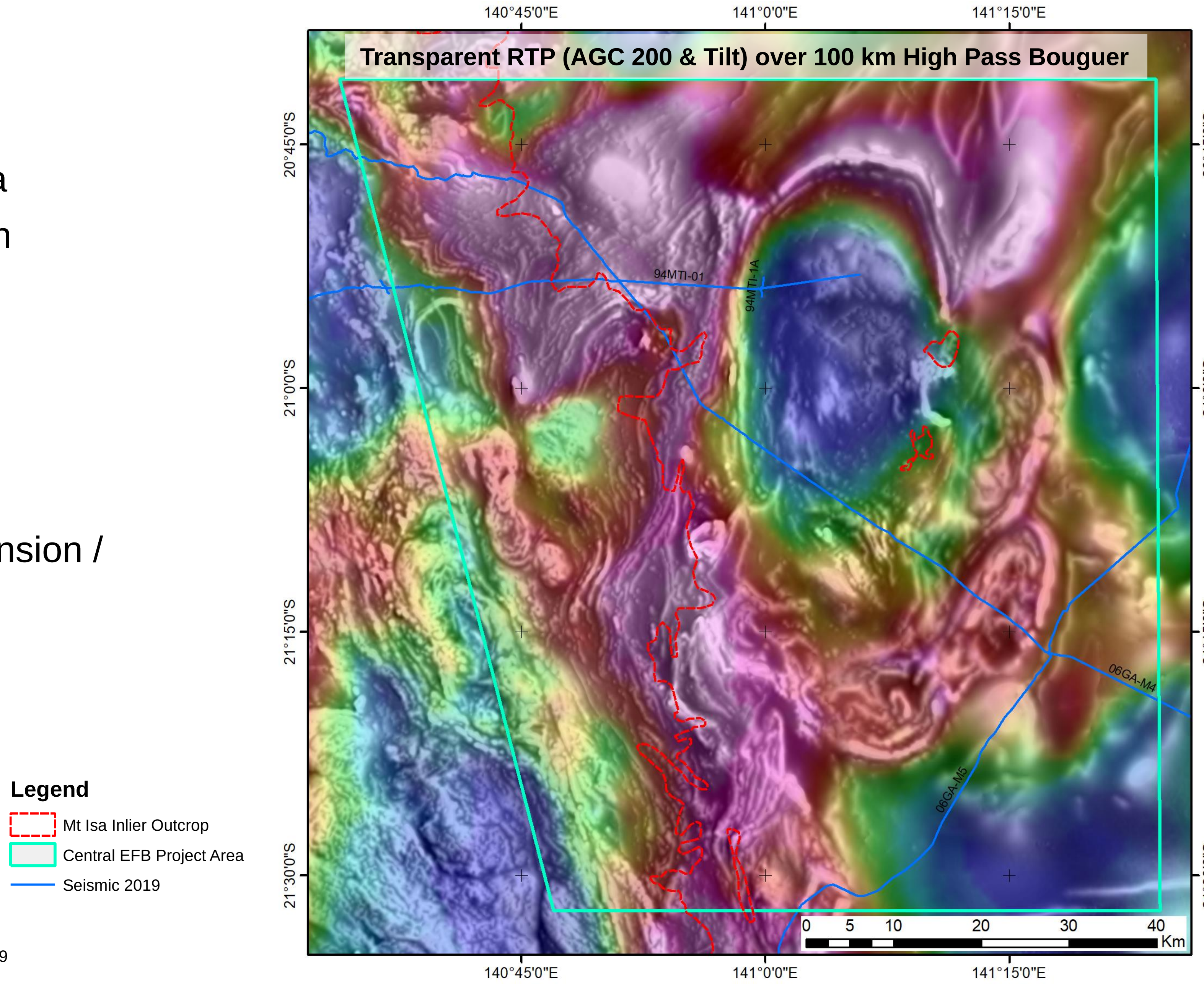
Location and seismic

Approach

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

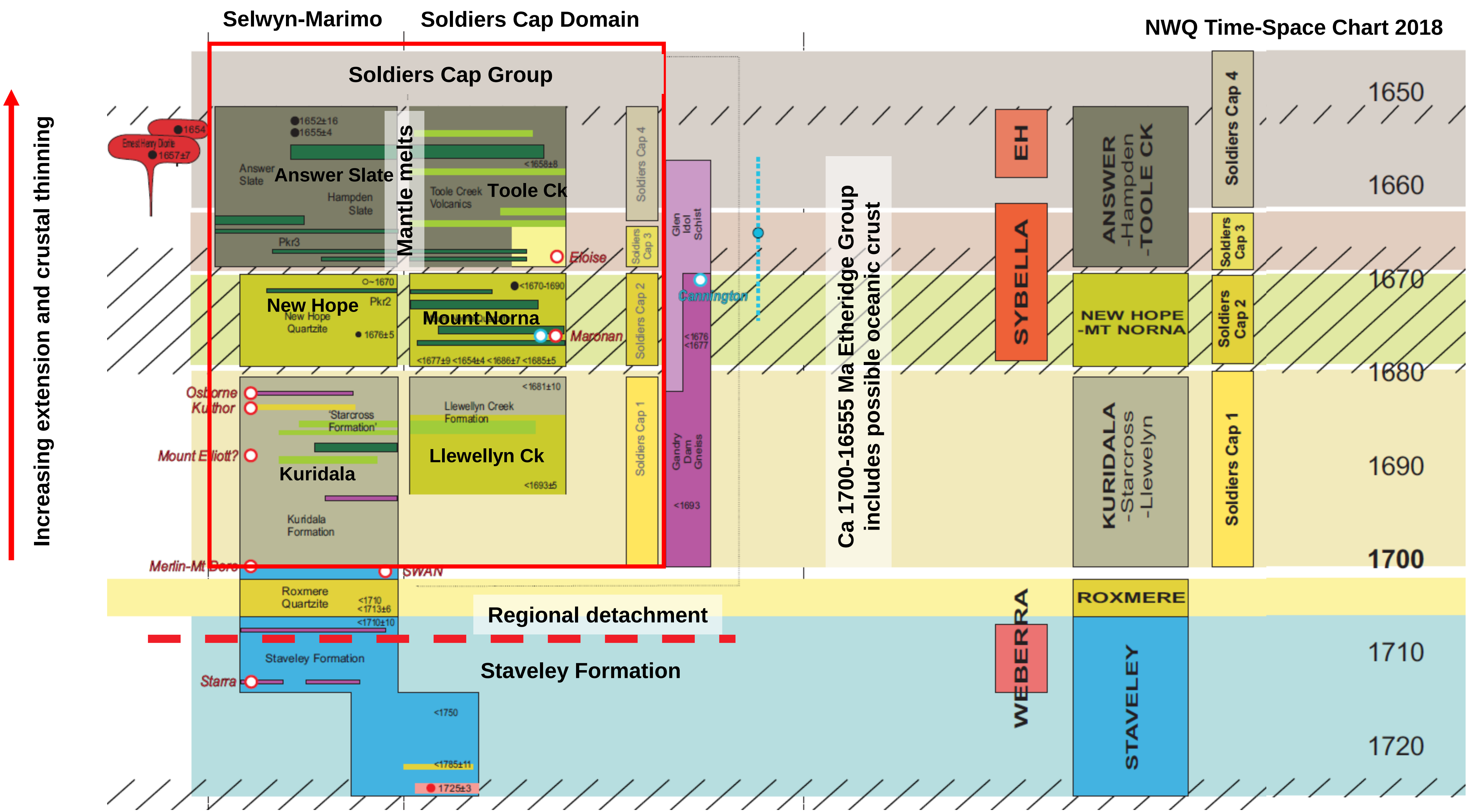
Outline

- Stratigraphy
- Regional seismic
- Evidence for SCG extension / hyperextension
- Seismic in AOI
- Conclusions



Sratigraphy

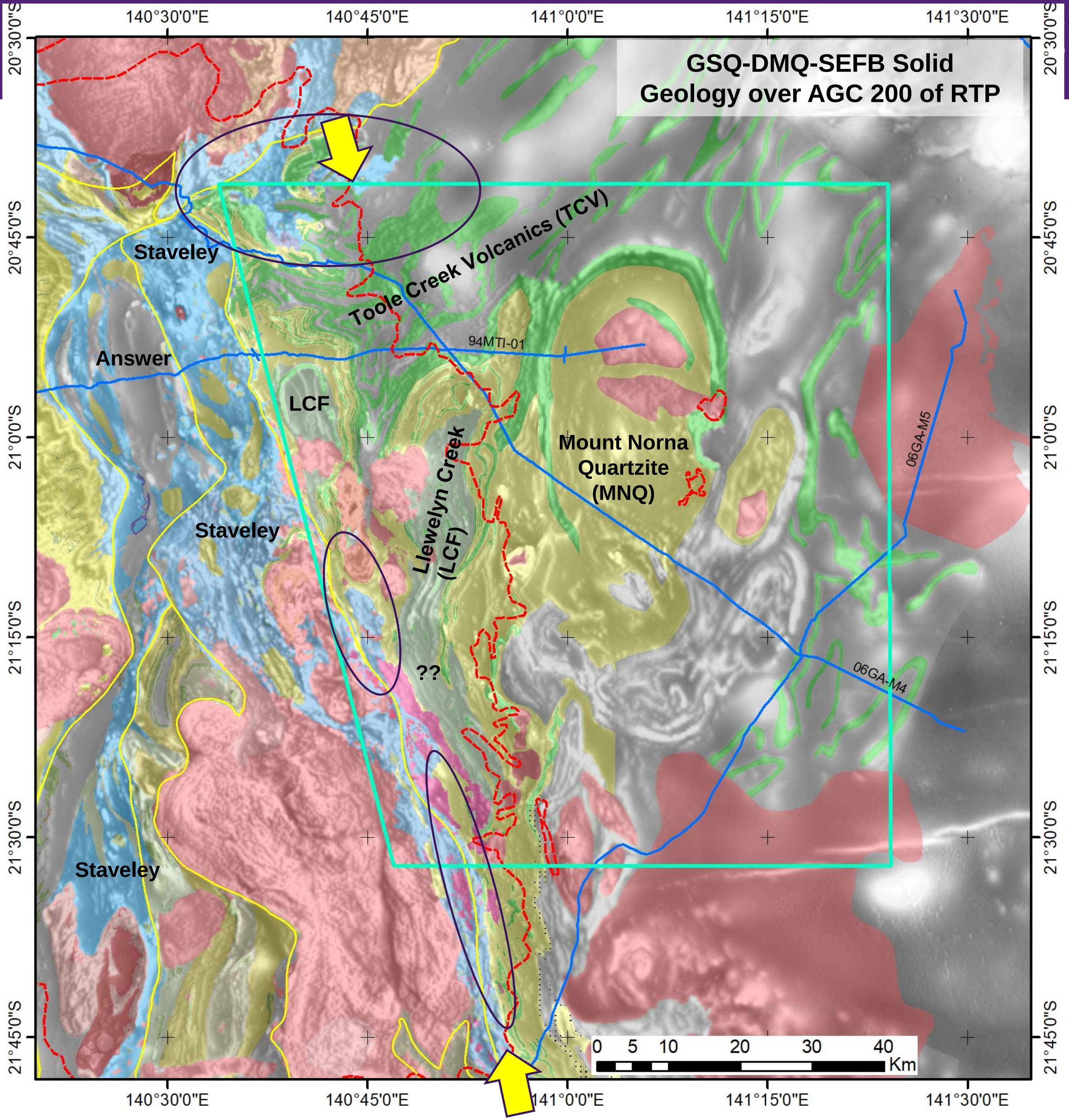
Isan Orogeny from ca 1606 Ma (low-P, high-T prograde metamorphism); crustal thickening (E-W shortening) ca 1590-1570 Ma



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



Legend

- Mt Isa Inlier Outcrop
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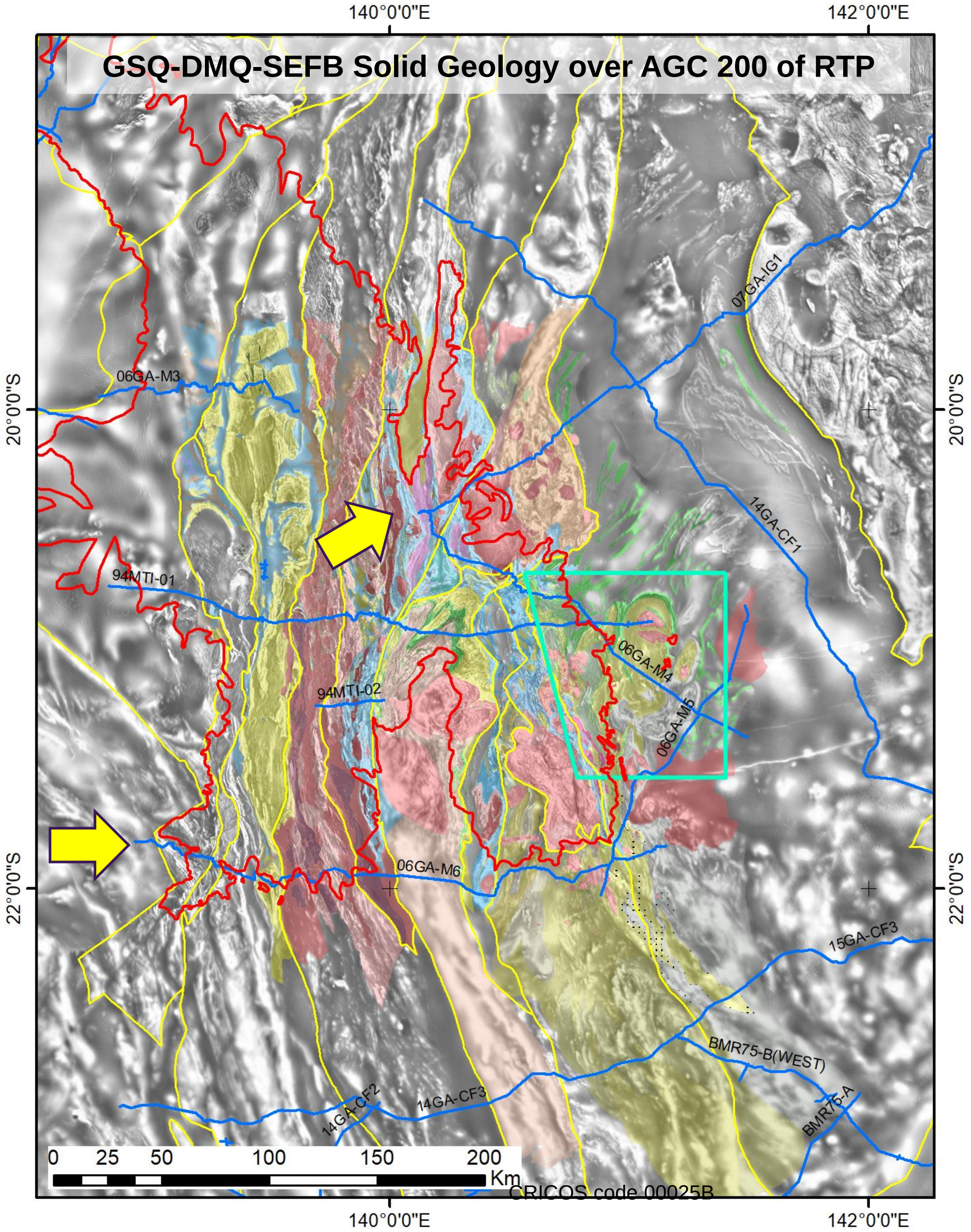
Location and seismic

Seismic data

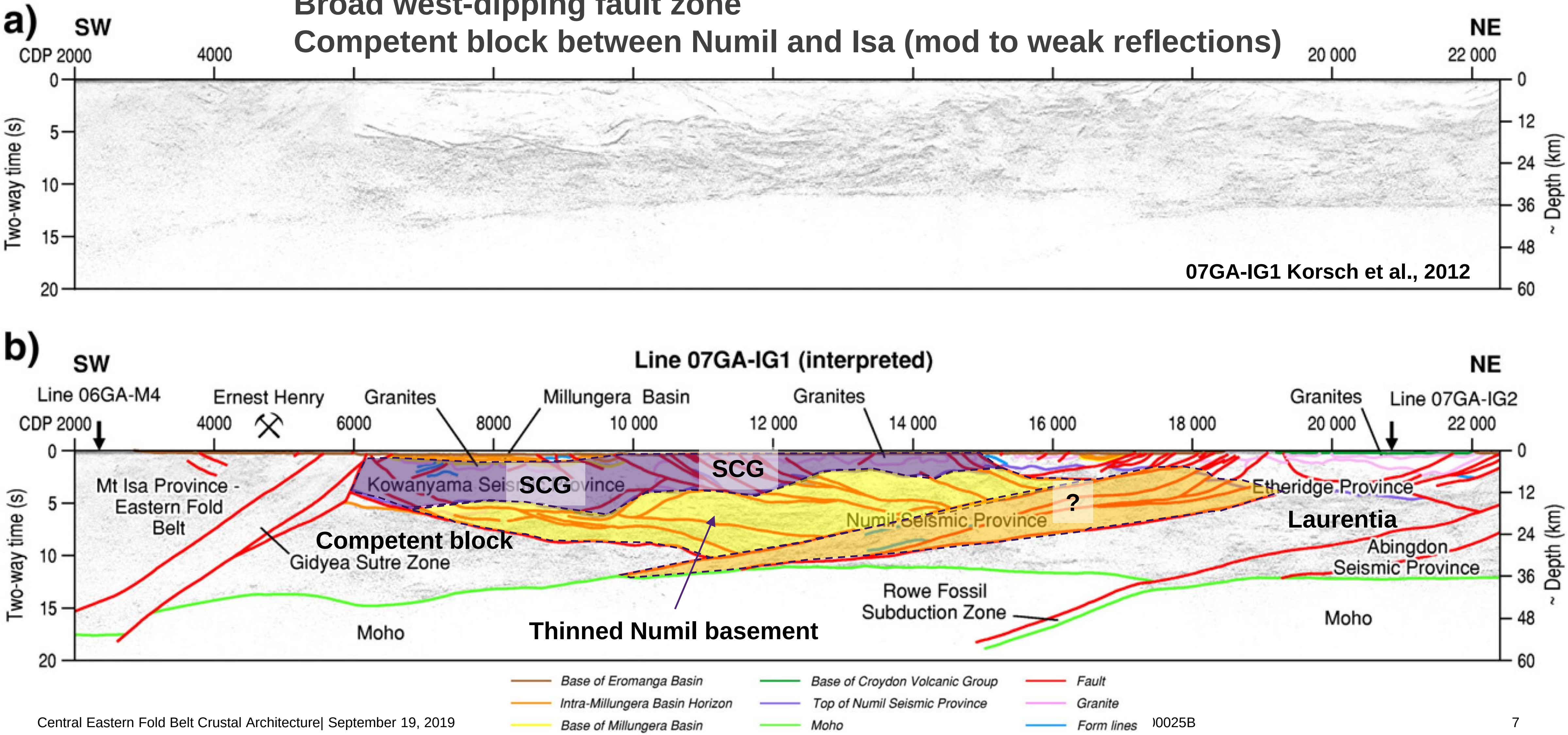
- Different and competing interpretations
- Variable data quality

- Some clear observations can be made
- …. provide fundamental constraints

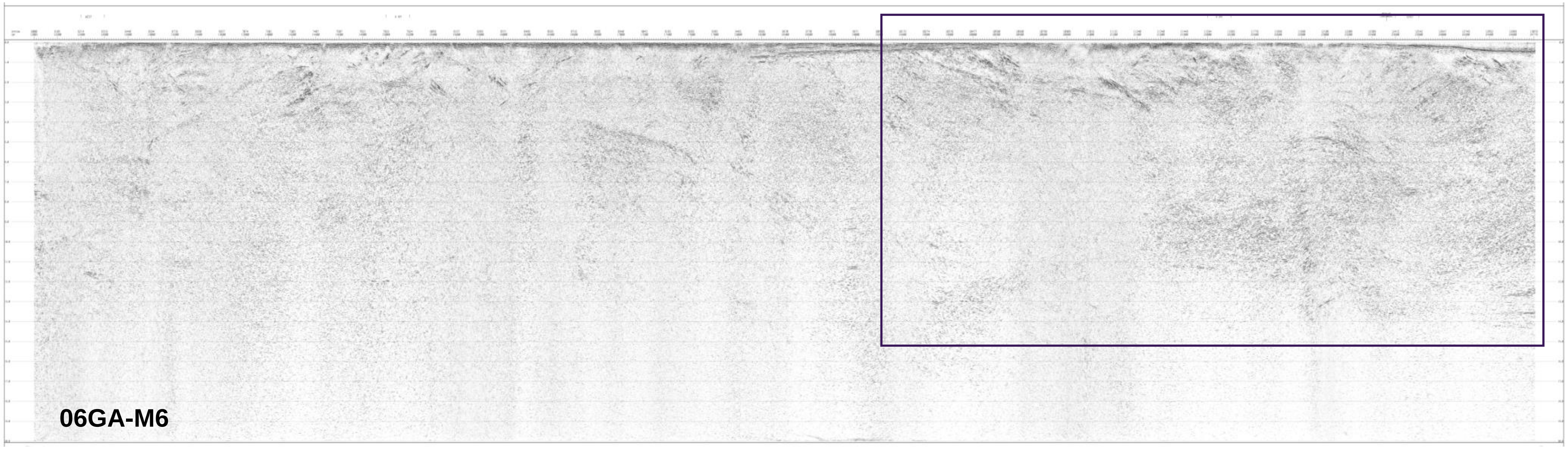


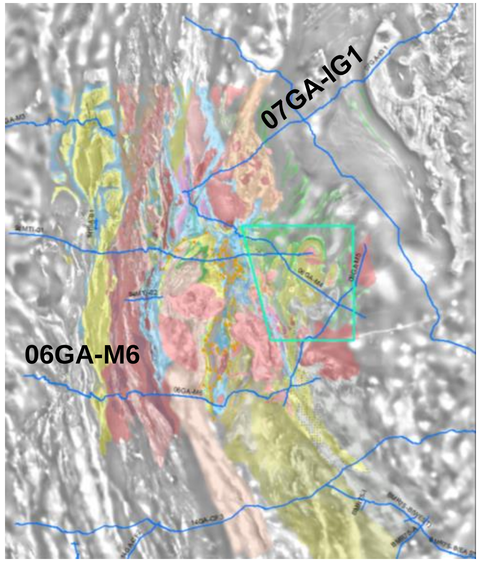
Regional Seismic

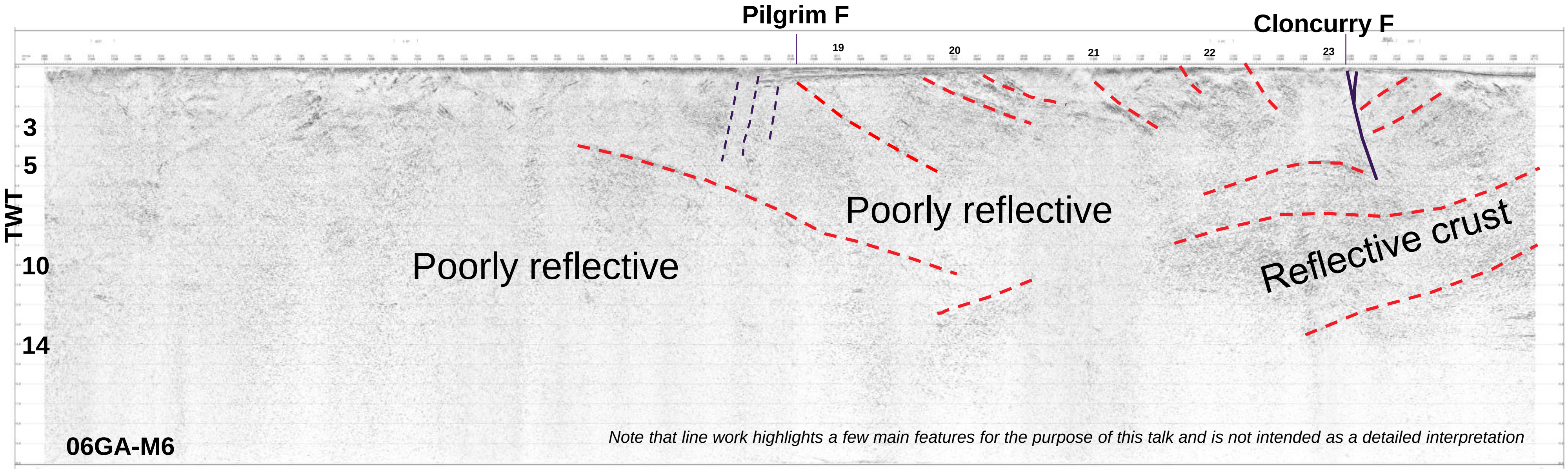
Numil crust highly reflective and thinner
“Isa” crust – poorly reflective and thicker
Broad west-dipping fault zone
Competent block between Numil and Isa (mod to weak reflections)



Regional Seismic



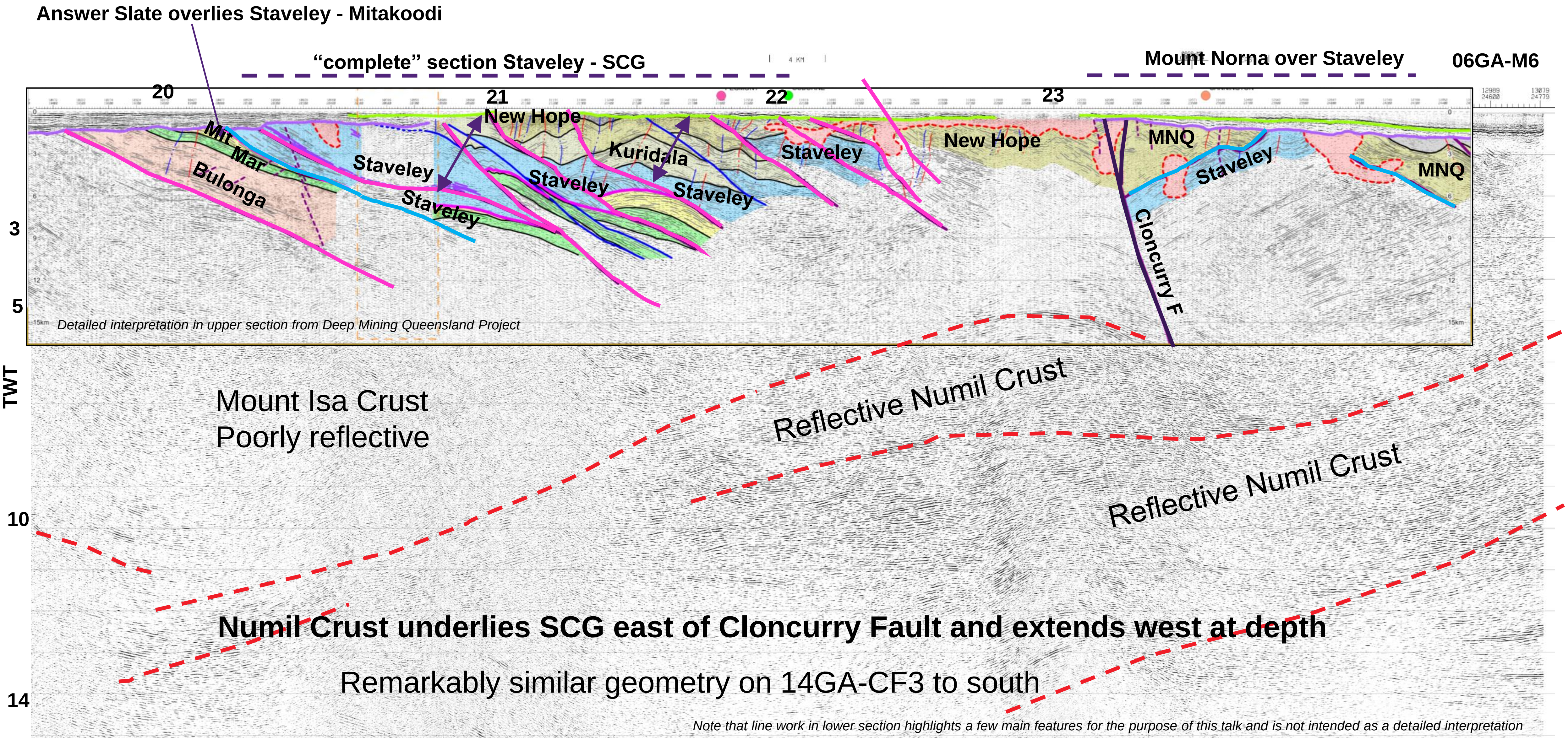




Prominent packages of reflectors (some may be faults of unspecified age)

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

Regional Seismic – DMQ interpretation



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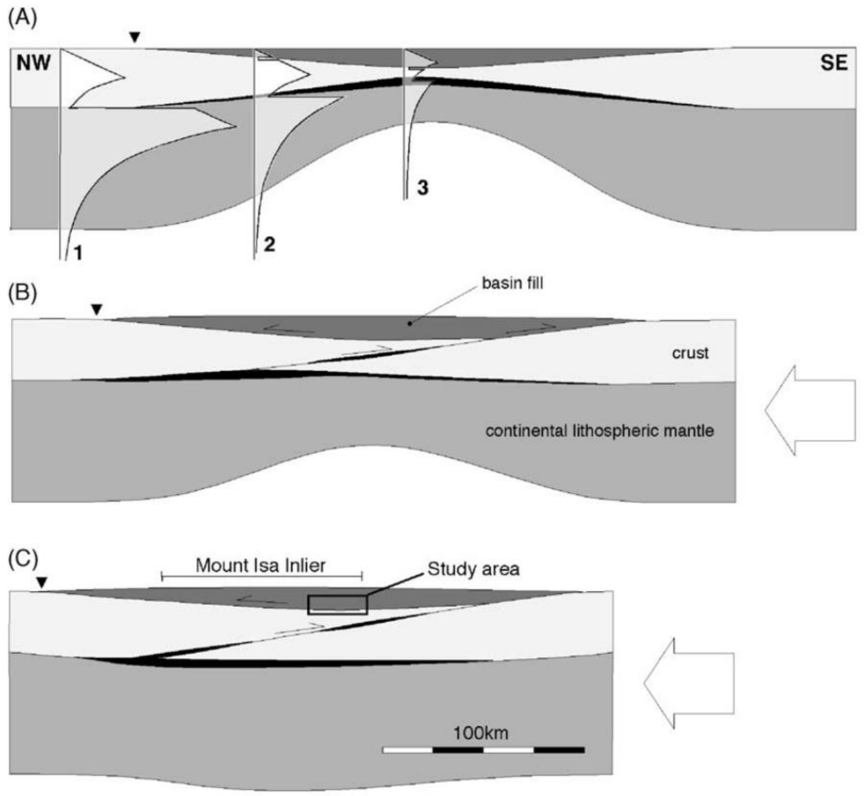
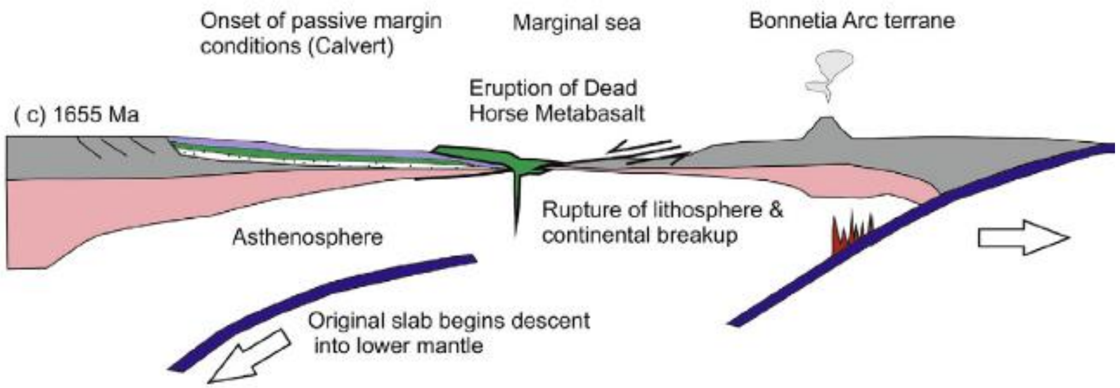
SCG extensional models - intracontinental basin (Ellis and Wyborn, 1984; Williams, 1998; Hattan, 2004; Giles et al., 2006) **or back-arc** (Gibson et al., 2008; 2016; 2018)

Difficult to quantify crustal thinning



Giles et al. (2006)



Gibson et al. (2018)

Extension

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

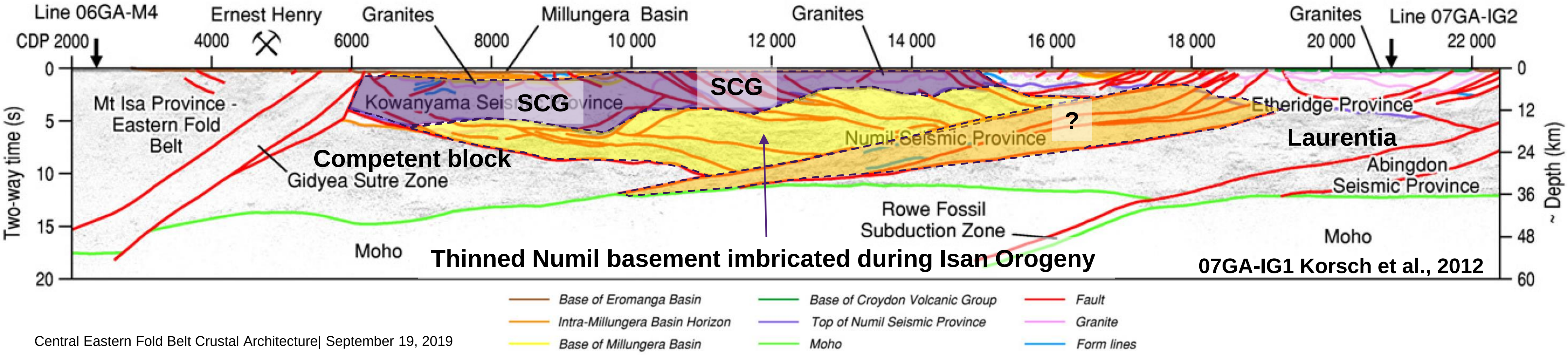
Possible oceanic crust to east (Etheridge Province; Baker et al., 2010)

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

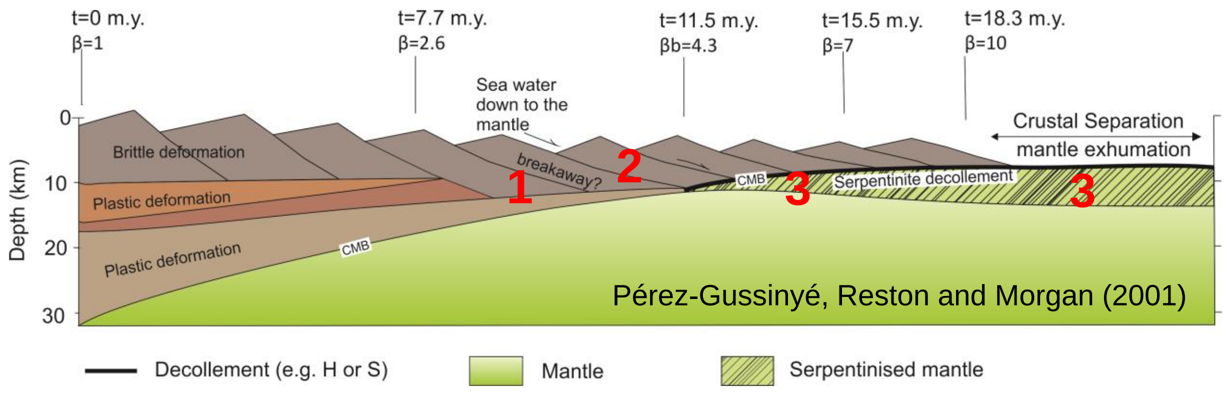
Implications for geometry of EFB prior to Isan Orogeny



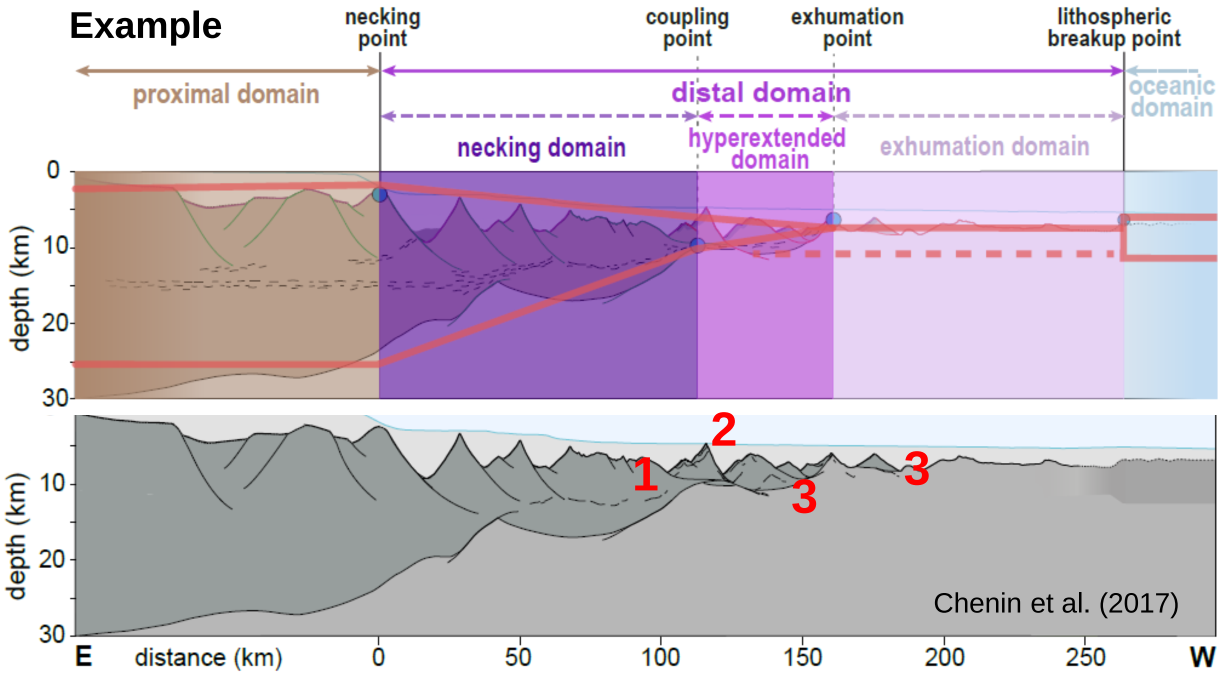
Extension and hyperextension

Insights from the geometry of extended margins

Schematic section



Example



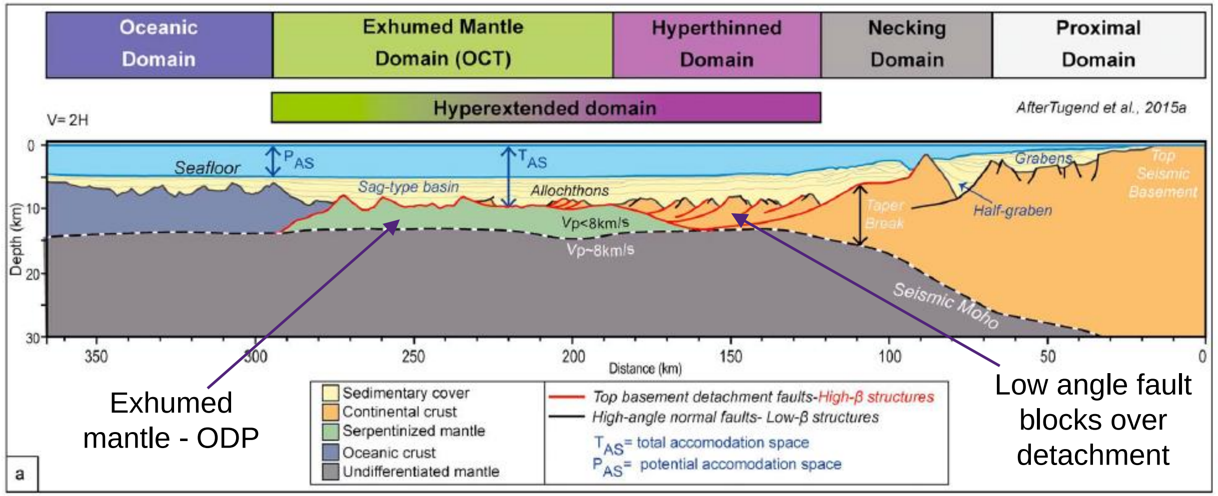
Hyperextension, serpentinisation and detachment faulting

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

Hyperextension - examples

Cardenas et al. (2018) Iberian margin (Portugal)



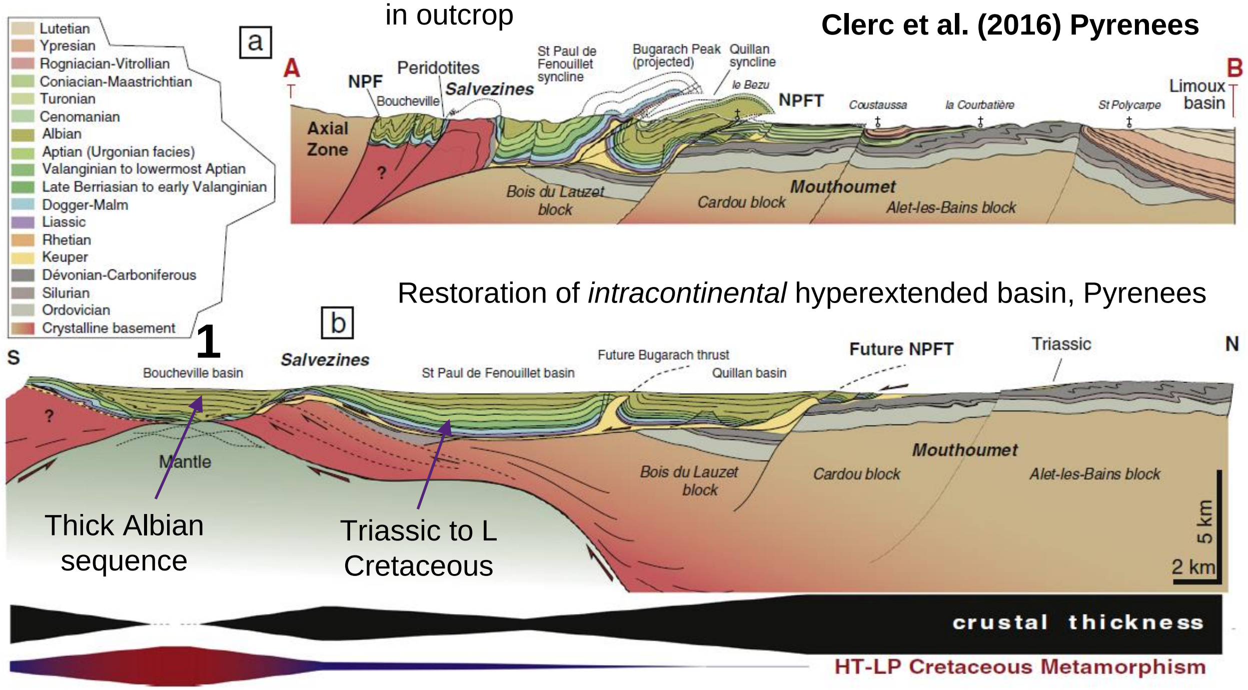
Exhumed mantle - ODP

Low angle fault blocks over detachment

Mantle peridotites in outcrop

Clerc et al. (2016) Pyrenees

Restoration of *intracontinental* hyperextended basin, Pyrenees

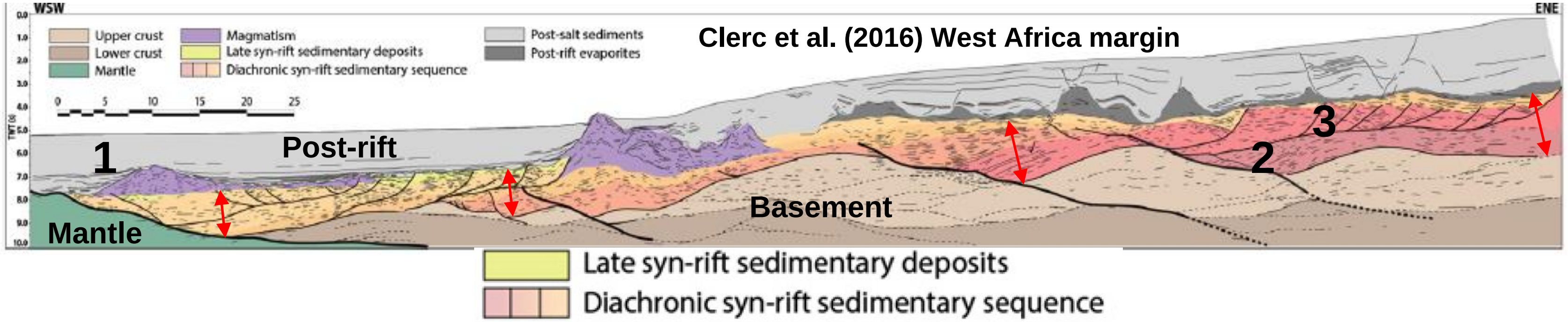


Thick Albian sequence

Triassic to L Cretaceous

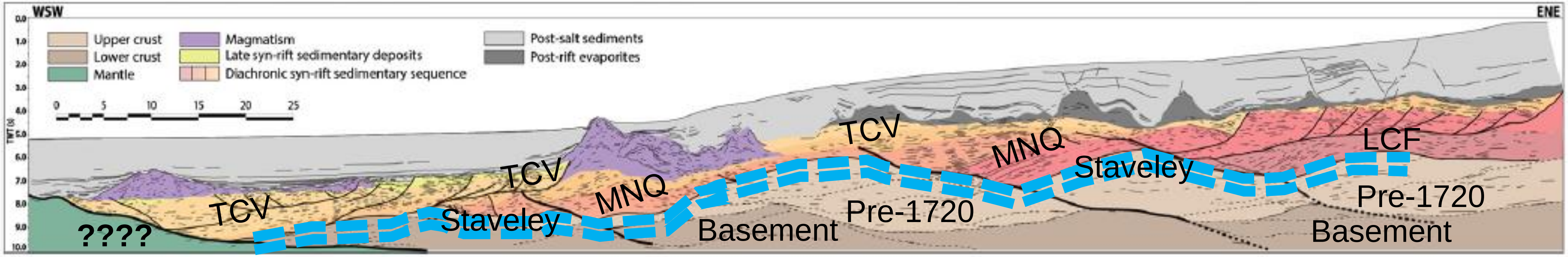
1. Zone of greatest thinning corresponds with area where more stratigraphy is missing (youngest units overlie detachment)
2. Syn-extension units have differences in areal extent
3. Older syn-extensional units can be faulted during ongoing extension

Clerc et al. (2016) West Africa margin



Hyperextension

Insights from the geometry of extended margins



Clerc et al. (2016)

Detachment – localised in Staveley carbonates

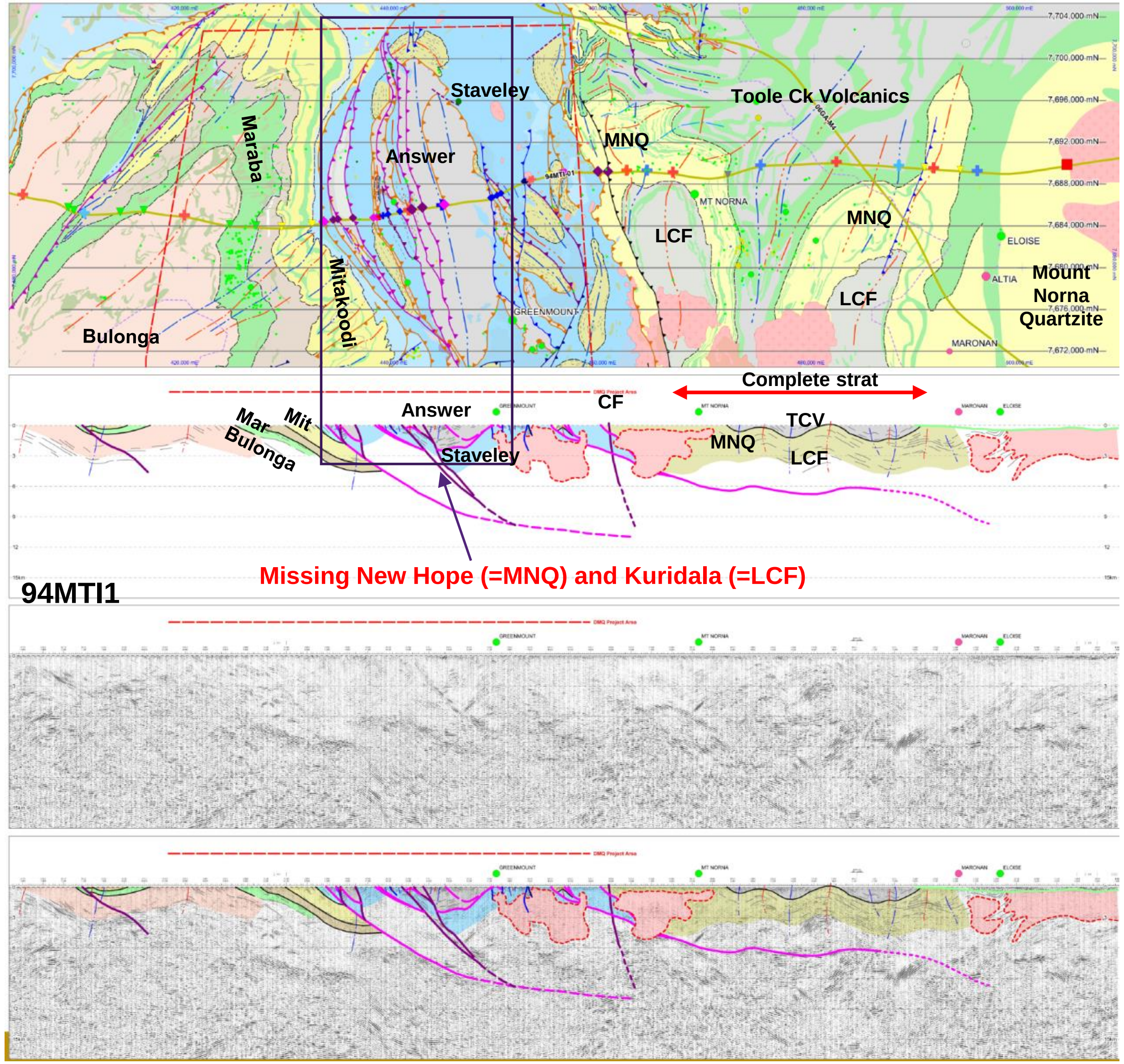
Detachment – "young over old" with missing stratigraphy

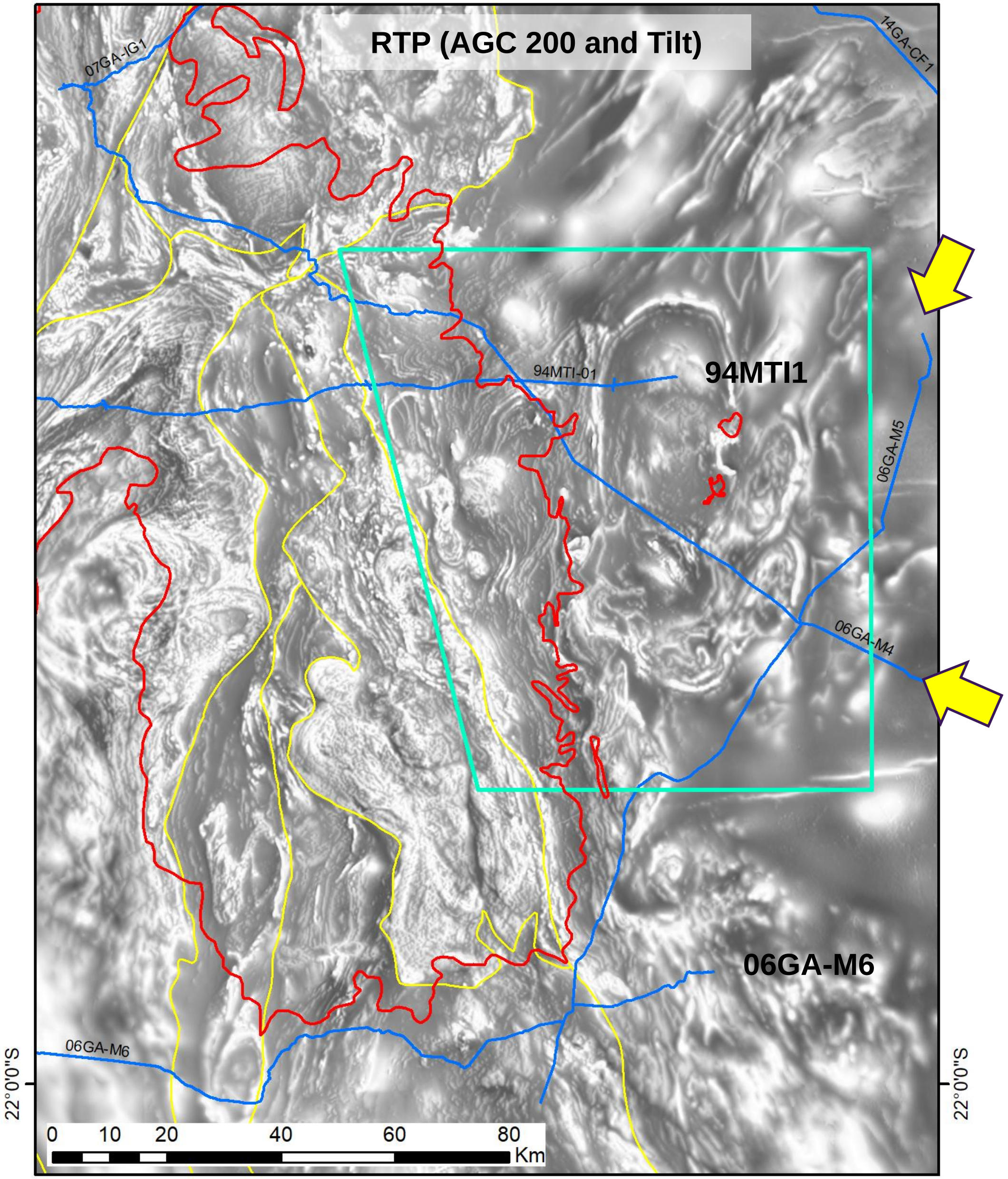
Older unit - Llewellyn Creek Formation – limited extent

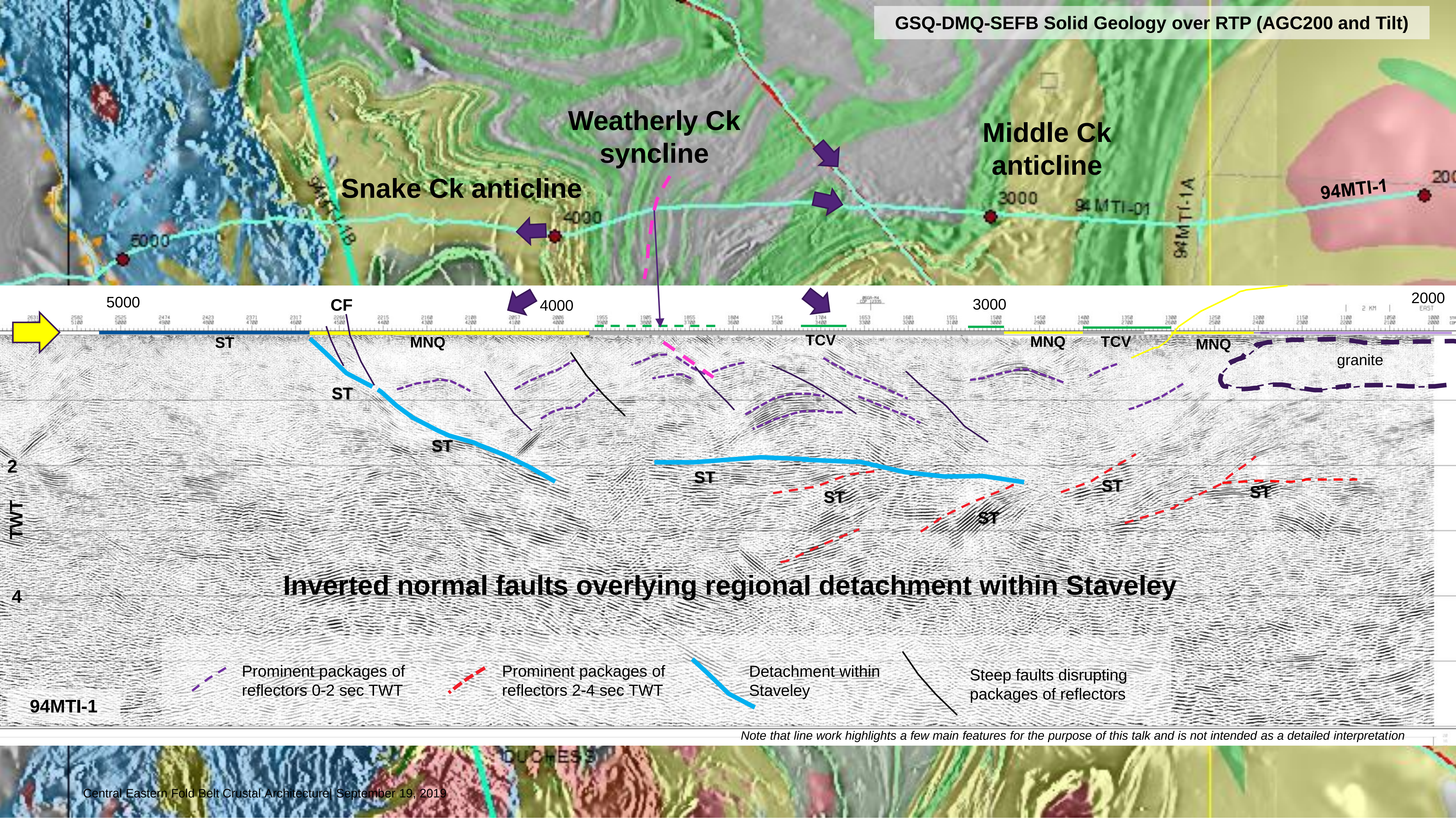
Observations consistent with an extensional setting

Possibly involving hyperextension

Seismic DMQ interpretation

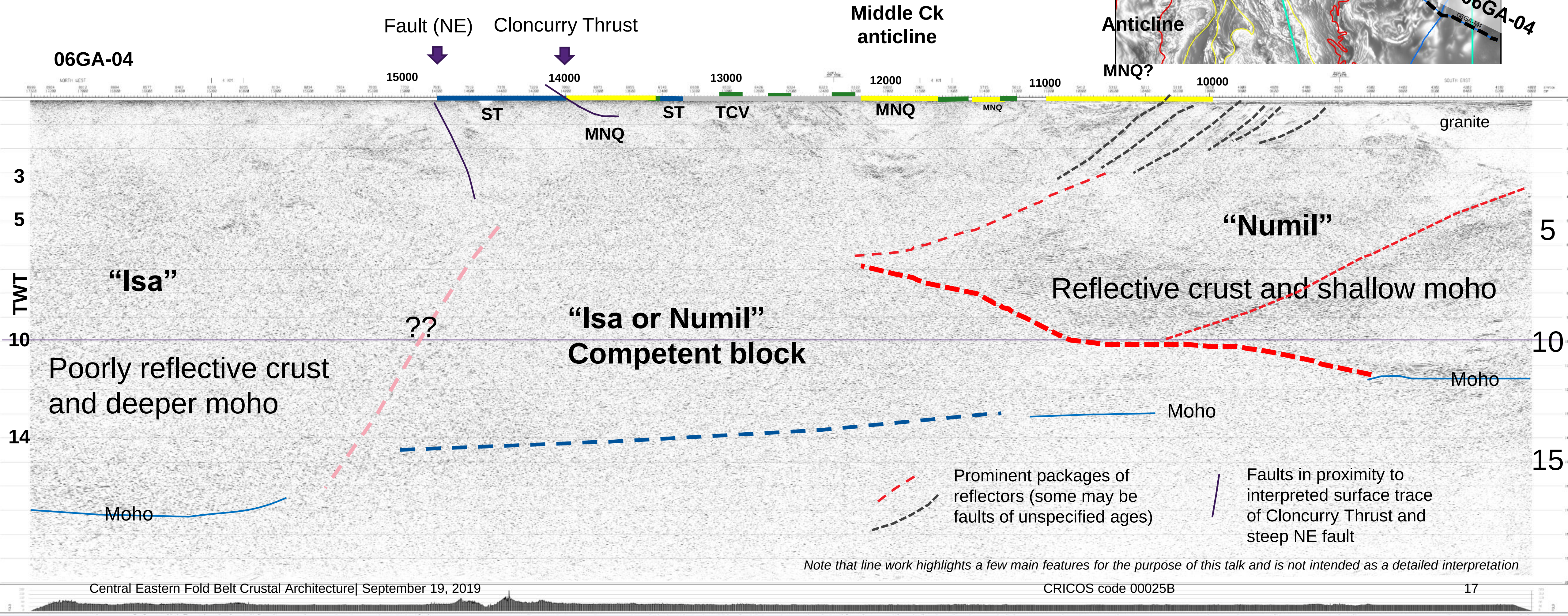


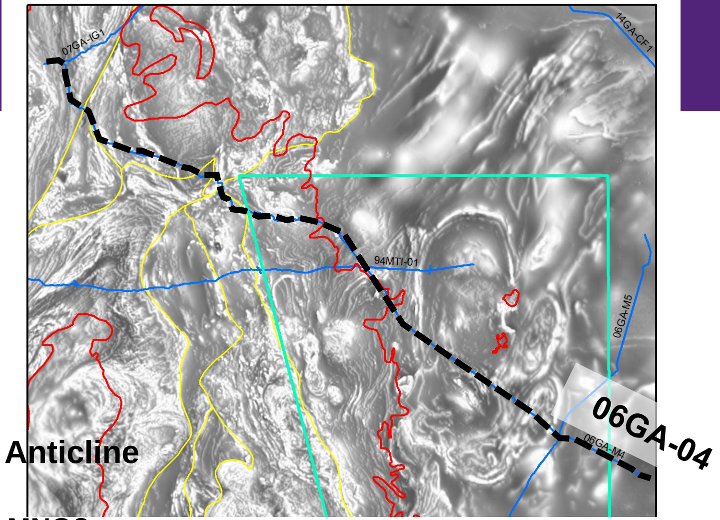




Note that line work highlights a few main features for the purpose of this talk and is not intended as a detailed interpretation

Seismic 06GA-M4





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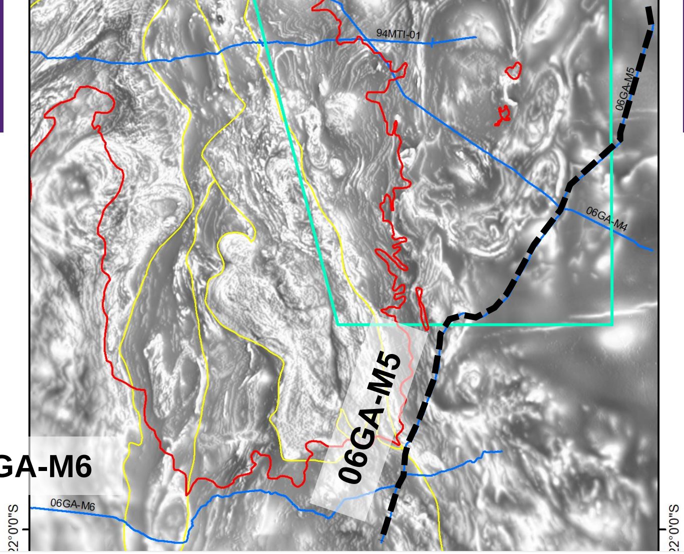
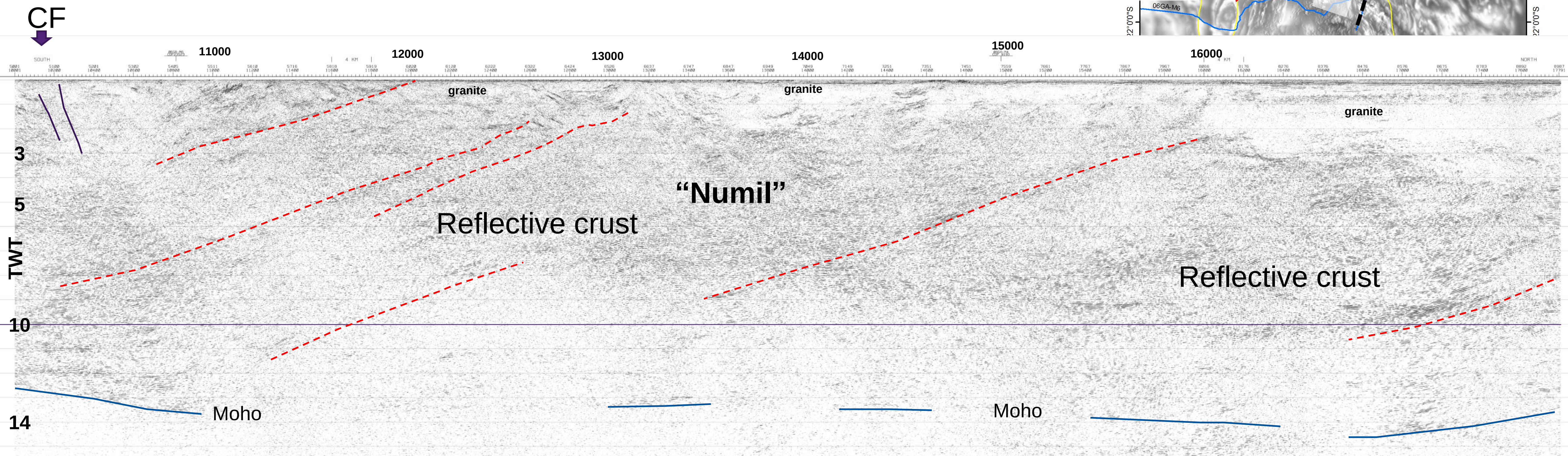
Seismic 06GA-M5





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

Steep faults in proximity to interpreted surface trace of Cloncurry Fault

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Summary

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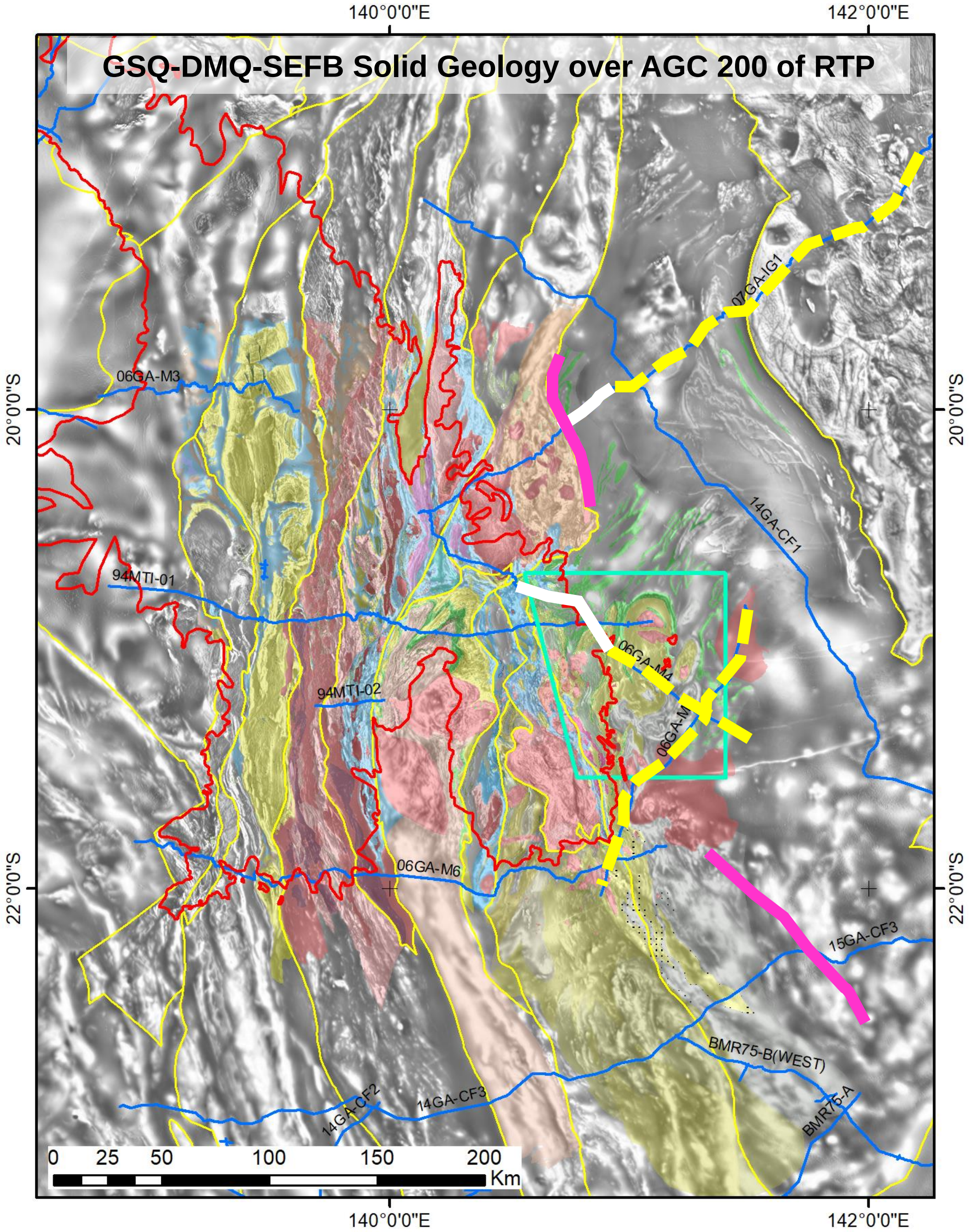
Seismic data is variable quality but provides clear information:

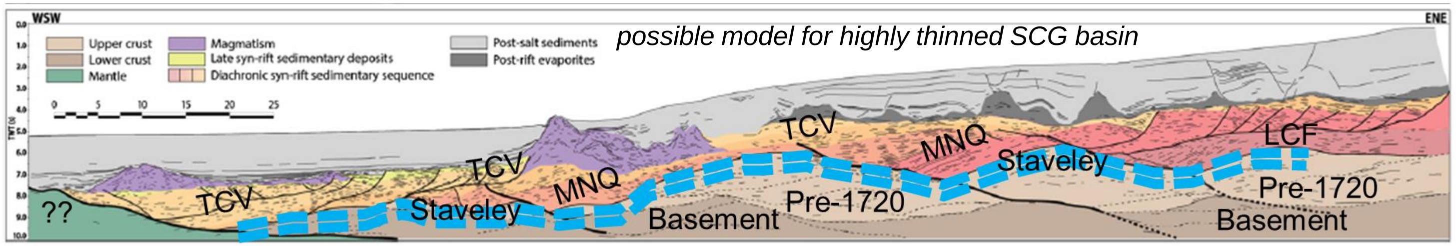
crustal architecture, structural evolution, and surface geology

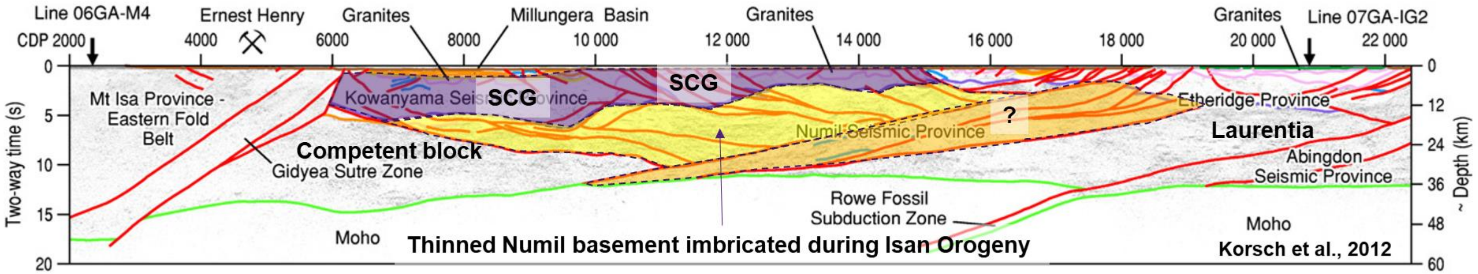
- Reflective crust of “Numil” extends beneath EFB and Soldiers Cap Group
- Buried competent block (07GA-IG1) may extend south (06GA-04)
- Gidyea “suture” – juxtaposition of crustal blocks “separated” during SCG extension
- Numil may represent highly attenuated “Isa” crust *or* was accreted prior to SCG deposition

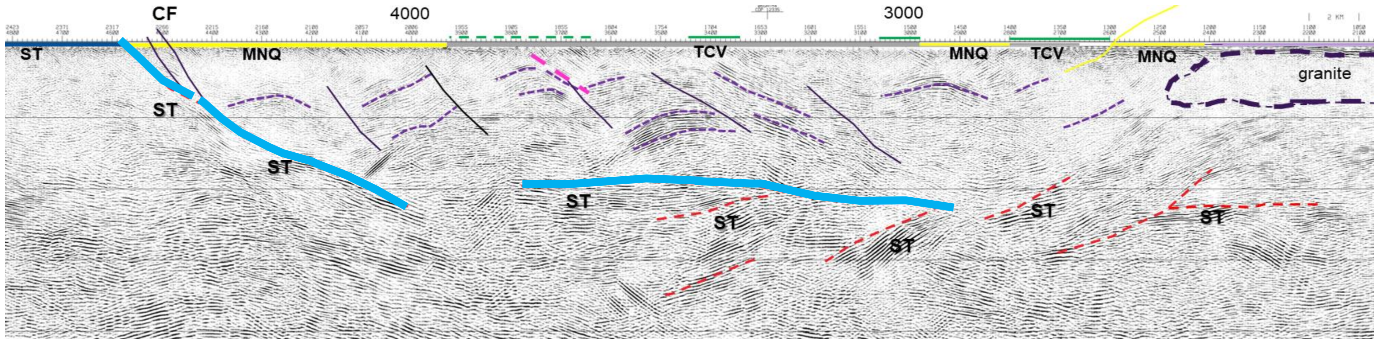


Summary

- 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







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Thank you

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