The Epic Saga of Tavan Har

Phanerozoic Continental Growth, Collisional Orogenesis, and Intraplate Deformation in Southeastern Mongolia

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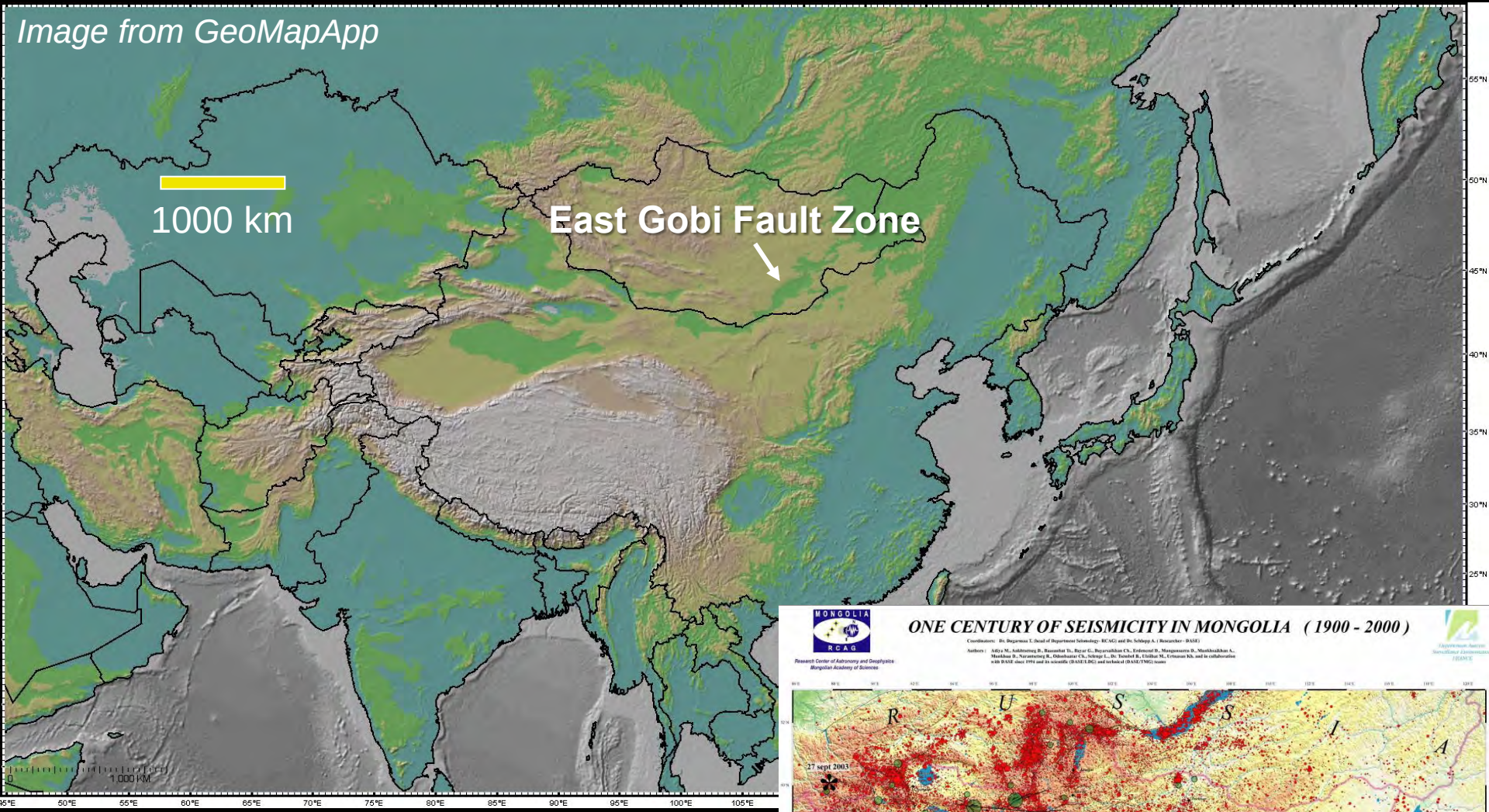
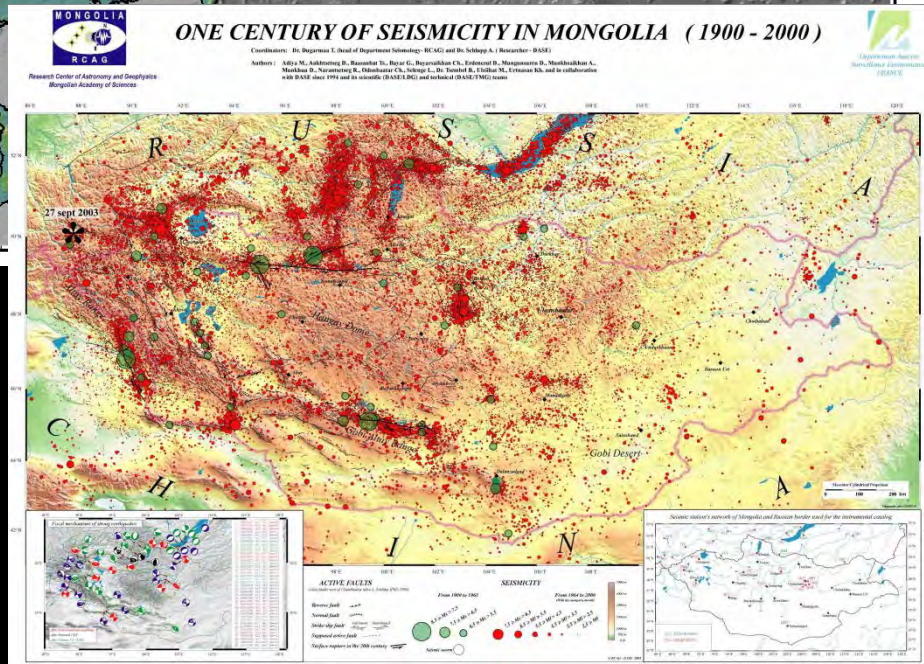
This saga's relevance to EarthScope goals

- **Faults and earthquake processes**
  - What structural and geologic factors give rise to intraplate regions seismicity?
- **Continental Structure**
  - How are continental structure and deformation related?
  - What are the fundamental controls on deformation of the continent?
  - How is deformation distributed throughout the continent?

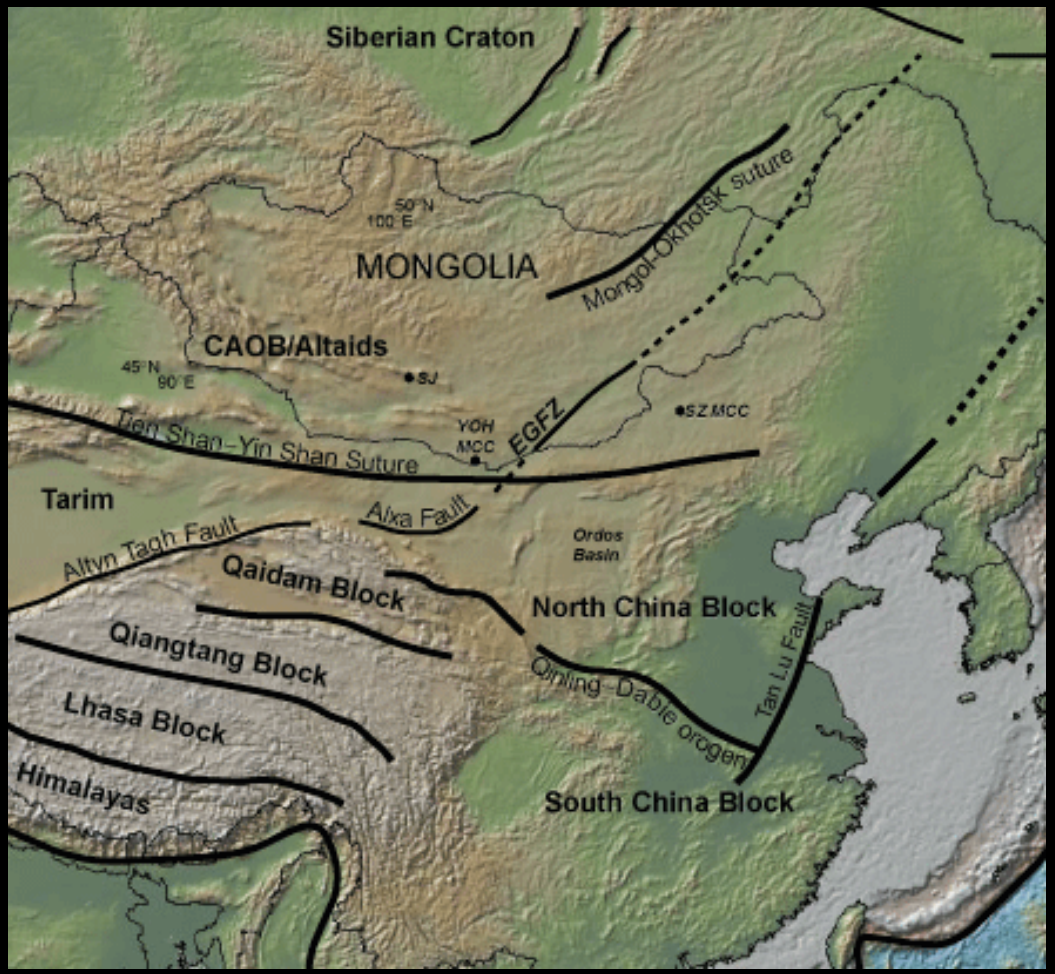


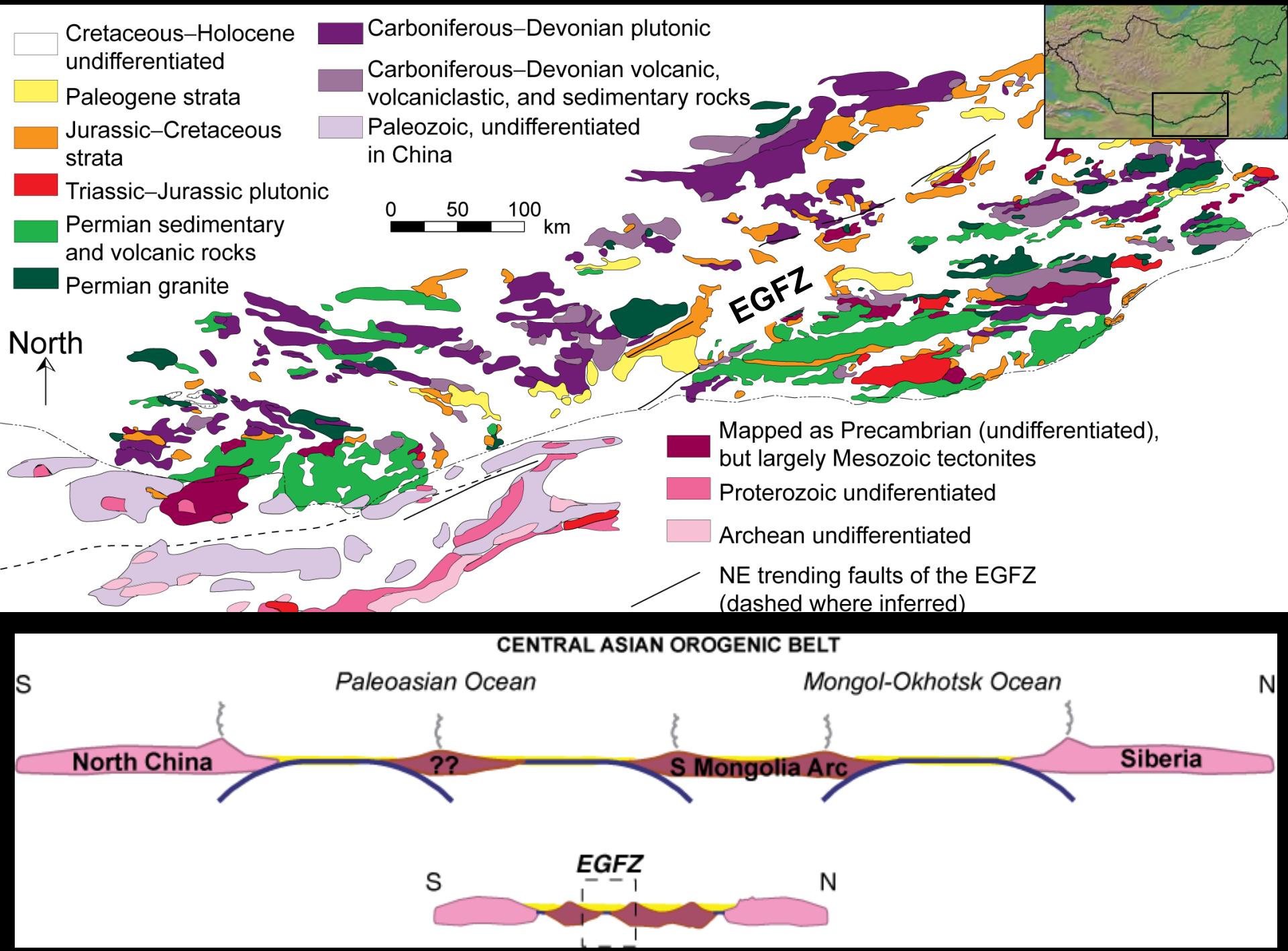


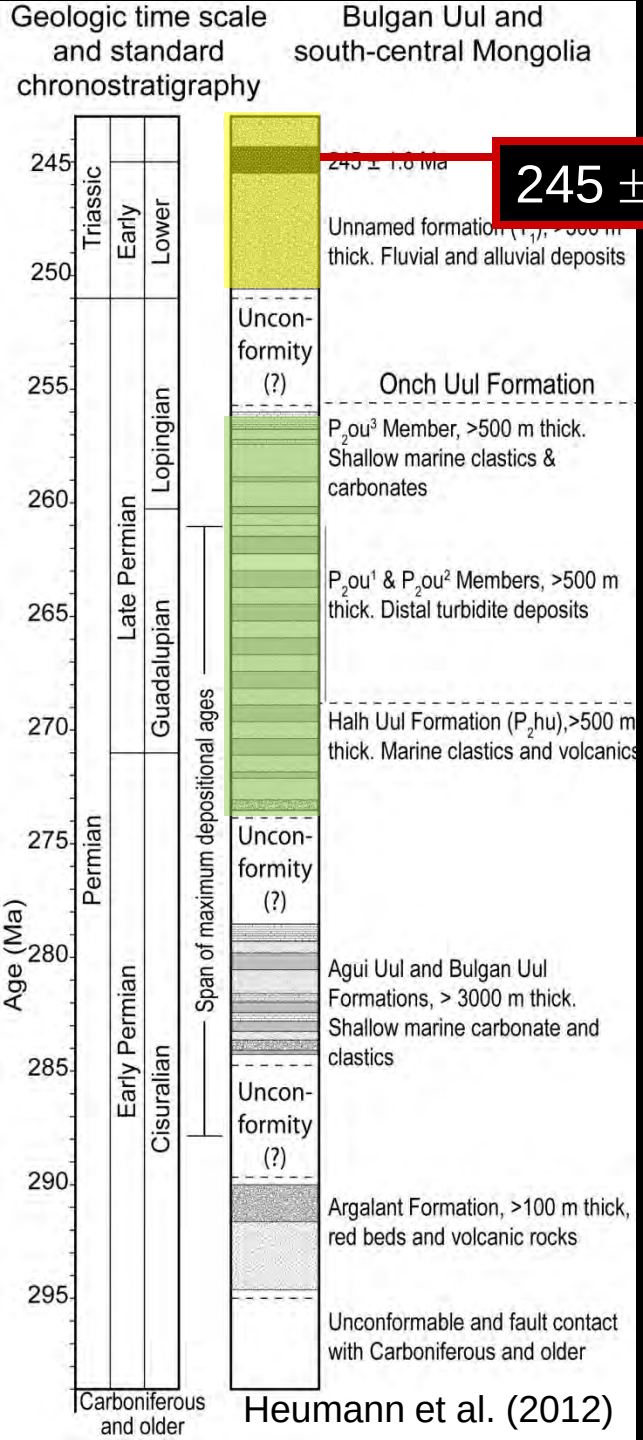
Modern intraplate deformation due to far field forces

Tectonic evolution of SE Mongolia

- Nucleus of Asian continental growth in Pz–Mz
- Mz–Cz intracontinental deformation



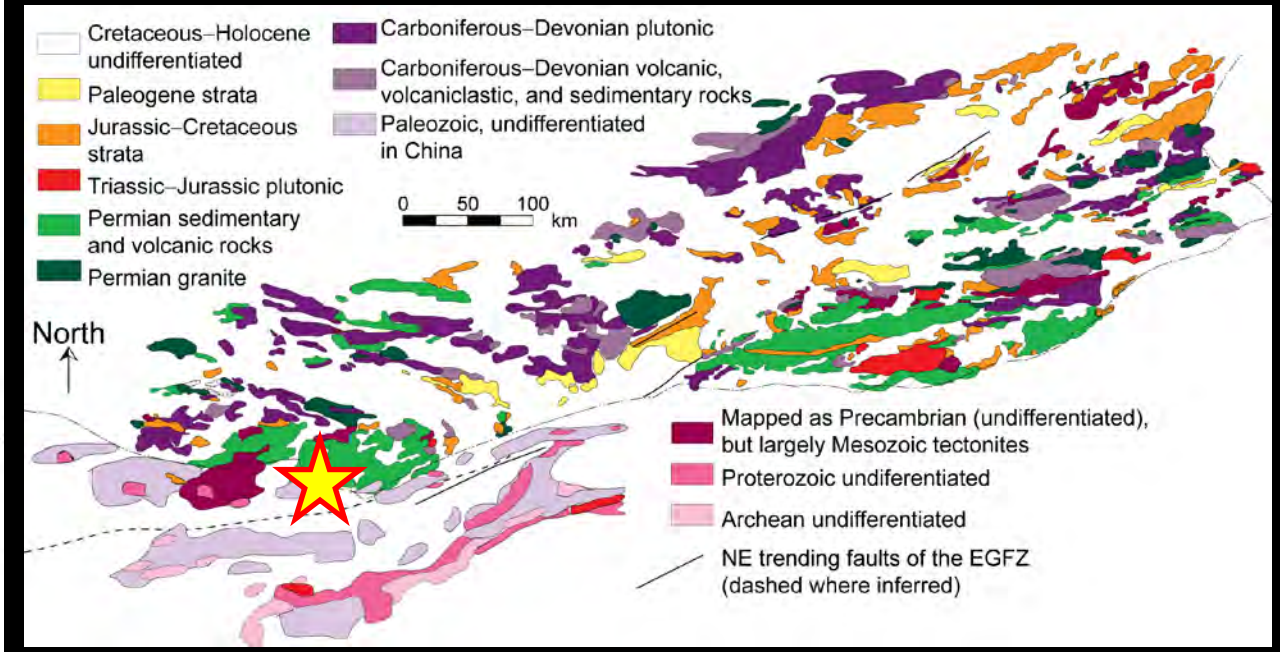

Cretaceous–Holocene undifferentiated
Paleogene strata
Jurassic–Cretaceous strata
Triassic–Jurassic plutonic
Permian sedimentary and volcanic rocks
Permian granite
Carboniferous–Devonian plutonic
Carboniferous–Devonian volcanic, volcaniclastic, and sedimentary rocks
Paleozoic, undifferentiated in China
0 50 100 km
North
EGFZ
Mapped as Precambrian (undifferentiated), but largely Mesozoic tectonites
Proterozoic undiferentiated
Archean undifferentiated
NE trending faults of the EGFZ (dashed where inferred)
CENTRAL ASIAN OROGENIC BELT
S
Paleoasian Ocean
Mongol-Okhotsk Ocean
N
North China
??
S Mongolia Arc
Siberia
EGFZ
S
N

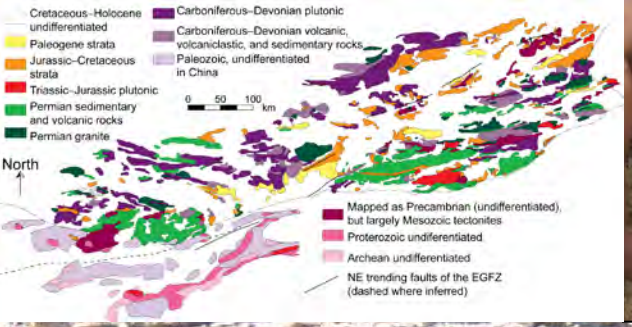


Heumann et al. (2012)

245 ± 1.8 Ma

- $^{40}Ar/^{39}Ar$ hbl age from sill provides minimum age for the marine to non-marine transition associated with closure of the Paleoasian ocean.

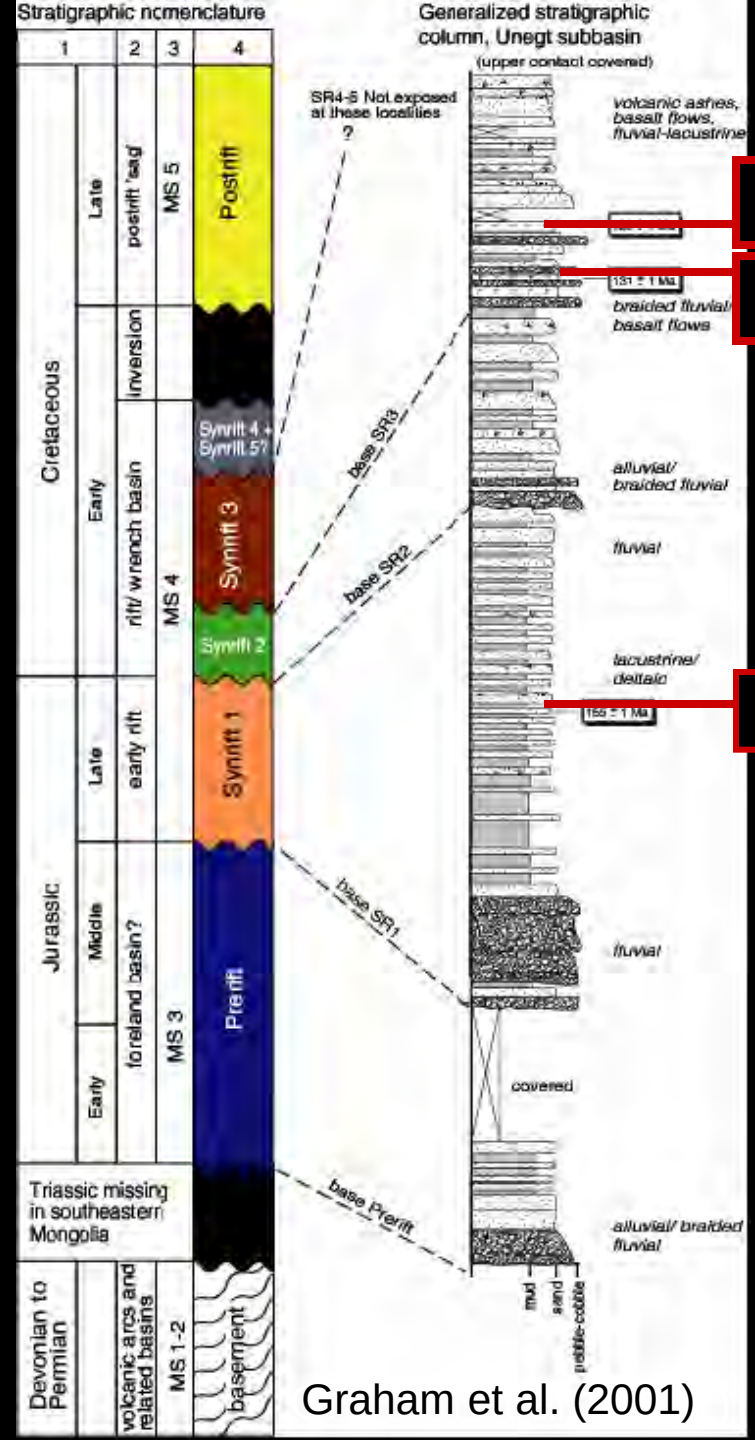




Upper Cretaceous

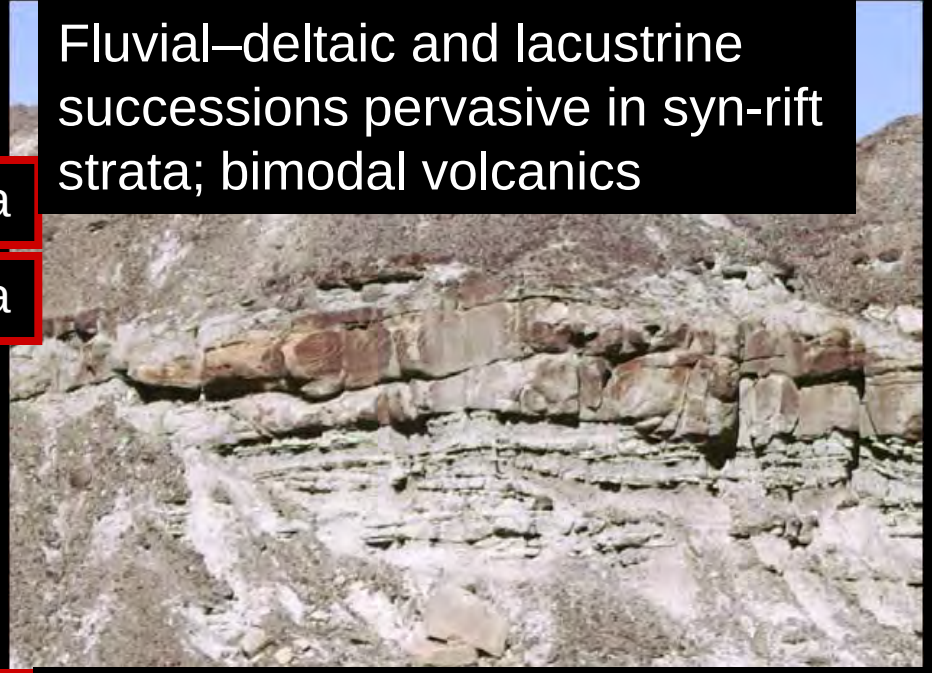
Lower Cretaceous

- Important time marker: regional unconformity between syn-rift J_3–K_1 and post-rift K_2



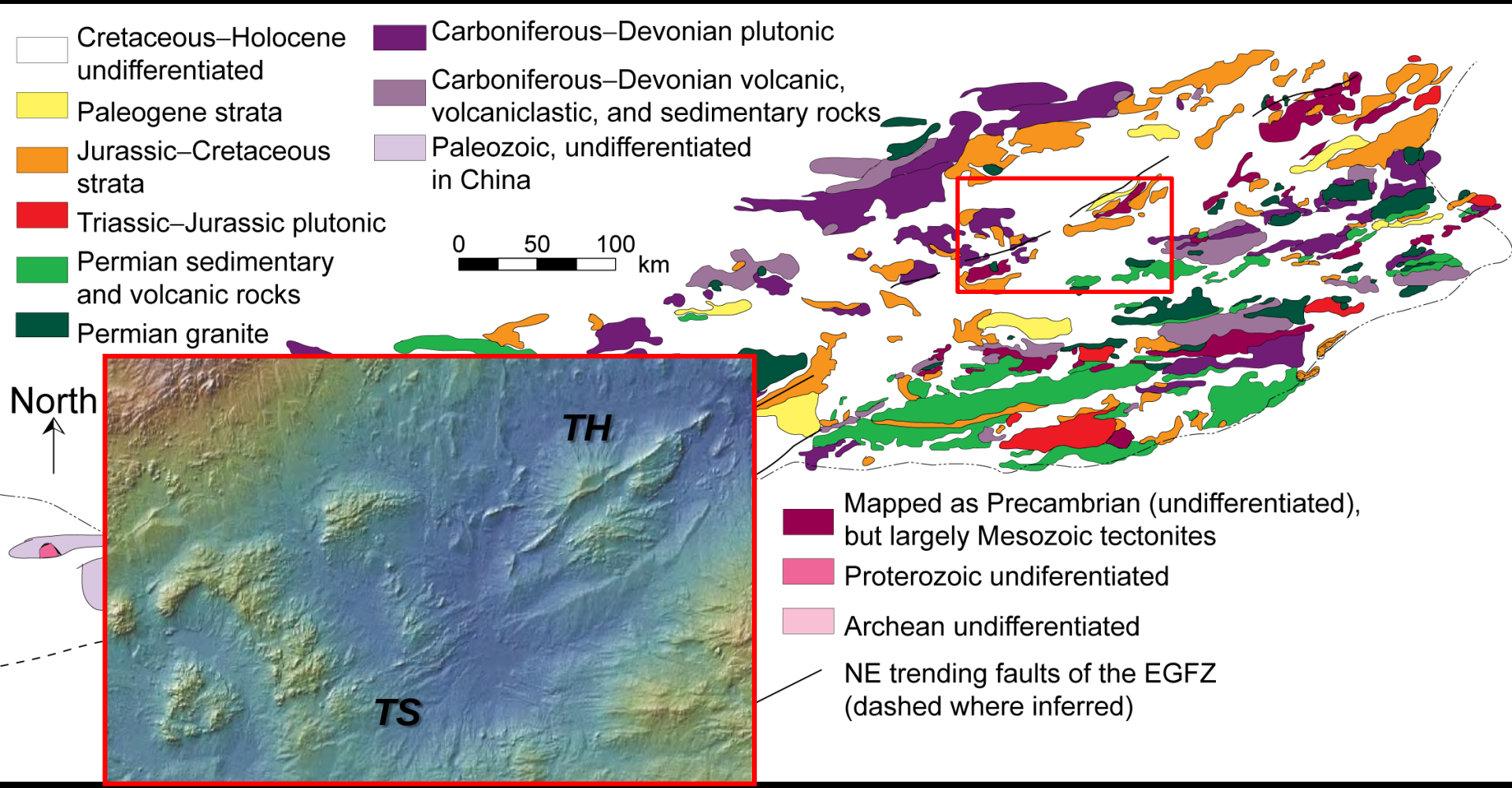
Graham et al. (2001)

Fluvial–deltaic and lacustrine successions pervasive in syn-rift strata; bimodal volcanics

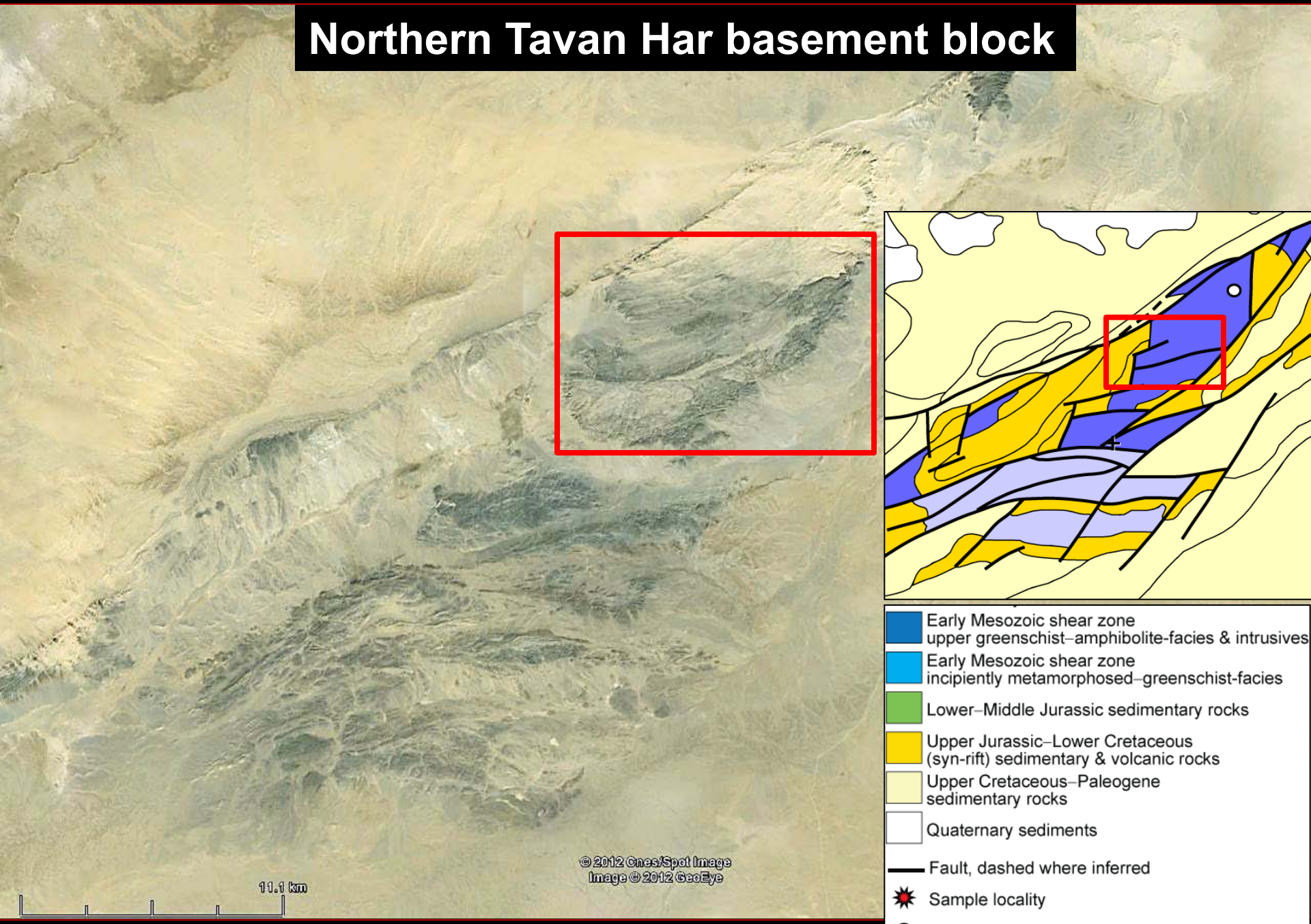


Pyroclastic surge deposit

Northern East Gobi Fault Zone



Northern Tavan Har basement block

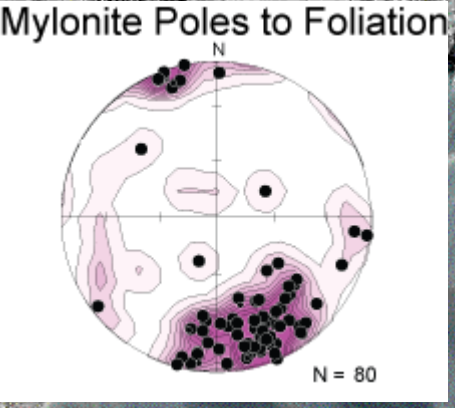


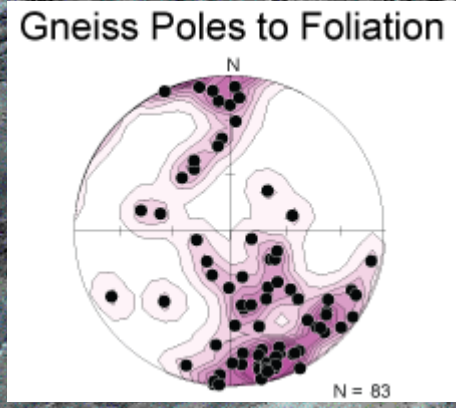

K_2
K_1
Pre-Cambrian???
K_{1-2}
1 km


Pre-Cambrian???
K1-2
1 km

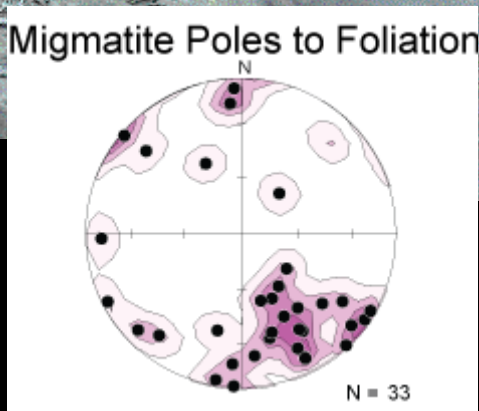

Pre-Cambrian???
K1-2
1 km


1 km



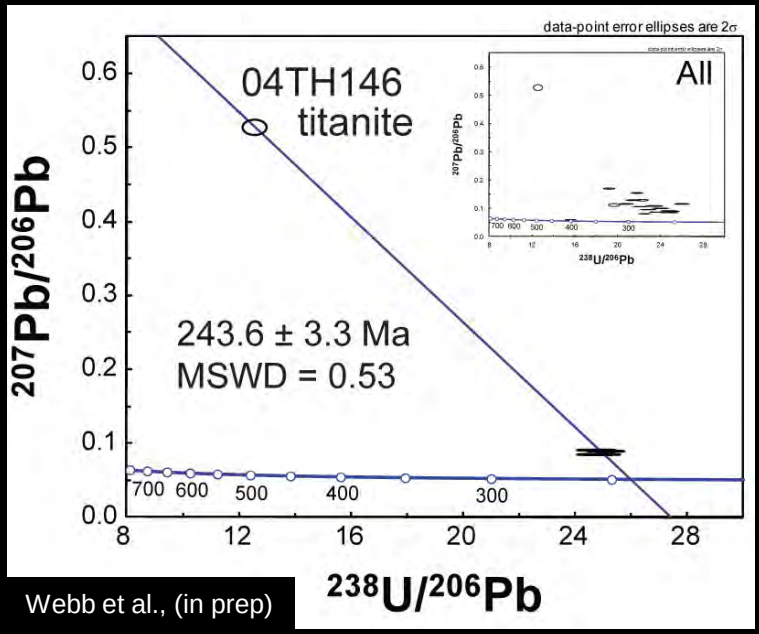


Stypula et al. (in prep)

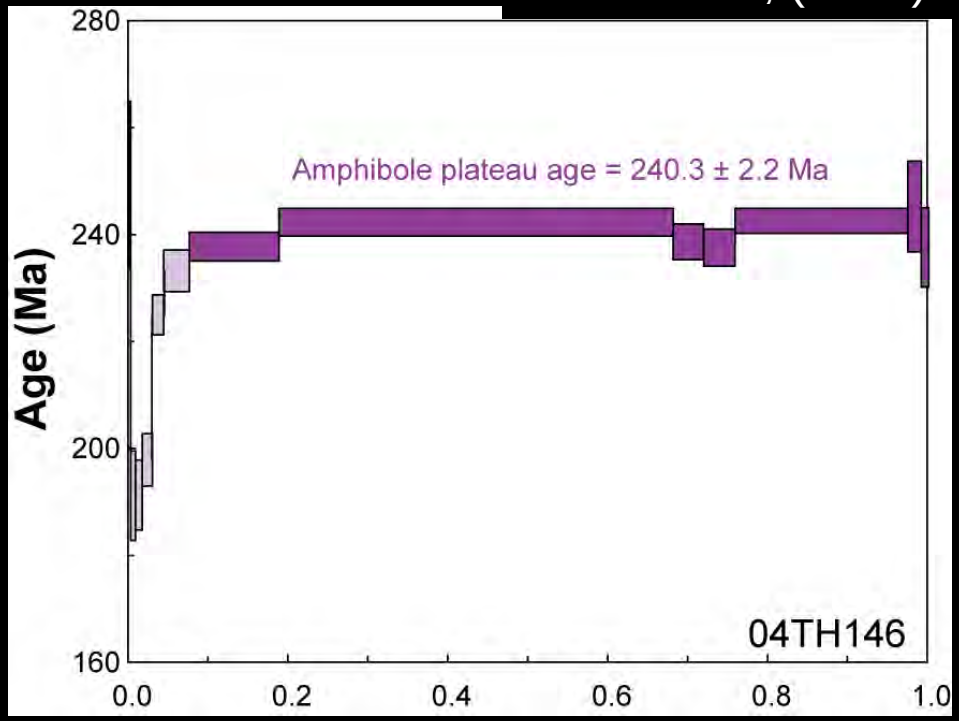


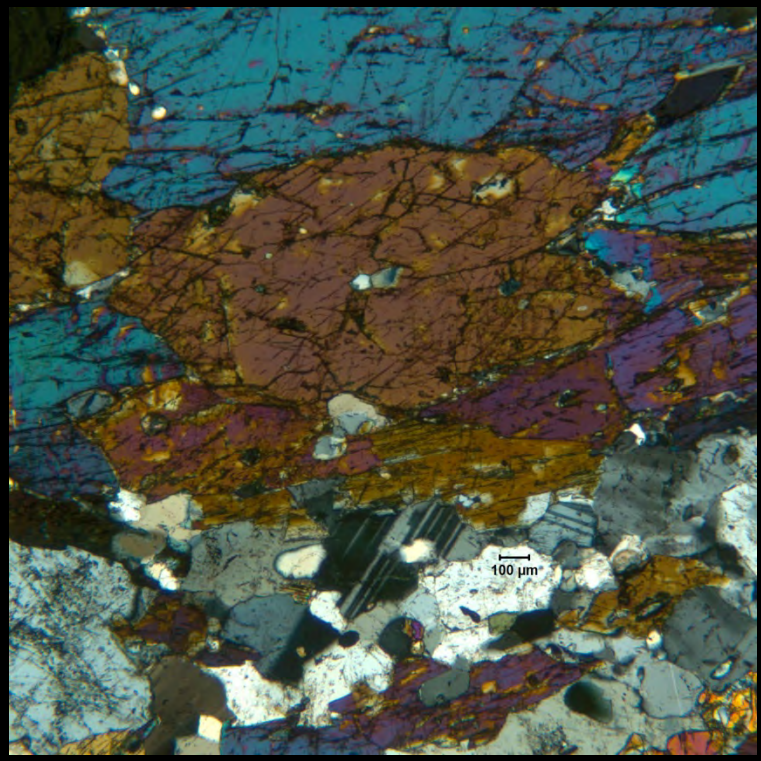
Migmatites: S tectonites
Mylonites and gneisses: S-L tectonites, sinistral shear
Syn- to post-kinematic intrusions

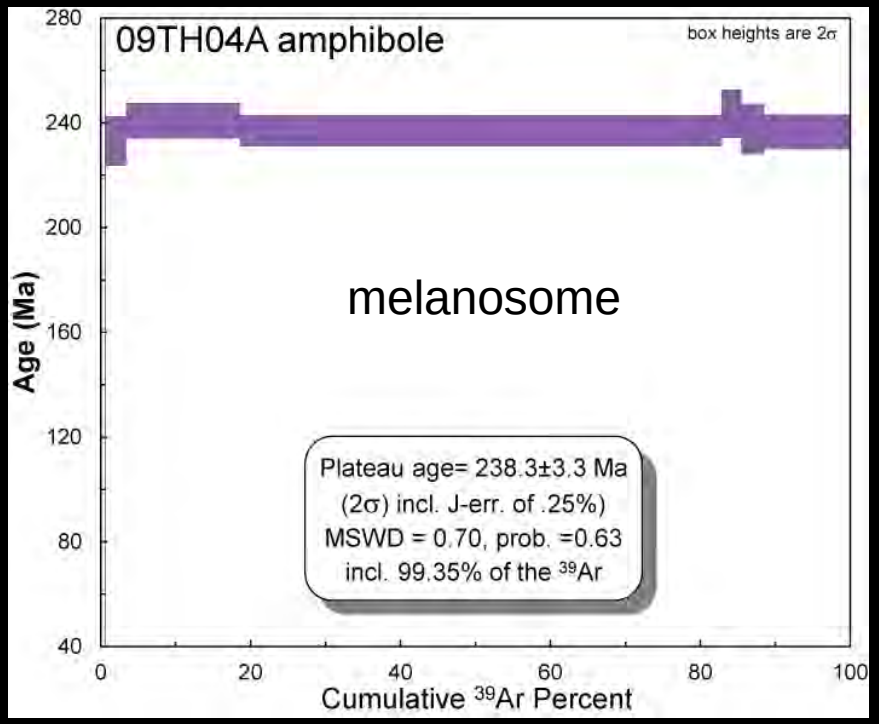
Webb et al., (2010)

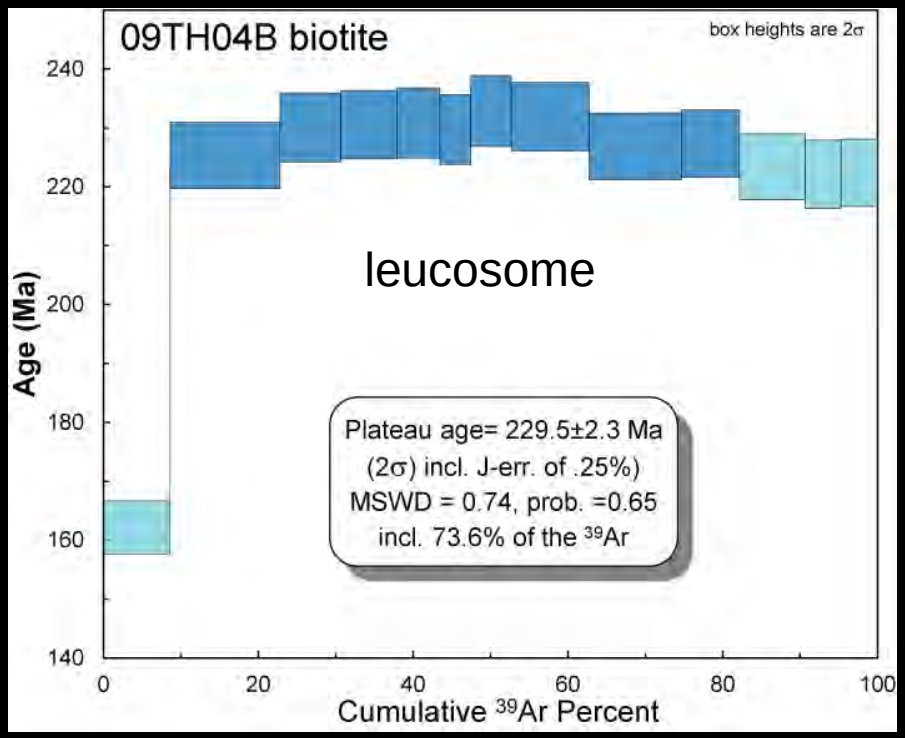


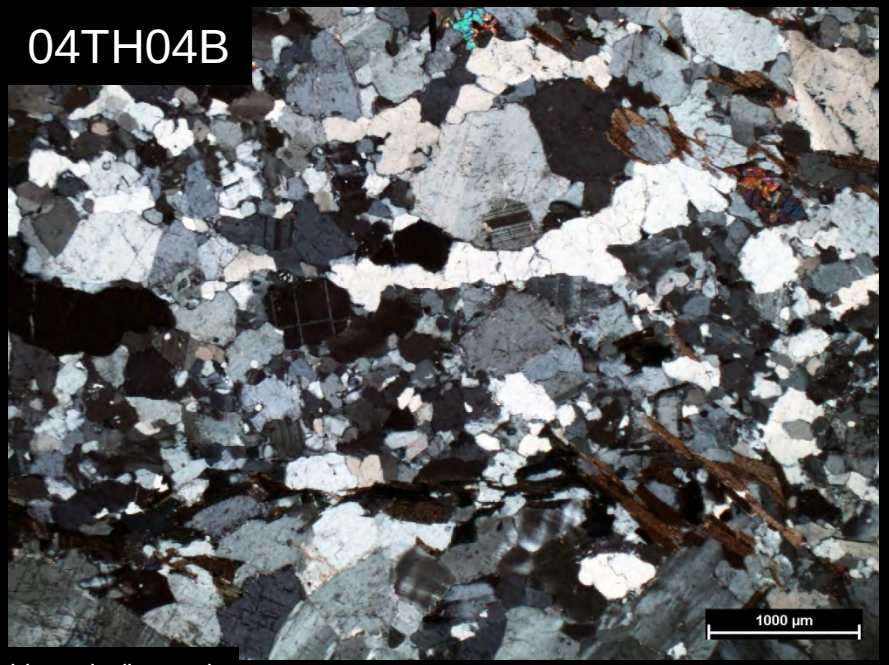
Webb et al., (in prep)



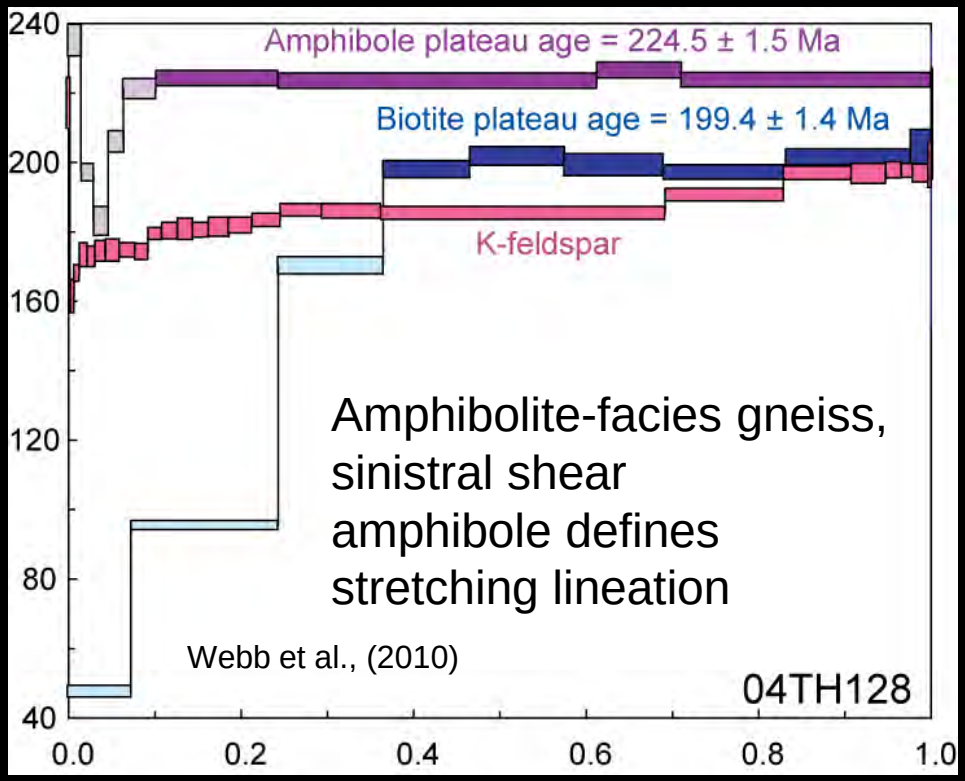


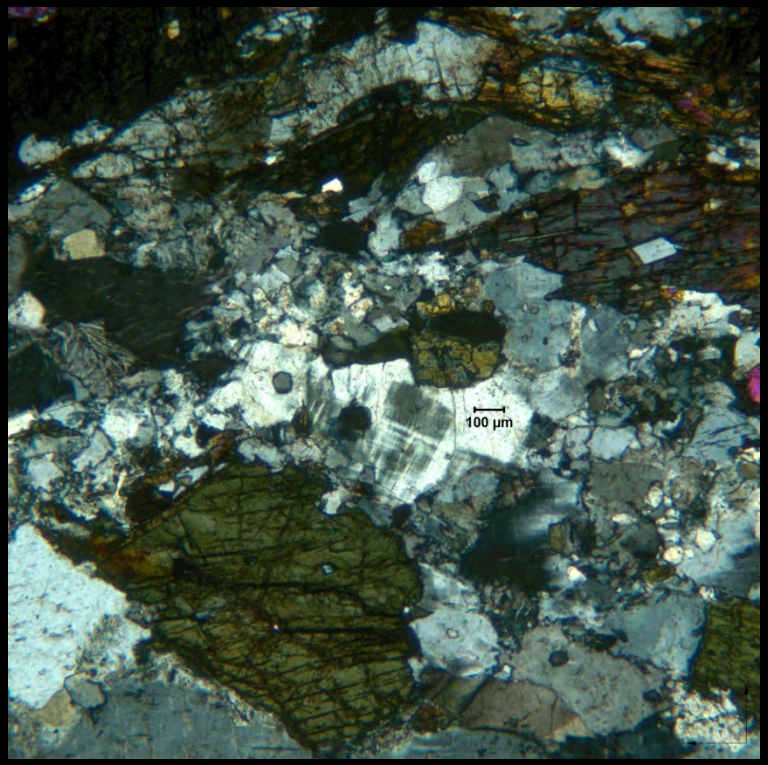


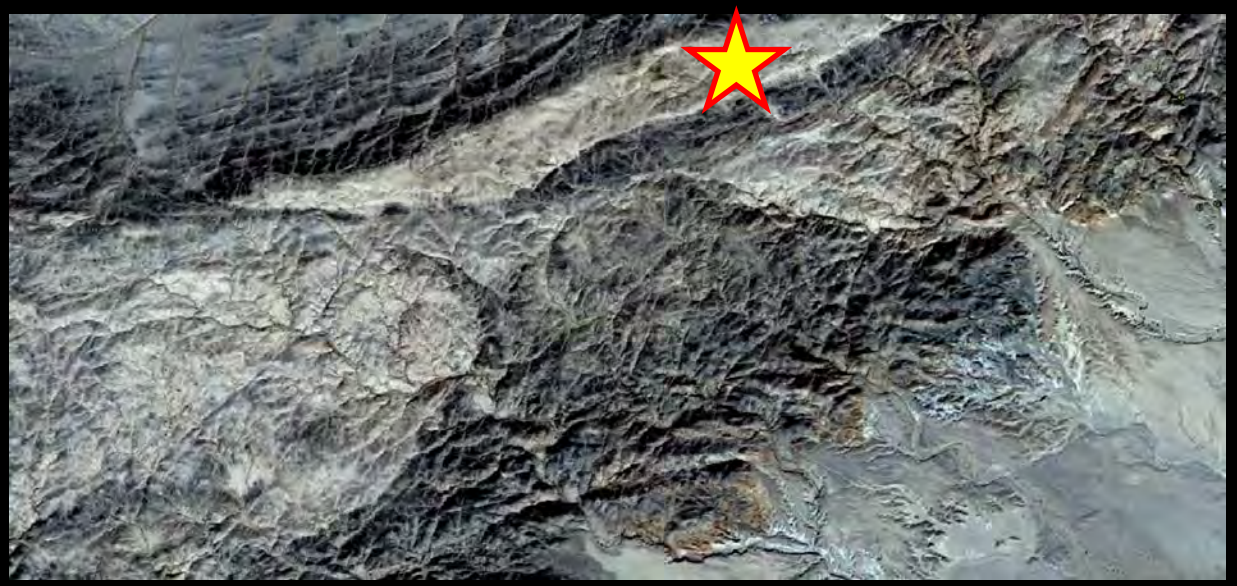




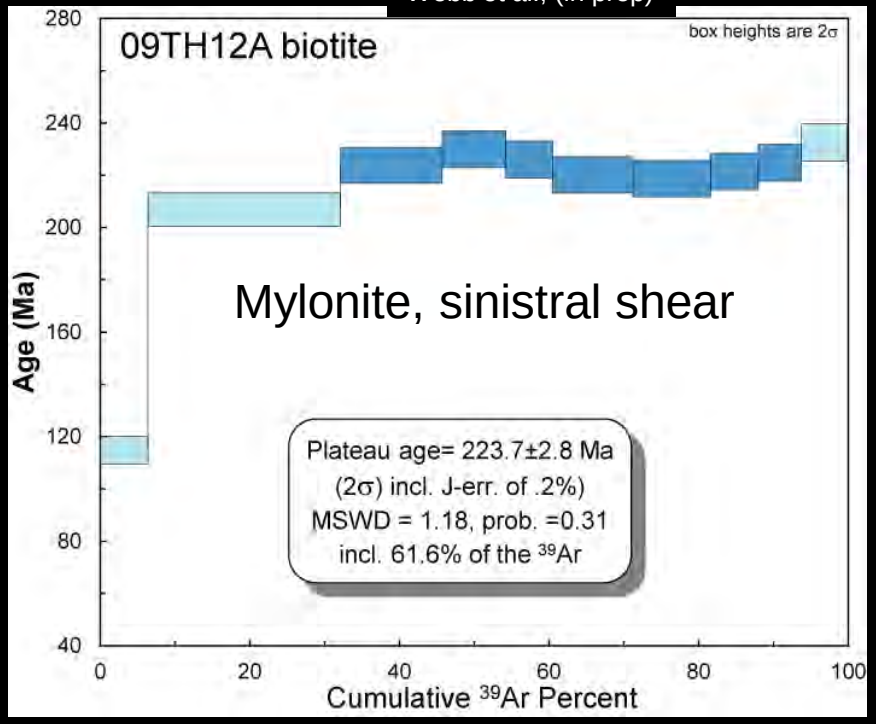
Webb et al., (in prep)

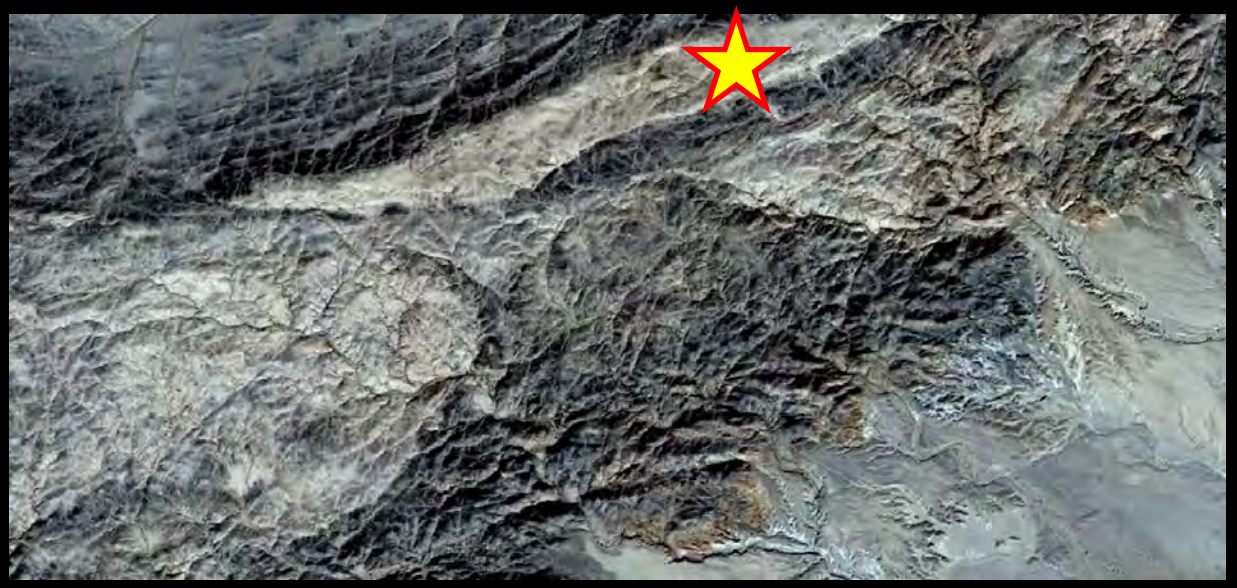

Amphibole plateau age = 224.5 ± 1.5 Ma
Biotite plateau age = 199.4 ± 1.4 Ma
K-feldspar
240
200
160
120
80
40
0.0
0.2
0.4
0.6
0.8
1.0
Amphibolite-facies gneiss, sinistral shear amphibole defines stretching lineation
Webb et al., (2010)
04TH128


100 µm

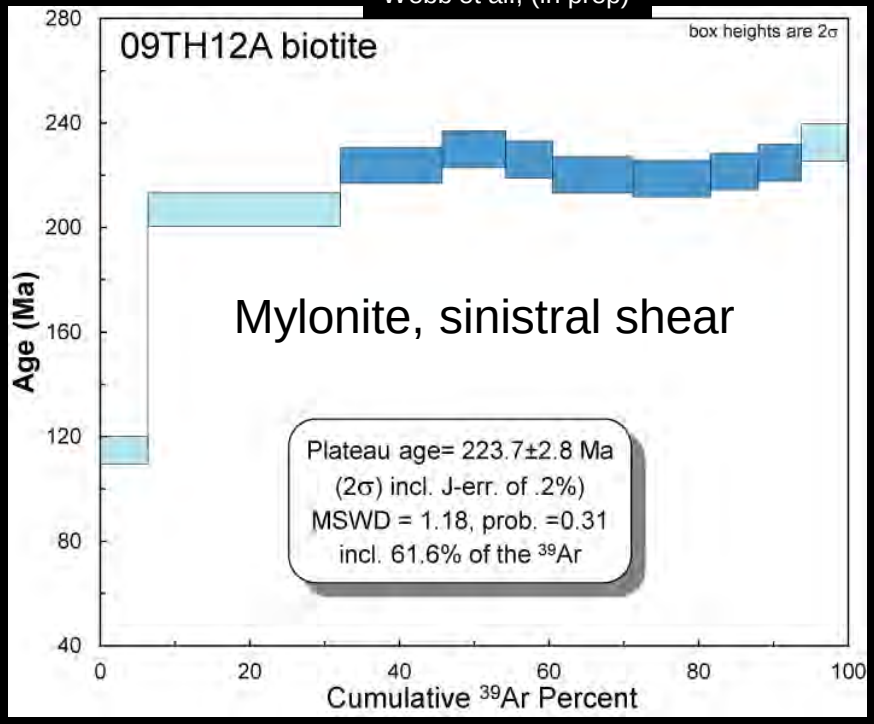


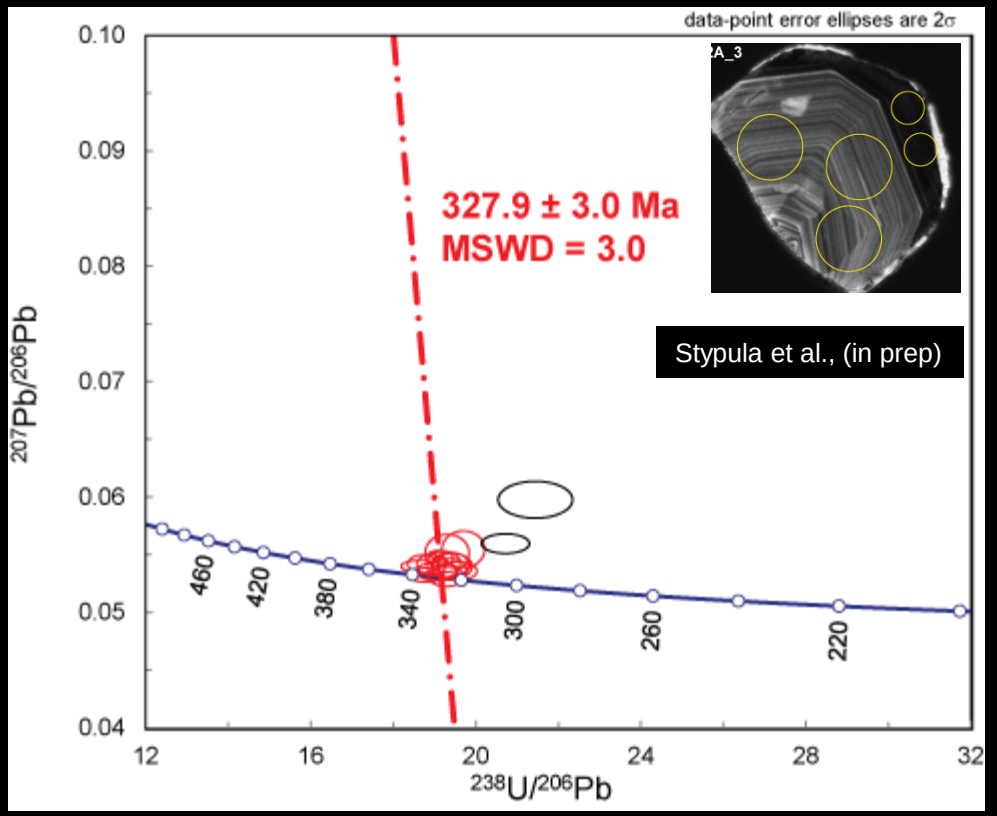
Webb et al., (in prep)





Webb et al., (in prep)

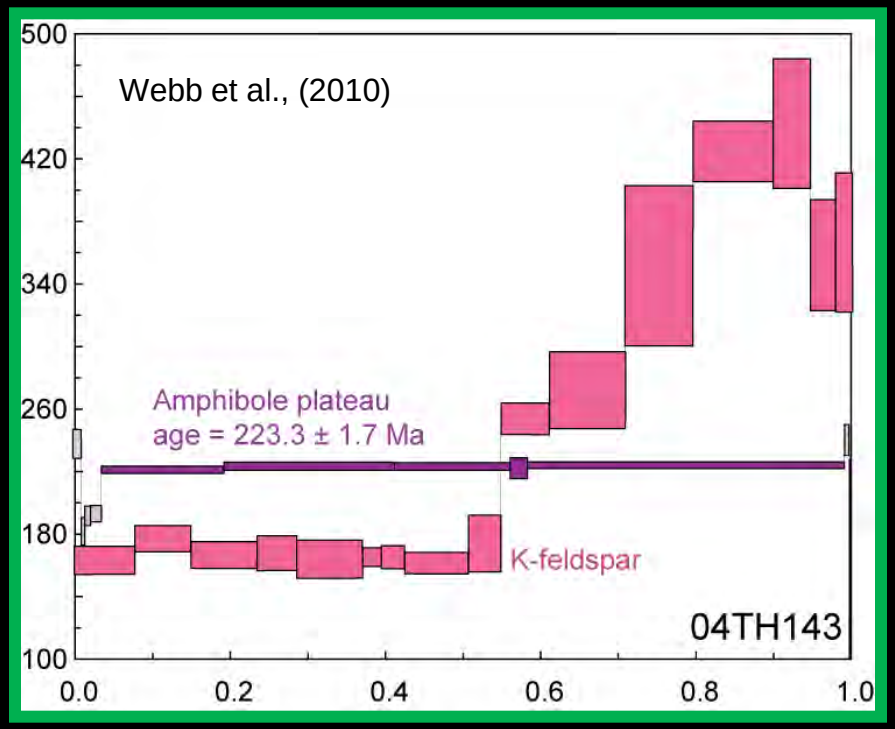


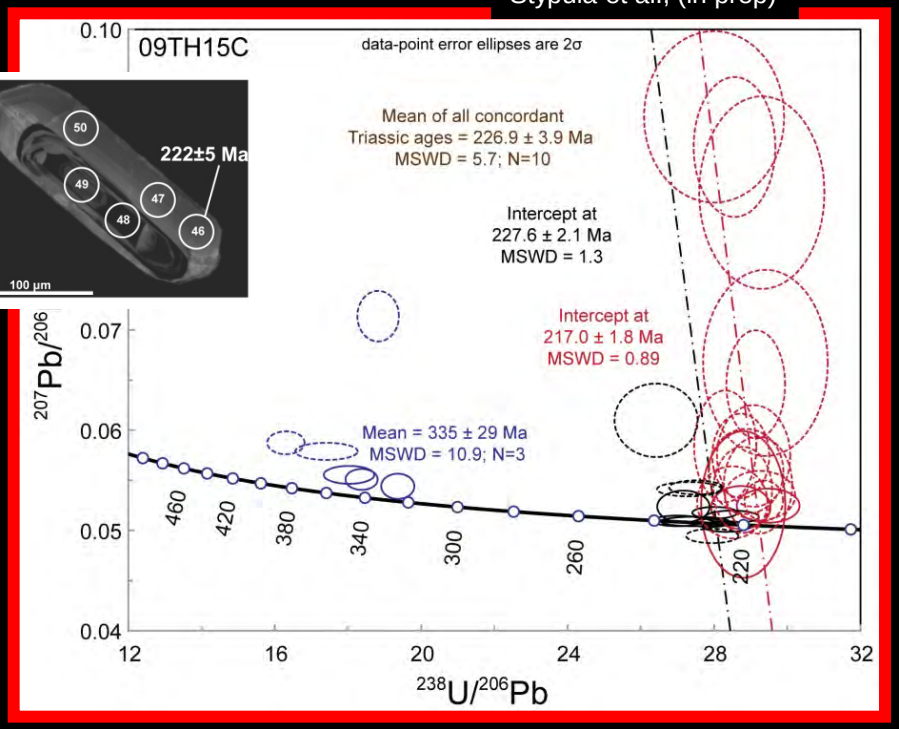


Stypula et al., (in prep)

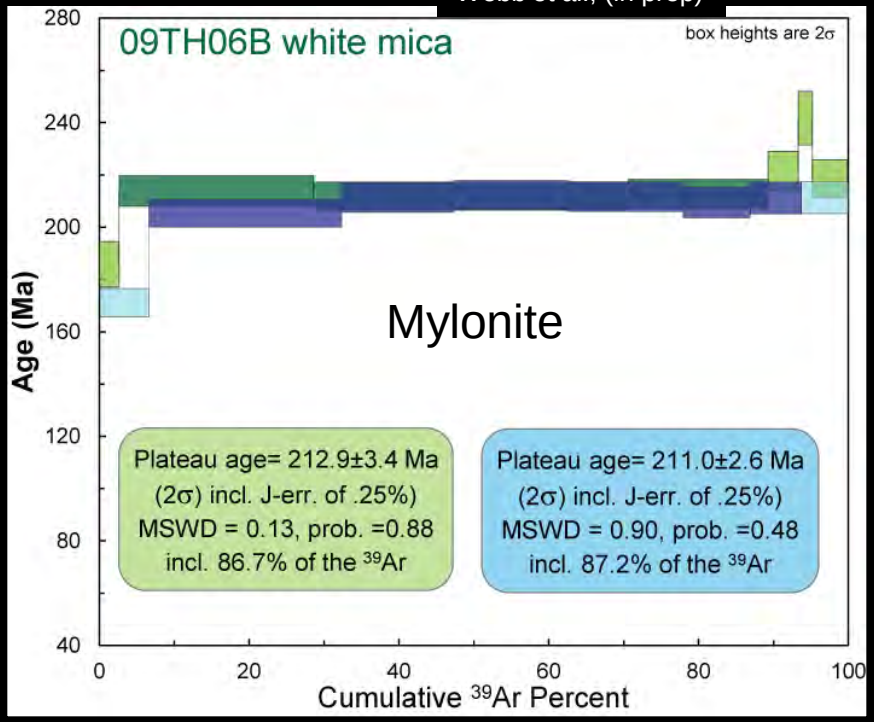
Synkinematic intrusions

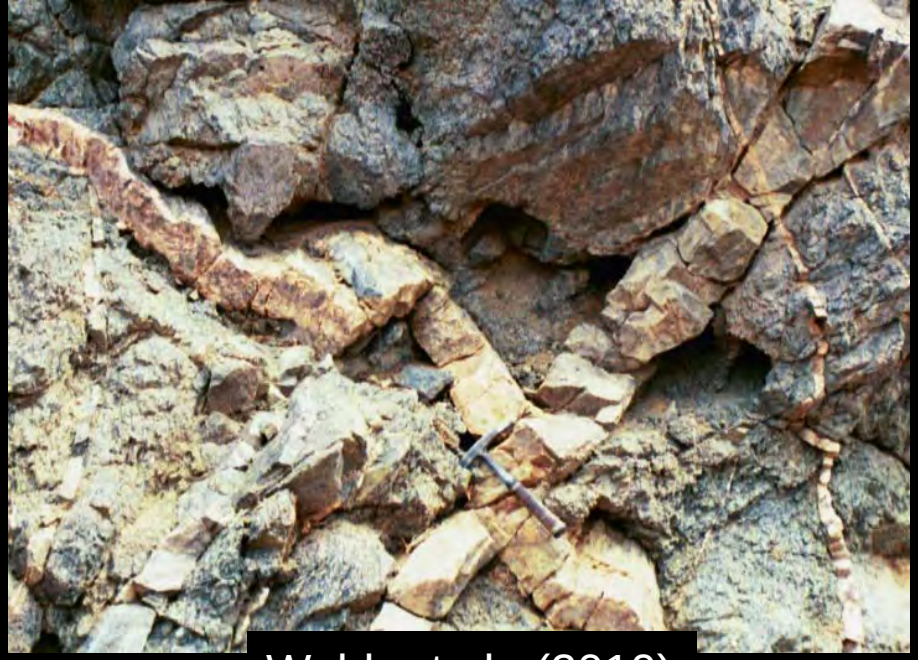
Stypula et al., (in prep)



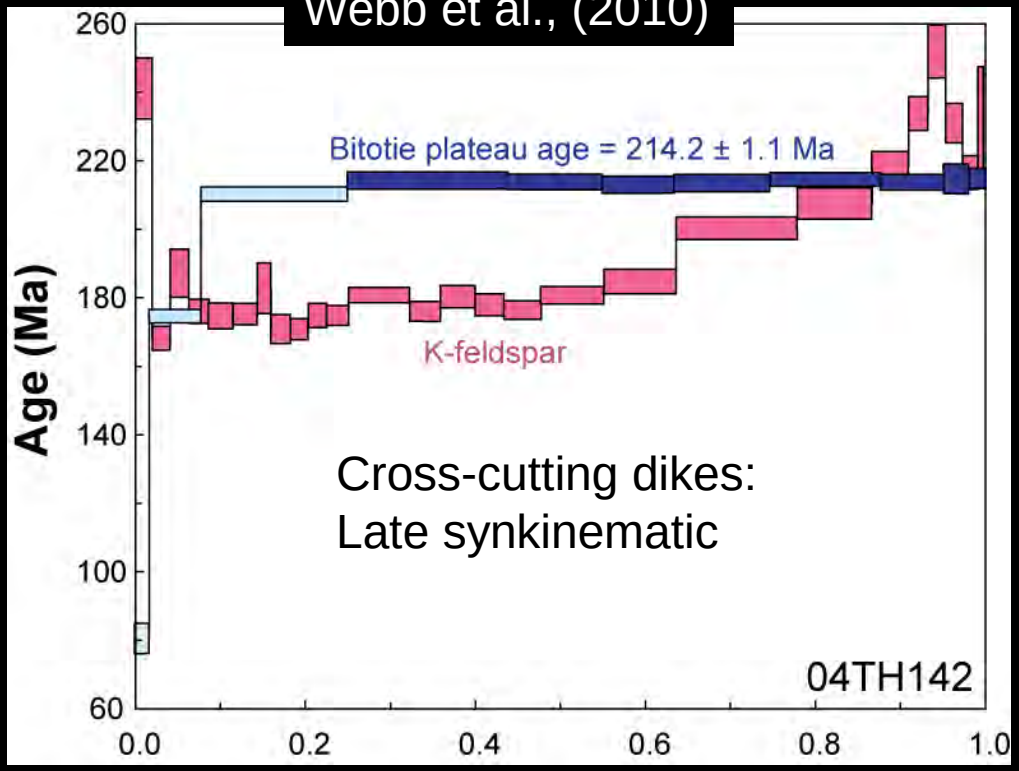


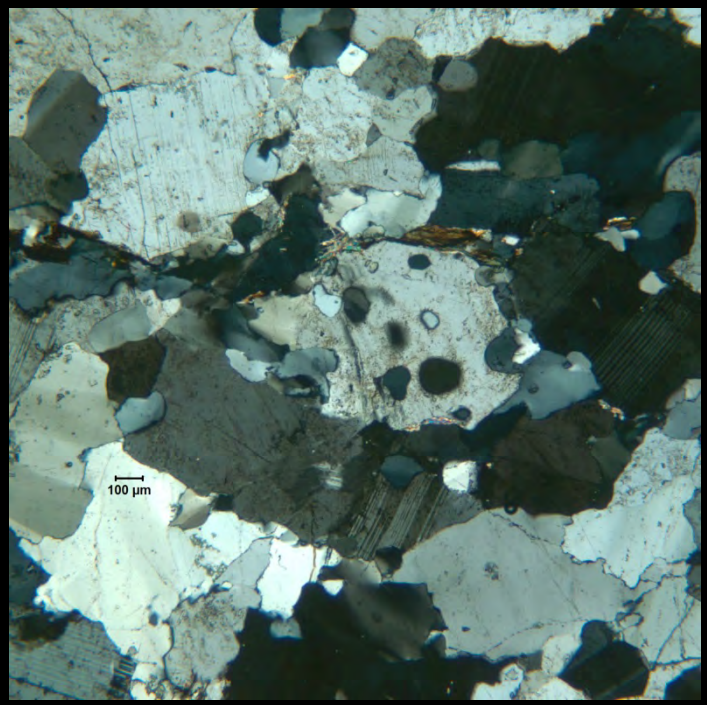
Webb et al., (in prep)



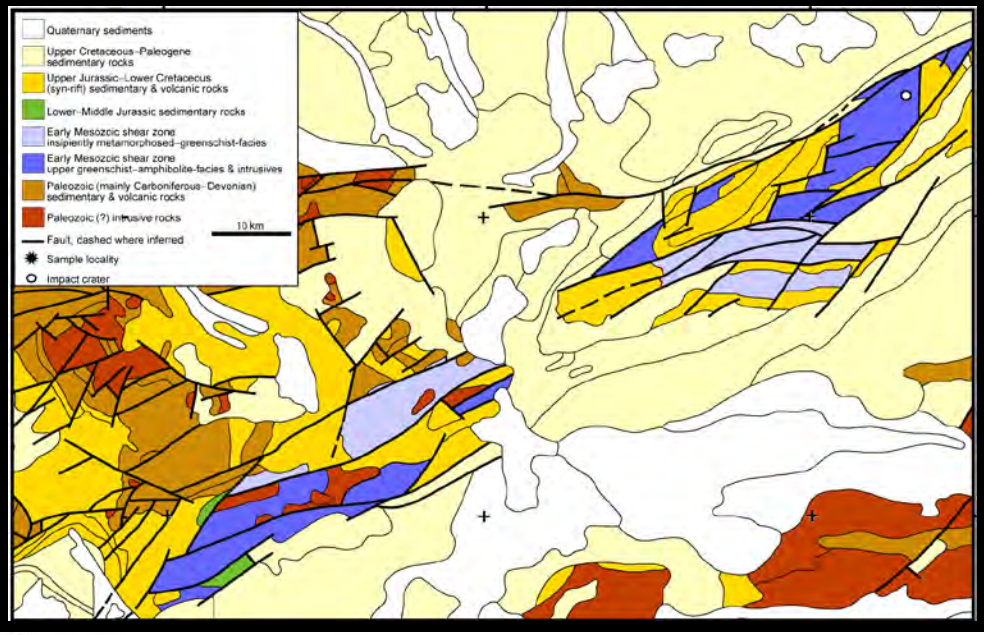


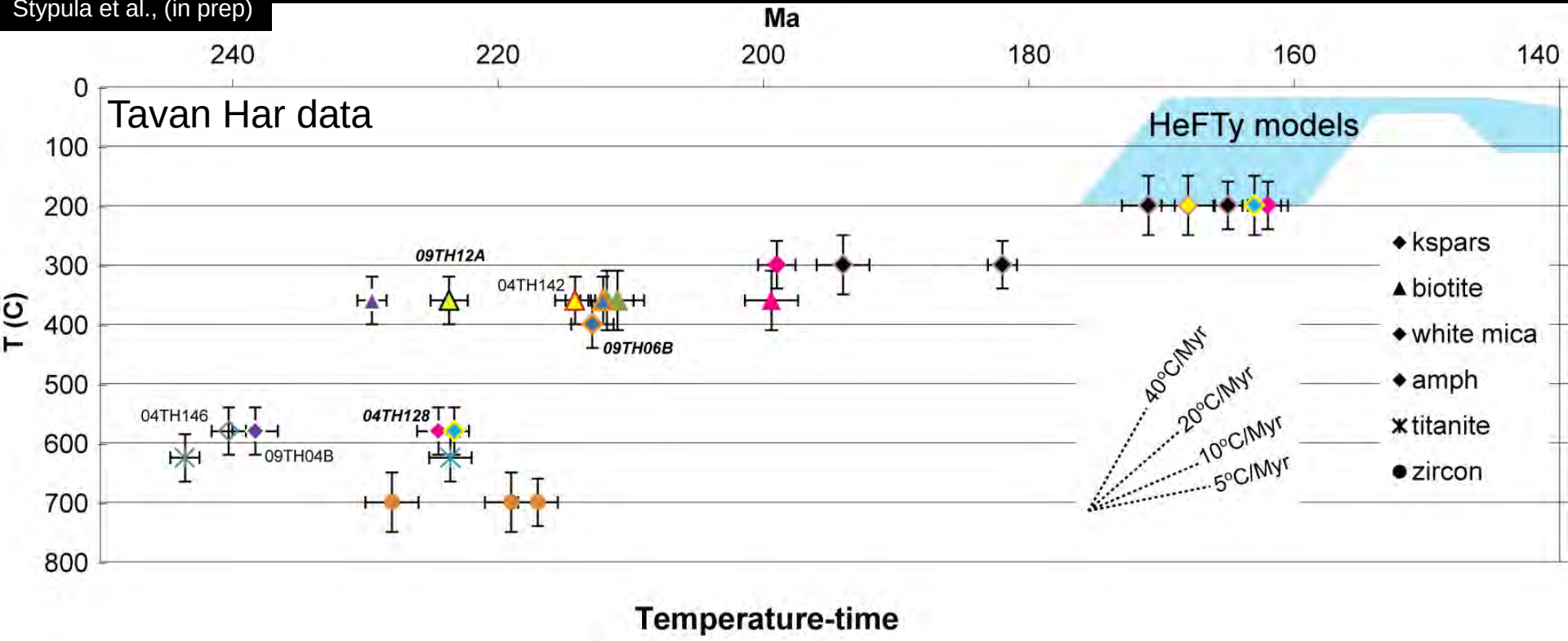
Webb et al., (2010)





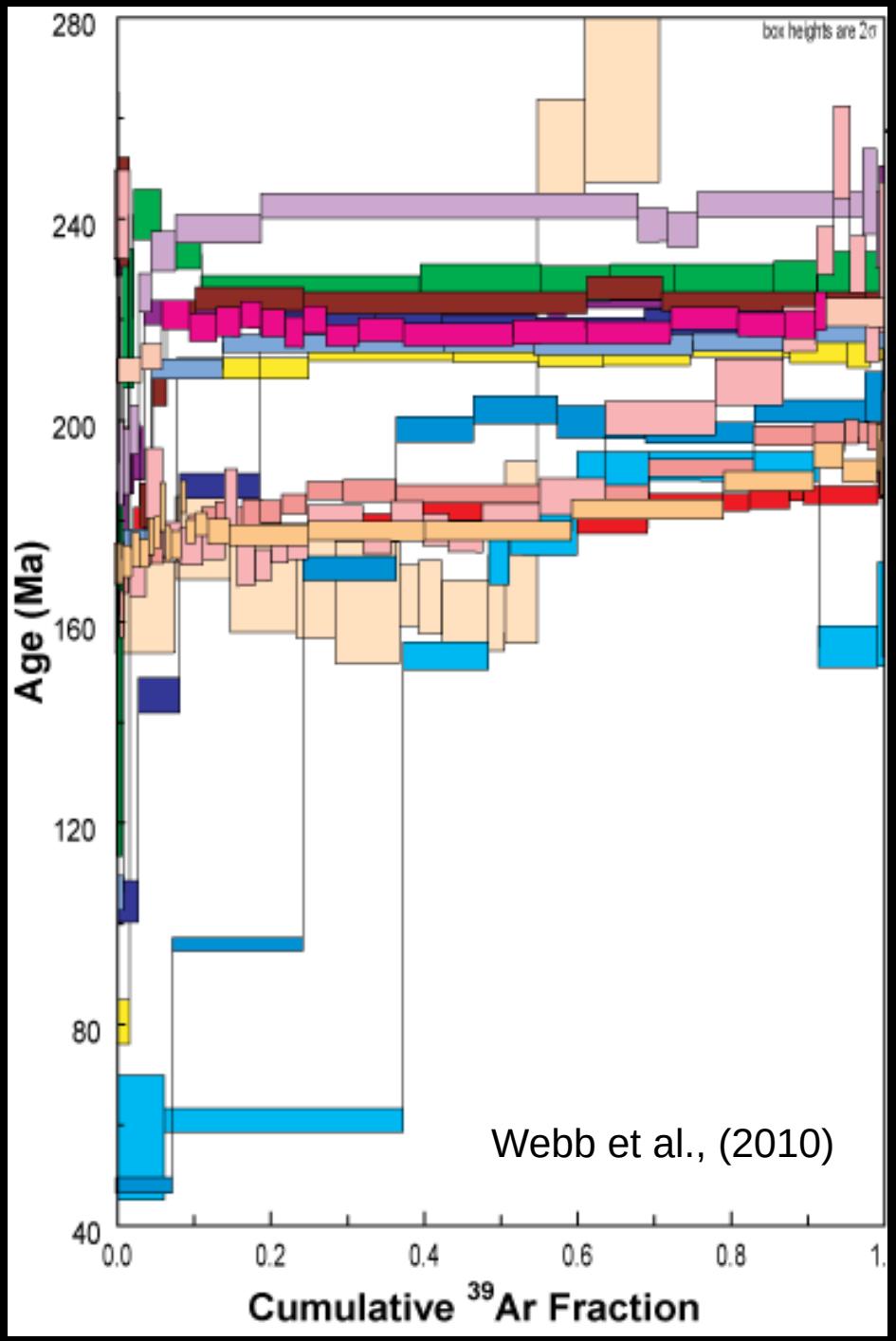
Webb et al., (2010)
Webb et al., (in prep)
Taylor et al., (in prep)
Stypula et al., (in prep)



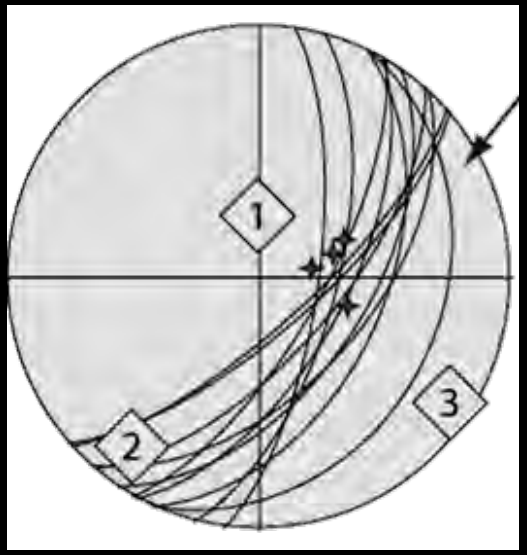


$^{40}Ar/^{39}Ar$ Summary

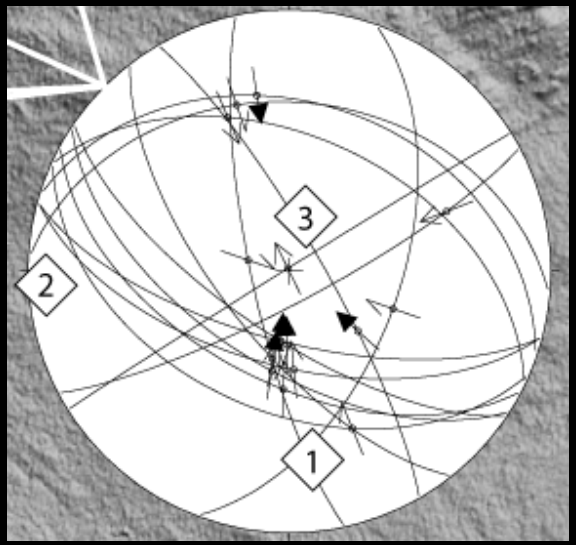
- Oldest ages c. 240 Ma obtained from migmatites
  - Minimum age for partial melting event
- Sinistral shear occurred @ ~225 Ma
  - Deformation at amphibolite-facies conditions
  - Synkinematic intrusions
- Waning of deformation, locally, by ~210 Ma
- All spectra are disturbed by argon loss…
  - Biotite most susceptible
  - Sample proximity to brittle faults

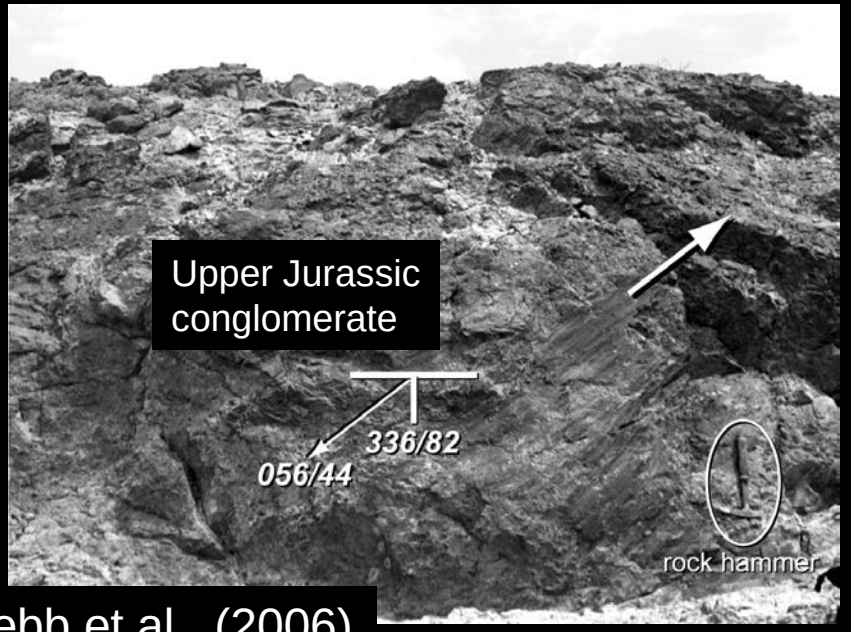


Late Jurassic–Early Cretaceous rifting



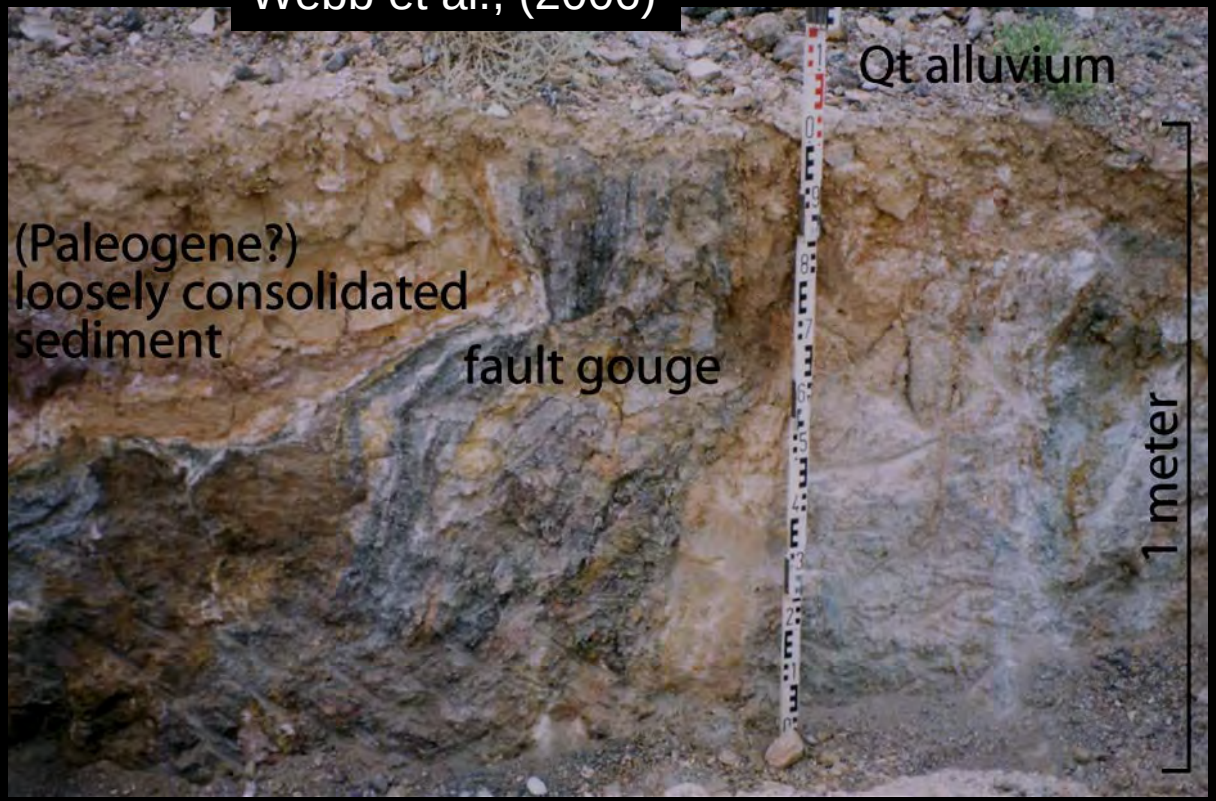
Mid-Late Cretaceous basin inversion

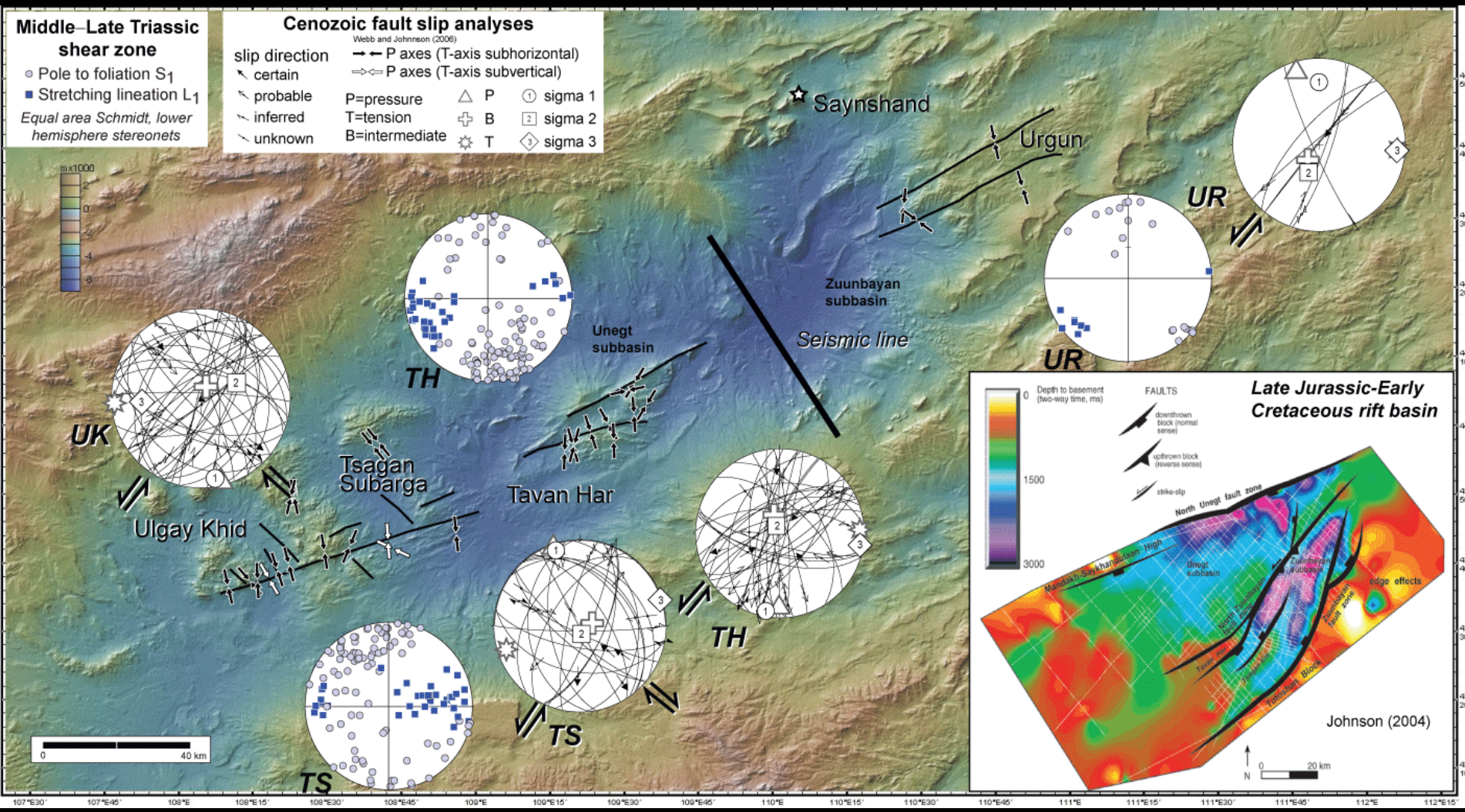




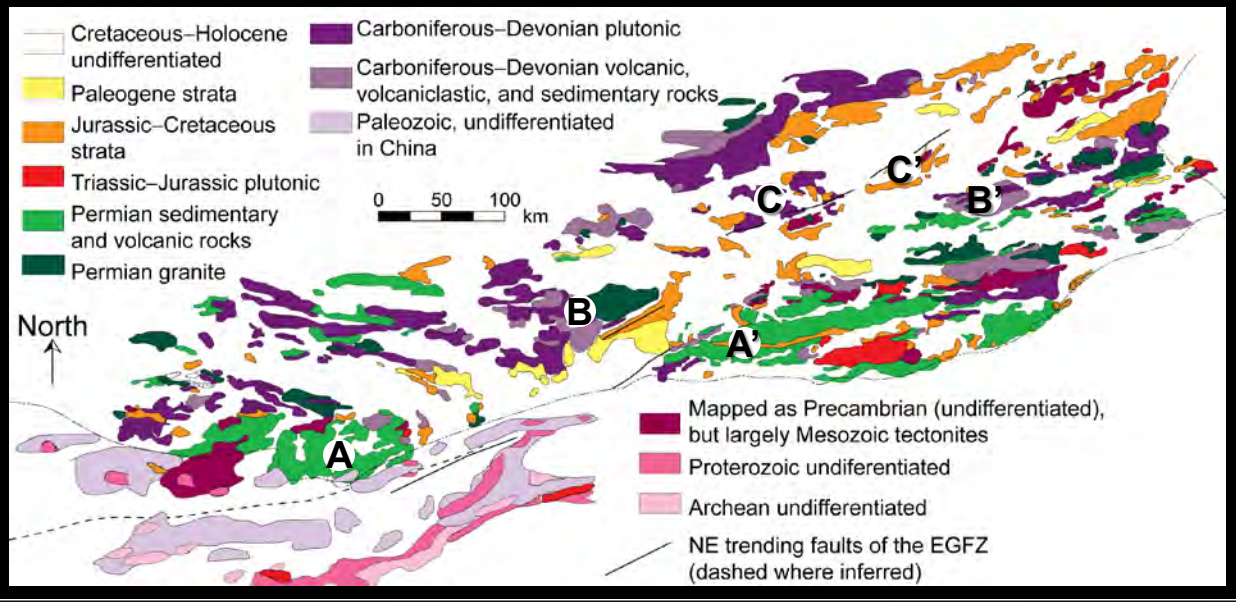
Webb et al., (2006)

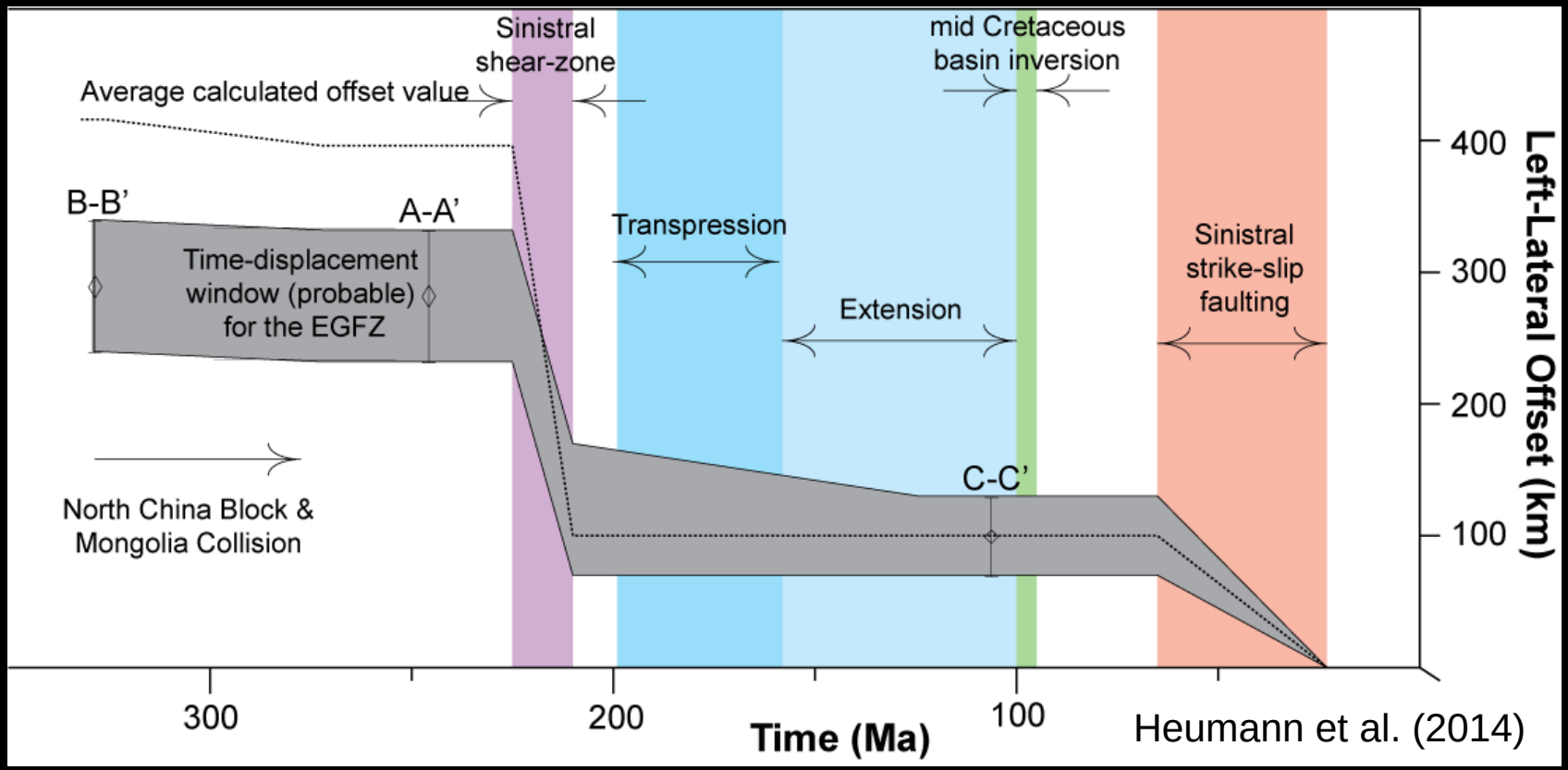
- NE-striking sinistral strike-slip faults
  - Cut K_2 post-rift & Cz sediments
  - Overlapped by Qt sediments
  - Associated with gouge zones and/or calcite mineral fibers on fault planes



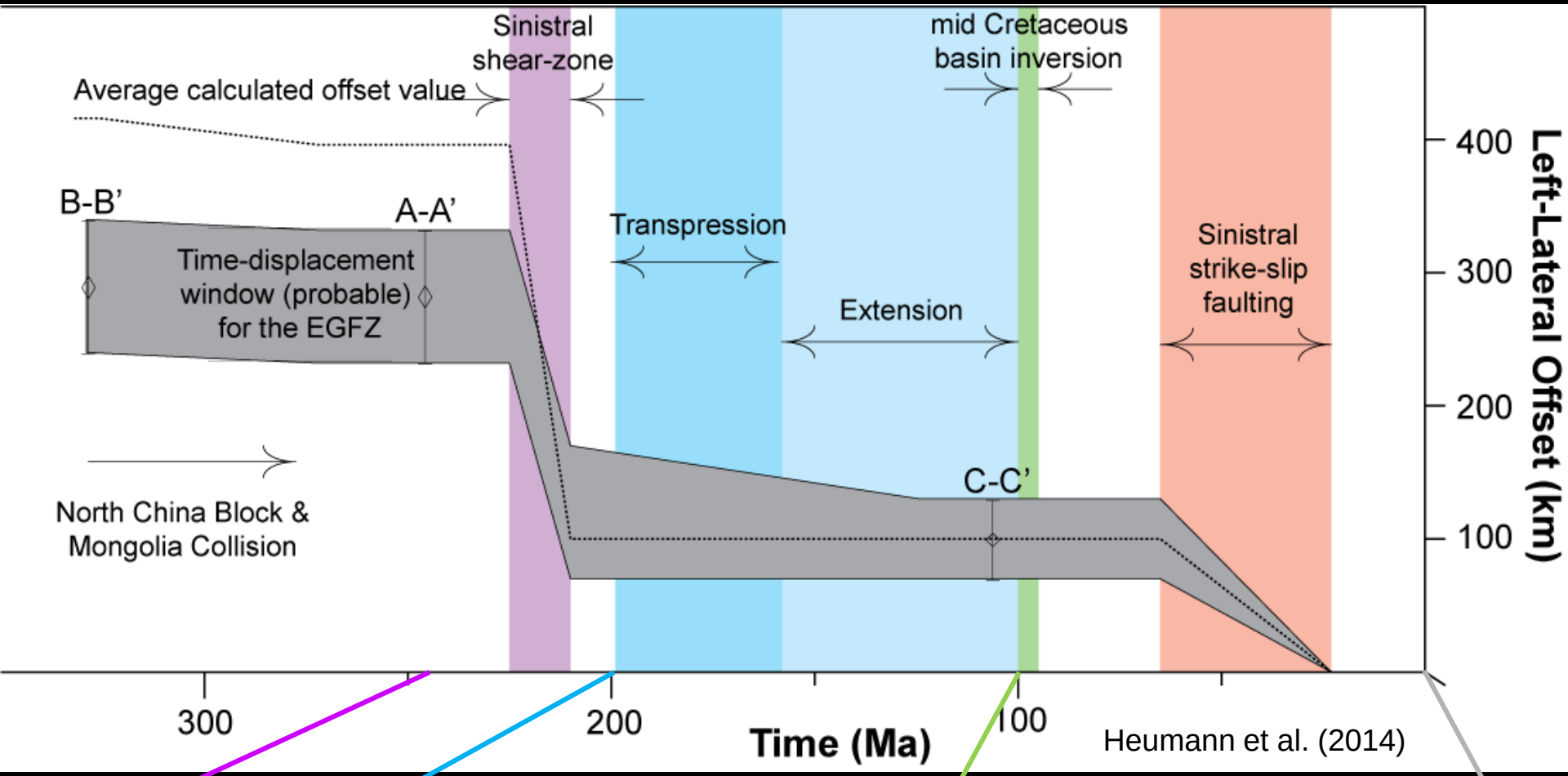


Webb et al., (2006)

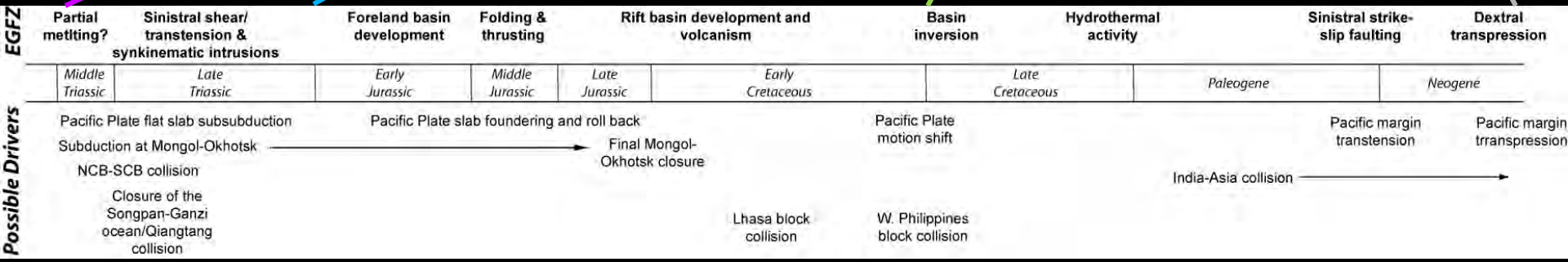




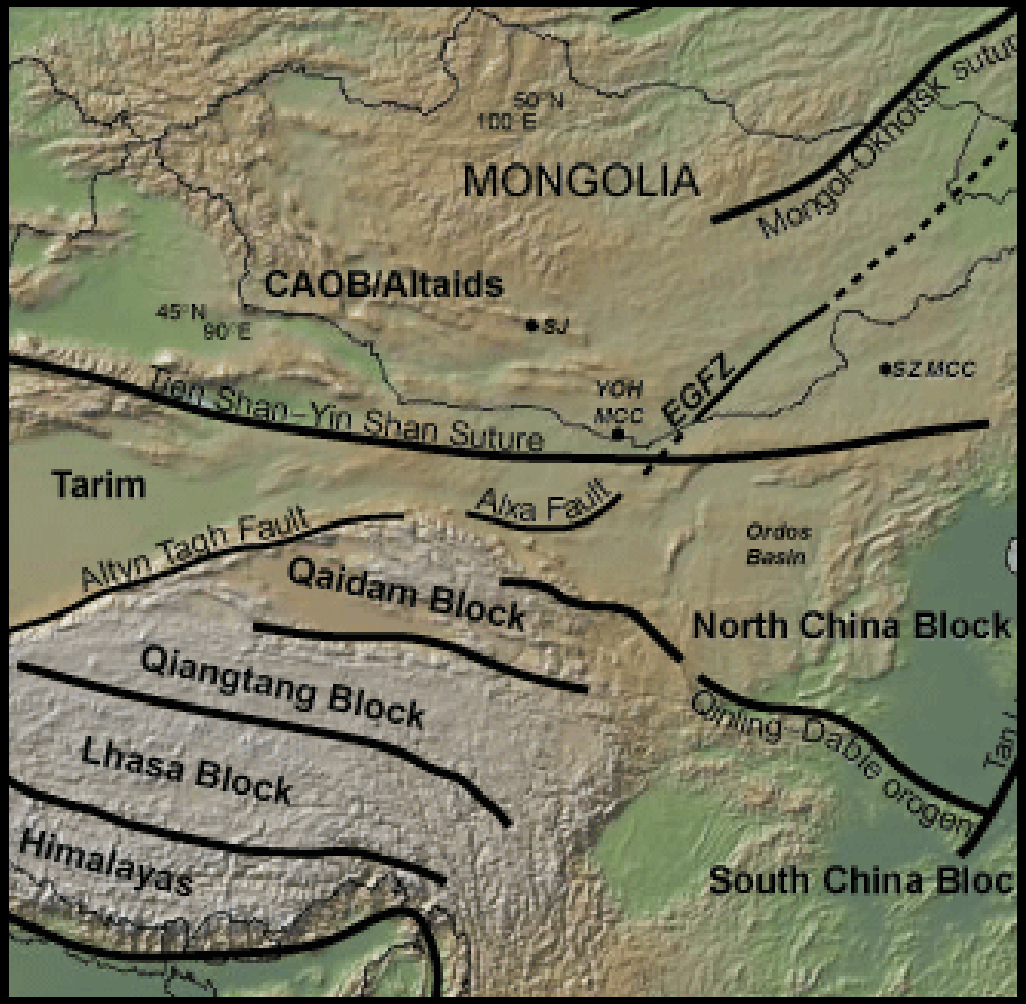
Heumann et al. (2014)



Heumann et al. (2014)



$^{40}Ar/^{39}Ar$ records key chapters of the saga — Integration of data sets is critical!



- Partial melting followed by major phase of sinistral shear ca. 225 Ma
- Reactivation history
  - Intraplate deformation focused in zone of heterogeneous, juvenile crust
  - Associated with collisions and Pacific Plate boundary evolution

Many years, many thanks to many people, consumption of many goat & sheep parts…

Cari Johnson (Univ. Utah),
Josh Taylor, Matt Heumann,
Merril Stypula, Graham Hagen-Peter,
Ch. Minjin, G. Sersmaa, G. Badarch,
Steve Graham & Marc Hendrix, Andrew Kylander-Clark…