Characteristics of metamorphic core complexes

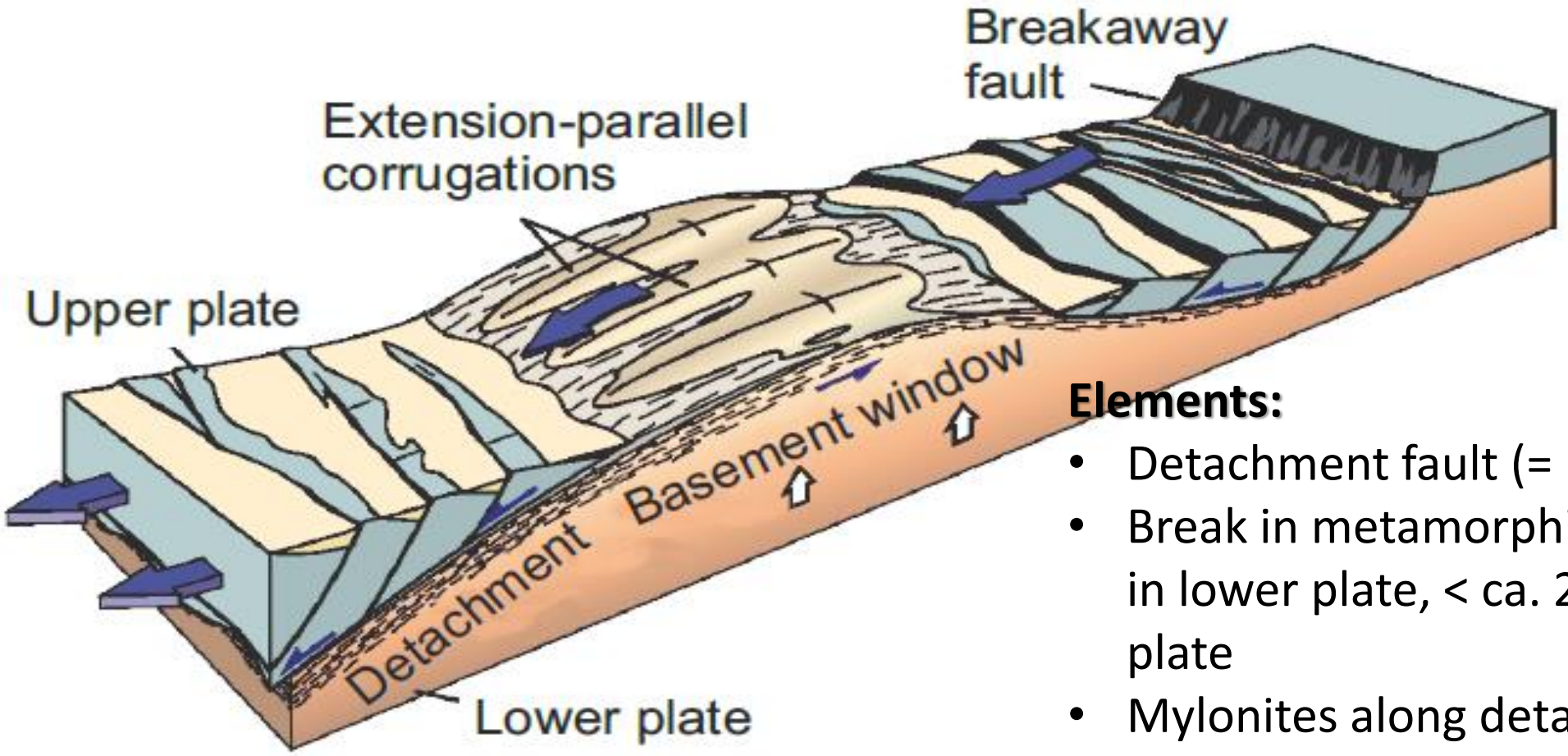
Franz Neubauer

With contributions by:

Shuyun Cao, Johann Genser, Fariba Kargaranbafghi, Farzaneh Shakerardakani, Georg Trost

Dept. Geography and Geology, Paris-Lodron-University of Salzburg, Hellbrunner Str. 34, A-5020 Salzburg, Austria. E-mail: Franz.Neubauer@plus.ac.at

Model of a classical Cordillerran-type metamorphic core complex (MCC)

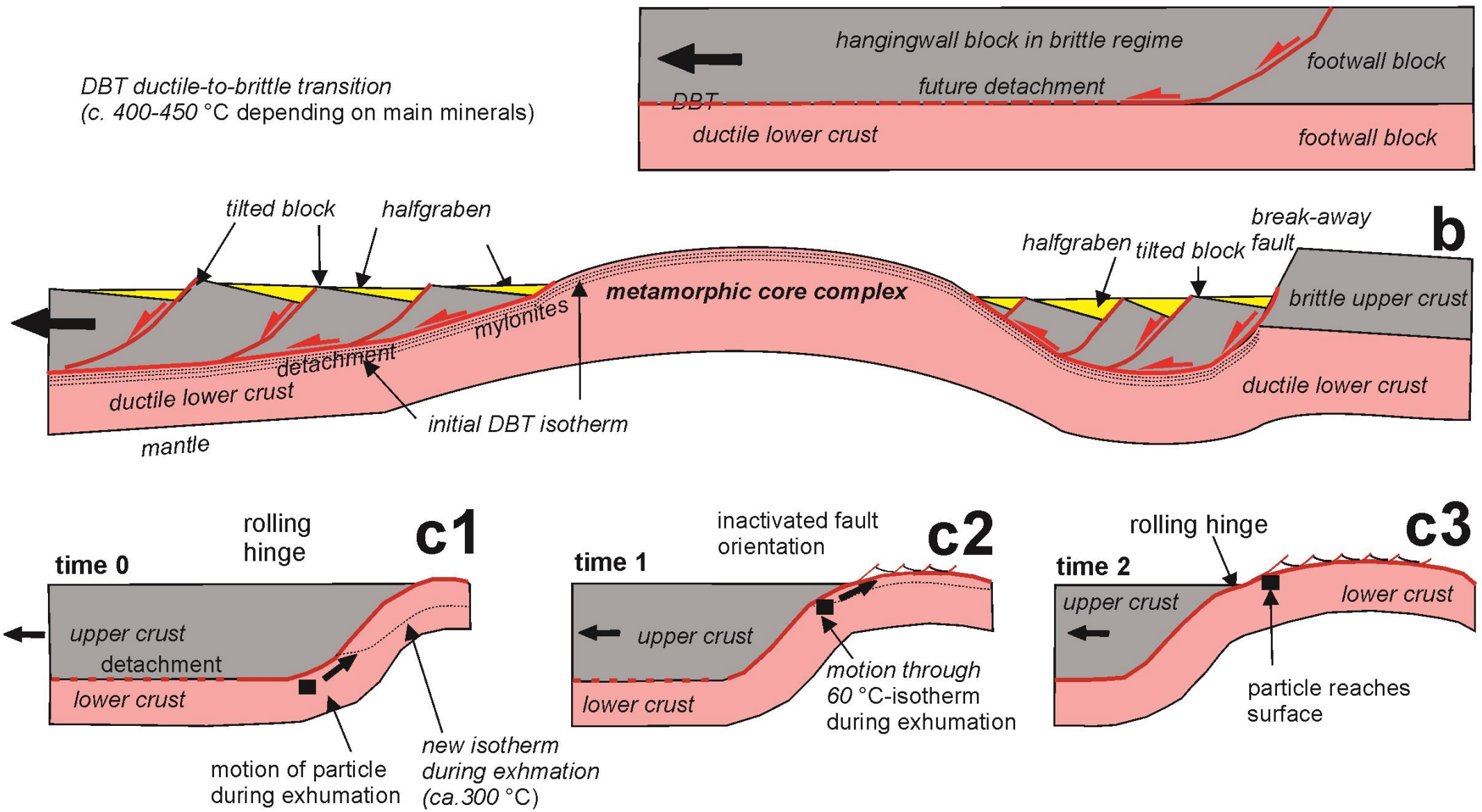


(From Fossen, 2016, Cambridge Univ. Press)

Elements:

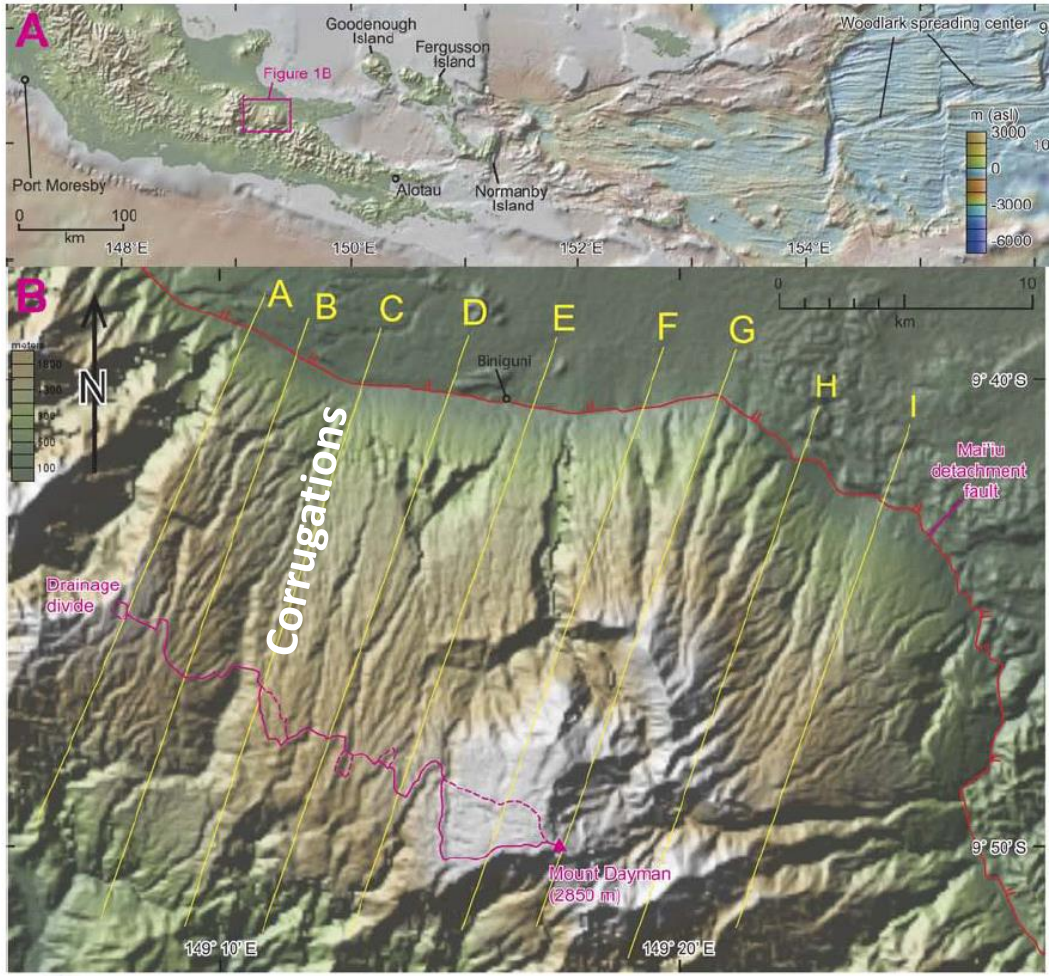
- Detachment fault (= low-angle normal fault)
- Break in metamorphism: ca. 500 °C or more in lower plate, < ca. 200 °C or less in upper plate
- Mylonites along detachment, overlain by cataclastic rocks
- Synextensional halfgraben at upper plate

Progressive evolution of a Cordillerran-type MCC



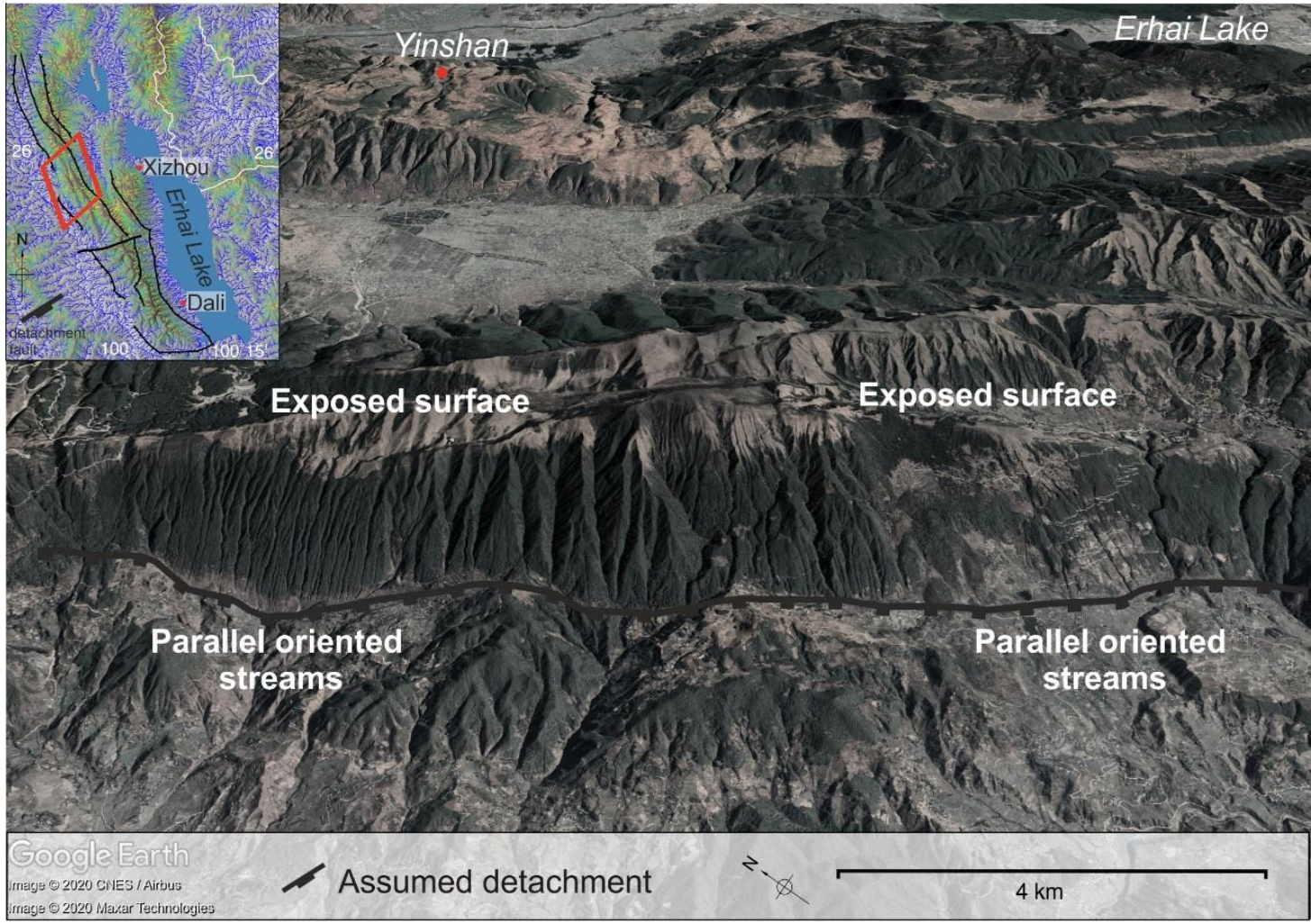
Recent landscape of very young continental MCCs: Development of drainage on pristine surfaces (parallel to corrugations)

Dayman-Suckling MCC, Papua New Guinea



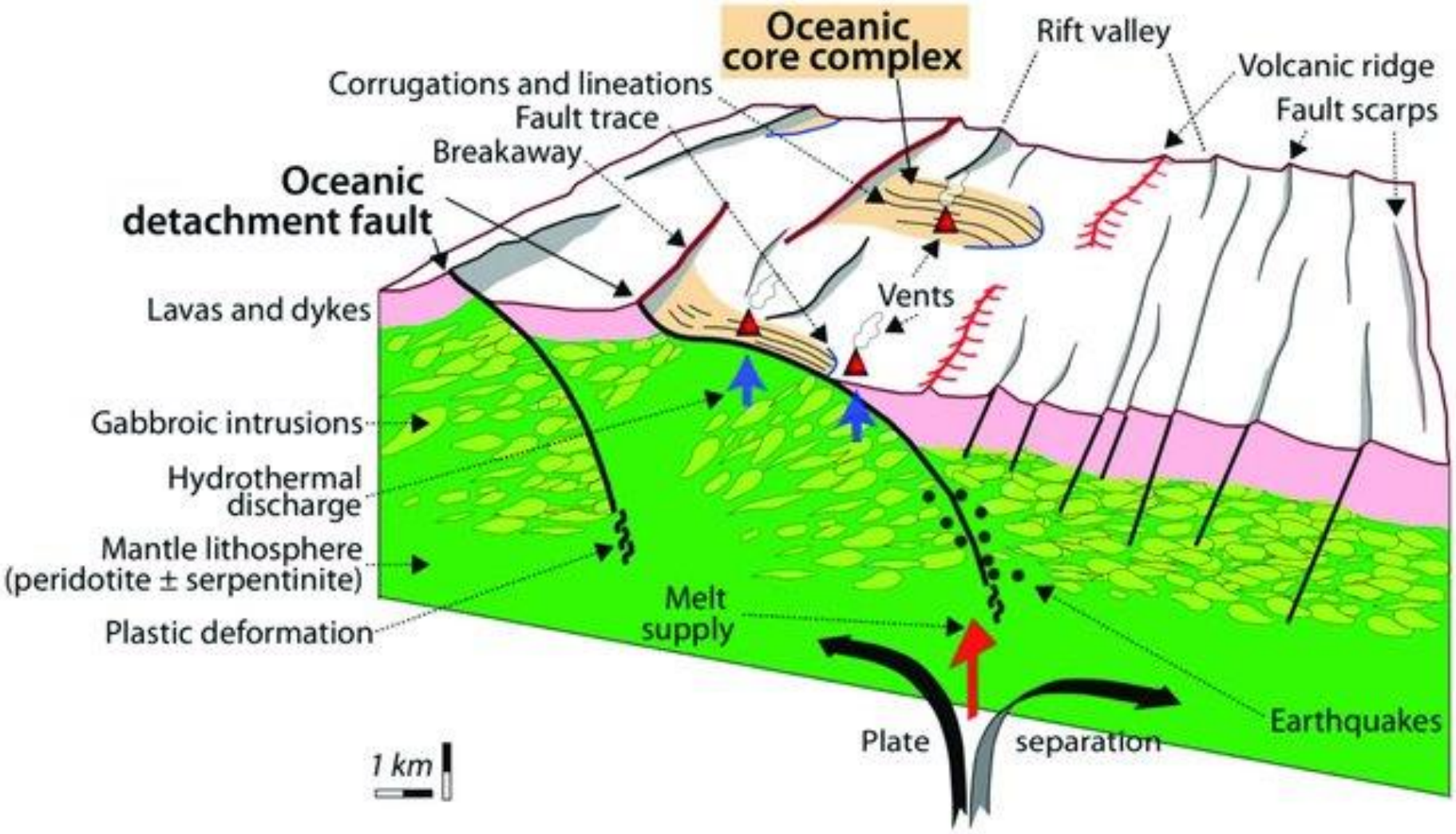
From Spencer, 2010

Diacang MCC along Red River fault, South China



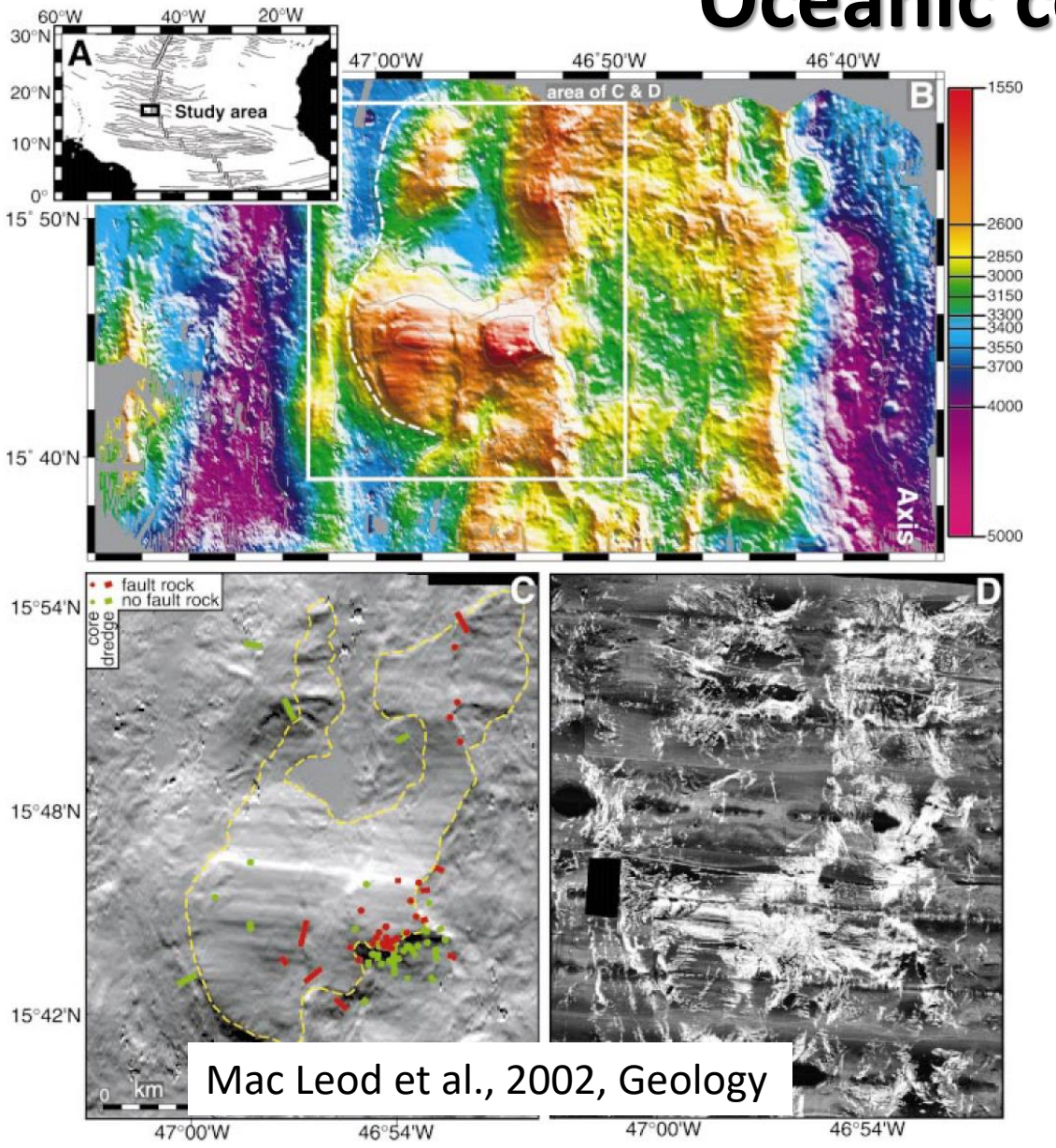
From Trost, G., 2020, PhD thesis, Univ. Salzburg

Oceanic core complex, sometimes associated with black smokers

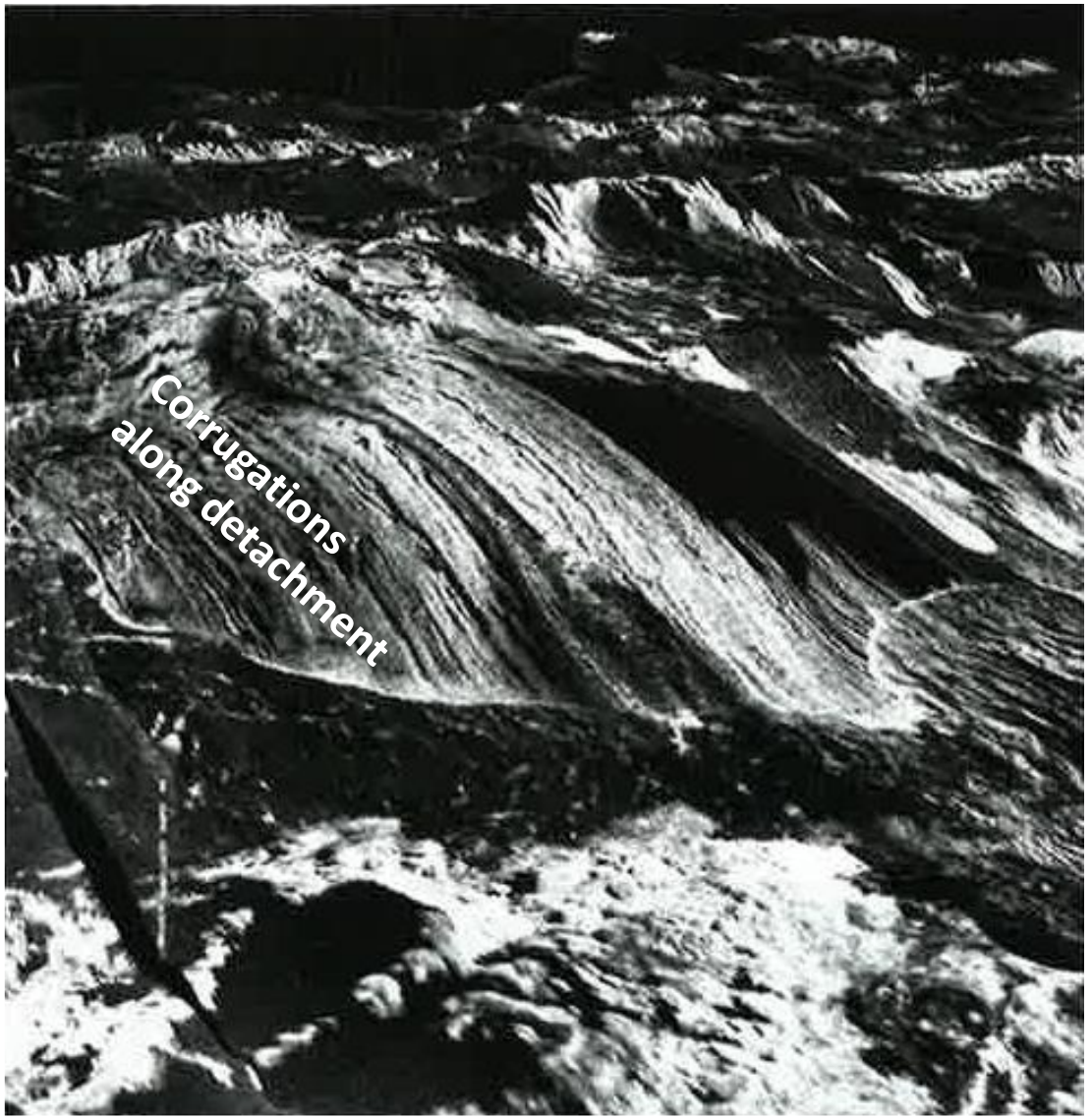


From: Karson et al., 2015, Discovering the Deep, Cambridge Univ. Press

Oceanic core complex

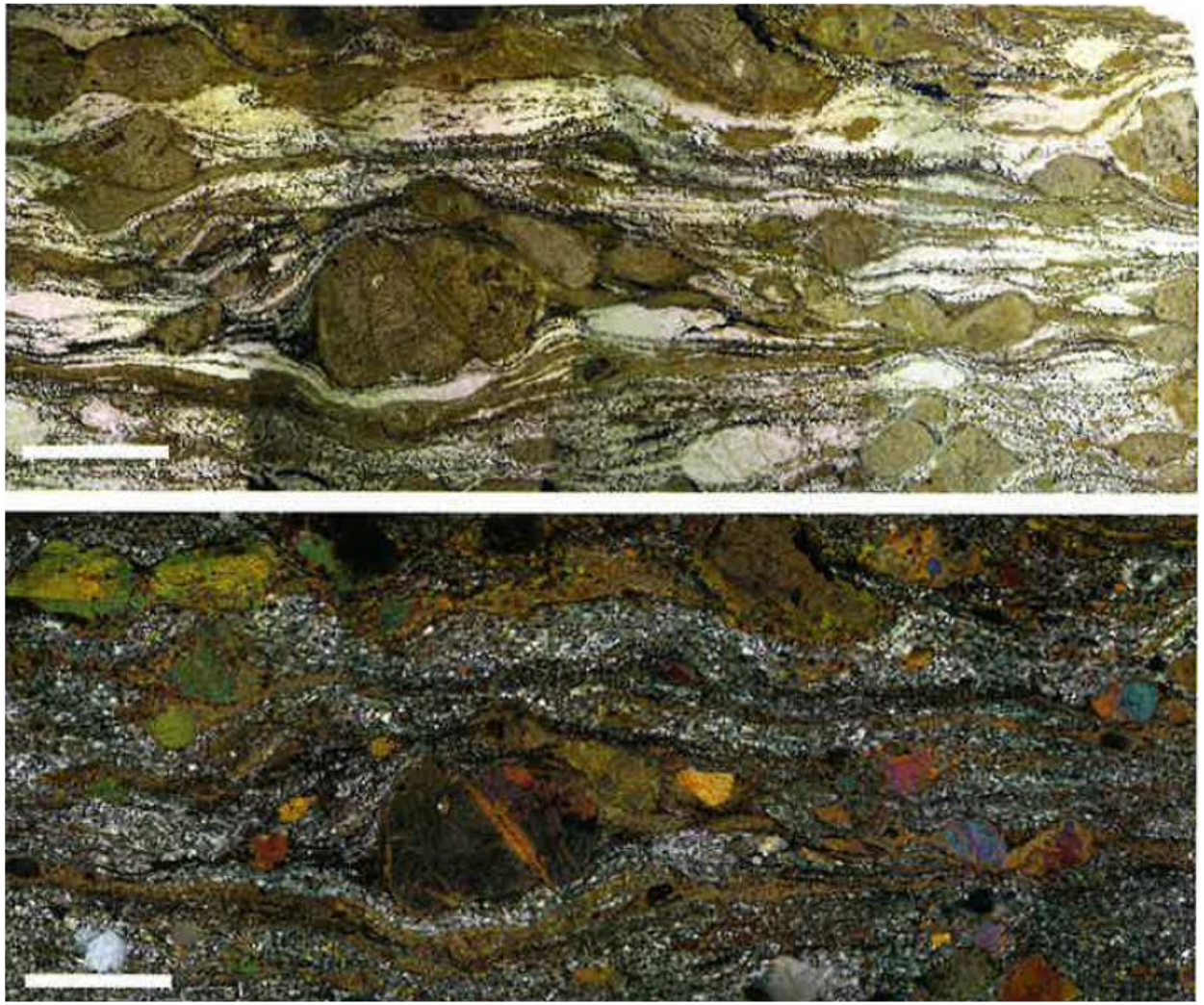


Mac Leod et al., 2002, Geology

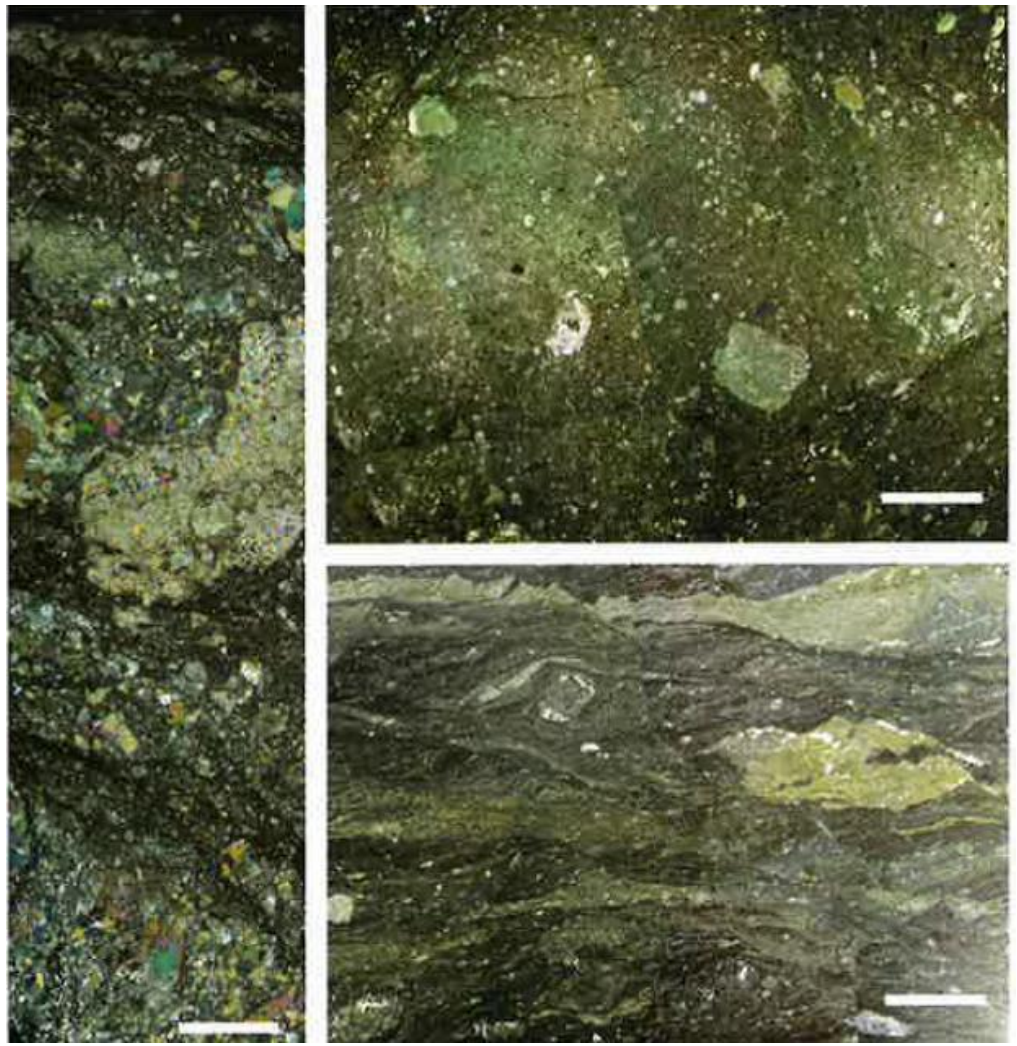


Oceanic core complex

Ductile structures, formed at c. 500-550 °C

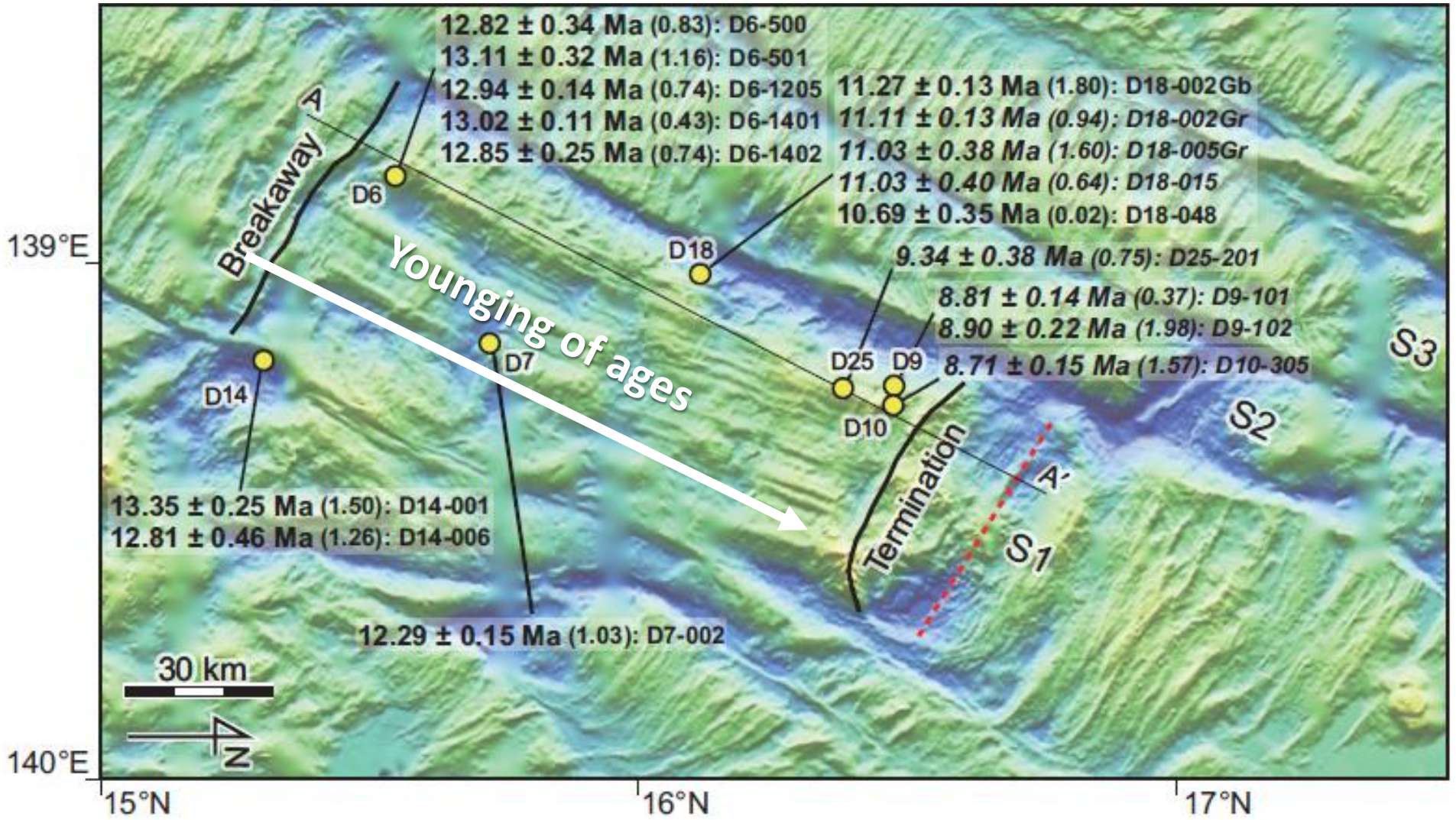


Brittle structures, formed at c. < 300 °C



From: Karson et al., 2015, Discovering the Deep, Cambridge Univ. Press

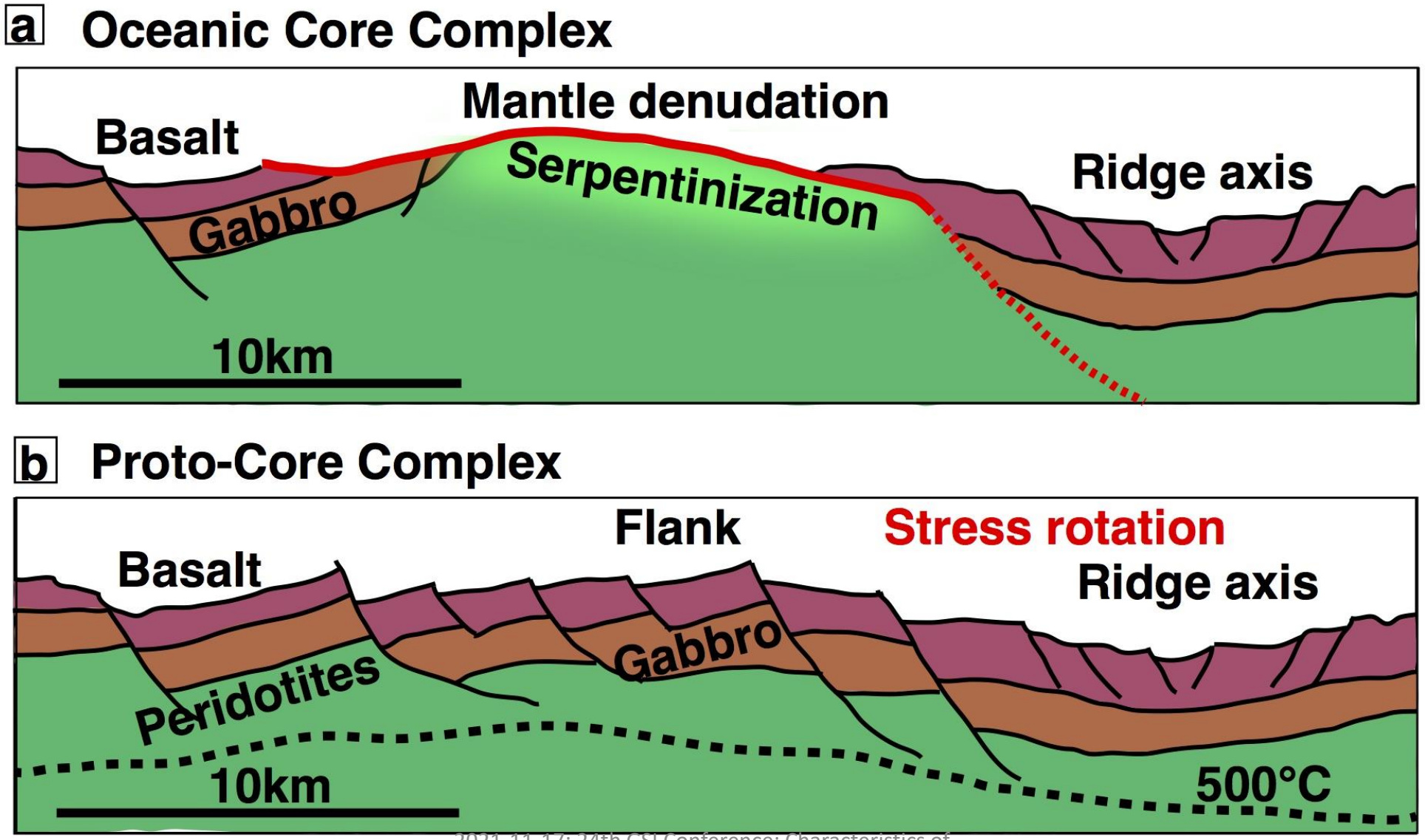
Oceanic core complex: Godzilla megamullion in Parece Vela Basin, Philippine Sea



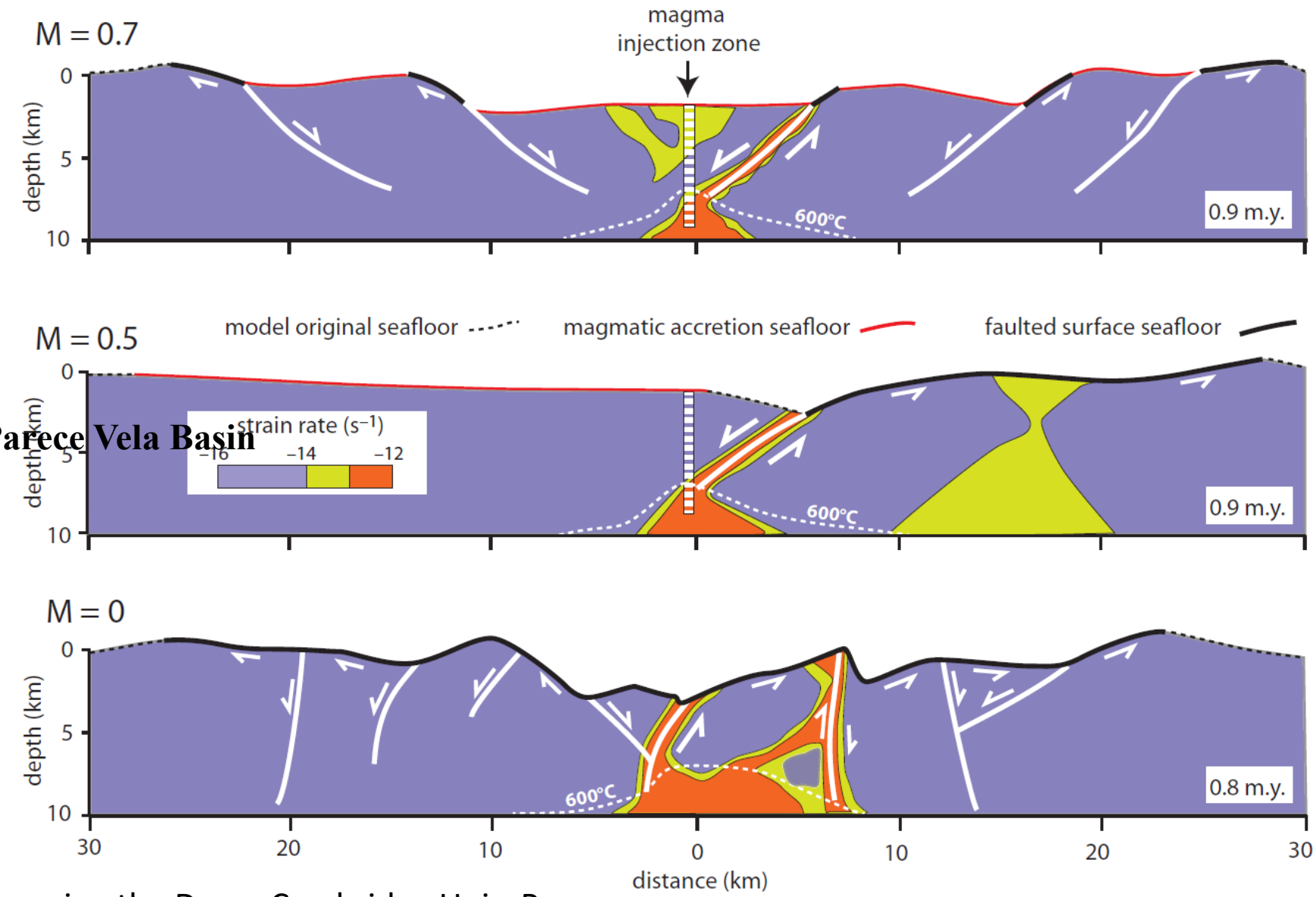
Tani et al., 2011, Geology

U-Pb zircon dating of gabbro and leucocratic rocks allows to estimate the rate of extension

Evolution of an oceanic core complex: extensive serpentinization

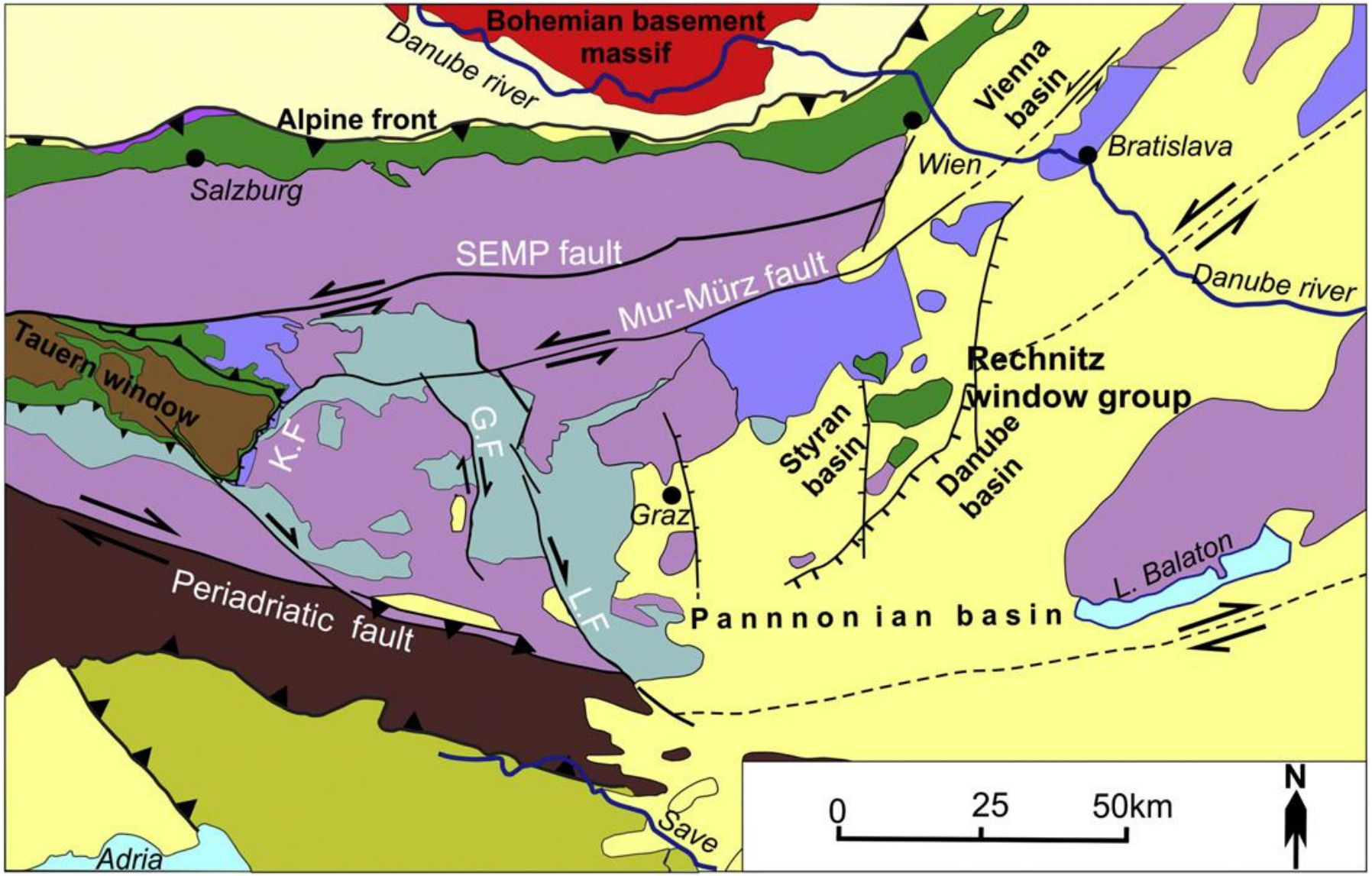


Modelling of an oceanic core complex: Note T-control of magma injection zone



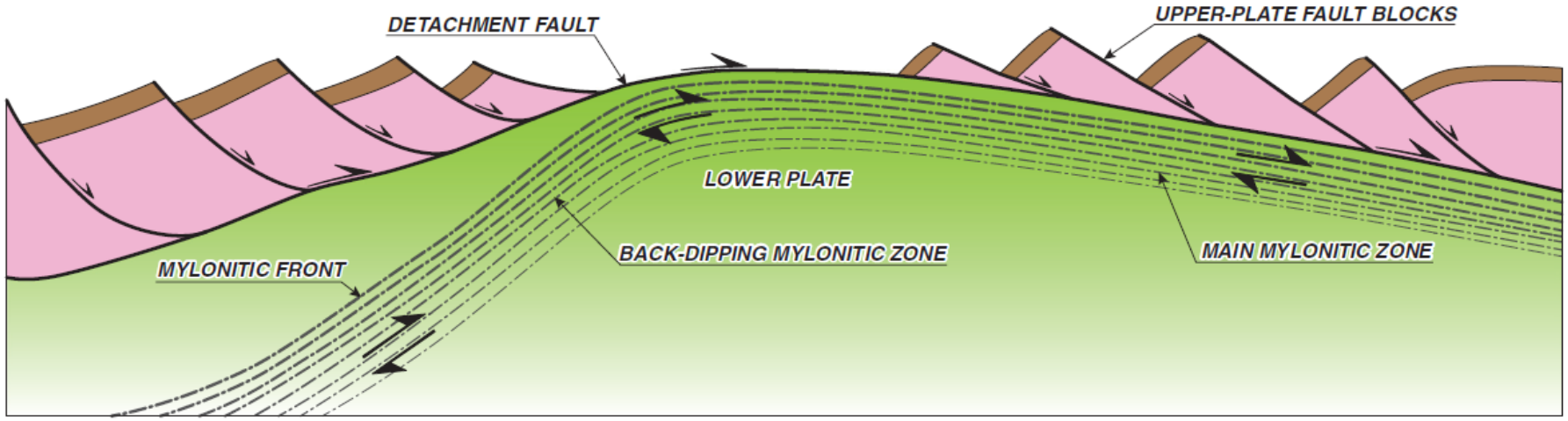
From: Karson et al., 2015, Discovering the Deep, Cambridge Univ. Press

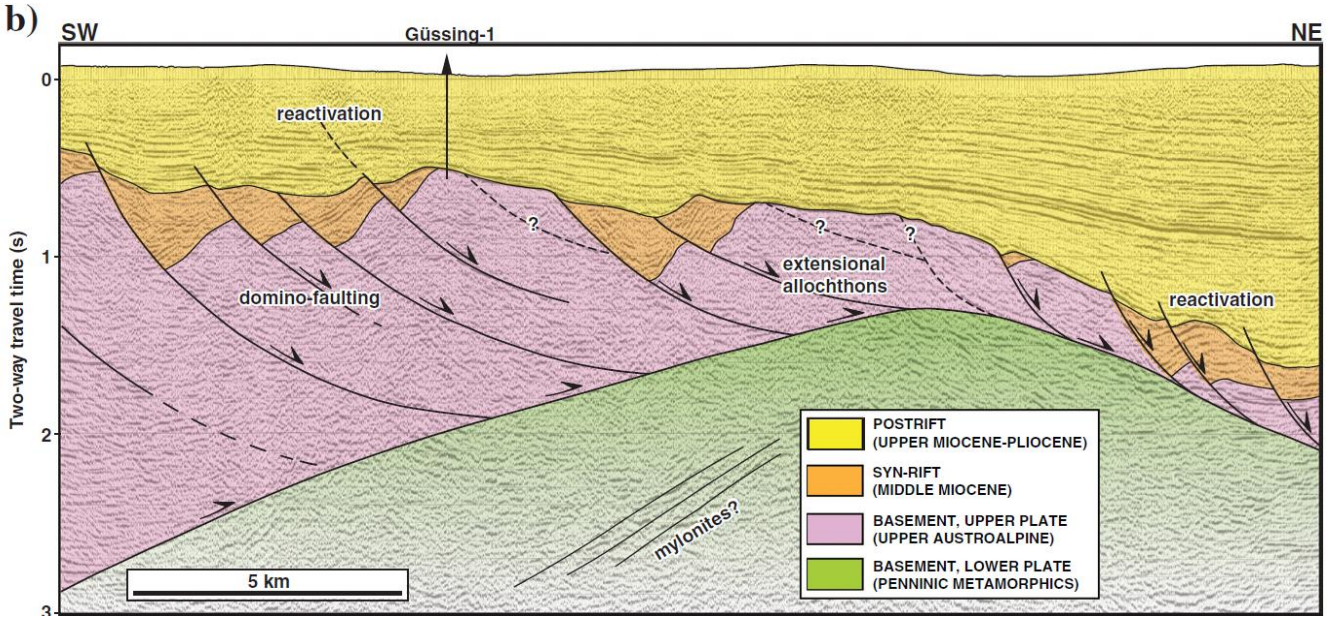
Cordillerran-type continental MCC: Some features of the Rechnitz MCC

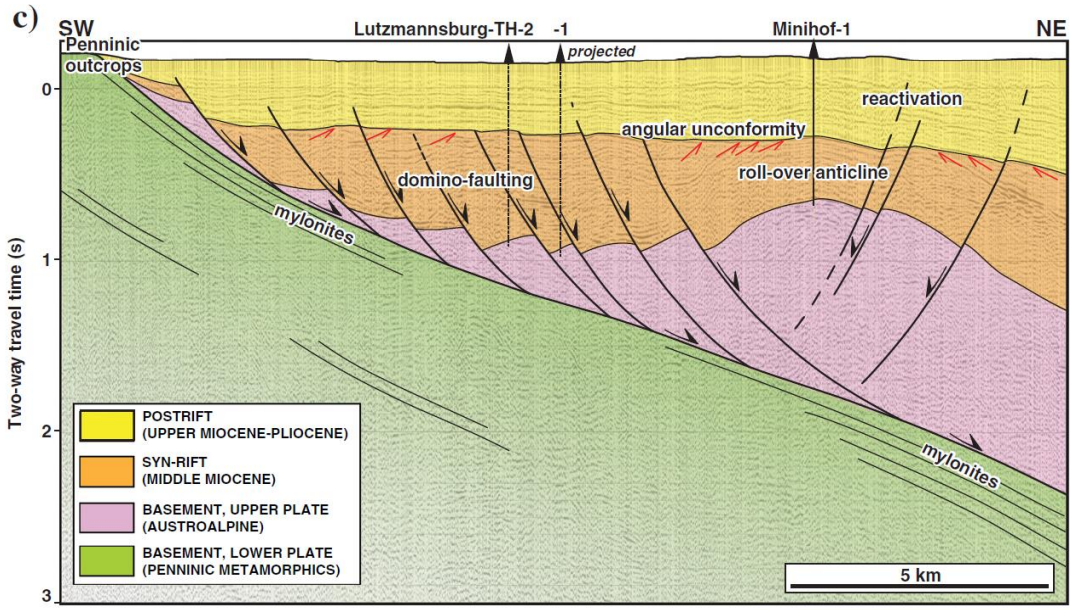


From Cao et al., 2013)

The Rechnitz MCC: Subsurface expression in seismic sections







(From Tari et al., 2020)

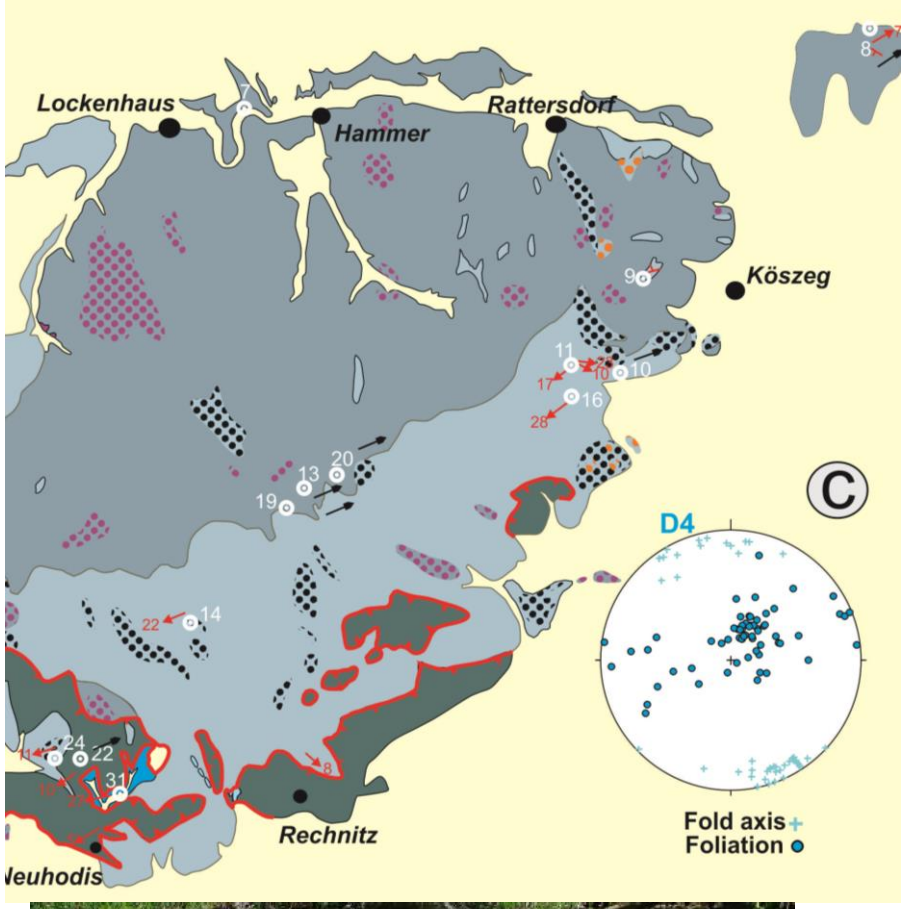
Stages of ductile deformation:

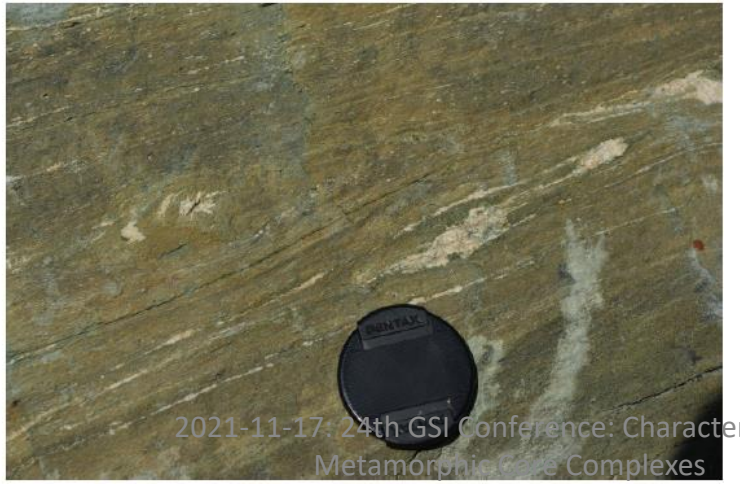
D1: Deformation during subduction / blueschist metamorphism incl. burial underneath Austroalpine nappe complex

D2: Thrusting of ophiolite over lower unit

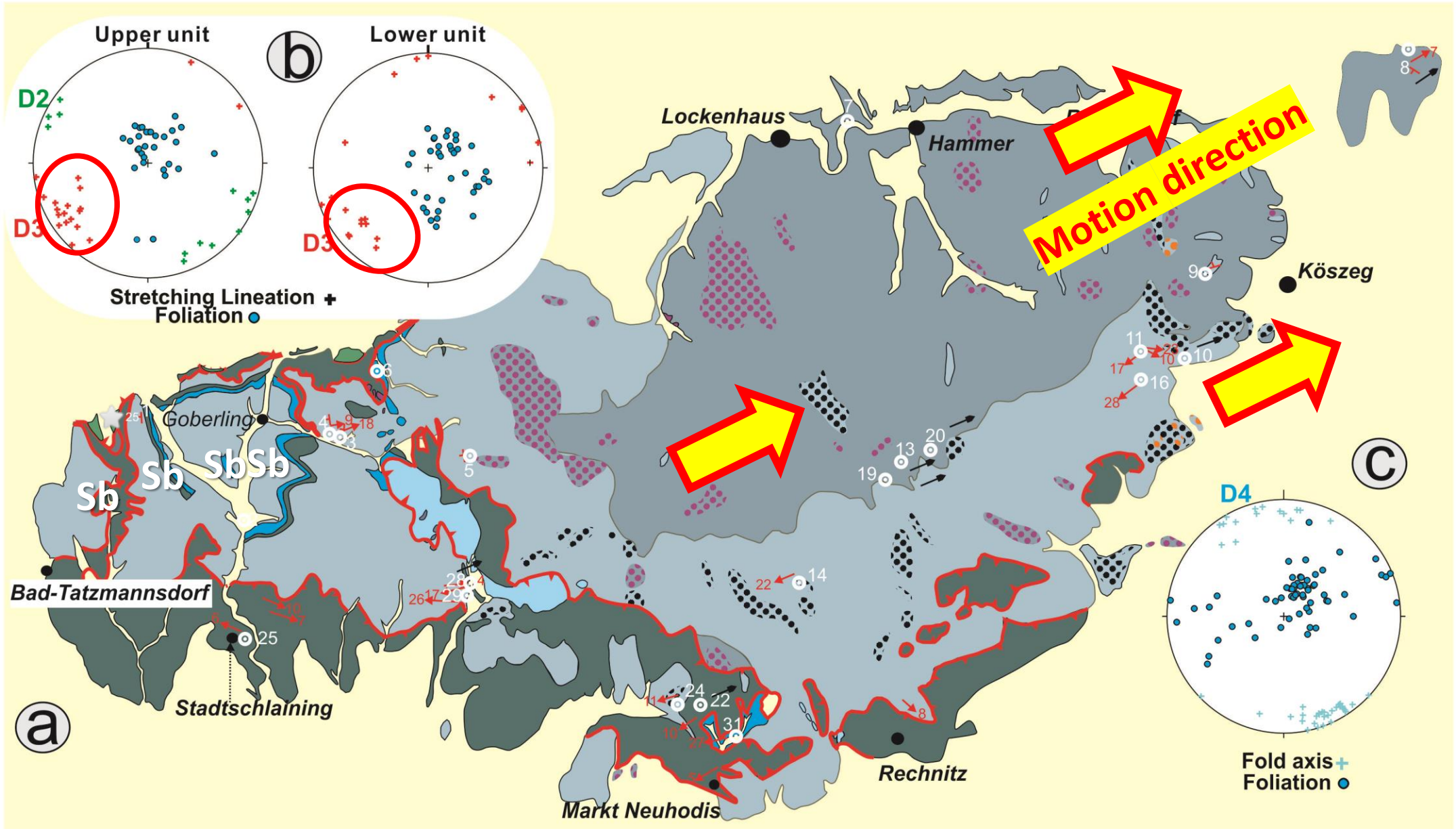
D3: Ductile extension/ normal faulting (ca. 20 – 15 Ma)

D4: Top-E vergent folding

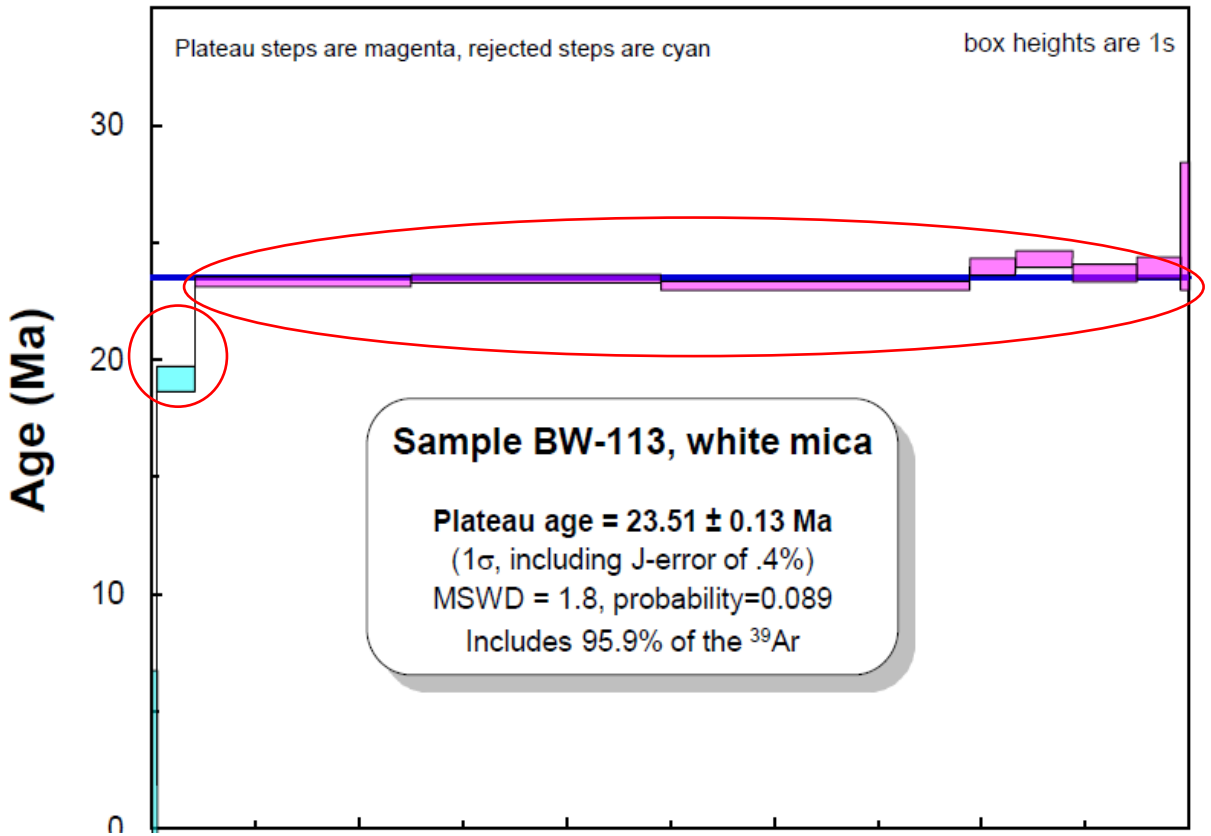




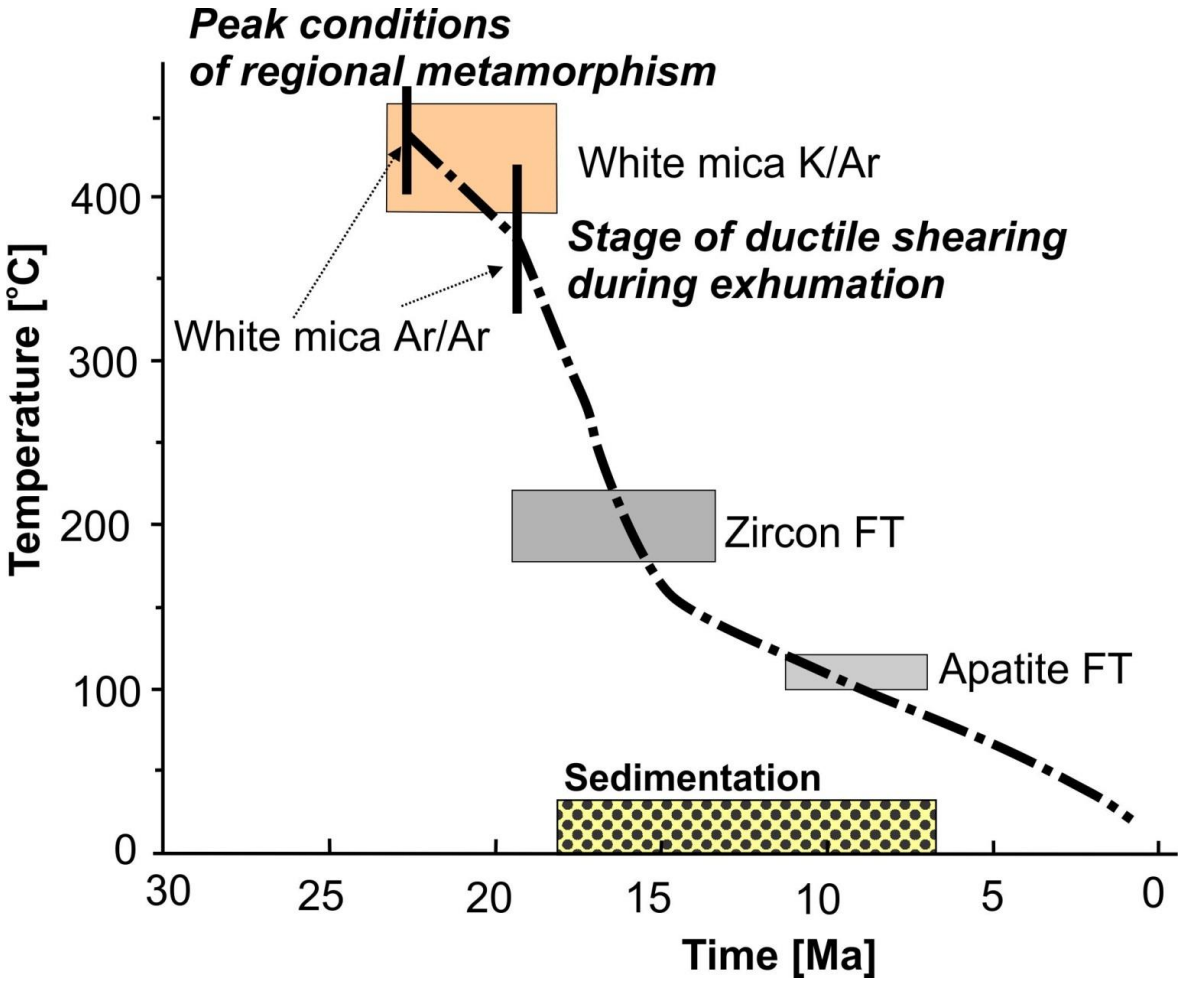
Stages of ductile deformation within the Rechnitz MCC



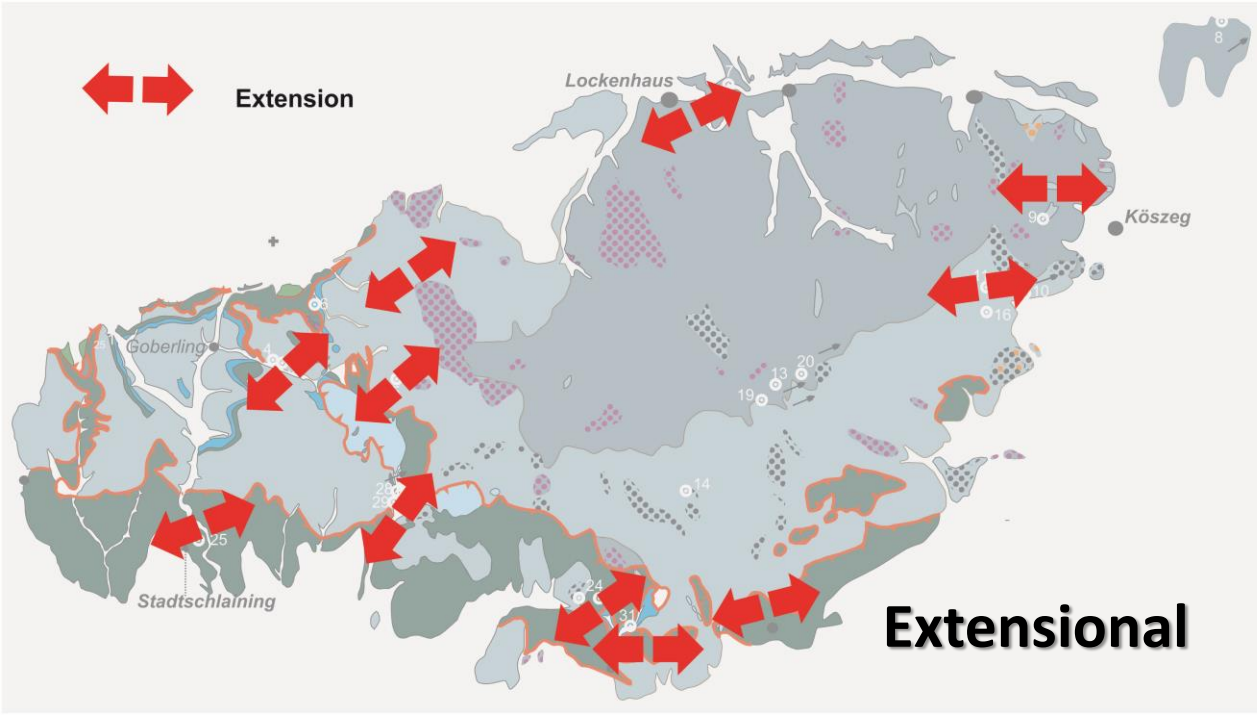
Some new mica ages: Formed at peak P-T (greenschist facies) conditions: 390 - 430°C, ca. 3 kb (Koller, 1985)



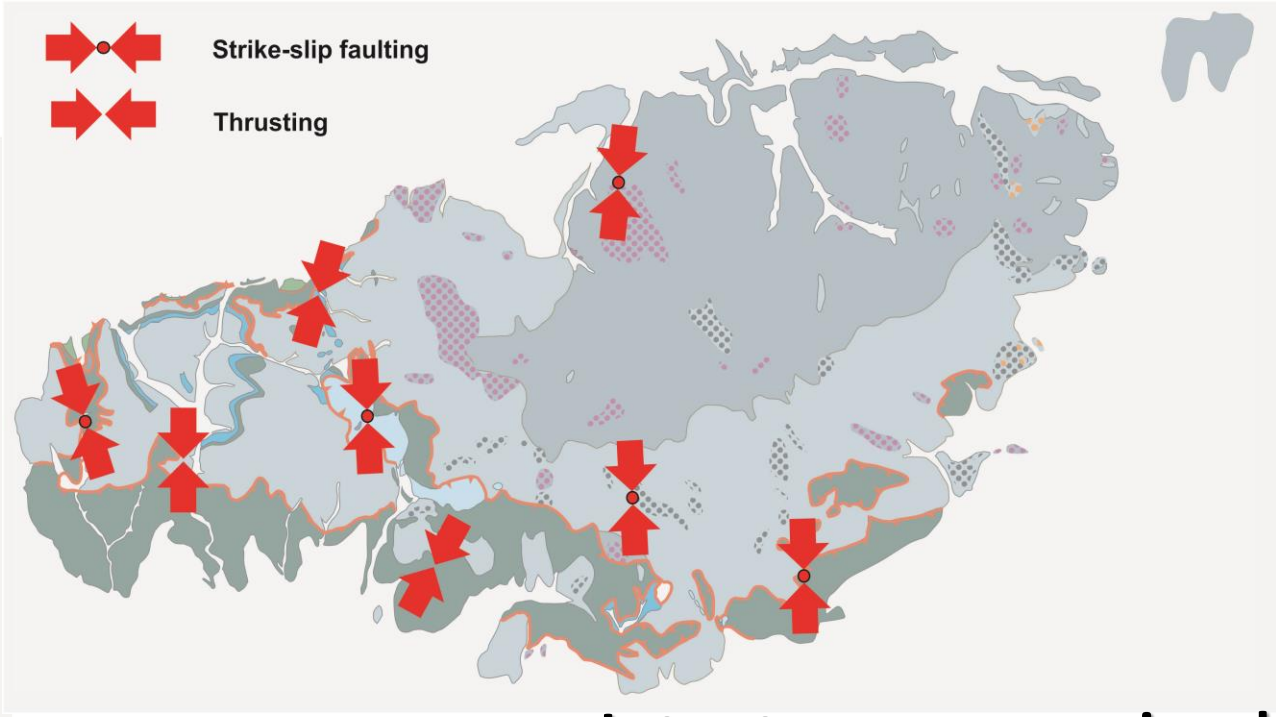
Cooling path of the Rechnitz MCC



Palaeostress data: fault and striae data



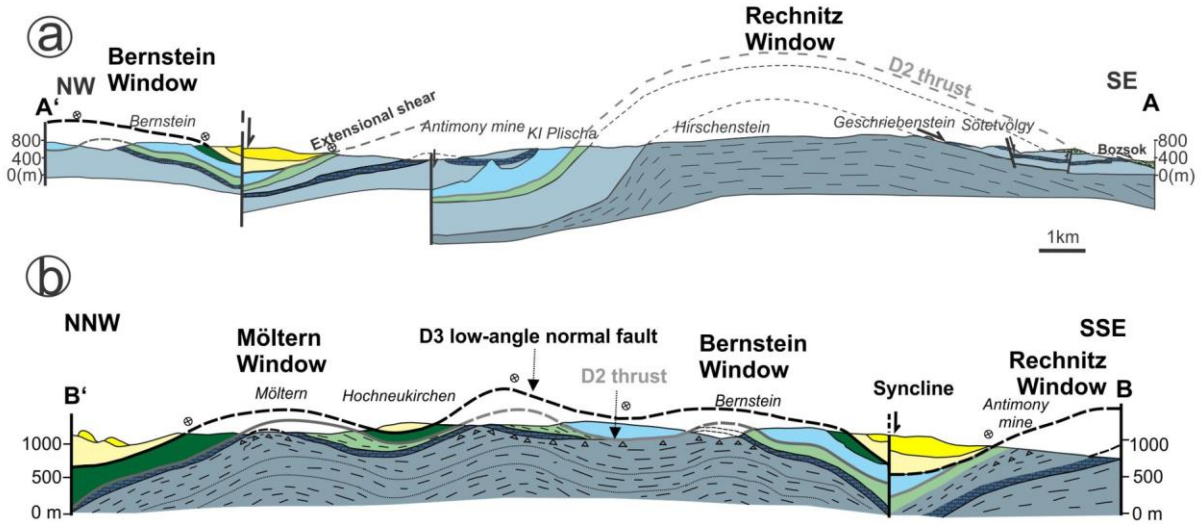
Extensional



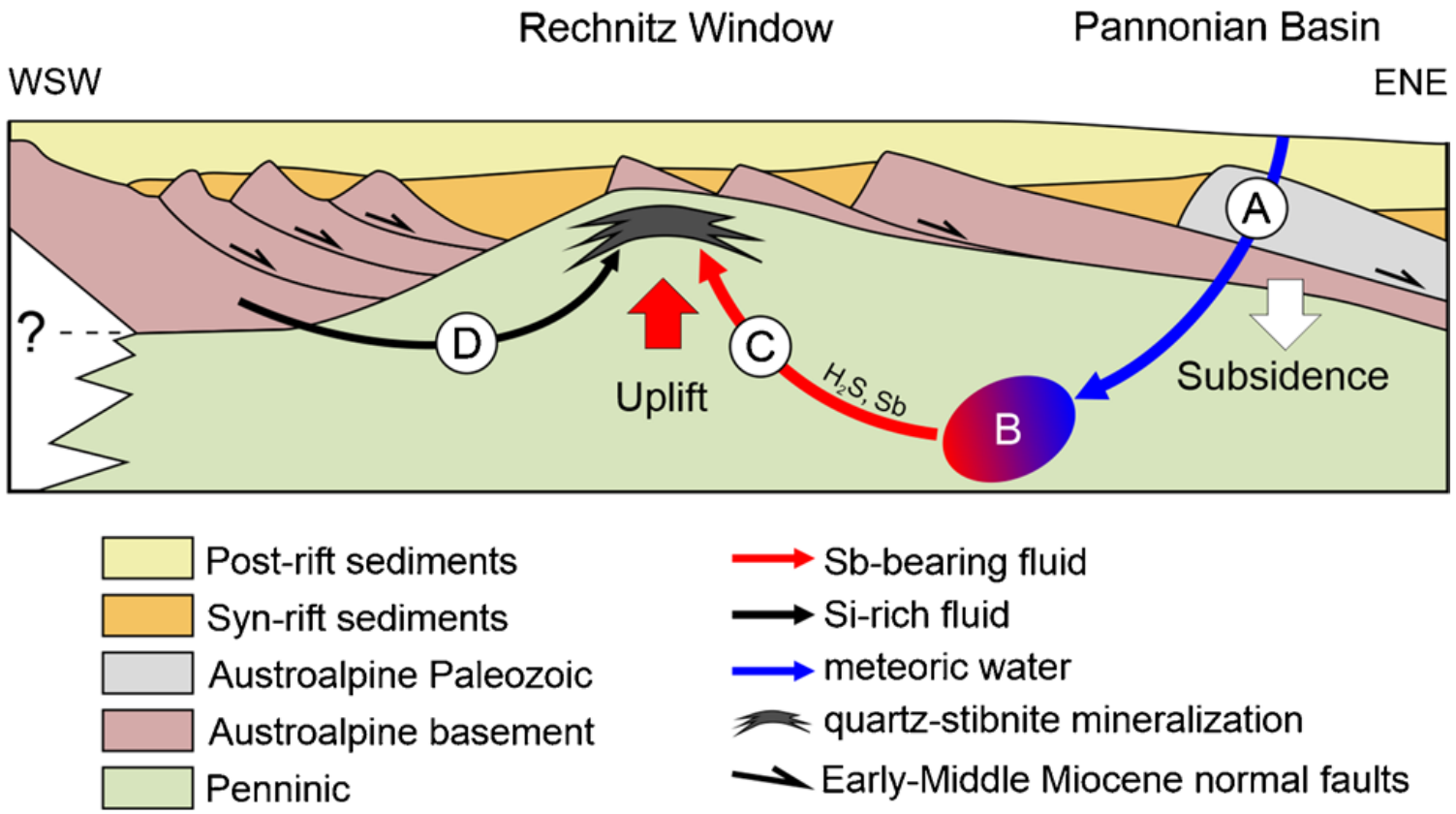
Late-stage compressional

Post-main-stage extension:

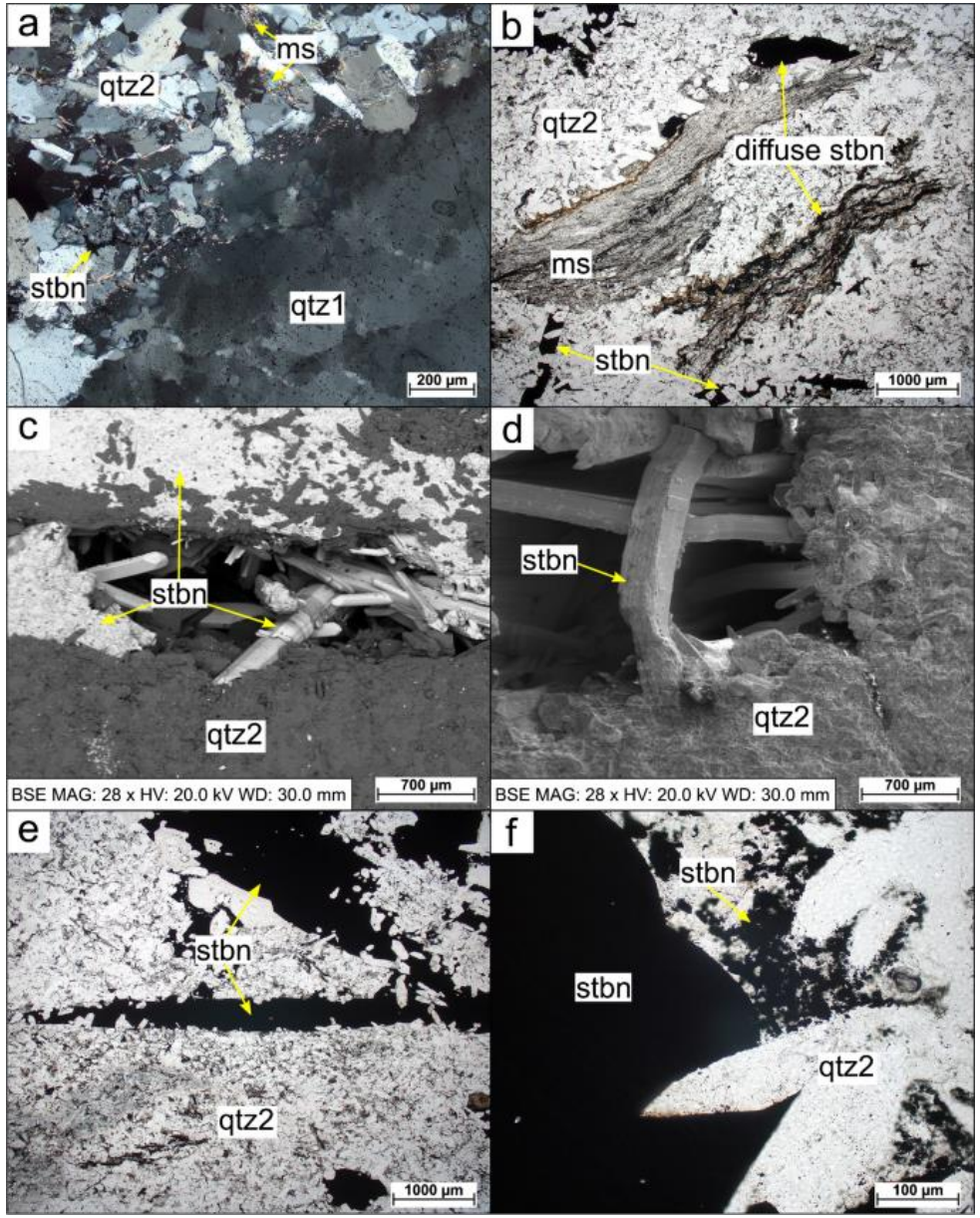
Large-wave length–low-amplitude folding with ca. ENE-WSW axes



Rechnitz MCC: Stibnite mineralization

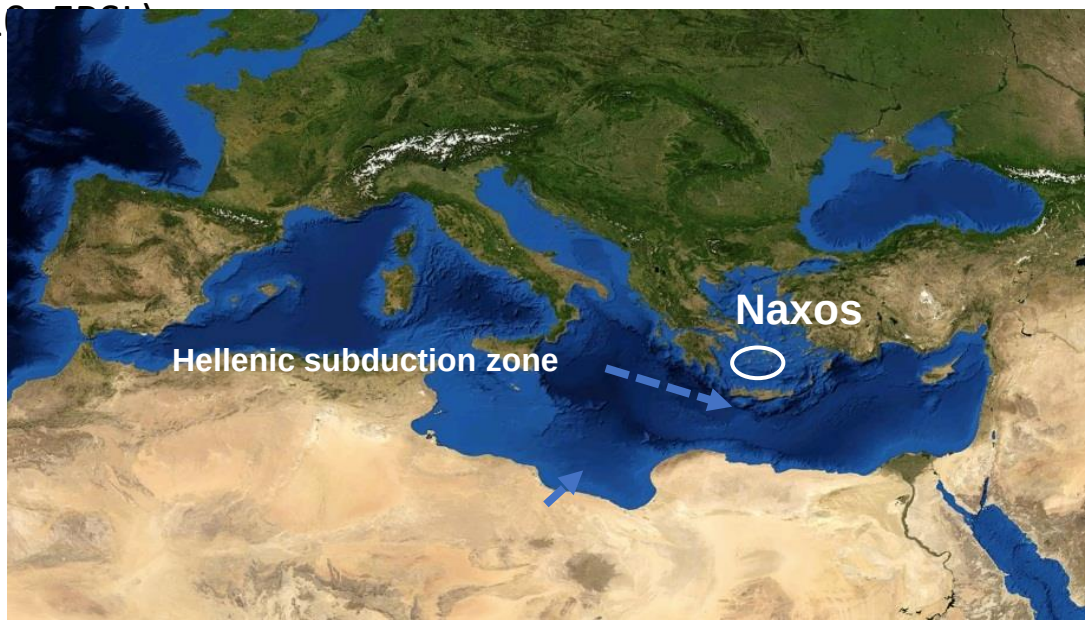


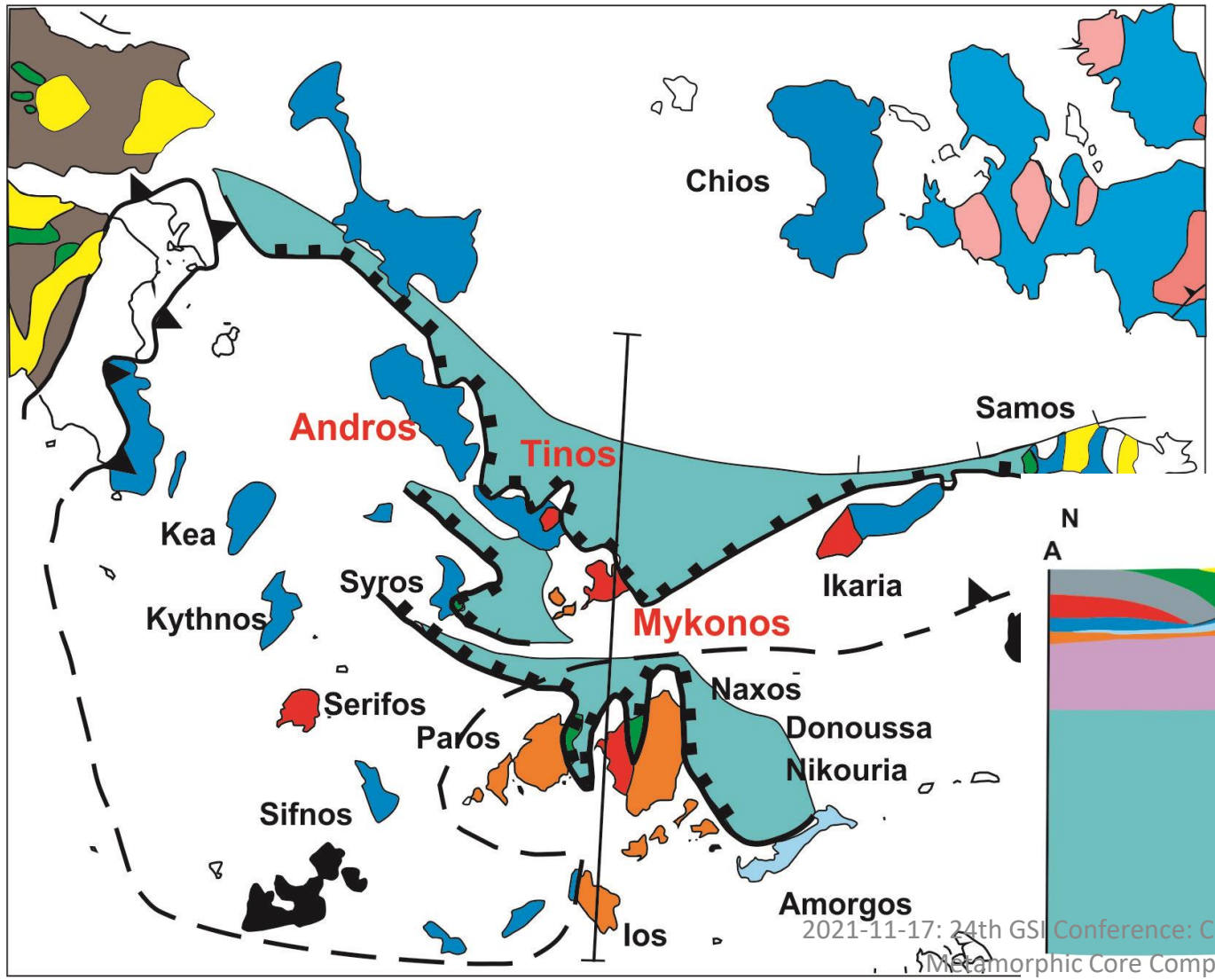
From Sośnicka et al. 2021, Mineralium Deposita

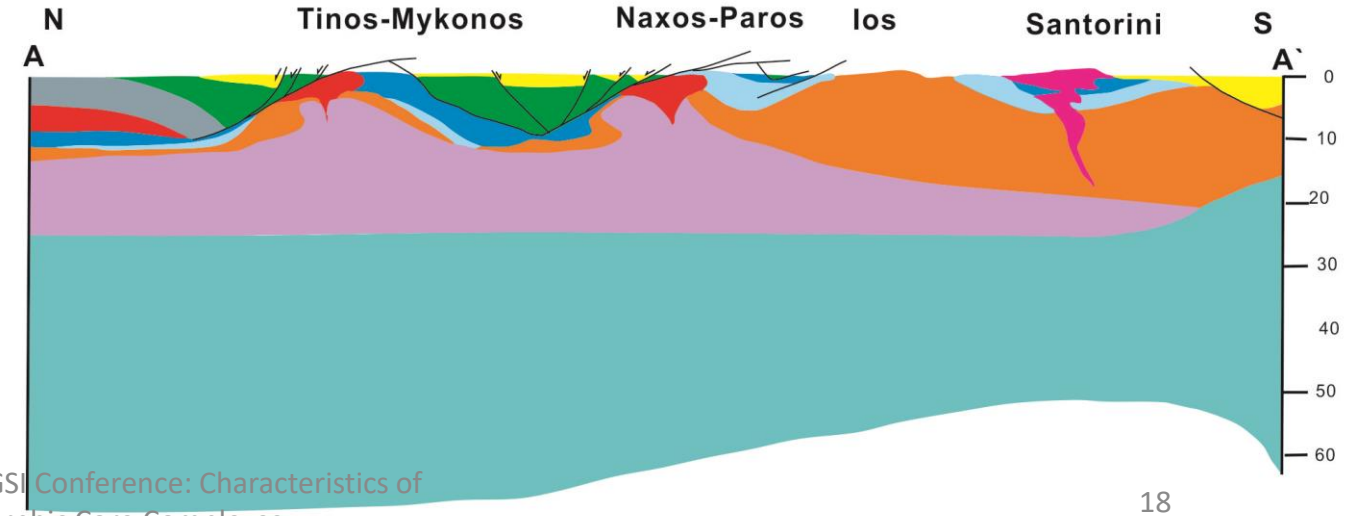


Naxos MCC, Aegean Sea extensional MCC related to compression

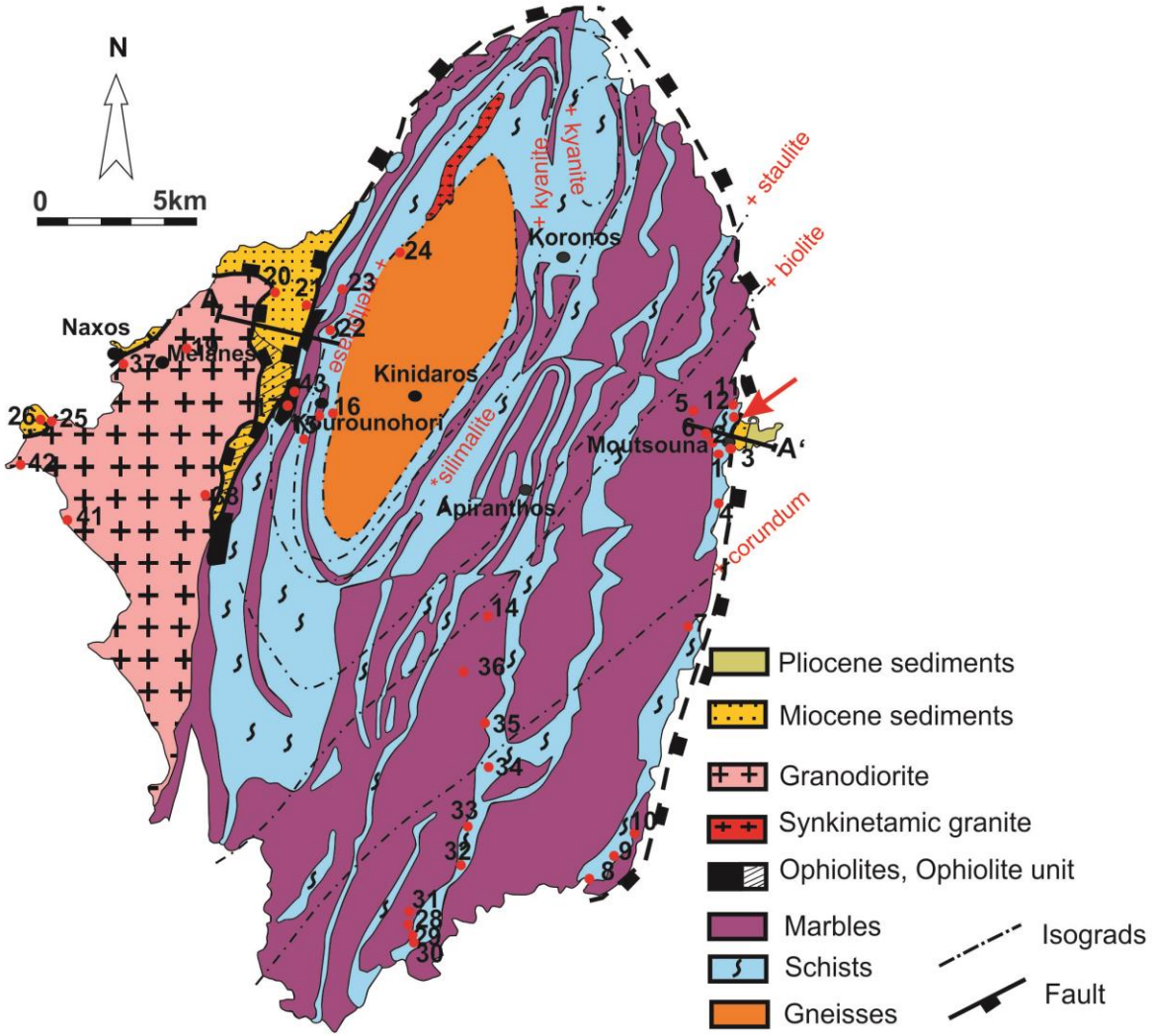
North Cycladic Detachment System (after Jolivet et al., 201[illegible])

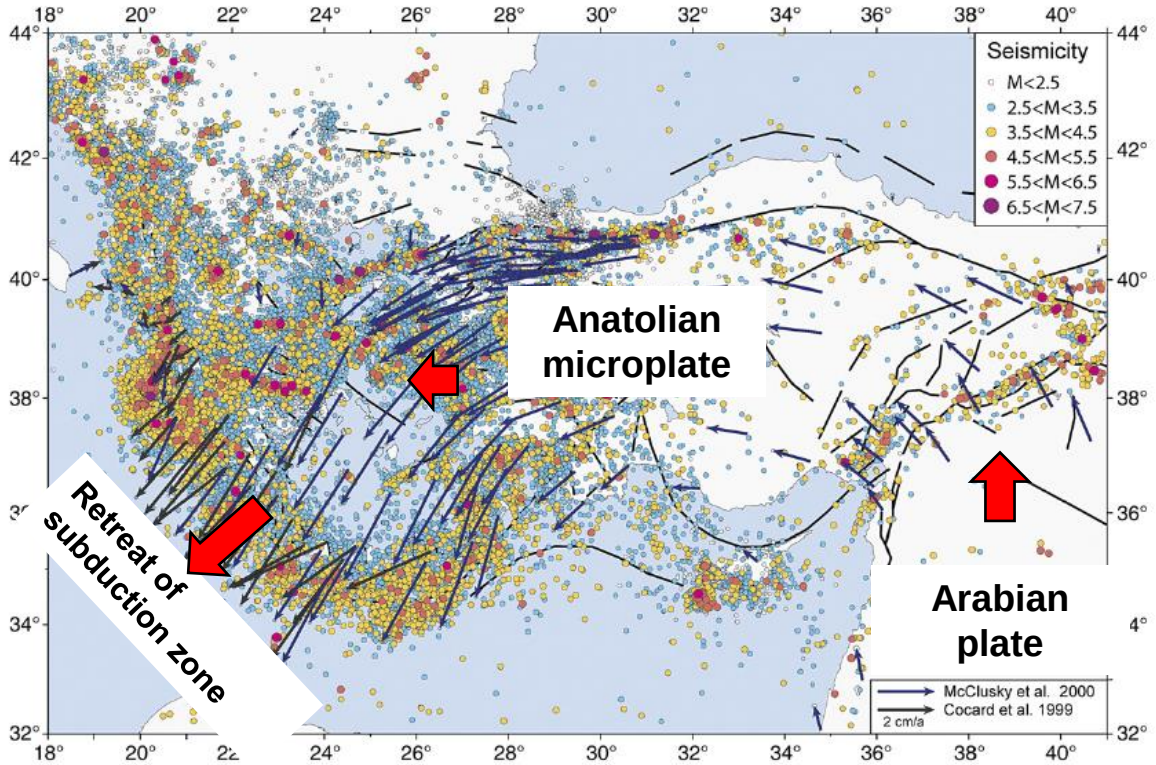






Present-day kinematics of the Eastern Mediterranian realm (from Cloetingh et al., 2007, Global and Planetary Change): Subtle kinematic relationship between retreat of subduction zone and lateral extrusion





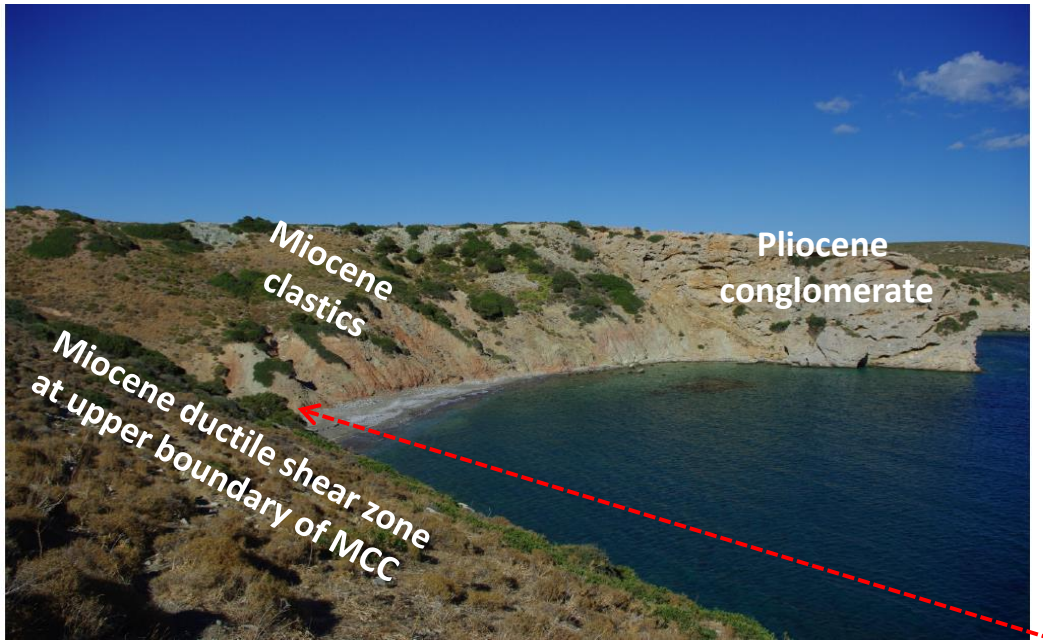
Hollenstein et al., 2008, Tectonophysics

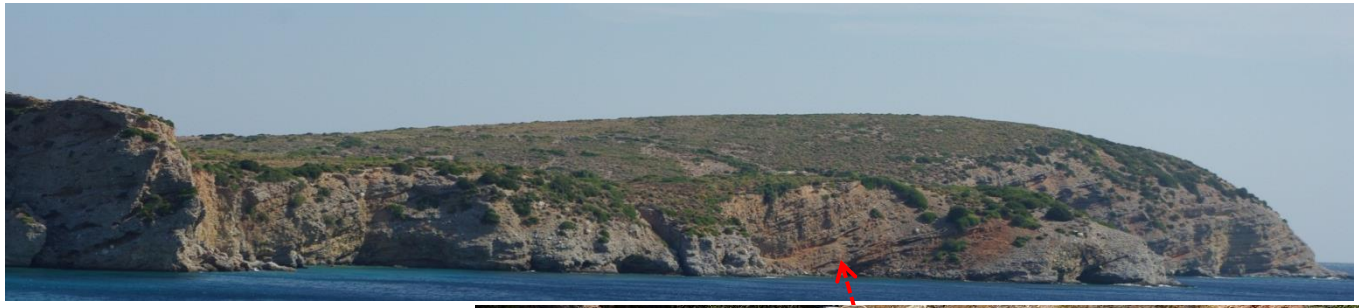
Geological structure of Naxos:

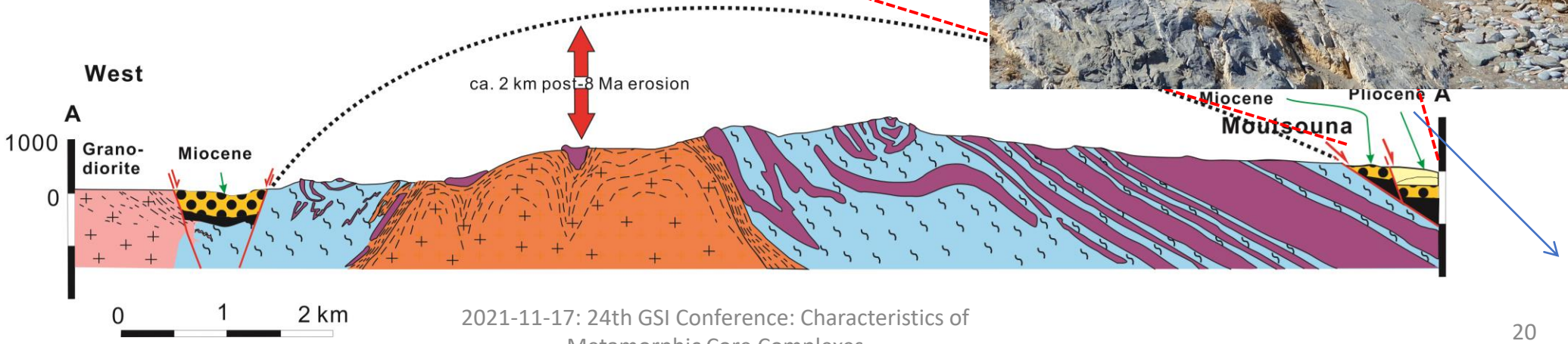
Lower plate: MCC with migmatite dome & Granodiorite (W)

Upper plate: Ophiolite nappe &Miocene & Pliocene sediments

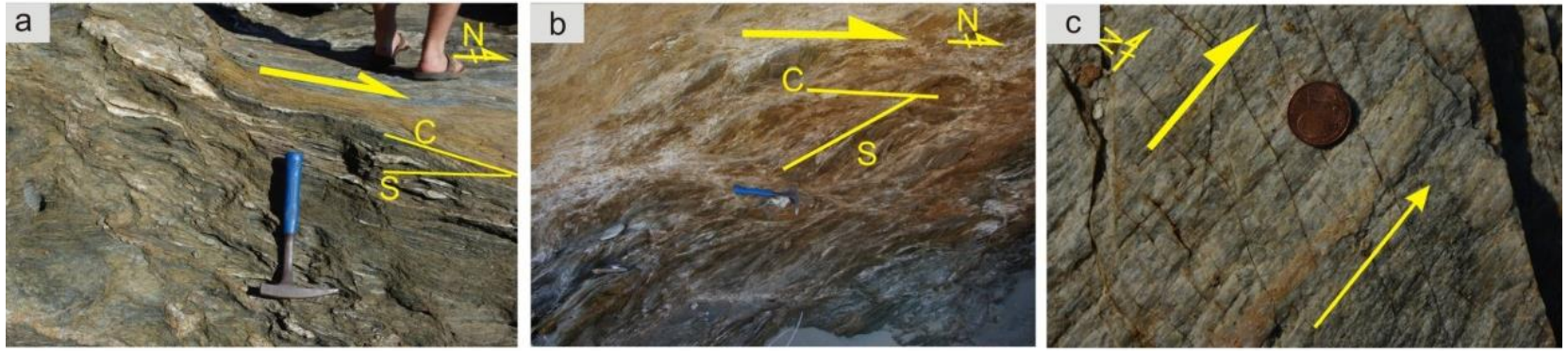
Naxos: boundary between lower and upper plate: ductile top-N shear zone structures

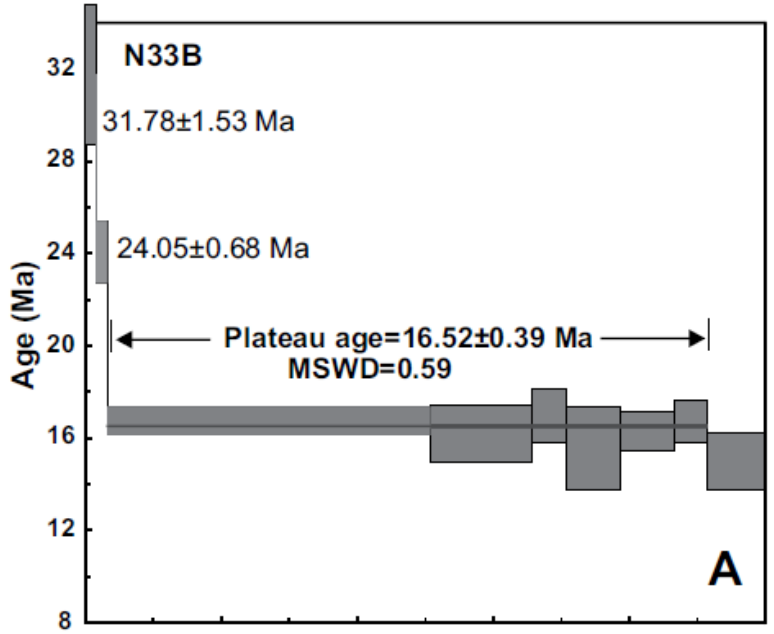




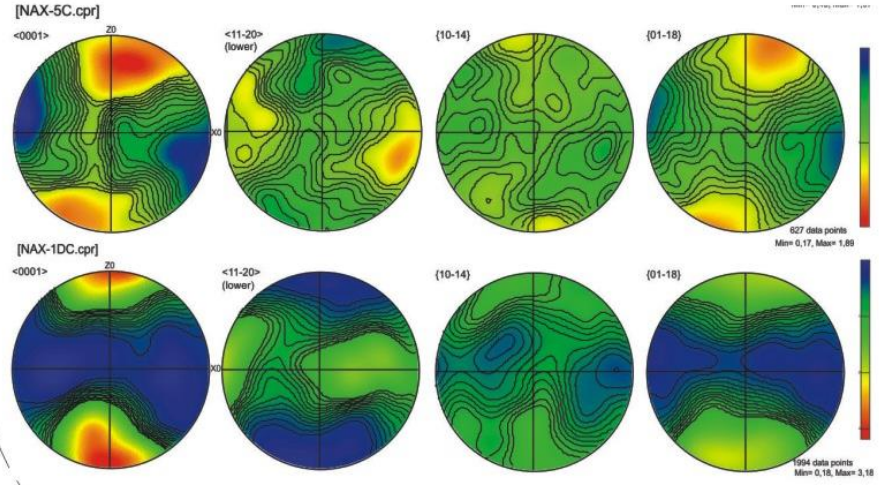


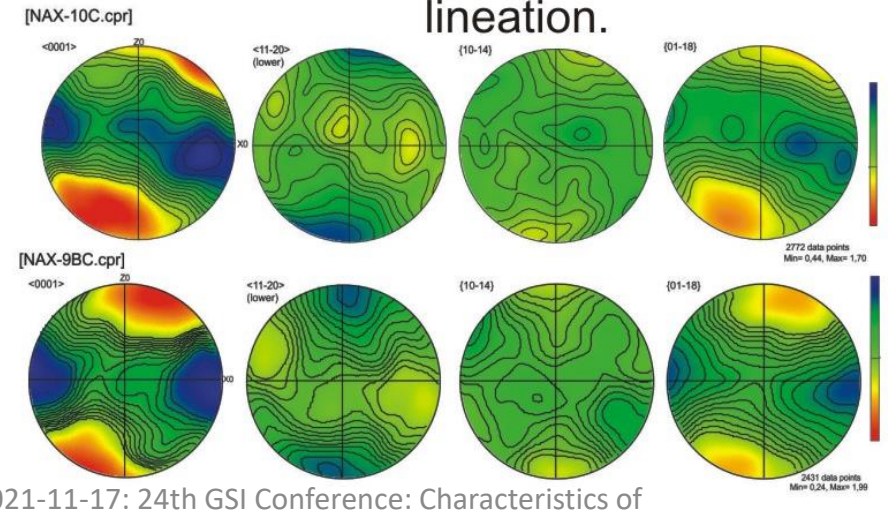
Naxos MCC: Lateral strike-slip boundary of a metamorphic core complex

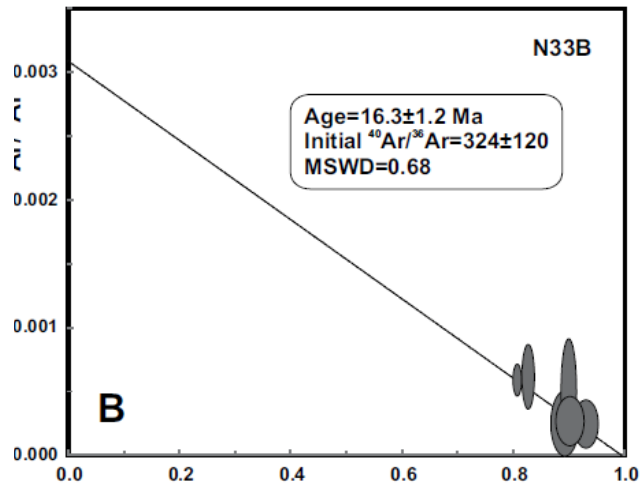




lineation.

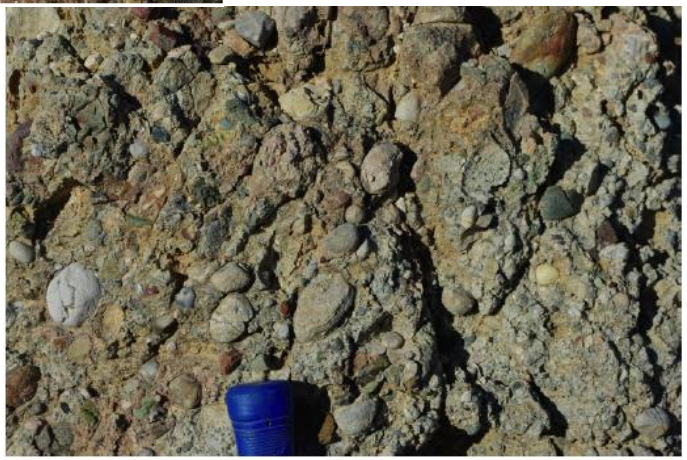


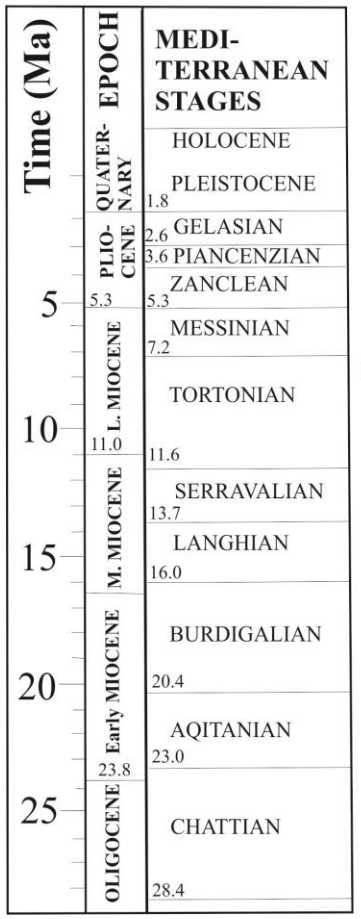


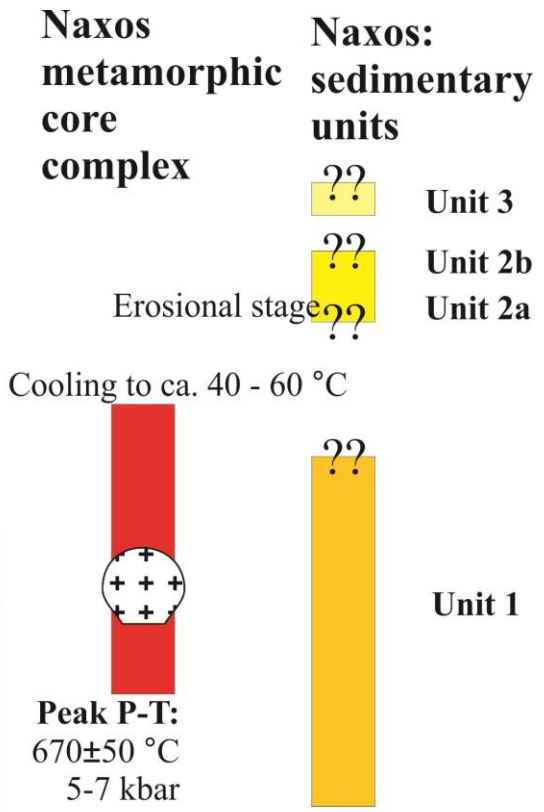


Three sedimentary units (coarsening upwards)

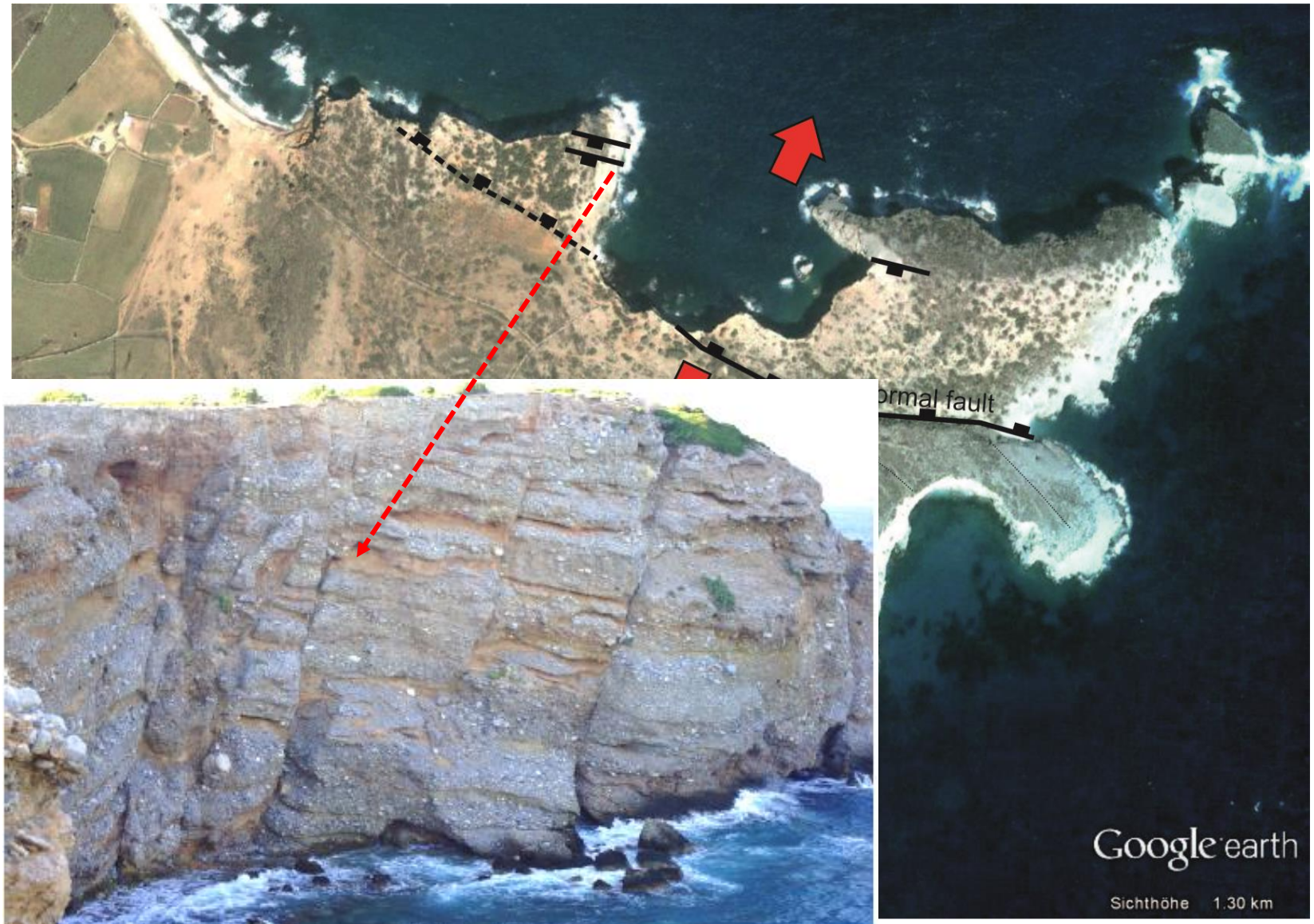
- **Unit 1: syn-exhumation**
- **Unit 2: erosion after folding**
- **Unit 3: post-exhumation overstepping MCC**



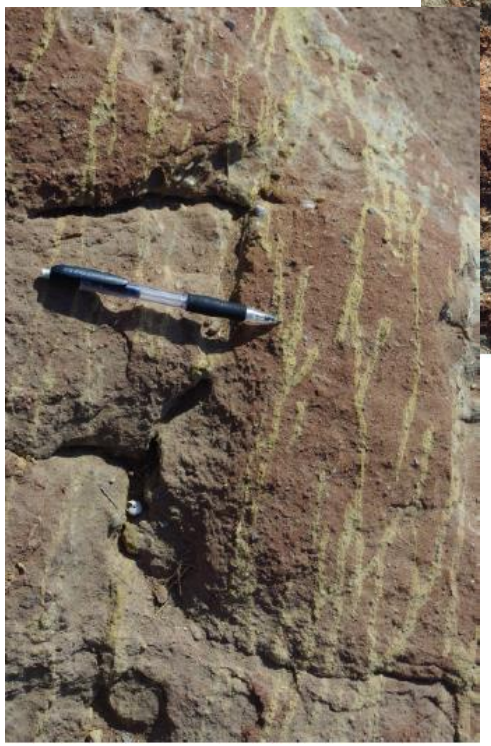




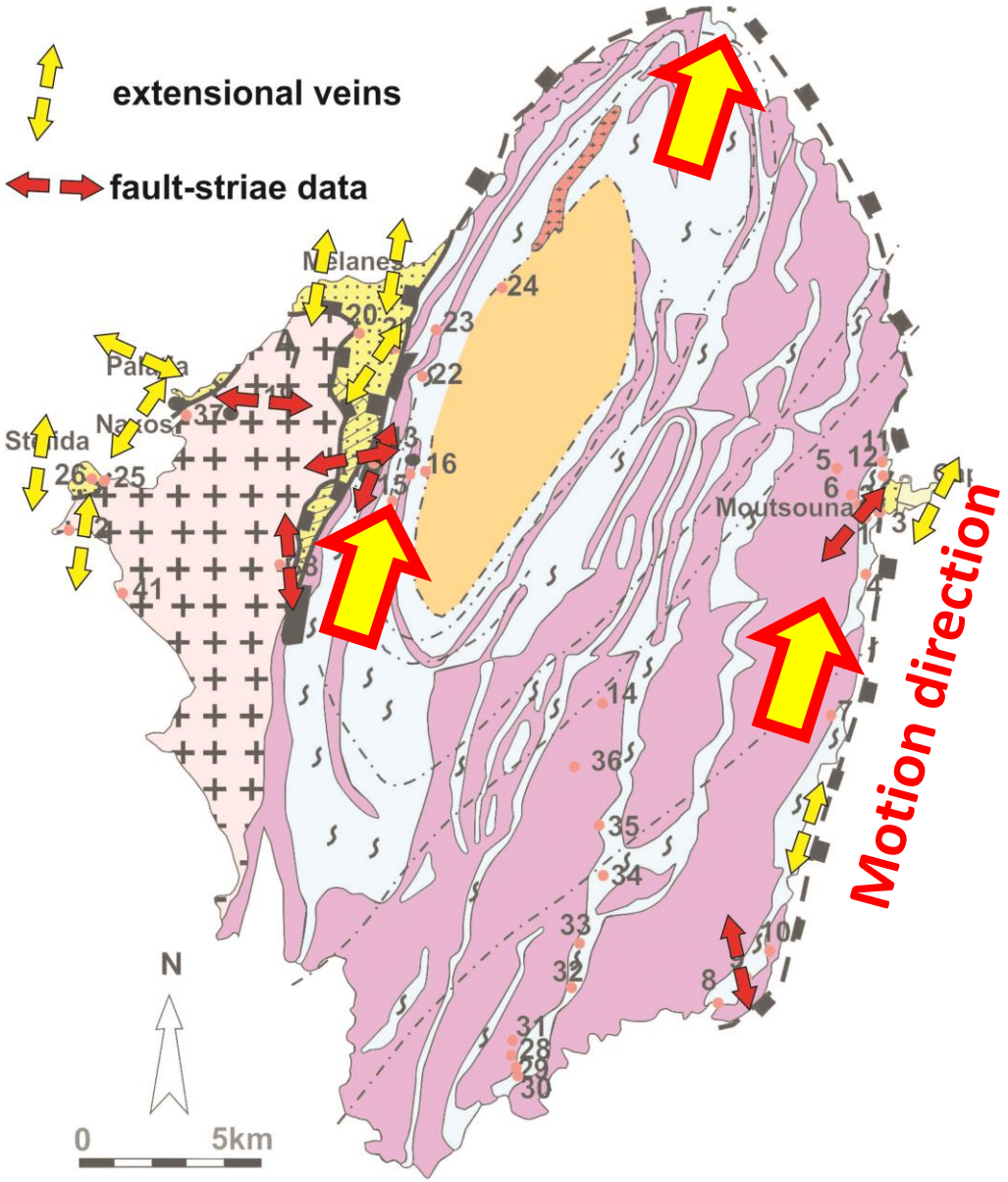
Moutsounas Peninsula: normal faults in Unit 2b due to NE-SW extension



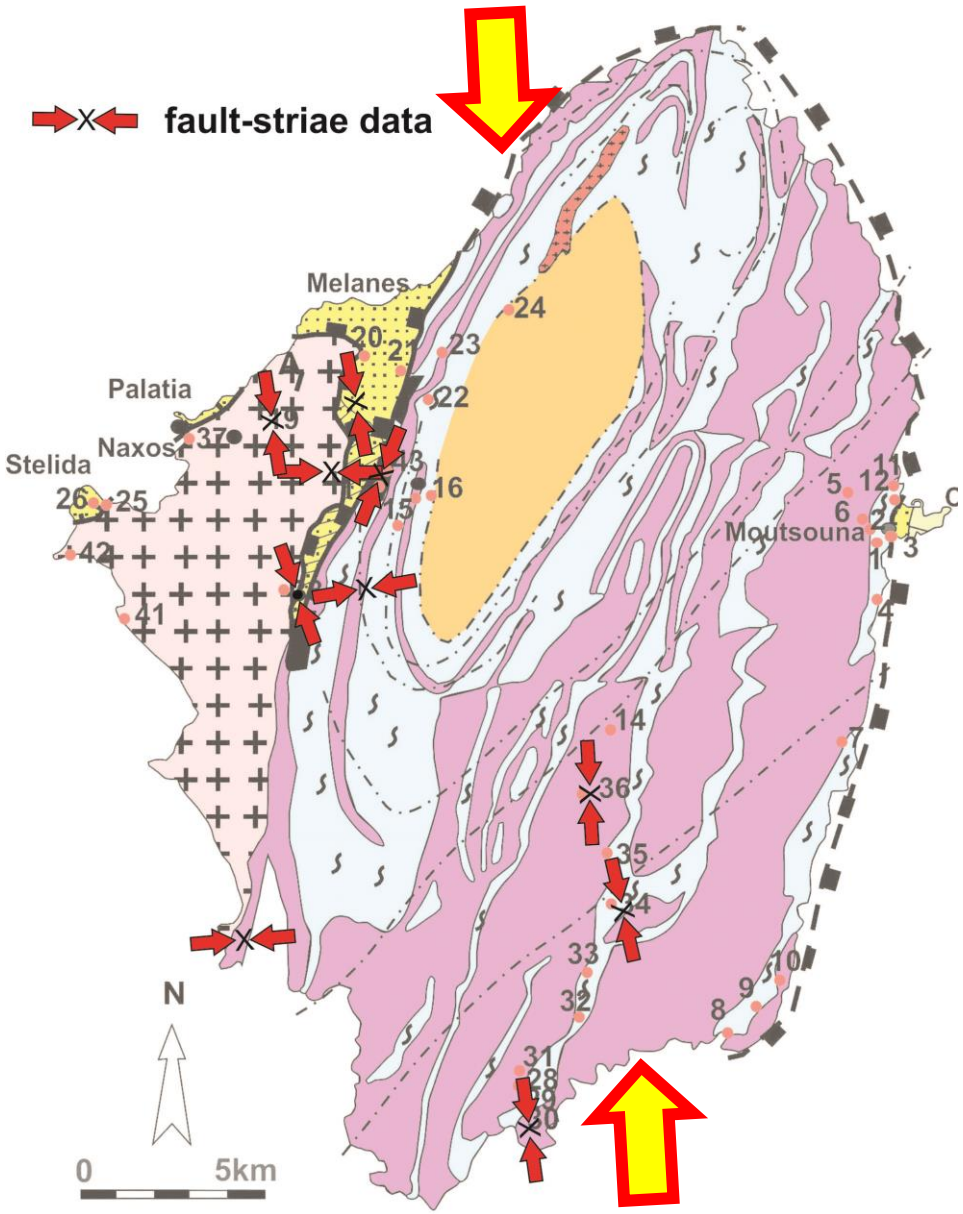
Hydrothermal activity and veining



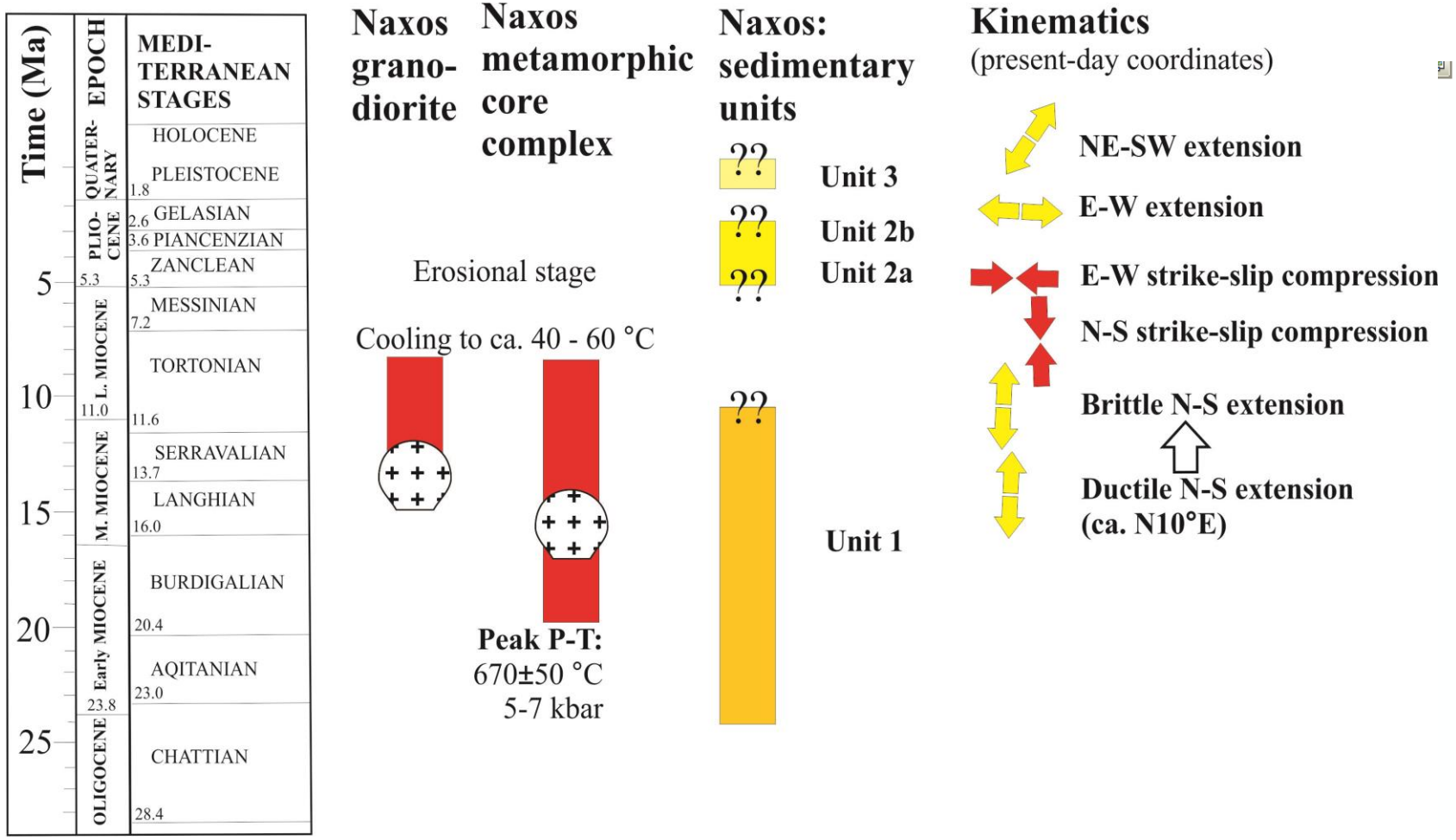
Brittle extensional structures



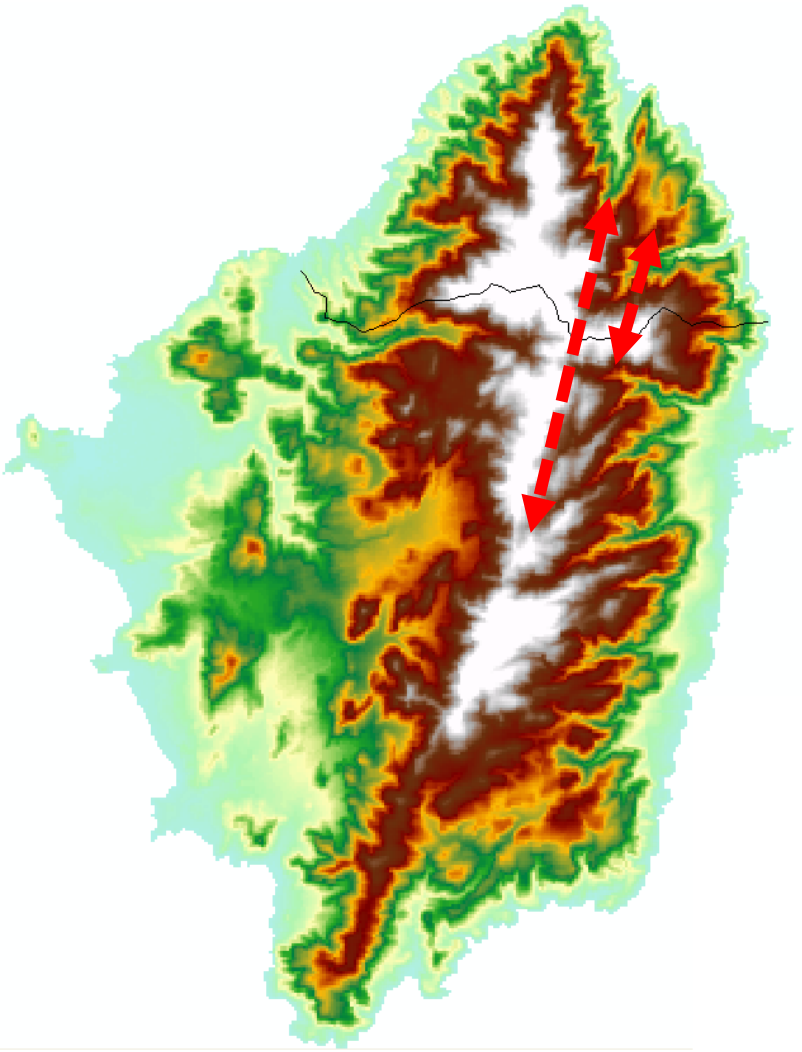
Brittle compressional structures



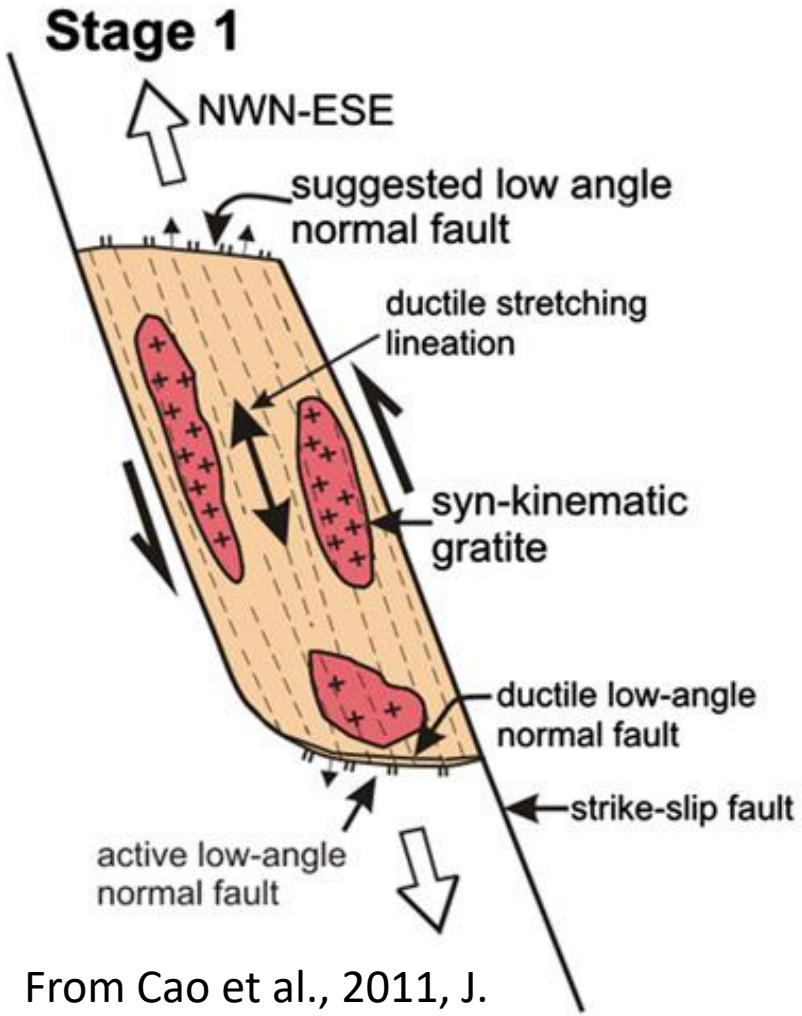
Kinematic stratigraphy of Naxos



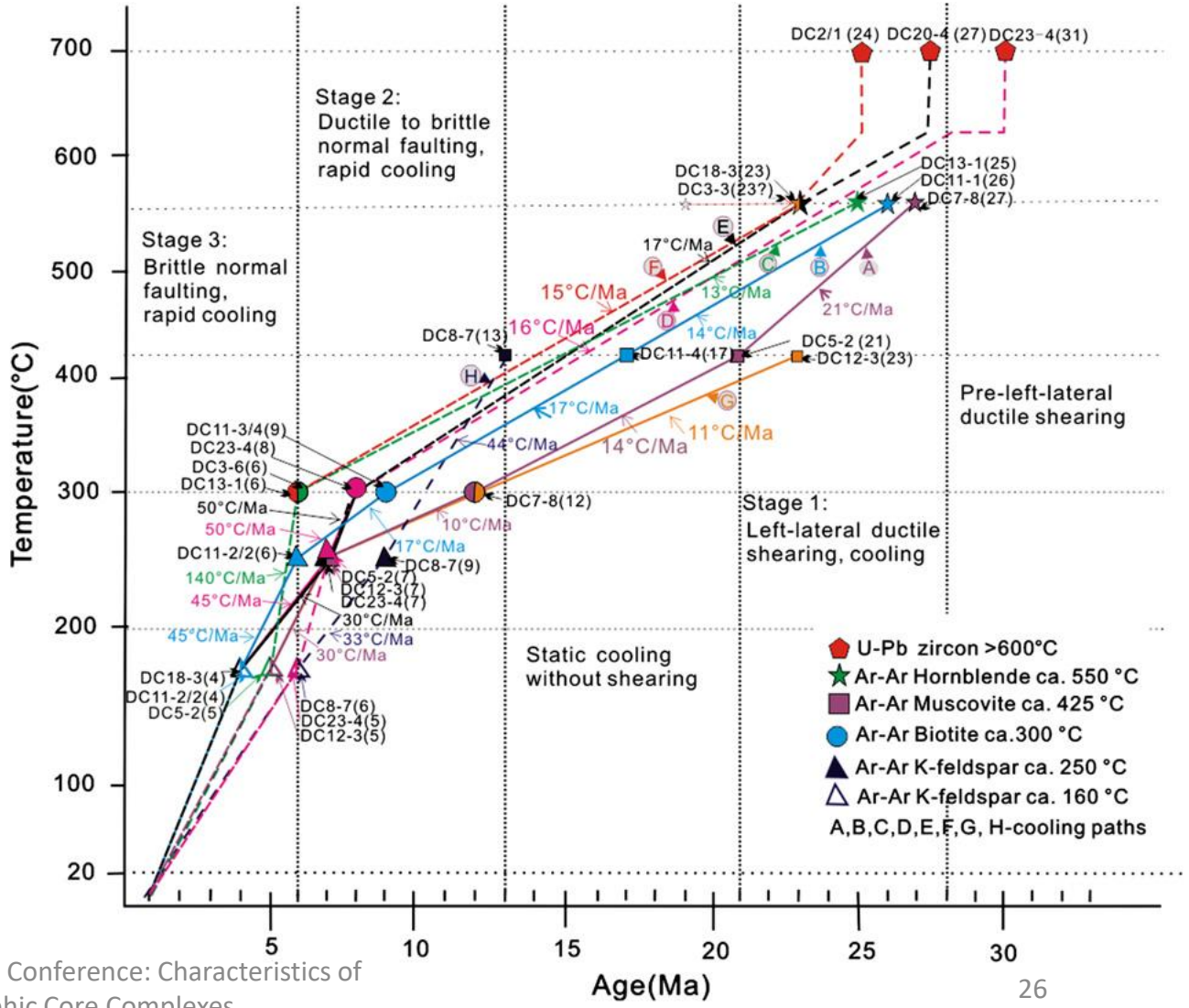
Morphology of Naxos: remnants of corrugations?



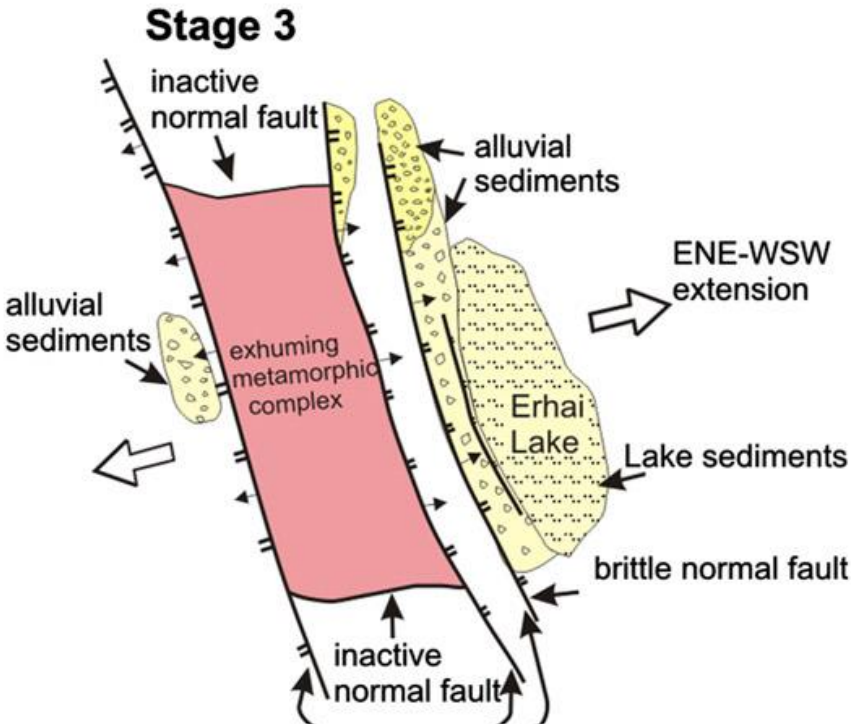
Diancang MCC as a MCC related to a major strike-slip fault system (Ailaoshan-Red River fault)



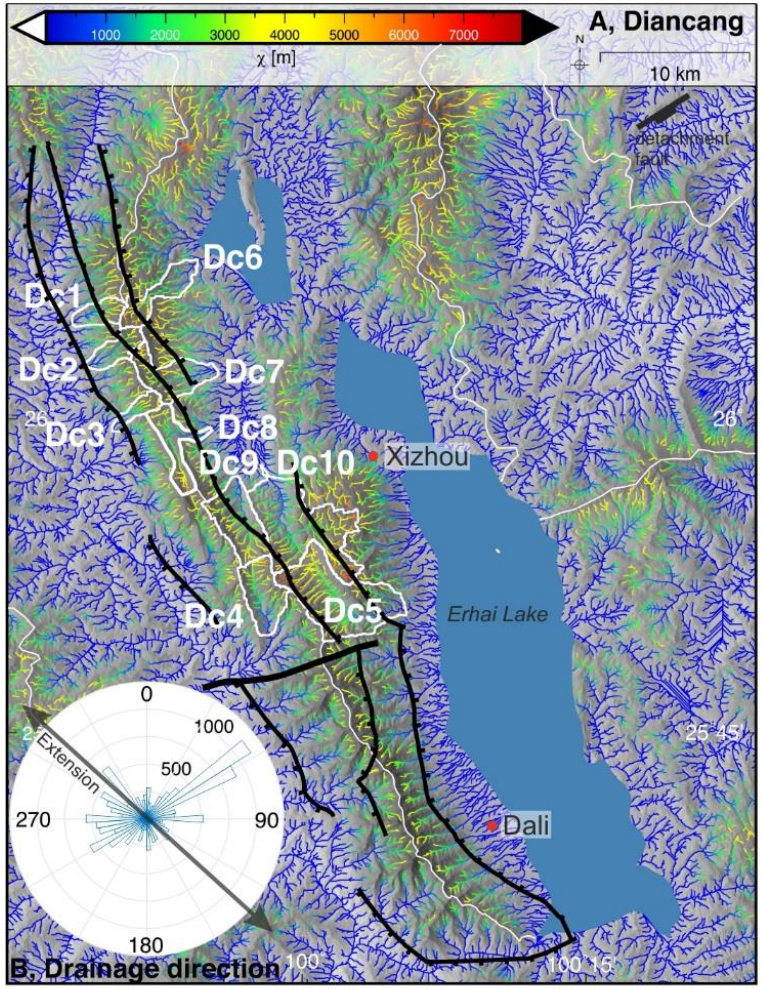
From Cao et al., 2011, J. Asian Earth Sciences

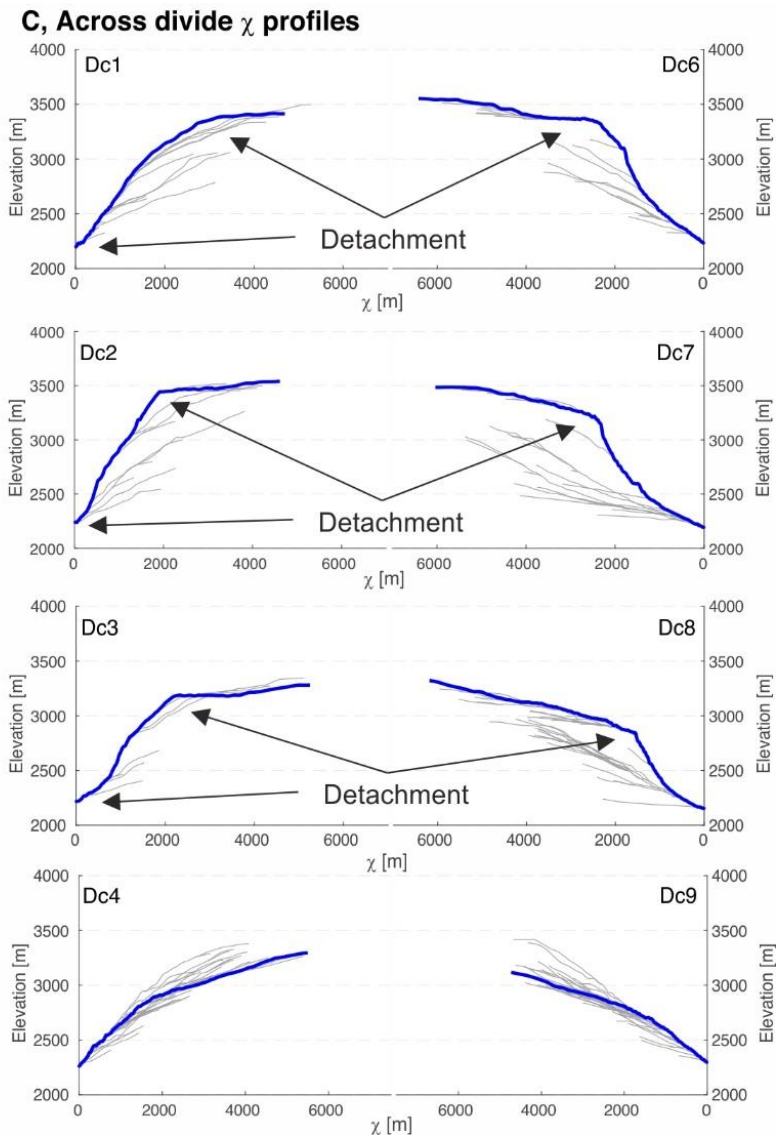


Landscape evolution of a subrecent MCC: Diancang MCC



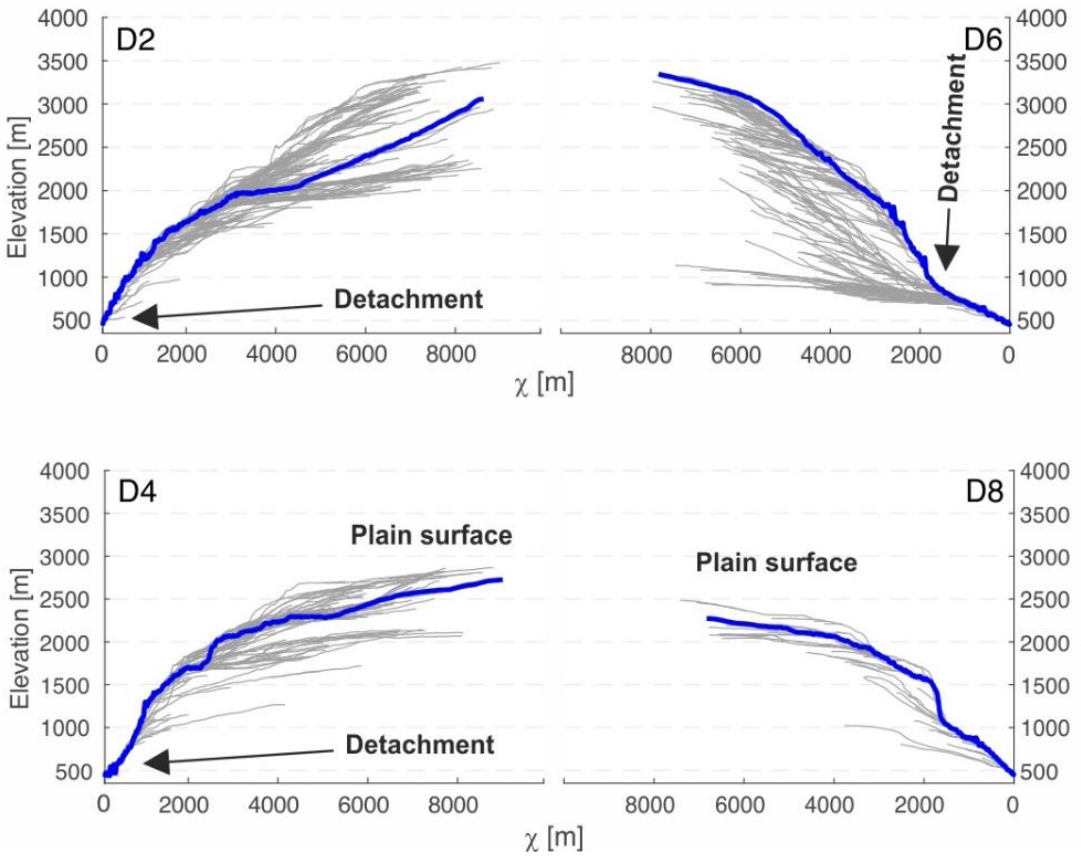
From Cao et al., 2011, J. Asian Earth Sciences



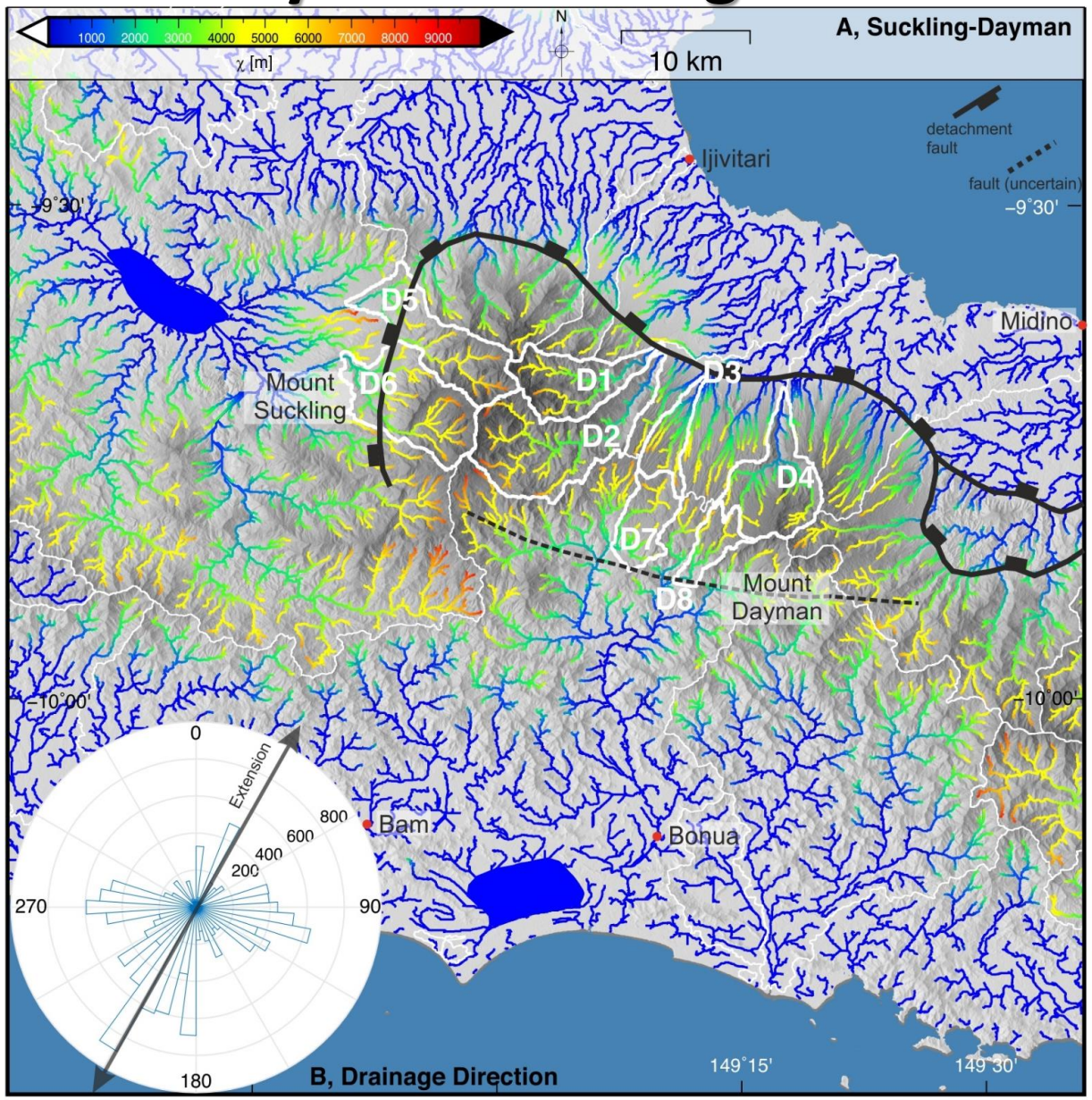


From Trost, G., 2020, PhD thesis, Univ. Salzburg

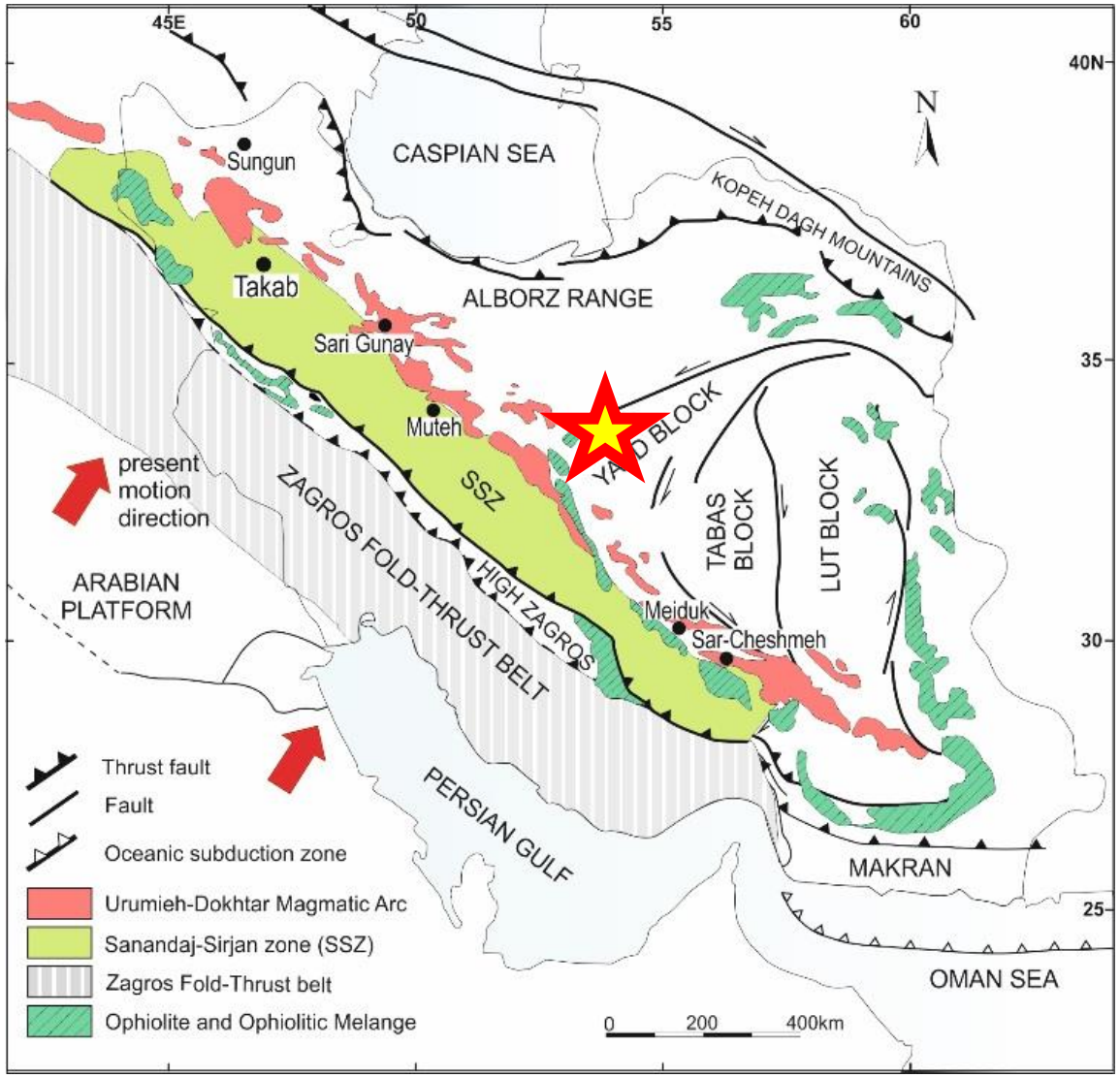
Landscape evolution of a subrecent MCC: Dayman-Suckling MCC



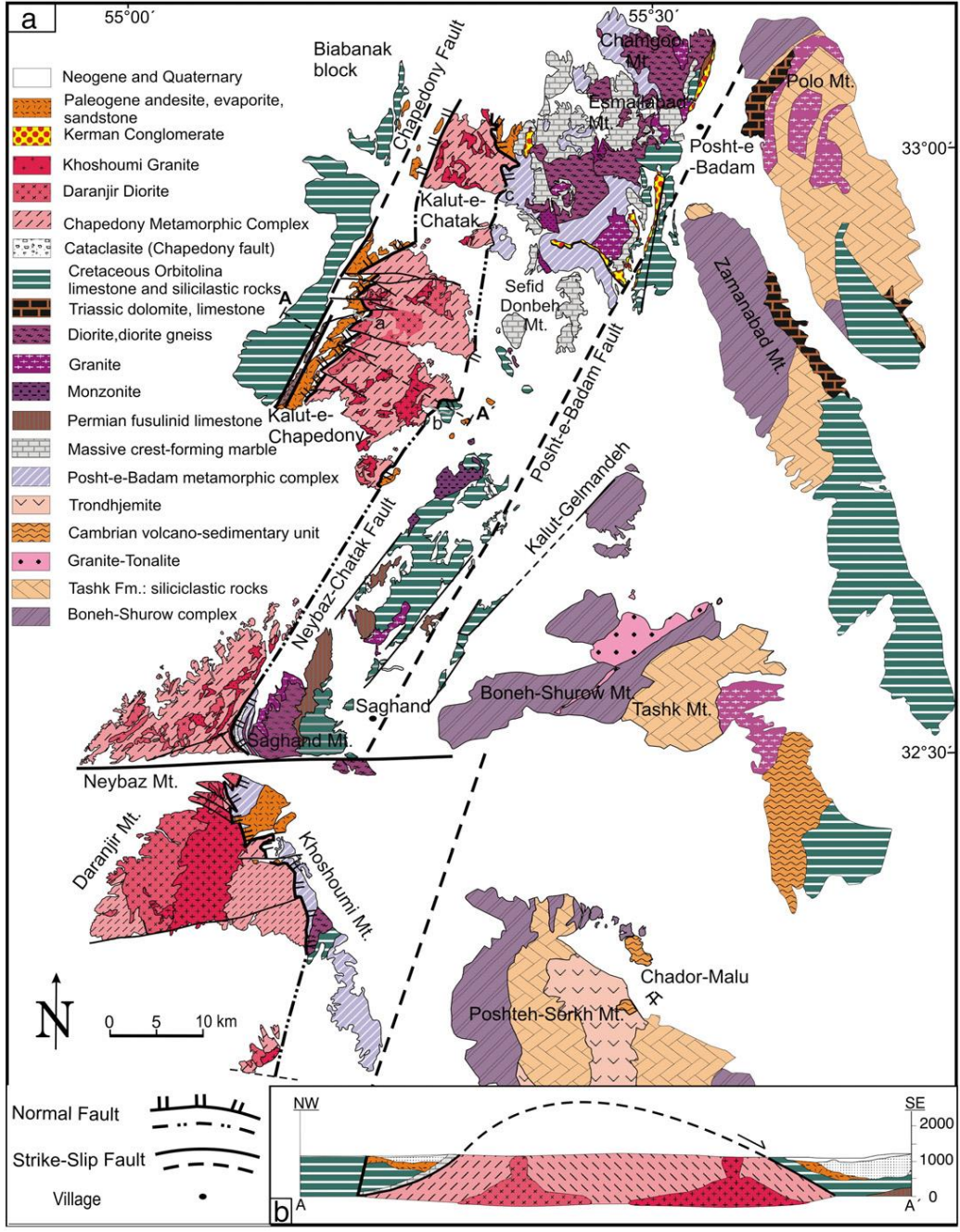
From Trost, G., 2020, PhD thesis, Univ. Salzburg



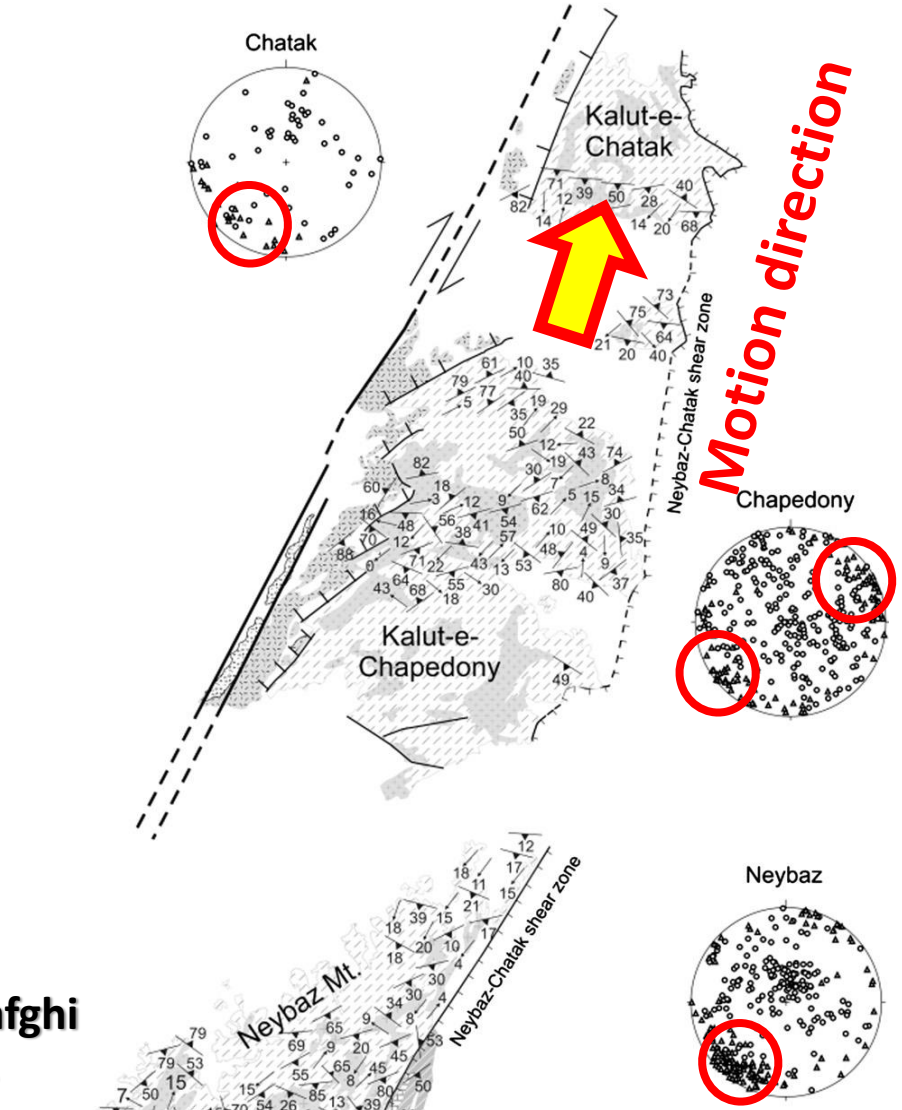
Chapedony MCC, Iran

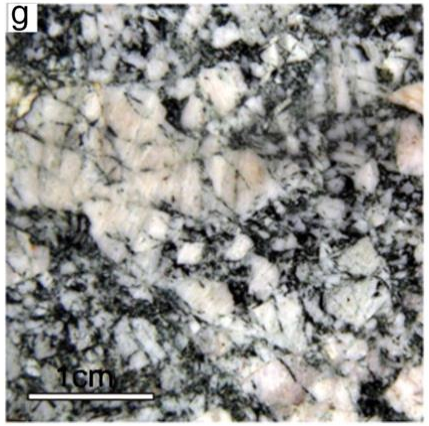


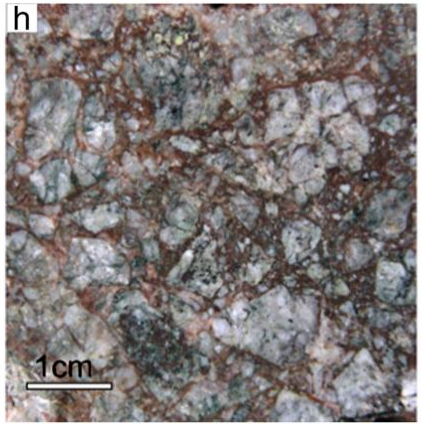
From Kargaranbafghi et al., 2012

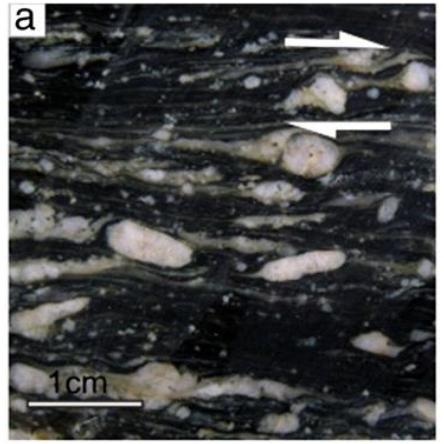


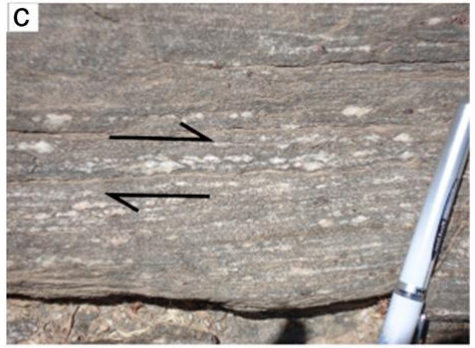
Chapedony MCC, Iran

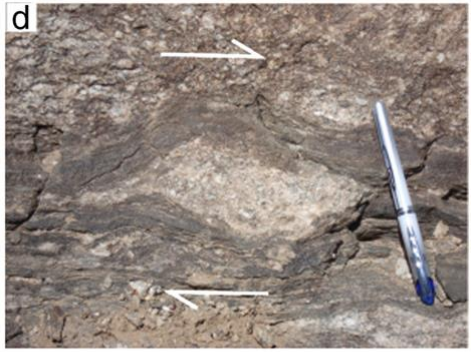


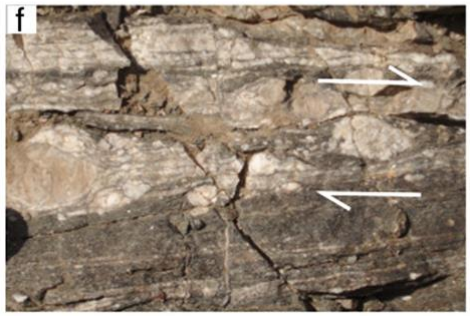






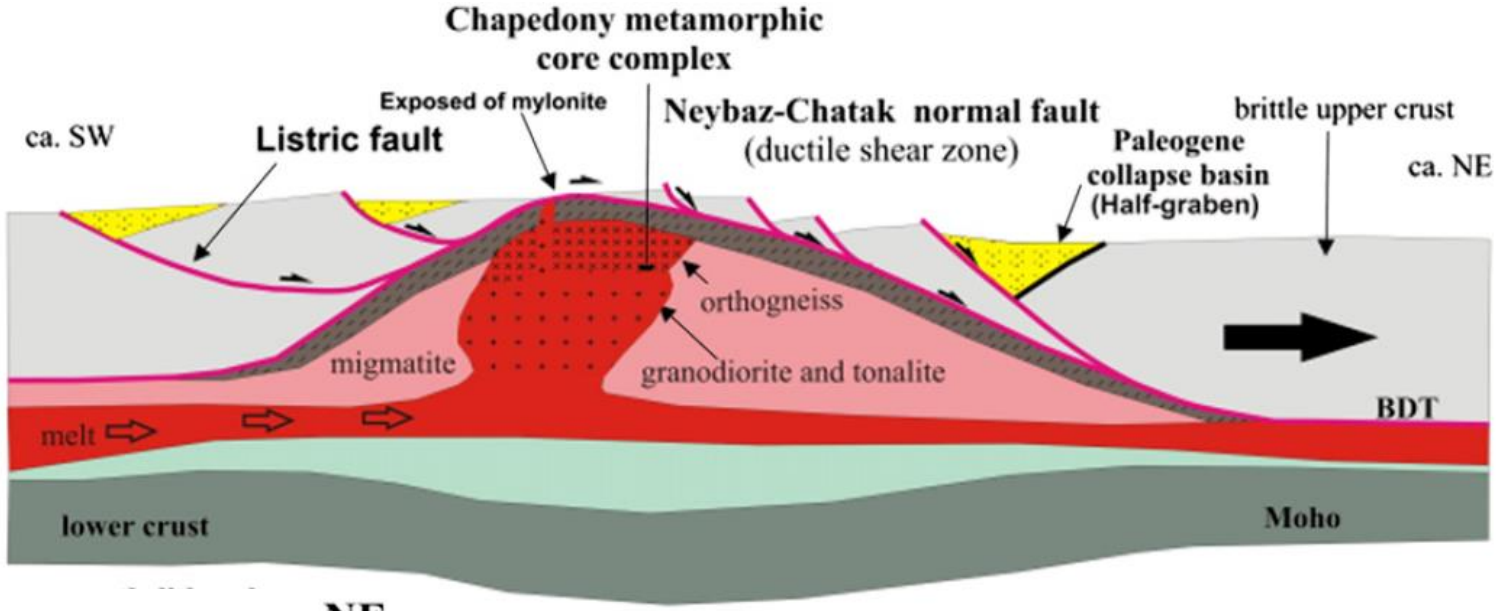


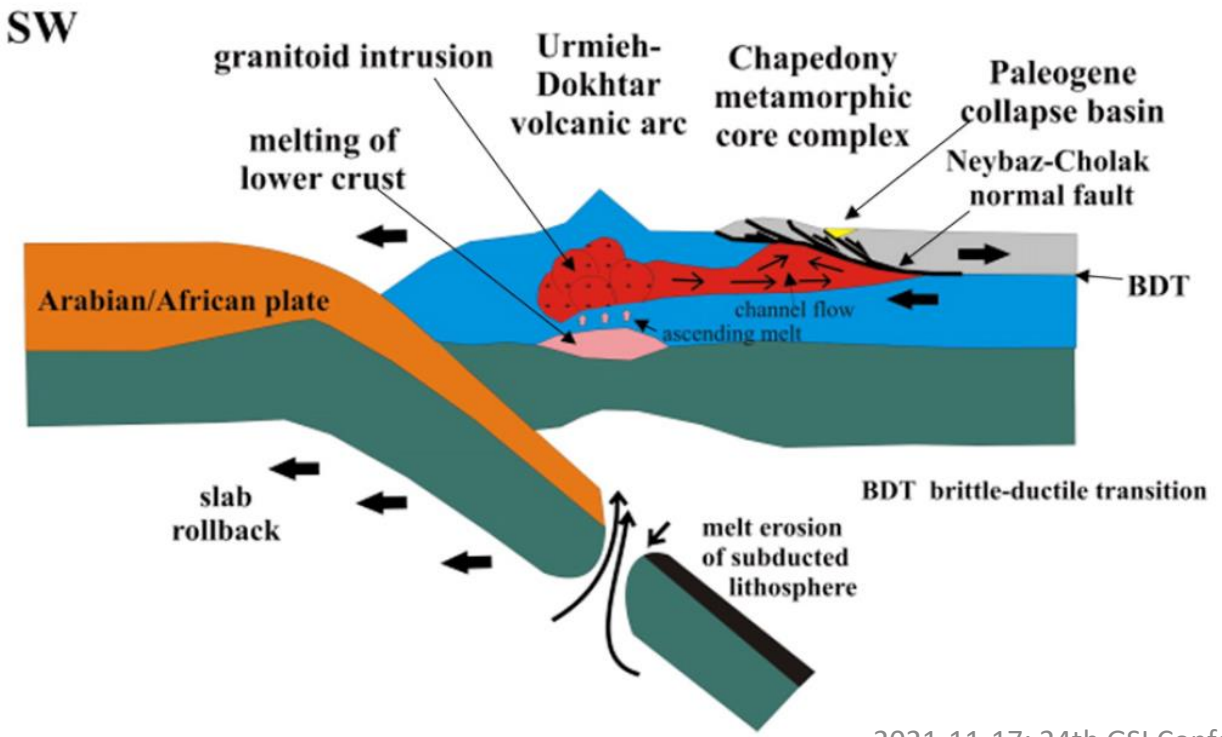




From Kargaranbafghi et al., 2013

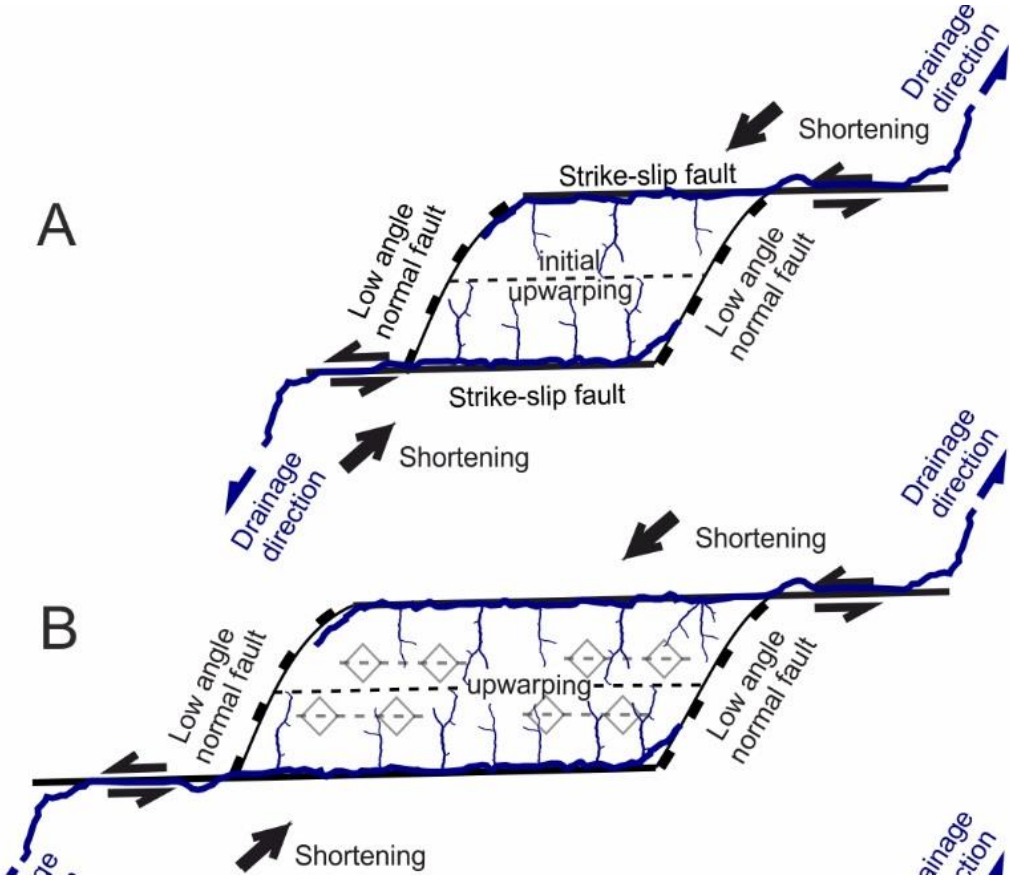
Chapedony NCC: Tectonic model

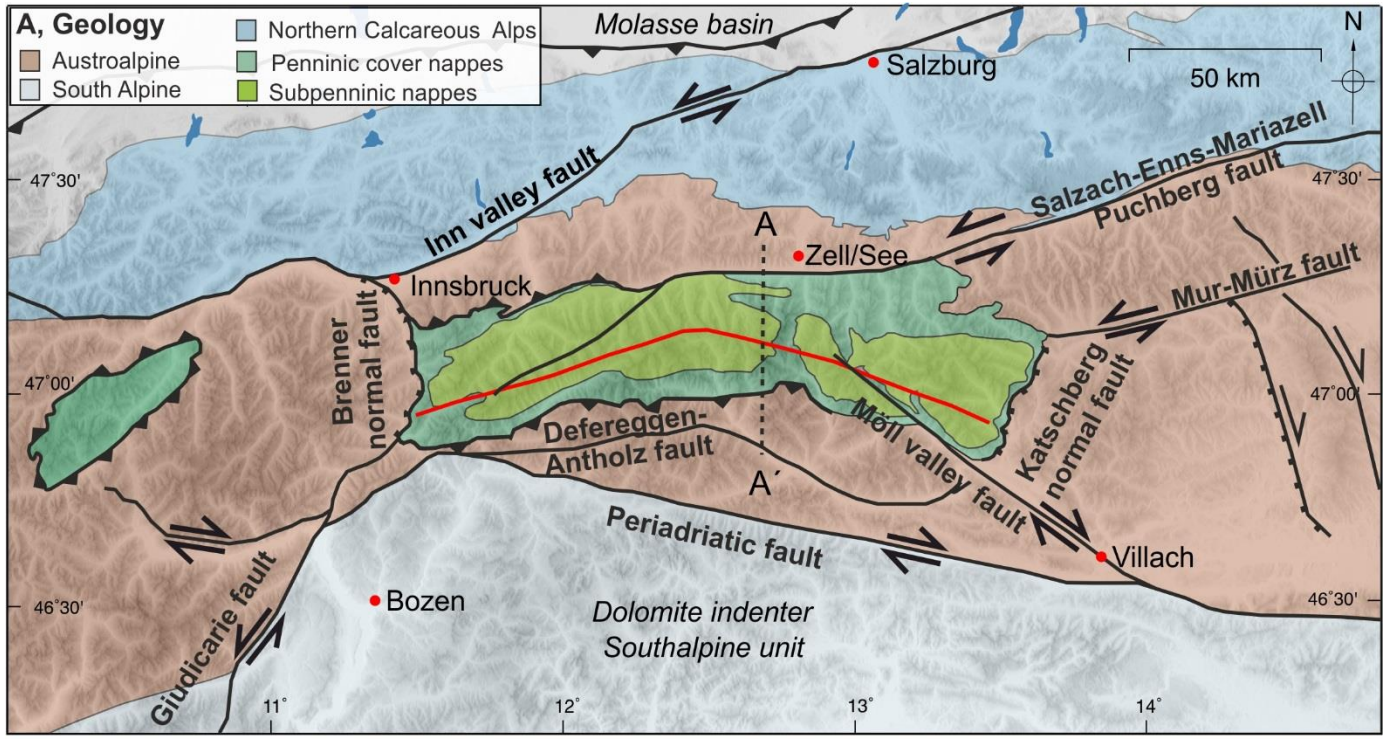


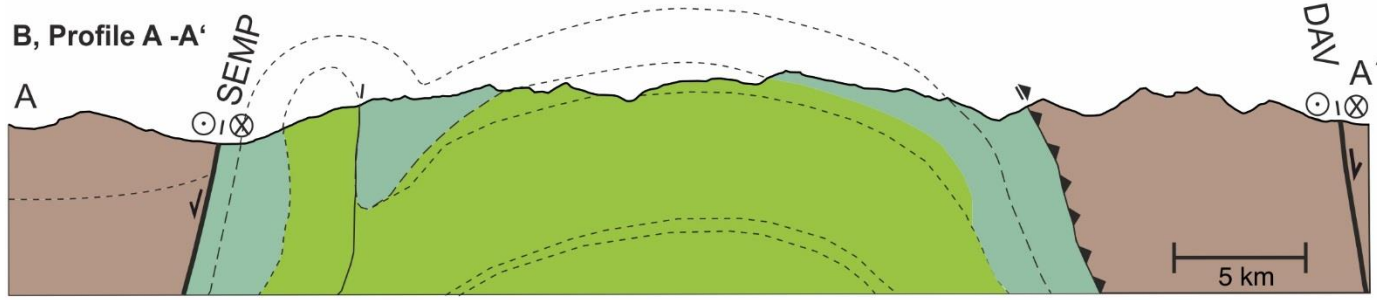


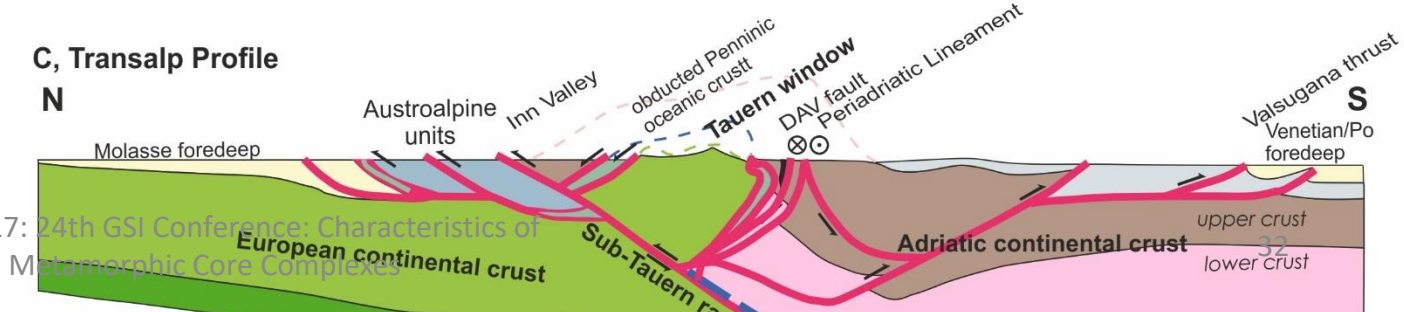
Kerman Conglomerate (Paleogene): halfgraben basin fill

Compressional MCC related to an overstep of the strike-slip fault system: Tauern MCC (Eastern Alps)

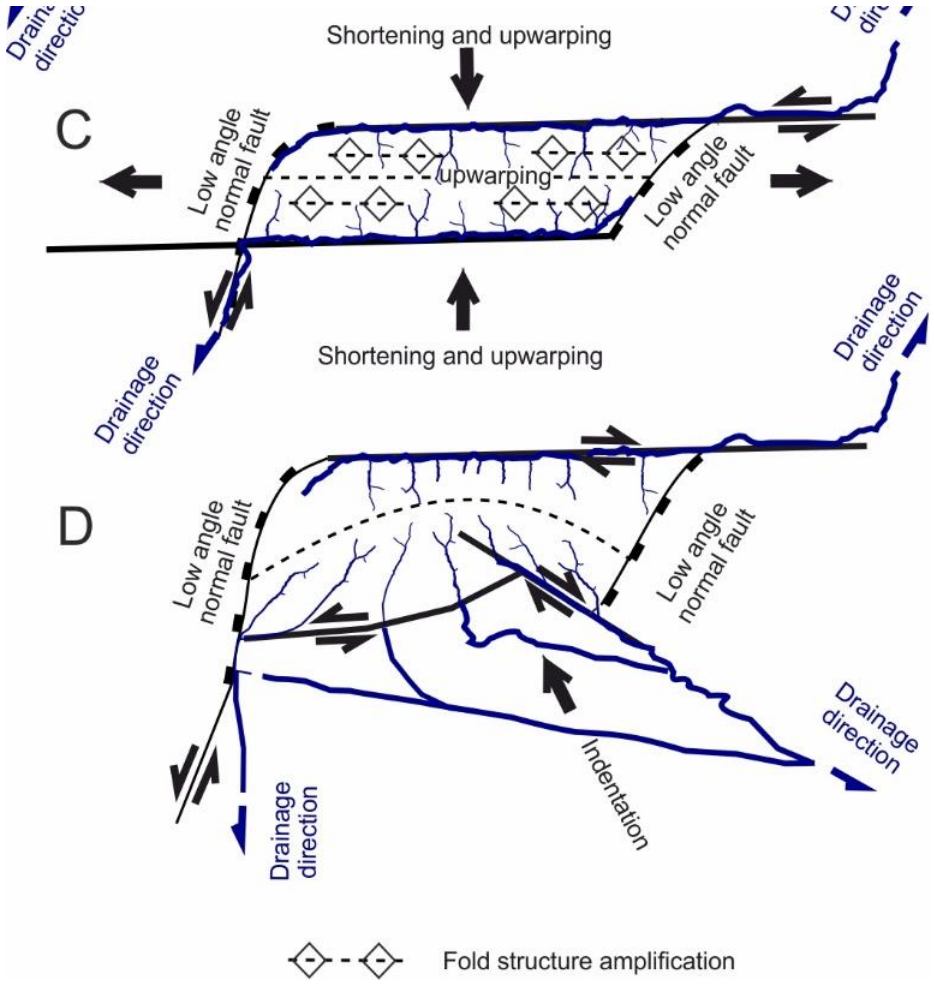


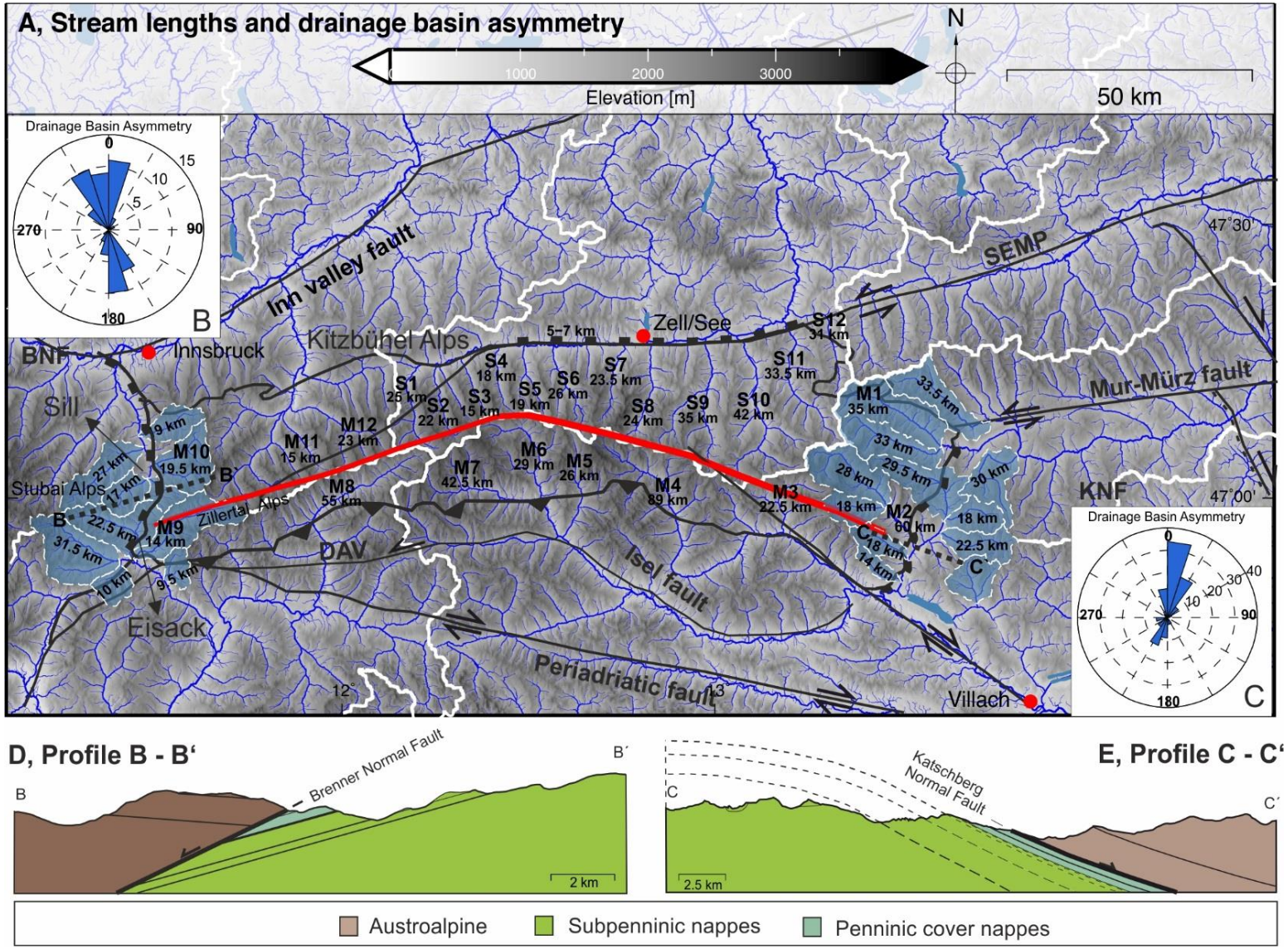






Tauern MCC (Eastern Alps)

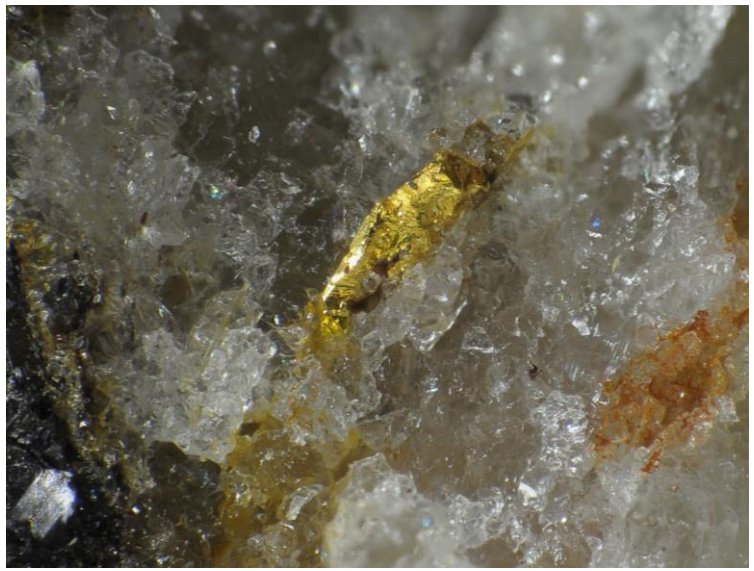


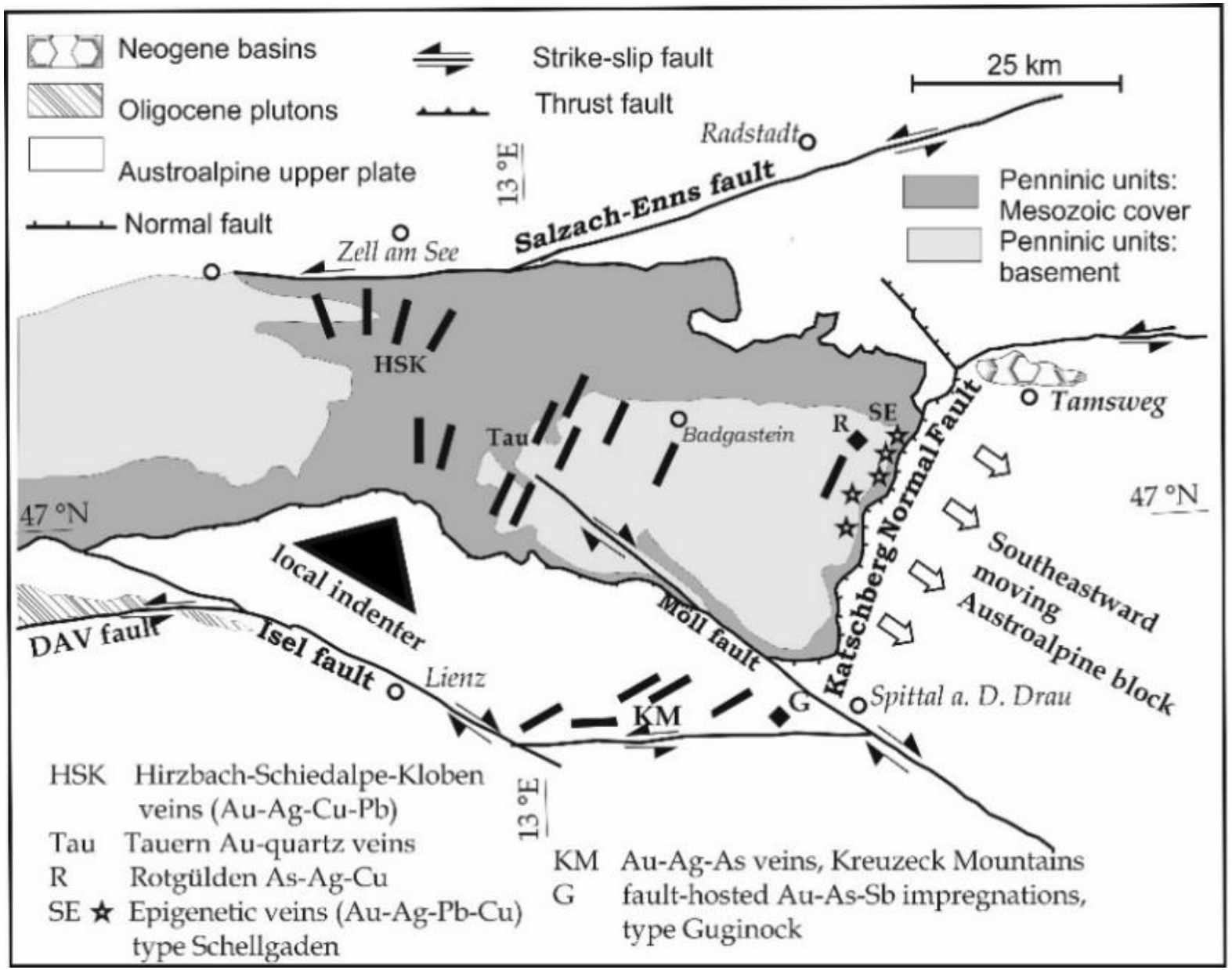


Tauern MCC: Mineralization

Au-quartz veins

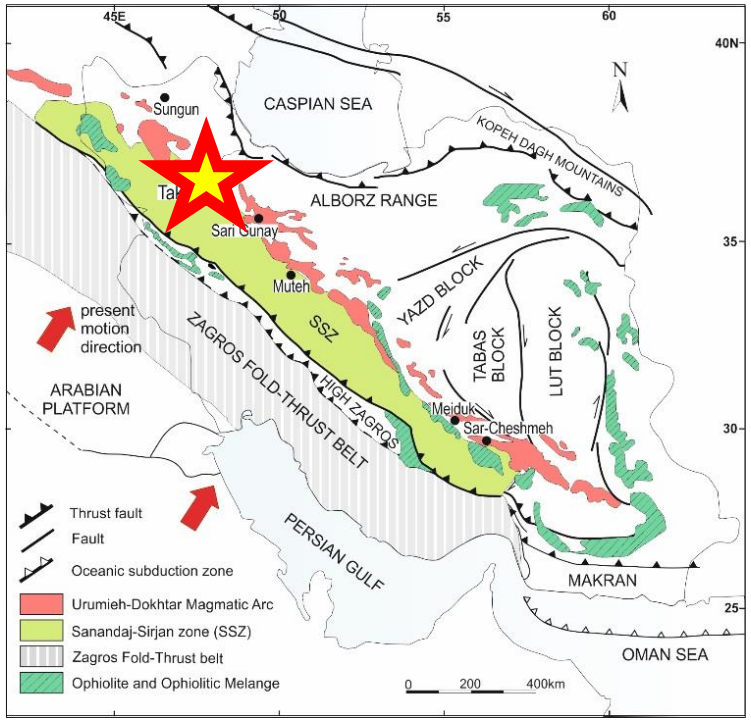
Polymetallic Ag-As deposits

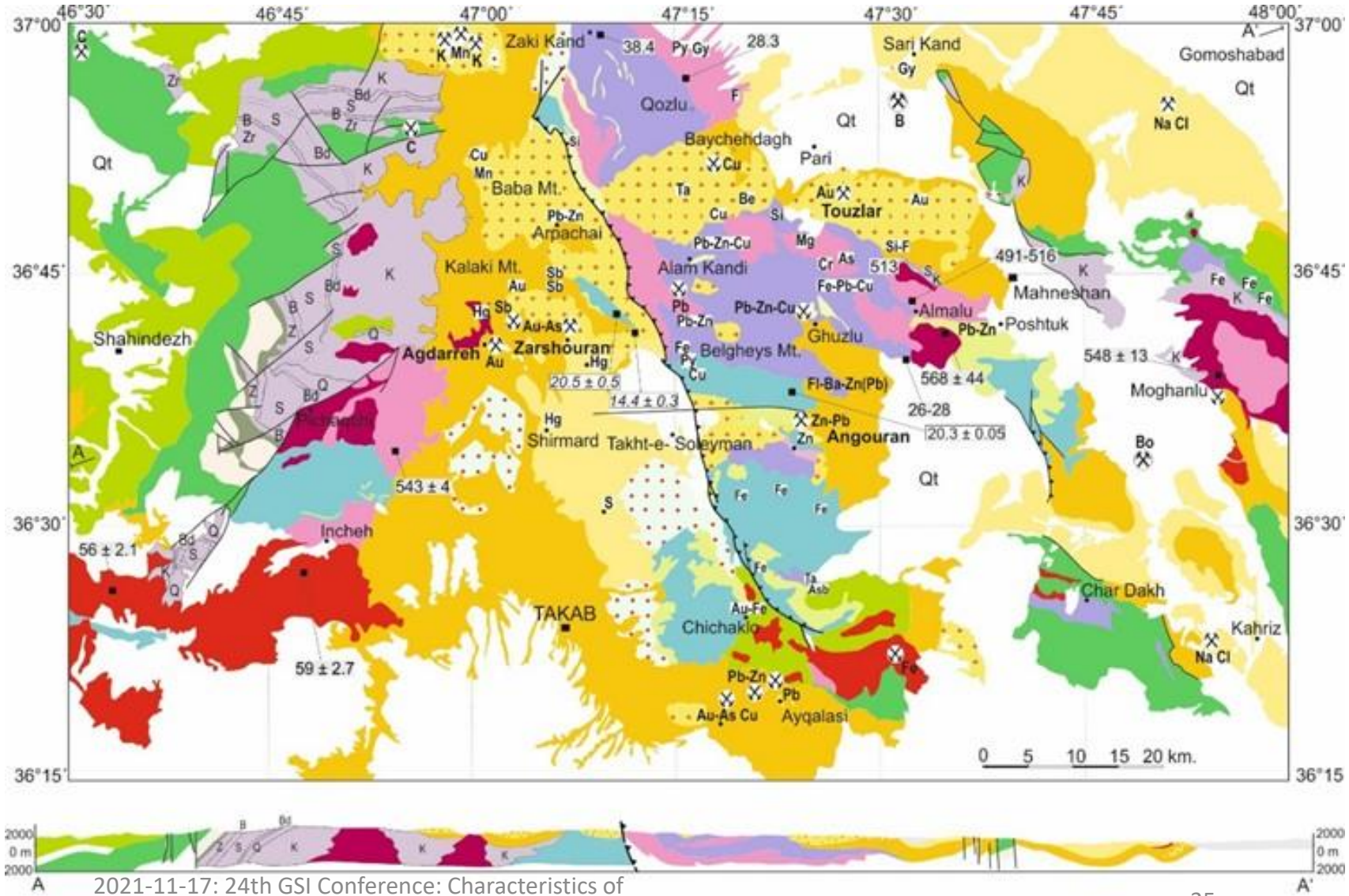




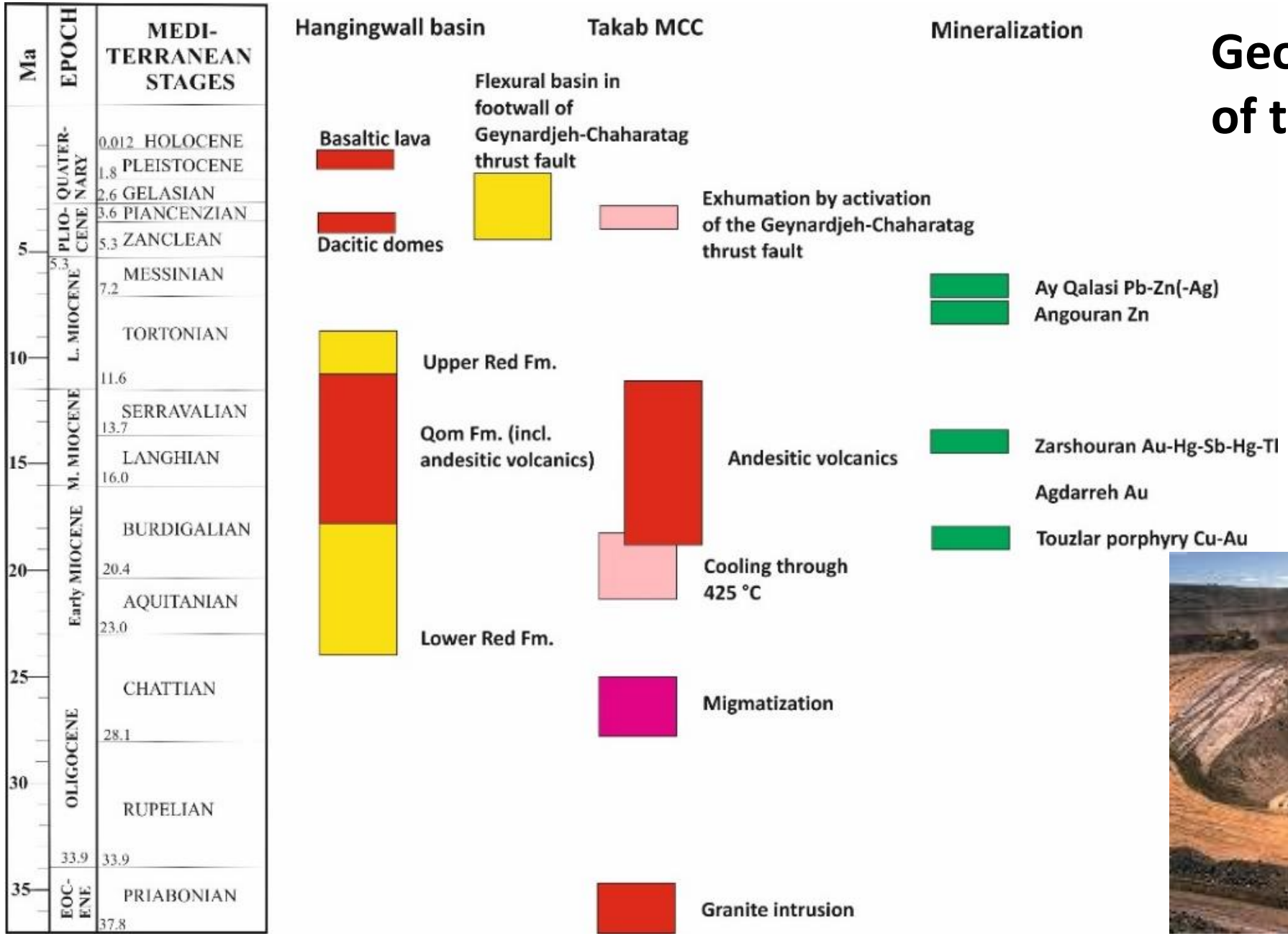
From Neubauer, 2004

The Takab MCC(?), Iran: A special, underinvestigated case



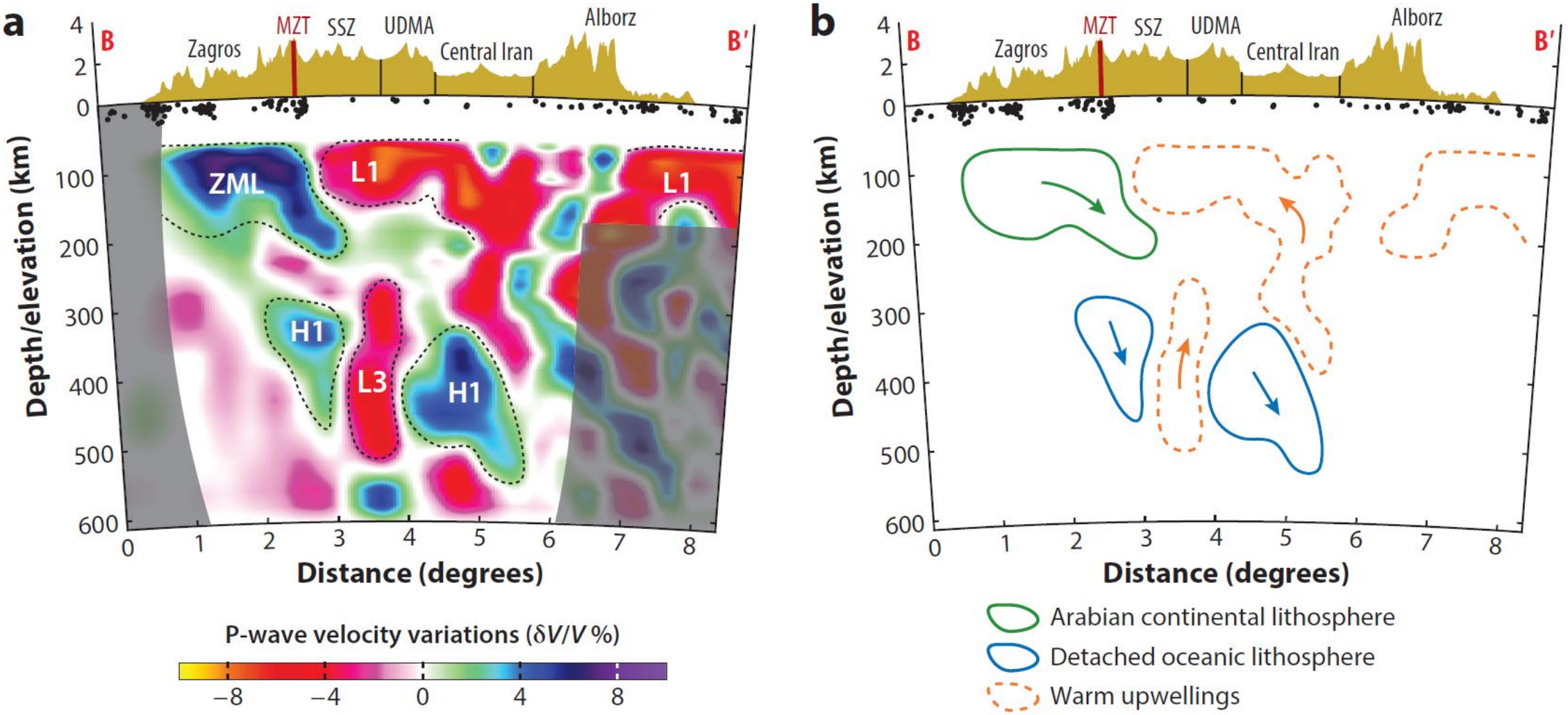


Geological development of the Takab area



(Neubauer & Shakerardakani, unpubl.)

Deep structure underneath the Takab MCC(?) from a nearby tomographic section

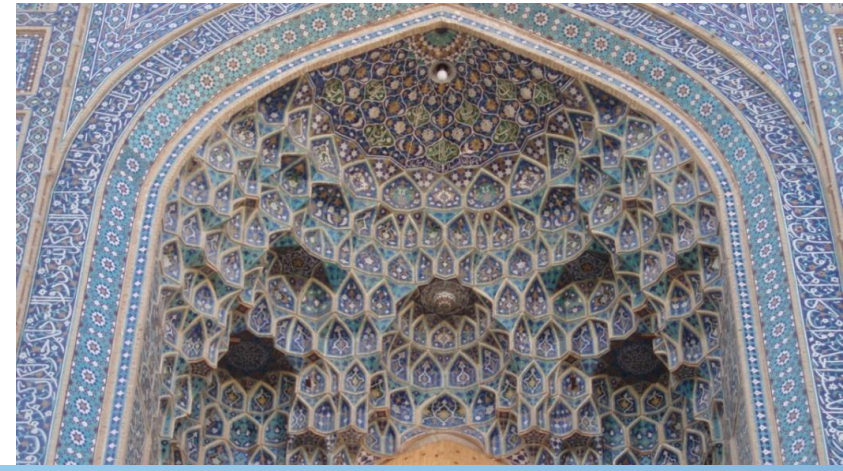


From Stern et al. (2021), after Mohammadi et al. (2019)

Conclusions

- Diversity of continental MCCs from purely extensional to compressional.
- Continental MCCs have a potential for ores, e.g., orogenic gold, and ore exploration.
- Oceanic core complexes exposes gabbro or serpentinized ultramafic rock leves and are sometimes associated with black smokers.
- Upper plate sedimentary basins allow study the succession of tectonic events.
- At present, increasing studies on the landscape evolution of formation of pristine detachment surfaces and of its decay.

Many thanks for your attention!



Au-mineralization („orogenic gold“) related to MCC, China