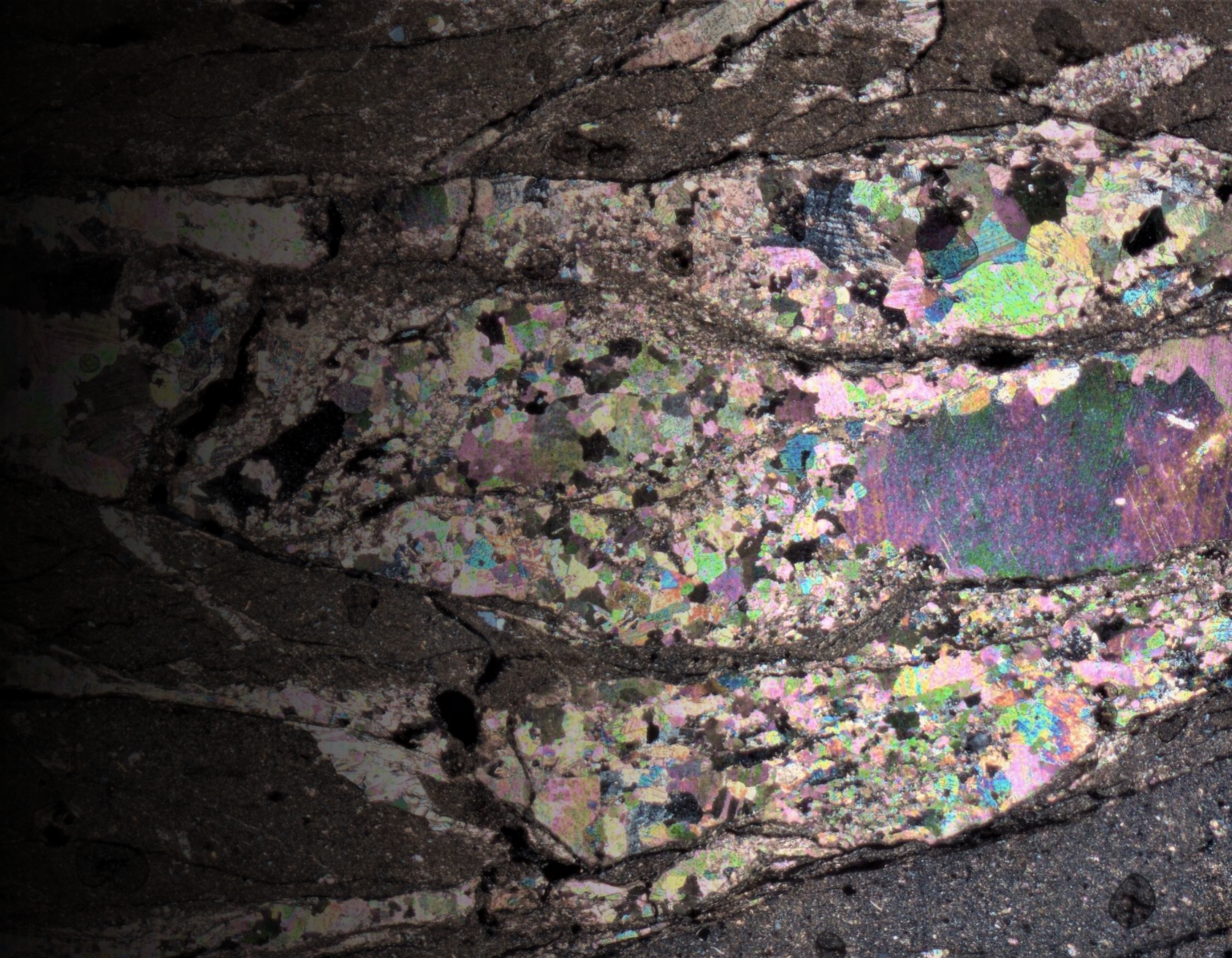
EGU General Assembly 2020

Heterogeneous stresses and deformation mechanisms at shallow crustal conditions, Hikurangi Subduction Margin, New Zealand



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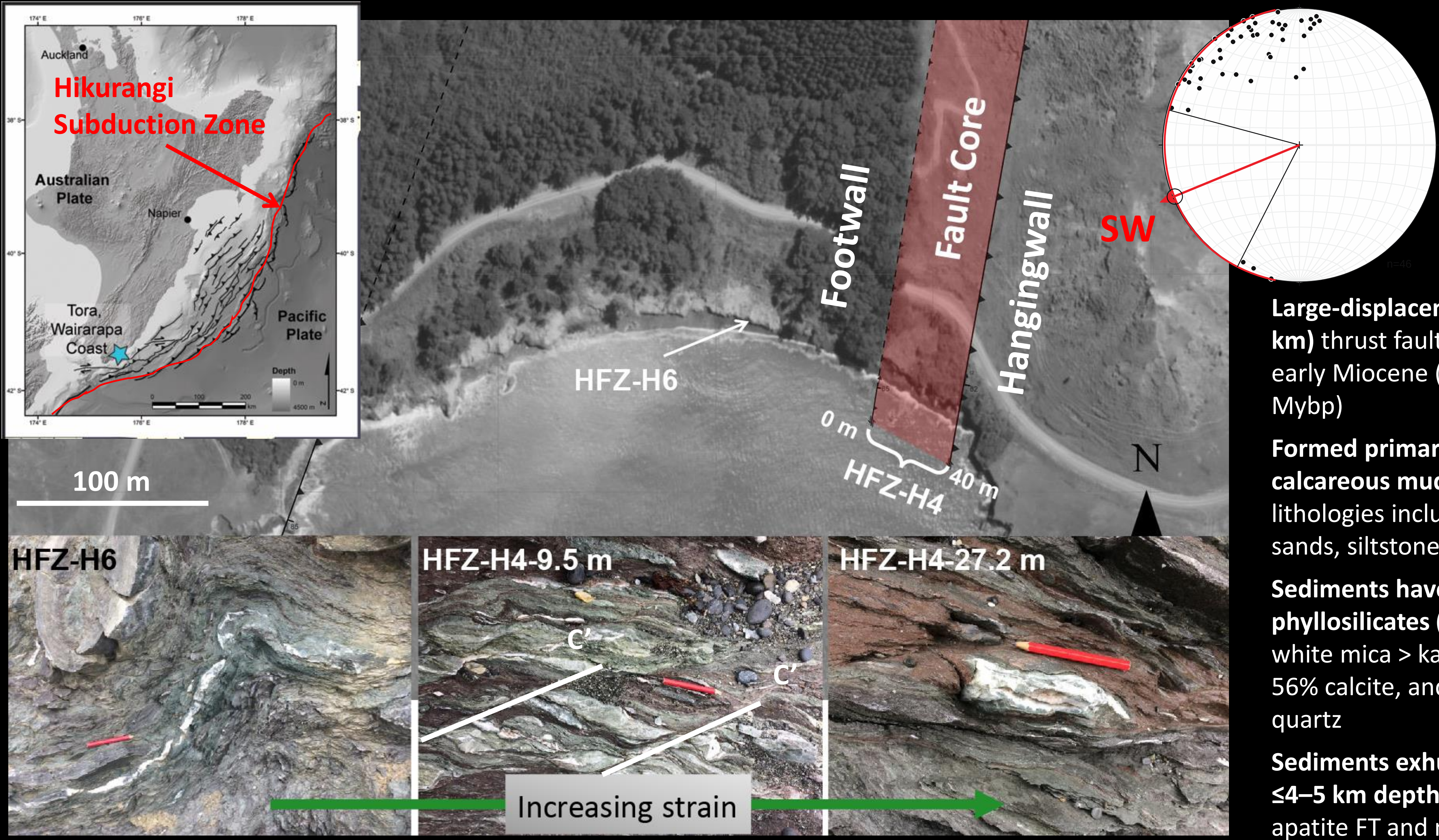
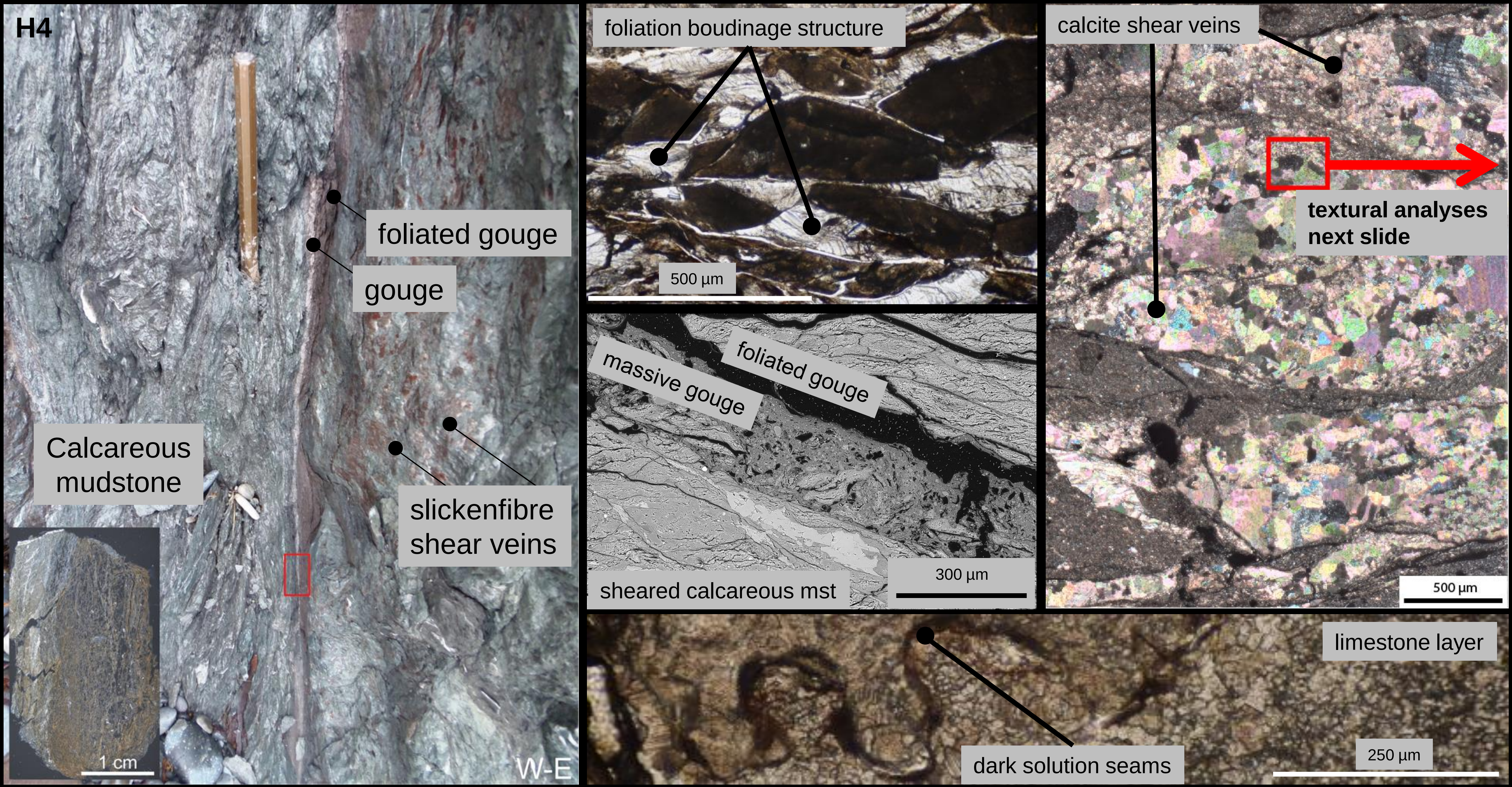


Large-displacement (~4–10 km) thrust fault active during early Miocene (~25–20 Mybp)

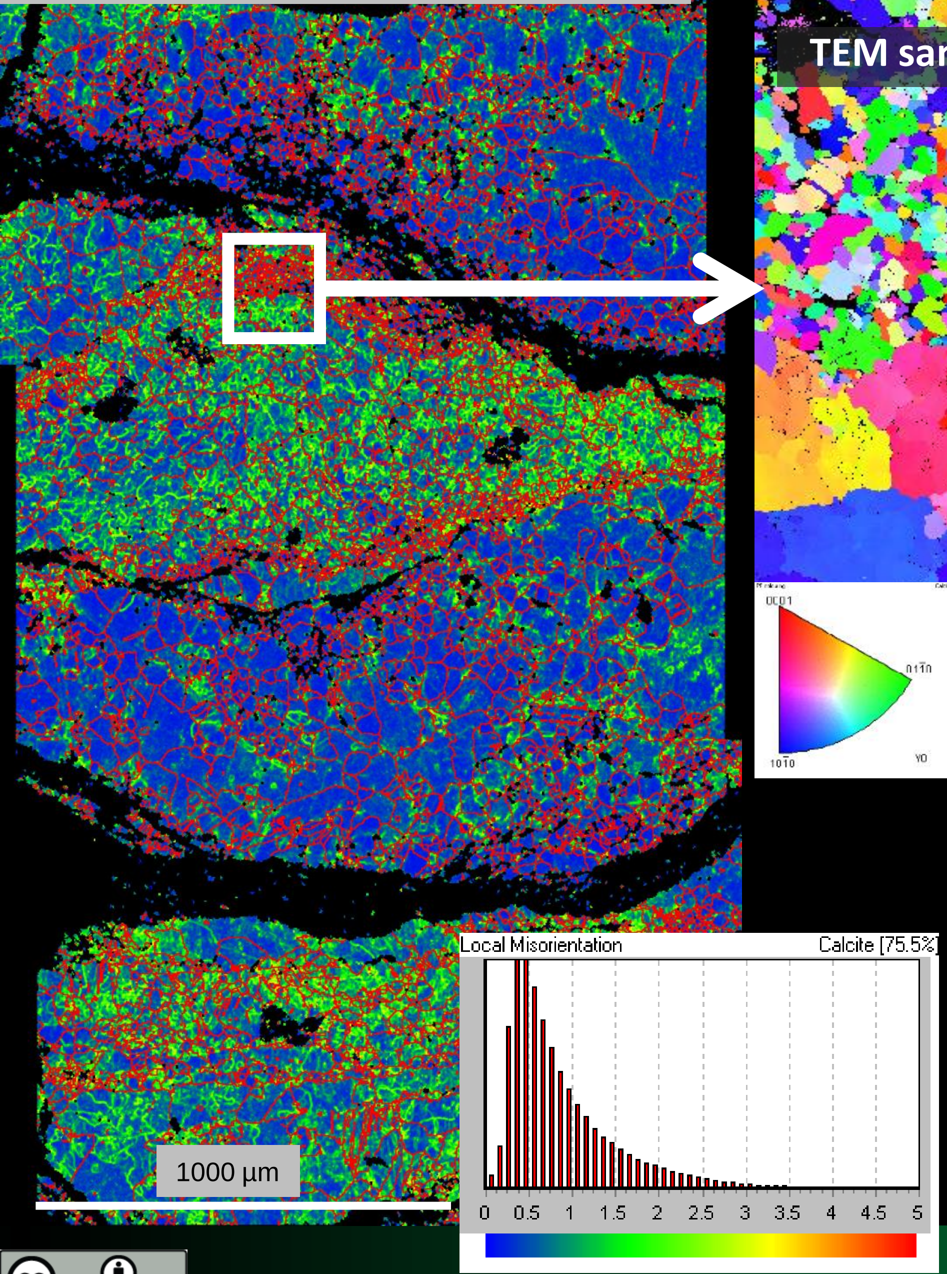
Formed primarily in Eocene calcareous mudstones; other lithologies include ribbon sands, siltstones, and marls

Sediments have 27–58% phyllosilicates (smectite > white mica > kaolinite), 7–56% calcite, and 15–30% quartz

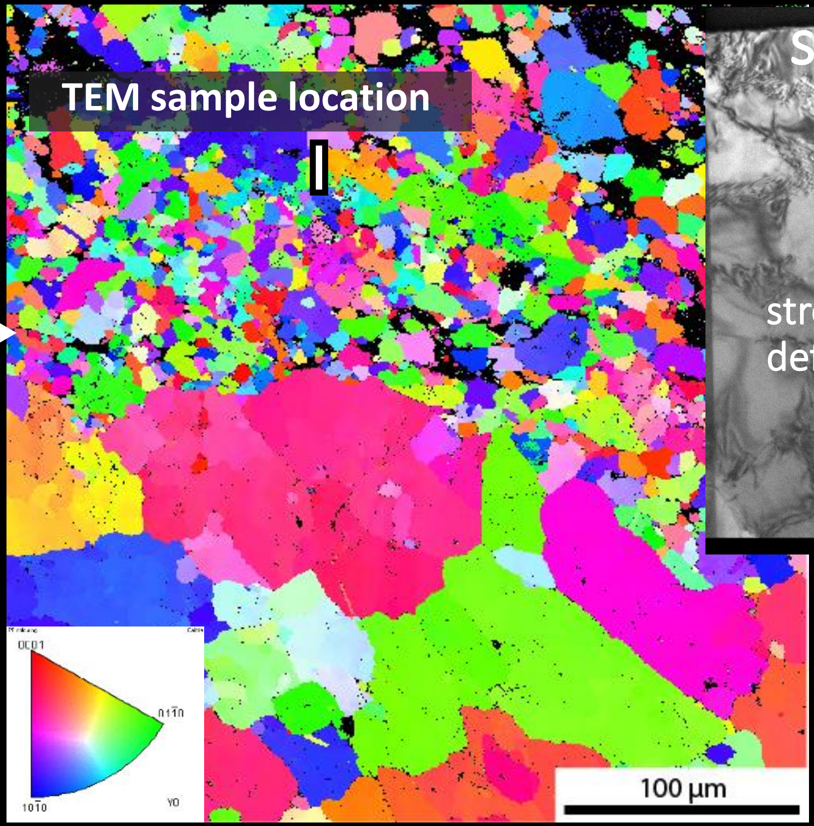
Sediments exhumed from ≤4–5 km depth based on apatite FT and mineralogy


H4
foliated gouge
gouge
Calcareous mudstone
slickenfibre shear veins
1 cm
W-E
foliation boudinage structure
500 µm
massive gouge
foliated gouge
sheared calcareous mst
300 µm
calcite shear veins
textural analyses next slide
500 µm
limestone layer
dark solution seams
250 µm

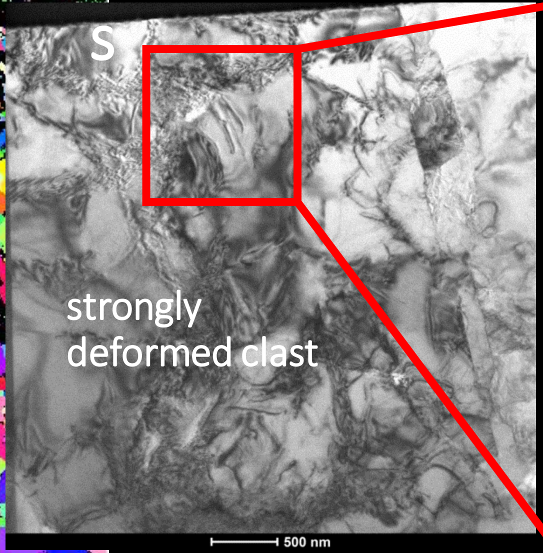
EBSD-based misorientation map of calcite shear veins



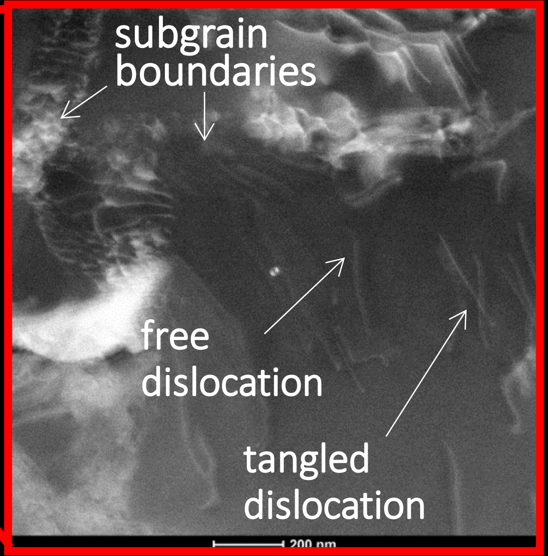
EBSD -based calcite orientation map

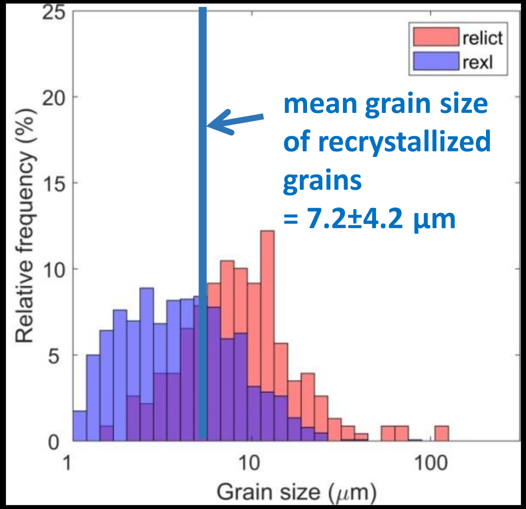


TEM – bright field image

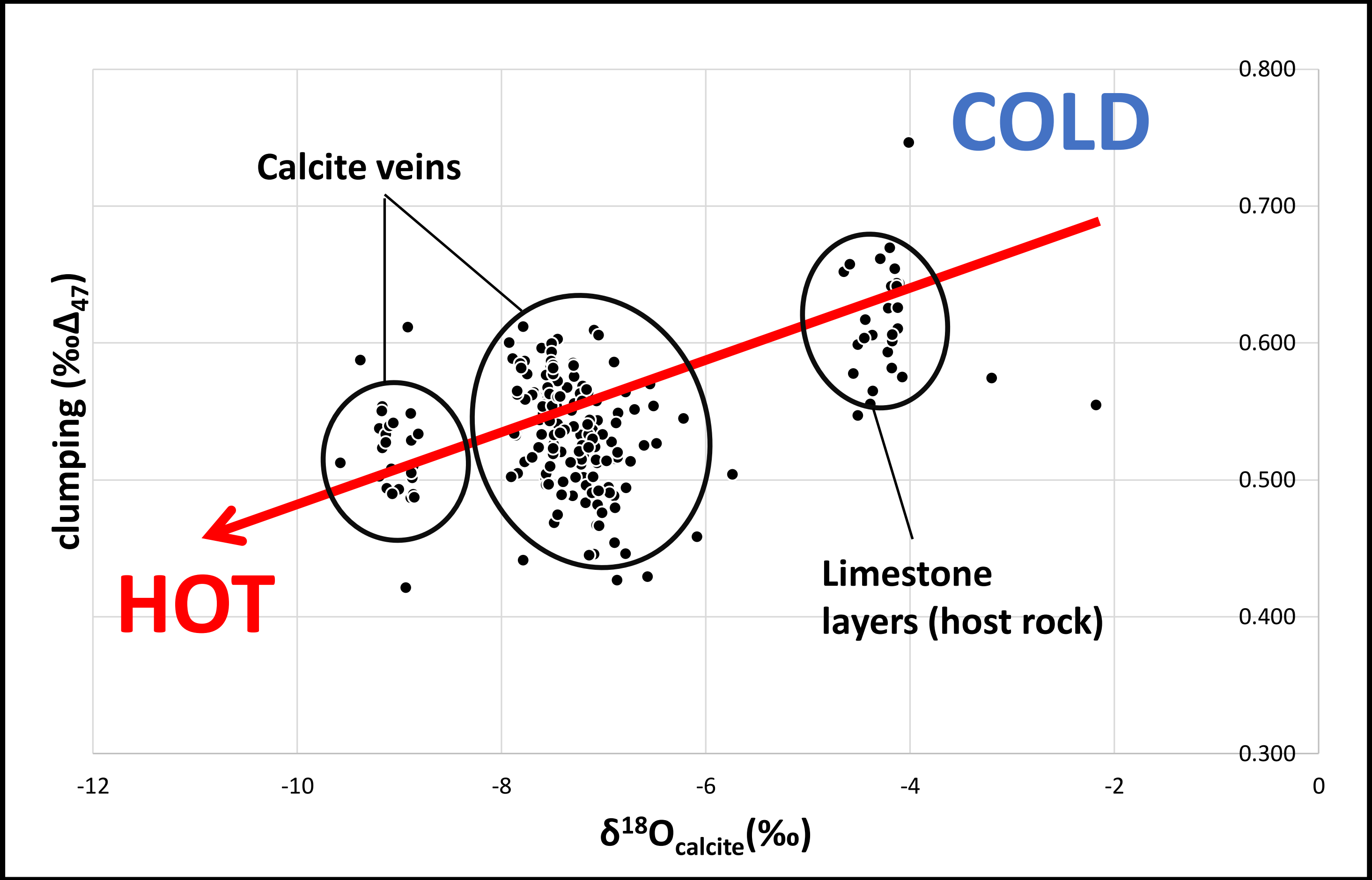


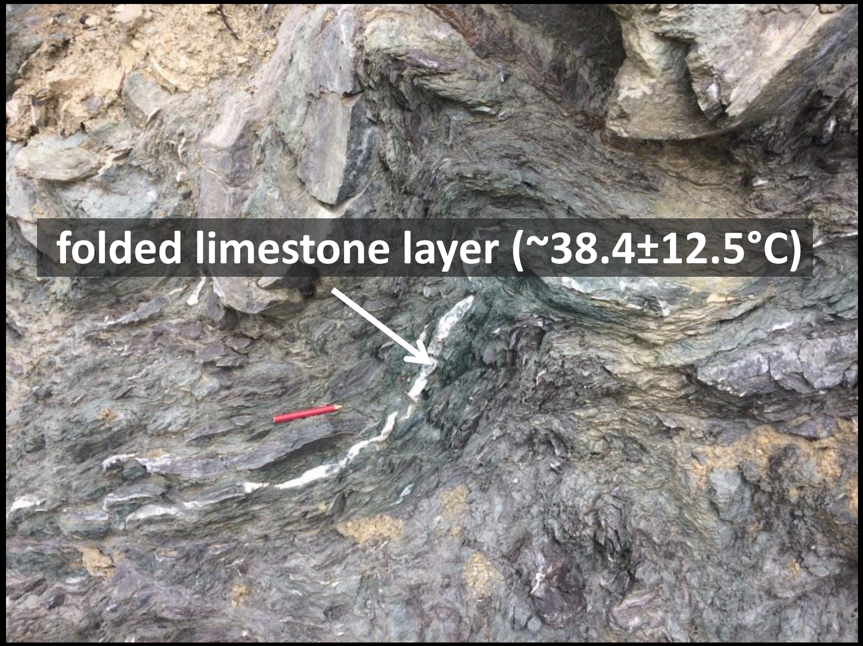
STEM – dark field image





Evidence for grain boundary migration, subgrain formation and high dislocation density!
But at what temperatures?





Clumped isotope measurements give independent estimates of the growth temperature and $\delta^{18}O$ of carbonate minerals, enabling the $\delta^{18}O$ of diagenetic waters from which the minerals grew to be calculated.

Clumped-isotope Thermometry of Calcite Veins and Limestone Layers

Our results indicate that:

(1) stresses are spatiotemporally heterogeneous in crustal fault zones containing mixtures of competent and incompetent minerals;

(2) heterogeneous deformation mechanisms, including frictional sliding, pressure solution, intracrystalline plasticity, and mixed-mode fracturing accommodate slip in shallow crustal fault zones;

(3) brittle fractures play a pivotal role in fault zone deformation by providing fluid pathways that promote fluid-enhanced recovery and dynamic recrystallisation in the deforming calcite at remarkably low temperatures (~60-140°C).

Together, field geology, microscopy, and clumped isotope geothermometry provide a powerful method for constraining the multiscale slip behavior of large-displacement fault zones.