Coupling between rifted oceanic crust and sedimentary deformation in the Fram Strait: implications for seafloor seepage and gas hydrate dynamics

EGU - 2022

GMPV6.3 – Fluid Flow in the upper crust: geysers, hydrothermal vents, mud volcanoes and cold seeps

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seamstress

TROMSØ RESEARCH FOUNDATION

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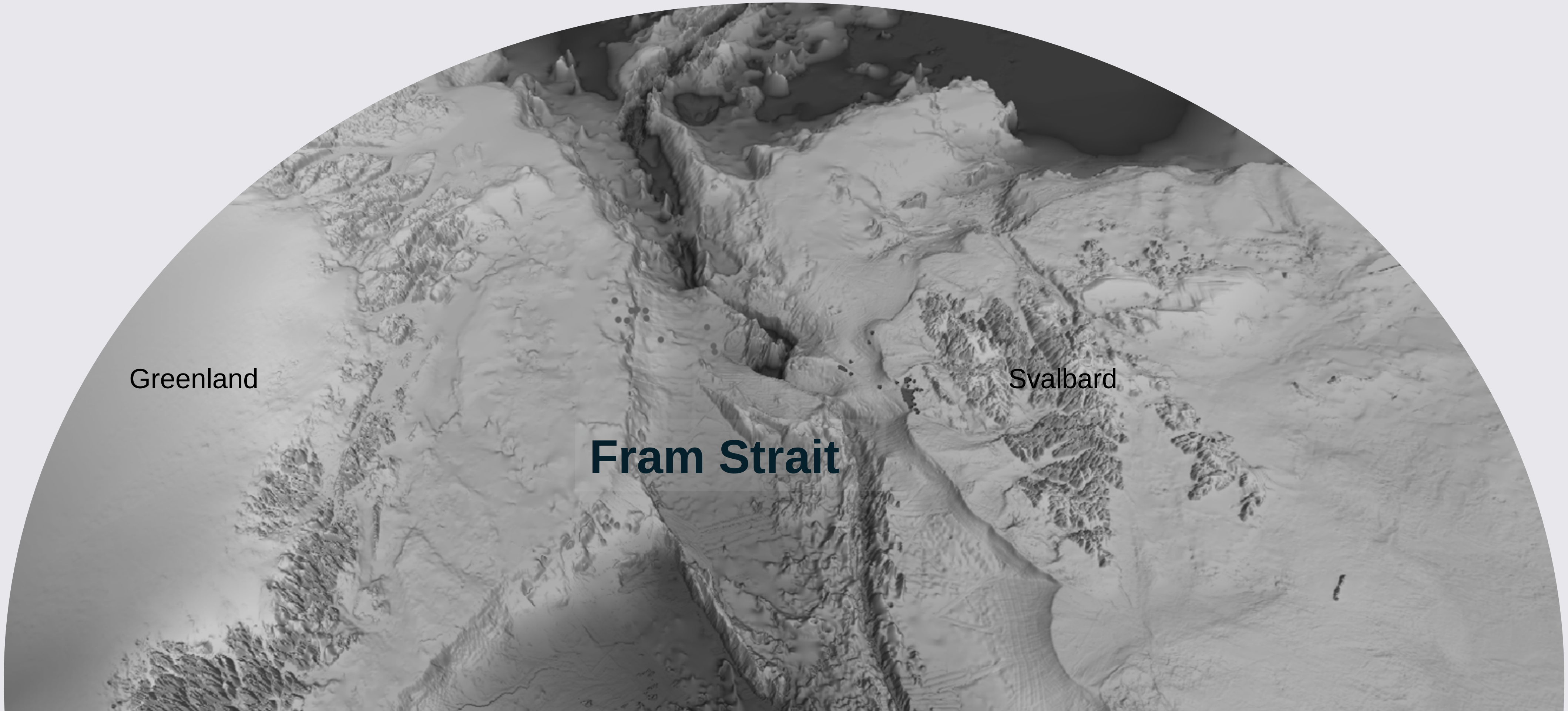
Outline

The Geological setting and motivation

Examples of coupled crustal-sediment deformation in the Fram Strait

Implications for gas hydrates and fluid dynamics

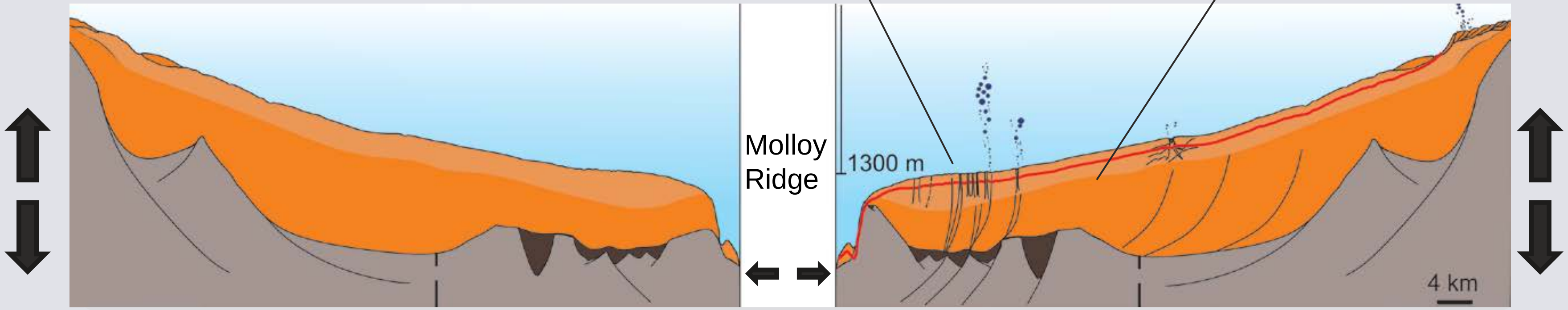


Has Plio-pleistocene sediment deformation been synchronous with rifting in the Fram Strait?

Not necessarily at steep slopes

Sedimentary faults converge to rift structures

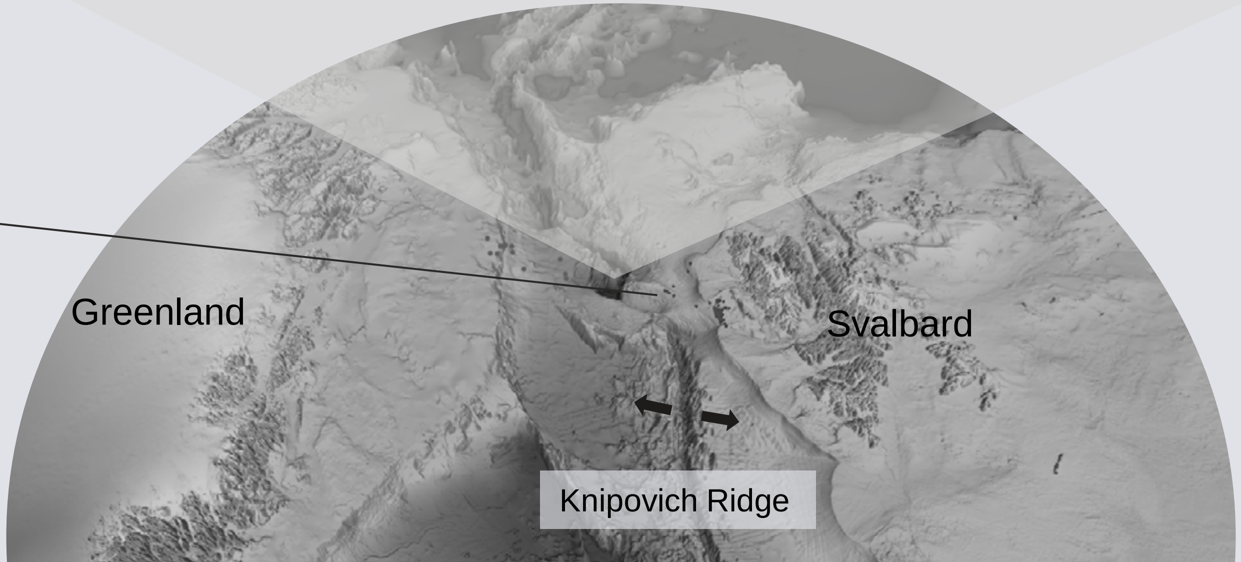
2-5 km sediment thickness



Continuous glacial isostatic adjustment

7 mm/yr

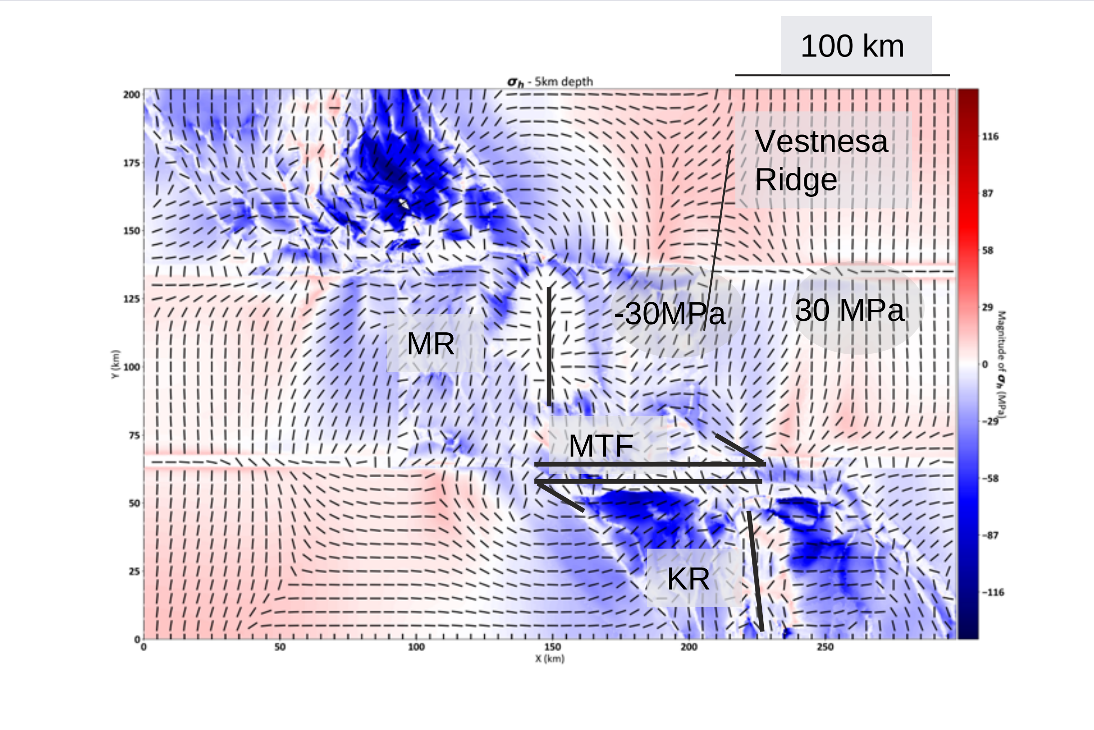
Earthquakes off ridge axes



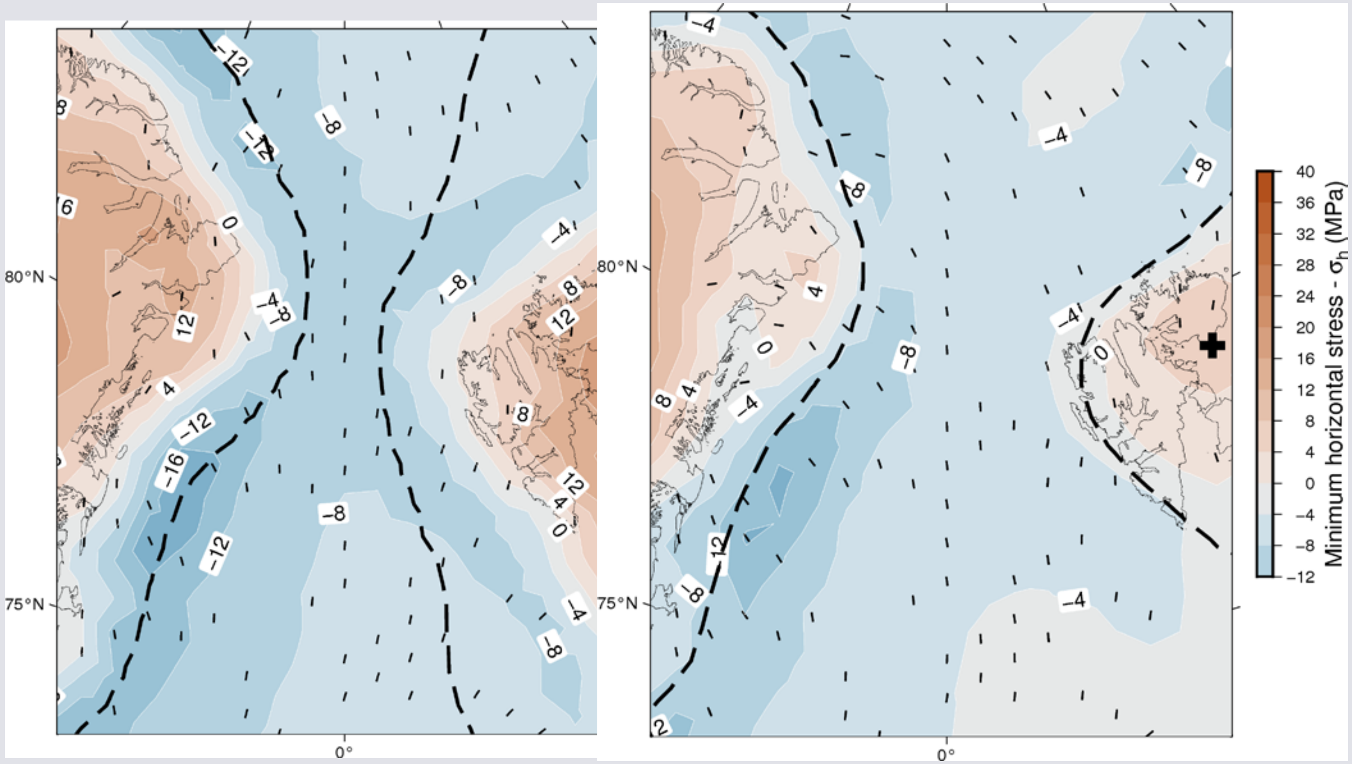
Seafloor seepage restricted to zones under a tensile stress regime

The tectonic stress regimen in the Fram Strait

The minimum horizontal tectonic stress due to oblique spreading varies from -30 MPa near the ridge axis to +30, ~50 km away from the ridge axis



(Beaussier et al., in prep)

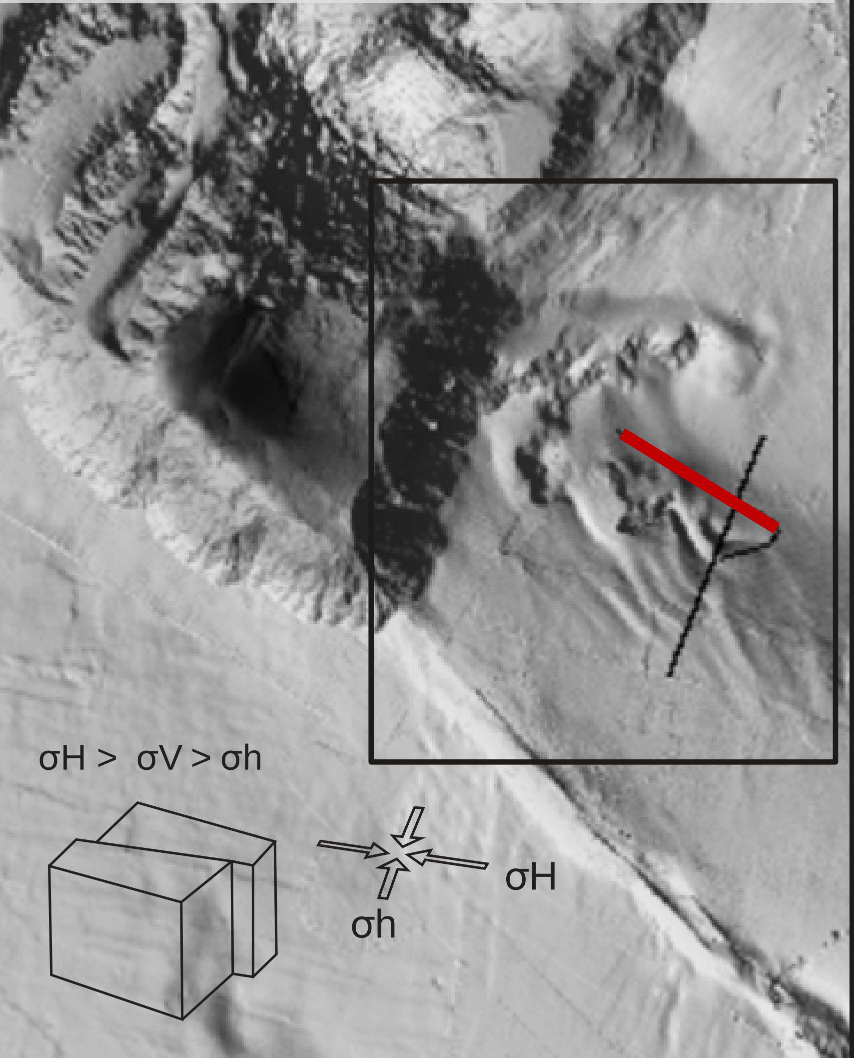


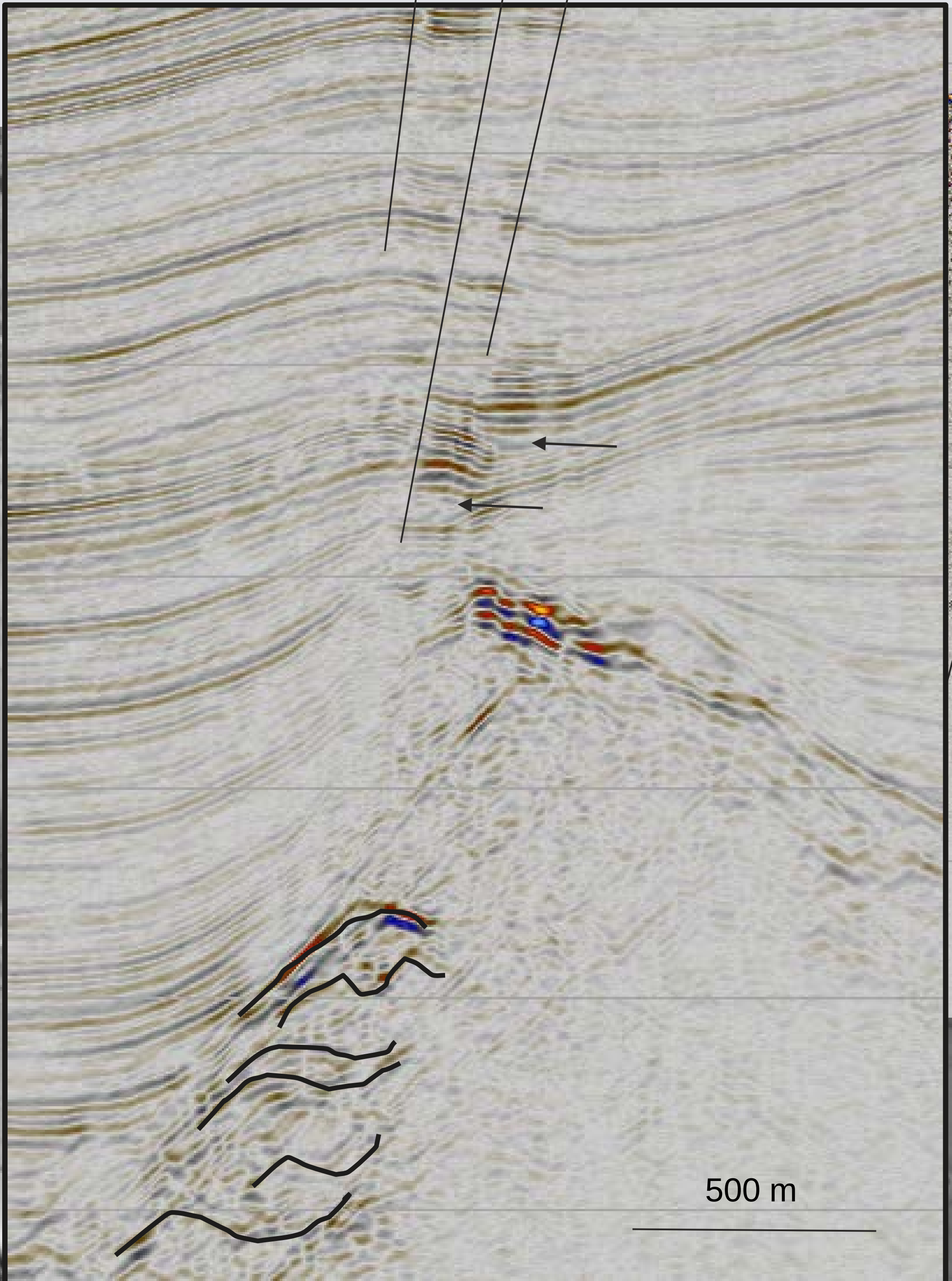
(Vachon et al., in review)

While the minimum glacial horizontal stress has fluctuated between -10 and -6 MPa through glacial cycles

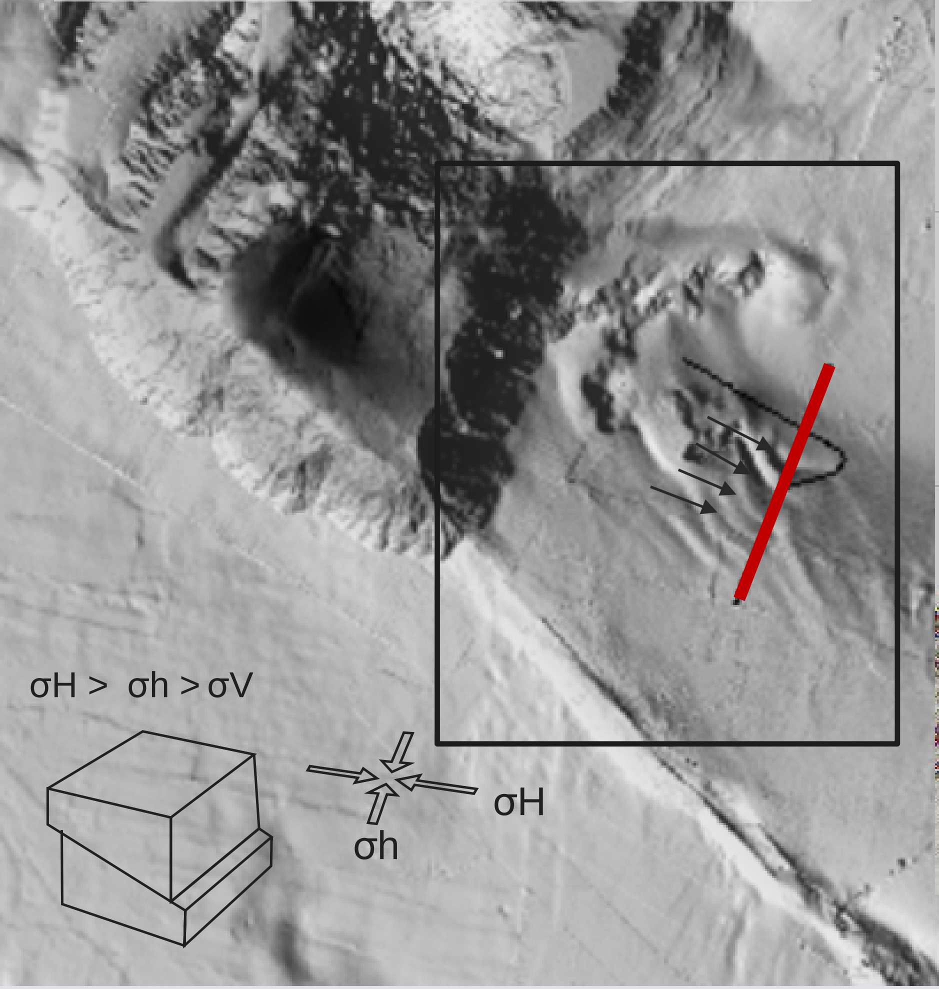
Evidence for sedimentary folding and faulting due to compression and strike slip deformation

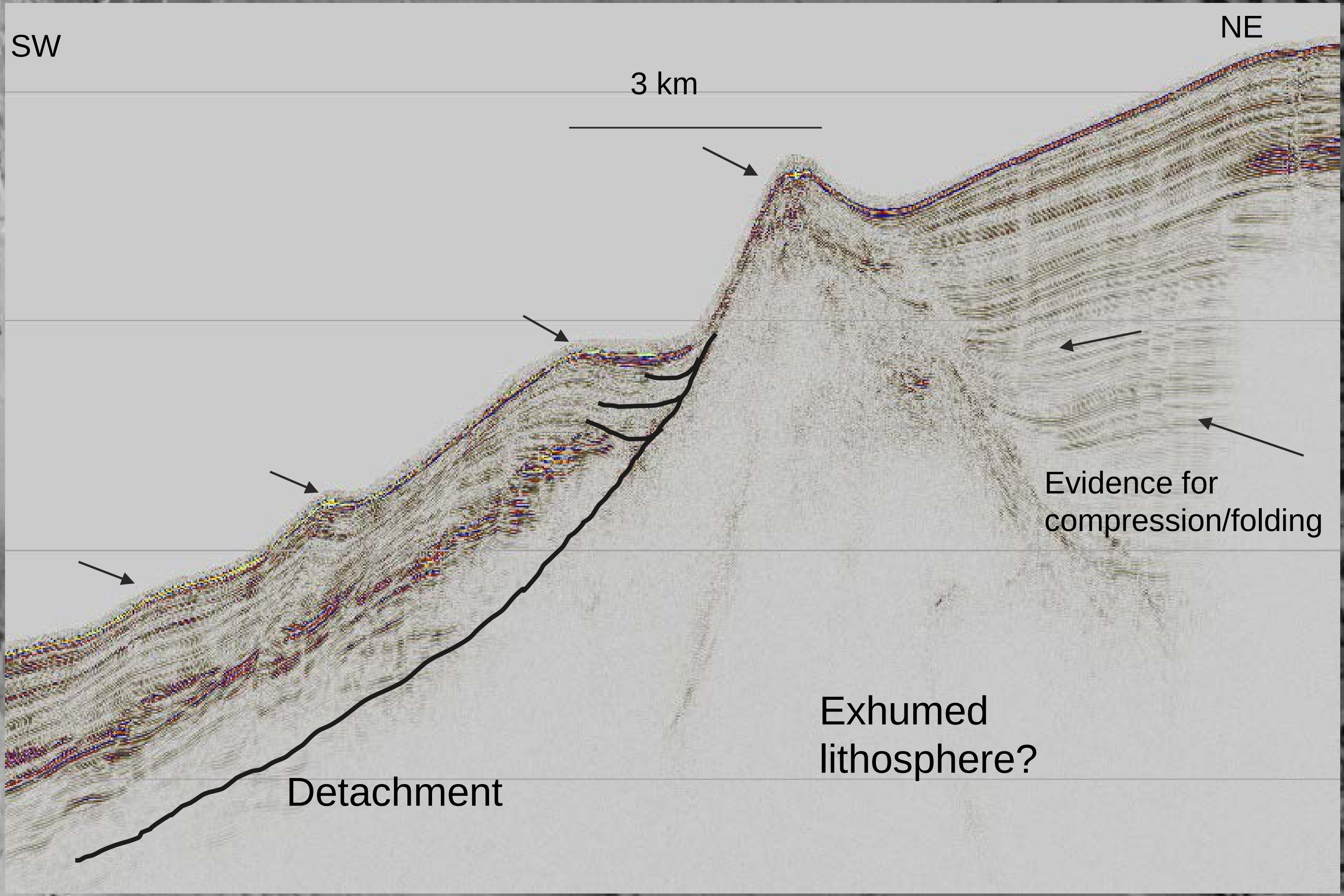
Evidence for transpression extending to the shallow sediment cover



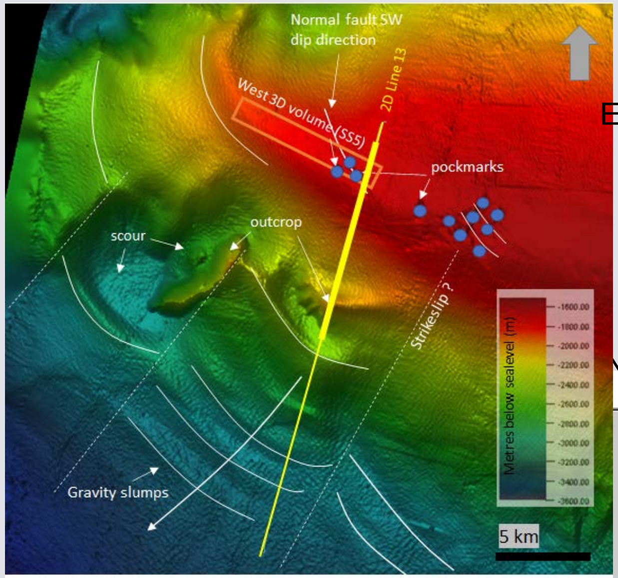


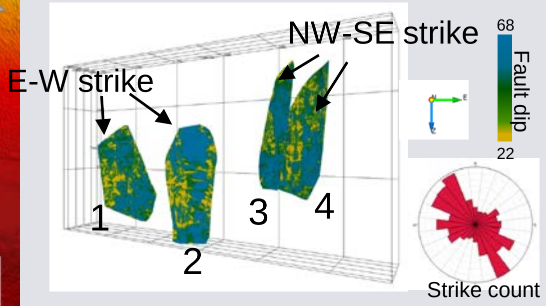
Evidence for detachment of the sediment cover from the oceanic crust

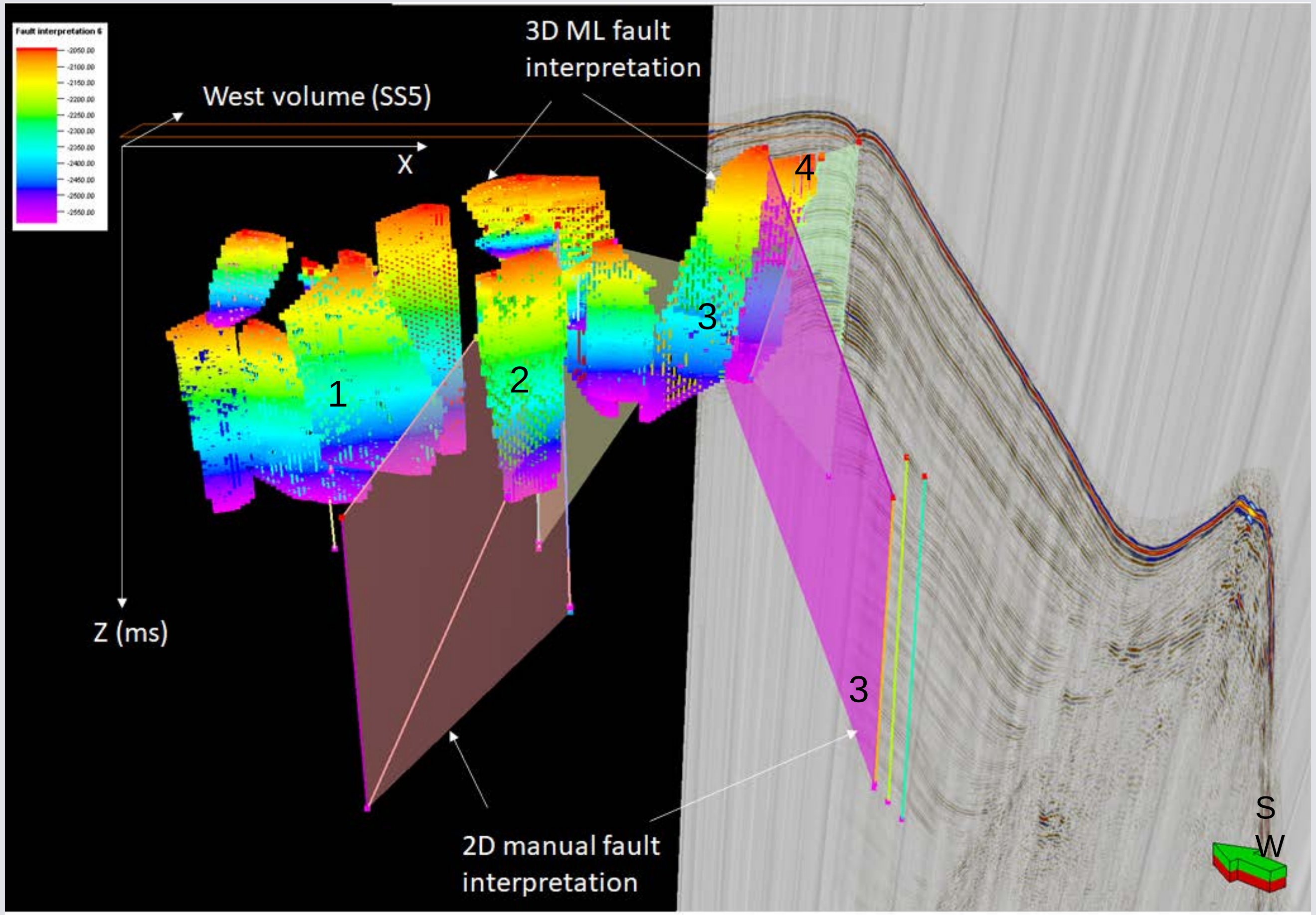


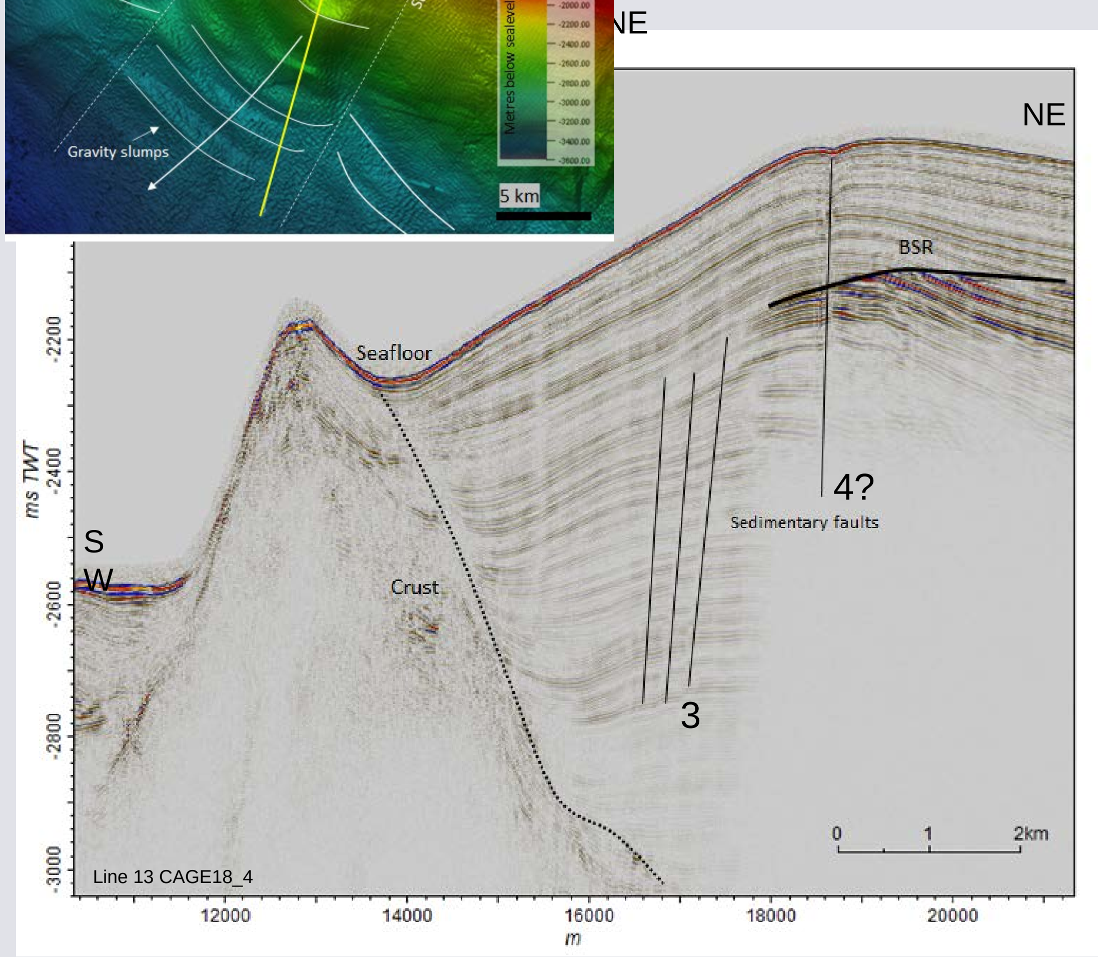


High resolution 3D seismic data reveal NW-SE trending sedimentary fault planes that match the strike of detachment (slump) structures





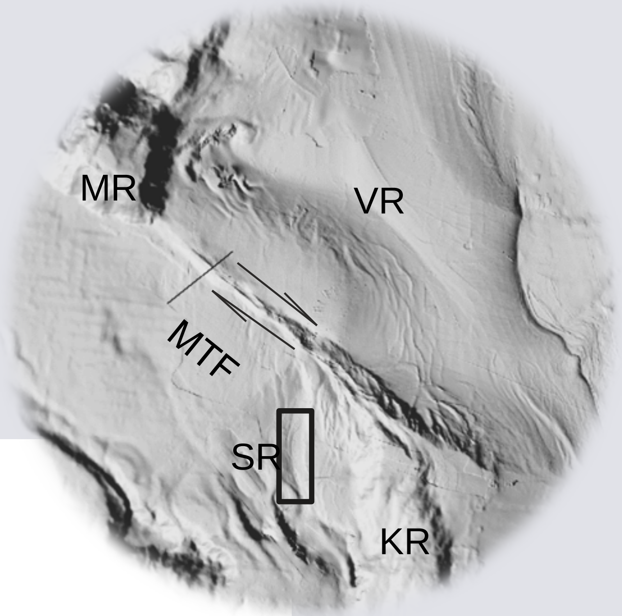




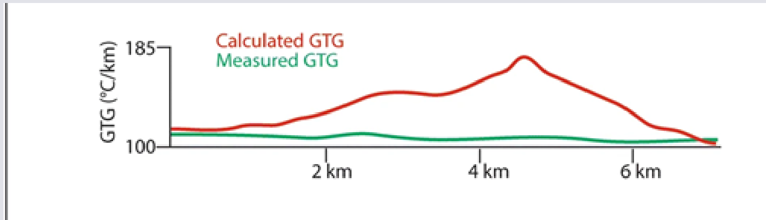
(Cooke et al., in prep)

Evidence for sedimentary faulting at oceanic crustal peaks

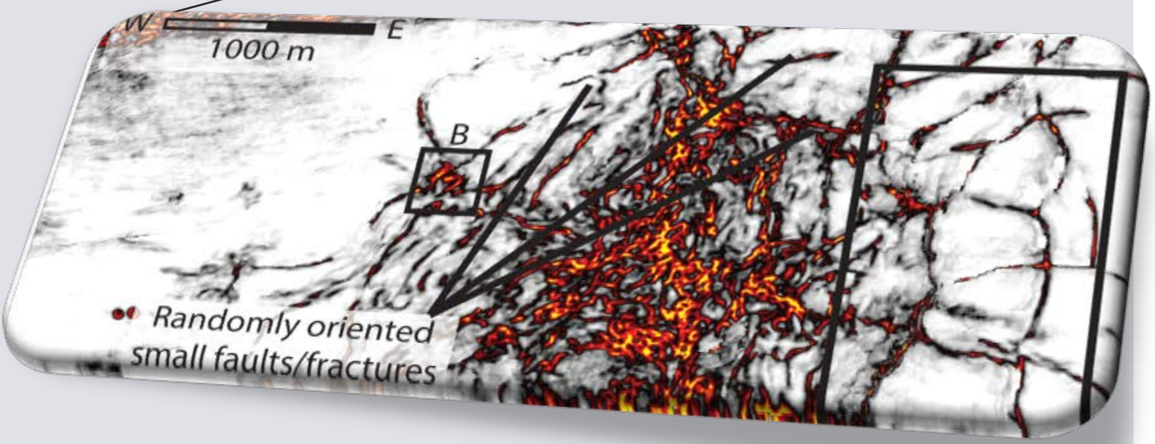
Sedimentary faults initiate at detachment fault peaks and drive warmer fluids into the shallow sediment, decreases the gas hydrate stability zone and promotes shallow radial fracturing

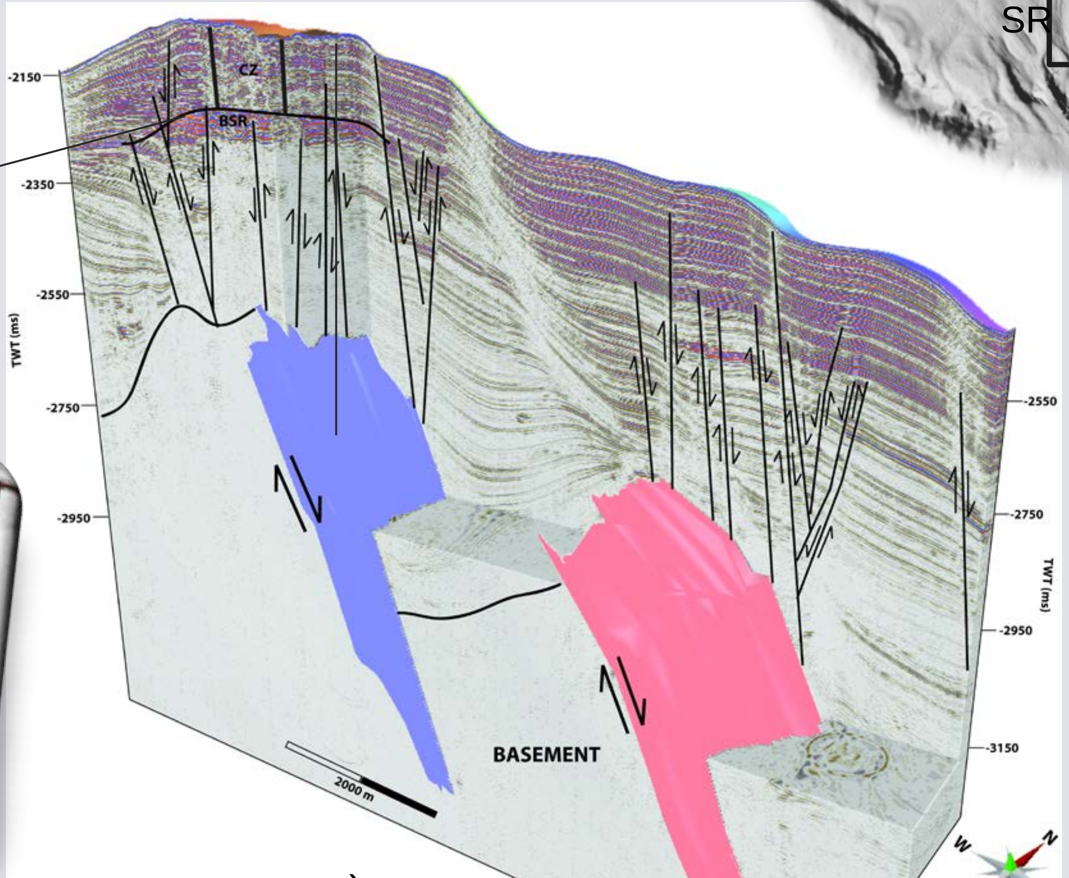


Thinning of the gas hydrate stability zone due to warmer and more methane dominated, crustal, fluid input



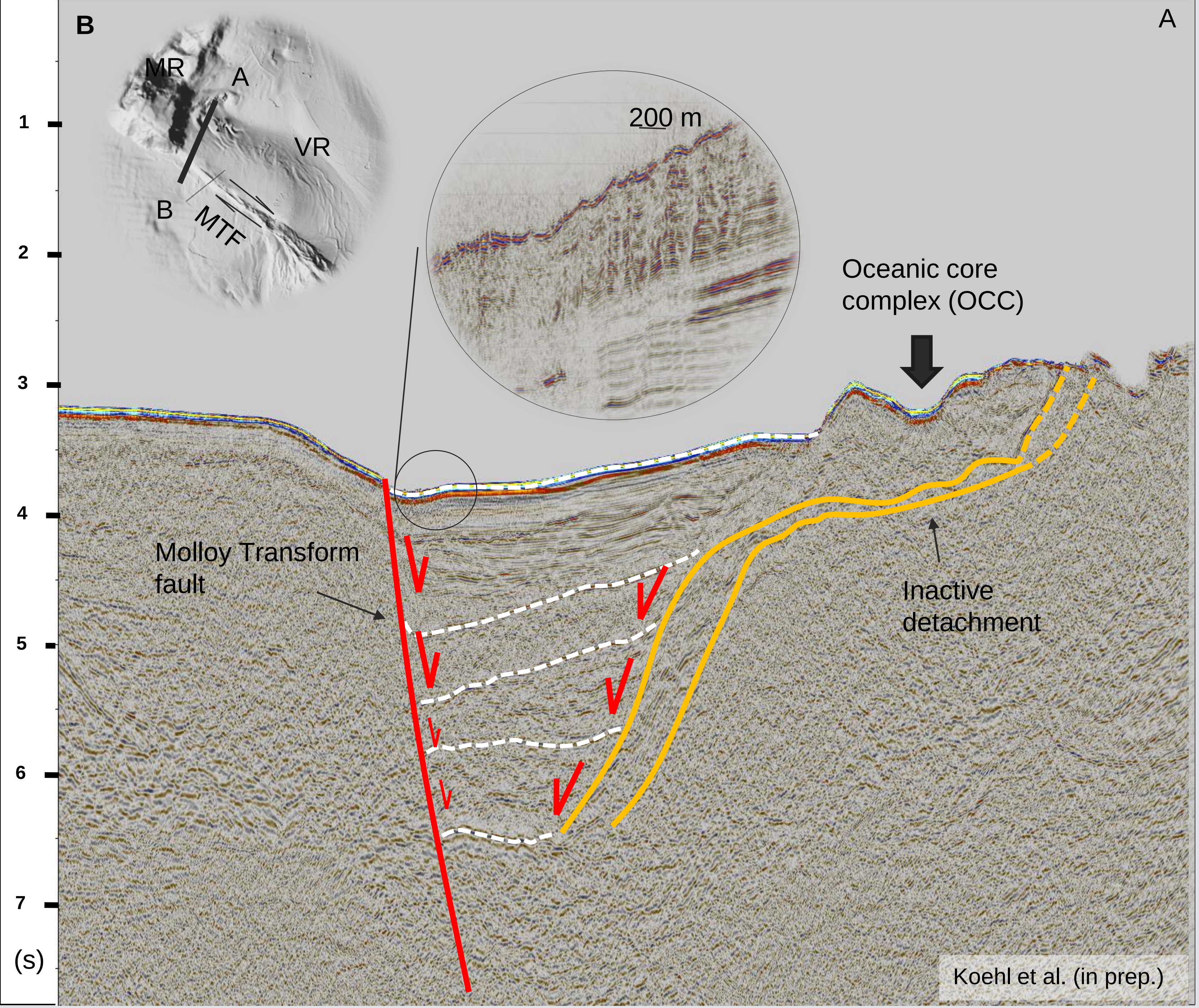
Waghorn et al., 2020





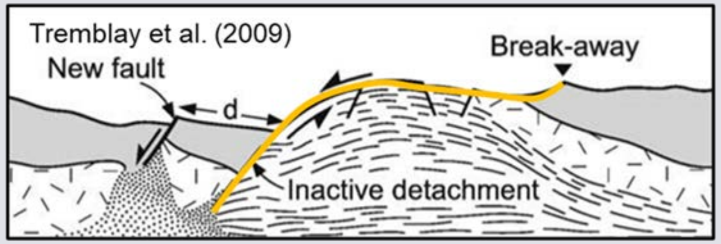
(Waghorn et al., 2018)

Sediment dewatering and degassing associated with crustal processes such as formation of oceanic core complexes, formation of serpentinite, sediment detachment and sliding



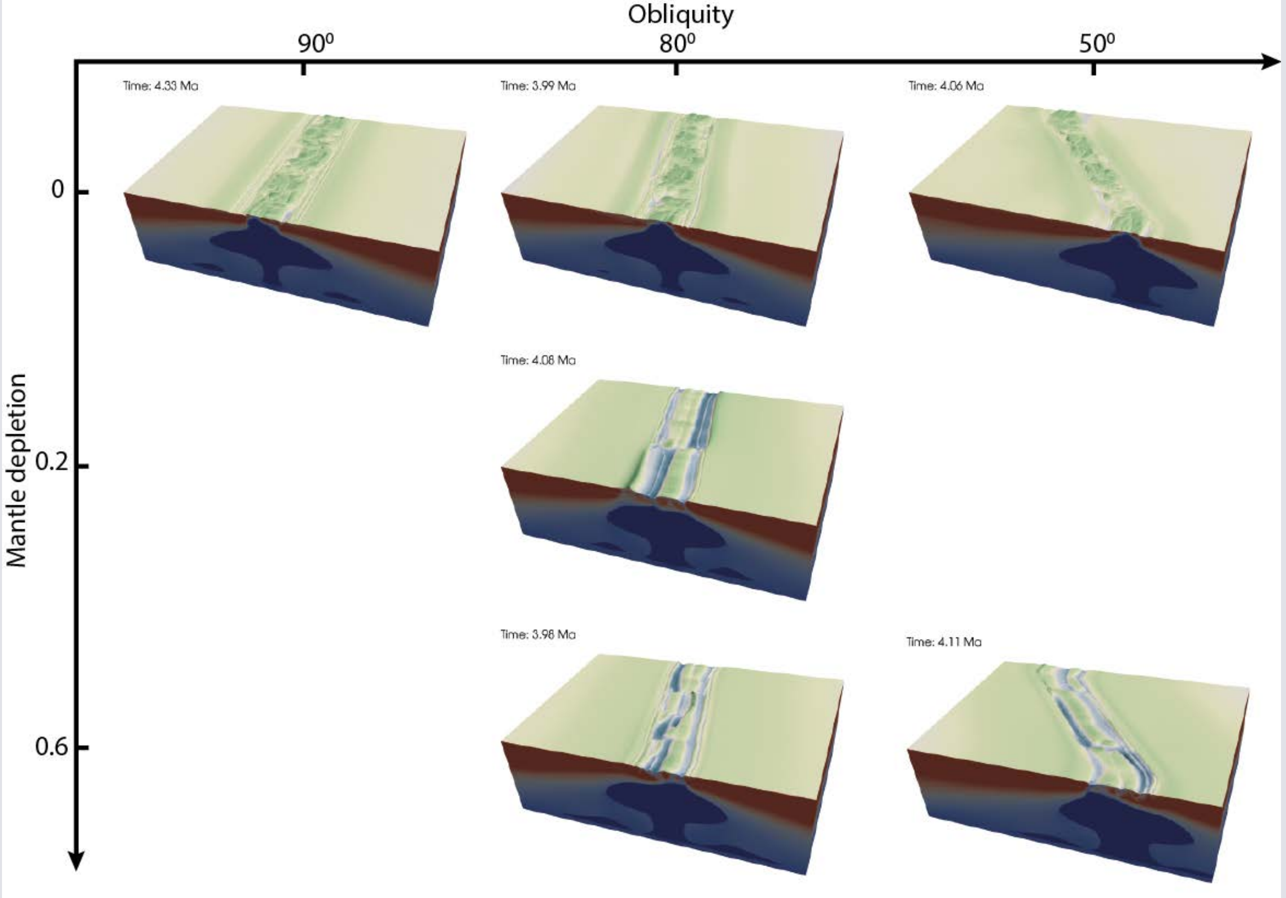
An oceanic core complexes (OCC) is interpretated at the inside corner of the MTF

Analogue fossil OCC onshore Canada



The OCC interpretation is supported by tectonic stress modeling

Coupled effect of obliquity and melt supply on ultra-slow spreading systems

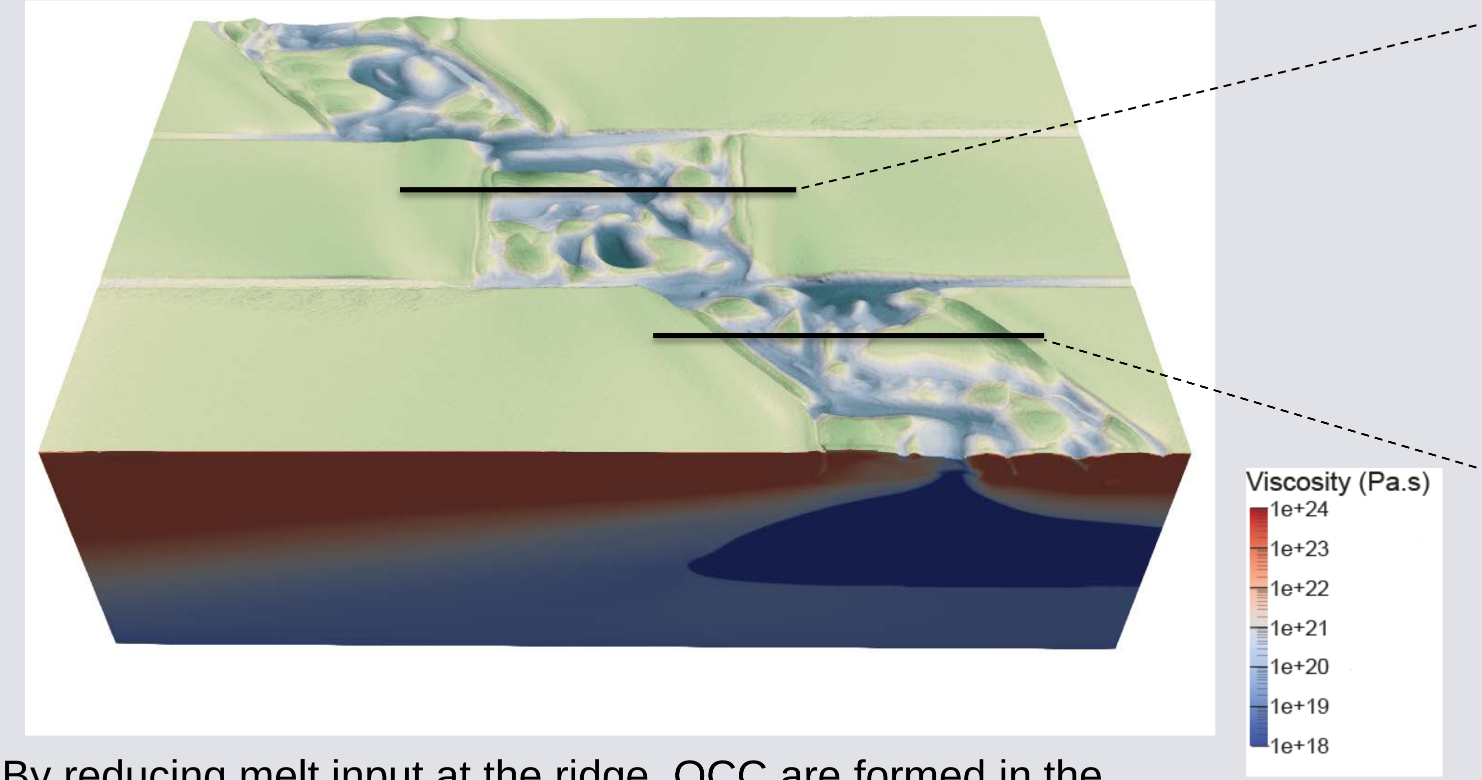


(Beaussier et al., EGU2020)

- The following figure summarizes how obliquity and magmatic supply interplay to affect the seafloor morphology (see notes for more explanations).
- In accordance with previous studies the results show that the magmatic supply is the main control on tectonic regimes. Low magmatic supply favours the formation of oceanic core complexes over crustal accretion and low angle detachment.
- Obliquity of the ridge plays a second order role. Higher obliquity favours longer ridge segments.

Fram Strait: interplay between ridge and transform systems

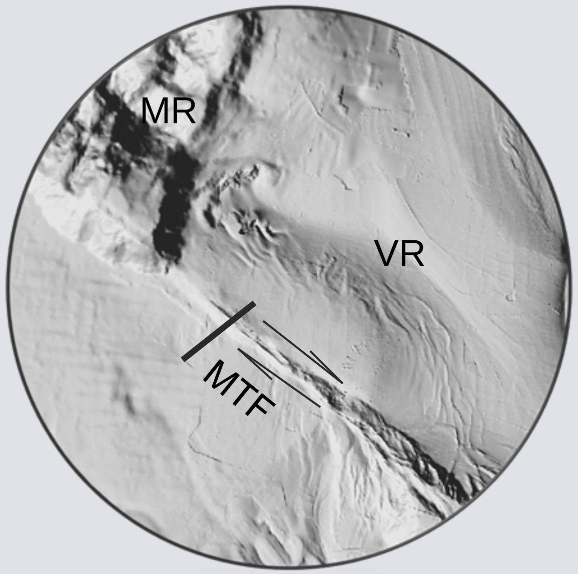
6.12 Ma



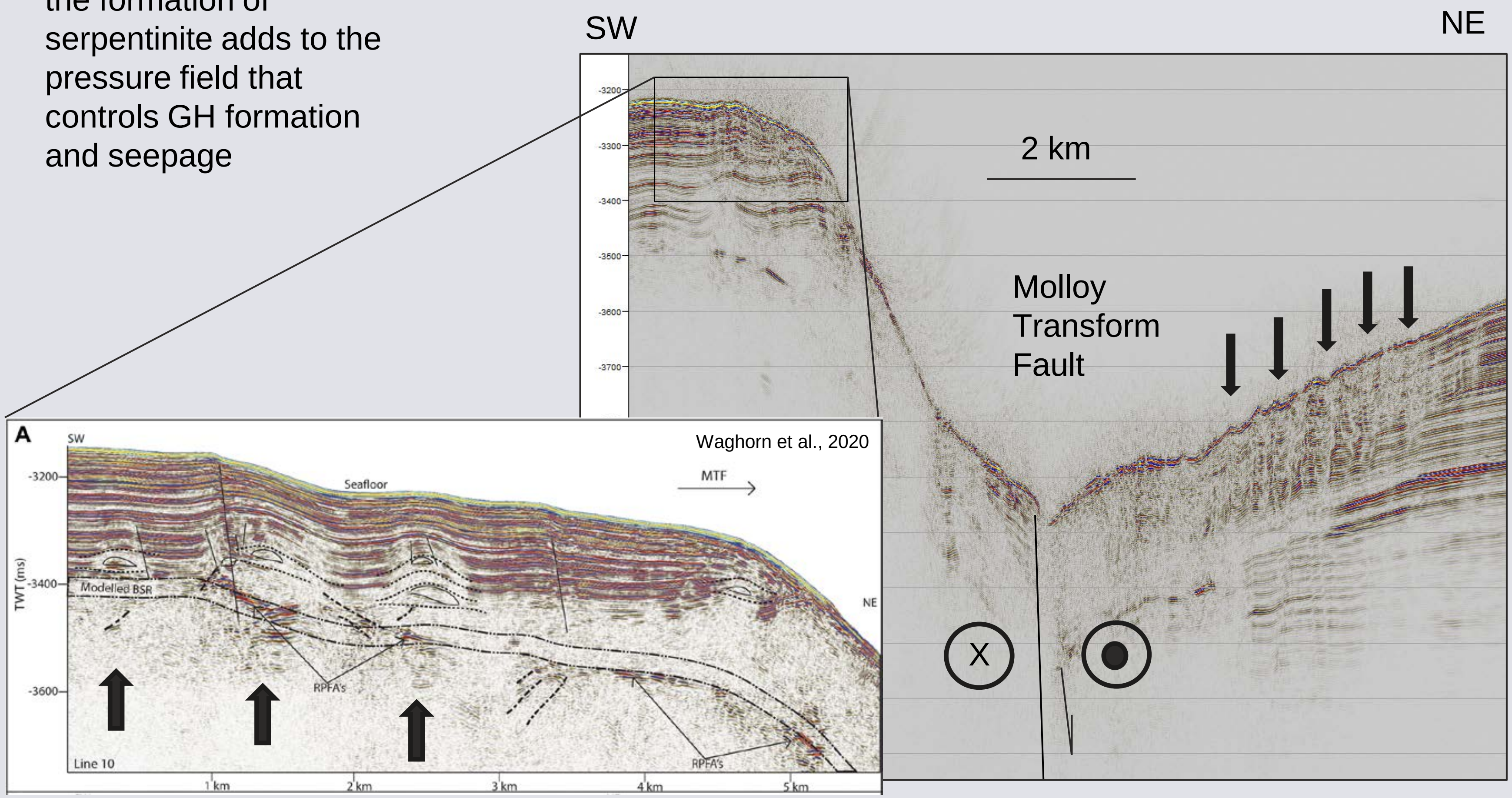
By reducing melt input at the ridge. OCC are formed in the orthogonal region.

(Beaussier et al., EGU2020)

Exhumation of upper mantel material and present day accommodation of regional stress due to slow spreading promotes faulting and alters the fluid flow regime within the sedimentary cover



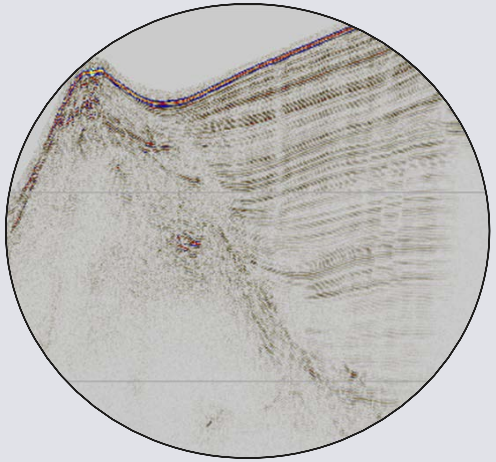
Fluids associated with the formation of serpentinite adds to the pressure field that controls GH formation and seepage



Summary

The regional stress regime in the Fram Strait is affected by oblique spreading and glacial isostacy

The margins are characterized by a thick sediment cover over oceanic and continental crust that is been faulted and folded following mid-ocean ridge spreading and glacial adjustment



Evidence for compressive and strike slip deformation suggests that glacio tectonic stress is transferred into the shallow sediment!

Regional horizontal stress affects the pressure field that controls gas hydrate and seepage dynamics across the margins