The role of oceanic fracture zones on the dynamics of subduction zones: from natural deformed samples to thermomechanical modelling.

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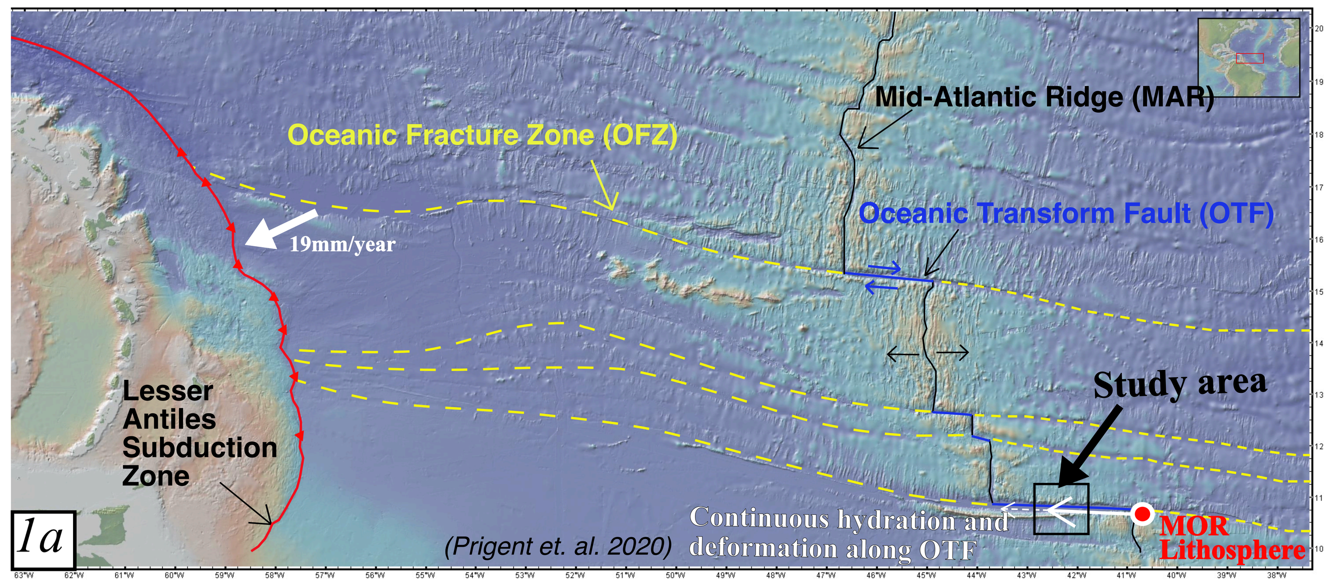
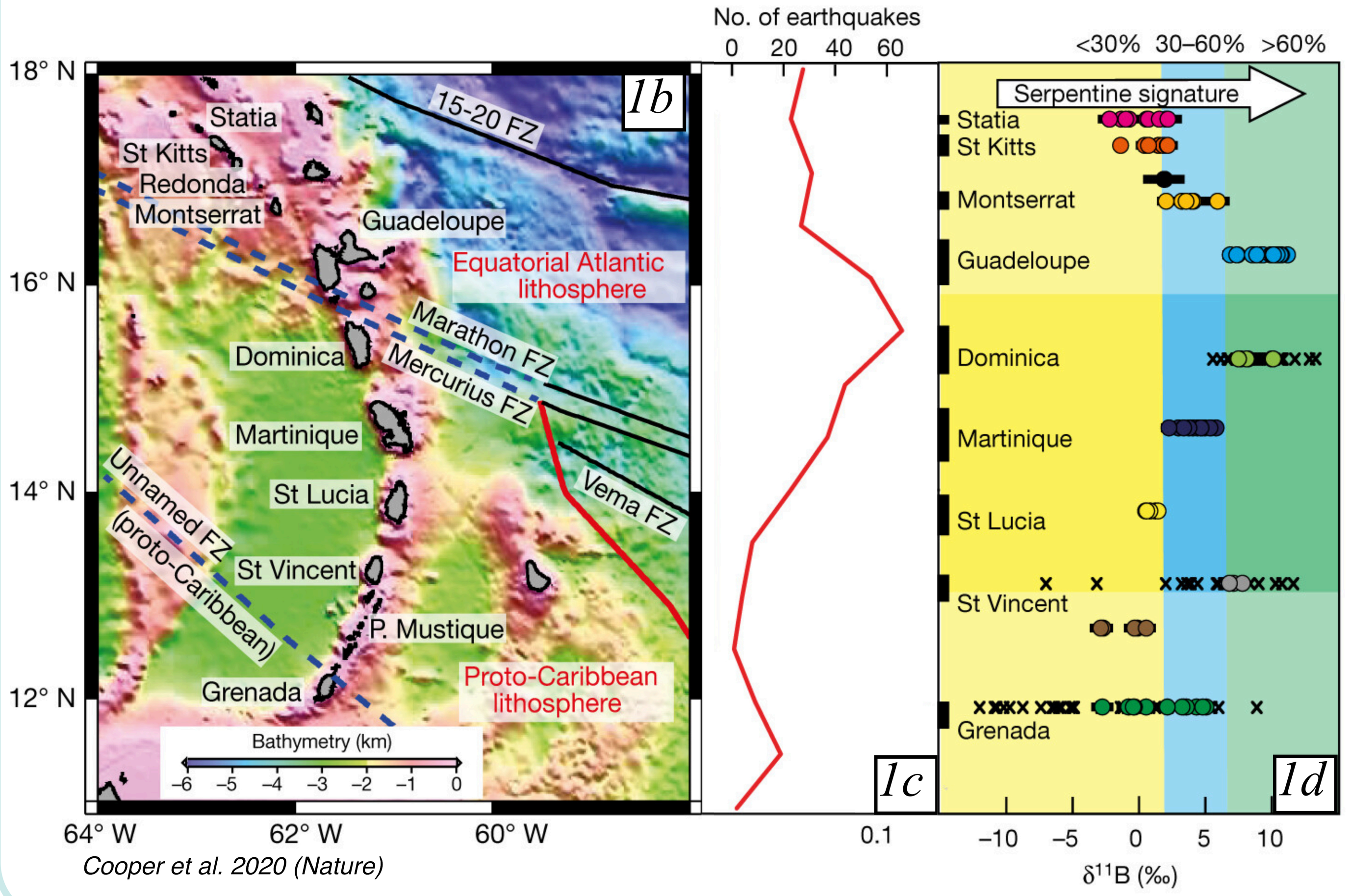
1. Background





Introduction

Oceanic Fracture Zones (OFZ) are remnants of oceanic strike-slip plate boundaries namely Oceanic Transform Faults (OTF), segmenting mid oceanic ridge (MOR) [Fig. 1a].

Subduction of OFZ in Lesser Antilles Subduction Zone [Fig. 1b], coincides with

-**Higher production of earthquakes** [Fig. 1c] and

-Distinct arc lava composition [**heavier Boron isotopic signature ($\delta^{11}B$)**] [Fig. 1d].

These observations suggest a strong influence of OFZ in subduction dynamics and distinct compositional, mechanical and seismogenic properties of the oceanic lithosphere on OFZ.

Since, OFZ are relict part of seismically active OTF, along which MOR lithosphere is progressively deformed and hydrated [Fig. 1a], it appears crucial to understand-

- Fluid-rock interaction on OTF

-Their consequence on the composition and rheology of the oceanic lithosphere

- Link between these interactions on OTF with OFZ-subduction

Question

-**Why** and **How** OFZ influence long and short term subduction dynamics?

Approach

1. *Examine geochemical and rheological modification of lithosphere on OTF*

-Characterise feedback between deformation and fluid rock interaction through integrated micro-structural, geochemical and rheological study of modified magmatic crust

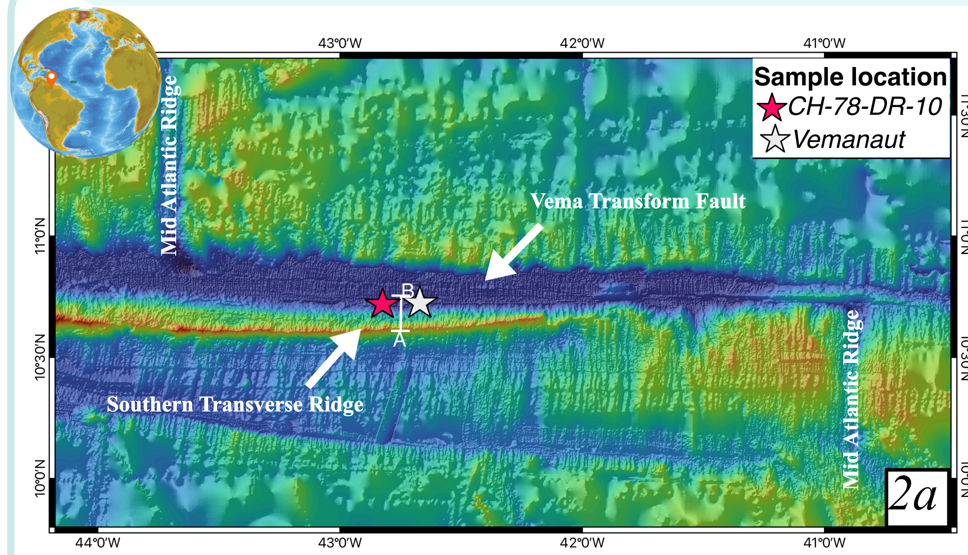
-Estimate chemical budget for the fault zone

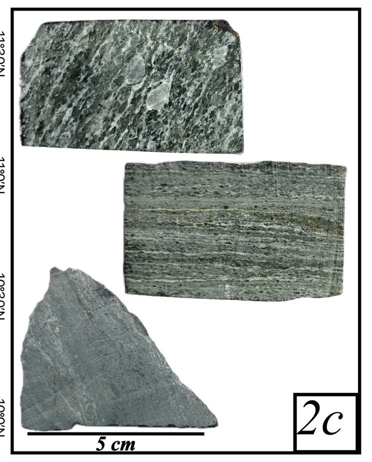
2. *Investigate impact of this modified magmatic crust on subduction dynamics, using numerical modeling, during OFZ subduction*

-Constrain slab metamorphic reactions and fluid fluxes at the subduction interface

-Evaluate its effect in subduction dynamics: thermal regime, interface rheological properties, fore-arc dynamics etc.

2. Study area





-Bathymetry map of ***Vema transform fault (Atlantic Ocean)*** with sample locations [Fig. 2a]

-***CH-78-DR-10***: Dredge haul by R/V Jean Charcot, 2900 m below ridge crest.

-***Vemanaut:*** Vemanaut campaign (1988) recovered Amphibolites recovered during Nautile dive no 4

-Geological Cross section of Vema transform fault (TF) along AB line shows ***composition of the TF*** [Fig. 2b].

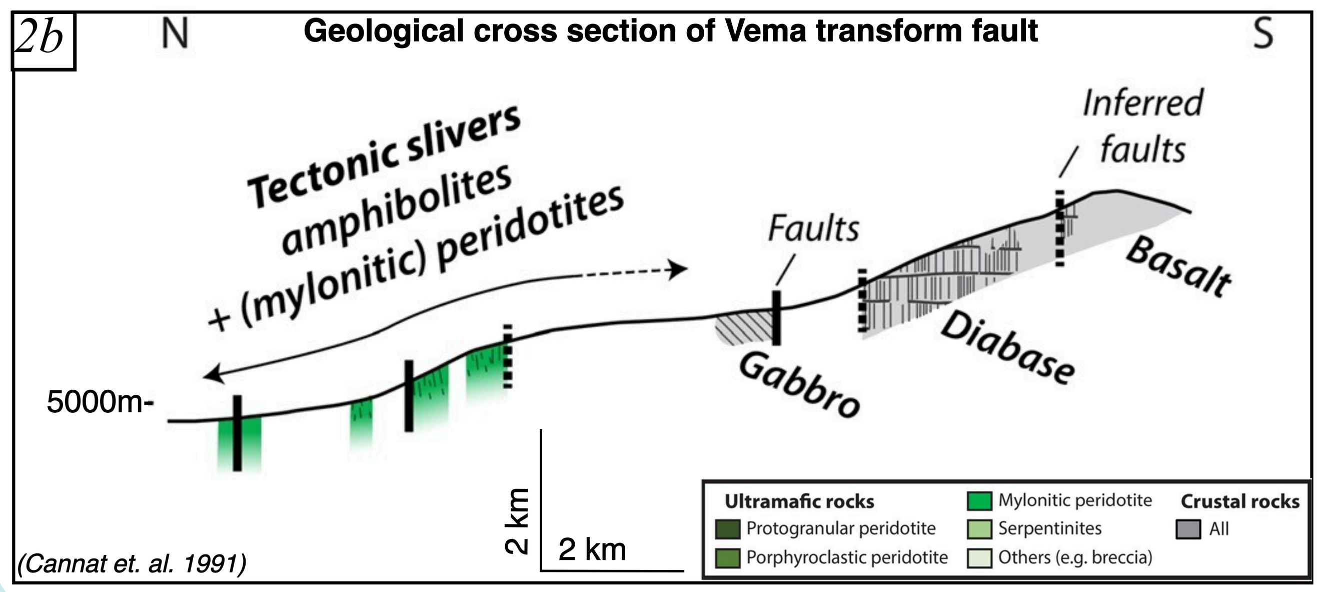
-*Deformed and hydrated amphibolite and peridotite at the bottom.*

-Overlainen by *gabbro, diabase and basalt, modified by fluid percolation through faults.*

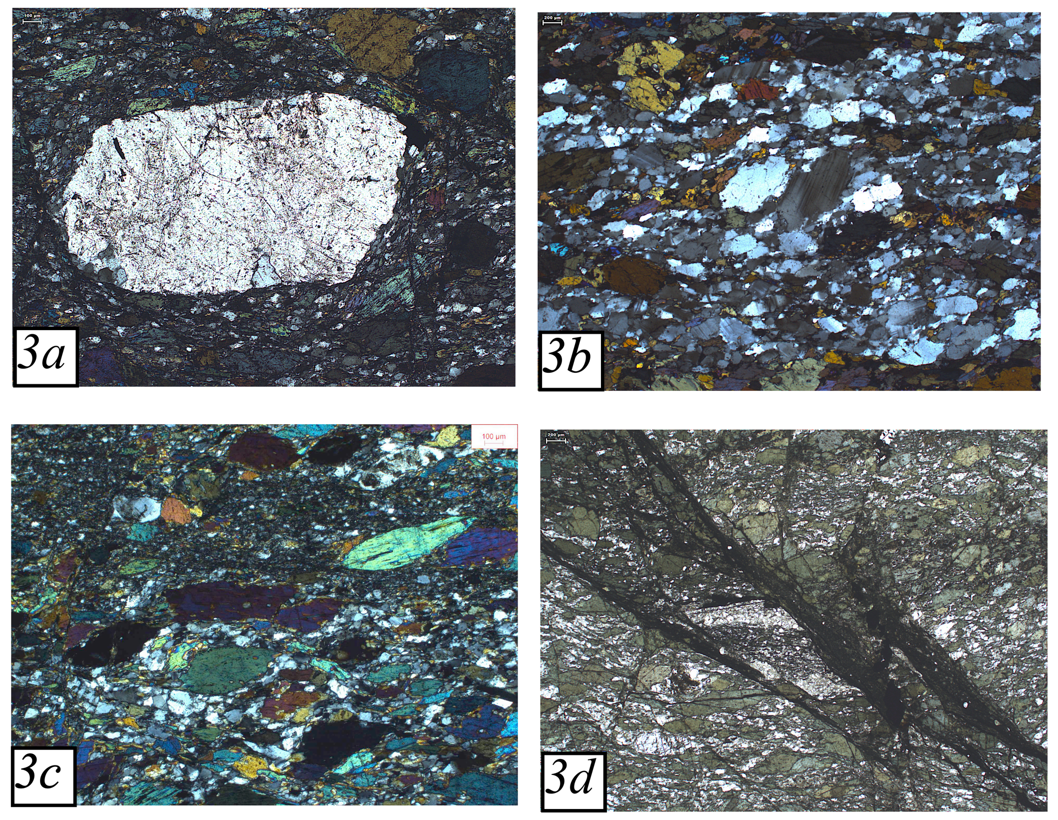
-Metagabbroic rocks are *highly deformed and diverse: mylonitic to ultramylonitic texture* [Fig. 2c]

-Less deformed rock (top and bottom) exhibits porphyroclasts within mylonitic layers.

-Ultramylonitisation and scarce porphyroclasts due to intense deformation (bottom).

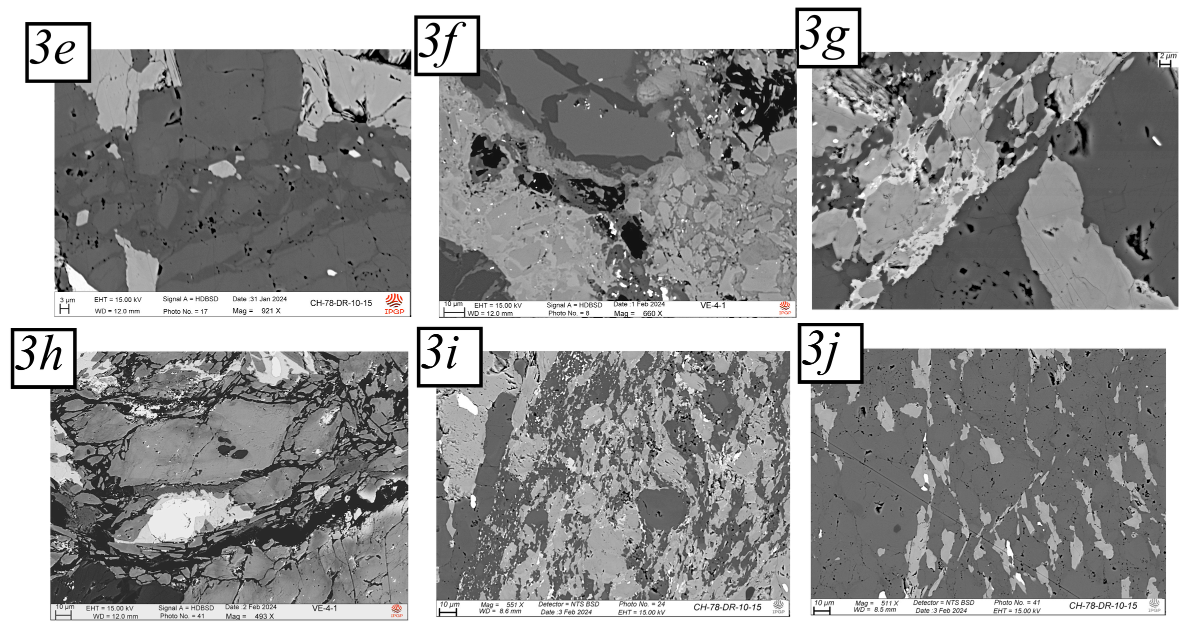


3. Petrological investigation



Pervasive brittle deformation accompanied by ductile deformation within amphibolites.

- **Fractured** plagioclase **porphyroclasts** with serriated boundary, **subgrain** formation and **grain boundary migration** [Fig. 3a]
- Subsequent deformation results in **mylonitic foliation** defined by recrystalised amphibole and plagioclase [Fig. 3b]
- **Grain size reduction** are seen in certain mylonitic layers, further crosscut by brittle fracture [Fig. 3c]
- **Ultramylonitic zones** cut across these mylonitic foliation, further affected by **later microfaulting** [Fig. 3d]



Brittle deformation: *Brecciation and fracturing*.

- In-situ brecciation of plagioclase [Fig. 3e] and amphibole [Fig. 3f]
- Fracture cross-cutting pre-existing foliation [Fig. 3g]

Fluid-rock interaction: in **amphibolite and greenschist facies**.

- Sodium zoning of plagioclase and amphibole crystalisation within cataclasite zone [Fig. 3e, 3g]
- Fracture-fill by sphene [Fig. 3g] and chlorite [Fig. 3h]

Ductile deformation: Within **ultramylonitic cataclastic layers**.

- Zoned 'delta' clast of plagioclase and amphibole [Fig. 3i]
- S-C structure defined by amphibole neoblasts [Fig. 3j].

Next Phase

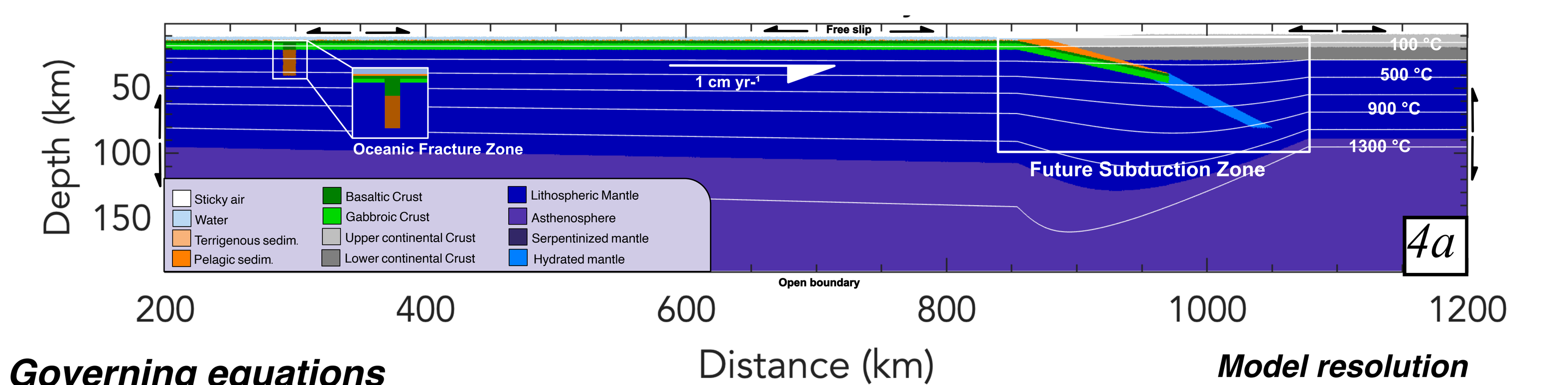
1. Mineral composition analysis (EPMA): *Correlation of mineral phases* with deformation events and *thermobarometry*

2. Bulk rock and in-situ chemical analysis (LA-ICPMS): *Constrain chemical changes* linked with deformation and fluid-rock interactions

3. Deformation micro-structural analysis (using EBSD): *Deformation mechanism*

4. 2D thermo-mechanical modeling

Initial set-up



Governing equations

-Mass, momentum and heat conservation equations.

-Solved with marker-in-cell technique [Gerya & Yuen, 2007]

-Visco-elasto-plastic rheologies constrained by laboratory experiments.

-I2ELVIS code, adapted from Menant et. al. (2019)

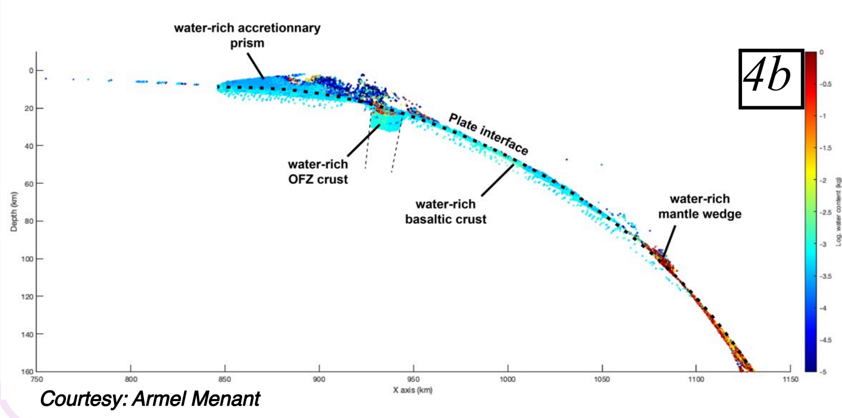
Model resolution

-Grid size

-X = 500m

-Y = 370m

-8,209,600 Markers



Fluid (de)hydration and transport:

-Stokes flow

-Fluid buoyancy

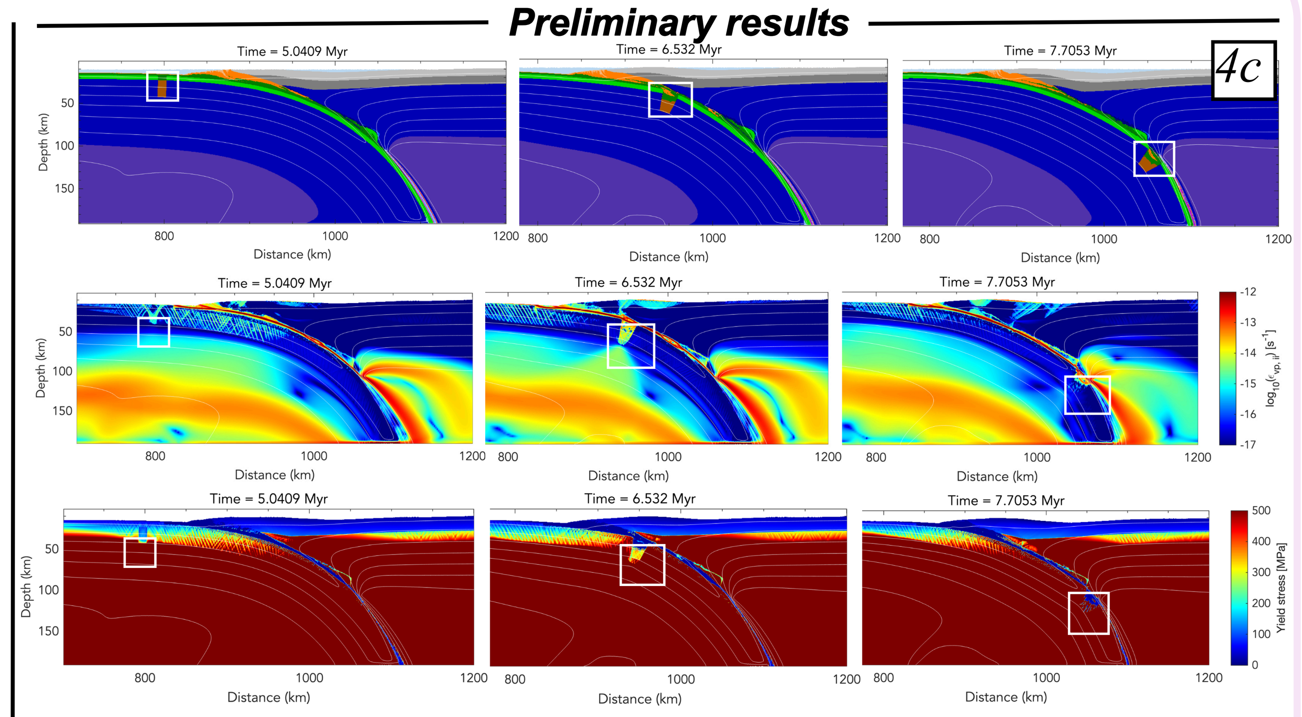
-Pressure gradients

Nature of fluid

-Pore water in sediments and basaltic crust

-Mineral bound water in sediments, basaltic and gabbroic crust

Preliminary results



Evolution of **composition(top row), strain rate (middle row)** and **Yield stress (bottom row)** for 3 time steps during OFZ subduction.

-Widening of OFZ, formation of graben, filled by materials from plate interface and overriding plate (top row)

-Decrease in plastic strength of OFZ: *Brittle deformation of the OFZ crust at higher depth* (middle and bottom row)

-Increase in plastic strength of OFZ mantle: Viscous deformation of OFZ mantle with localised fluid controlled brittle deformation (bottom row and Fig. 4b

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