

New ILP Task Force: Deep Into the Subduction Channel (Acronym: DISC)

Probing subduction zones: what is the physical nature of the subduction channel ?

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Ambition : understanding the geodynamics and rheology of subduction zone interfaces.

=> fits in programme theme 3 & 4 of the ILP (Continental and oceanic lithosphere)

=> aims at first-order problems in modern integrated Solid Earth Science centred on the lithosphere such as those outlined by the ILP: fate of subducted lithosphere; deformation and evolution of the oceanic and continental lithosphere in subduction zones

In practice : Combining geophysics/geochemistry, metamorphic petrology and thermomechanical modelling

Keywords : *subduction, melange, rheology, tomography, numerical modelling, obduction*

Scope

Subduction zones are crucial areas for understanding lithospheric-scale coupling between plates, risk assessment, or studying vertical movements and material recycling on Earth. Following England and Holland (1979) and Shreeve and Cloos (1986), most authors envision the plate-slab interface as a subduction channel, in which material may move partly independently from the upper and lower plates.

In detail, the nature and structure of the subduction channel is still poorly constrained, however (Gerya et al., 2002; Abers et al., 2006; Raimbourg et al., 2007; Yamato et al., 2007; Hilairet et al., 2008; Monié & Agard, 2009 and references therein). Furthermore, understanding what controls the detachment and migration of km-scale fragments metamorphosed to high-pressure low-temperature conditions in subduction zones is crucial to constrain subduction channel processes and interplate mechanical coupling.

Over the past recent years, a wealth of geophysical and petrological data were gathered. Yet, for the most part, these data have not been sufficiently combined, partly due to a mismatch in scale (both in space and time), to provide us with a clear and modern view of the subduction interface.

In that sense, this task force aims at «bridging the gap » between communities (as first initiated and coined by the conference held in Bochum, May 2007 : « Subduction dynamics : bridging the scales ») and at fostering joint collaboration and research.

The incentive for this task force lies in the fact that :

1) During the past five years, high resolution reflexion and tomographic imaging of subduction planes has showed (from bottom to top across the plate-slab interface):

- a composite layer of slab oceanic crust (in places traced down to c. 400 km), cut into 5-10 km-large pieces or less due to large magnitude ruptures, slab bending and/or inherited earlier fracture patterns, underlain by partly hydrated slab mantle.

- low-velocity layers, 2-8 km thick, located on top of the slab on several subduction zones and interpreted as sediments, serpentinites highly hydrated crustal material or slivers lying along the plate-slab interface. These layers are our best picture so far of what a subduction channel might look like.

- a highly hydrated (30-40vol%) and serpentinitized mantle wedge corner. Across the mantle wedge permeable barrier, whose tip coincides with the downdip limit of the seismic locked

zone (at c. 40 km), partial interplate decoupling occurs, while repeated hydrofracturing (and fluid transfer) may be responsible for episodic tremor slip and slow slip events.

This overall picture is supported by thermodynamical models of dehydration reactions and plate-slab interface mineralogy accounting for the double seismic zones observed in many subductions. The picture, however, with a resolution of 3-5 km, is somewhat blurred when attempting to match petrological observations.

2) Petrological studies now provide detailed T-depth-time-fluid evolution, with a spatial resolution of a km or less (thanks to improved thermobarometry and pseudosections). It is yet unclear whether observations support melange (Viso, Entrelor) or single pass dynamics (Zermatt-Saas) in the subduction channel, nor have researchers so far engaged in determining its lithological/physical state in detail for rheological purposes.

3) Thermomechanical models, on the other hand, have provided insightful views on subduction dynamics and exhumation models yet about on rheological laws, fluid migration, kinetics... Note that thermomechanical models of the subduction plane/channel either point to extreme mixing in the subduction channel (Gerya et al., 2002) or to movements of individual slices (Yamato et al., 2007).

Some fundamental questions thus remain to be addressed : what , where, when ?...

For example, crustal (+ mantle) slices likely migrate upwards along some sort of a channel, but the following questions remain: how do these rocks detach from the sinking slab, at which depth(s), do they circulate in a complex melange zone or as large-scale imbricated slices? To which extent are slab- or mantle wedge-derived serpentinites (or sediments) effectively present in the channel ? What is the amount of underplated material deep in the subduction channel ? What is the dynamic behaviour of this « channel »: ranging from single pass upward flow at restricted time periods... to extreme mixing in the subduction zone ?

Time has come to make significant progress in our understanding of subduction zones and get a much refined view of the physical conditions and processes at work along the subduction interface.

This task force will bring together specialists from various complementary fields with unprecedented high-resolution techniques: high-precision thermobarometry and P-T-t path determination, fully coupled thermodynamic and mechanical numerical modelling, high-resolution lithospheric and crustal-scale constraints from geophysics and geochemistry.

Suggested targets

- Different views on a « frozen » subduction channel (exhumed thanks to continental subduction)? Comparing key outcrops from the W. Alps (Zermatt-Saas, Entrelor, Viso, Voltri).
- Real melange formation ? Probing the subduction zone thanks to the Sistan ocean
- Confronting geophysics and petrology : towards a high-resolution image of the subduction channel ?
- Obduction : how much continental subduction is needed to choke a subduction zone ? Comparing Turkey-Oman-New Caledonia

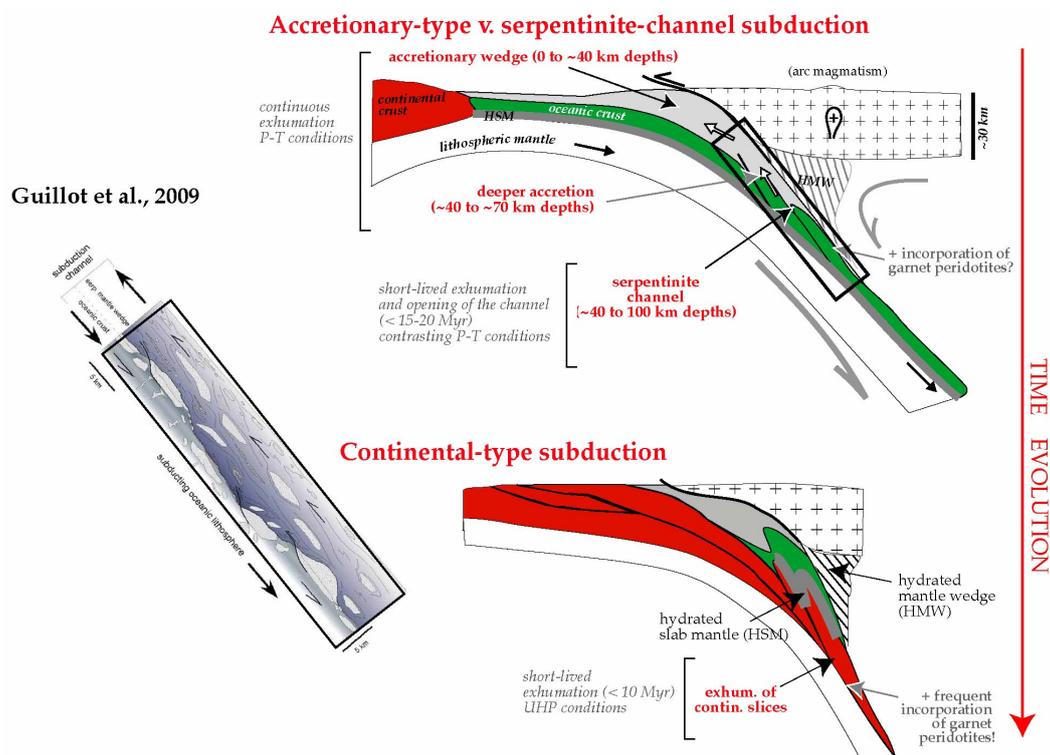
- Thermomechanical modelling : parametric studies for getting mechanical imbricates and fluid fluxes matching natural observations

Expected deliverables

- Conference in the Alps, in may-june 2011

- Book :

« Probing the subduction interface »...



Anticipated Participants (non-exhaustive list!...)

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