Thousand Leagues under the Ocean Trench: Shallow-Depth Slab Decarbonation Prevents Recharge of the Deep Carbon Cycle

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Among all known terrestrial planets in our solar system Earth is the only planet that has plate tectonics. Plate tectonics have created a thermodynamic and chemical disequilibrium by recycling Earth's most common volatiles and building blocks (e.g. silica) [1]. The subduction of plates and the resurfacing of fresh mantle material at rift basins, are thus believed to be primary controls on the geochemical cycle of carbon [2]. This makes subduction zones an important link between the Earth's surface and its interior, and is therefore critical to the cycling of Earth's carbon and water. The processes associated with carbon storage and release in shallow subducting slabs are a debated topic (e.g. [3]) and and here we present new ideas on how fluid-driven decarbonation reactions may operate at a large-scale.

The Deep Carbon Cycle

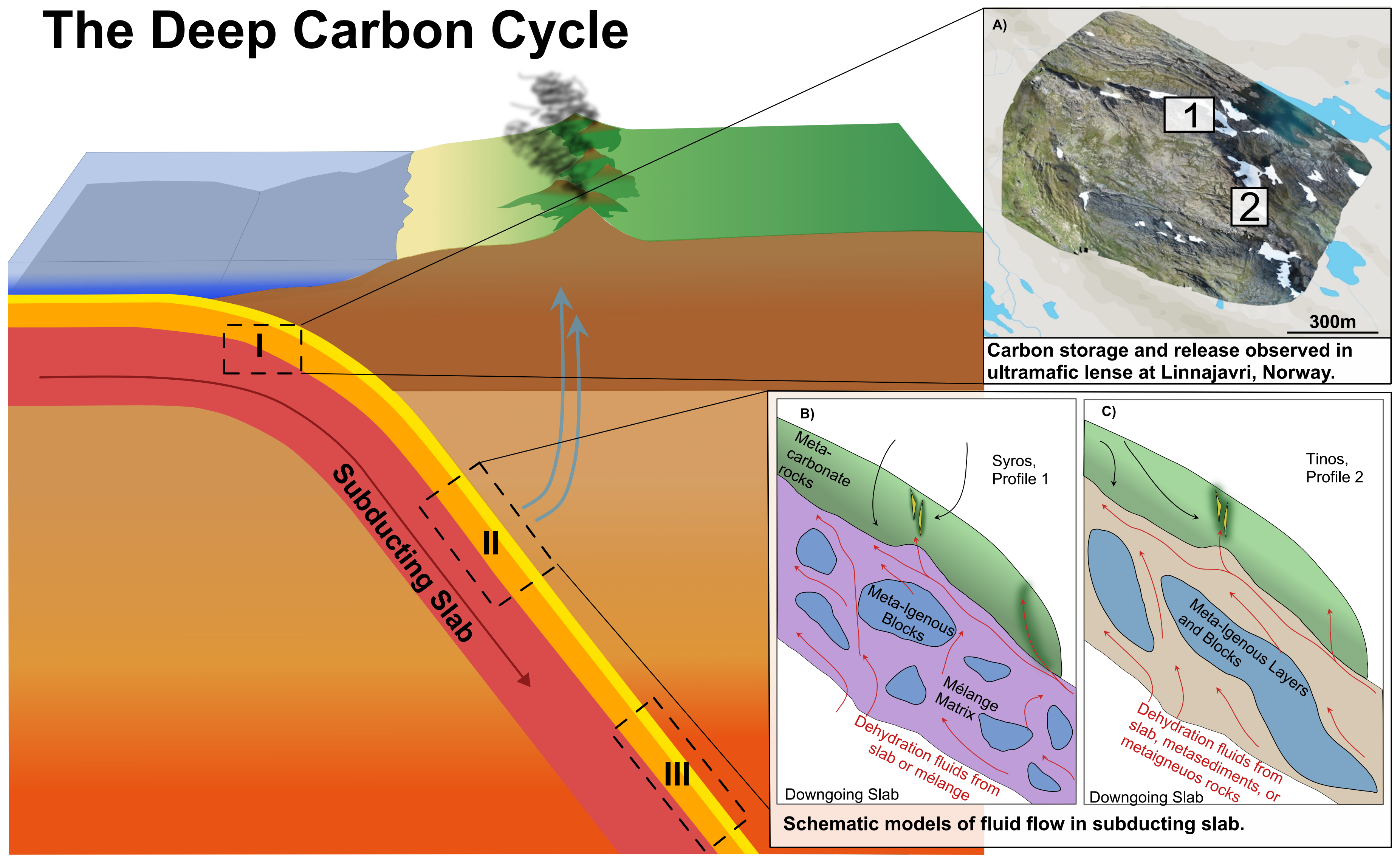

Figure 1: The deep carbon cycle [Adapted from 4,5].

I. Shallow slab carbonation and decarbonation.

II. Deeper slab carbon release via fluid-induced decarbonation reactions in the subducting slab enriching upward moving fluids and melts in carbon (B,C).

III. Carbon moving into the deeper mantle, becoming a potential source for diamond formation.

- What causes decarbonation at shallow depth (I) and where carbon is transported is still poorly understood.

Deciphering the Mechanism of Carbon Release:
Linnajavri Field Observation

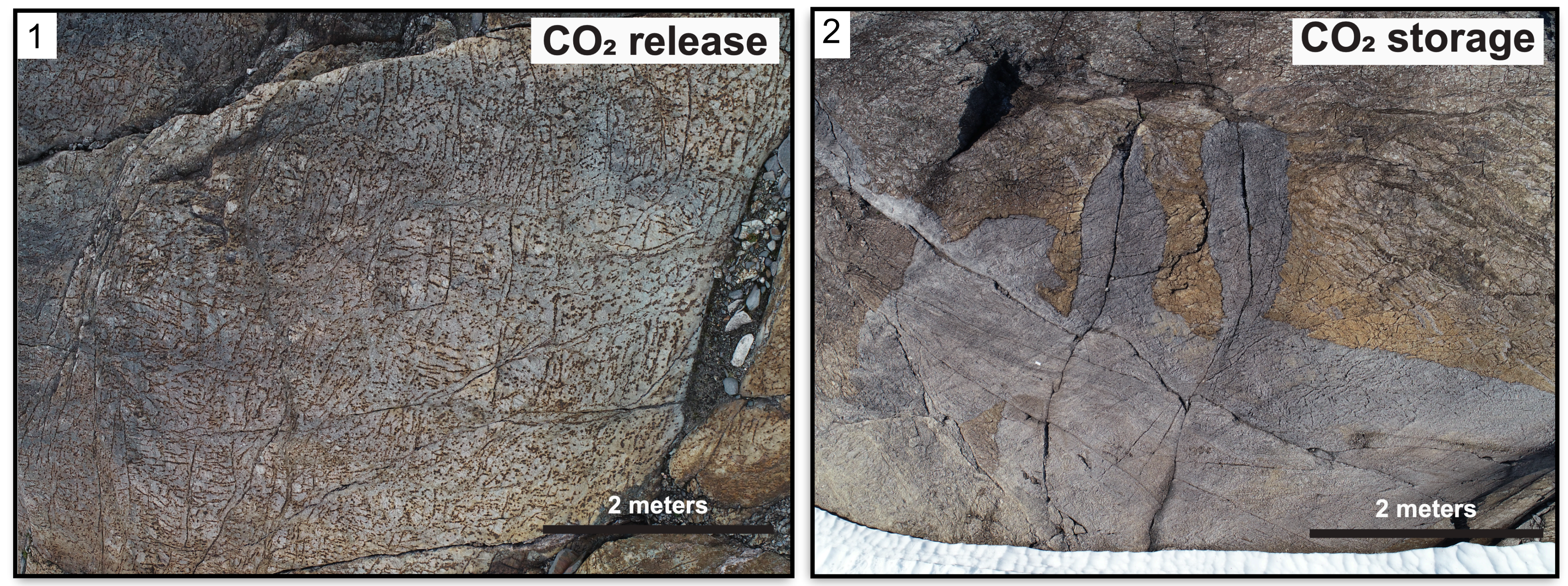

Figure 2: Carbonated serpentinite showing distinct alteration patterns.

- The outcrops studied show large-scale exposure of clearly defined reaction fronts allowing the conditions and geometry of fluid migration to be studied (locations indicated on Fig.1A).
- Evidence for decarbonation and carbonation can be found in close proximity (Fig.1A).
- Decarbonation at Linnajavri potentially occurred at P-T conditions significantly below carbon stability limit suggesting a higher carbon reactivity.
- The mobilisation of CO_2 generates a distinct decarbonation transport network (Fig.2.1).
- This study aims to provide new insight into the onset of decarbonation during subduction of oceanic lithosphere.

Summary

Carbon has a major influence on processes and conditions in the Earth's interior and at its surface.

The varying inventories of carbon in the near surface and mantle are still not fully constrained.

Carbon is transported between the Earth's surface and interior through the subduction of tectonic plates.

Devolatilization of subducting tectonic plates can lead to the release of significant amounts of carbon.

Reactive fluid flow can lead to mobilisation of volatiles. *The exact mechanisms involved, and condition required are, however, still not fully understood.*

Influence on the short- and long-term carbon cycle.

Free volatiles (e.g. C) can be transported along faults, fractures and grain boundaries back to the Earth's surface or into the deep mantle.

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