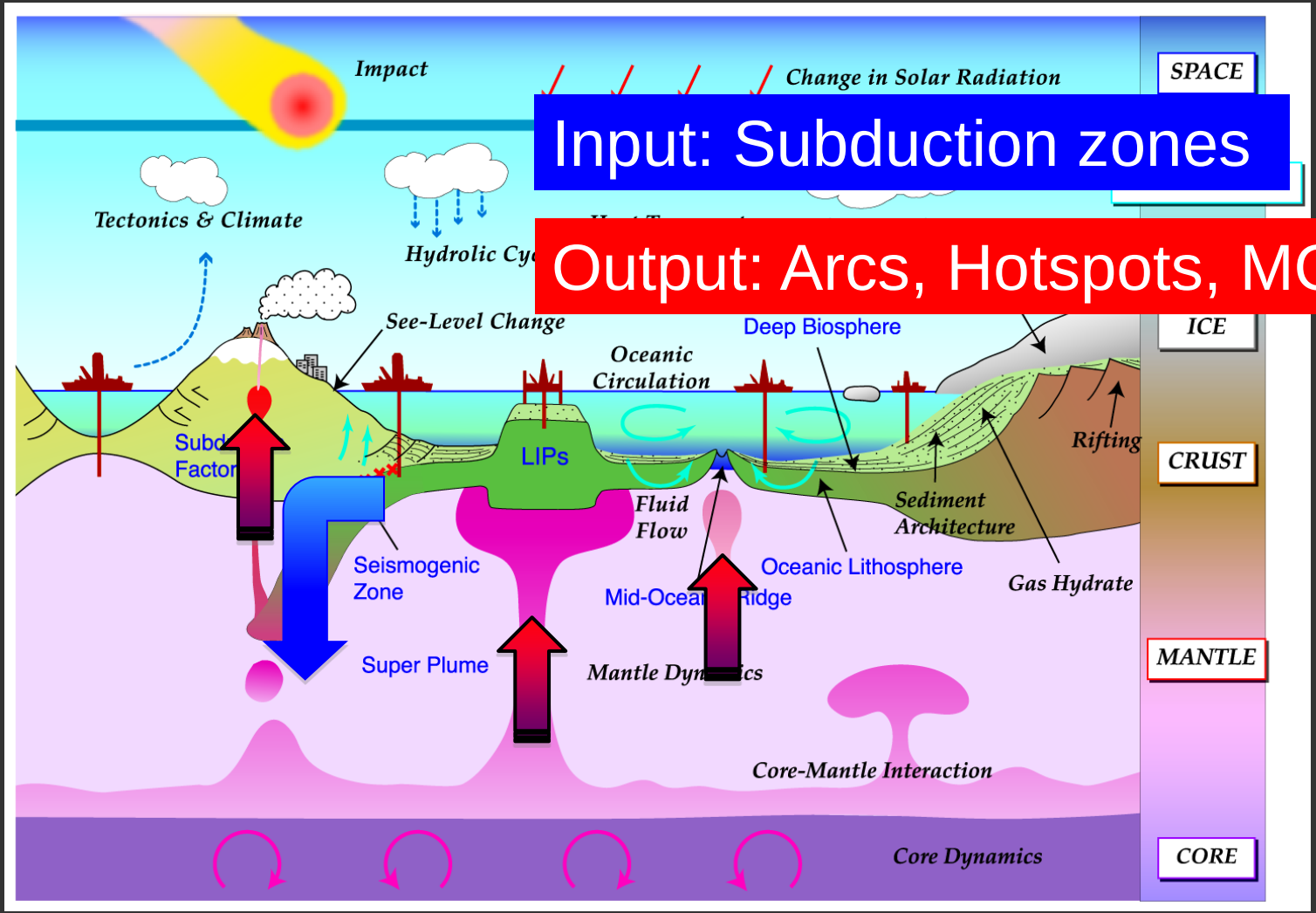
Mantle Dynamics and Geochemical Cycle:
What can Ocean Drilling contribute?

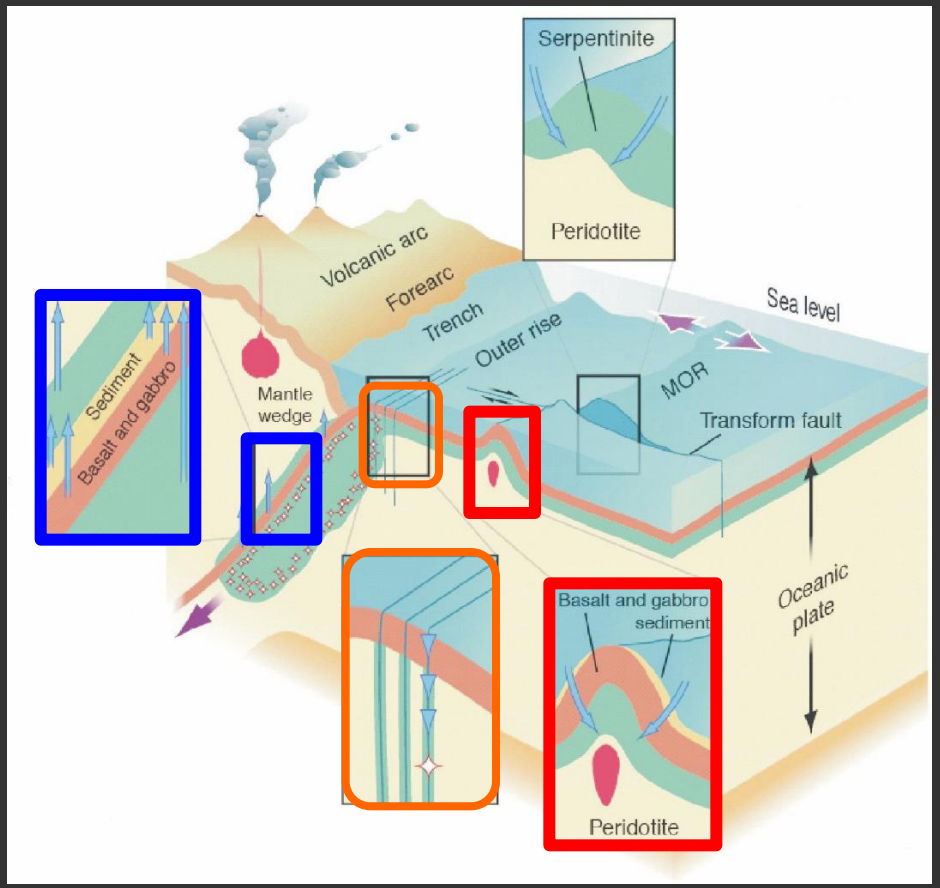
- *Geochemical Cycle: input and output*
- *Subduction Factory*
- *Carbon Transfer at Deep Mantle*
- *Diamond in Oceanic Mantle?*
- *Carbon/Water Cycle and Ocean Drilling*

Y. Tatsumi (IFREE/JAMSTEC)

Geochemical Cycle in the Earth's Interior



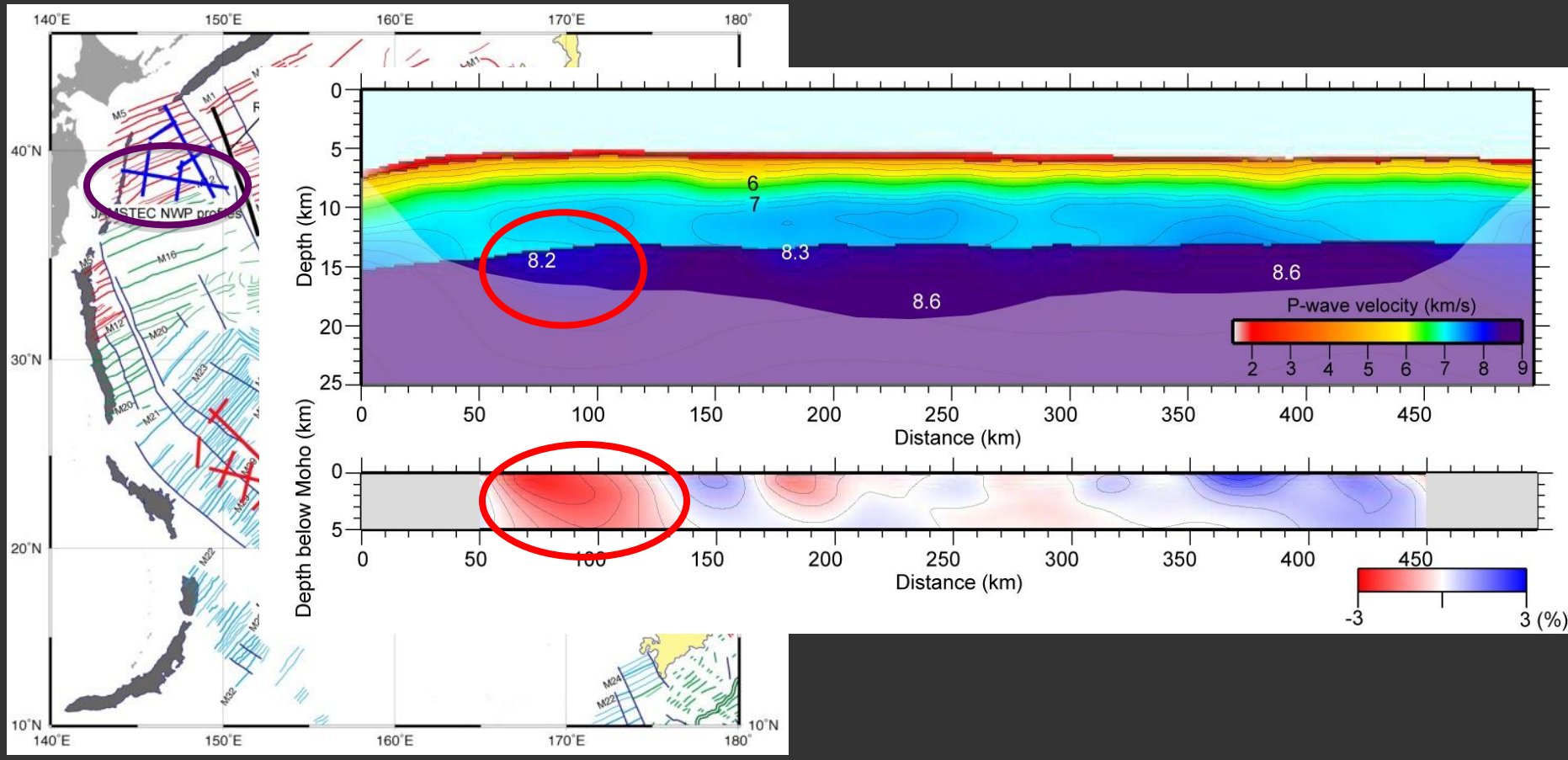
H_2O Cycle in Subduction Zone



- ✧ Hydration at MOR
- ✧ Dehydration at SZ
  - → Earthquakes
  - → Magmatism

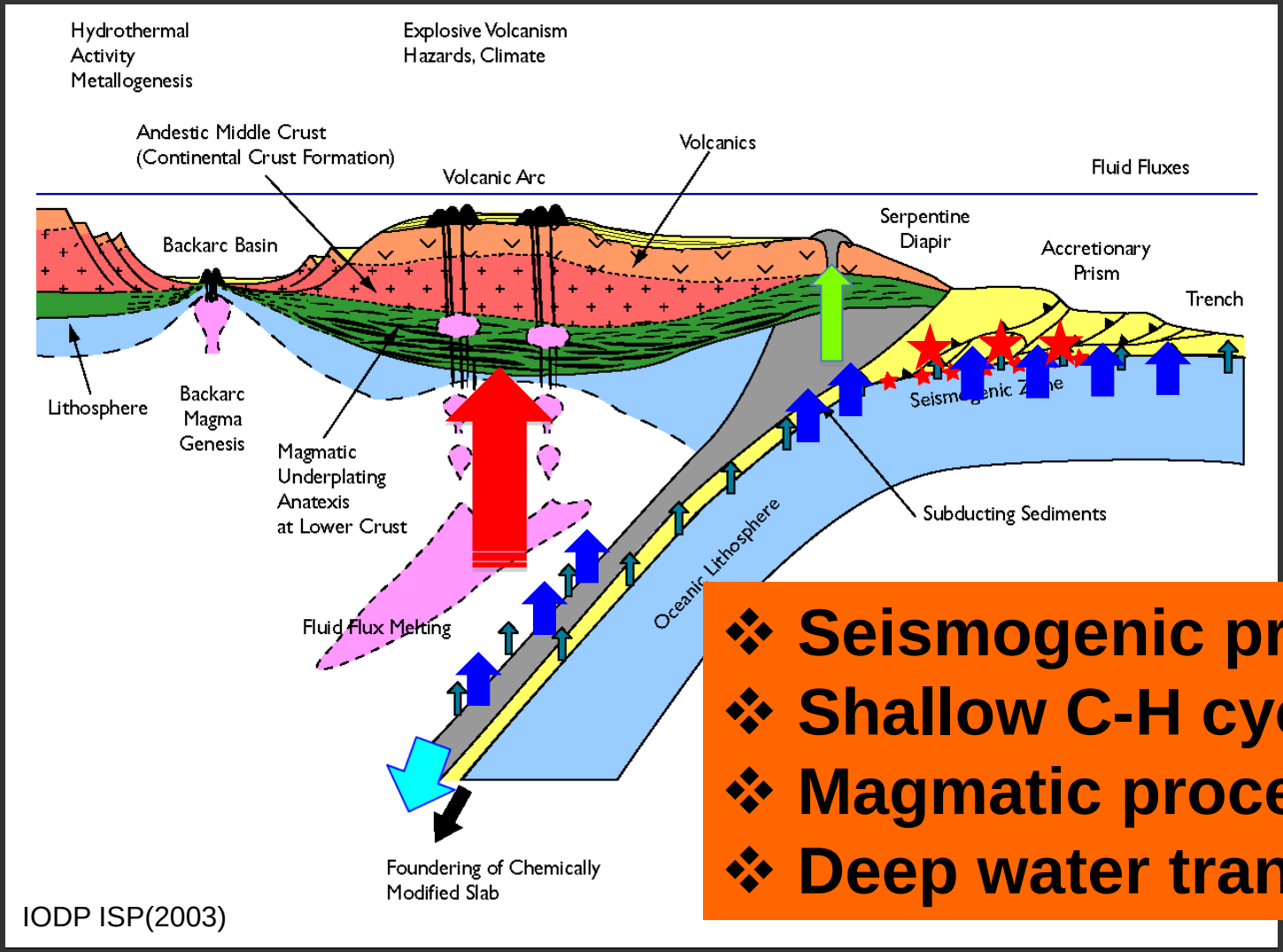
- ✧ Massive Hydration at 'Outer Rise', plate bending region immediately before its subduction

Low-V Uppermost Mantle at Outer Rise



Massive hydration under tensional regime?

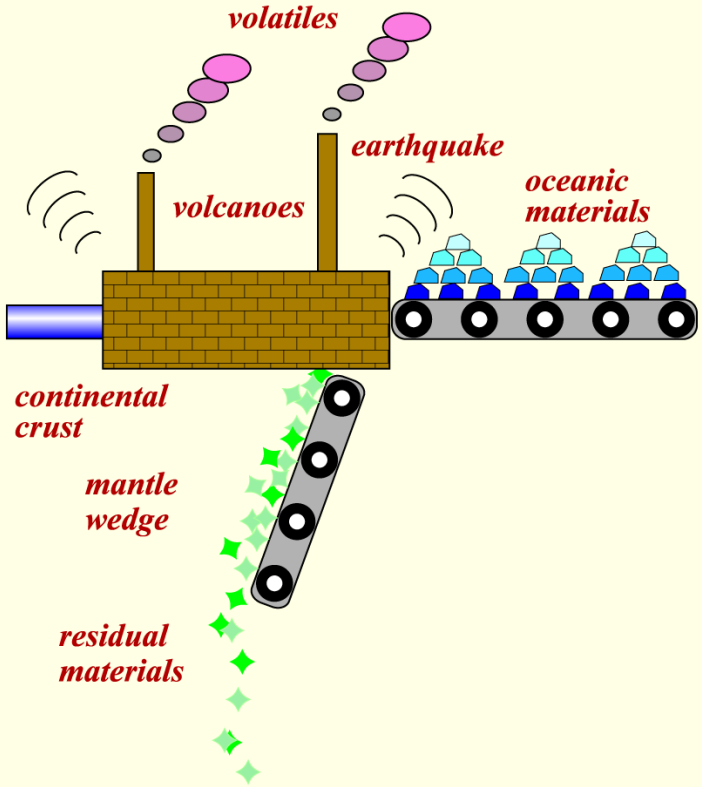
Effect of massive H_2O supply



IODP ISP(2003)

- Seismogenic processe
- Shallow C-H cycles
- Magmatic processes
- Deep water transfer

Subduction Factory



Raw materials

- Oceanic material:
  sediments + MORB
- Mantle wedge material

Products

- Magma/Volcanoes
- Volatiles
- Continental crust

Wastes

- Chemically modified sediment
- Chemically modified/fresh MORB
- Anti-continent

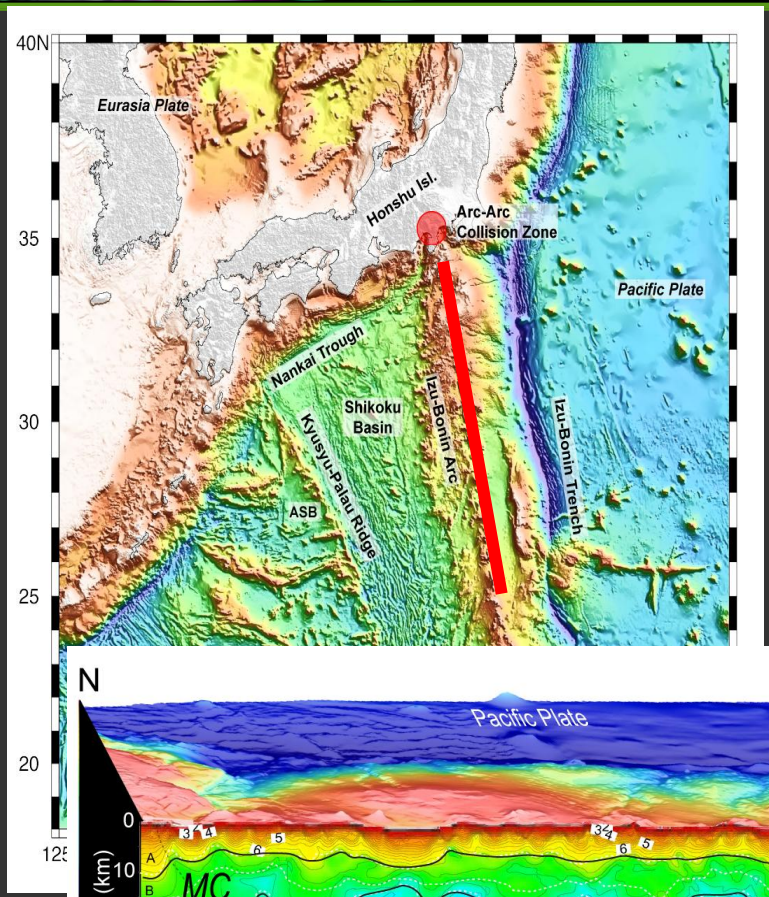
Continental Crust: a product of SubFac

Continental Crust:

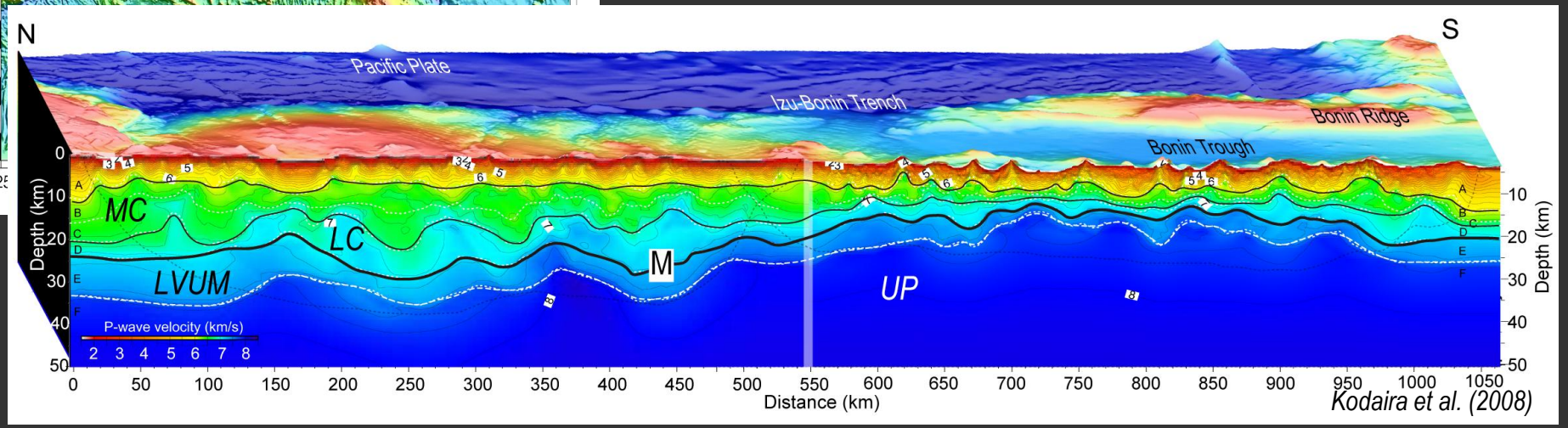
- occupies **less than 1%** of the total mass of the solid Earth
- is a characteristic reservoir of **light elements**
- should provide the key to decoding the Earth evolution
- shows an **intermediate, andesitic** average composition
- could thus have been created at **subduction zones**

However, arc primary magma is generally basaltic, not andesitic!!

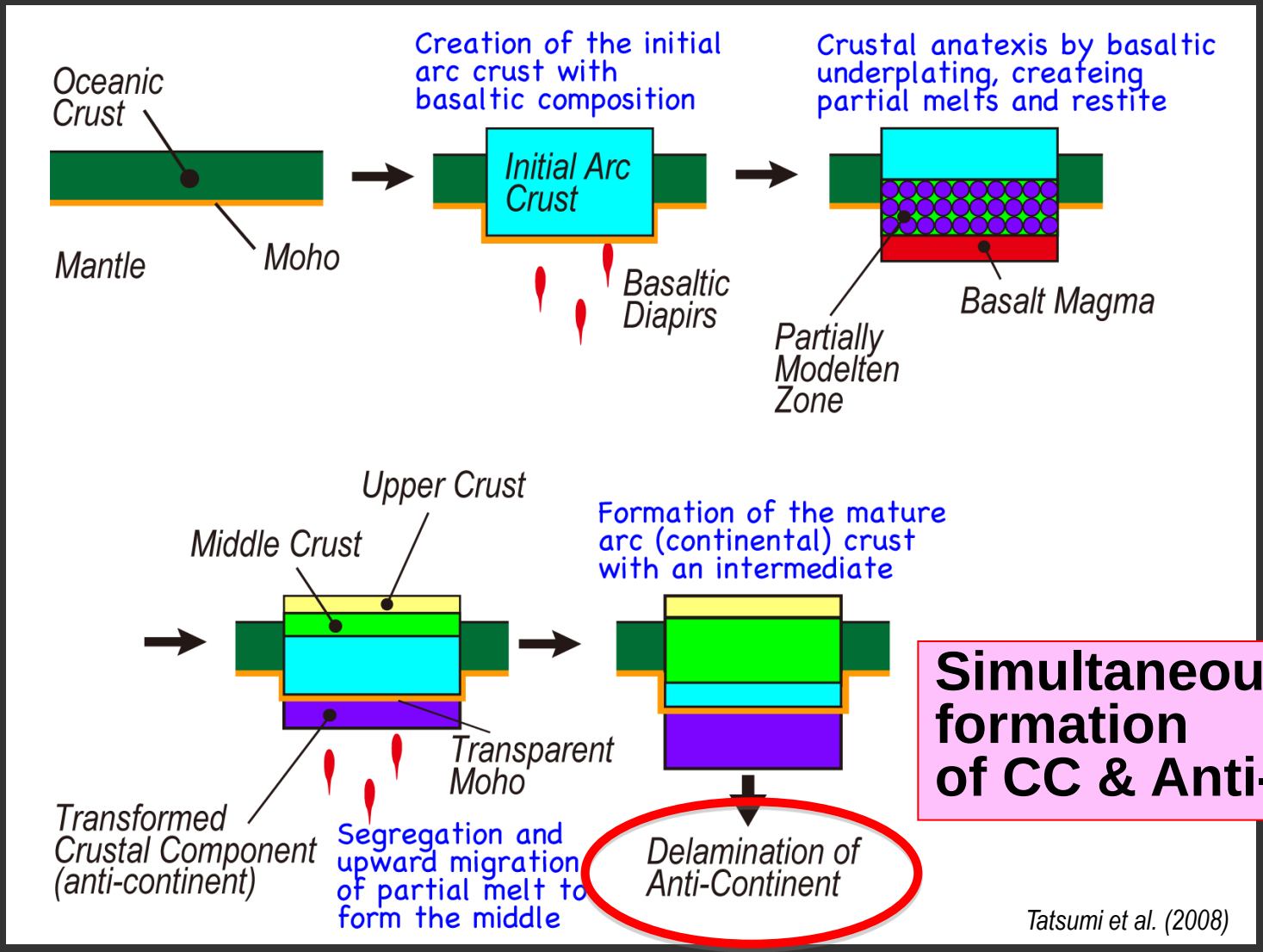
Oceanic Arc: a site of CC formation?



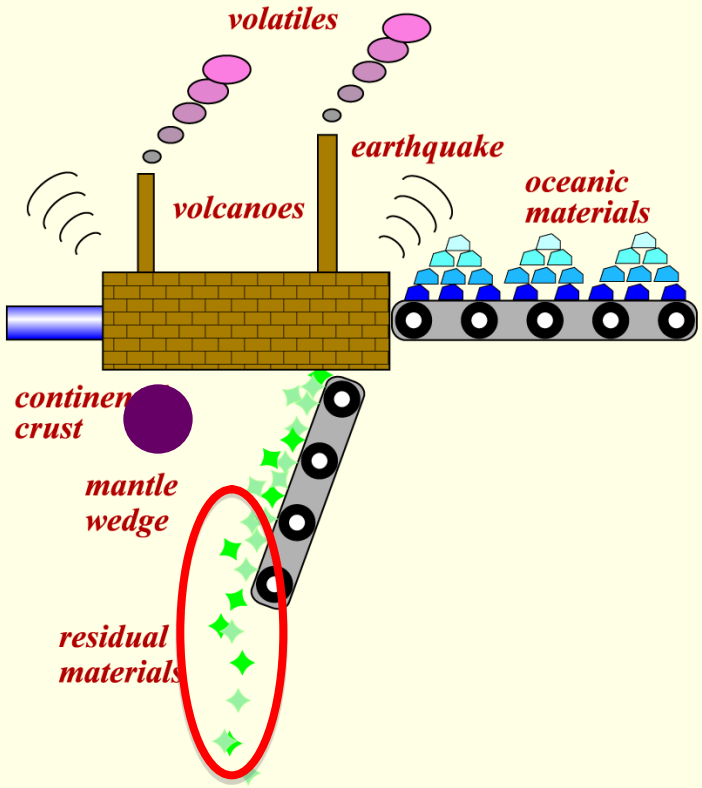
- ✓ Created on the oceanic crust with no contribution of the pre-existing continental crust
- ✓ General distribution of the middle crust with 6.0-6.5 km/s *Vp*
- ✓ *Vp* identical to average *Vp* of CC



Arc Crust Evolution & CC-ACC Formation



SubFac Wastes

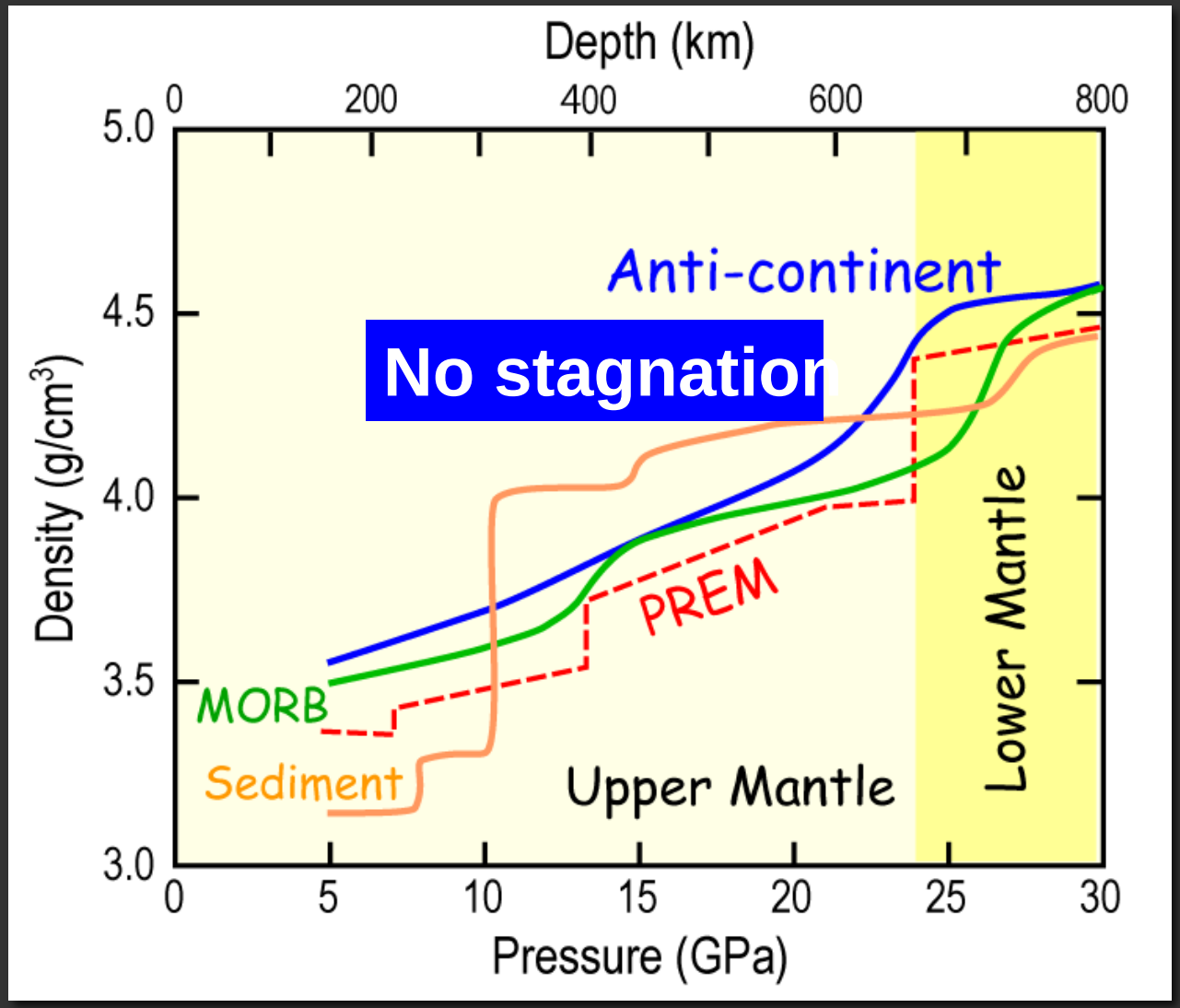


Dehydrated, chemically modified

- ✧ **oceanic crust**
- ✧ **sediments**
- ✧ **anti-continent**

Fate of SubFac wastes?

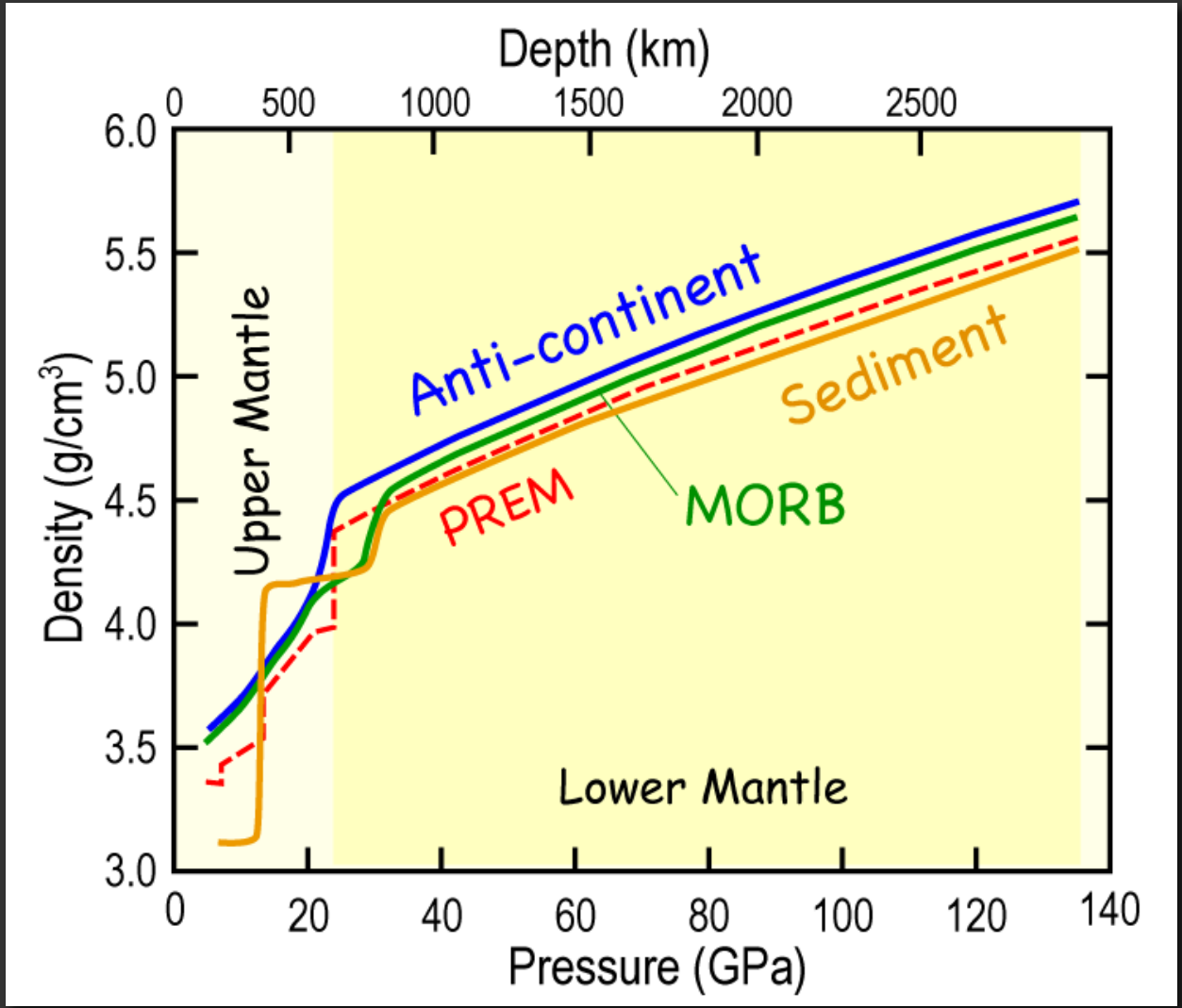
Fate of SubFac Wastes



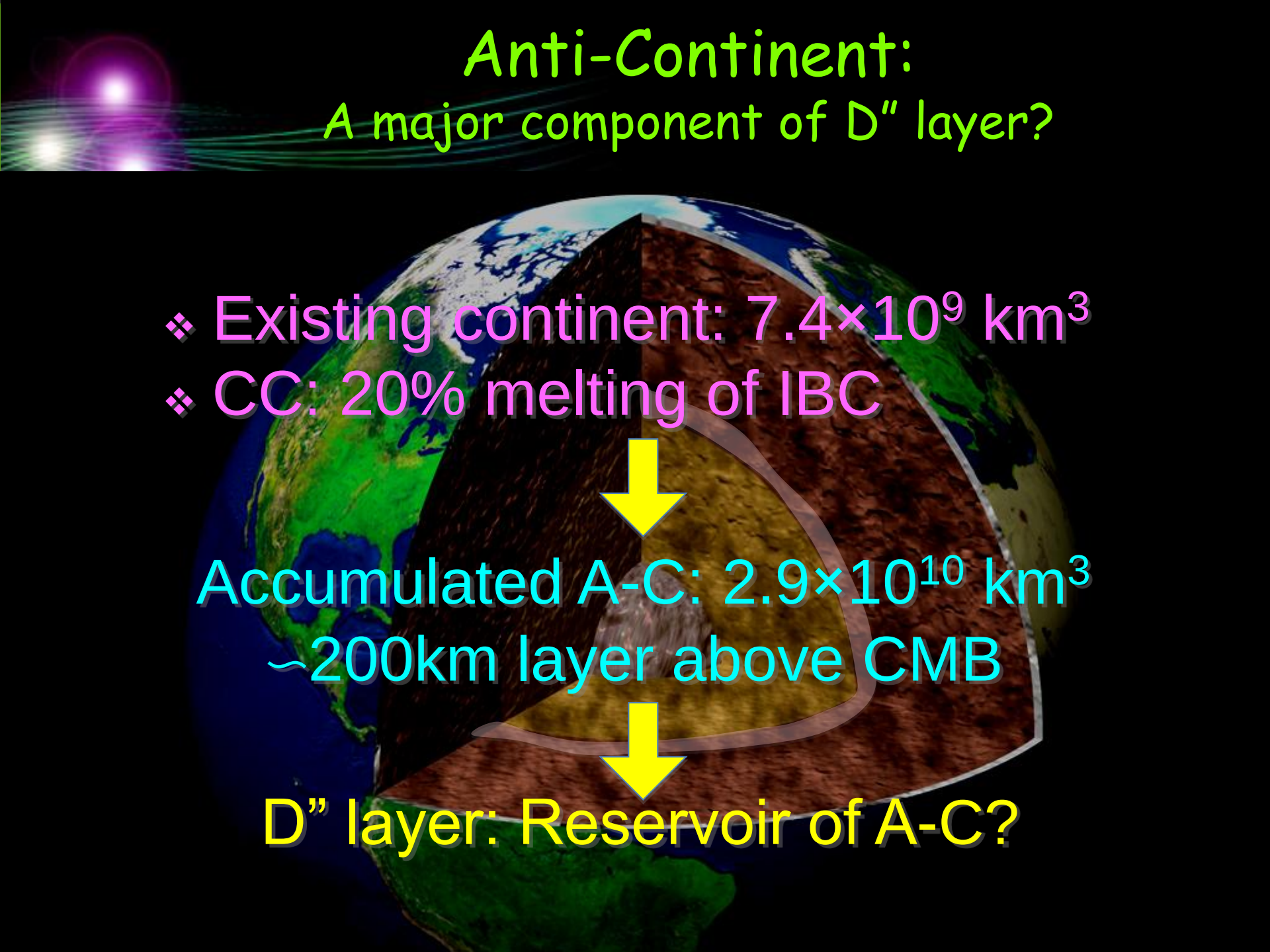
Stagnant Slab

Fate of SubFac Wastes

Accumulation of A-C at the base of the mantle



Anti-Continent:
A major component of D" layer?



- Existing continent: 7.4×10^{9} km^3
- CC: 20% melting of IBC

↓

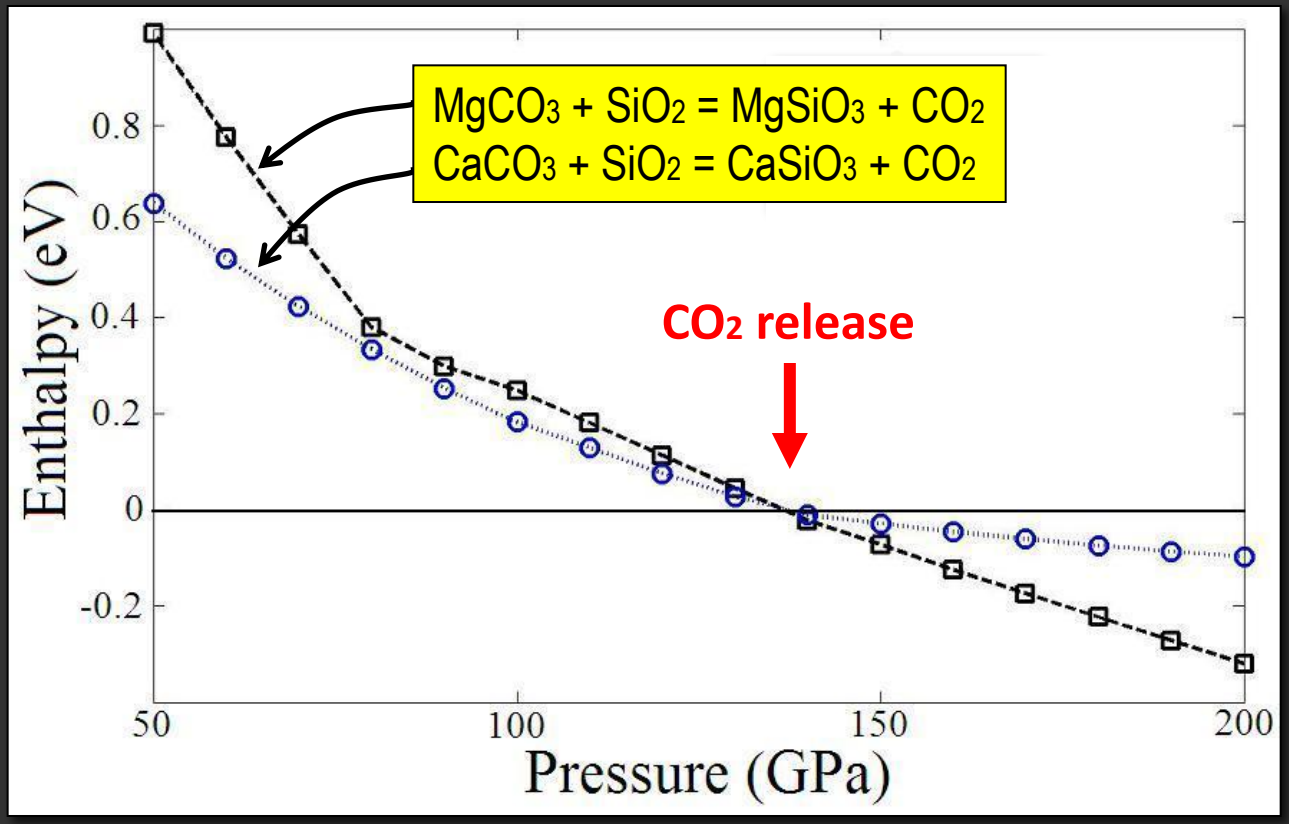
Accumulated A-C: 2.9×10^{10} km^3

≈200km layer above CMB

↓

D" layer: Reservoir of A-C?

Stability of Carbonates in SubFac Wastes: Sediments ± MORB

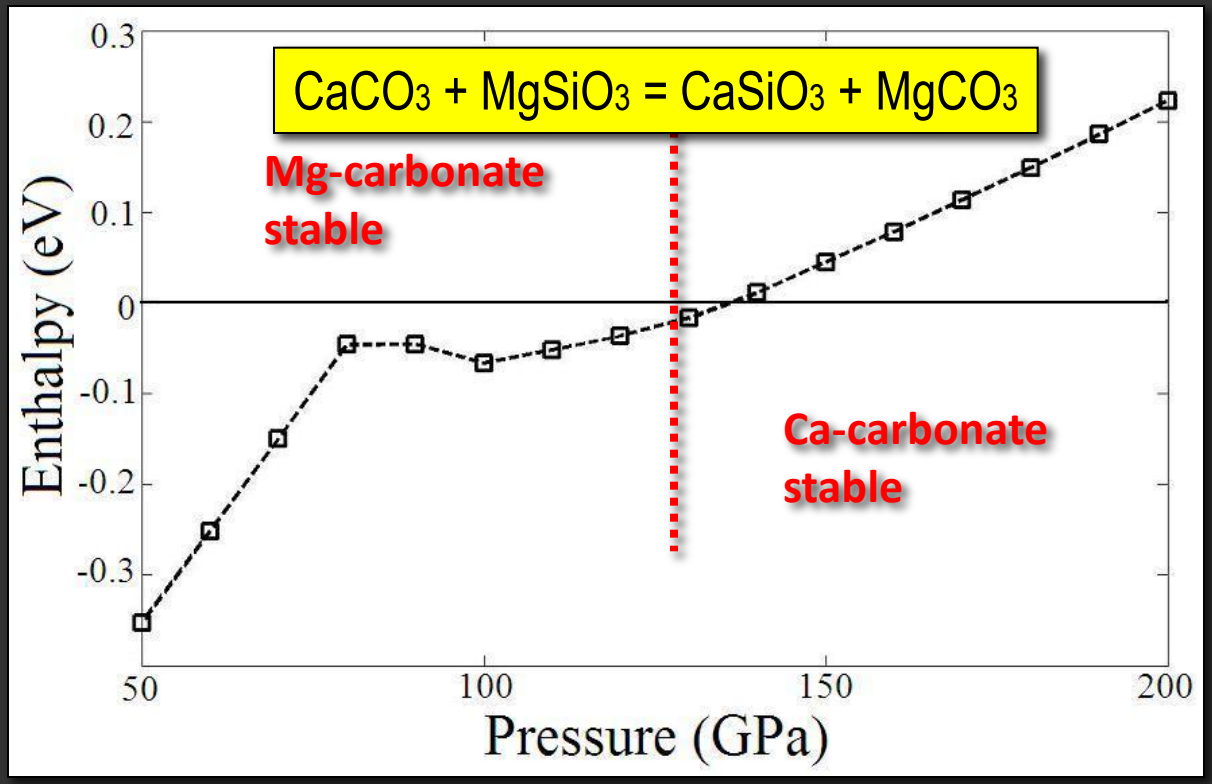


Oganov, Ono et al. (2008)

Carbonates + SiO_2 in Sed/MORB is stable in the whole mantle

Possible CO_2 release at the base of mantle

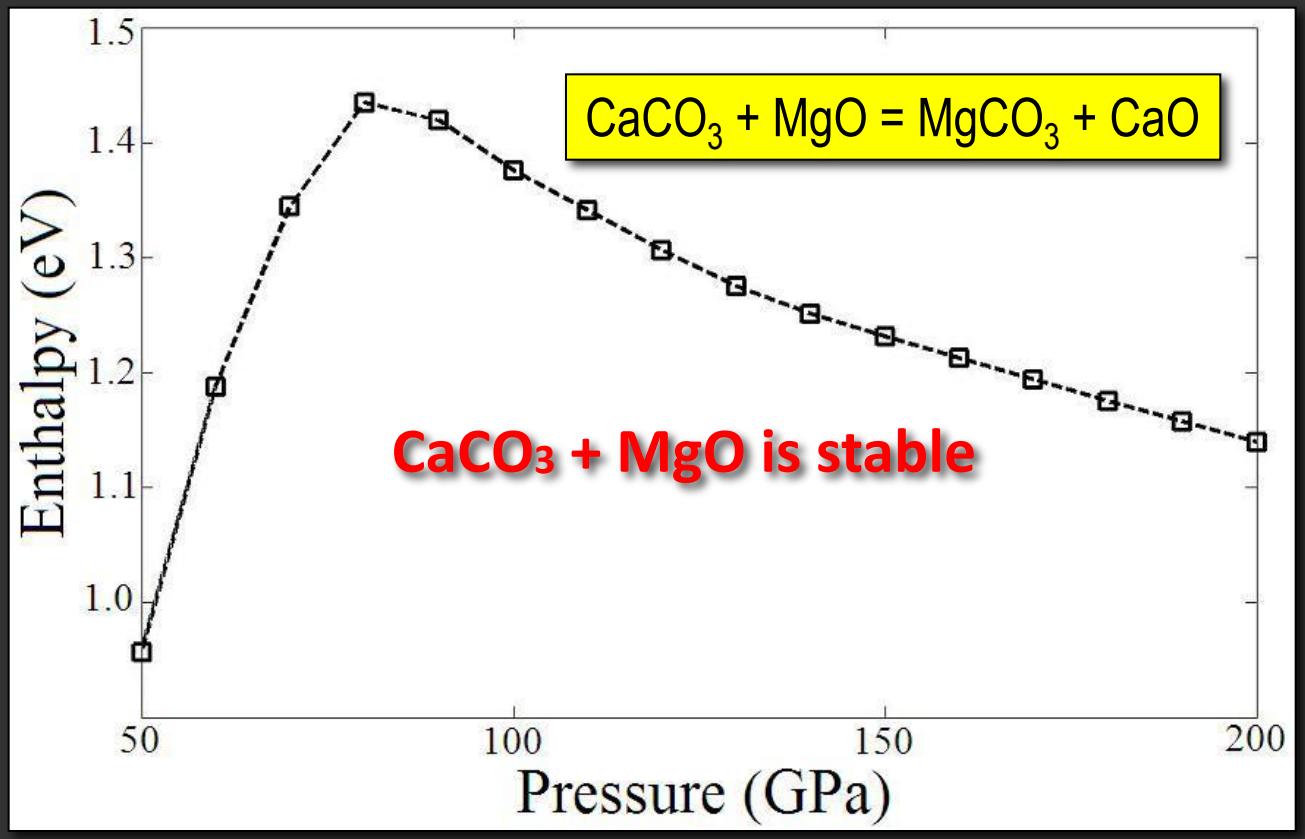
Stability of Carbonates in SubFac Wastes: Anti-continent, peridotites ± MORB



Oganov, Ono et al. (2008)

Mg-carbonate is more stable than Ca-carbonate

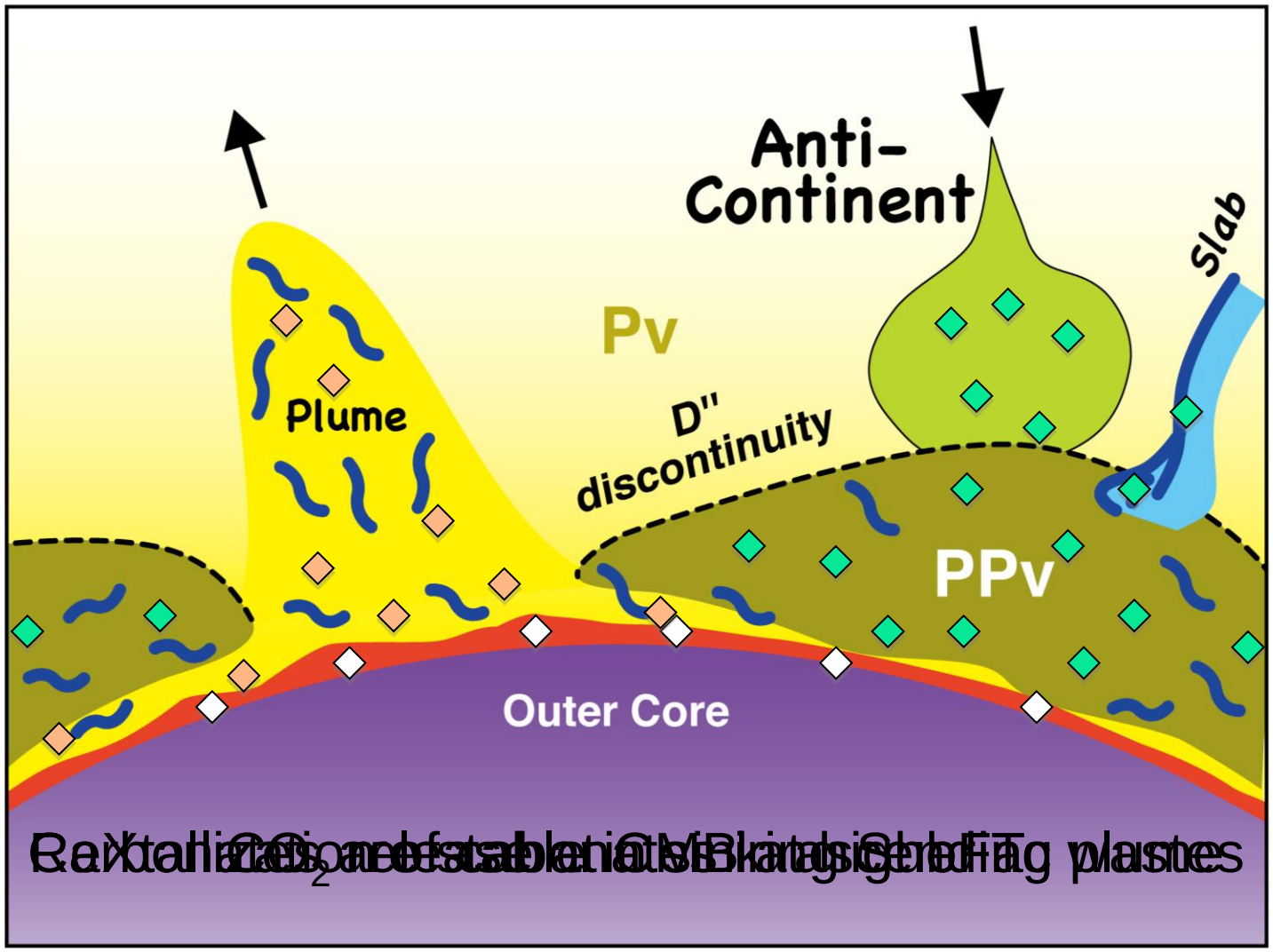
Stability of Carbonates in SubFac Wastes: Peridotites



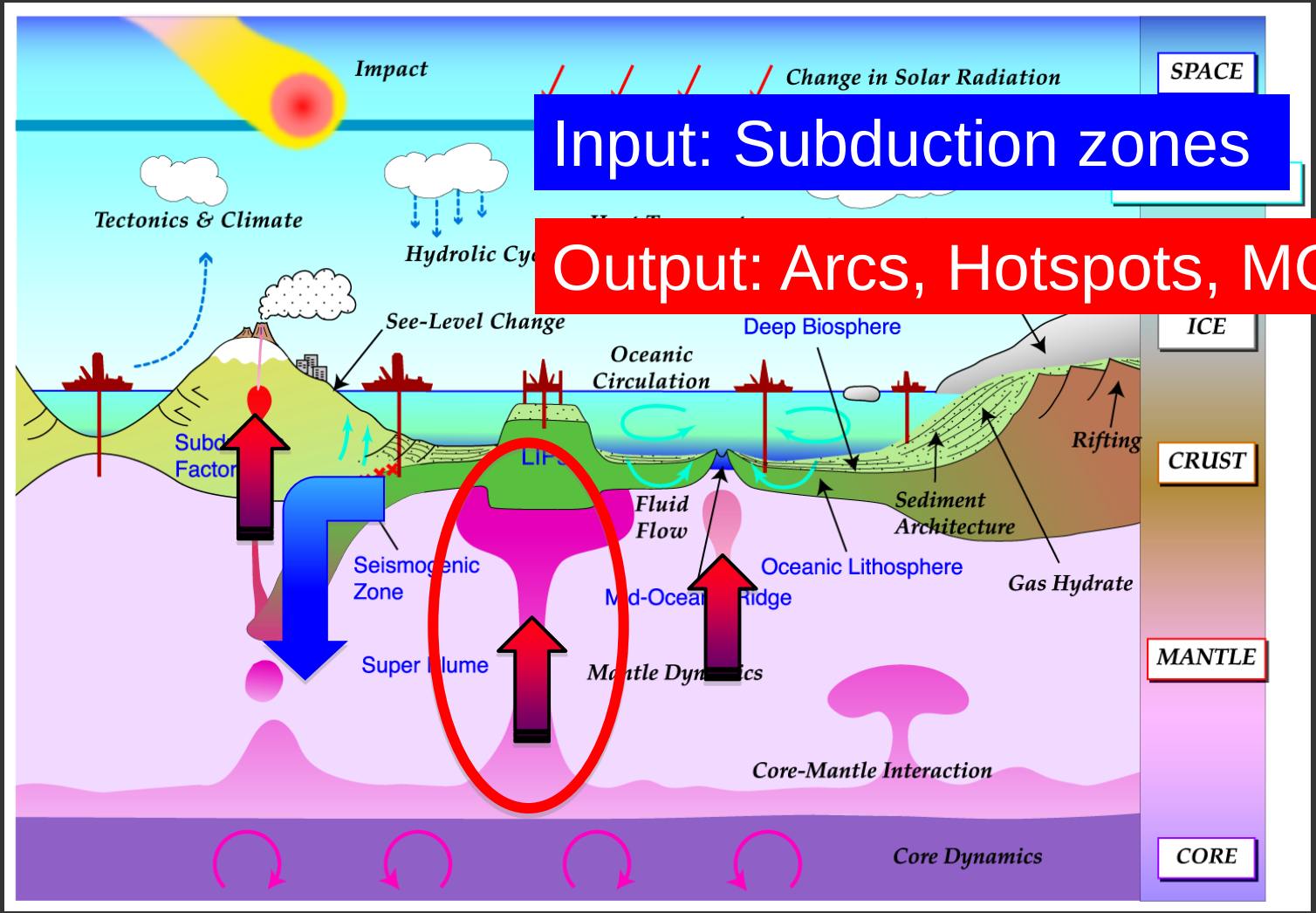
Oganov, Ono et al. (2008)

Carbonates are stable in the whole mantle along goetherm but unstable and release CO_2 at higher T, i.e., close to CMB.

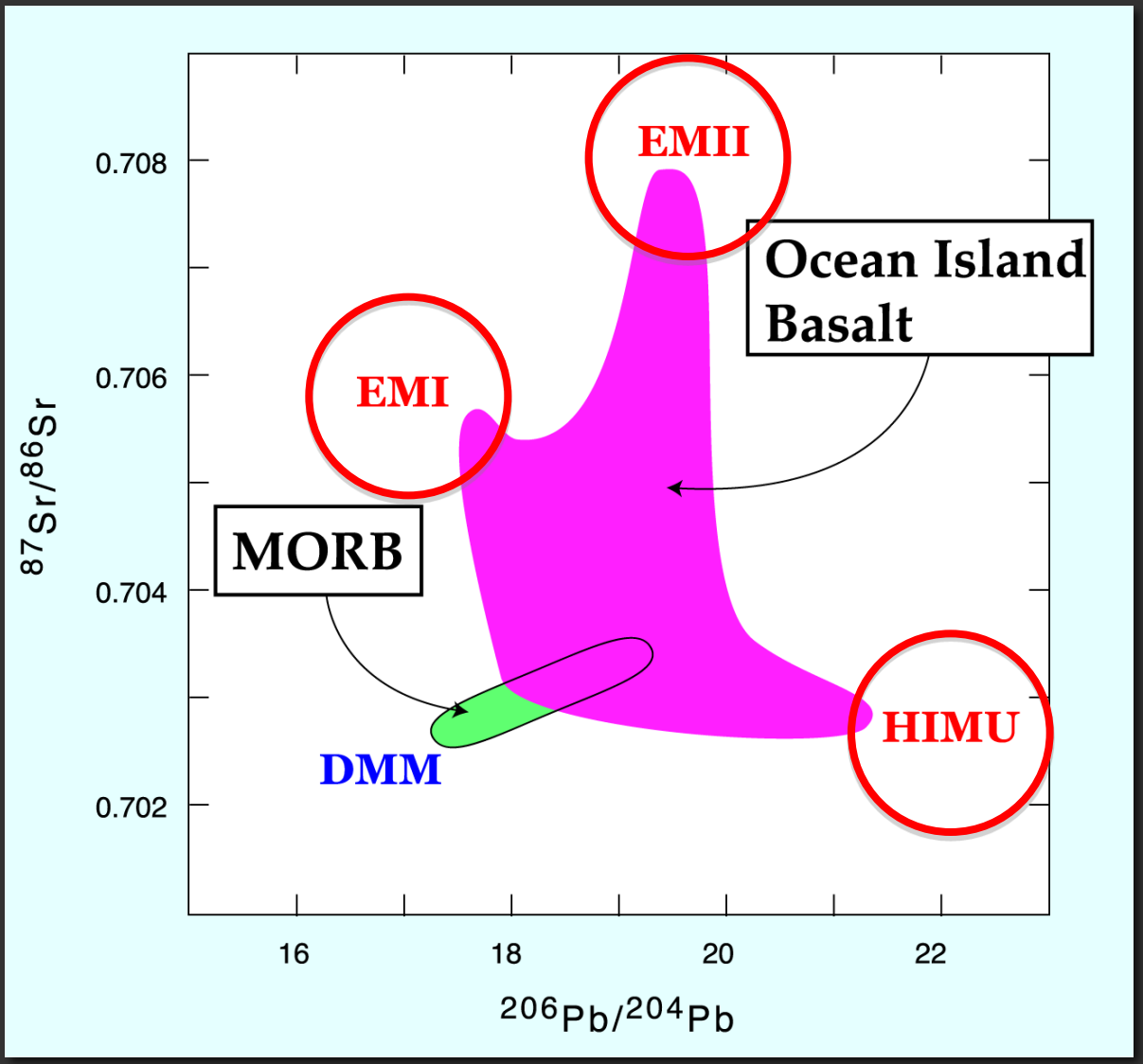
Carbon Transfer at CMB



Geochemical Cycle in the Earth's Interior



Mantle Geochemical Reservoirs

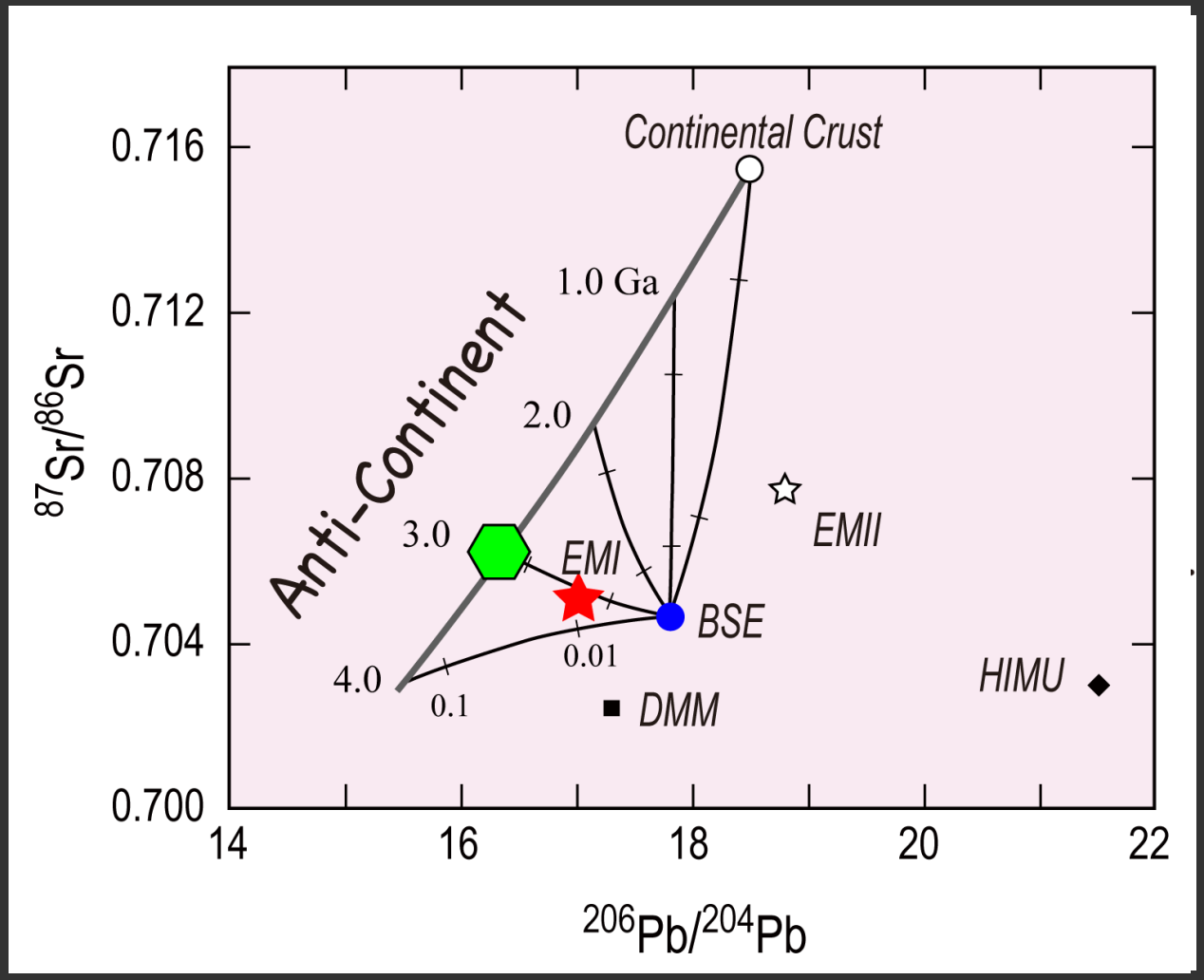


3 enriched reservoirs in the deep mantle

vs.

3 wastes from SubFac

Isotopic Evolution of SubFac Wastes



Dehydrated Sediments

↓

EMII

Dehydrated Oceanic Crust

↓

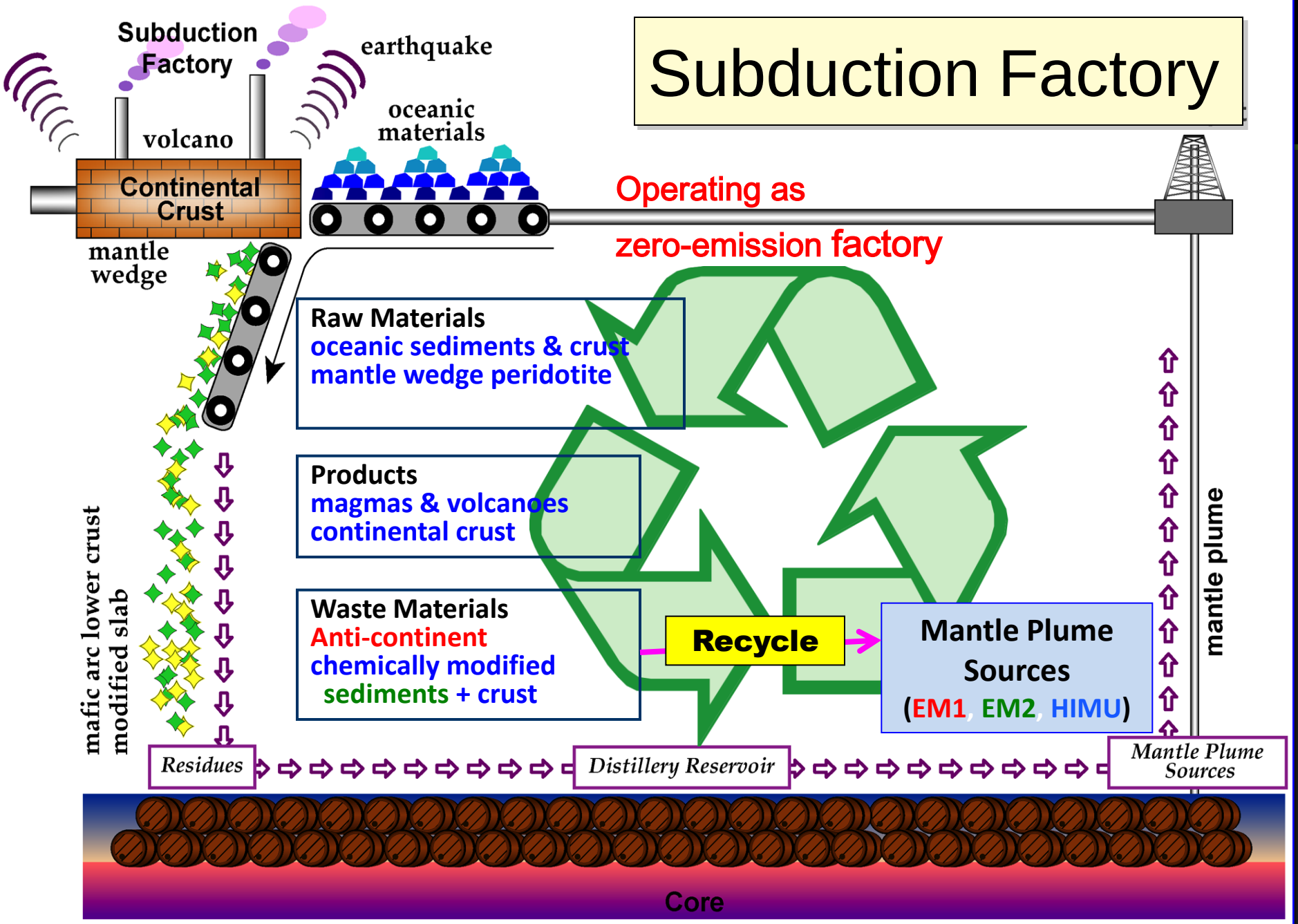
HIMU

Anti-Continent

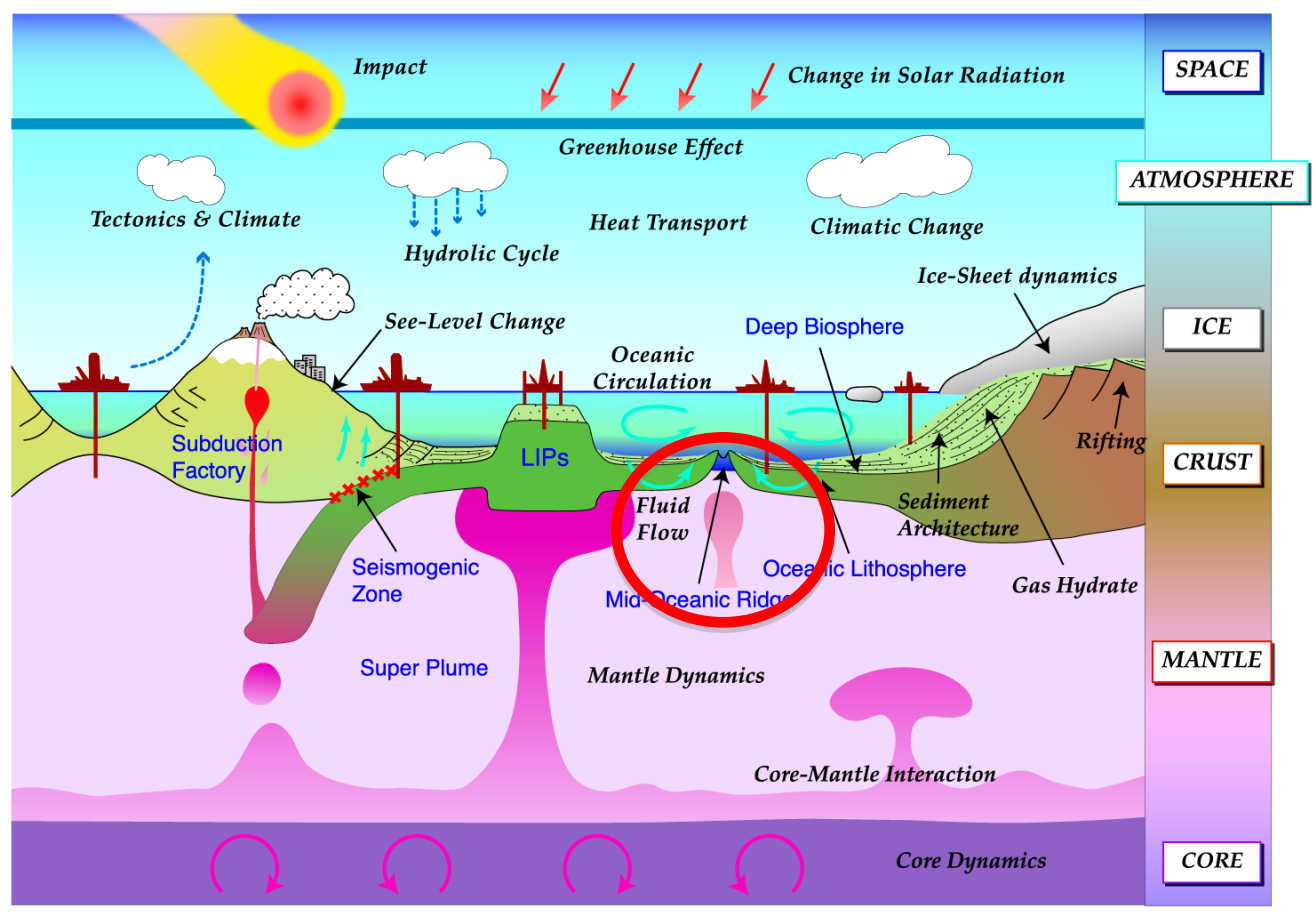
↓

EMI

Subduction Factory

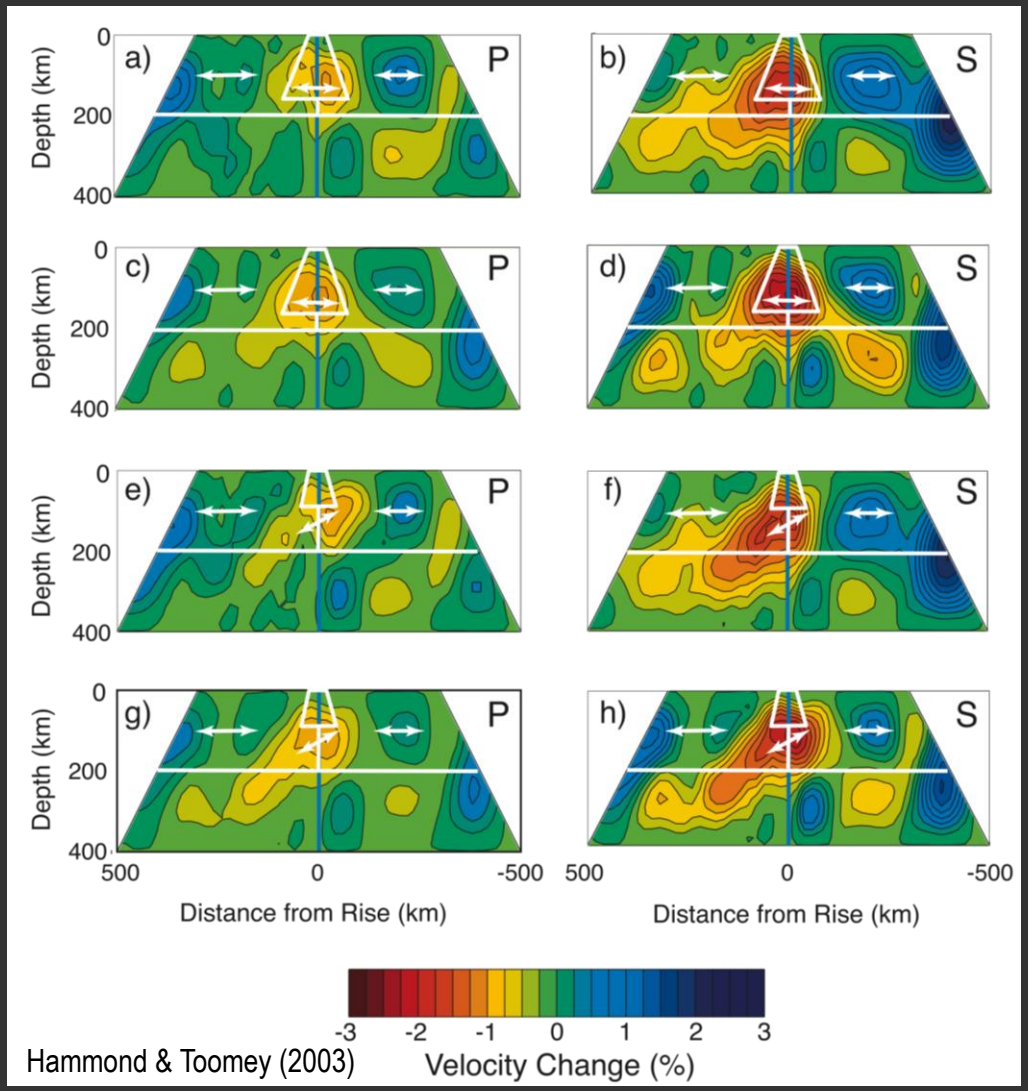


Oceanic Crust and its Source



Shallow mantle origin of OC via passive mantle upwelling

Shallow upwelling beneath MOR



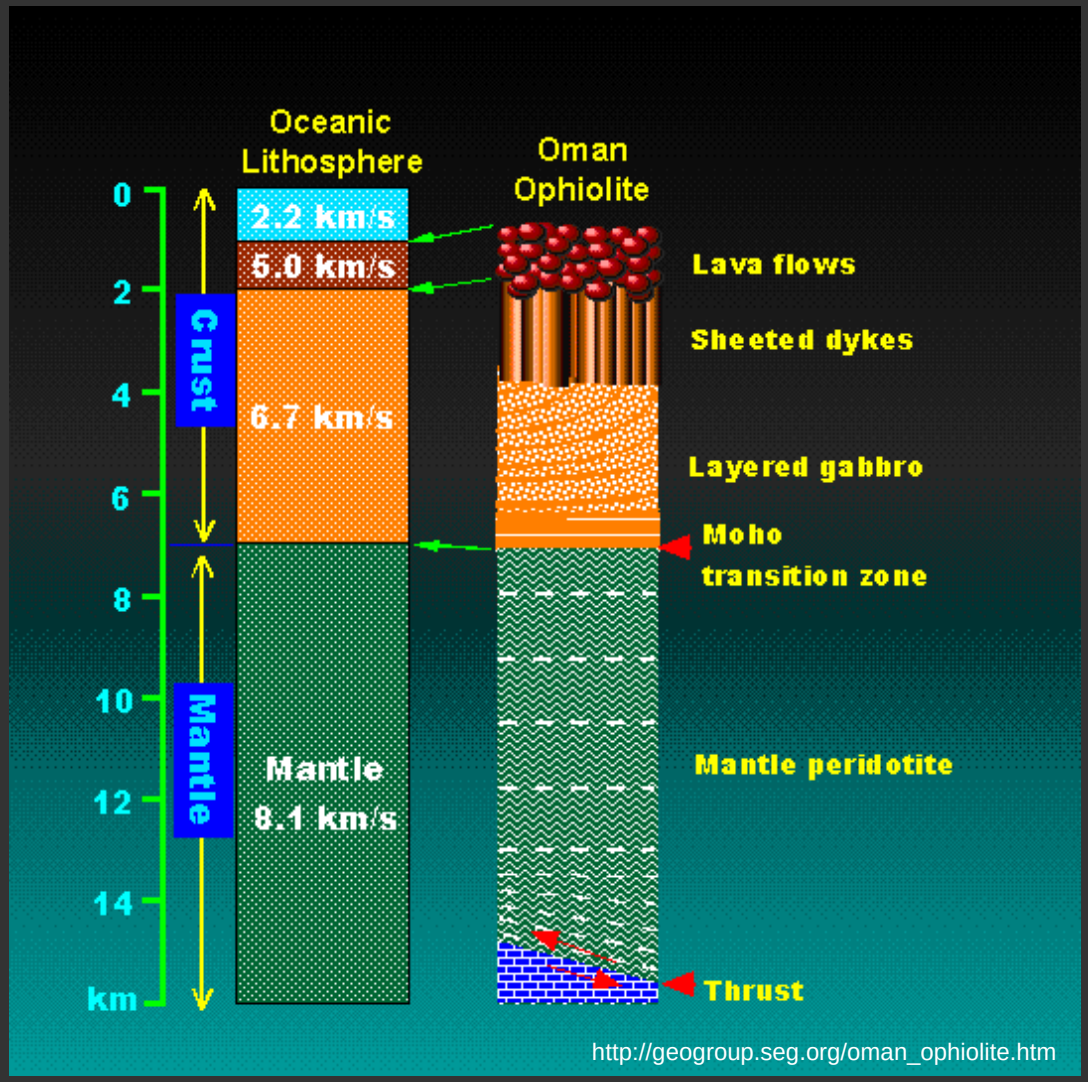
Hammond & Toomey (2003)

Plate divergence

↓

Passive upwelling of asthenospheric mantle

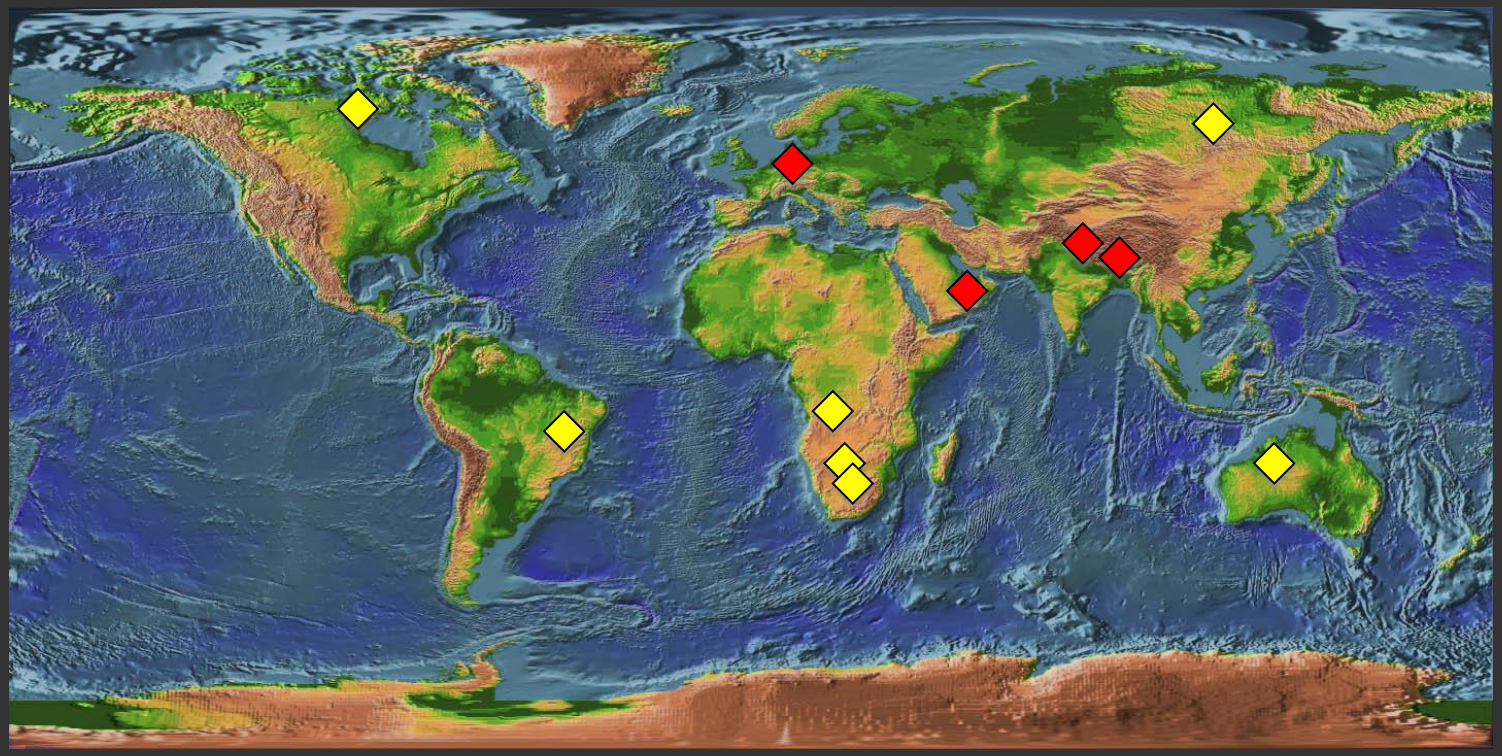
Ophiolite: obducted oceanic crust



- Lithologies similar to an inferred oceanic crust
- 'Fossil' crust/mantle of the ocean floor

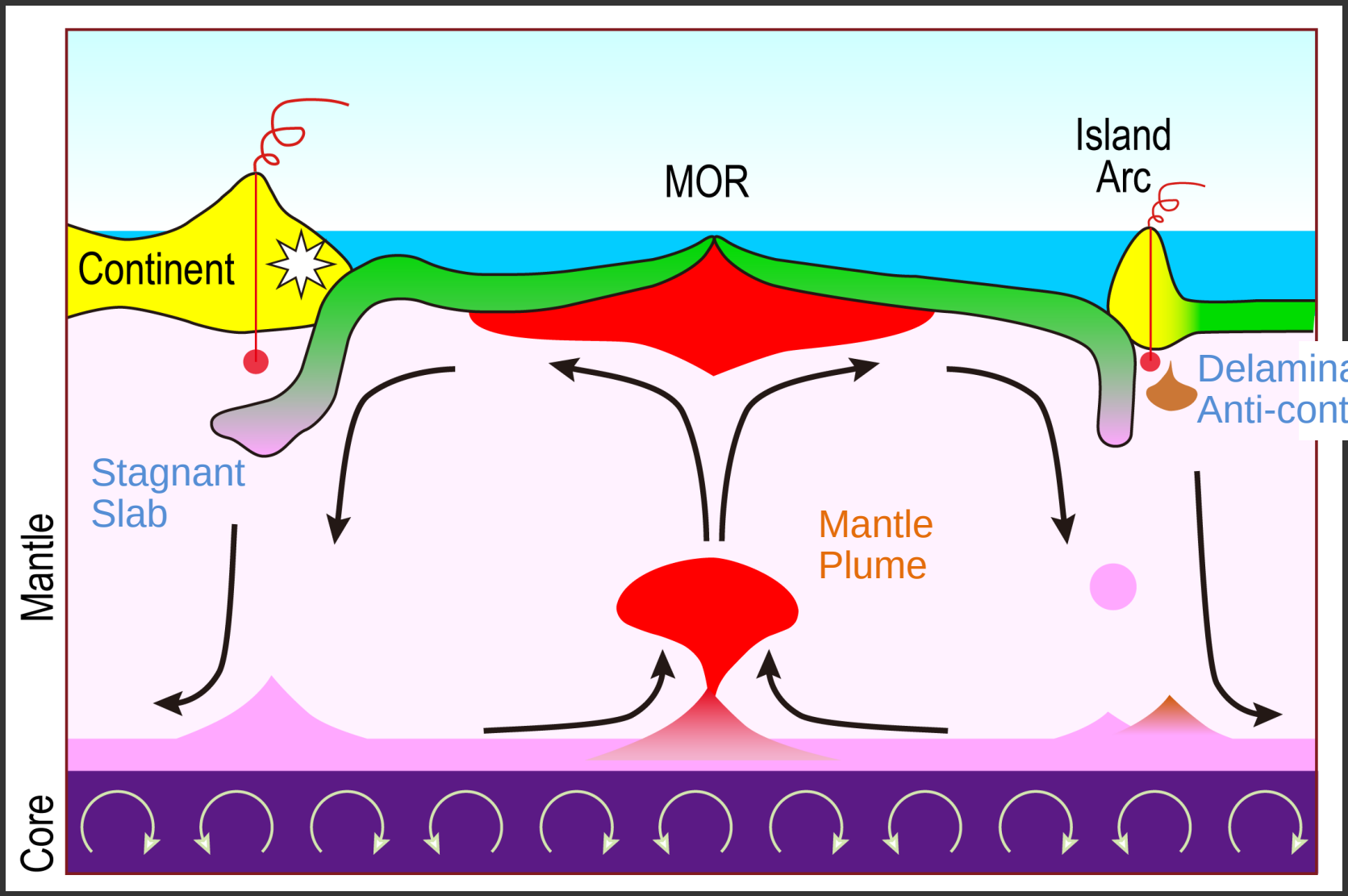
Diamond from Ophiolites

Diamonds: high-P carbon found
exclusively from kimberlites in continents

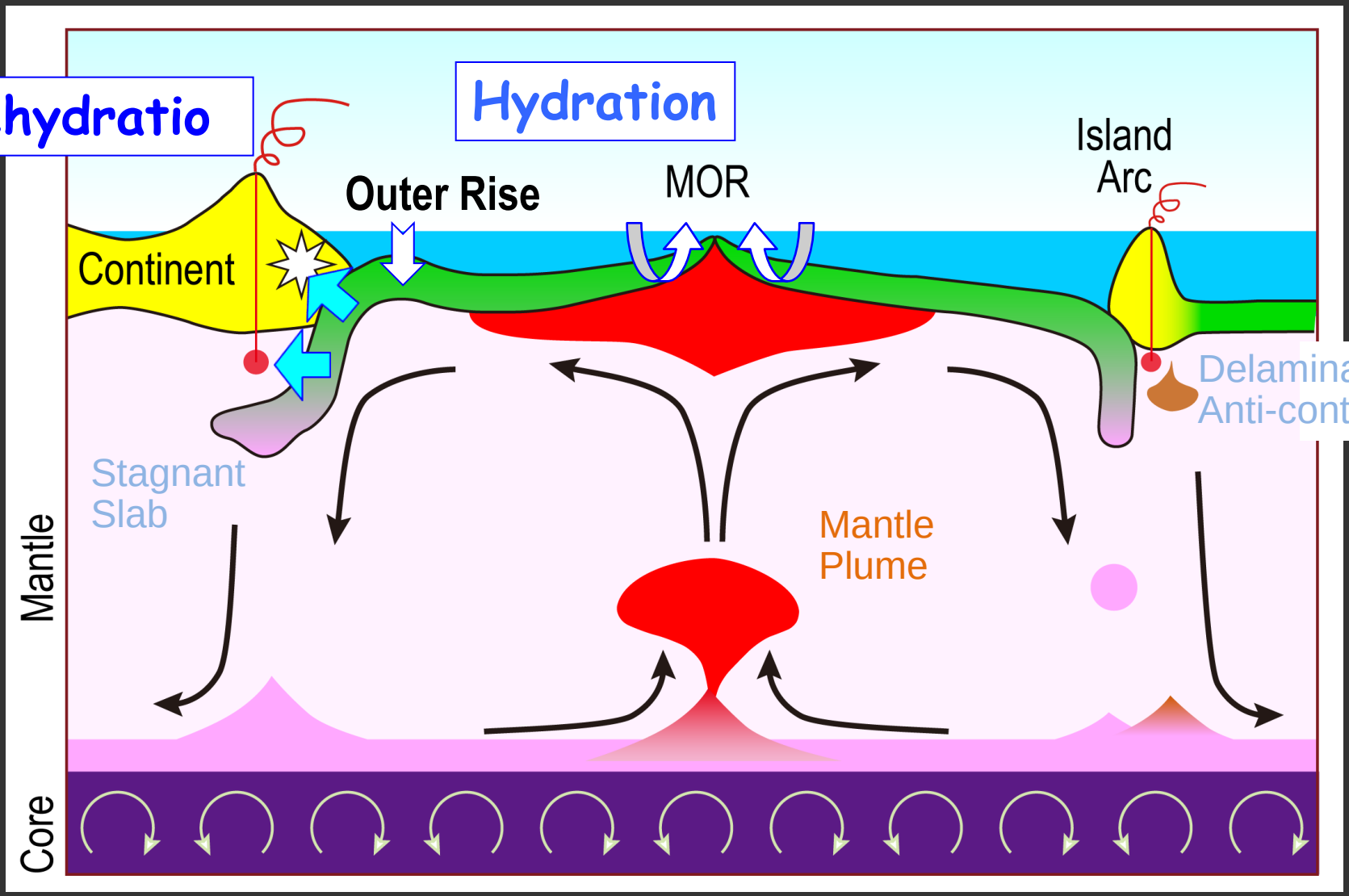


Diamond & high-P C-bearing minerals from ophiolites
→ Deep Mantle Origin for Oceanic Mantle??

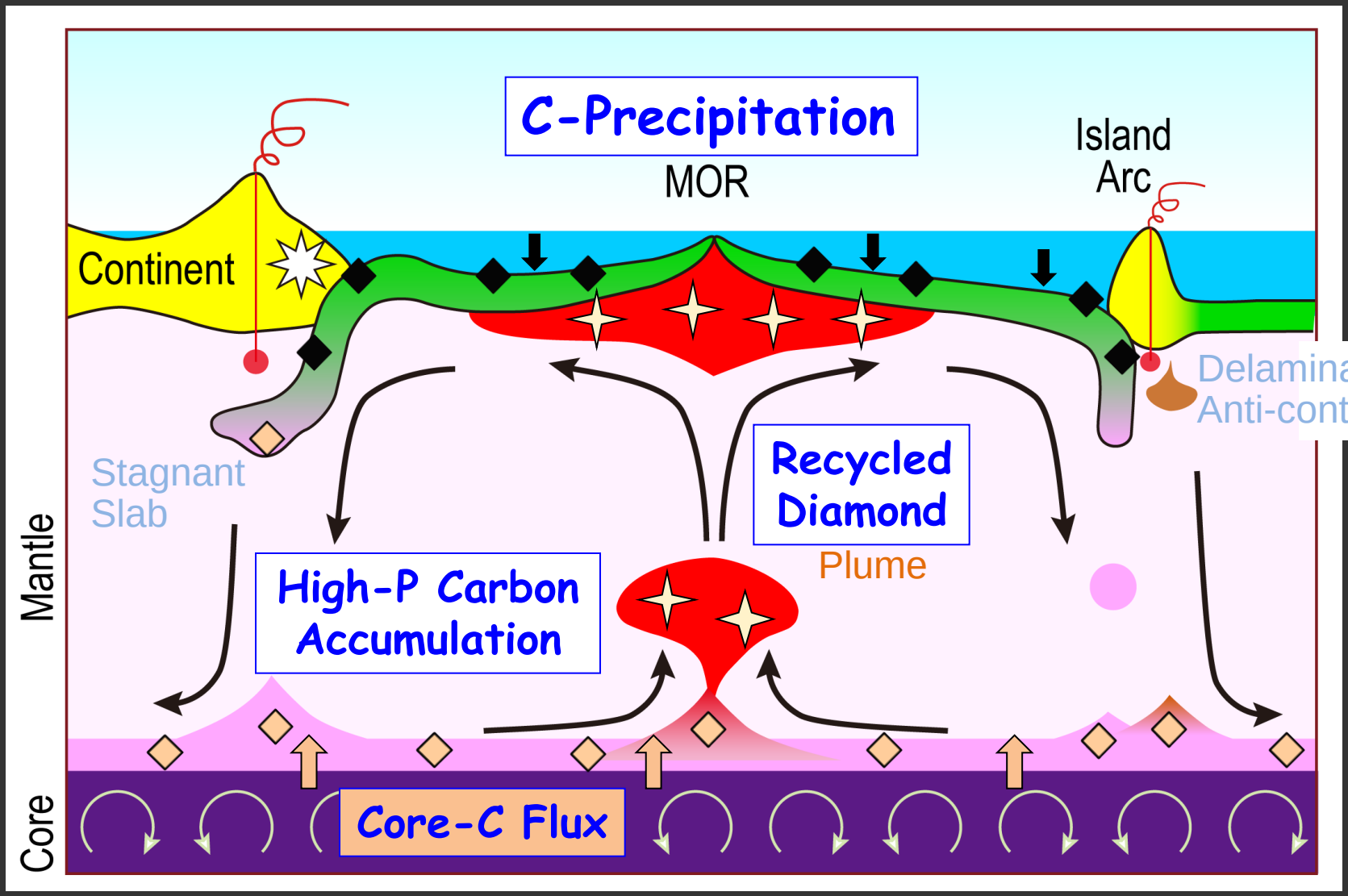
Scientific Ocean Drilling
Towards Comprehending C-H Cycle



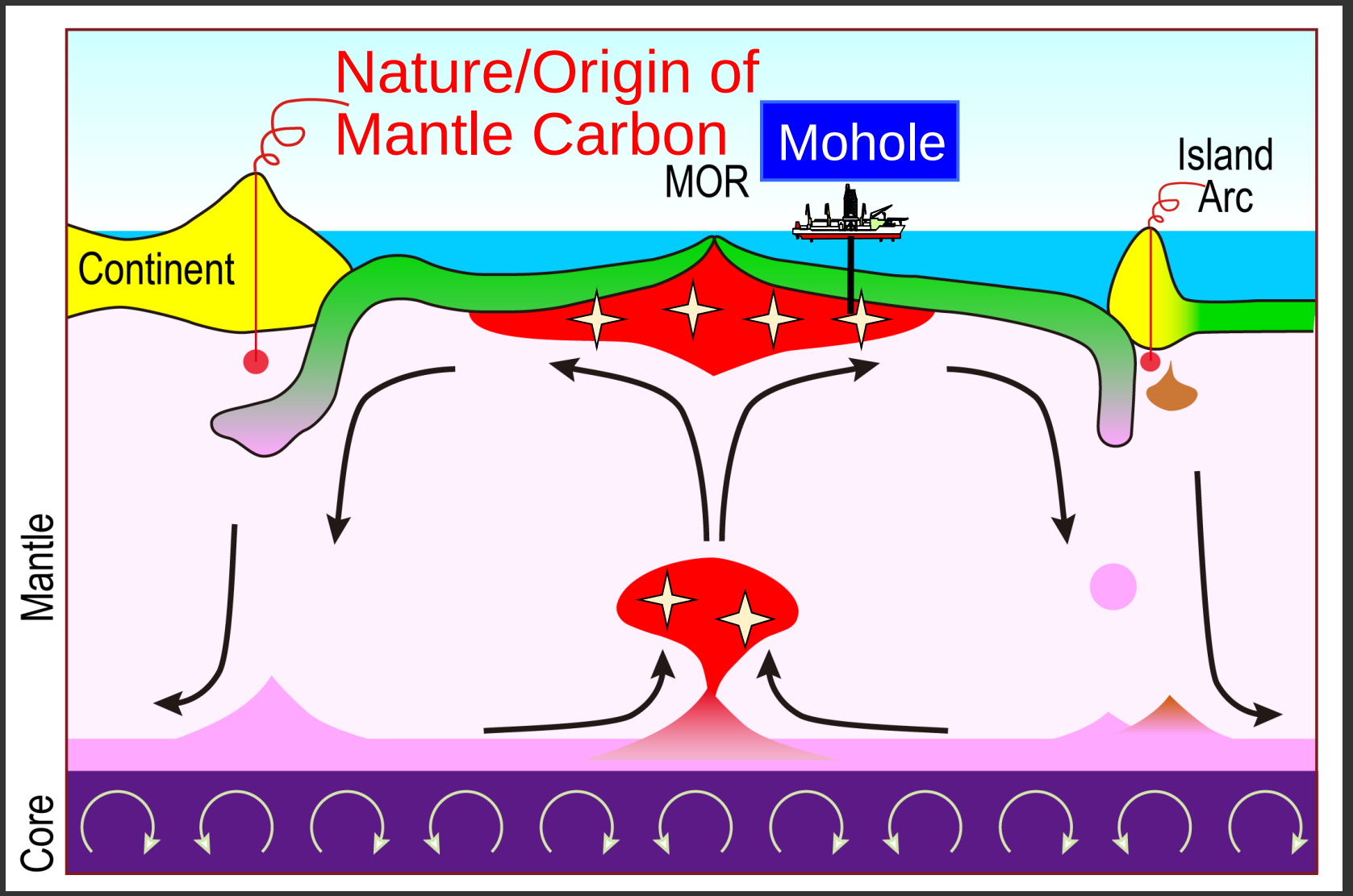
H_2O Cycle and Earthquake/Magmatism



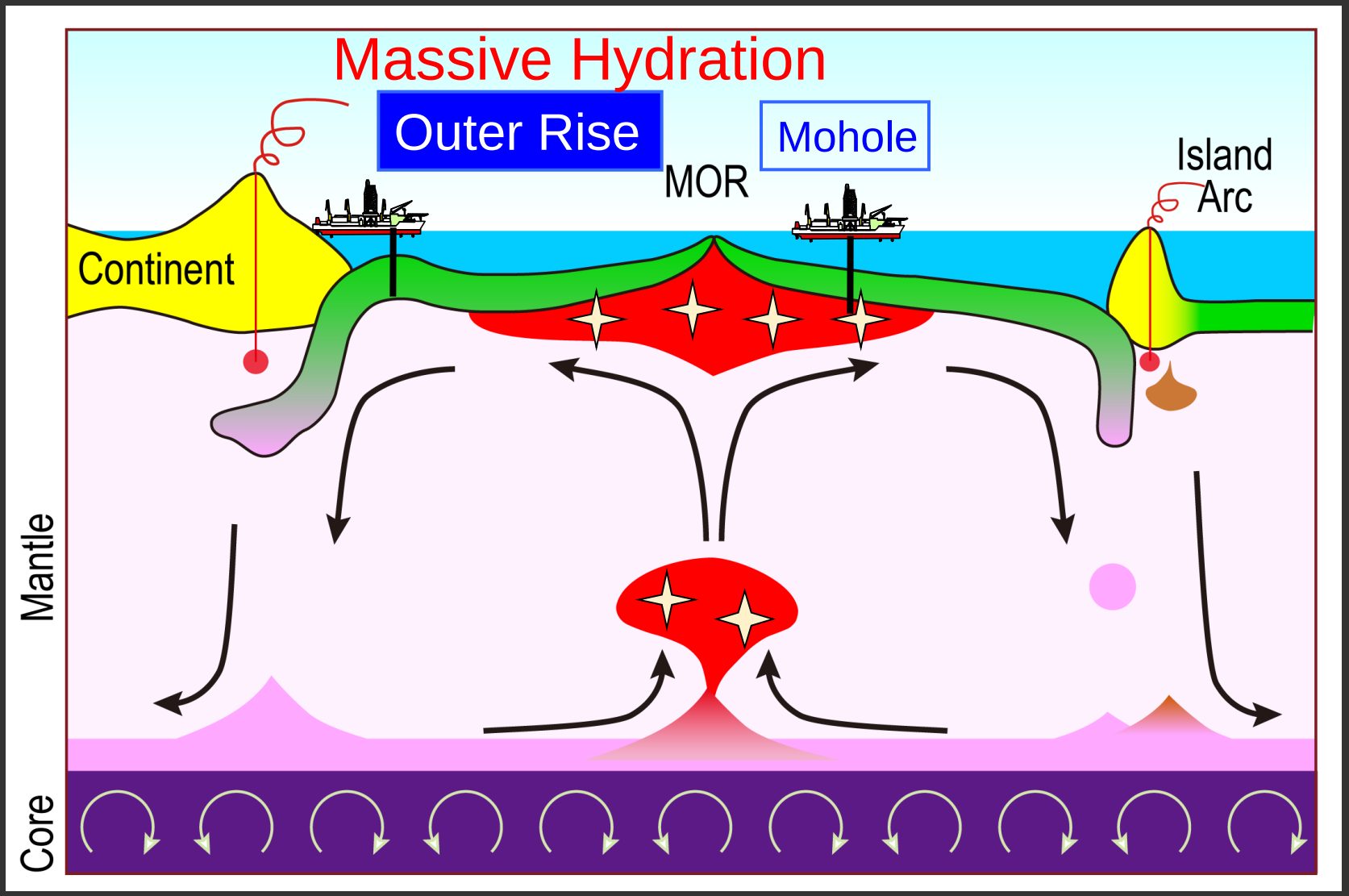
Carbon Cycle and Sub-Oceanic Mantle Diamond



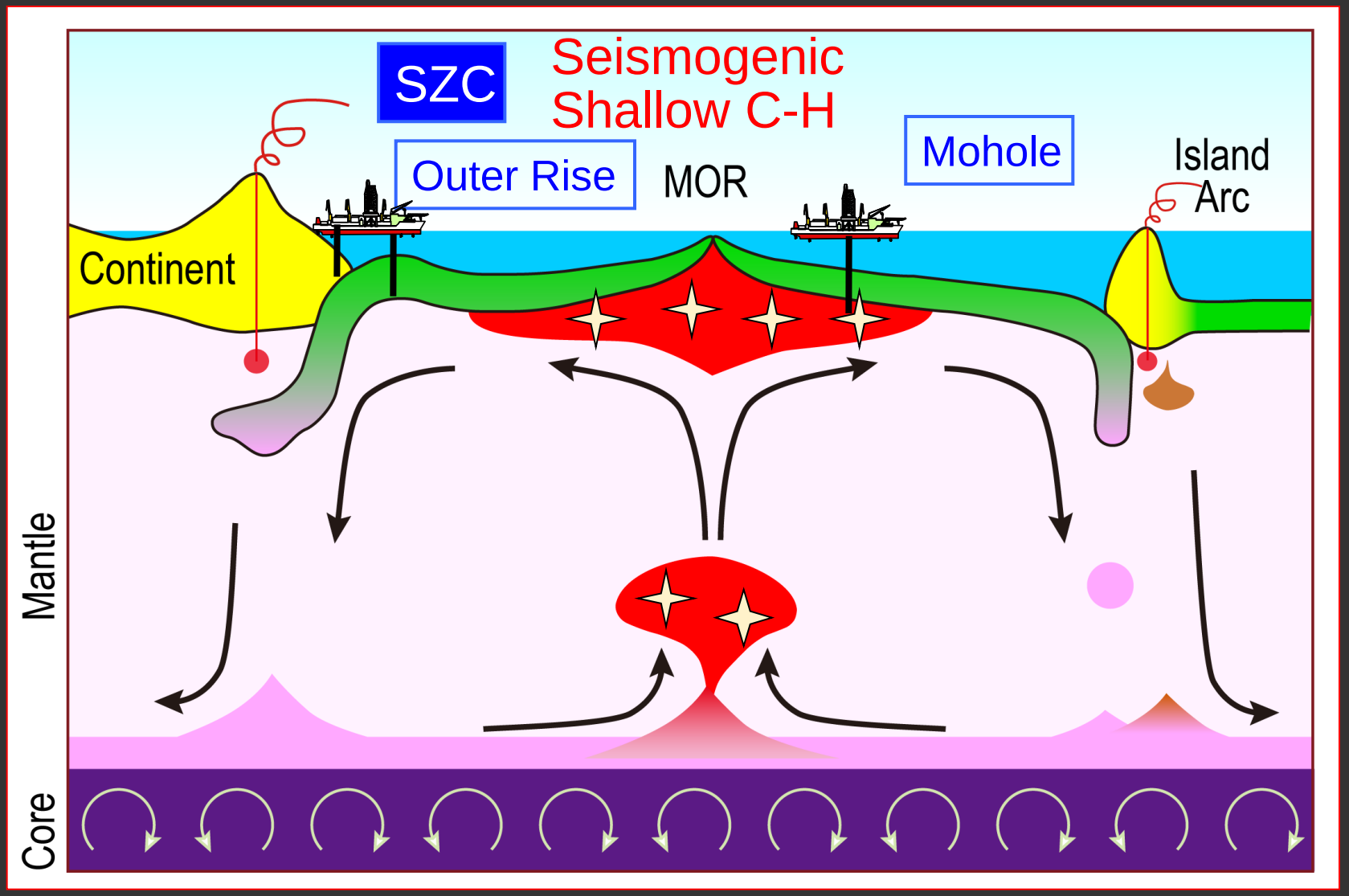
Chikyu Missions: MoHole



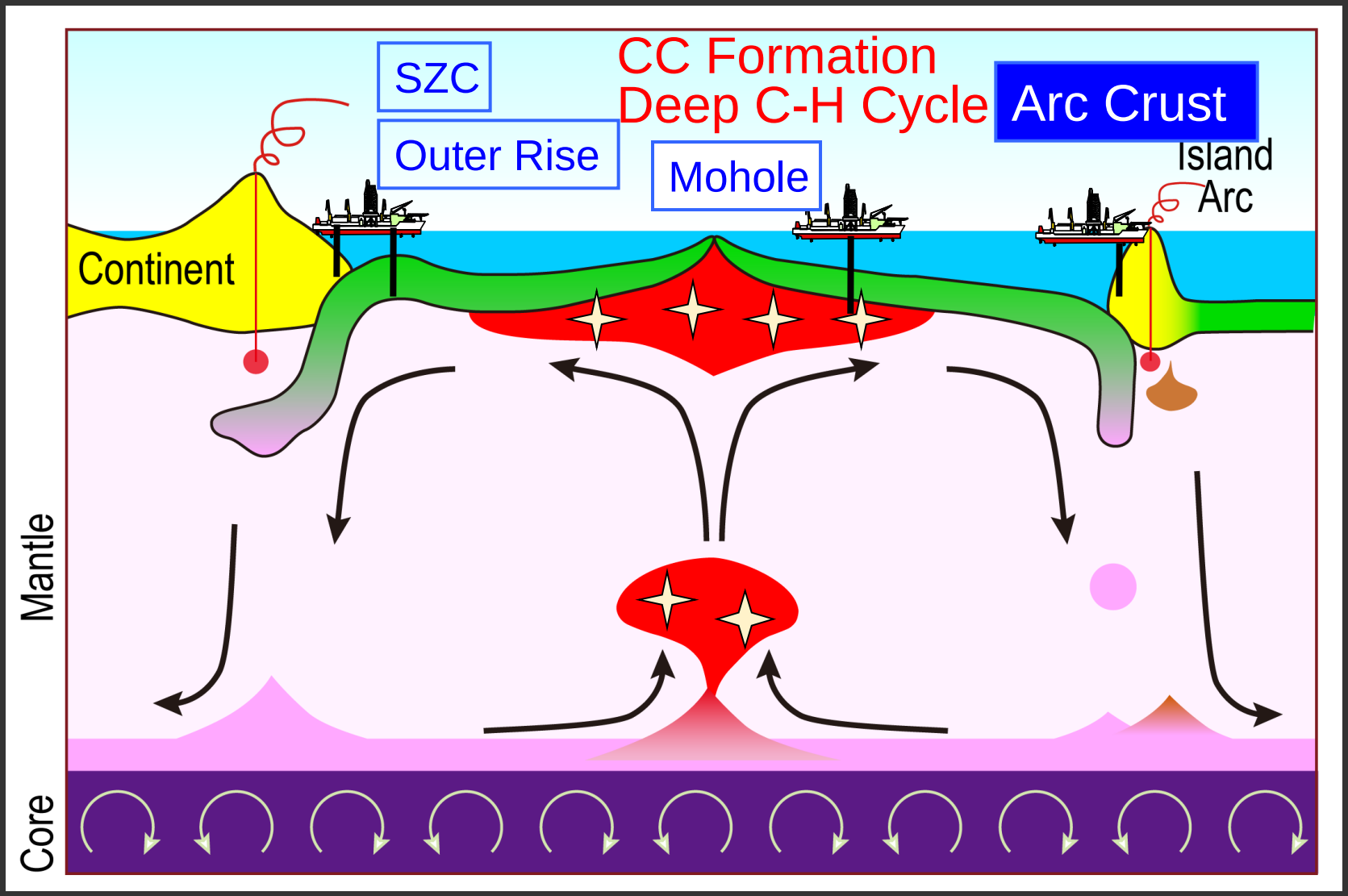
Chikyu Missions: Outer Rise



Chikyu Missions: SZ Complex



Chikyu Missions: Arc Crust



Sail together

towards understanding C-H cycle in Earth system

Seeking for diamond and peridot m(。^_^。)m