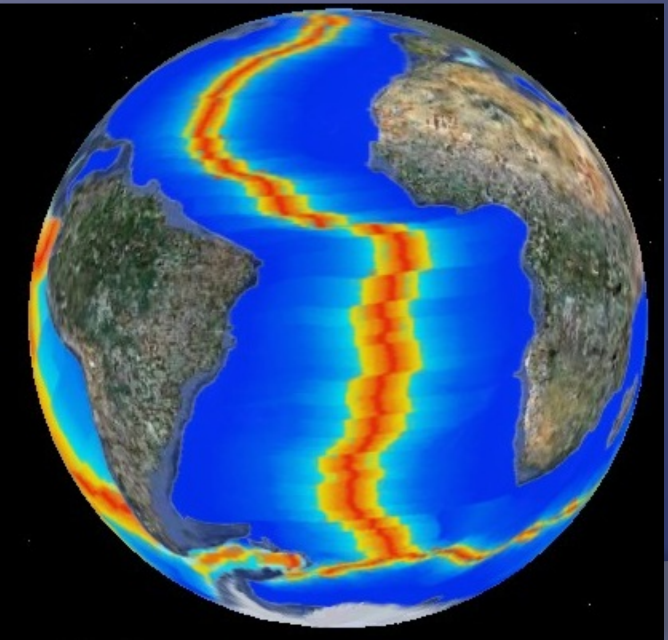
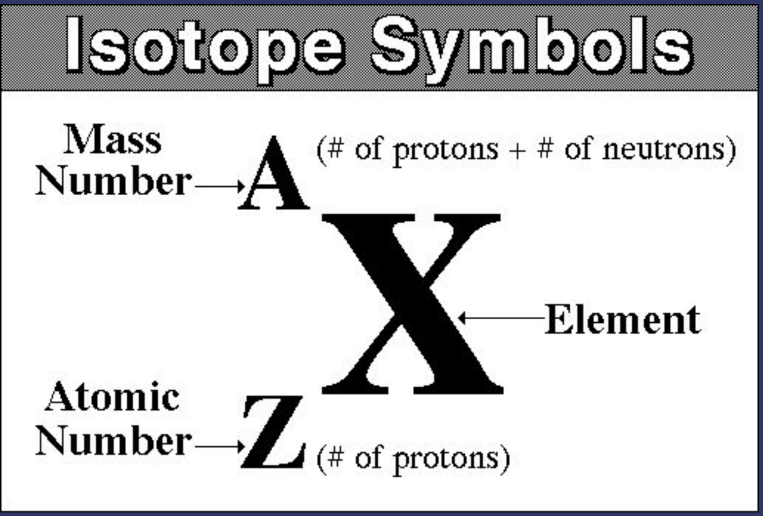
Sarah Lambart - 2016

LECTURES 17-18: OCEANIC MAGMATISM



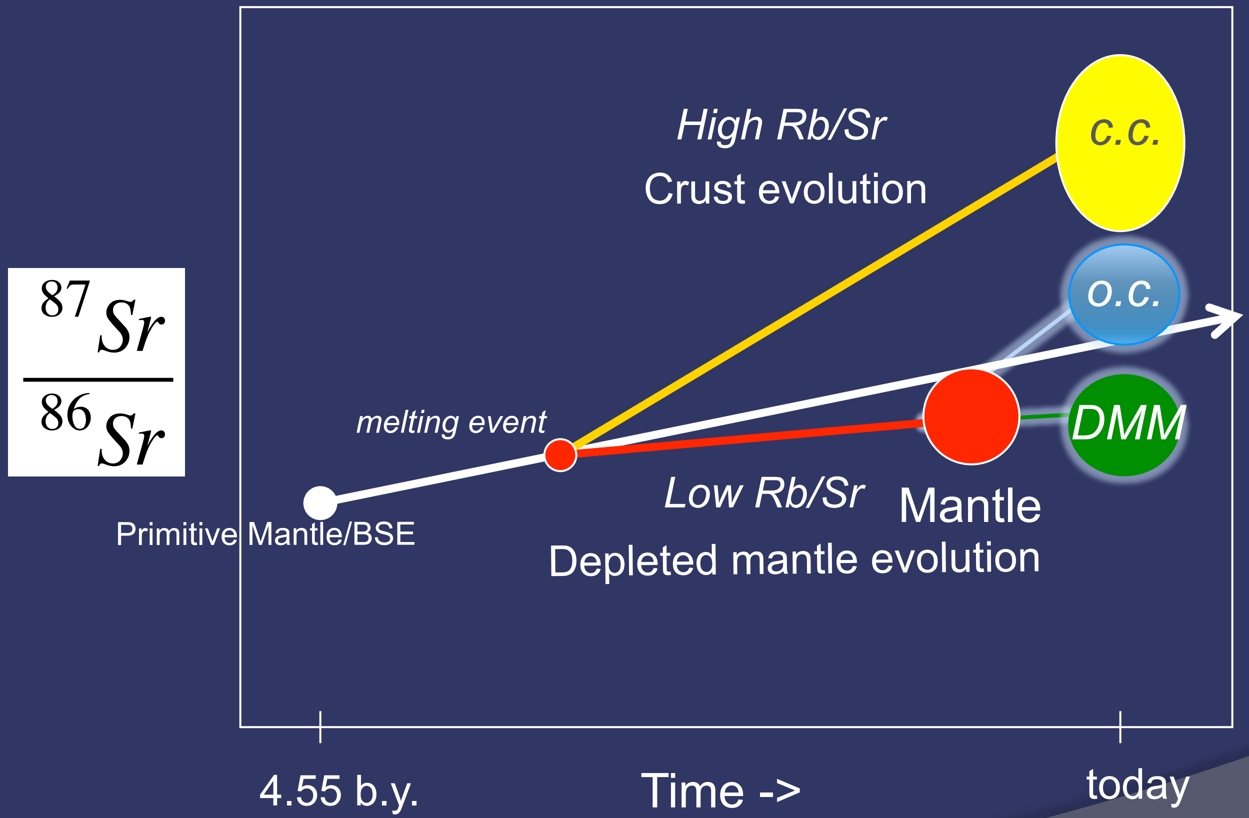
Recap Lecture 16: Isotopes 101



- Radioactive (parent) vs. radiogenic (daugher) isotopes
- Unstable (radioactive) vs stable isotopes
- Uses: for dating (geochronology) and as tracers (source composition)

Recap Lecture 16: Isotopes 101

- As tracers:
  - Ex.: $^{87}Sr/^{86}Sr$: DMM < co < cc

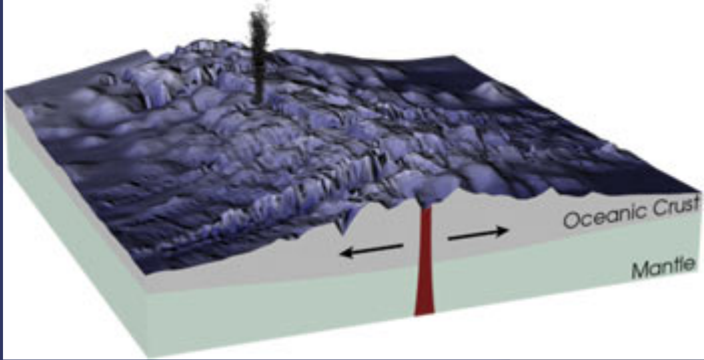


Recap Lecture 16: Isotopes 101

- As tracers:
  - Ex.: $^{87}Sr/^{86}Sr$: DMM < co < cc
  - *Isotopes do not fractionate during partial melting and crystallization processes!!!* ⇒ $^{87}Sr/^{86}Sr$ (source) = $^{87}Sr/^{86}Sr$ (magma)

⇒ if $^{87}Sr/^{86}Sr$ (magma) ≠ constant ⇒ several source components (subducted oc, subducted sediments, subcontinental lithosphere, ect…) or crustal contamination (AFC)

Mid-Ocean Ridges Basalt (MORB)

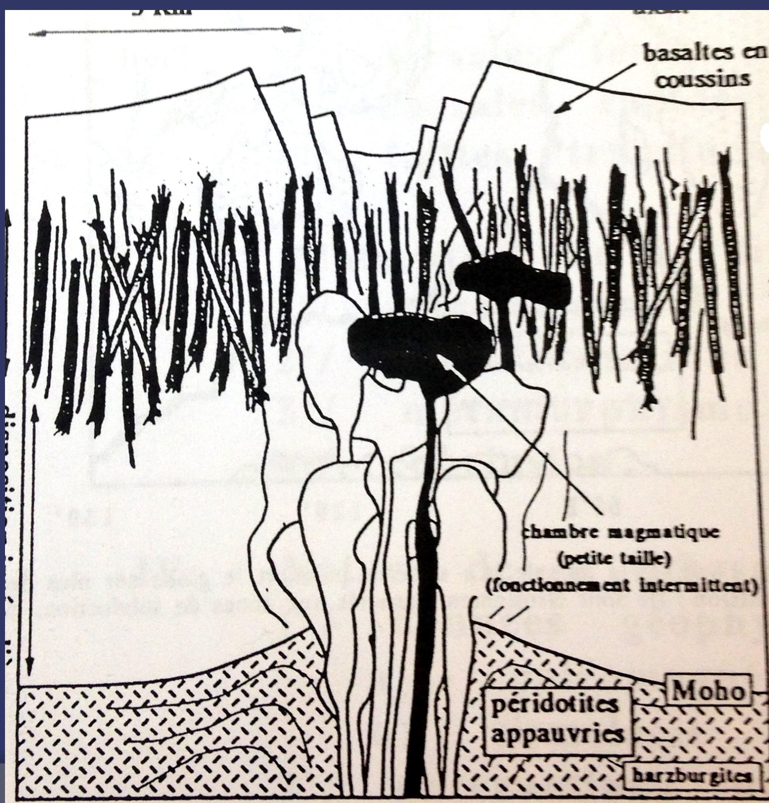


- Facts:
  - Oceanic floors: 60% of Earth's surface
  - Most of the rocks produced at ridges are MORB
  - Large compositional variability
    3) Source composition
    2) Melting conditions (Pressure, Temperature)
    4) Melt segregation and transport
    1) Magma differentiation/crystallization

Structure of Mid-Ocean Ridges

- Ridges: submarine (most of the time) mountain chains ≈ 3000m

Slow-spreading ridge:
Ex.: Mid-Atltantic ridge : 2cm/yr



Fast-spreading ridge:
Ex.: EPR: 10 cm/yr

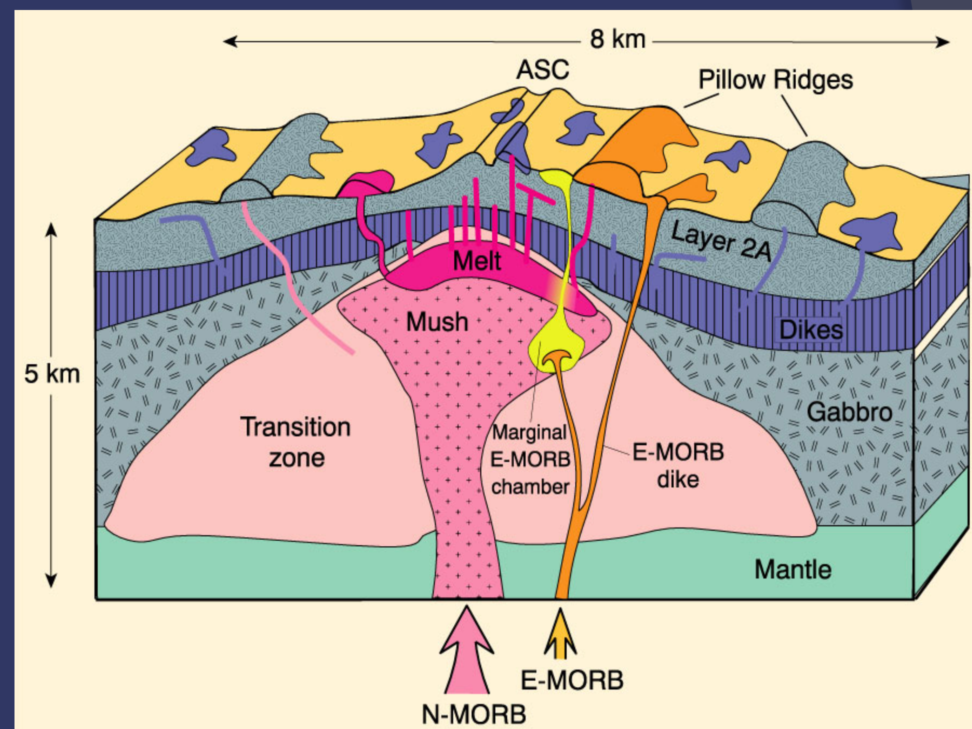


Fig. 13-15 in Winters

Structure of Mid-Ocean Ridges

- Ridges: submarine (most of the time) mountain chains ≈ 3000m

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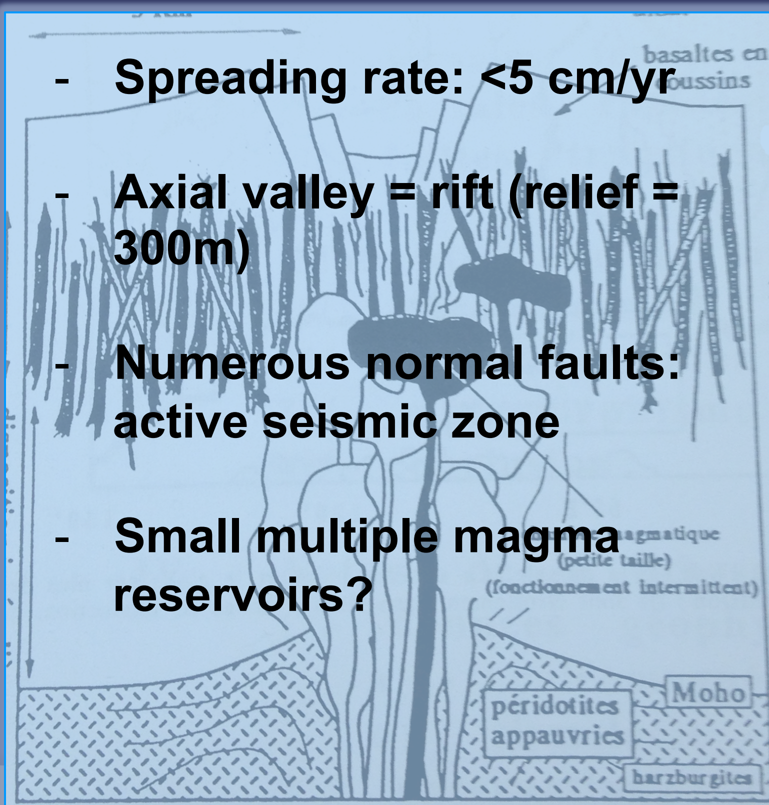
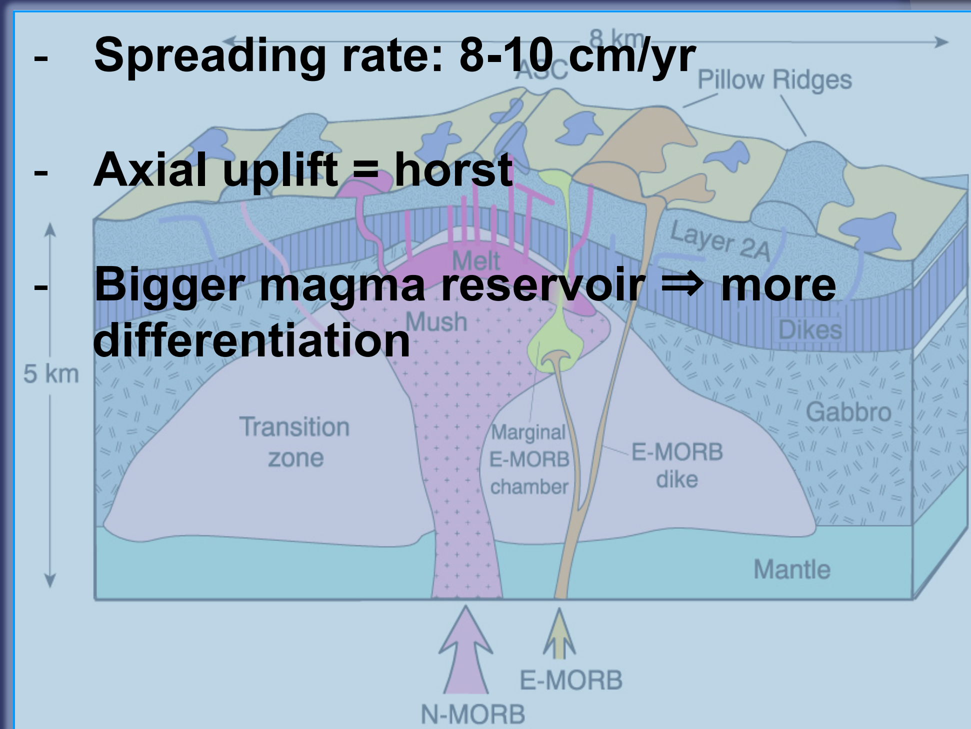


- Spreading rate: <5 cm/yr
- Axial valley = rift (relief = 300m)
- Numerous normal faults: active seismic zone
- Small multiple magma reservoirs?

Fast-spreading ridge:
Ex.: EPR: 10 cm/yr



- Spreading rate: 8-10 cm/yr
- Axial uplift = horst
- Bigger magma reservoir ⇒ more differentiation

The oceanic lithosphere

- Maturation

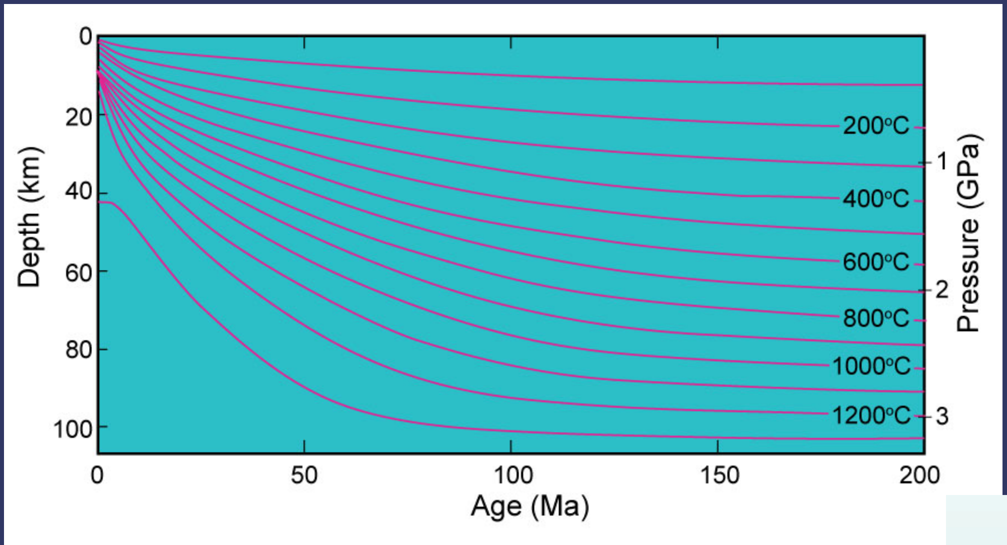
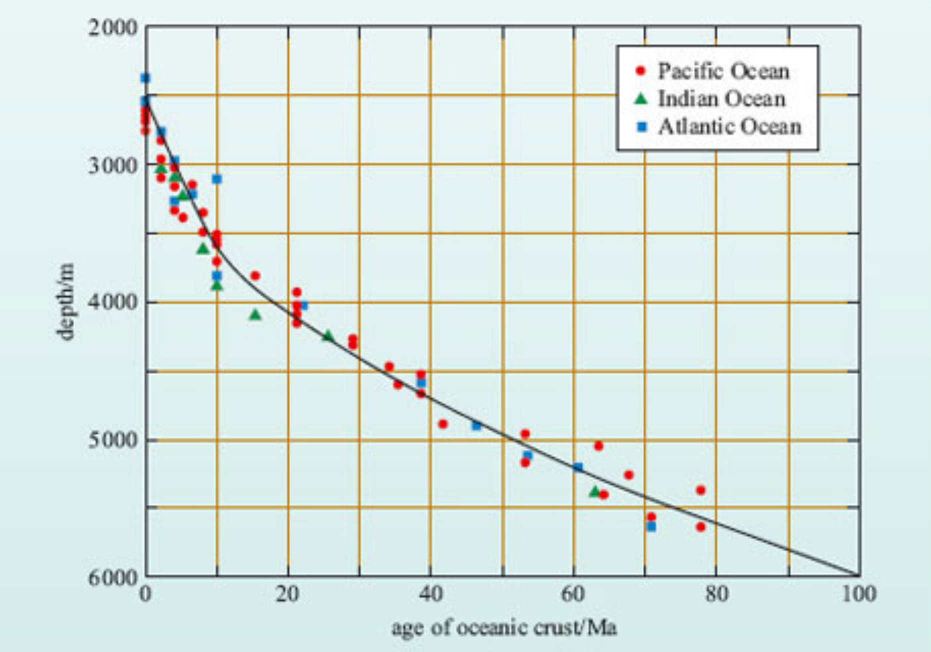


Fig. 1-10 in Winters

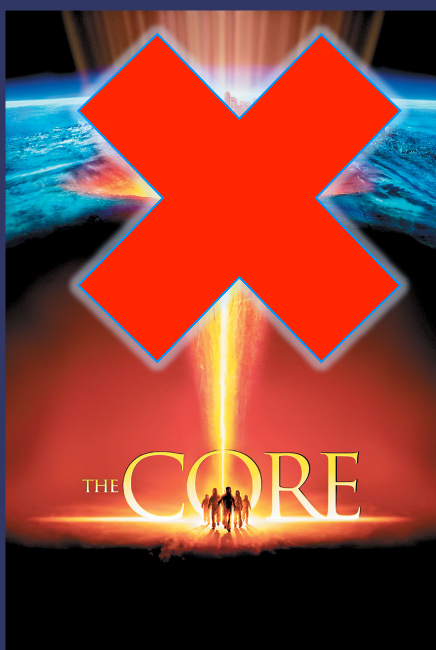
$d(m) = 2500 + 350\ T^{1/2}\ (Ma)$

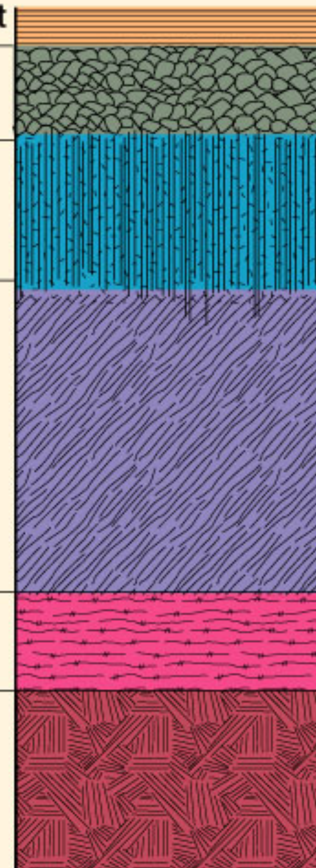


The oceanic lithosphere

- Structure

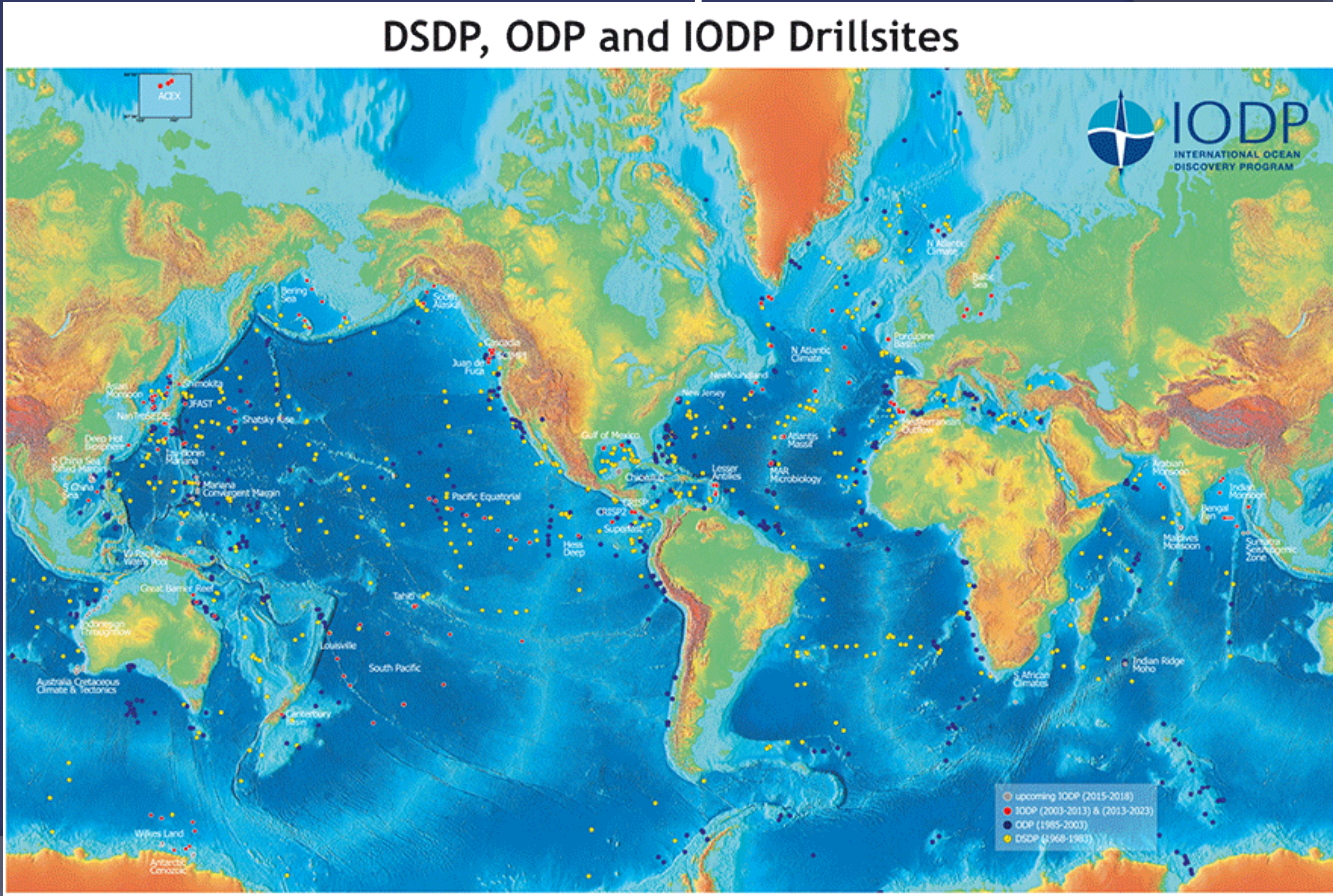
Fig. 13-5 in Winters





Lithology	Ocean Crustal Layers	Typical Ophiolite Thickness (km)	Normal Ocean Crust ave.	Normal Ocean Crust P wave vel. (km/s)
Deep-Sea Sediment	1	~ 0.3	0.5	1.7 -2.0
Basaltic Pillow Lavas	2A & 2B	0.5	0.5	2.0 - 5.6
Sheeted dike complex	2C	1.0 - 1.5	1.5	6.7
Gabbro	3A	2 - 5	4.7	7.1
Layered Gabbro	3B			
Layered peridotite	4	up to 7		8.1
Unlayered tectonite peridotite				

The oceanic lithosphere



The oceanic lithosphere

- Structure

Fig. 13-5 in Winters

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Layered peridotite	4	up to 7		8.1
Unlayered tectonite peridotite				

1) Magma differentiation

2) Melting conditions

3) Source composition

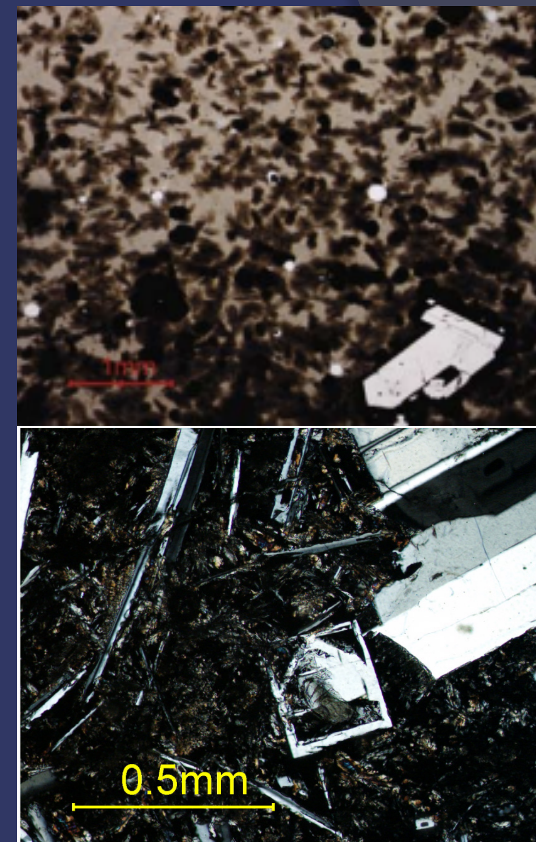
1) Evidence for low pressure crystallization

- Petrography:

≠ textures
  - Microlites
  - Prophyritic

Imperial College London

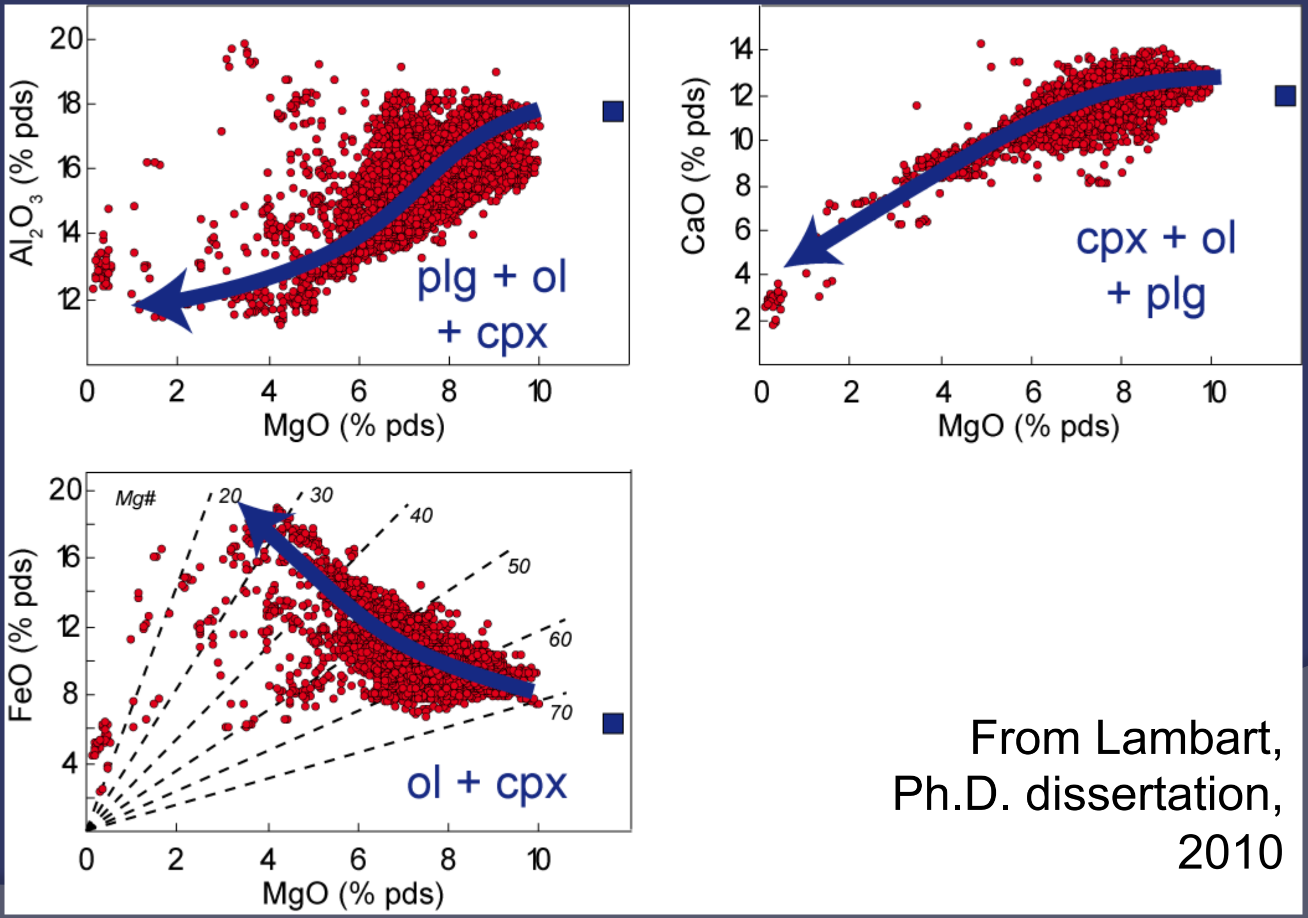
- Paragenesis:
  - Ol (Mg-rich) ± Sp
  - Cpx
  - Plg



Smith and Perfit, 2007

1) Evidence for low pressure crystallization

- Geochemistry:



From Lambart, Ph.D. dissertation, 2010

1) Evidence for low pressure crystallization

- Experimental petrology:

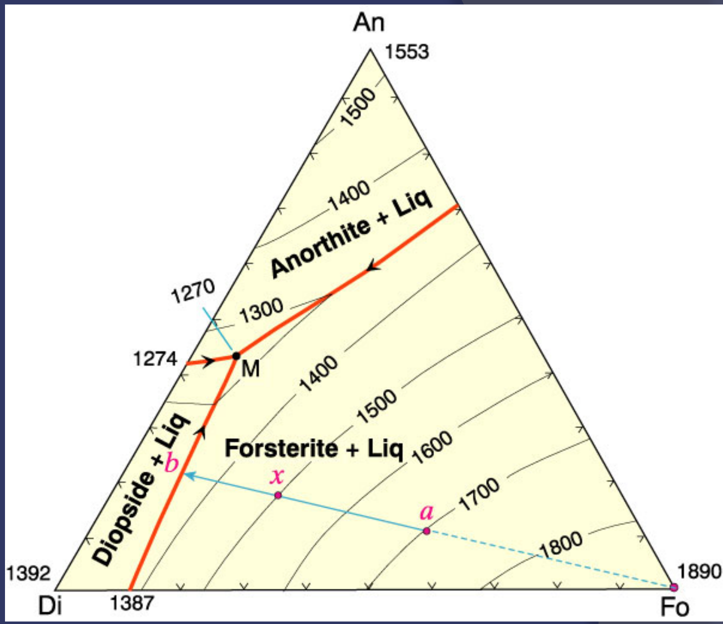
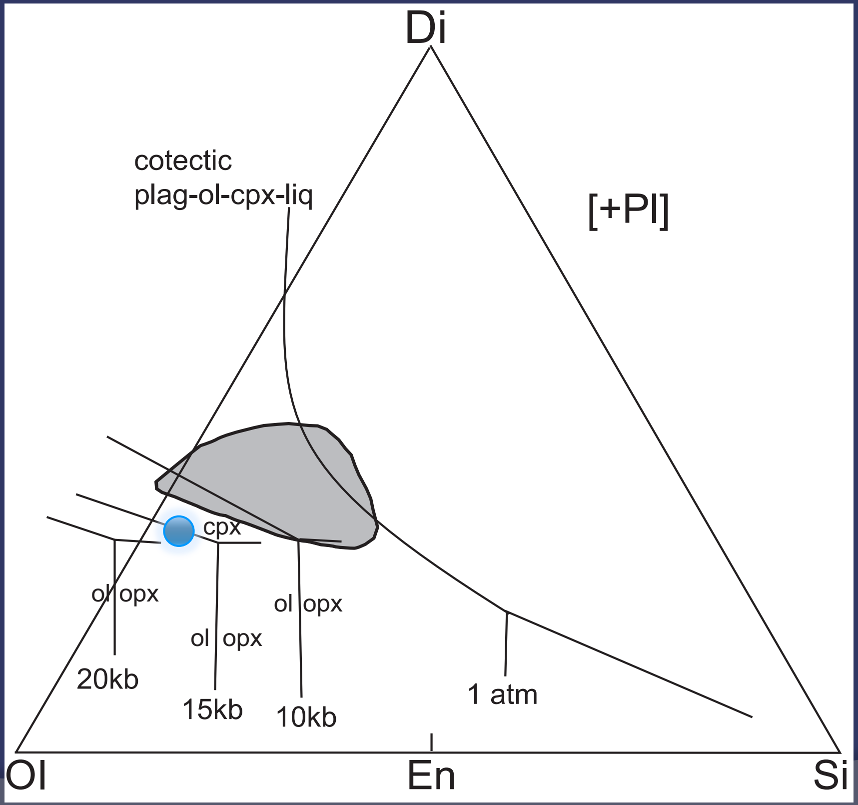


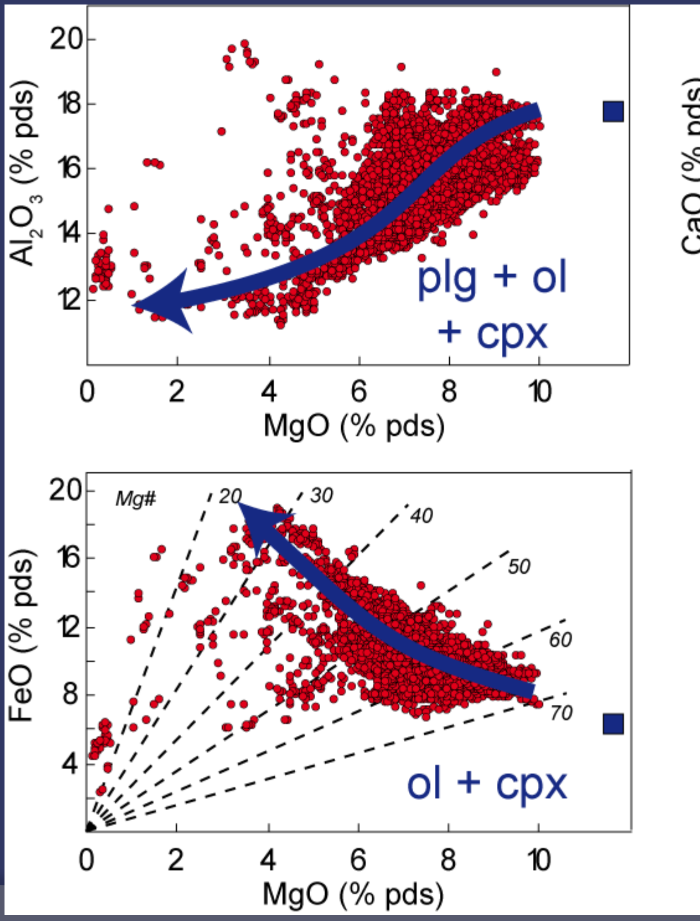
Fig. 7.1 in Winters



Lambart et al., 2009

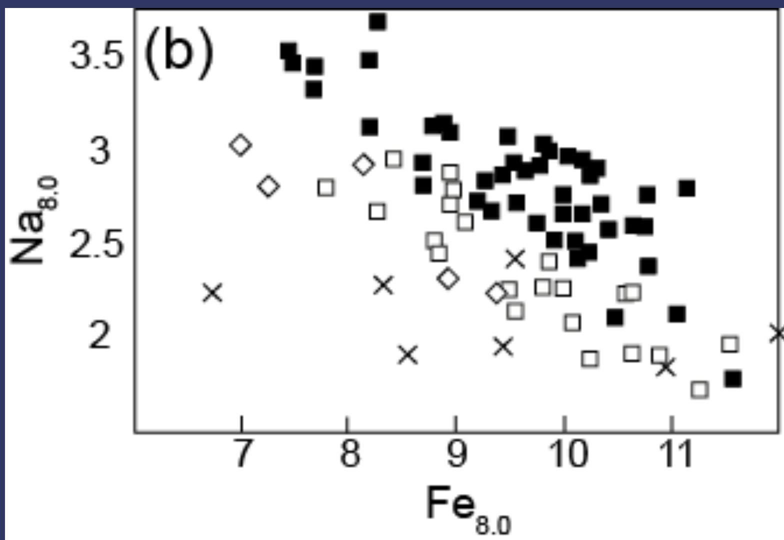
1) Evidence for low pressure crystallization

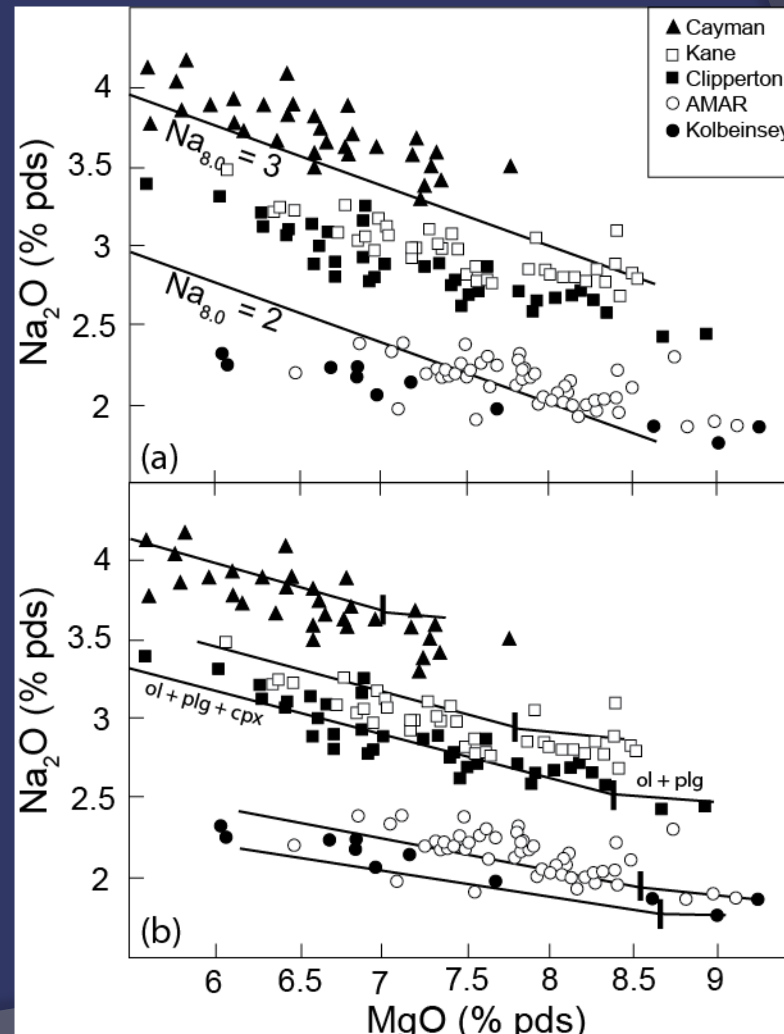
- Geochemistry:



Crystallization of ol + plg + cpx ⇒ ↘ MgO

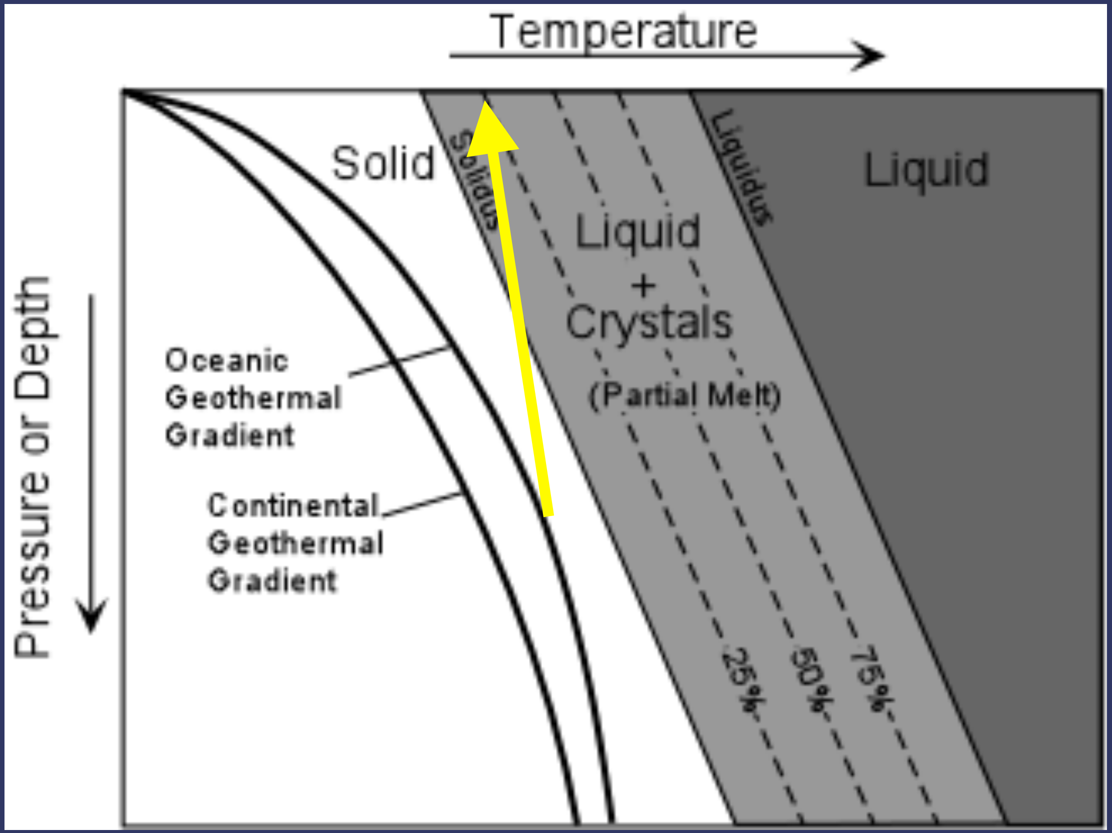
1) Correction for low pressure crystallization





Modified from Langmuir et al., 1992

2) Identify the melting process



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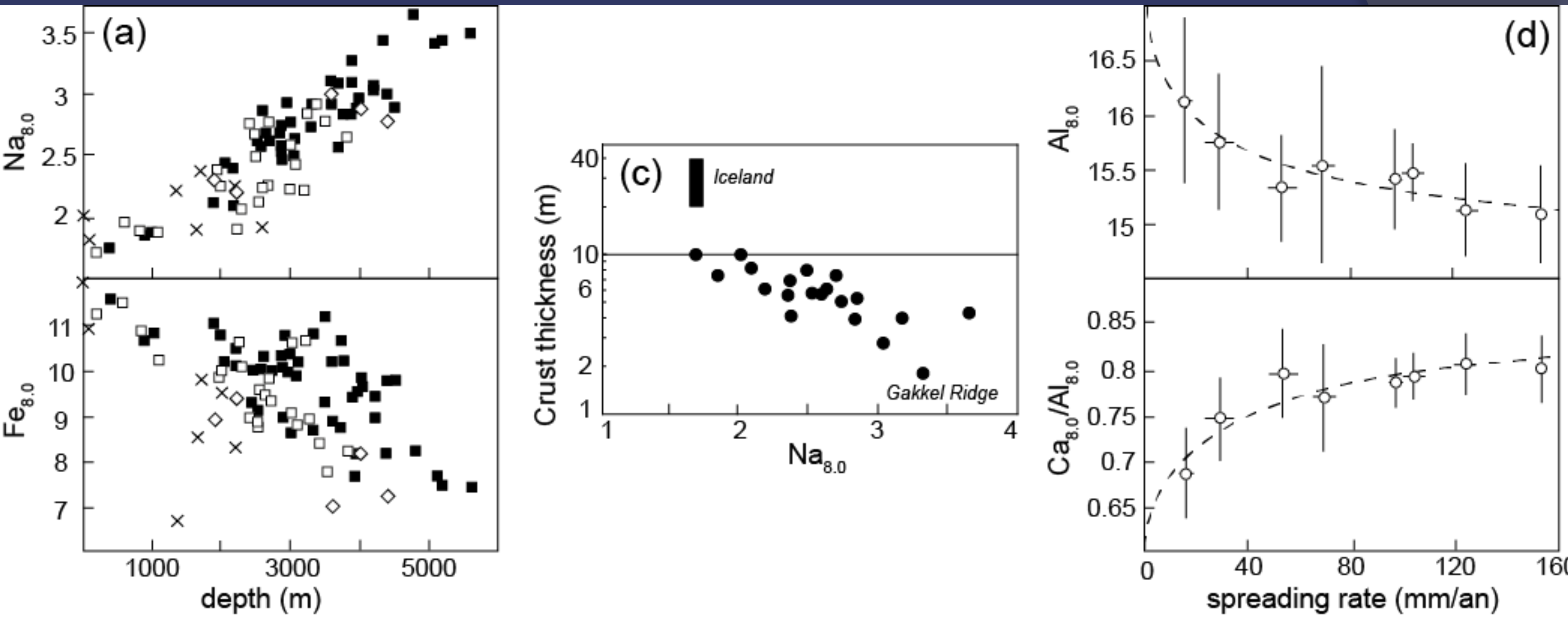

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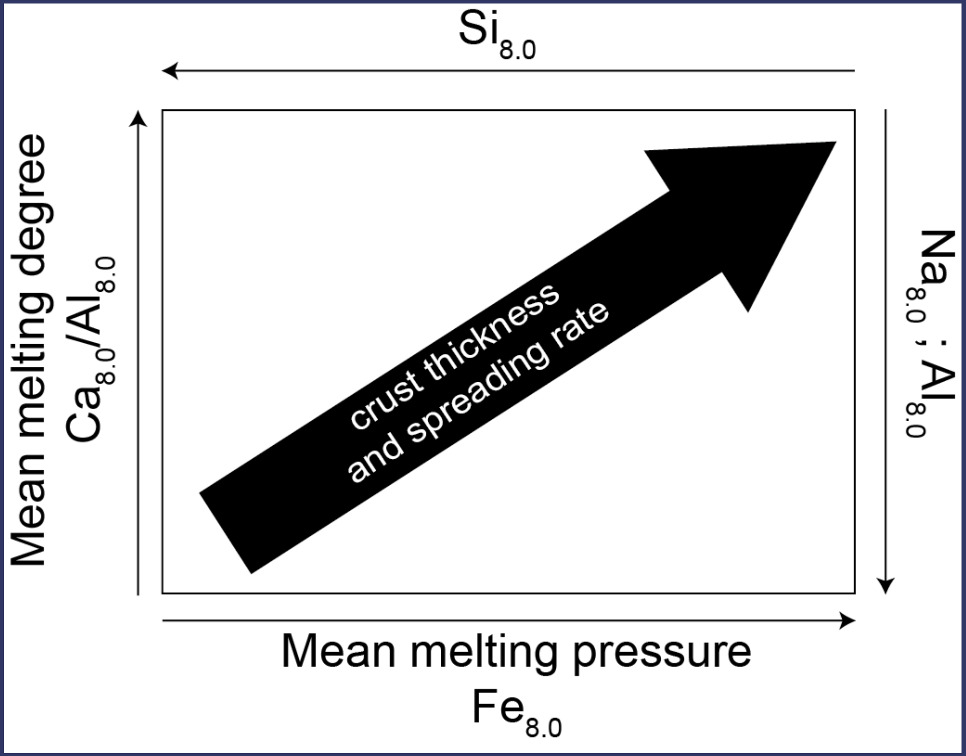
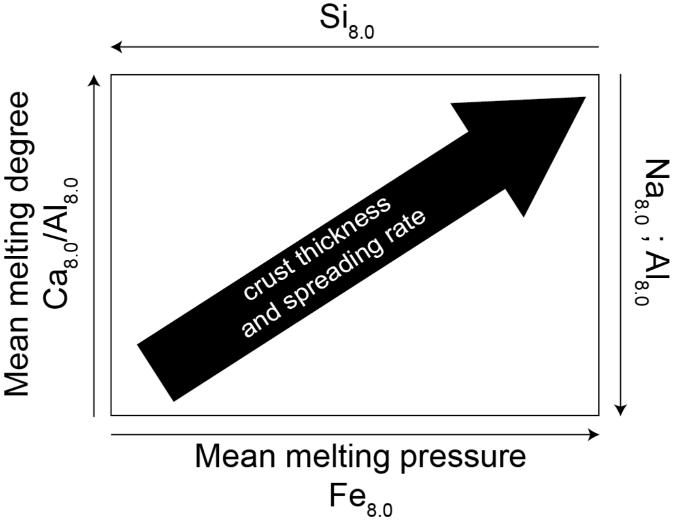
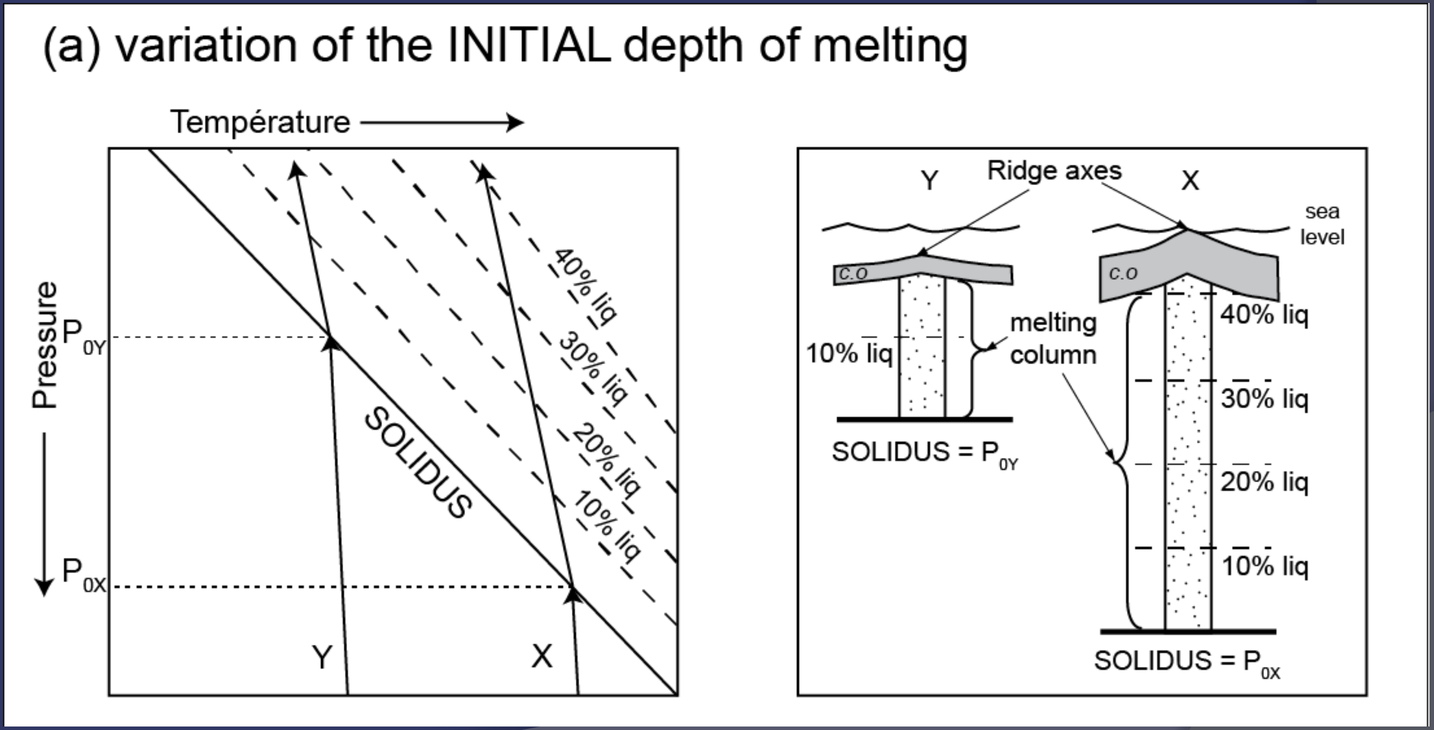


Major element variations of primary MORB: variations of F_{mean} and P_{mean}

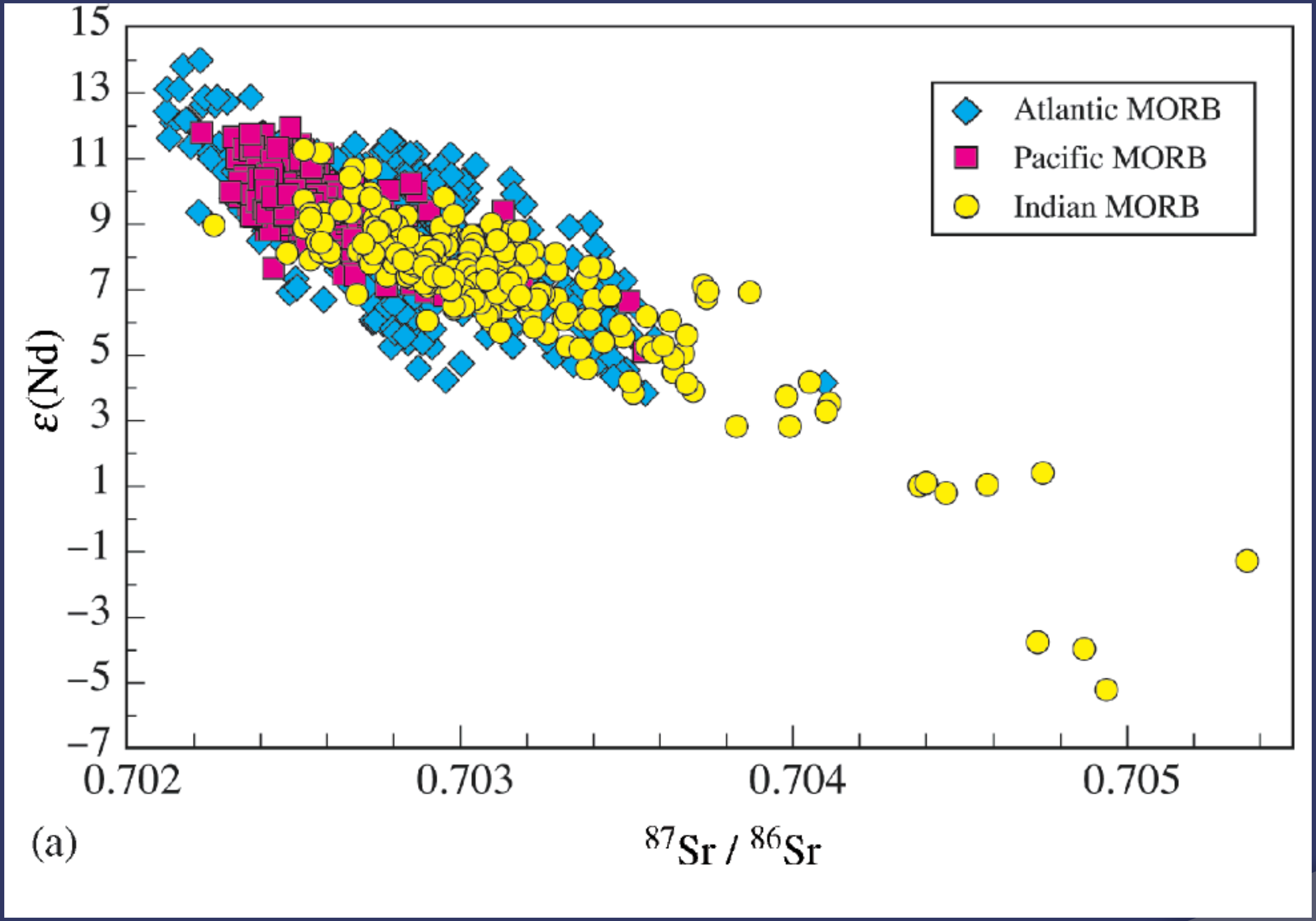
2) Identify the melting process





From Klein and Langmuir, 1987

3) Source composition



From Hofmann, 2003, Treatise on Geochemistry, Volume 2.

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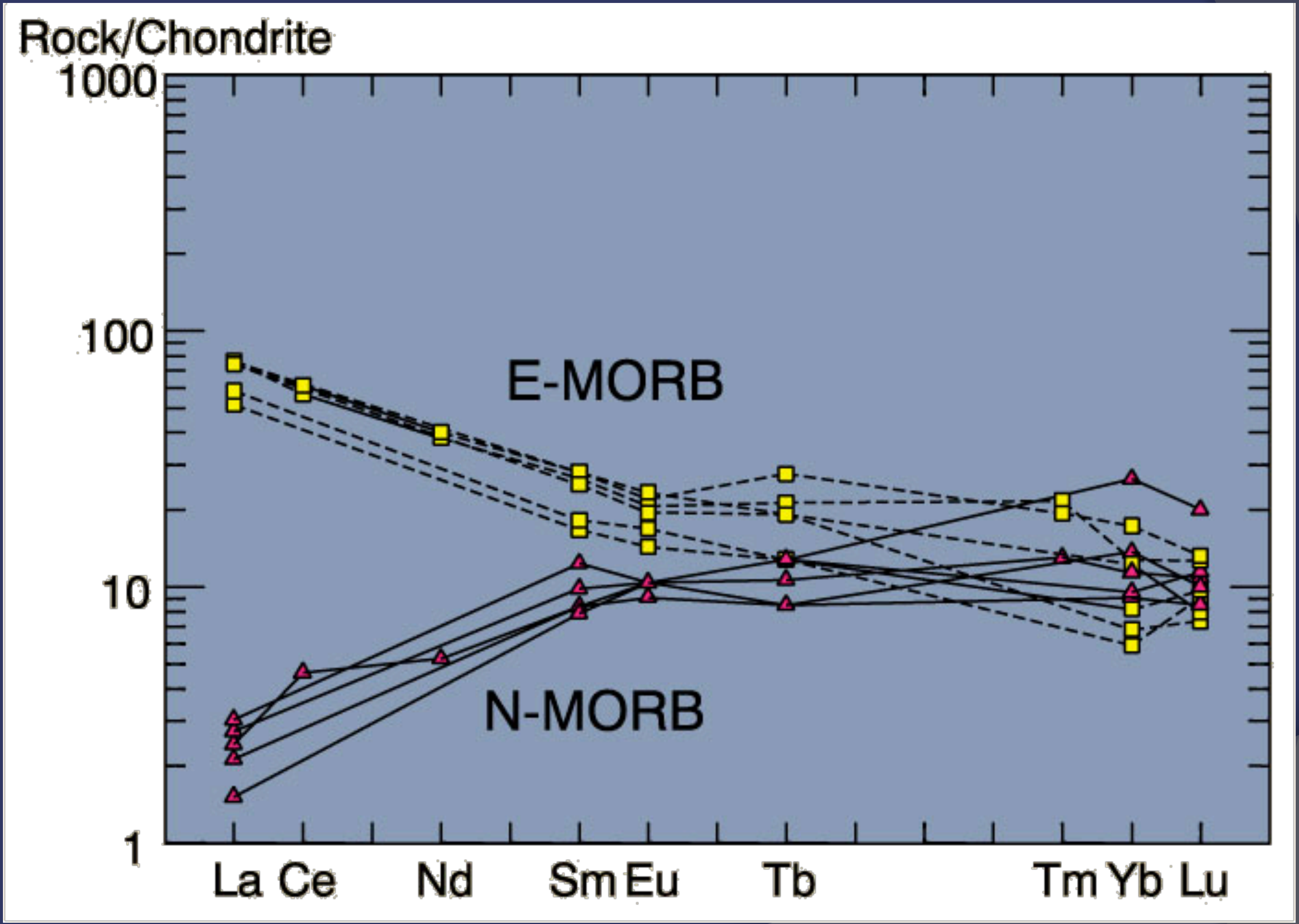


Fig. 13.11 in Winters

3) Source composition

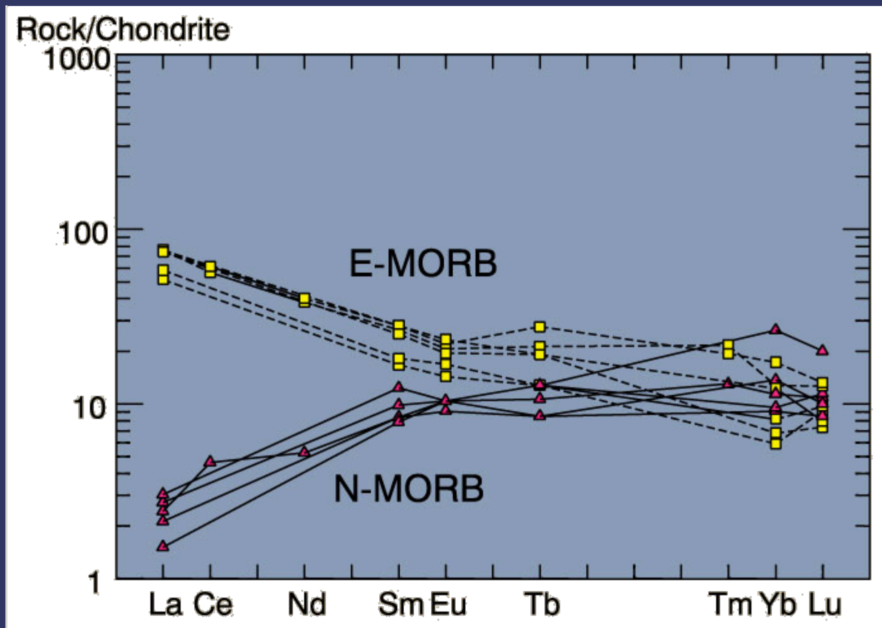
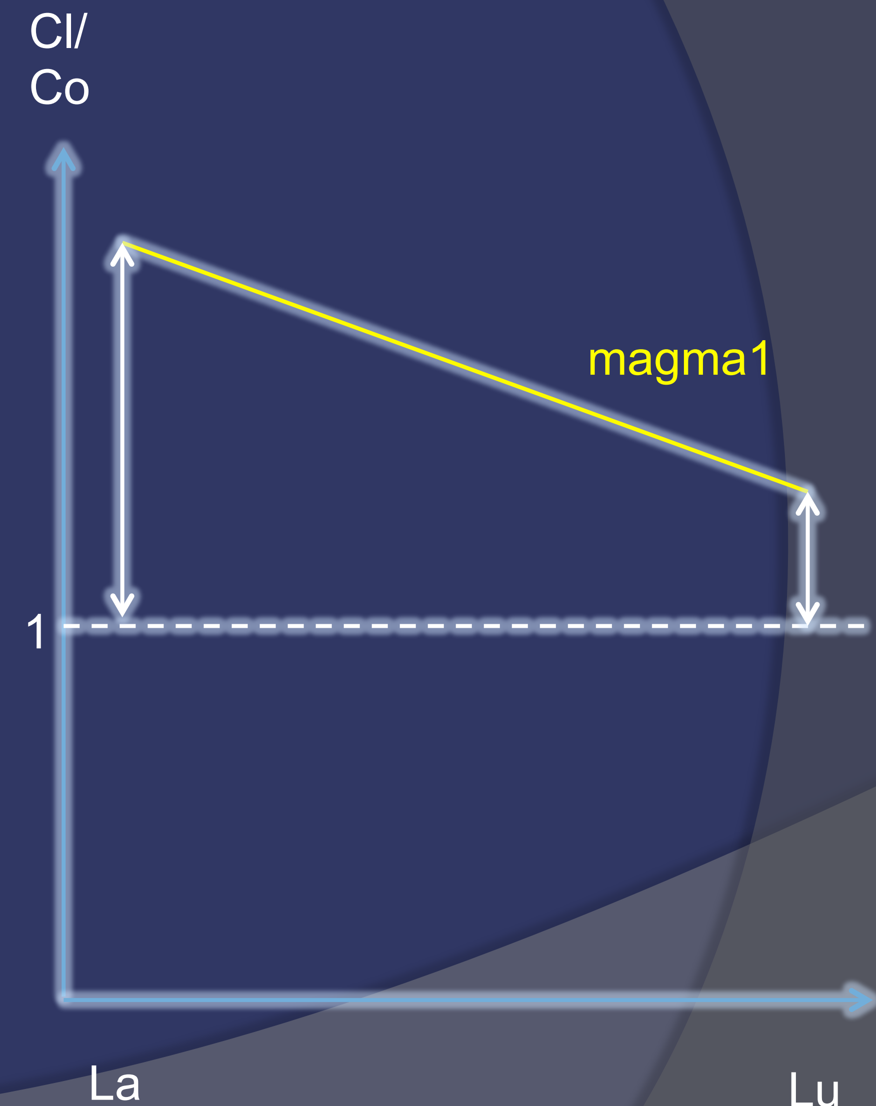


Fig. 13.11 in Winters



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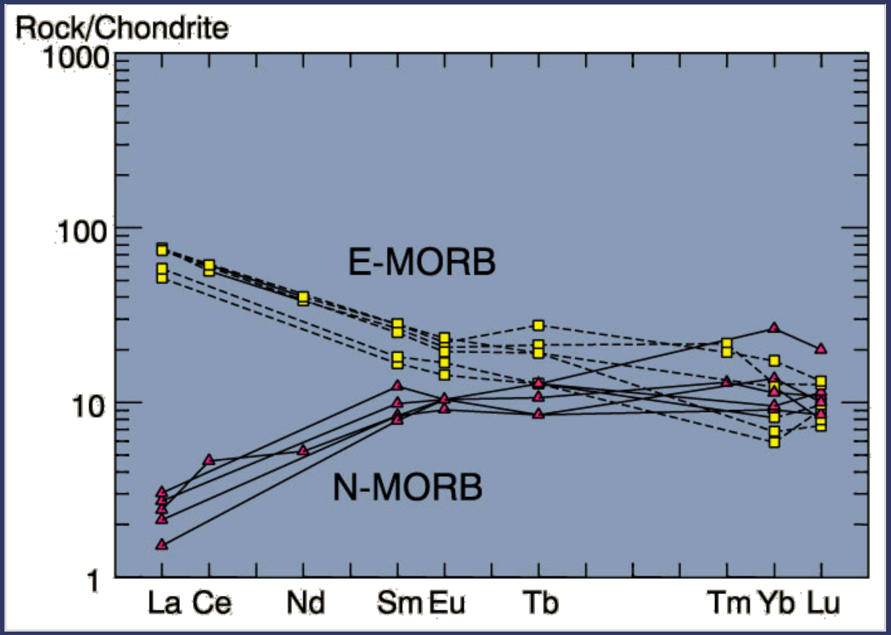

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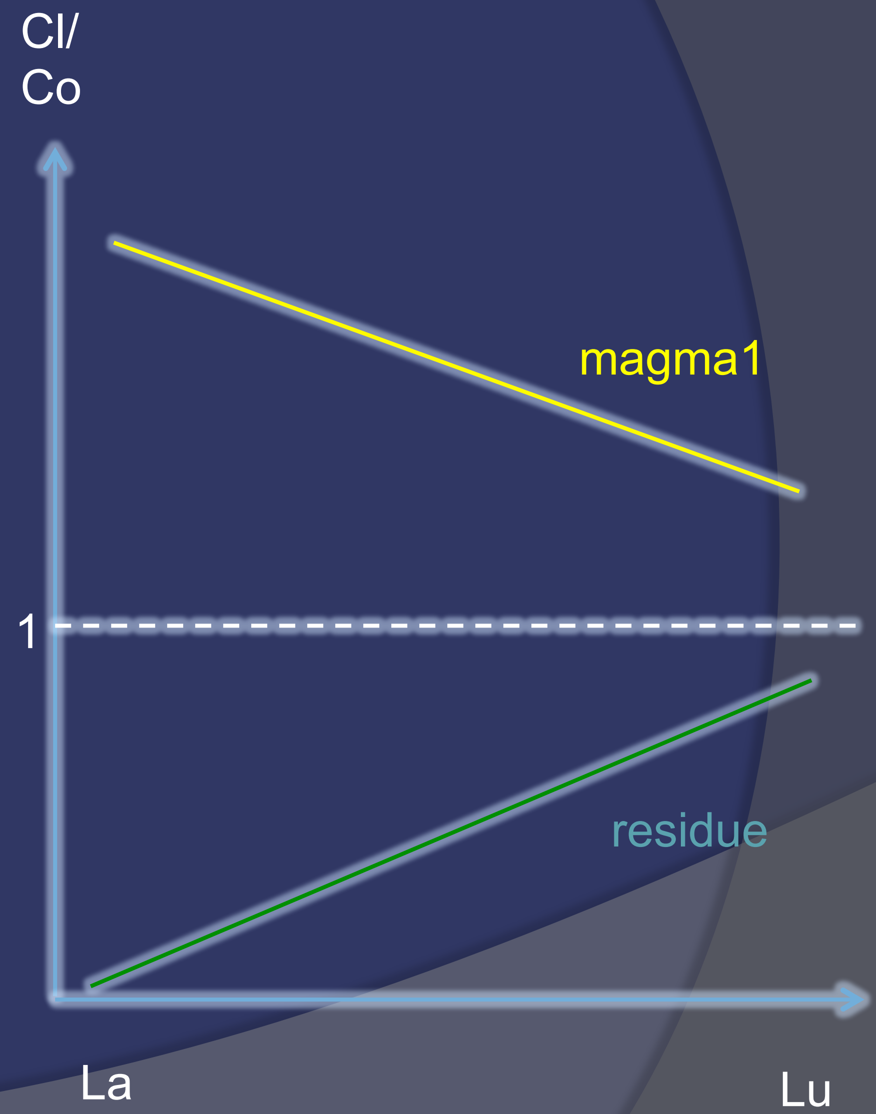

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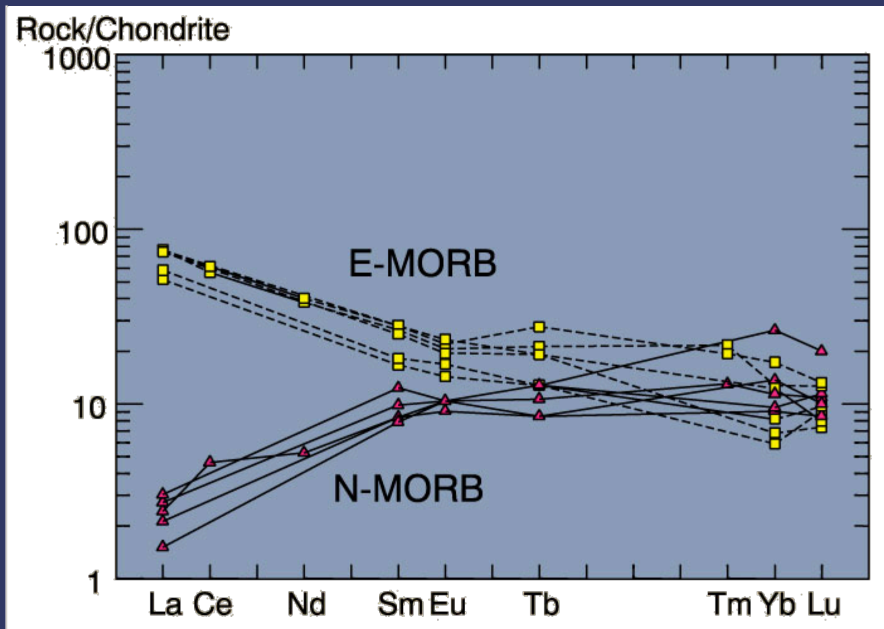

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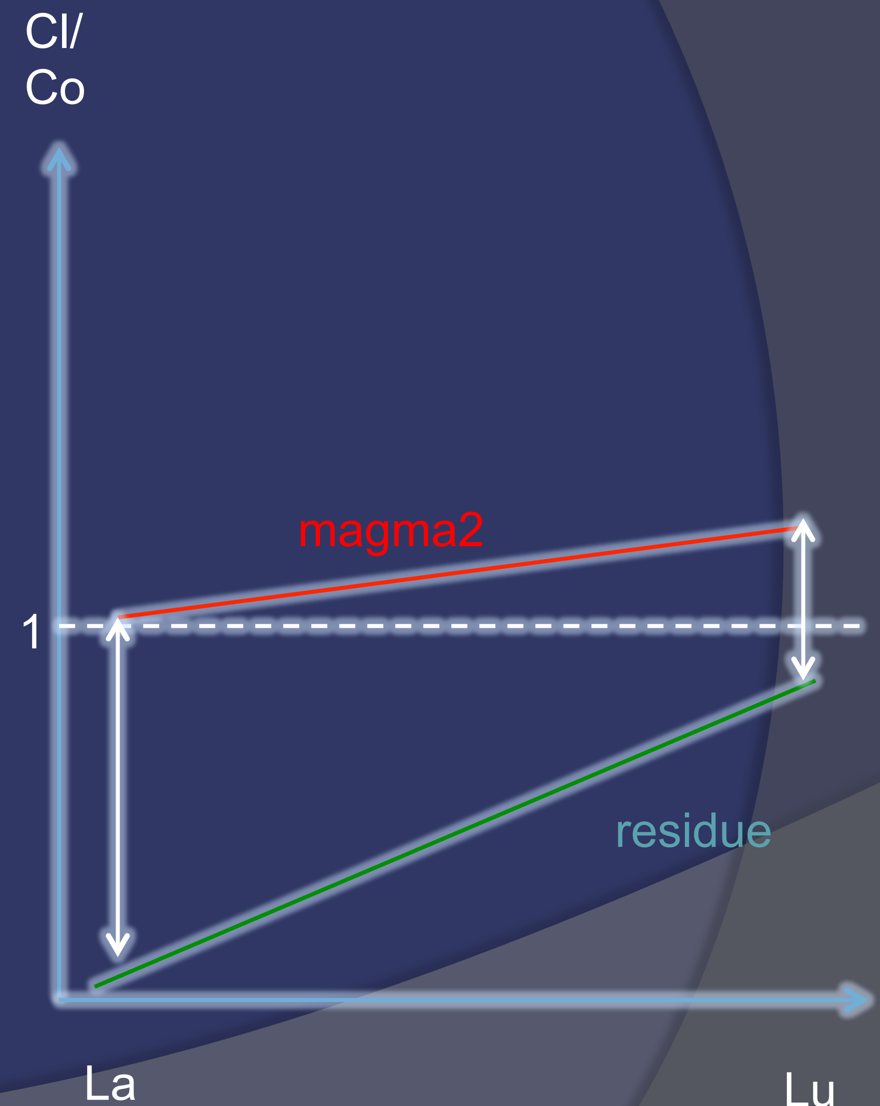

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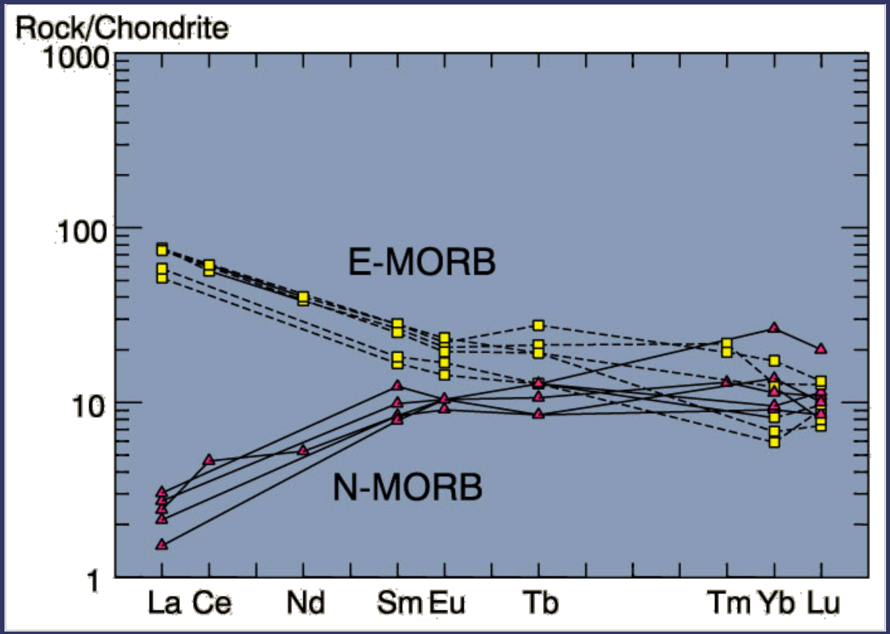

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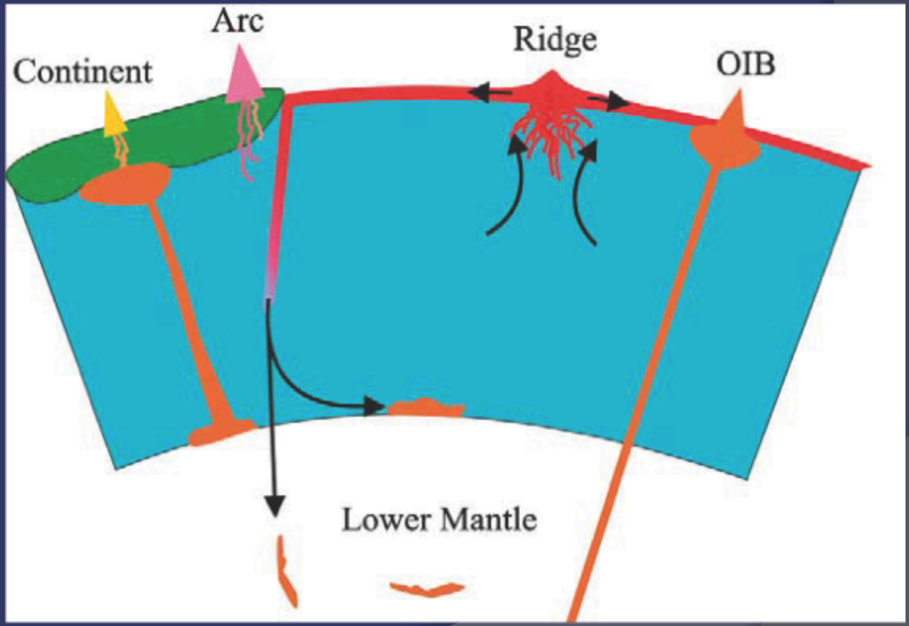
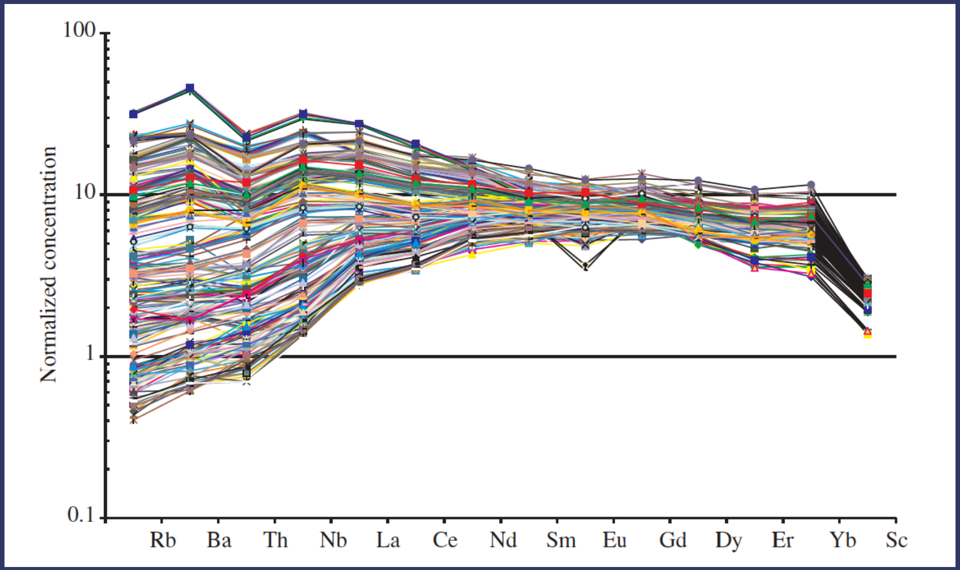


From Meiborn and Anderson, 2003, EPSL 217

3) Source composition



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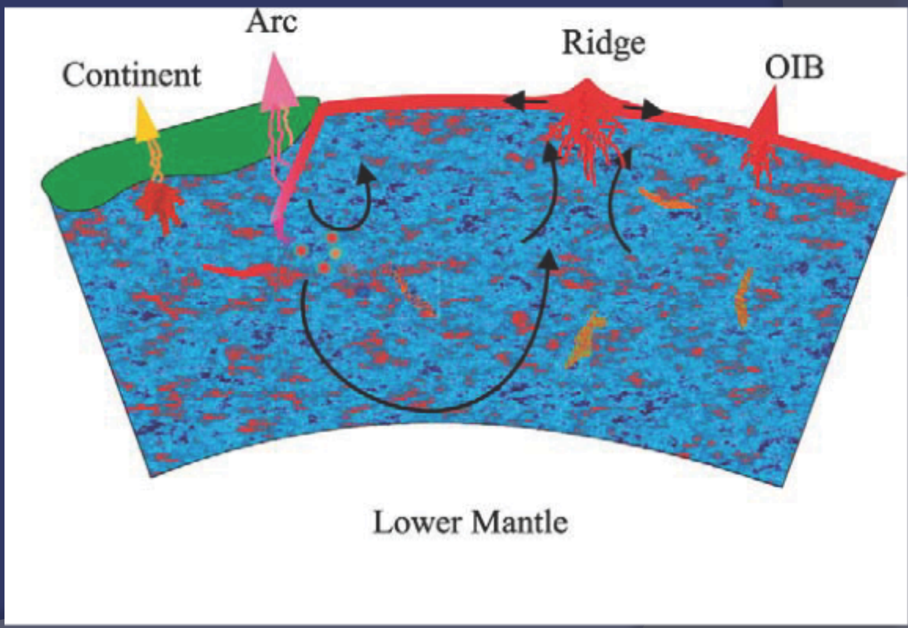
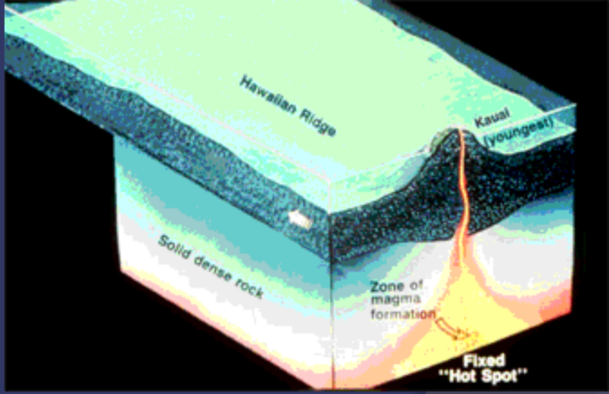


From Meiborn and Anderson, 2003, EPSL 217

Summary

- Most of the variation in major element compositions: low pressure crystallization
- “Rest” of the variation in major element compositions: different thermal states of the mantle
- Variations of isotopic compositions and part of the variation in trace element compositions: source heterogeneity

Ocean Island Basalt (OIB)



http://www.windows2universe.org/

- Facts:
  - Commonly associated with "hot spot"

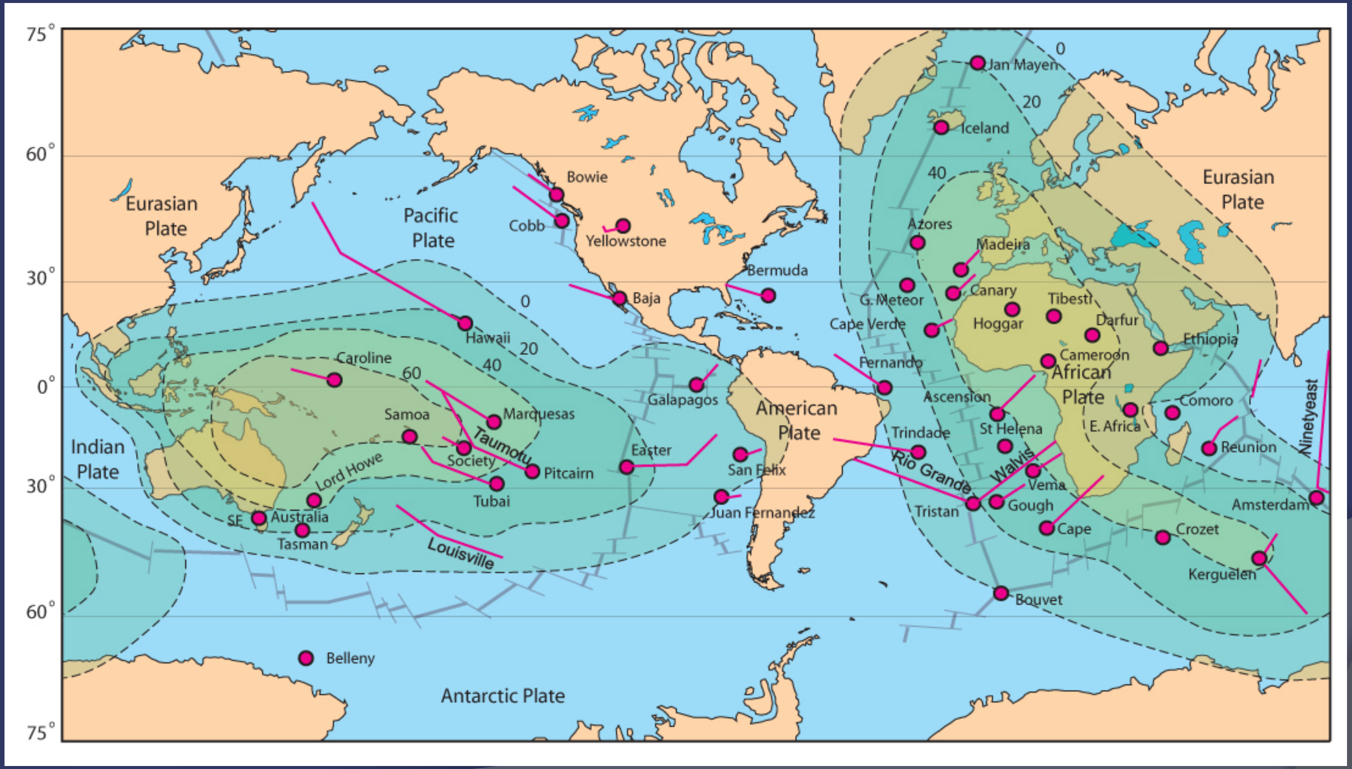


Fig. 14.1 in Winters

Ocean Island Basalt (OIB)

- Facts:
  - Commonly associated with “hot spot”
  - Much bigger compositional variations
    - Series: strongly alkaline to tholeiitic

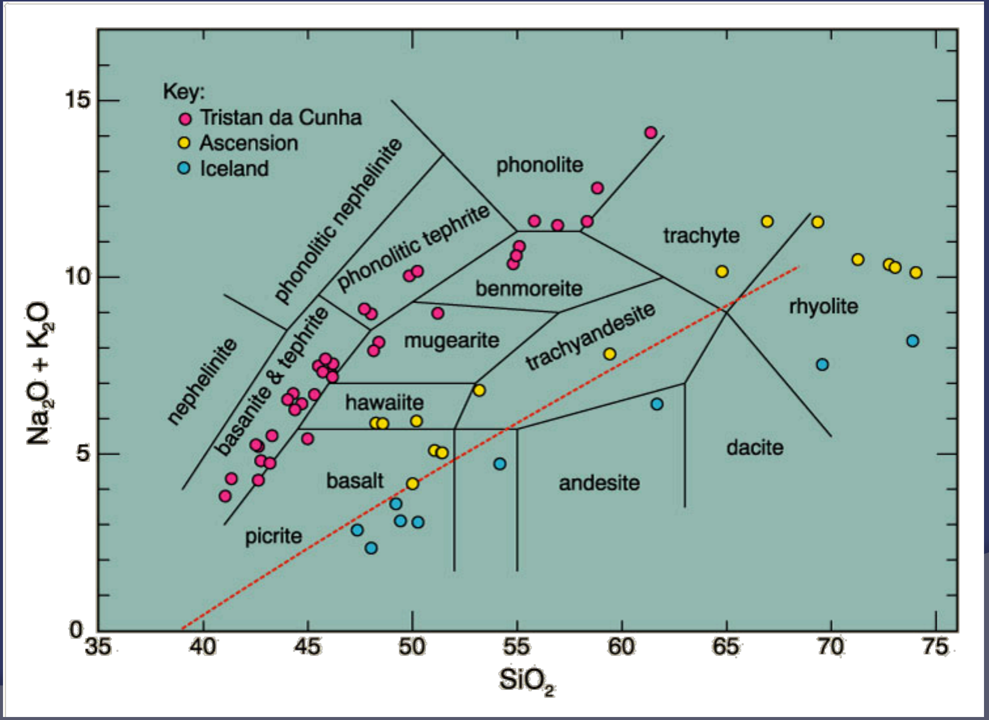


Fig. 14.3 in Winters

Ocean Island Basalt (OIB)

- Facts:
  - Commonly associated with "hot spot"
  - Much bigger compositional variations
    - Series: strongly alkaline to tholeiitic
    - Trace elements

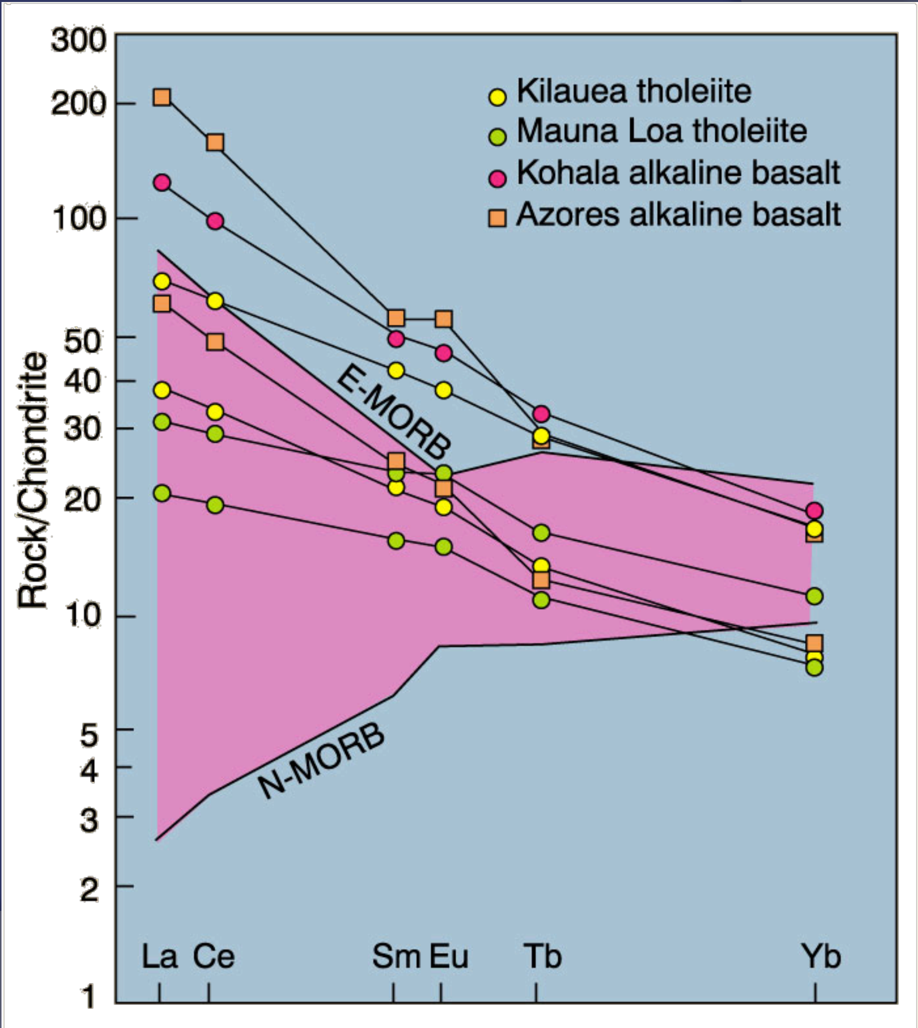
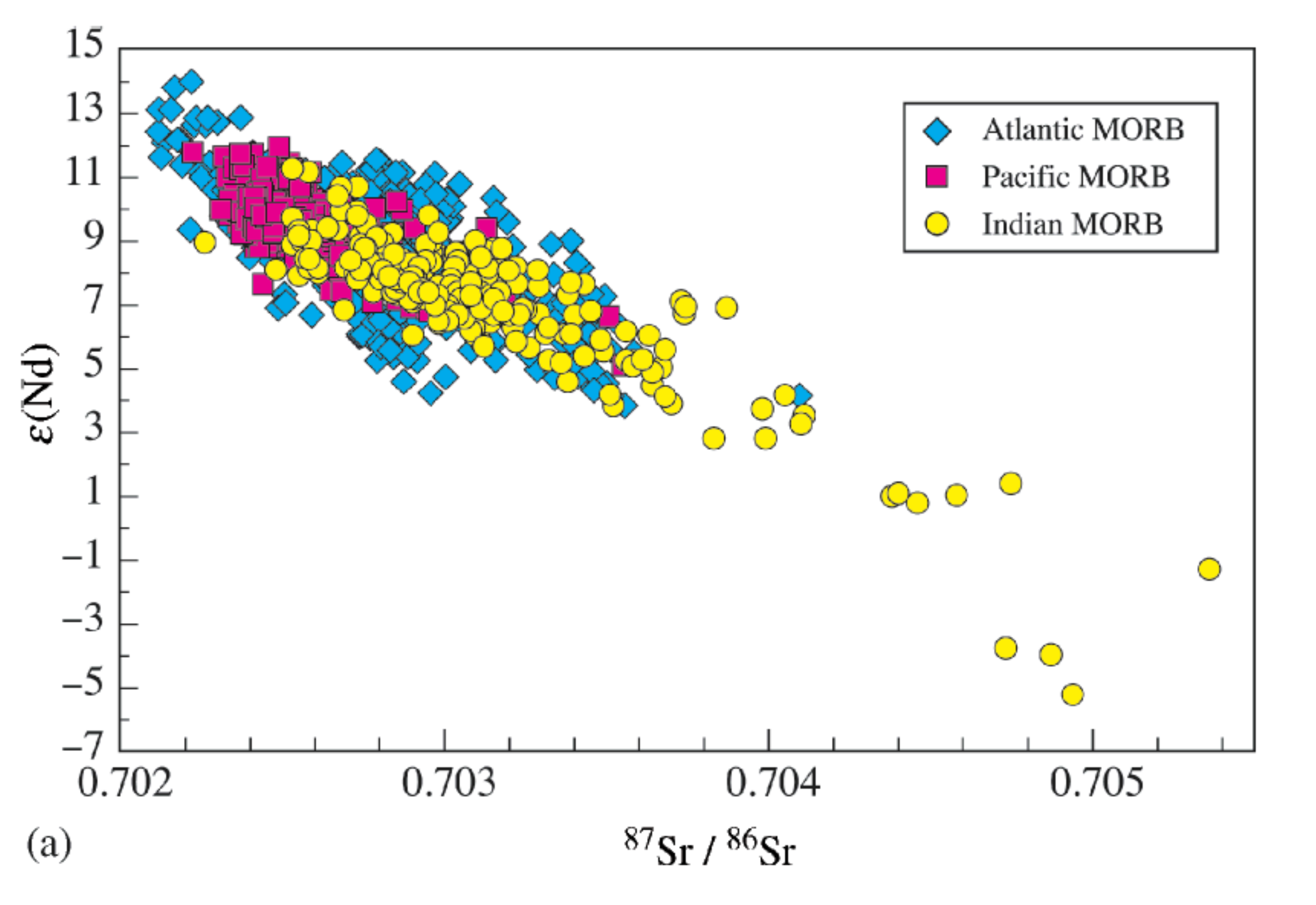


Fig. 14.4 in Winters

Ocean Island Basalt (OIB)

- Facts:
  - Commonly associated with “hot spot”
  - Much bigger compositional variations
    - Series: strongly alkaline to tholeiitic
    - Trace elements
    - Isotopes



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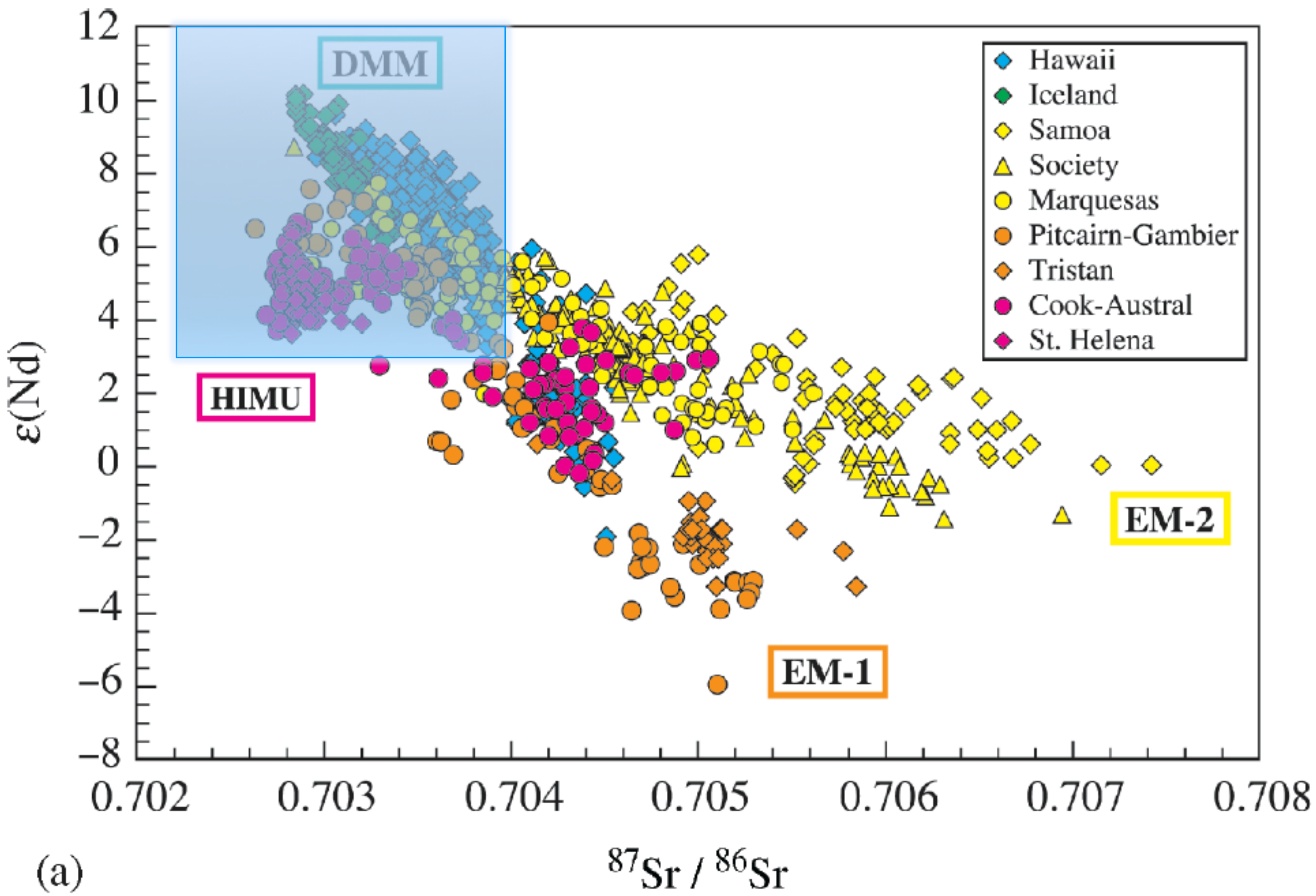

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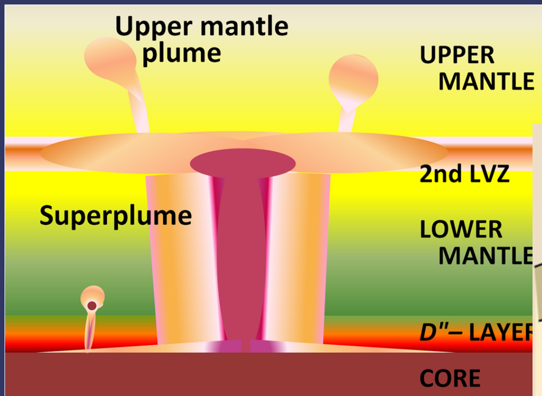
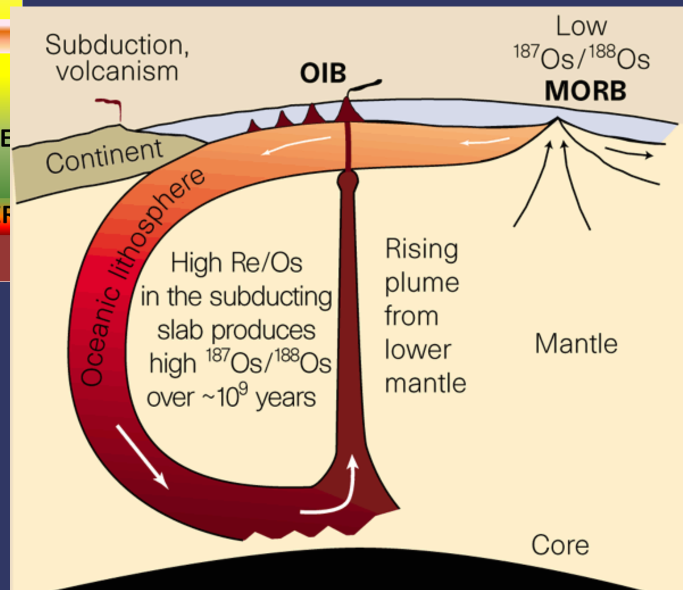
Ocean Island Basalt (OIB)

- Facts:
  - Commonly associated with “hot spot”
  - Much bigger compositional variations
    - Series: strongly alkaline to tholeiitic
    - Trace elements
    - Isotopes
- Summary:
  - Decompression melting of a high temperature and strongly heterogeneous mantle source

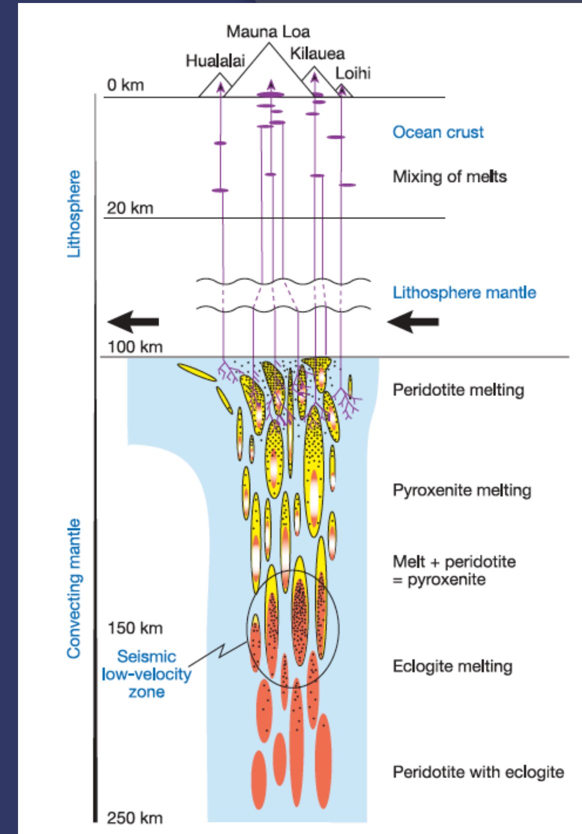
OIB Mantle source?



Matyska, 2007, GSA

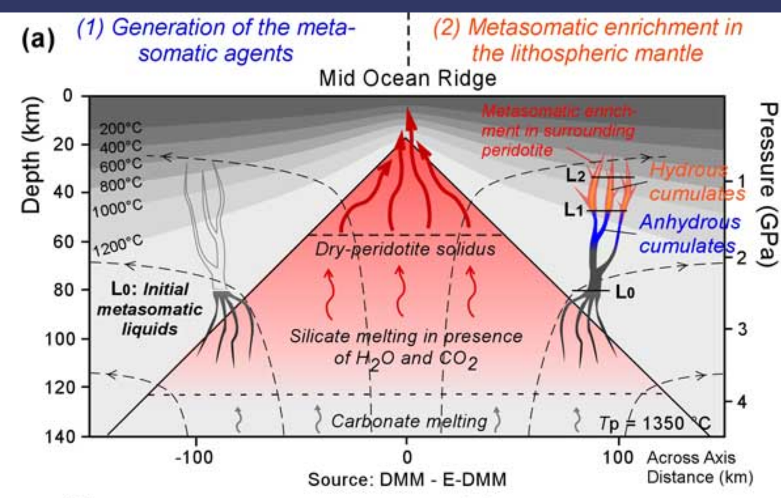


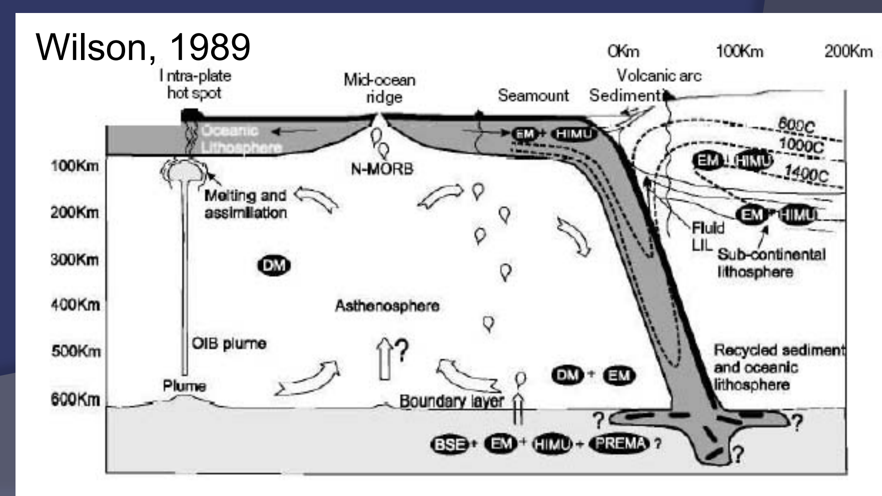
Halliday, Nature, 1999



Sobolev et al., Science, 2005

Pilet et al., Nature, 2011





NEXT TIME

Magmatism in subduction zone

TO READ:

Chapters 16-17

FIGURE PRESENTATION