Geochemical Constraints on Archean Mantle Dynamics

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Geochemistry and Geodynamics

- Historically has been focused on reservoirs (primitive mantle, EM1, EM2, HIMU,D"…)

- New data constrain ages and timescales of mantle processes

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Main points

- Helium isotopes do not require a primitive mantle or layered mantle convection

- Mantle evolution is punctuated by large melting events in the Archean/Proterozoic
- The source of plumes (ocean islands) has ancient (> 2 Ga) heterogeneities in it
- Mixing time in the convecting mantle is < 2 Ga old

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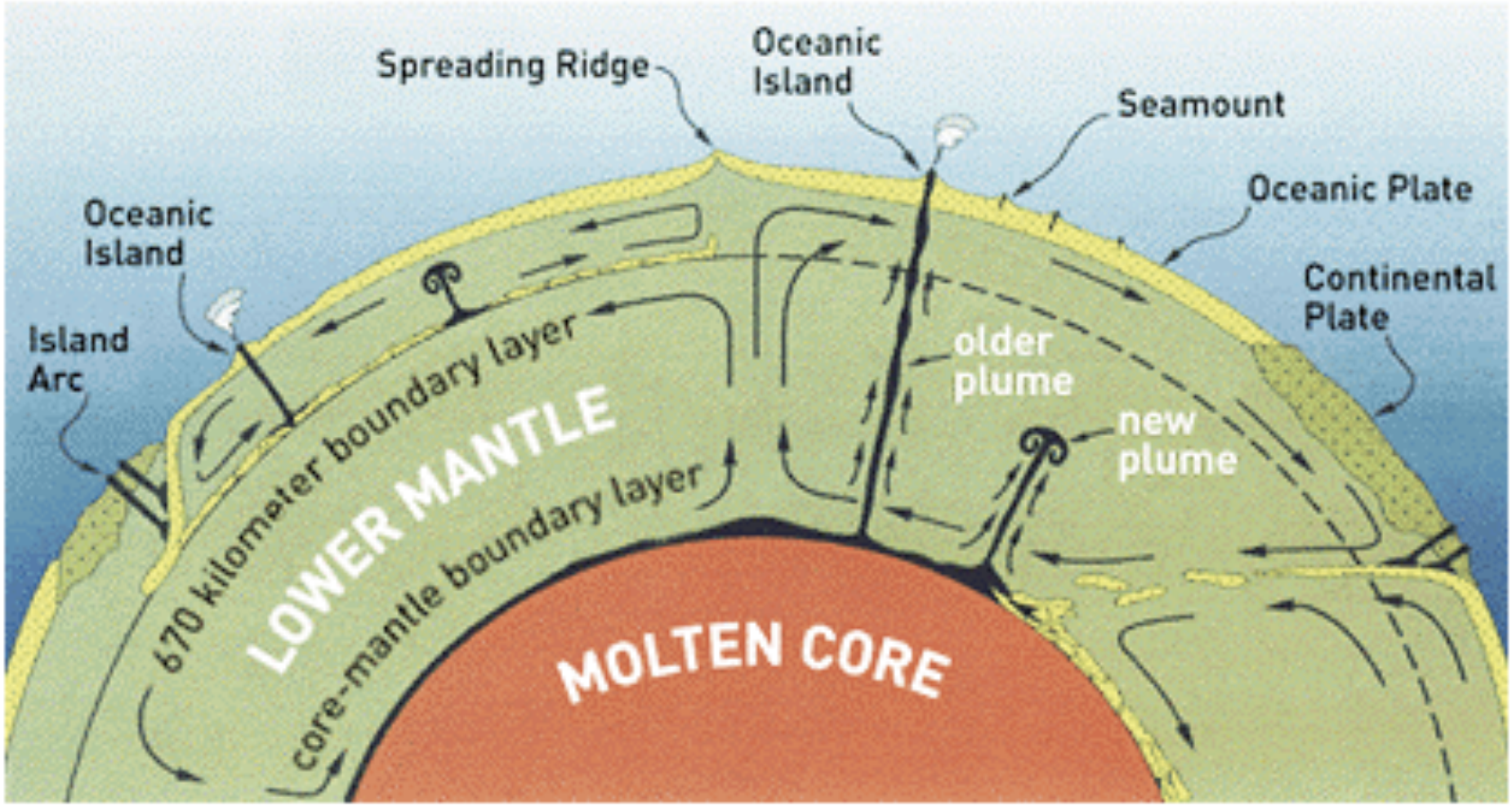
Pattern of Mantle Convection?



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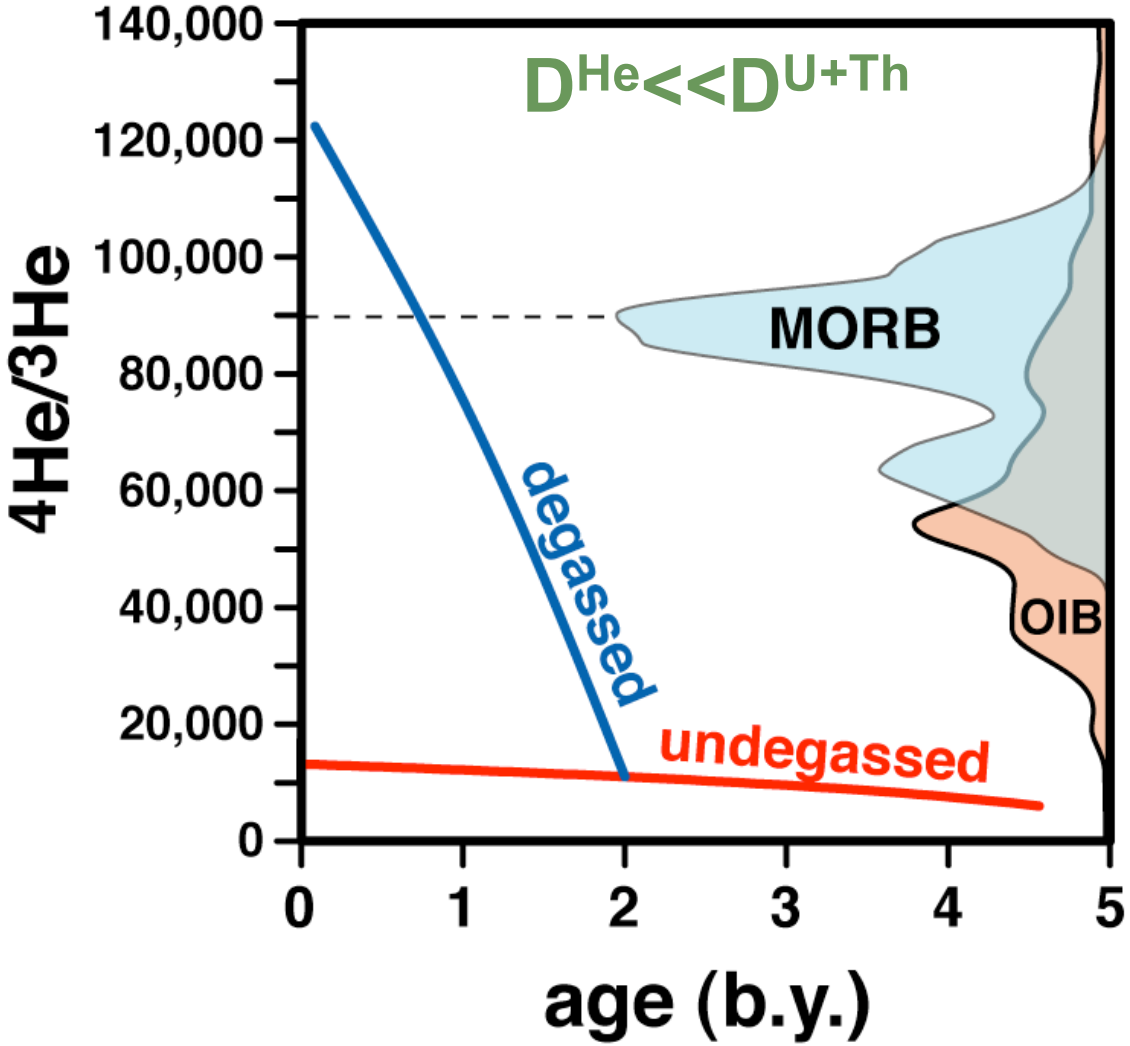
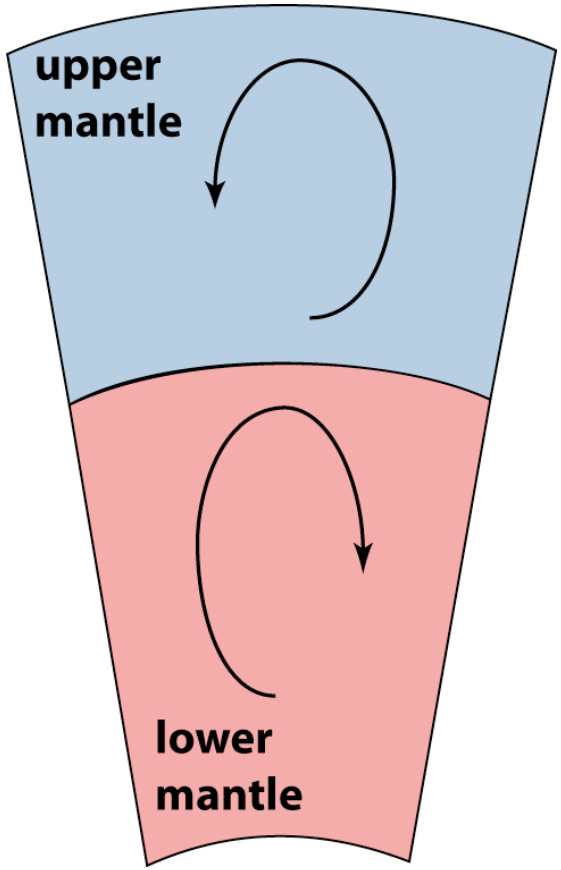
Layered mantle convection





Allegre, Kurz,
Moreira, Porcelli…

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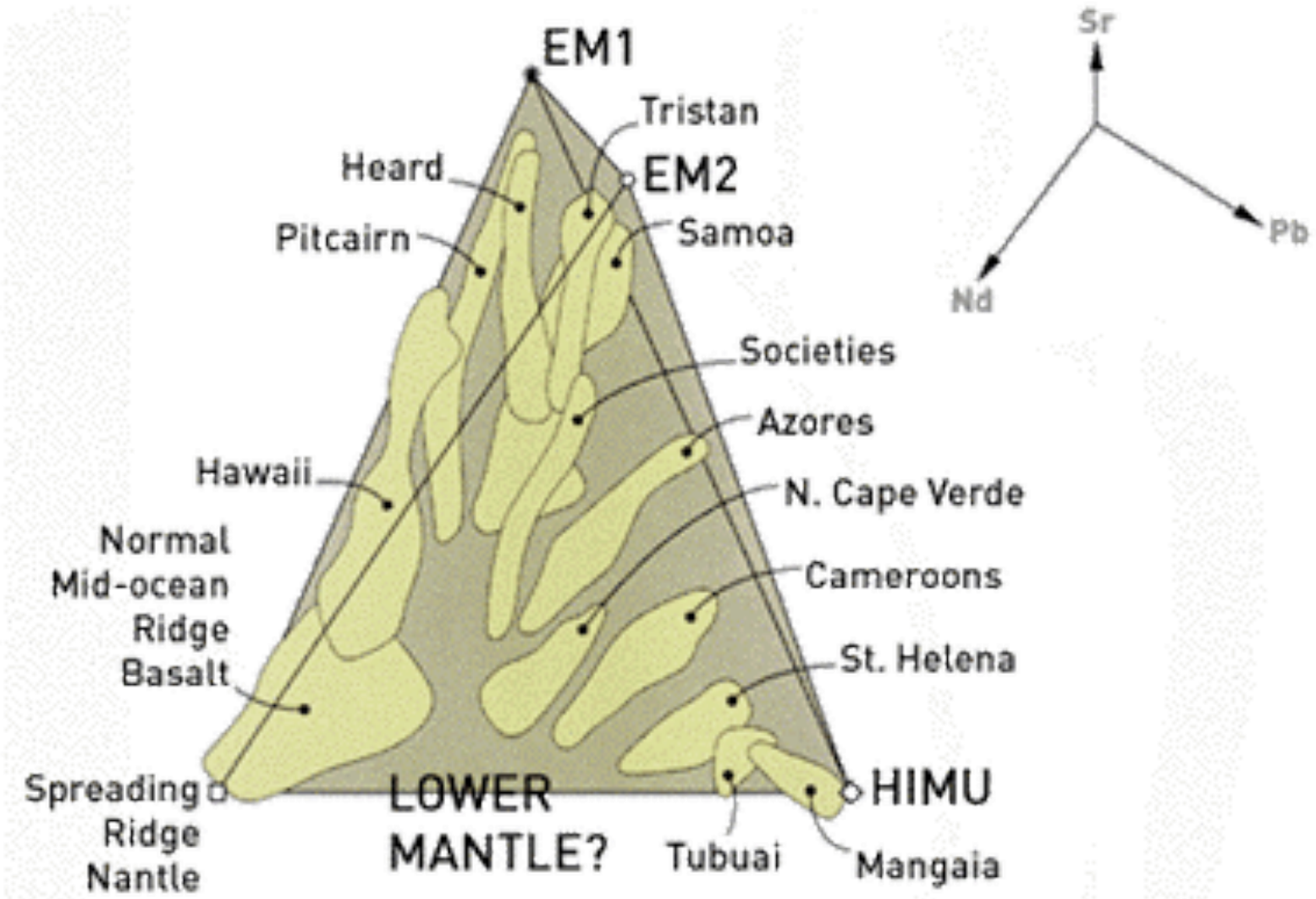

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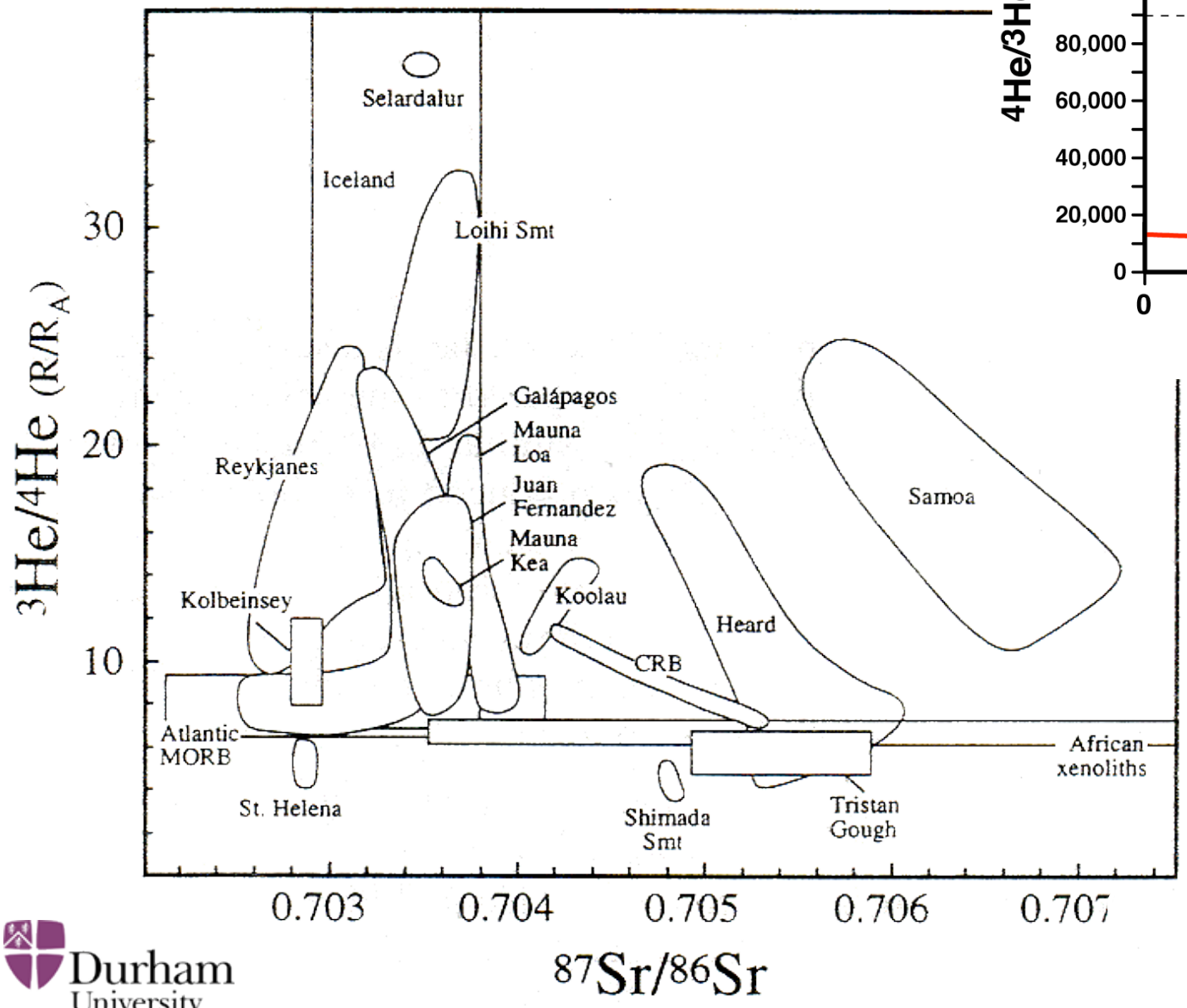
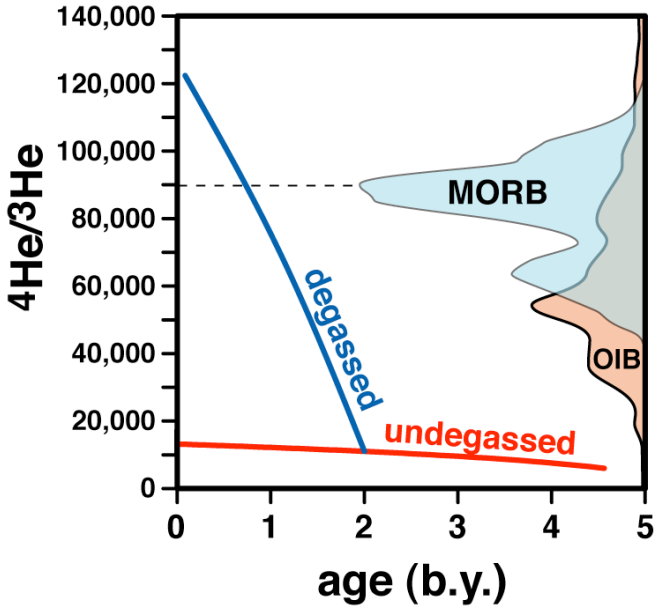
Zindler and Hart, 1986

Graham, 2002





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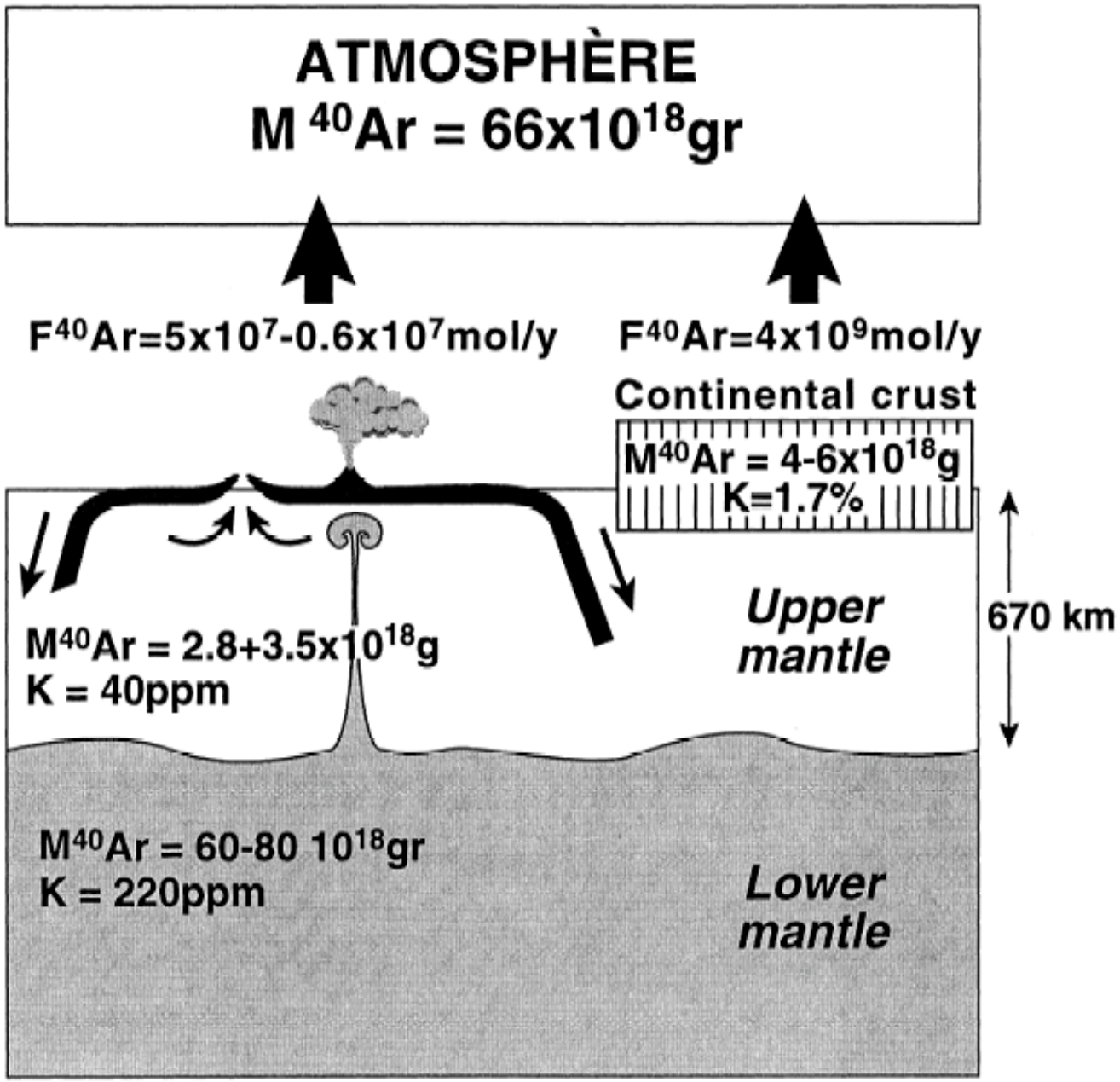

Allegre et al., 1996

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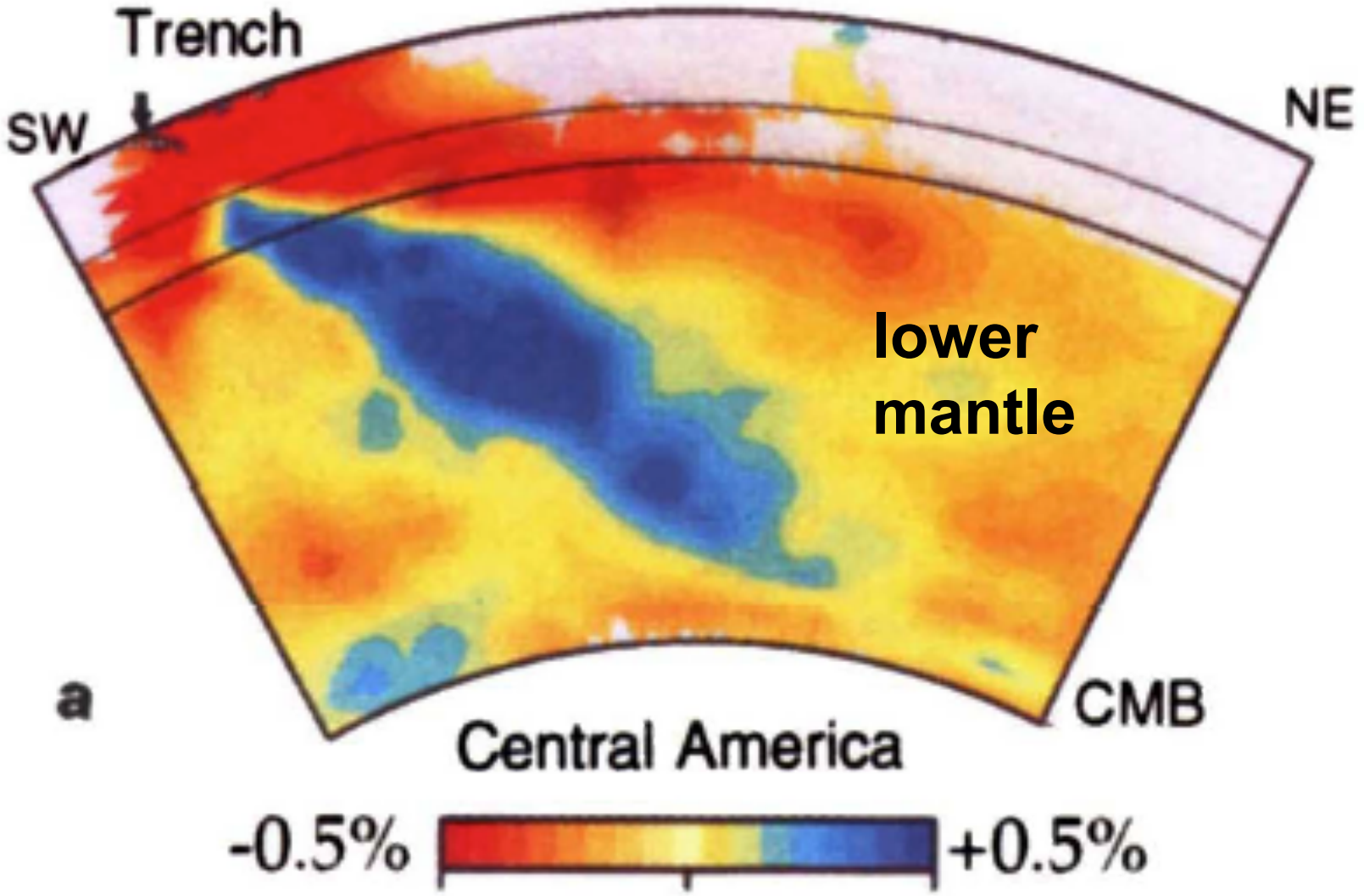
So what’s the problem?



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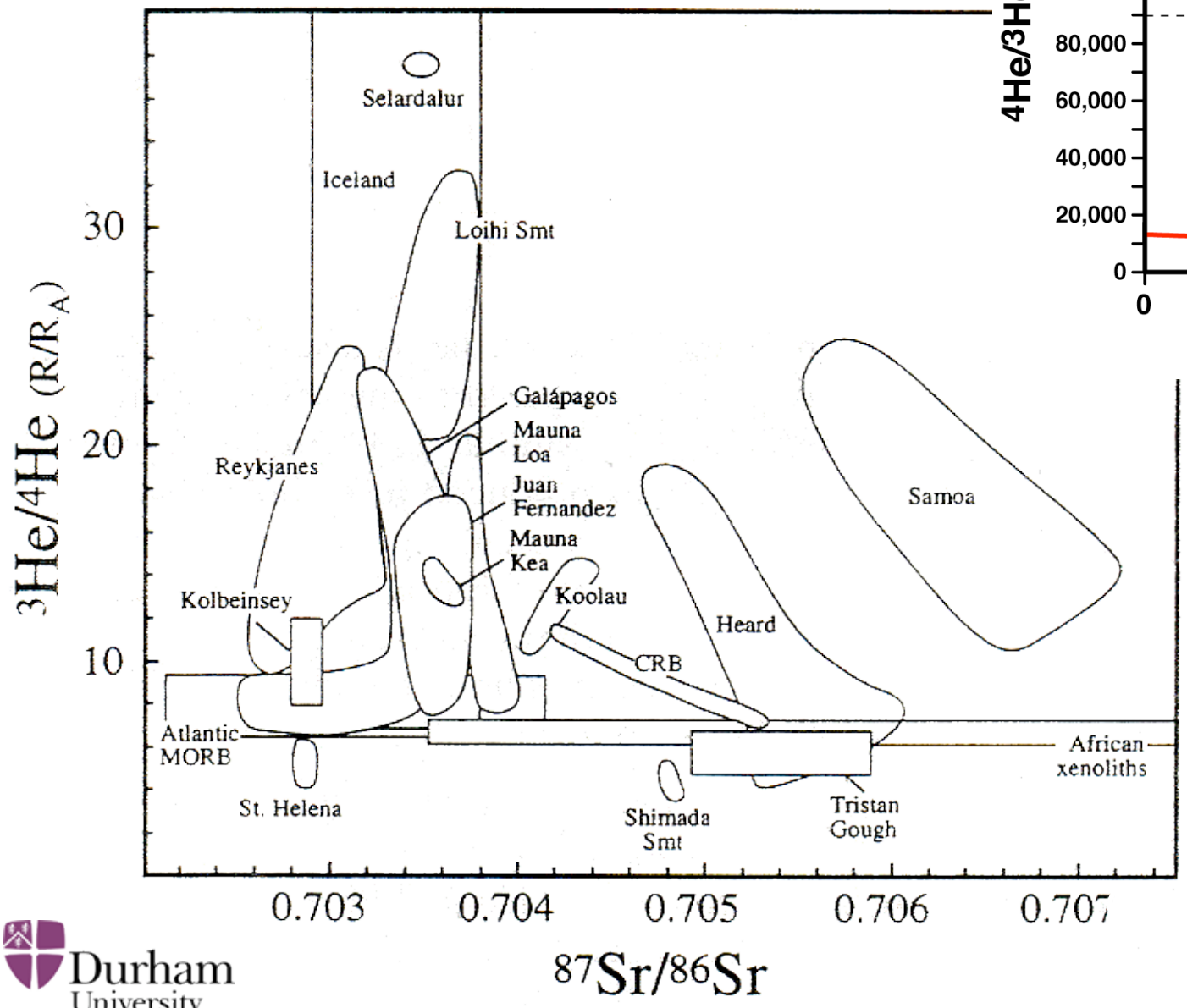
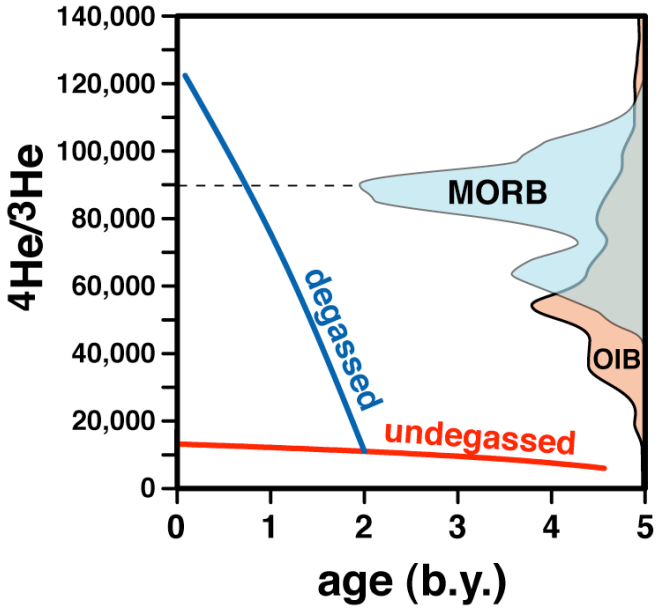
van der Hilst et al., 1997

Graham, 2002





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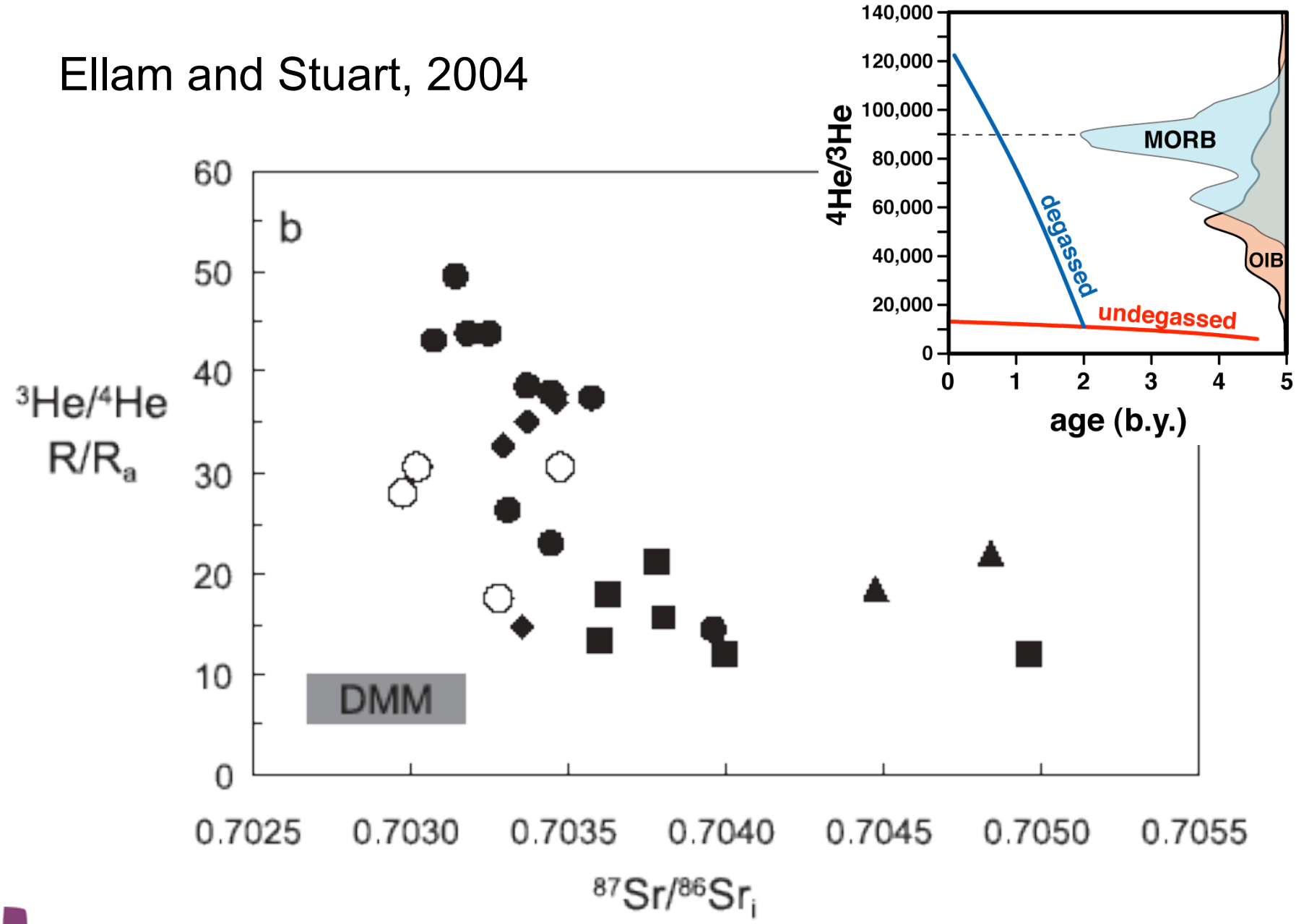
Ellam and Stuart, 2004



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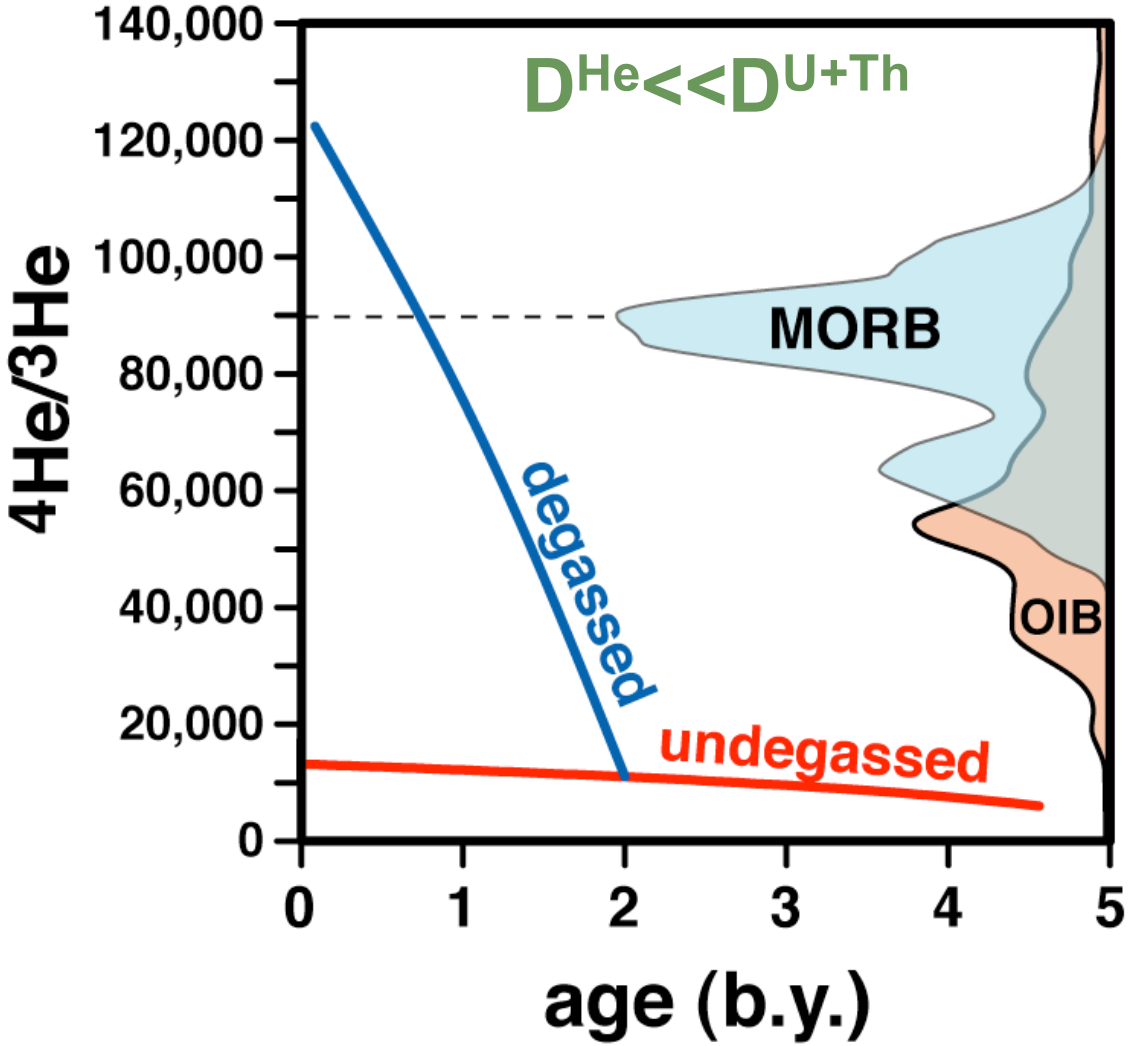
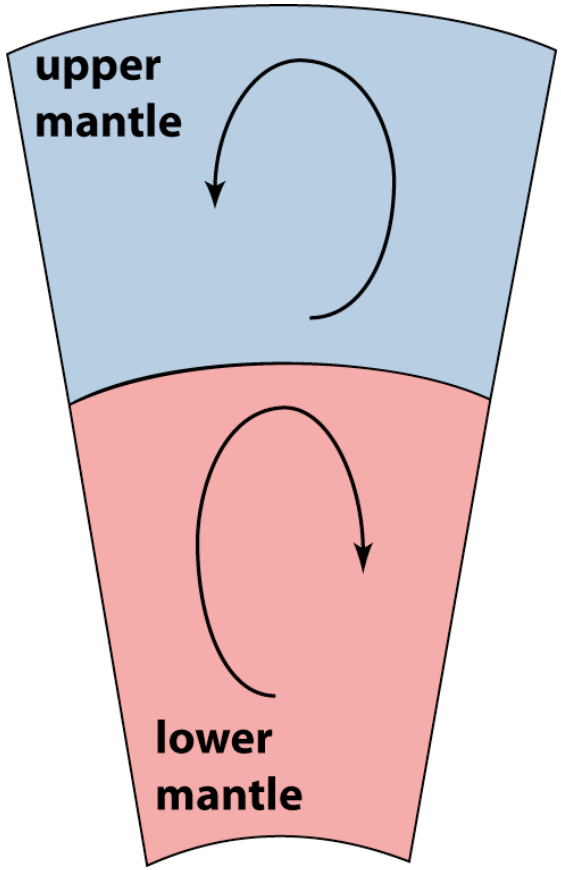
Layered mantle convection





Allegre, Kurz,
Moreira, Porcelli…

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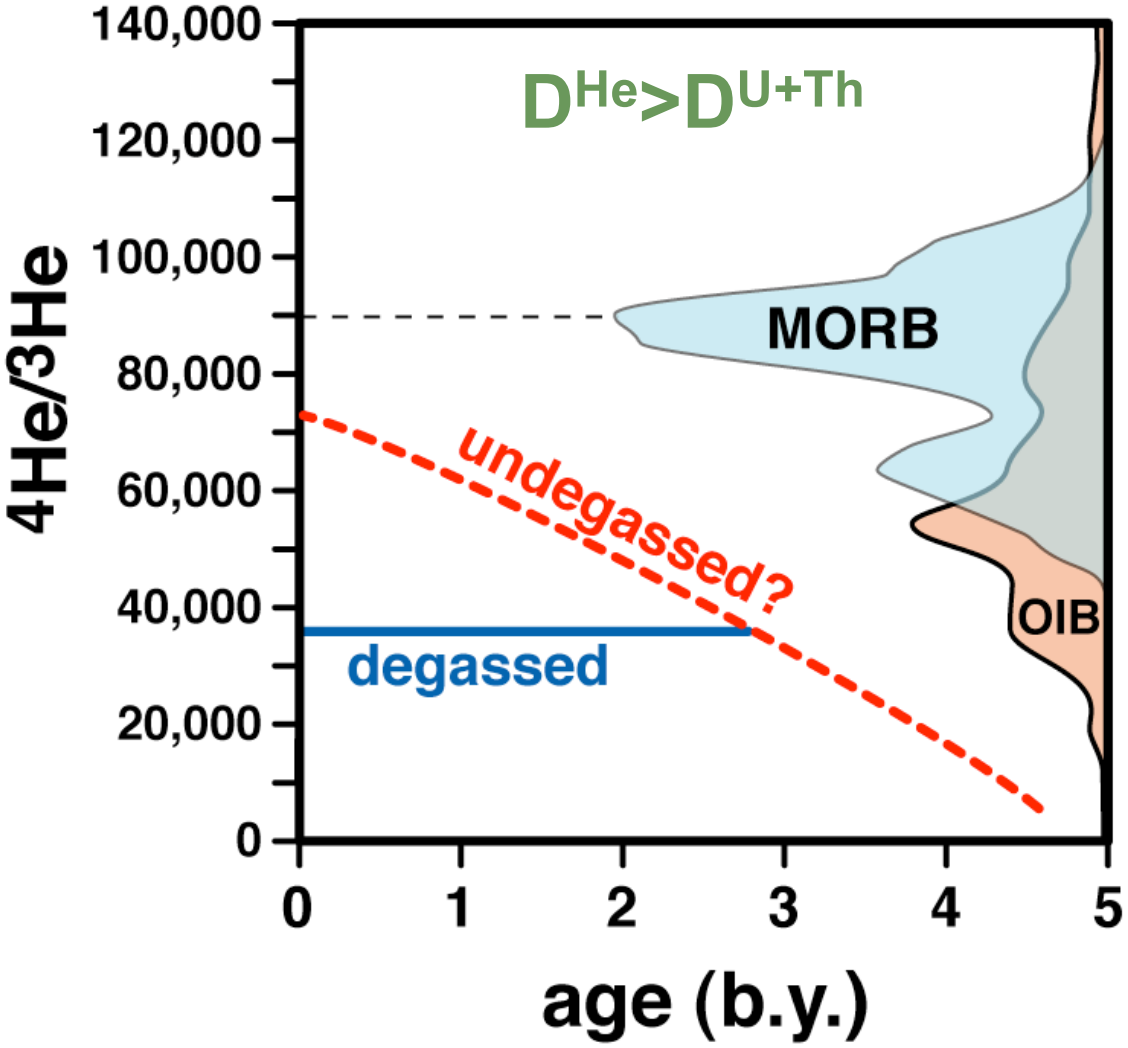
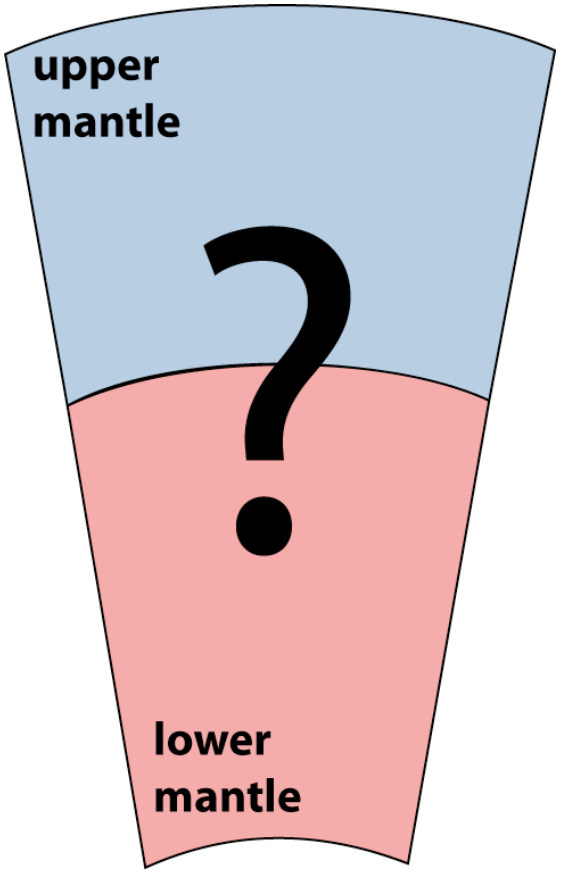
If He more compatible than U+Th…





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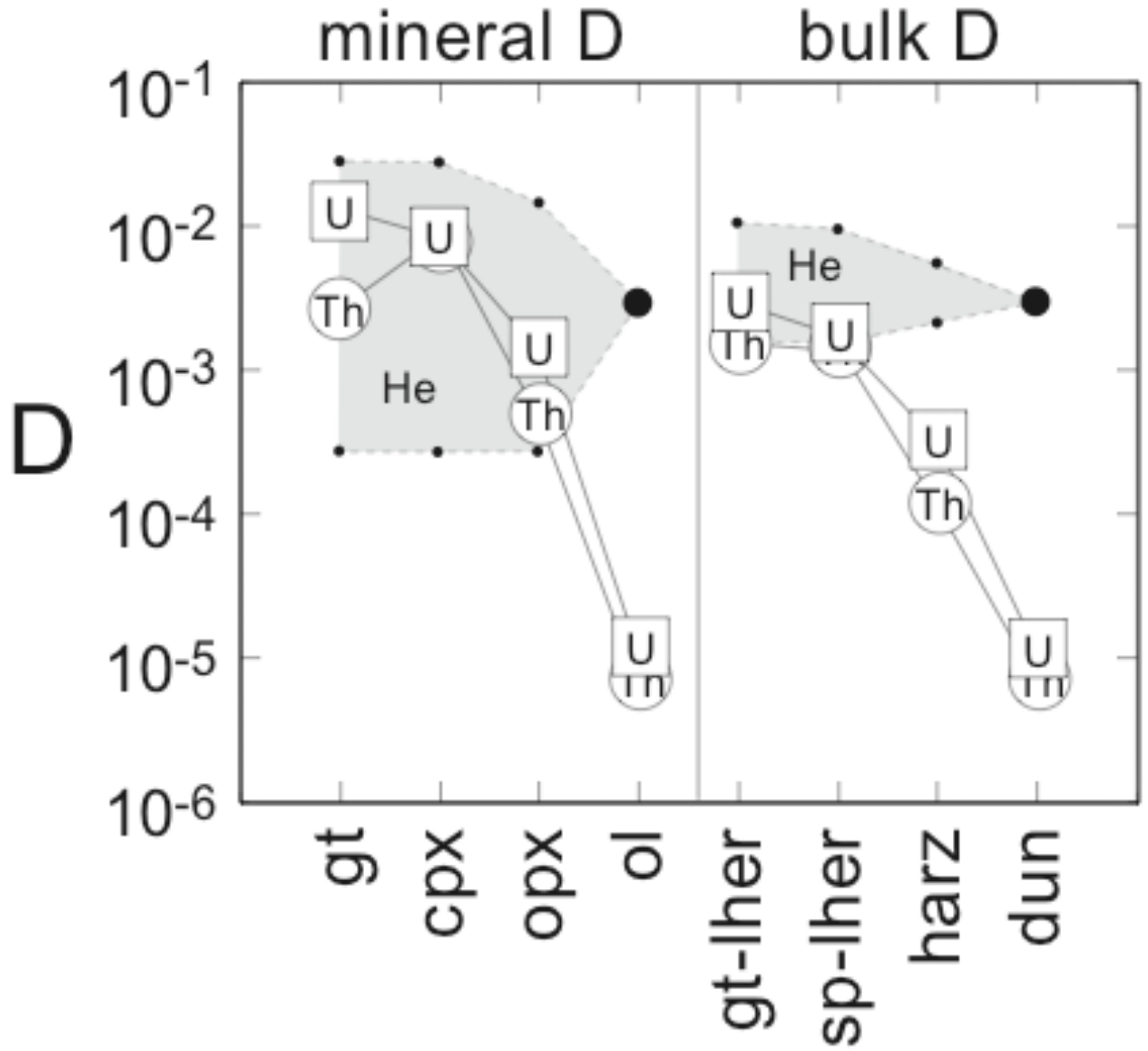

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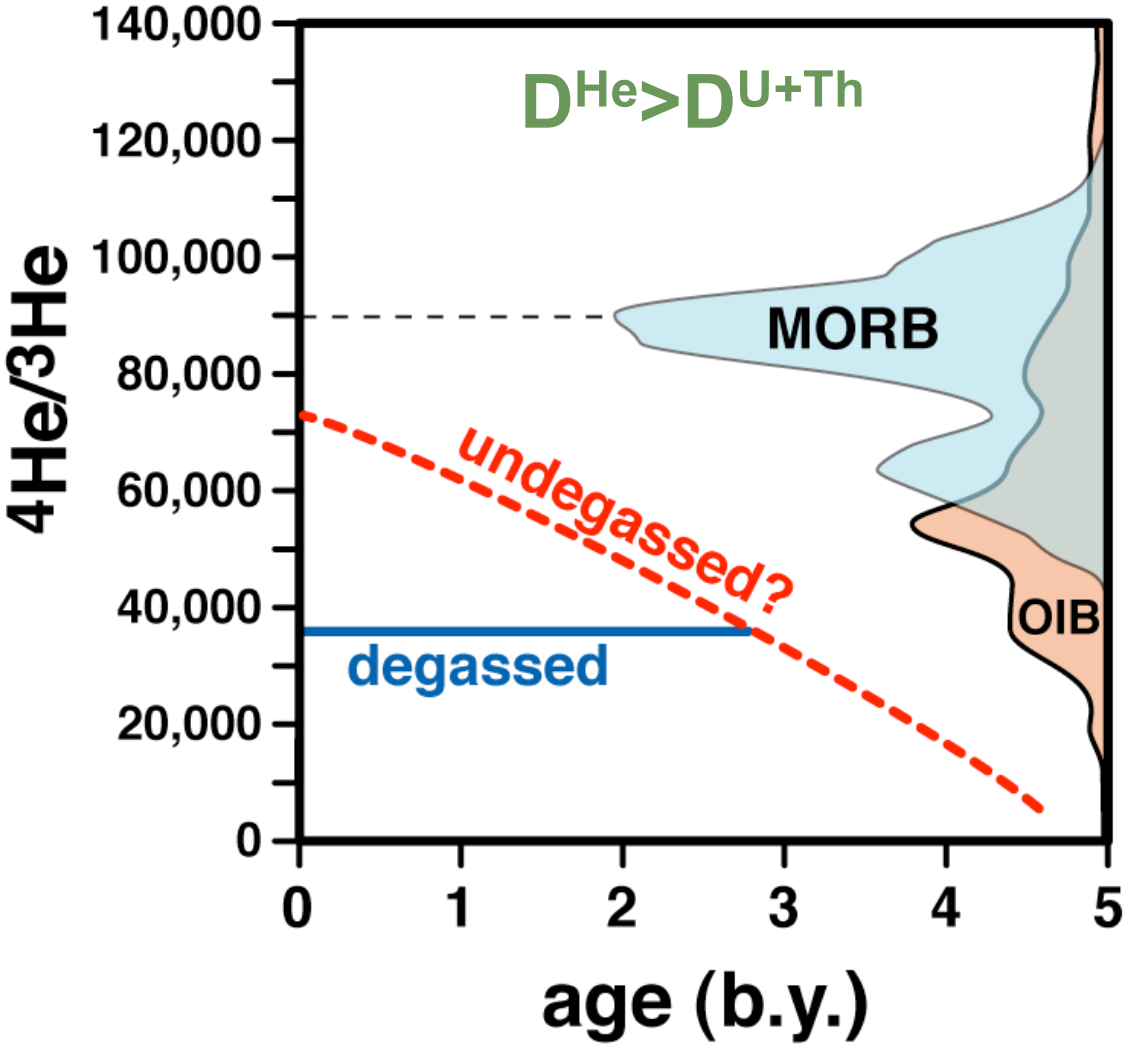
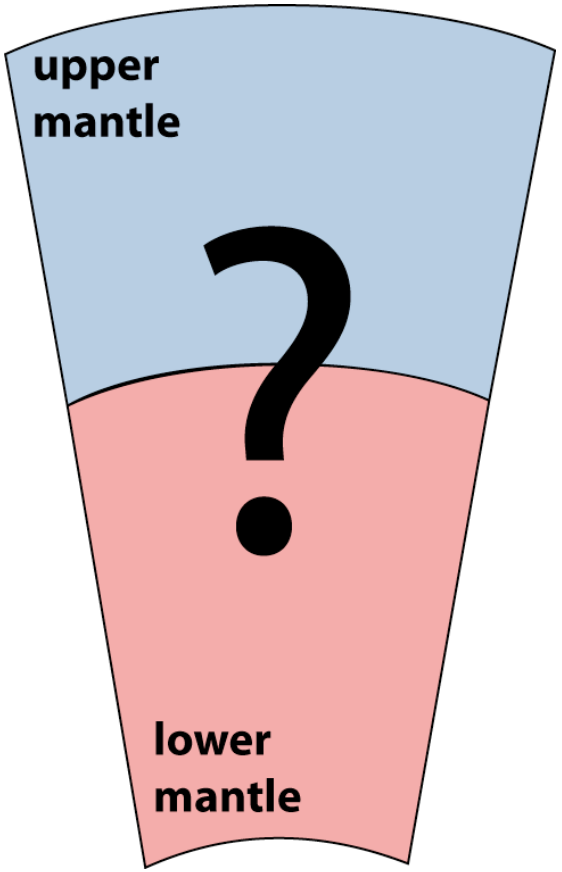
Parman et al., Nature 2005

If He more compatible than U+Th…





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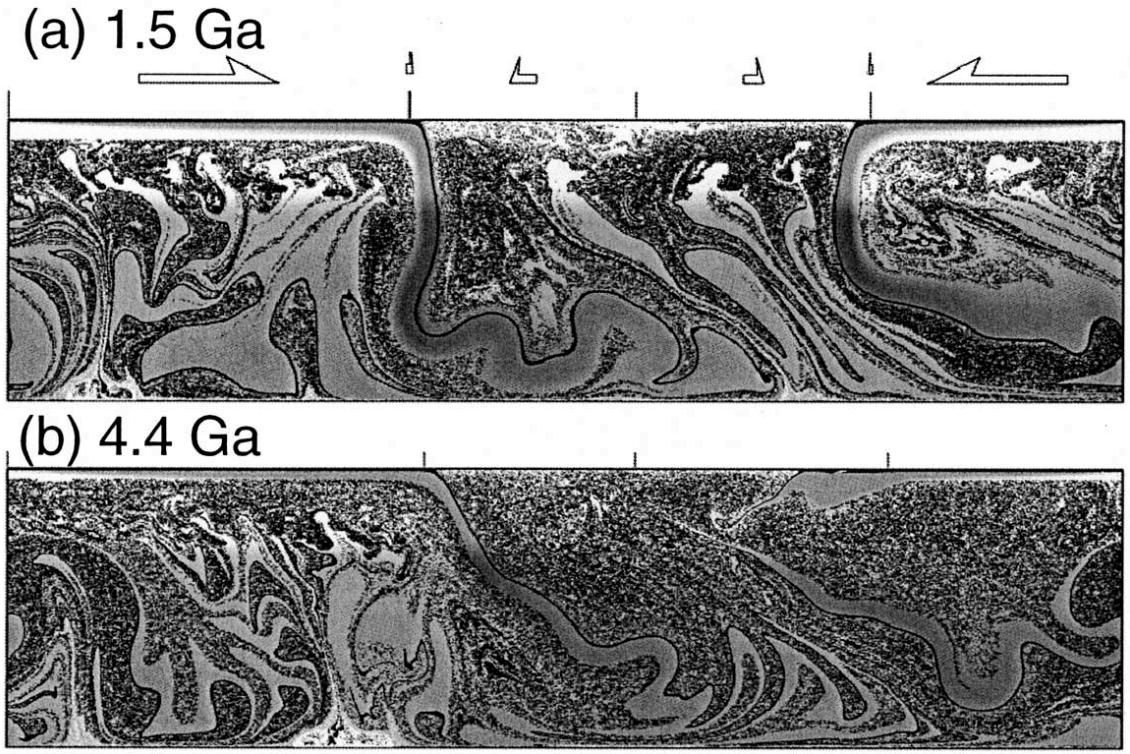
Implications

- Primitive mantle not required by He isotopes
- Whole mantle convection is consistent with data



Davies, 2002

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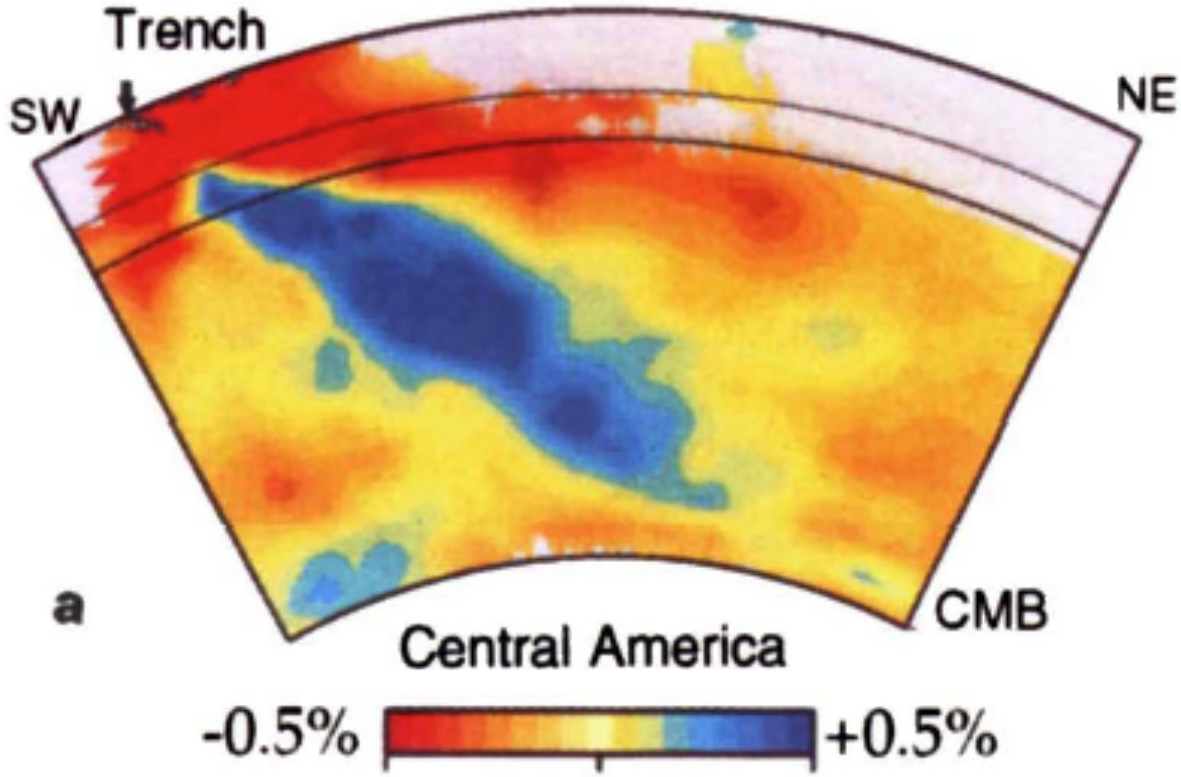
He isotopes do not require the existence of primitive mantle



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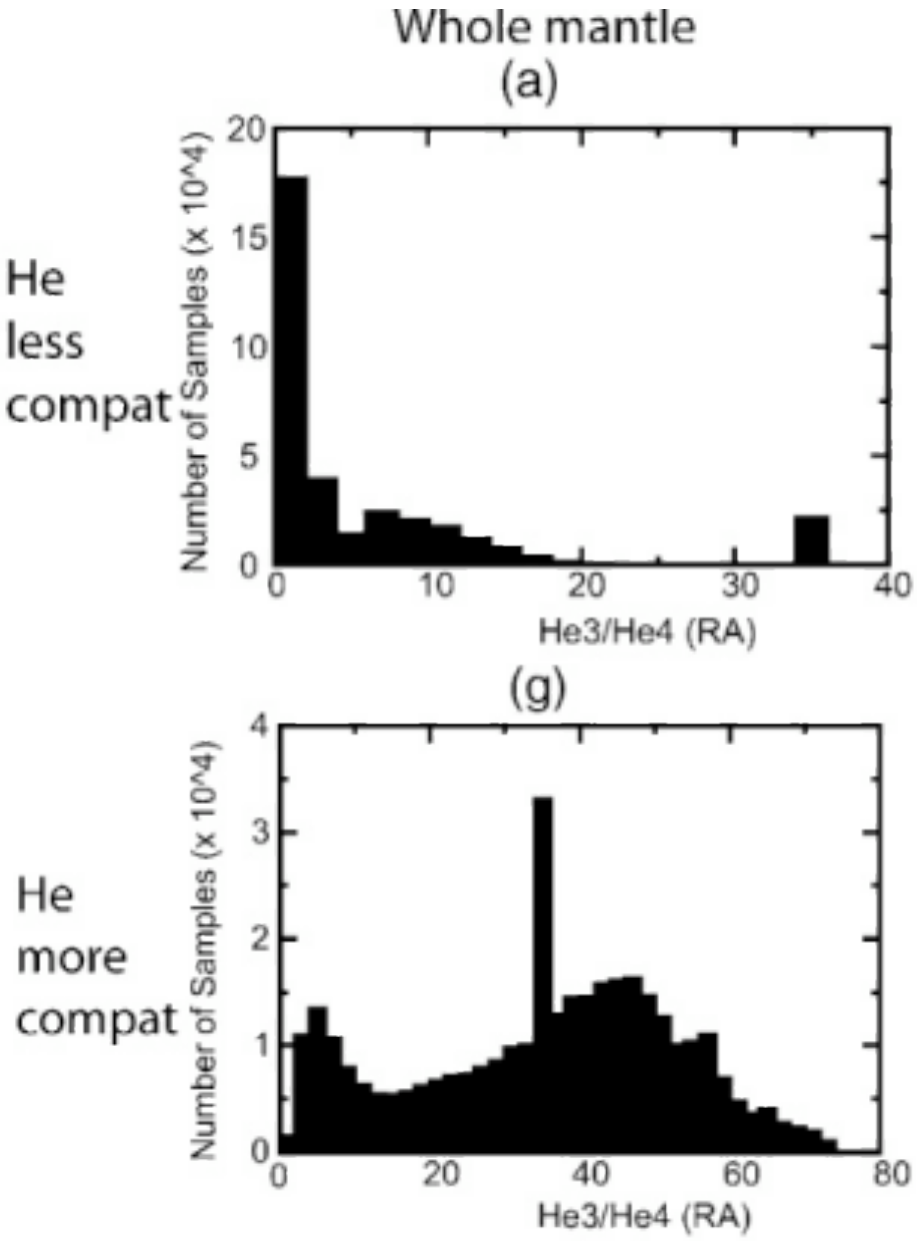
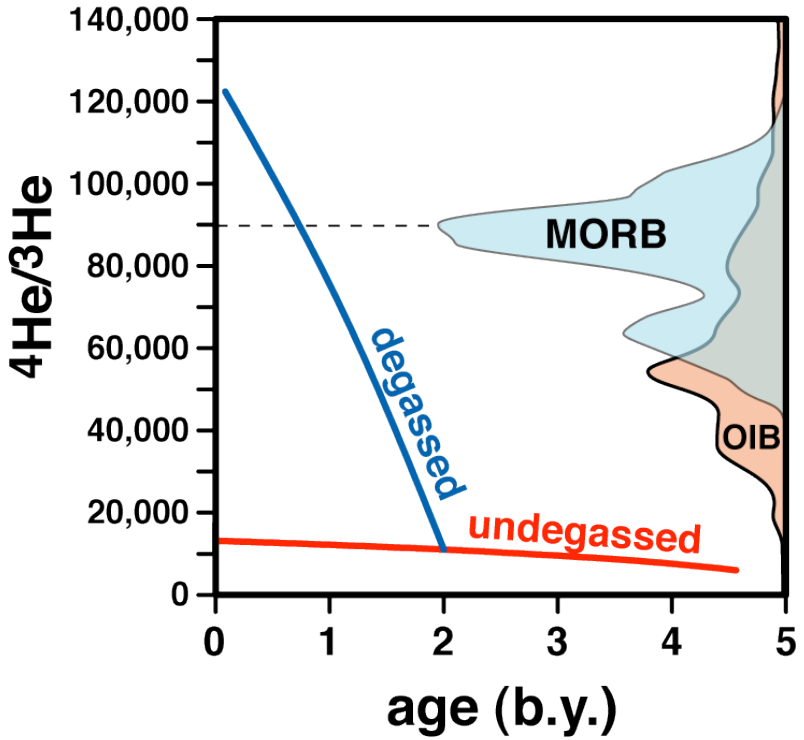


Xie & Tackley, 2004



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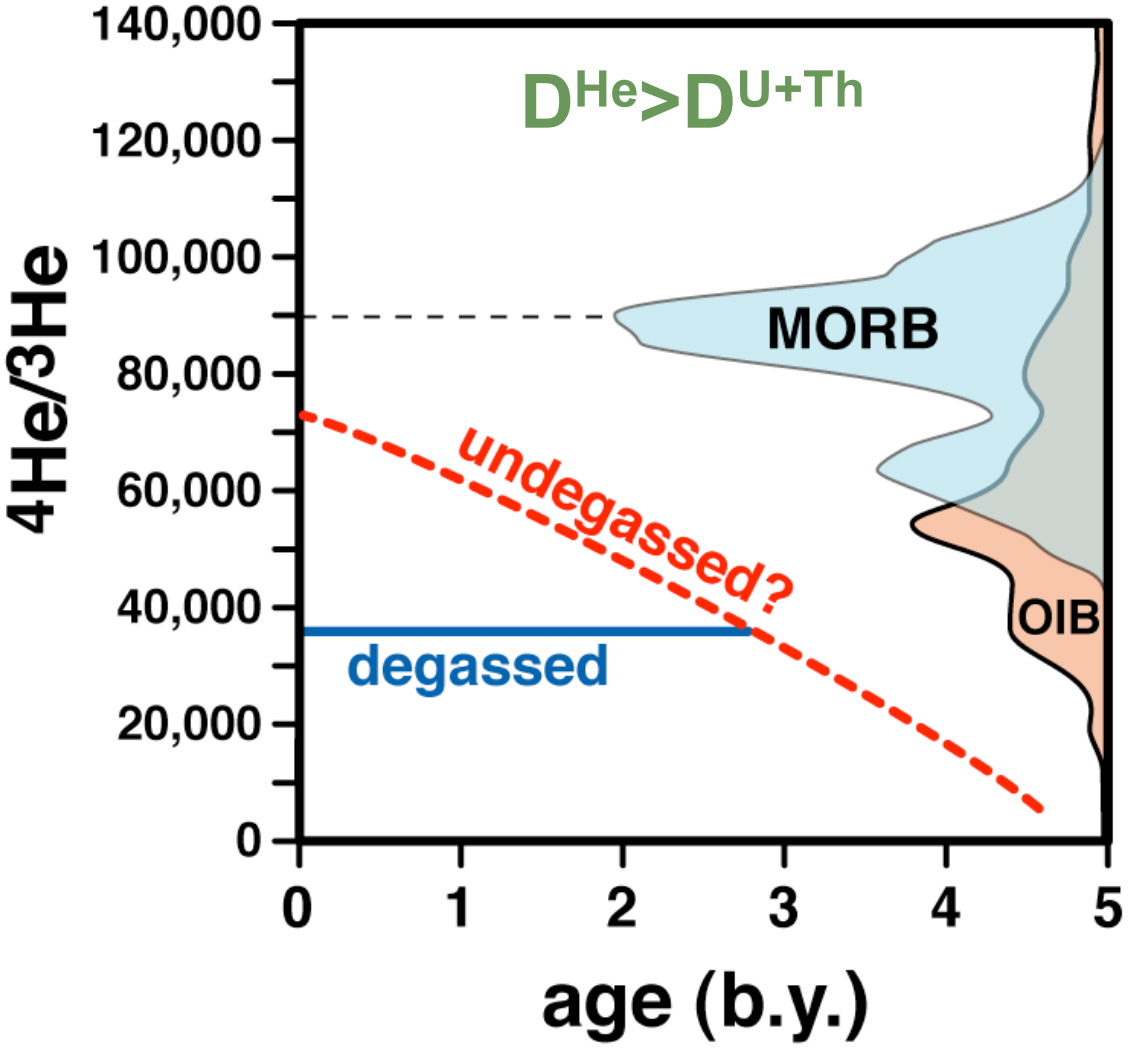

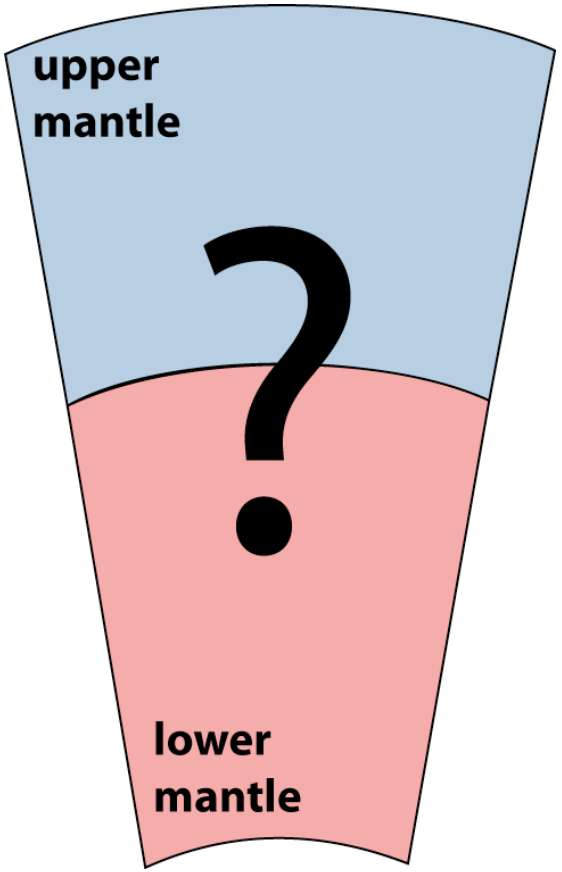

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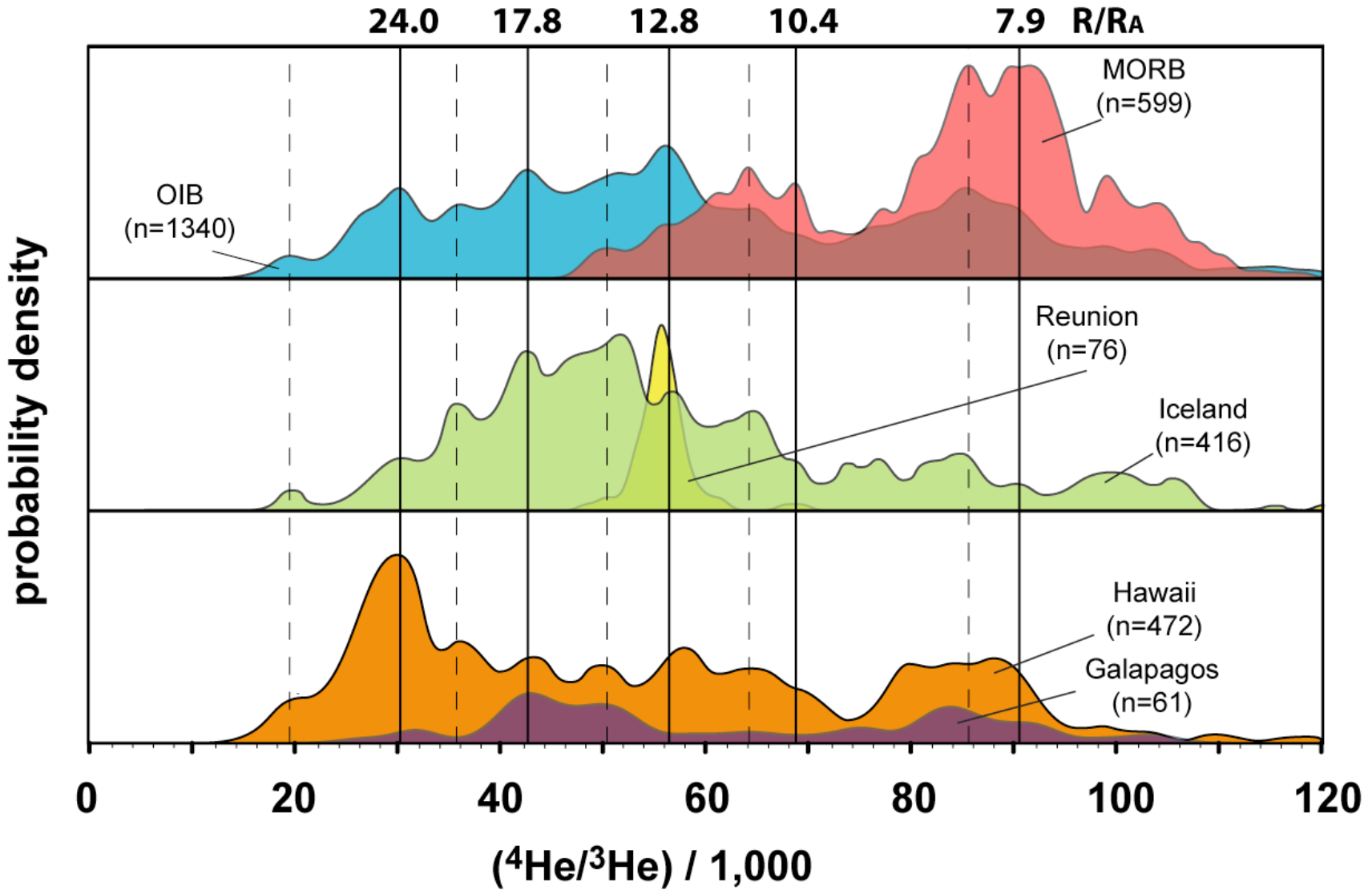

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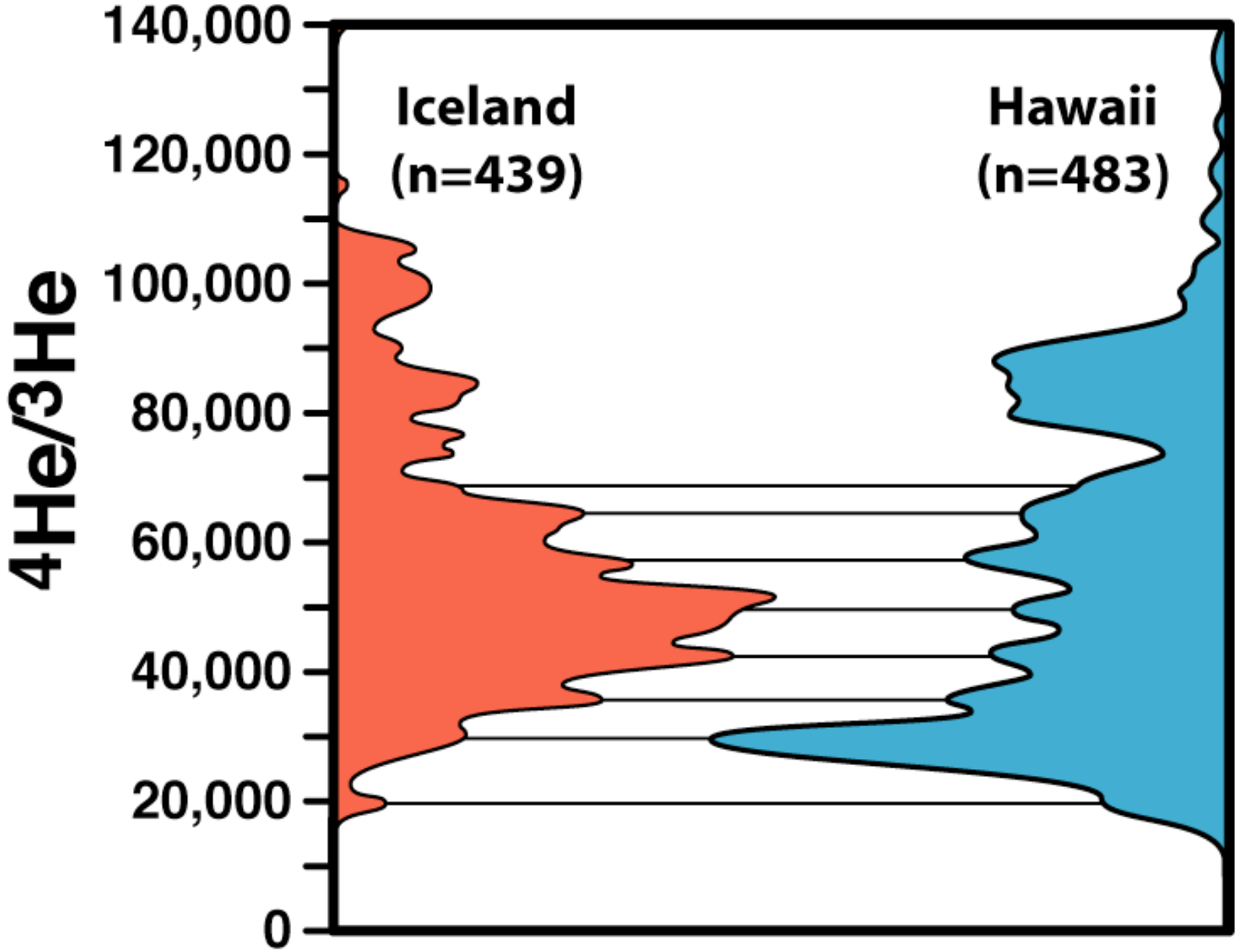
Database kindly provided by
Atosa Abedini, USGS



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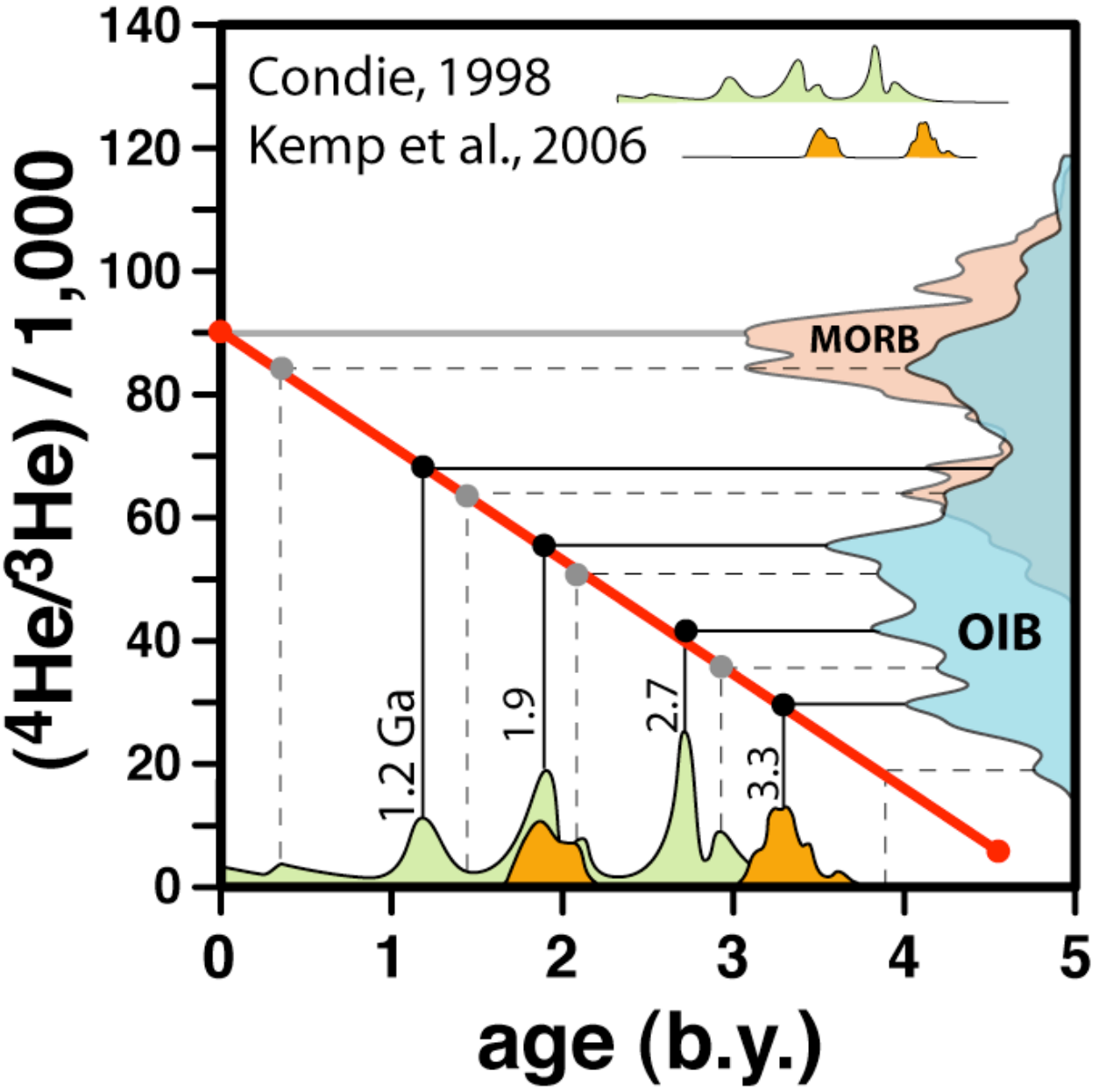
Parman, Nature, 2007



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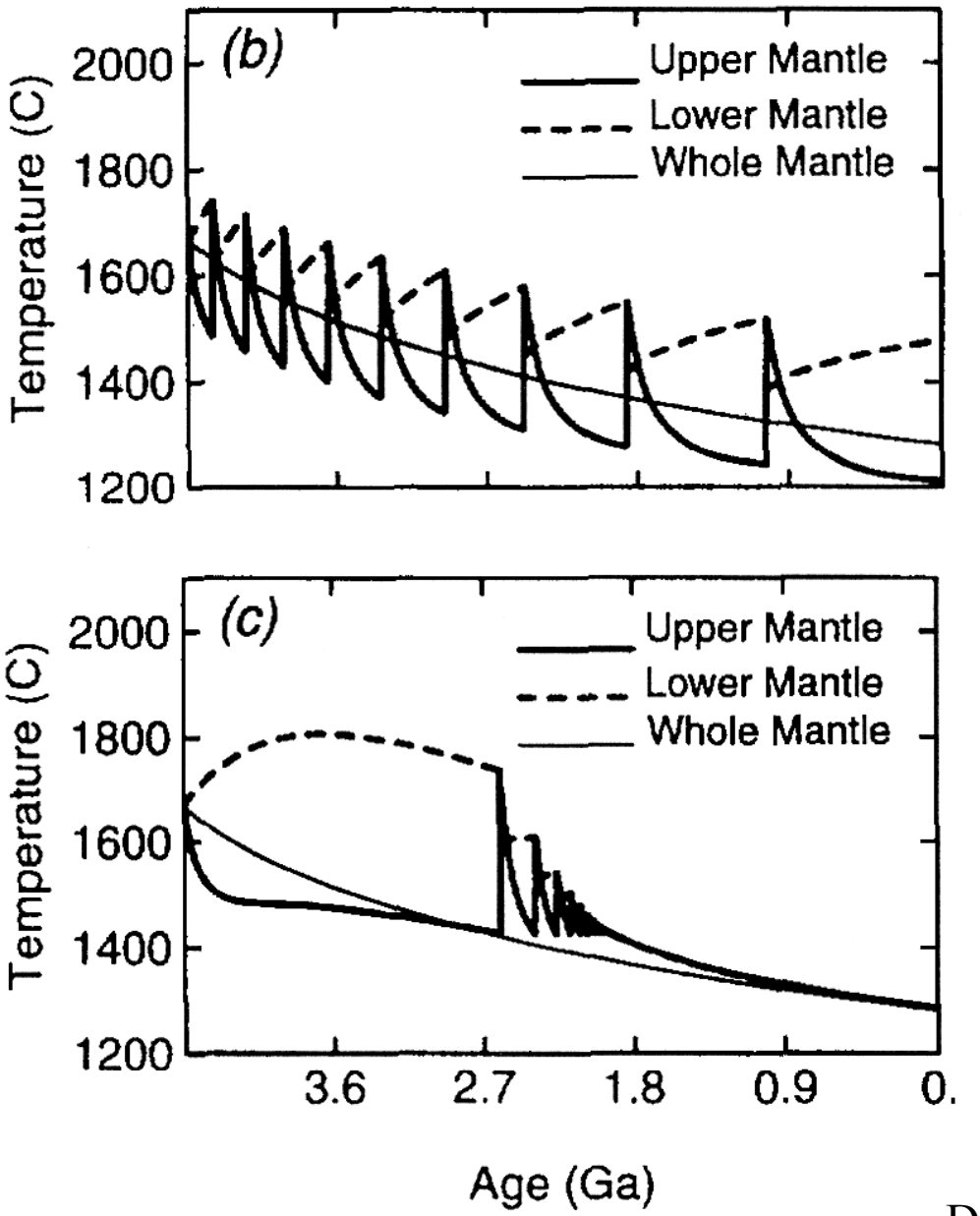
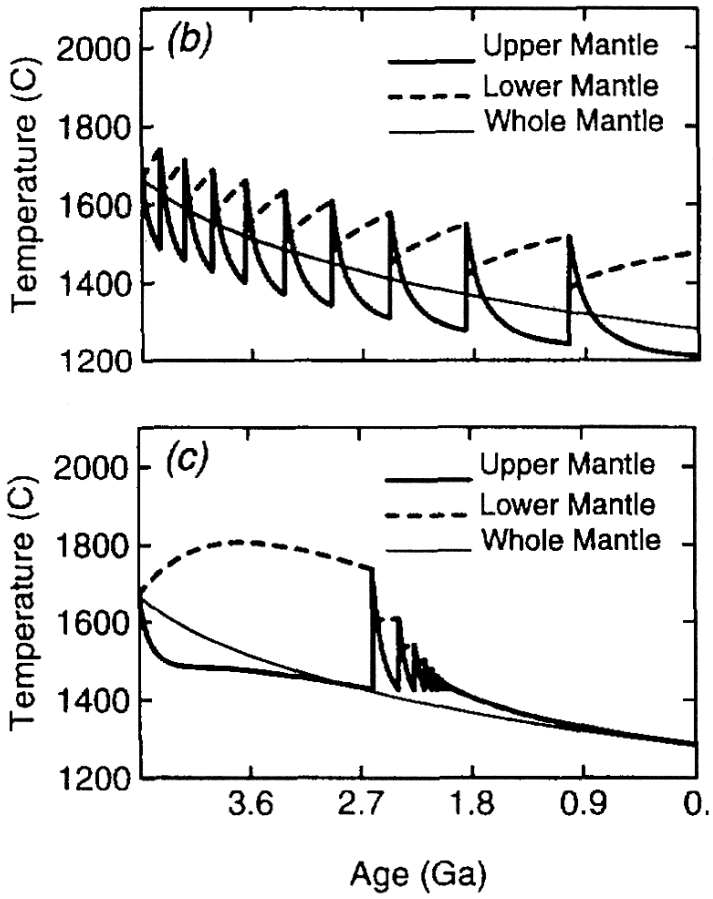


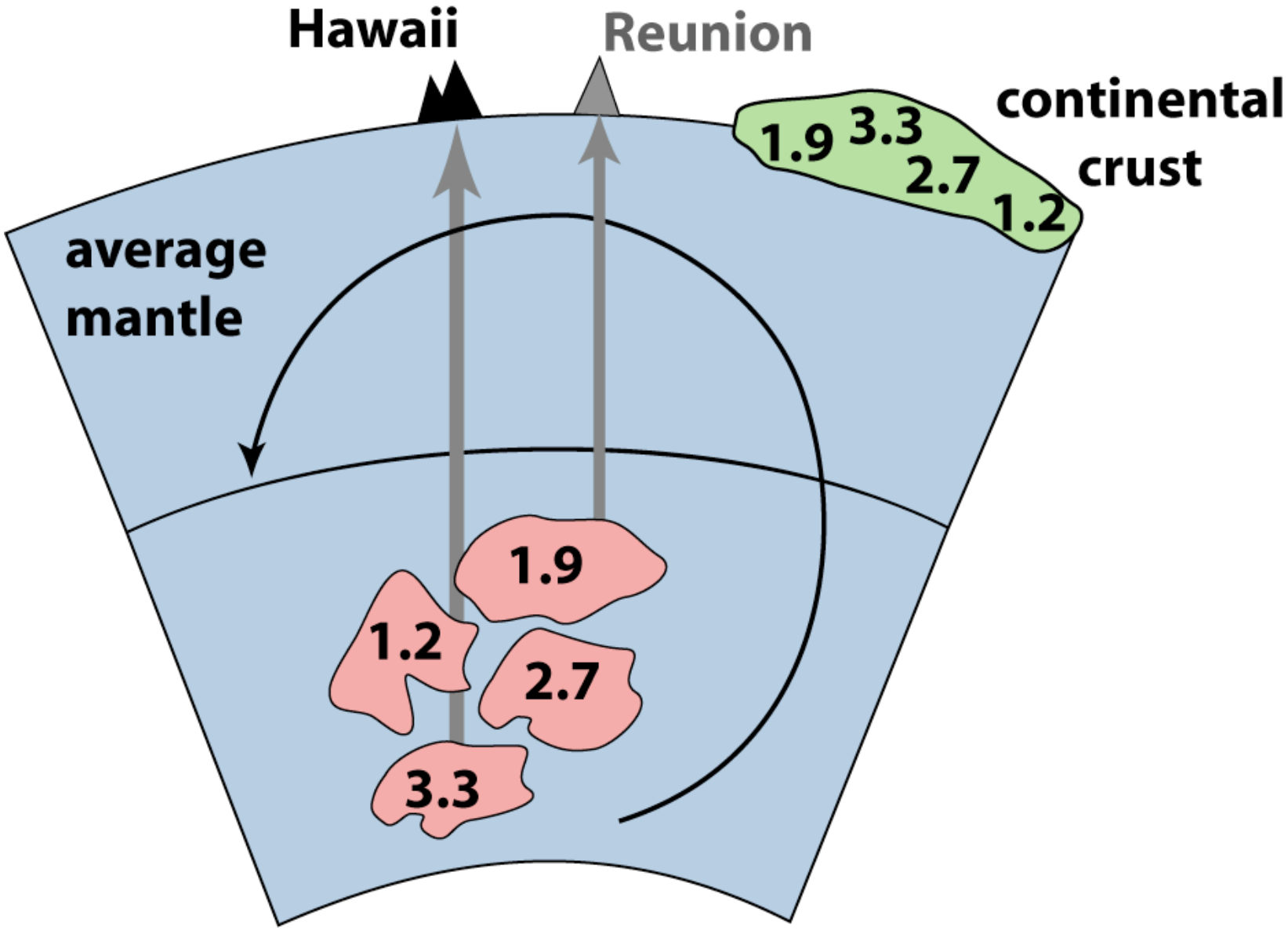
Davies, EPSL (1995)

Implications

- Mantle convection in Archean was punctuated by large melting events
- These events appear to have produced large areas of the continental crust



Davies, EPSL (1995)



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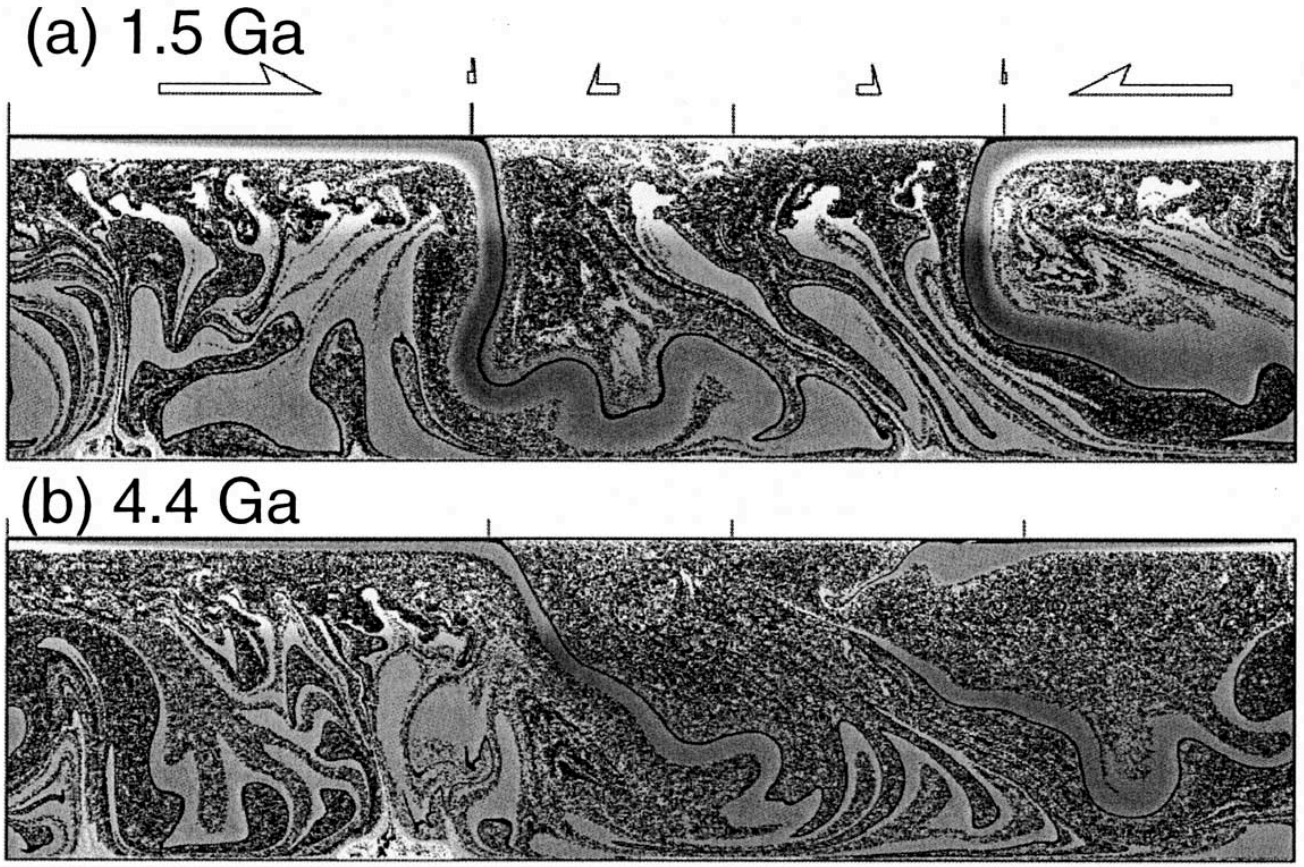
Where is plume source?



Davies, 2002

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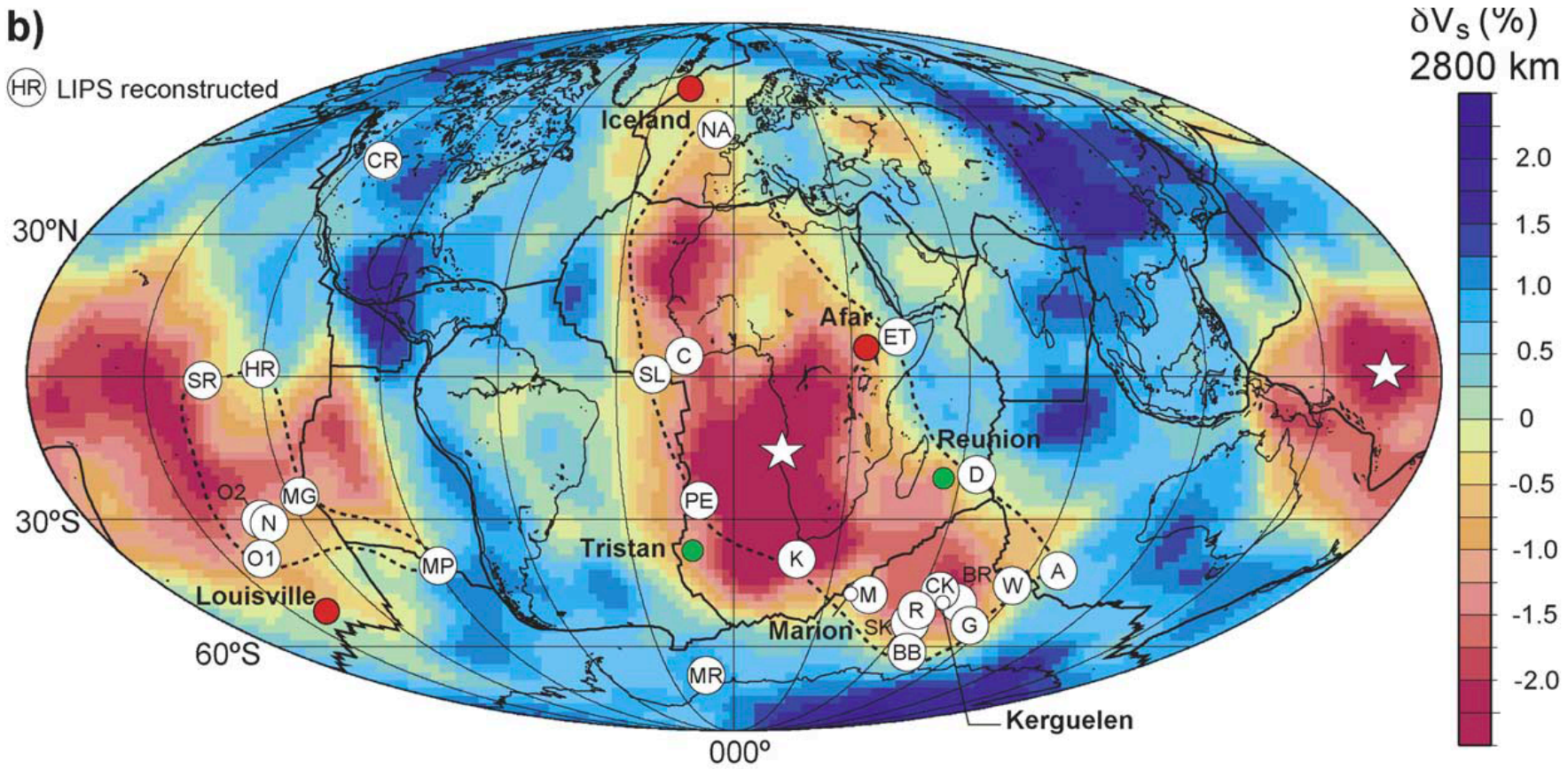

Burke & Torsvik, 2004

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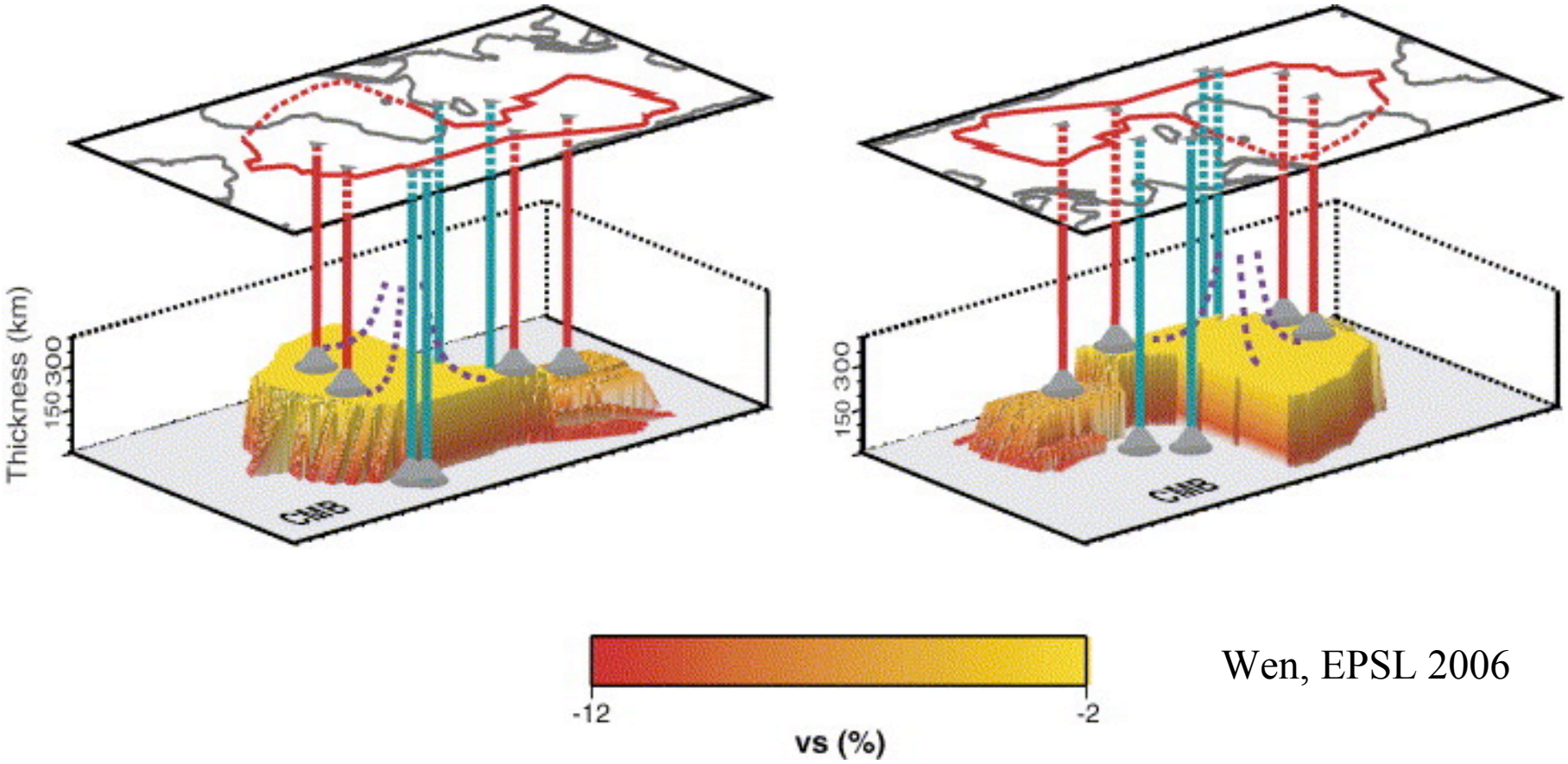

Wen, EPSL 2006

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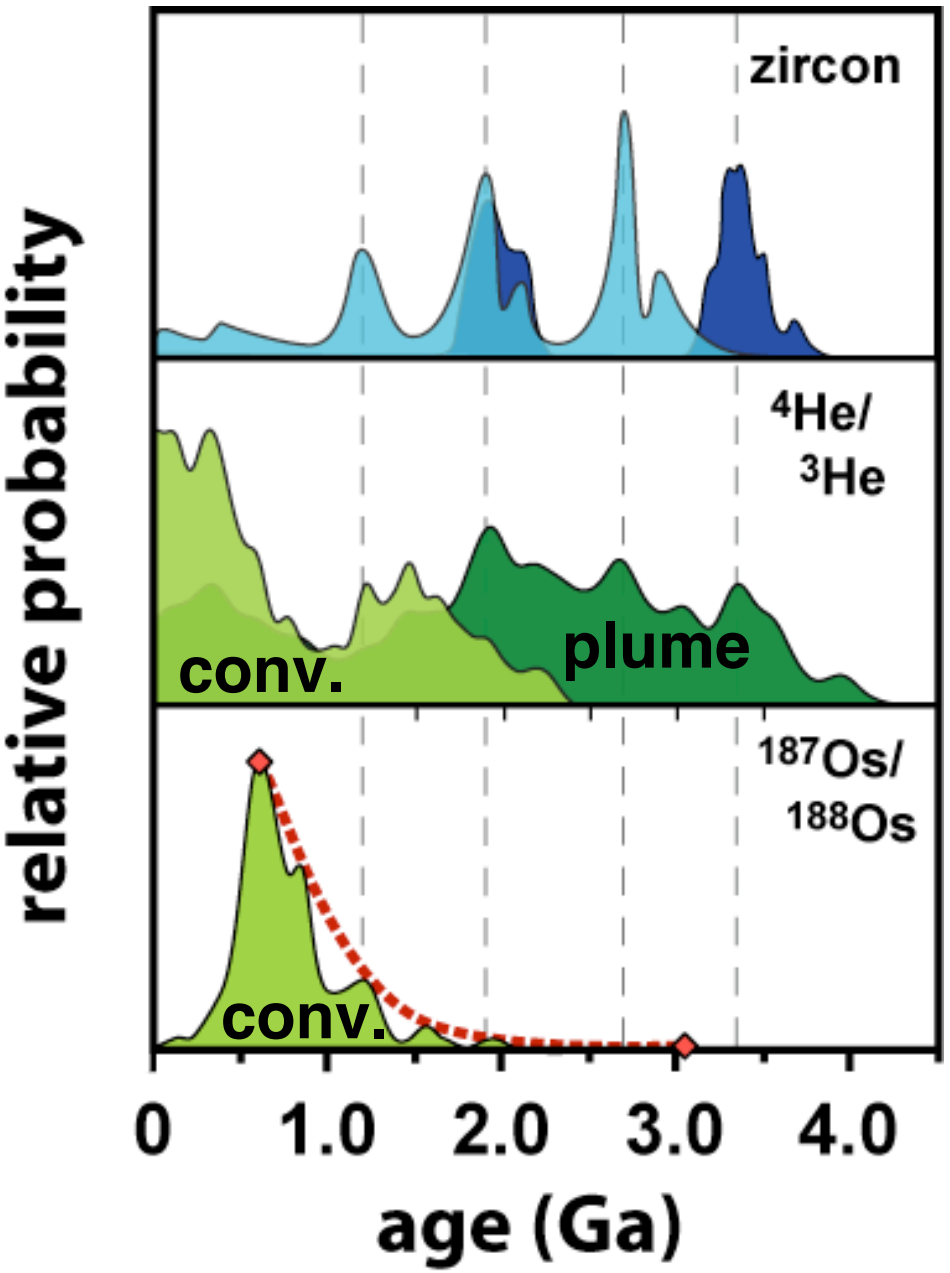

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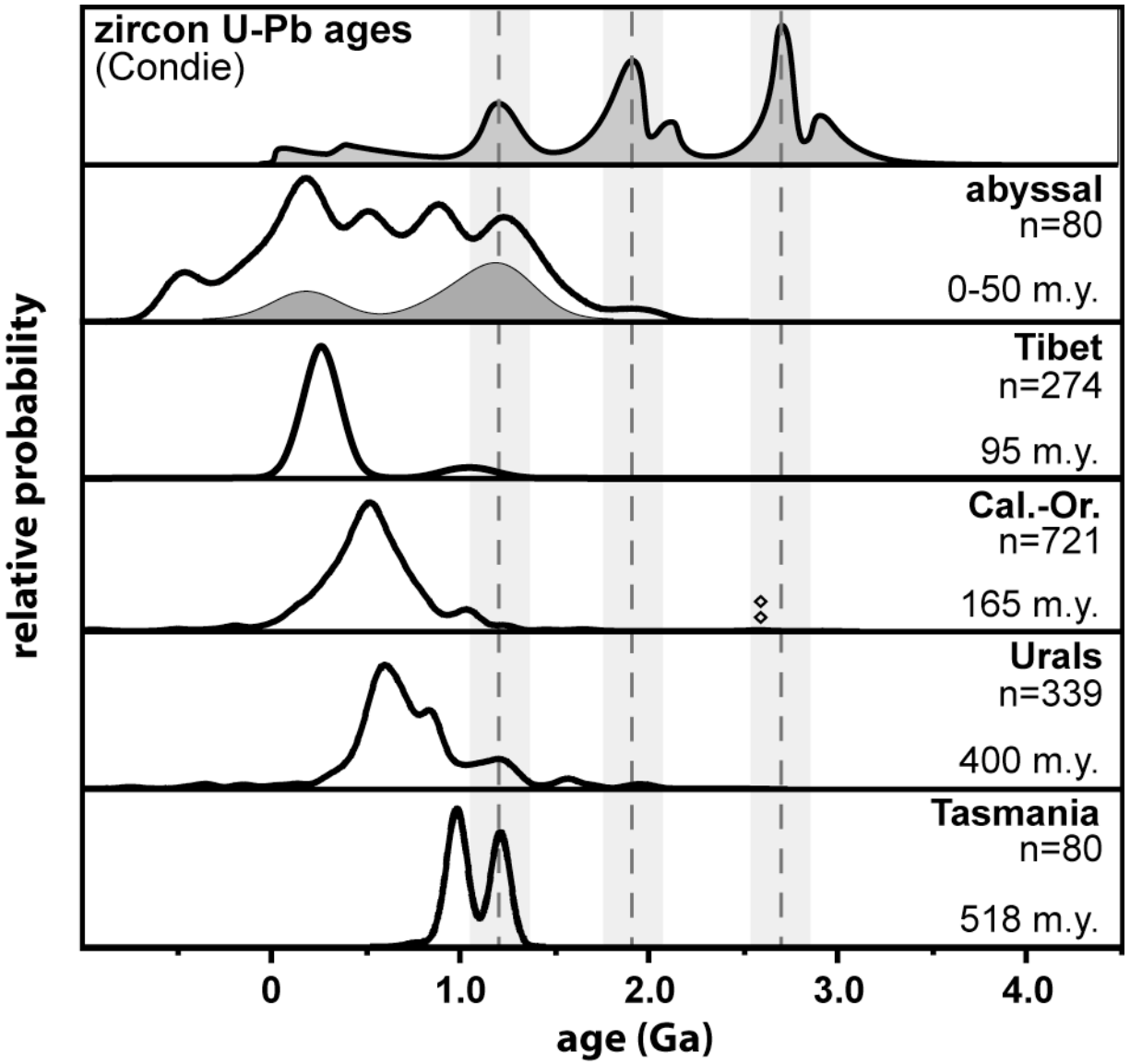
Pearson, Parman and Nowell, Nature, 2007



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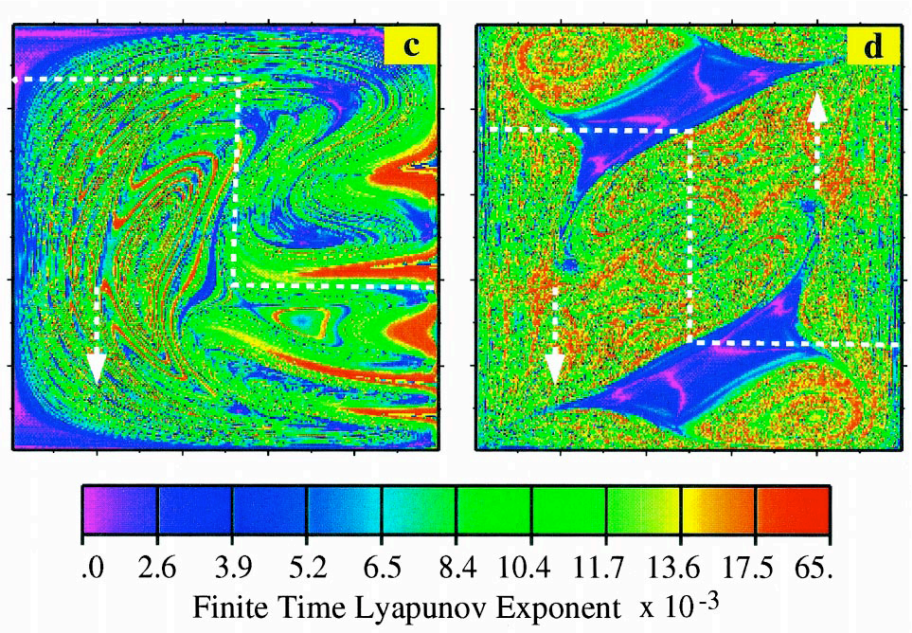
Implications

- Plume source is ancient
- Convecting mantle (MORB source) is <2 Ga old



Ferrachat & Ricard, 1998

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The End

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