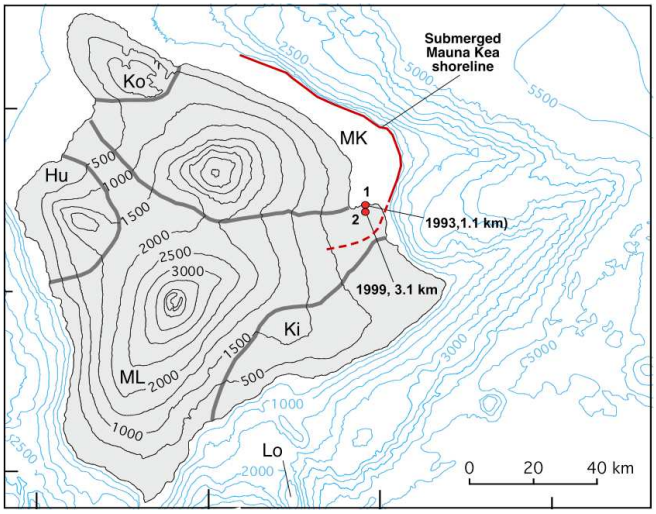
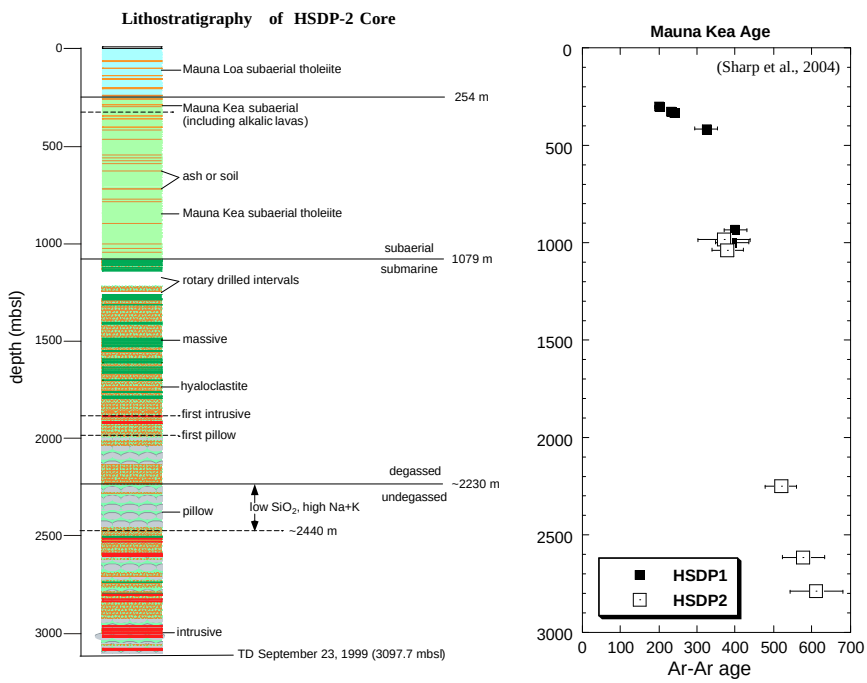
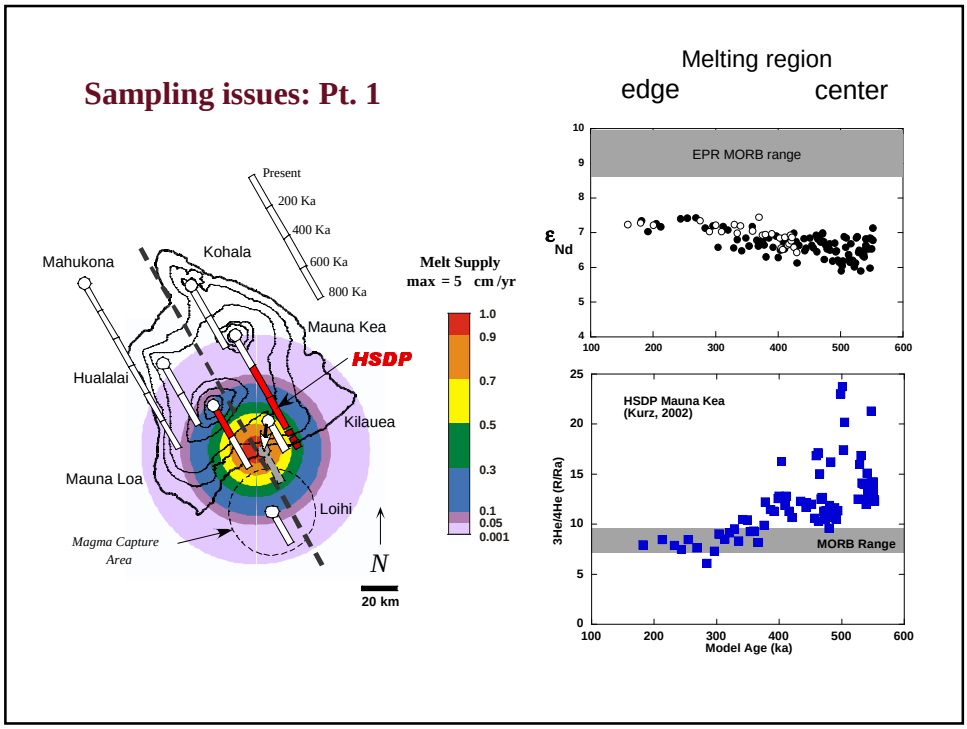
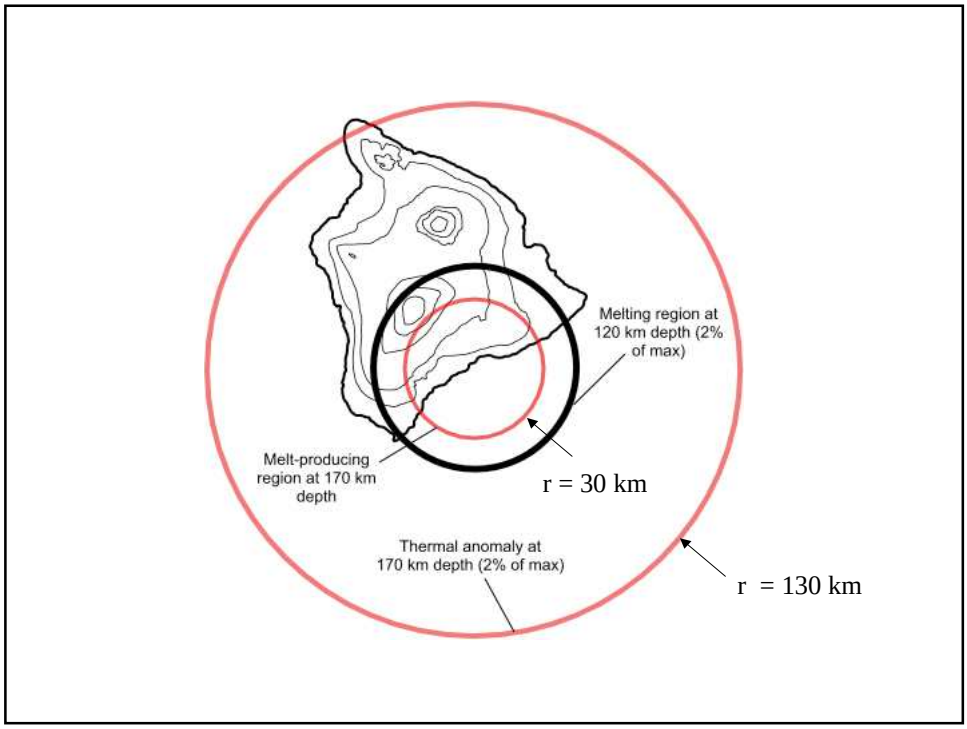
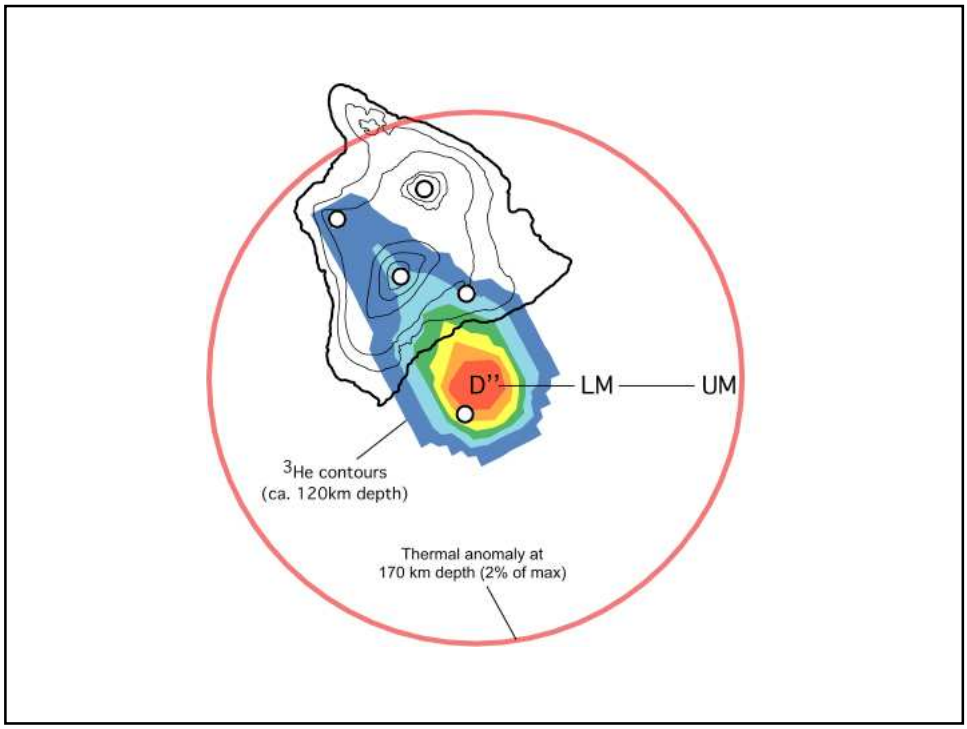


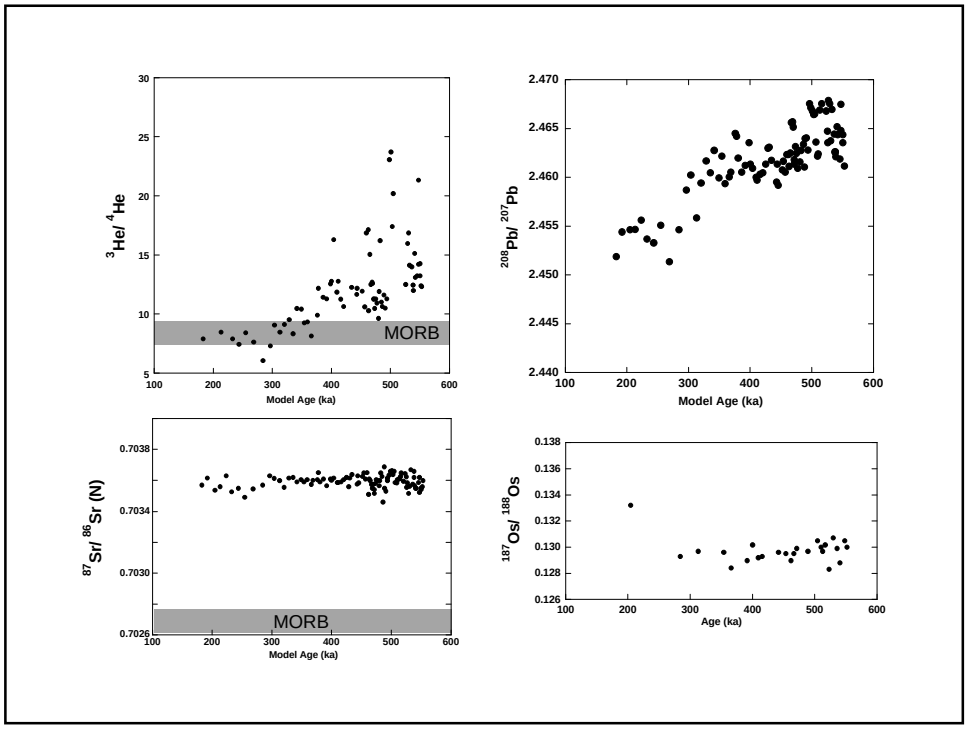
HSDP - a detailed look at the Hawaiian plume (and CMB?)

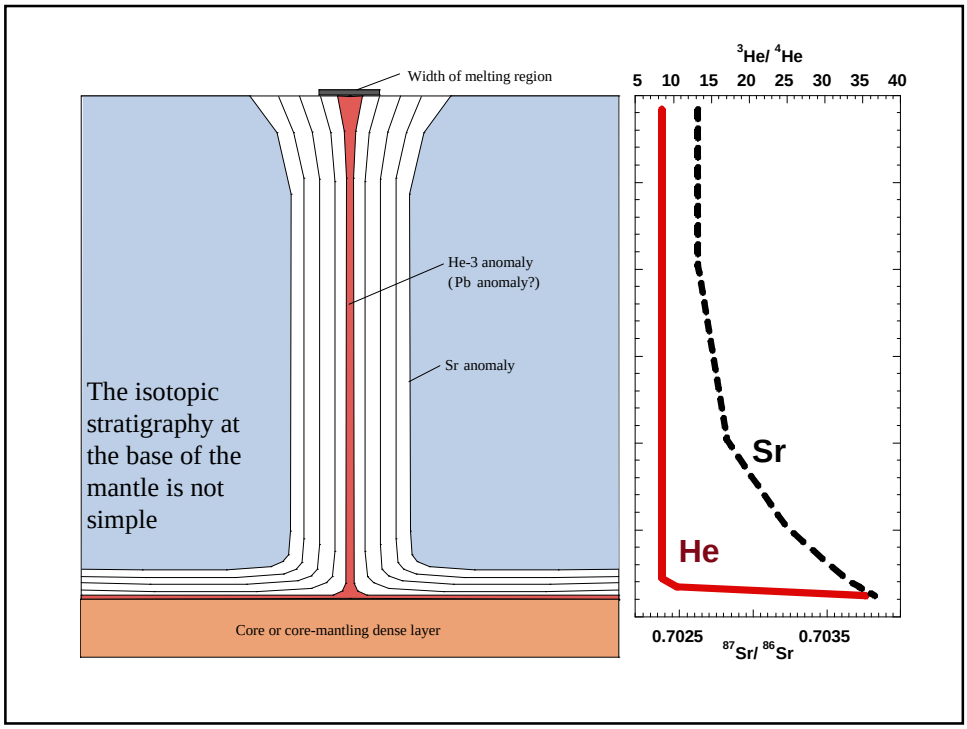


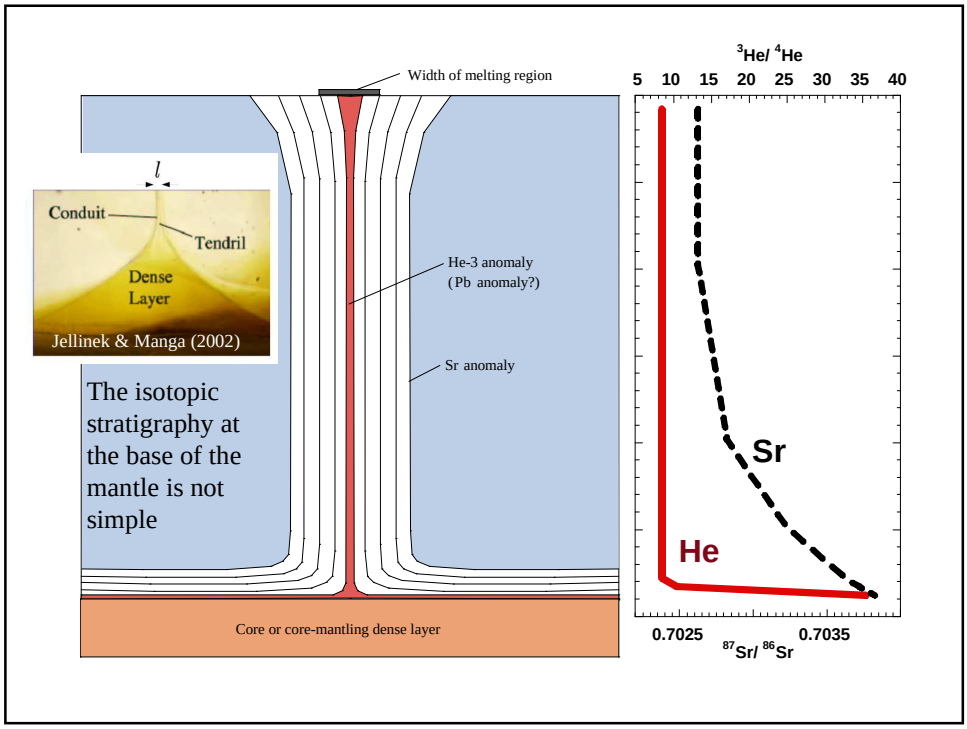

Sampling issues: Pt. 1
Present
200 Ka
400 Ka
600 Ka
800 Ka
Mahukona
Kohala
Mauna Kea
HSDP
Hualalai
Kilauea
Mauna Loa
Loihi
Magma Capture Area
N
20 km
Melt Supply
max = 5 cm /yr
1.0
0.9
0.7
0.5
0.3
0.1
0.05
0.001
Melting region
edge
center
EPR MORB range
εNd
HSDP Mauna Kea (Kurz, 2002)
3He/4He (R/Ra)
MORB Range
Model Age (ka)


Melting region at 120 km depth (2% of max)
Melt-producing region at 170 km depth
r = 30 km
Thermal anomaly at 170 km depth (2% of max)
r = 130 km


D''
LM
UM
3He contours
(ca. 120km depth)
Thermal anomaly at
170 km depth (2% of max)


3He/ 4He
MORB
Model Age (ka)
208Pb/ 207Pb
Model Age (ka)
87Sr/ 86Sr (N)
MORB
Model Age (ka)
187Os/ 188Os
Age (ka)

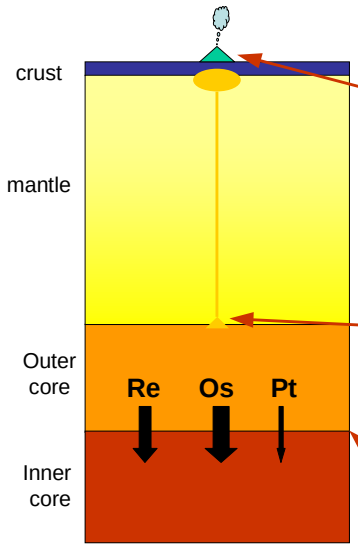

Width of melting region
He-3 anomaly
(Pb anomaly?)
Sr anomaly
The isotopic stratigraphy at the base of the mantle is not simple
Core or core-mantling dense layer
$^3He/^4He$
5 10 15 20 25 30 35 40
Sr
He
0.7025
0.7035
$^{87}Sr/^{86}Sr$


Width of melting region
l
Conduit
Tendril
Dense Layer
Jellinek & Manga (2002)
He-3 anomaly
(Pb anomaly?)
Sr anomaly
The isotopic stratigraphy at the base of the mantle is not simple
Core or core-mantling dense layer
$^3He/^4He$
5 10 15 20 25 30 35 40
Sr
He
0.7025
0.7035
$^{87}Sr/^{86}Sr$

^{186}Os data also interpreted as entrained outer core material; correlates w/ ^{3}He

Brandon et al. (1999)

Re, Os, Pt and core -mantle interaction?

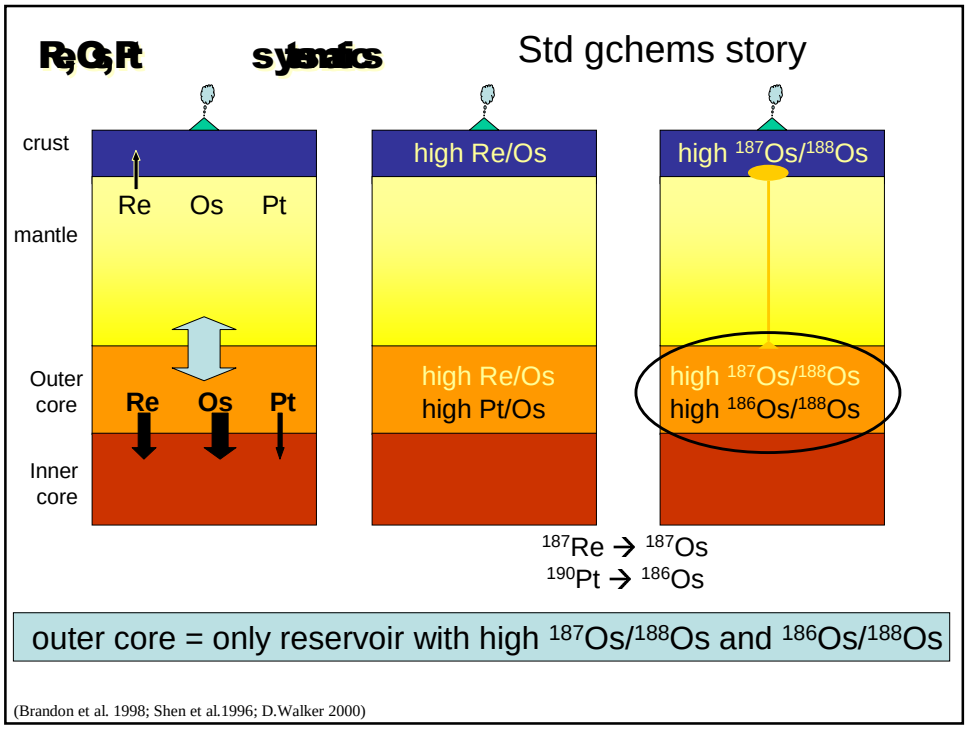


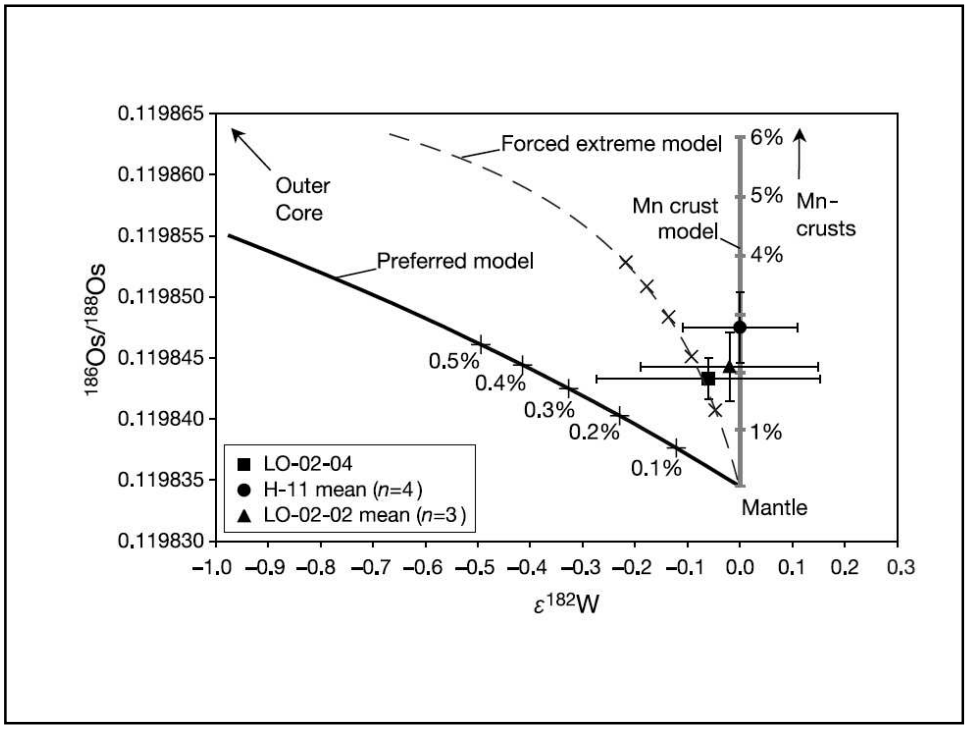
Observations:
high values of ^{186}Os/^{188}Os and ^{187}Os/^{188}Os in Hawaiian lavas, Siberian lavas, and Os-rich alloys

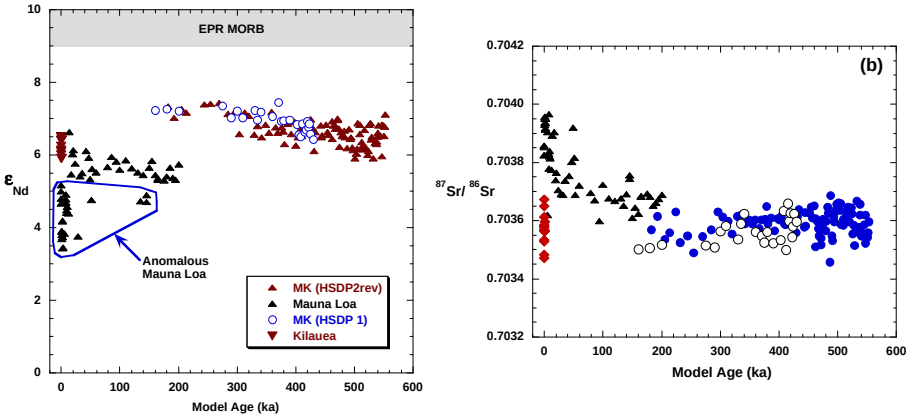
Hypothesis:
Entrainment of ~1 wt% outer core material in plume

Depends on:
Inner core-outer core partition coefficients for Re, Os, Pt

(R. Walker et al. 1997; Brandon et al. 1998; Meibom & Frei 2002)

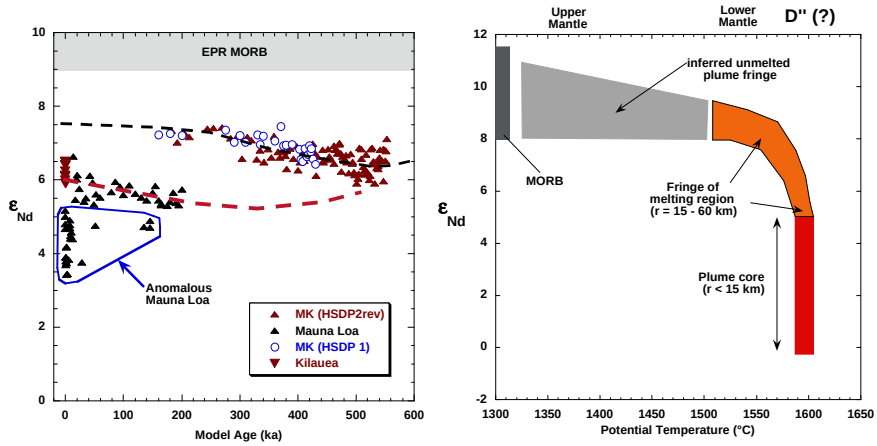

Re, Os, Pt systematics
Std gchems story
crust
mantle
Outer core
Inner core
Re
Os
Pt
high Re/Os
high Re/Os
high Pt/Os
high 187Os/188Os
high 187Os/188Os
high 186Os/188Os
187Re → 187Os
190Pt → 186Os
outer core = only reservoir with high 187Os/188Os and 186Os/188Os
(Brandon et al. 1998; Shen et al.1996; D.Walker 2000)


Forced extreme model
Outer Core
Preferred model
Mn crust model
Mn-crusts
6%
5%
4%
1%
0.5%
0.4%
0.3%
0.2%
0.1%
Mantle
LO-02-04
H-11 mean (n=4)
LO-02-02 mean (n=3)
186Os/188Os
ε182W



Mauna Loa data suggest that core of plume is longitudinally heterogeneous

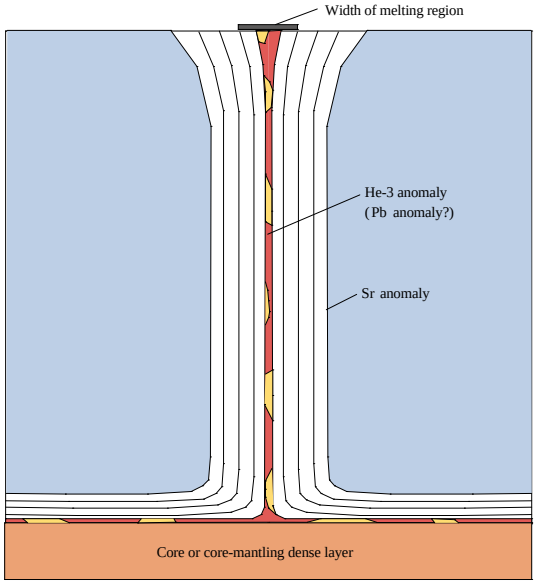
Recent deviant lavas from Mauna Loa require longitudinal heterogeneity along the axis of the plume



The axial part of the plume is longitudinally heterogeneous;

The inner fringe of the plume is less heterogeneous

The outer fringe is invisible (no melting)



Conclusions

- Different isotopic anomalies are not spatially correlated in the lowermost mantle
- The ^{3}He anomaly is not a general feature of the "lower mantle" but is a feature of the ***base*** of the mantle
- Most of the mantle between the plume source and the surface could have R/Ra ≈ 8; however, there are no lavas to represent this entrained material
- The Sr isotope anomaly ($^{87}Sr/^{86}Sr \approx 0.70365$) at Hawaii is a broad feature and the isotopic composition could represent a large volume of the lower mantle under Hawaii
- Patterns for Hf, Nd, Os resemble Sr; but ^{208}Pb resembles ^{3}He
- Juxtaposing isotopic data with physical models can yield new perspectives