Announcements

Reading for Wed: p.363-399!!!

p.362-366; p.373-378; p.383-386; p.392-394; p.395-399

Last lecture on Wednesday

Bring food for pizza party

Bring class notes, labs, book

- N-MORBs: $^{87}Sr/^{86}Sr < 0.7035$ and $^{143}Nd/^{144}Nd > 0.5030$, → depleted mantle source
- E-MORBs extend to more enriched values → stronger support distinct mantle reservoirs for N-type and E-type MORBs

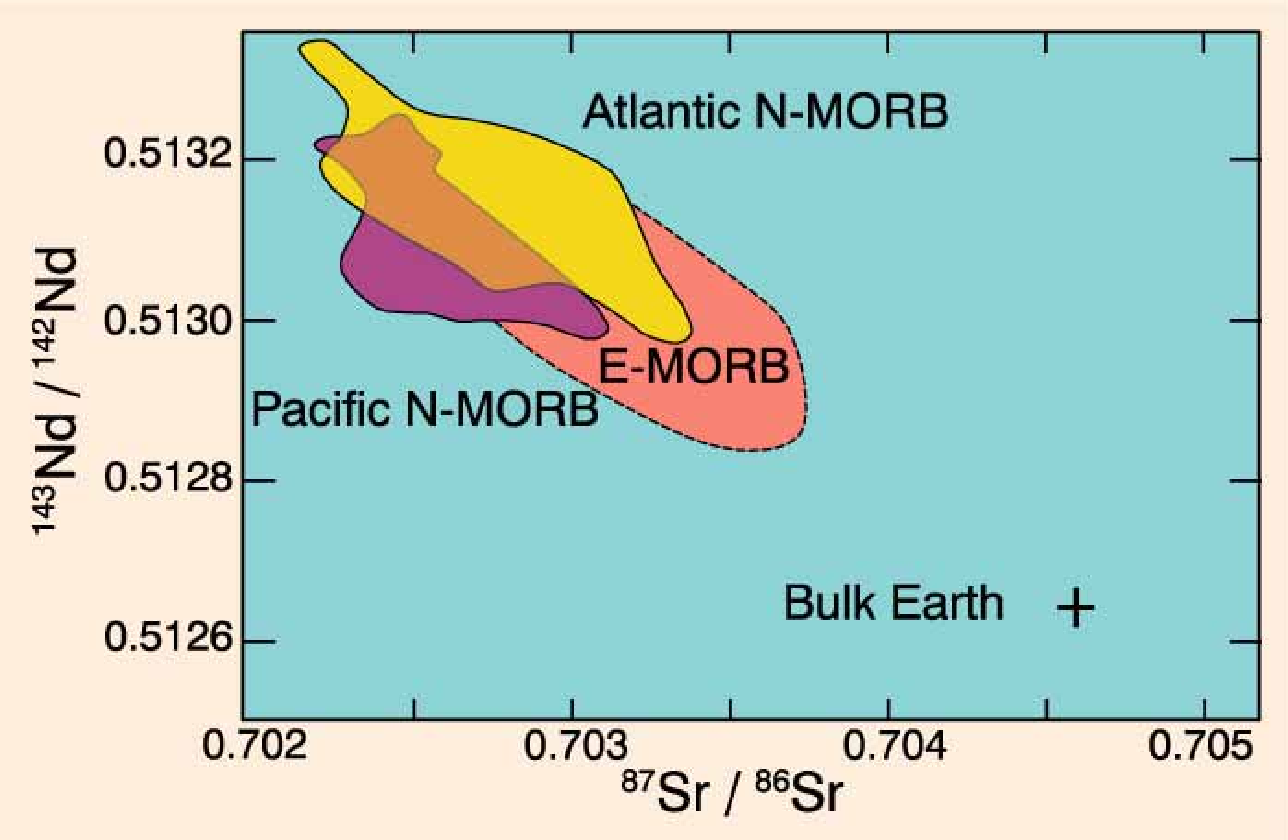


Figure 13-12. Data from Ito et al. (1987) Chemical Geology, 62, 157-176; and LeRoex et al. (1983) J. Petrol., 24, 267-318.

Simple Mixing Models

Binary

All analyses fall between two reservoirs as magmas mix

Ternary

All analyses fall within triangle determined by three reservoirs

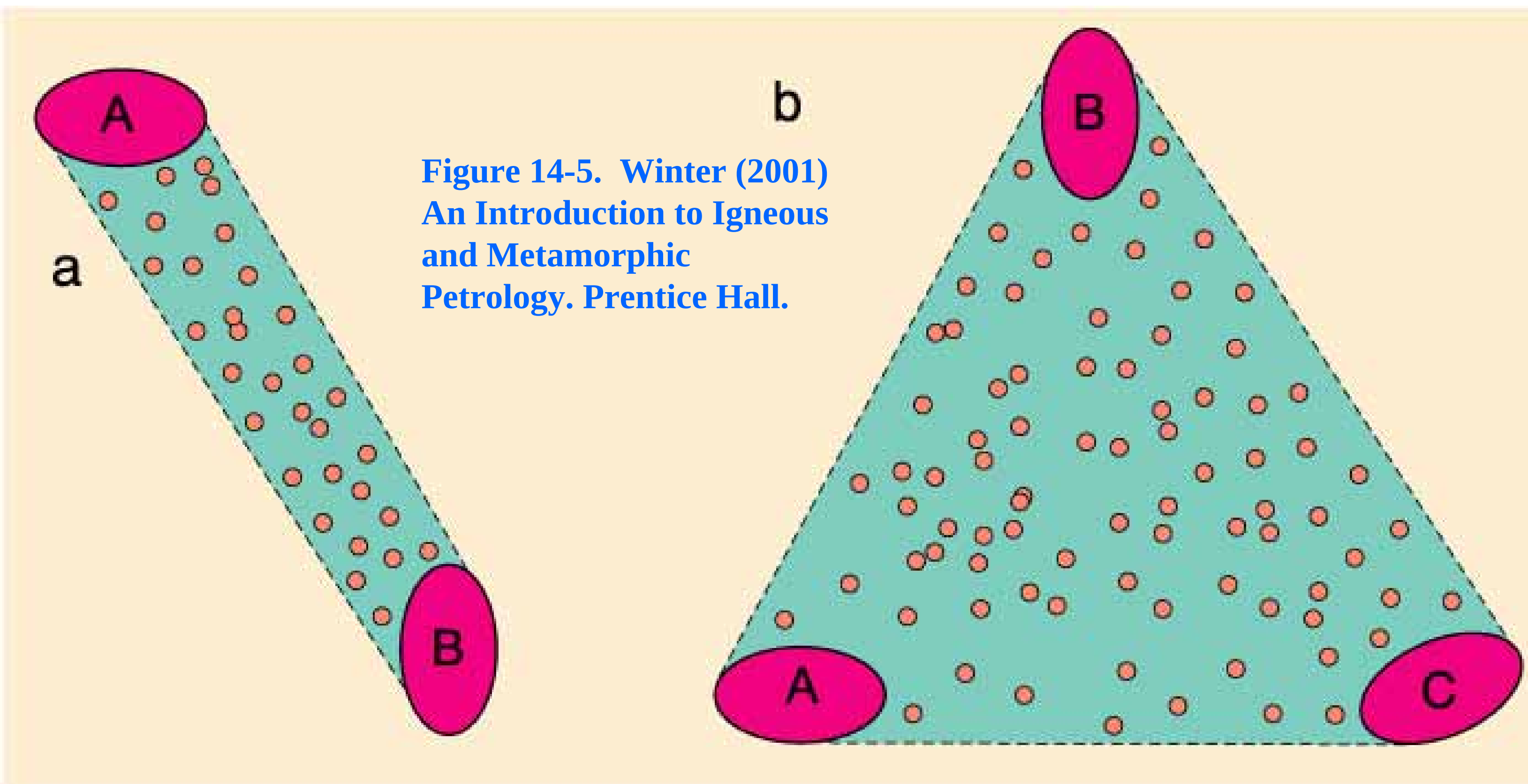


Figure 14-5. Winter (2001) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.

Some favorite geochemical components

Table 14–5 Approximate Isotopic Ratios of Various Reservoirs

	$^{87}Sr/^{86}Sr$	$^{144}Nd/^{143}Nd$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$
Bulk Earth	0.7052	0.51264	18.4	15.58
DM	0.7015–0.7025	0.5133–0.5136	15.5–17.7	<15.45
PREMA	0.7033	< 0.5128	18.2–18.5	15.4–15.5
HIMU	0.7025–0.7035	0.511–0.5121	21.2–21.7	15.8–15.9
EMI	c 0.705	< 0.5112	17.6–17.7	15.46–15.49
EMII	> 0.722	0.511–0.512	16.3–17.3	15.4–15.5
Continental Crust	0.72–0.74	0.507–0.513	up to 28	up to 20

Data from Rollinson (1993) pp. 233–236.

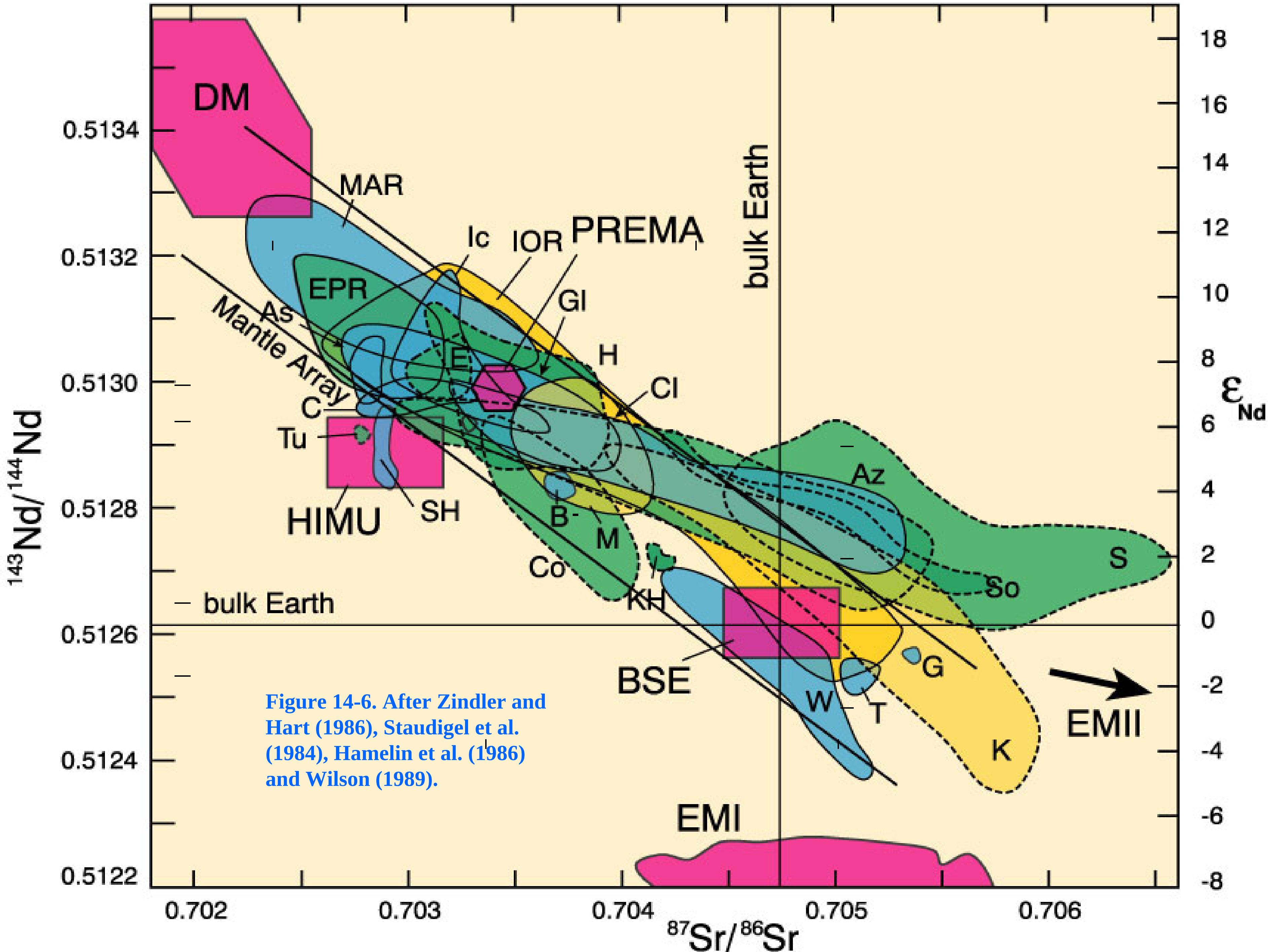


Figure 14-6. After Zindler and Hart (1986), Staudigel et al. (1984), Hamelin et al. (1986) and Wilson (1989).

Mantle Reservoirs

1. DM (Depleted Mantle) = N-MORB source

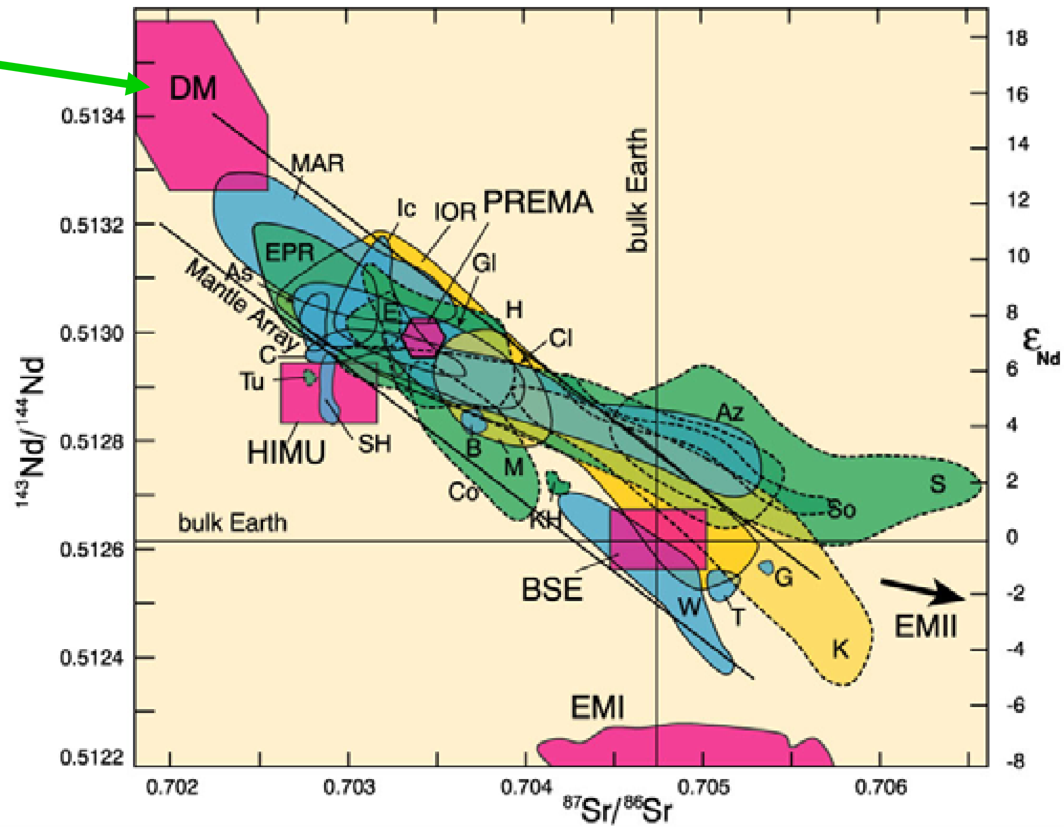
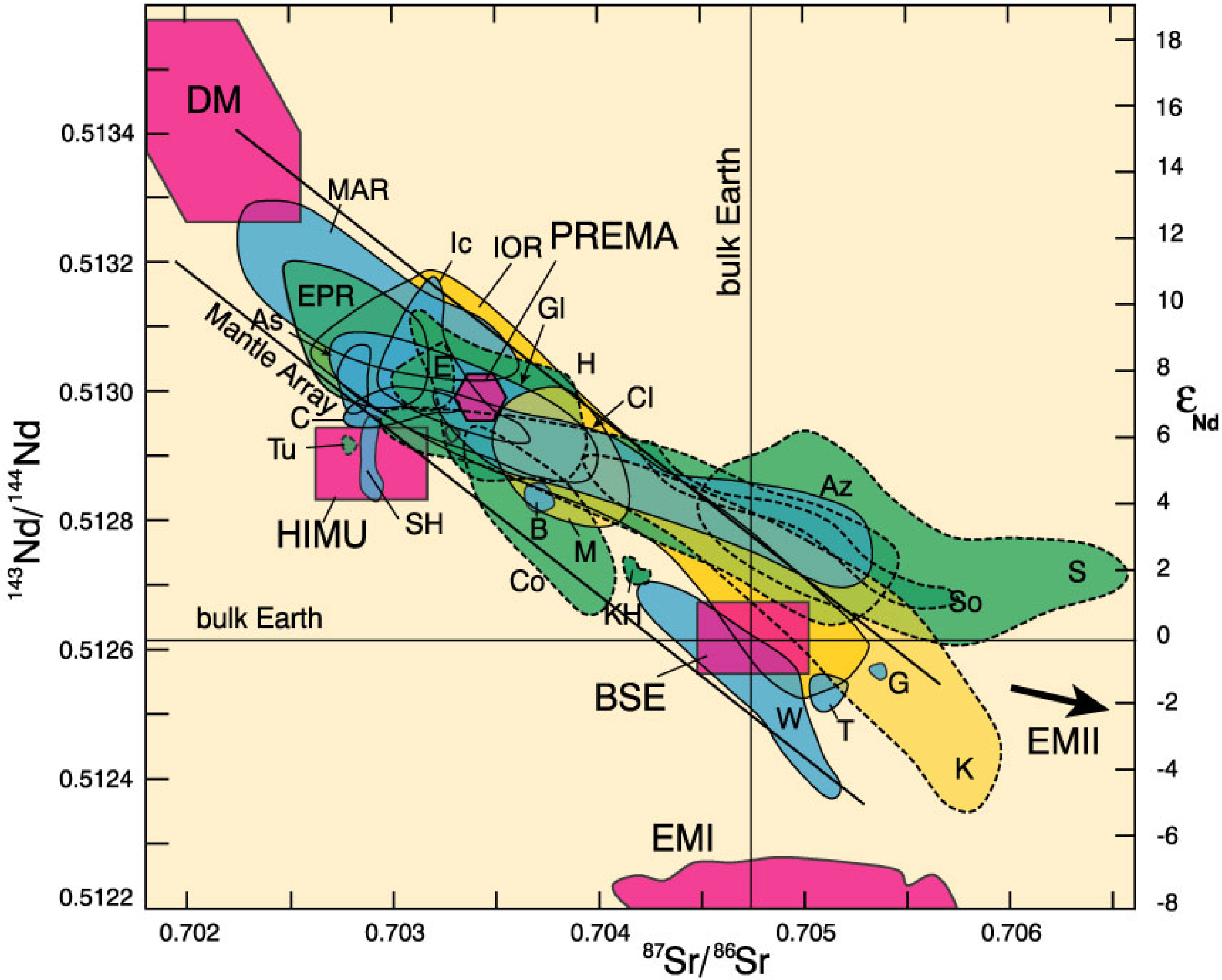


Figure 14-6. After Zindler and Hart (1986), Staudigel et al. (1984), Hamelin et al. (1986) and Wilson (1989).

2. BSE (Bulk Silicate Earth) or the Primary Uniform Reservoir

Reflects the isotopic signature of the primitive mantle as it would evolve to the present without any subsequent fractionation i.e. neither depleted nor enriched…just plain old mantle

Several oceanic basalts have this isotopic signature, but there are no compelling data that *require* this reservoir (it is *not* a mixing end-member), but falls within the space defined by other reservoirs



3. EMI = enriched mantle type I has lower $^{87}Sr/^{86}Sr$ (near primordial)

4. EMII = enriched mantle type II has higher $^{87}Sr/^{86}Sr$ (> 0.720, well above any reasonable mantle sources

Since the Nd-Sr data for OIBs extends beyond the primitive values to truly enriched ratios, there must exist an enriched mantle reservoir

Both EM reservoirs have similar enriched (low) Nd ratios (< 0.5124)

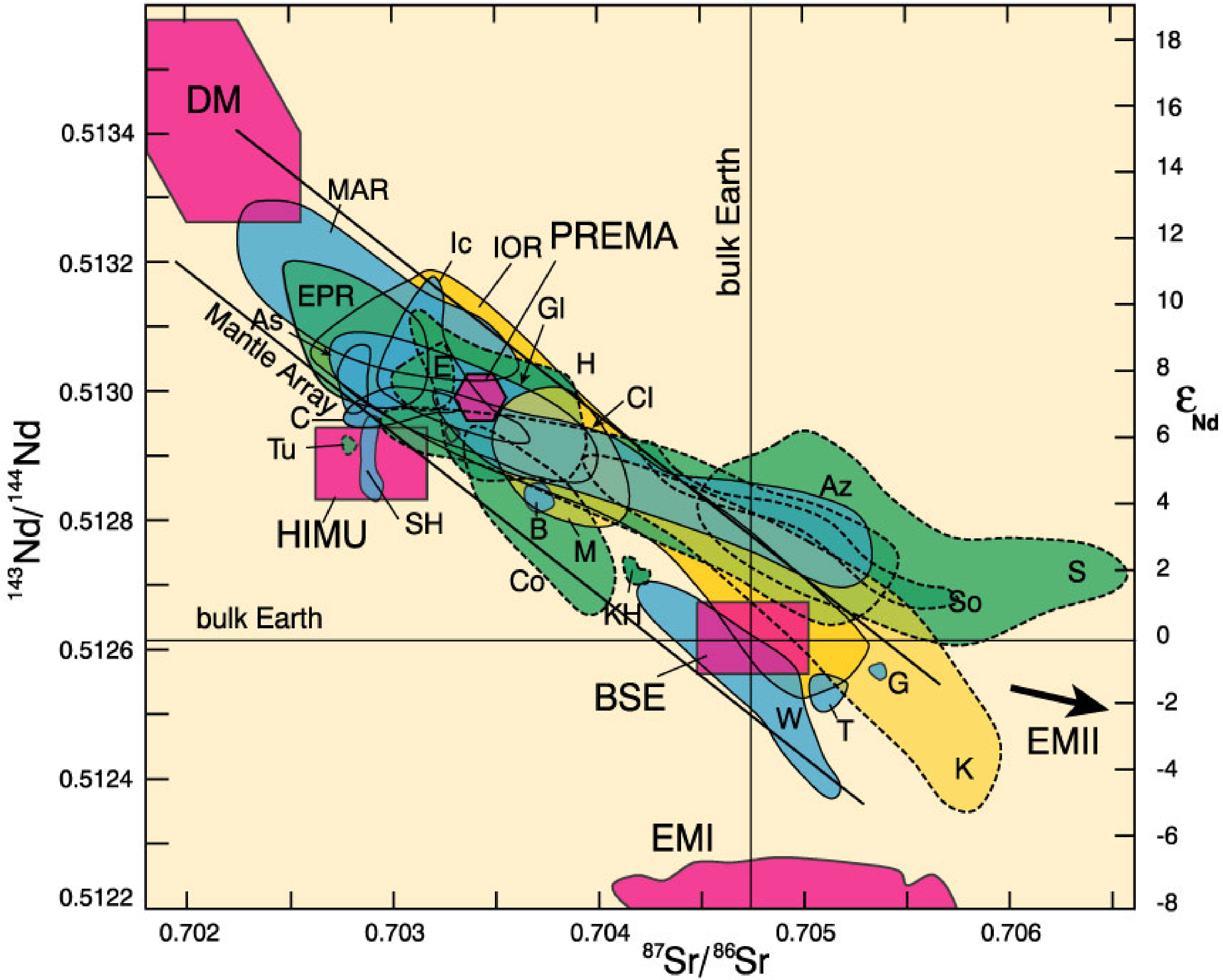


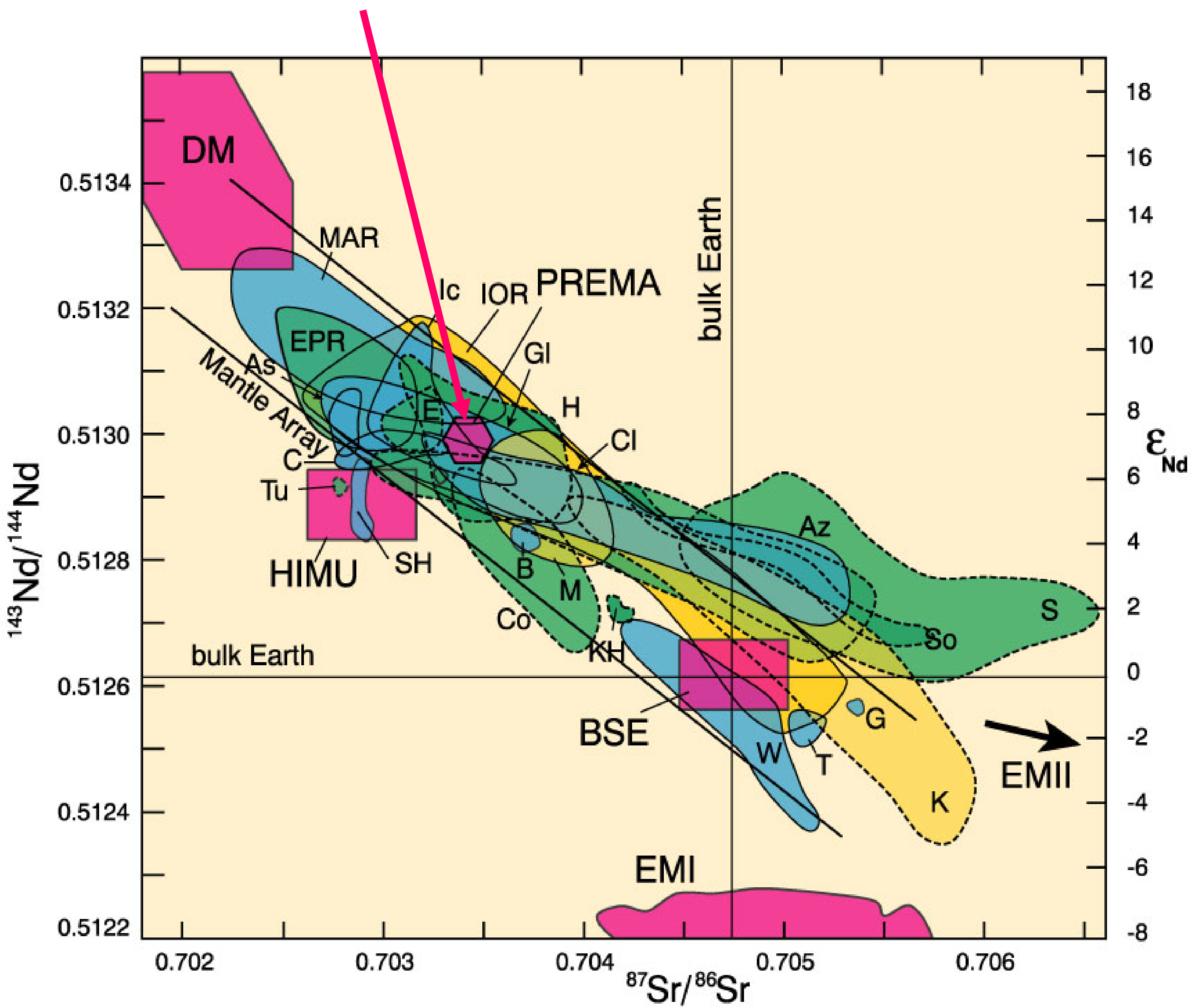
Figure 14-6. After Zindler and Hart (1986), Staudigel et al. (1984), Hamelin et al. (1986) and Wilson (1989).

5. PREMA (PREvalent MAntle)

Figure 14-6. After Zindler and Hart (1986), Staudigel et al. (1984), Hamelin et al. (1986) and Wilson (1989).

Also not a mixing end-member
PREMA represents another restricted isotopic range that is very common in ocean volcanic rocks

Although it lies on the mantle array, and could result from mixing of melts from DM and BSE sources, the abundance of melts with the PRIMA signature suggests that it may be a distinct mantle source



Pb Isotopes

Pb produced by radioactive decay of U & Th

9-20 $^{238}U \rightarrow {}^{234}U \rightarrow {}^{206}Pb$

9-21 $^{235}U \rightarrow {}^{207}Pb$

9-22 $^{232}Th \rightarrow {}^{208}Pb$

Pb is quite scarce in the mantle

- Mantle-derived melts susceptible to contamination
- U, Pb, and Th are concentrated in continental crust (high radiogenic daughter Pb isotopes)
- ^{204}Pb is non-radiogenic, so $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{206}Pb/^{204}Pb$ increase as U and Th decay
- Oceanic crust has elevated U and Th content (compared to the mantle) as will sediments derived from oceanic and continental crust
- Pb is a sensitive measure of crustal (including sediment) components in mantle isotopic systems
- 93.7% of natural U is ^{238}U, so $^{206}Pb/^{204}Pb$ will be most sensitive to a crustal-enriched component

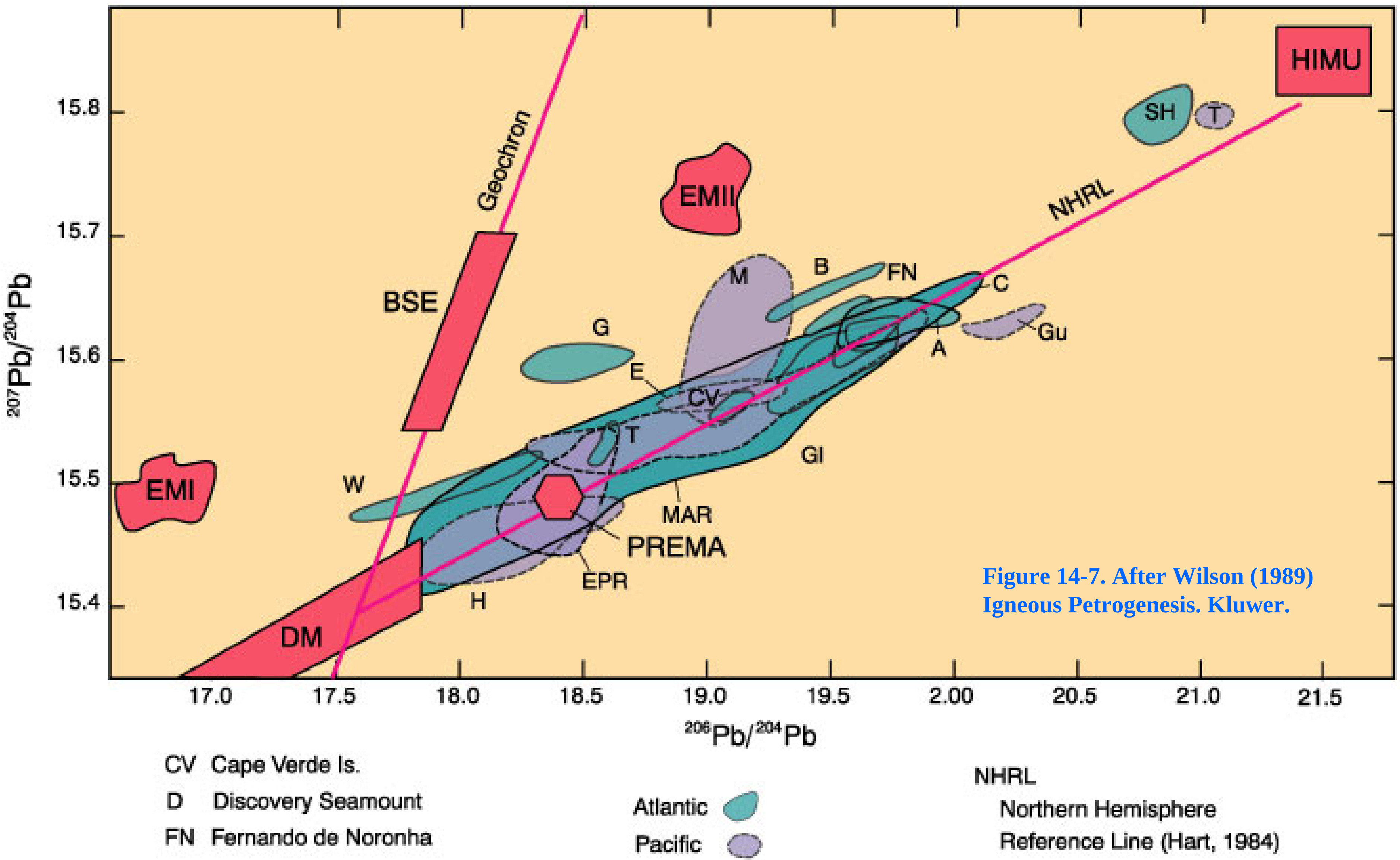
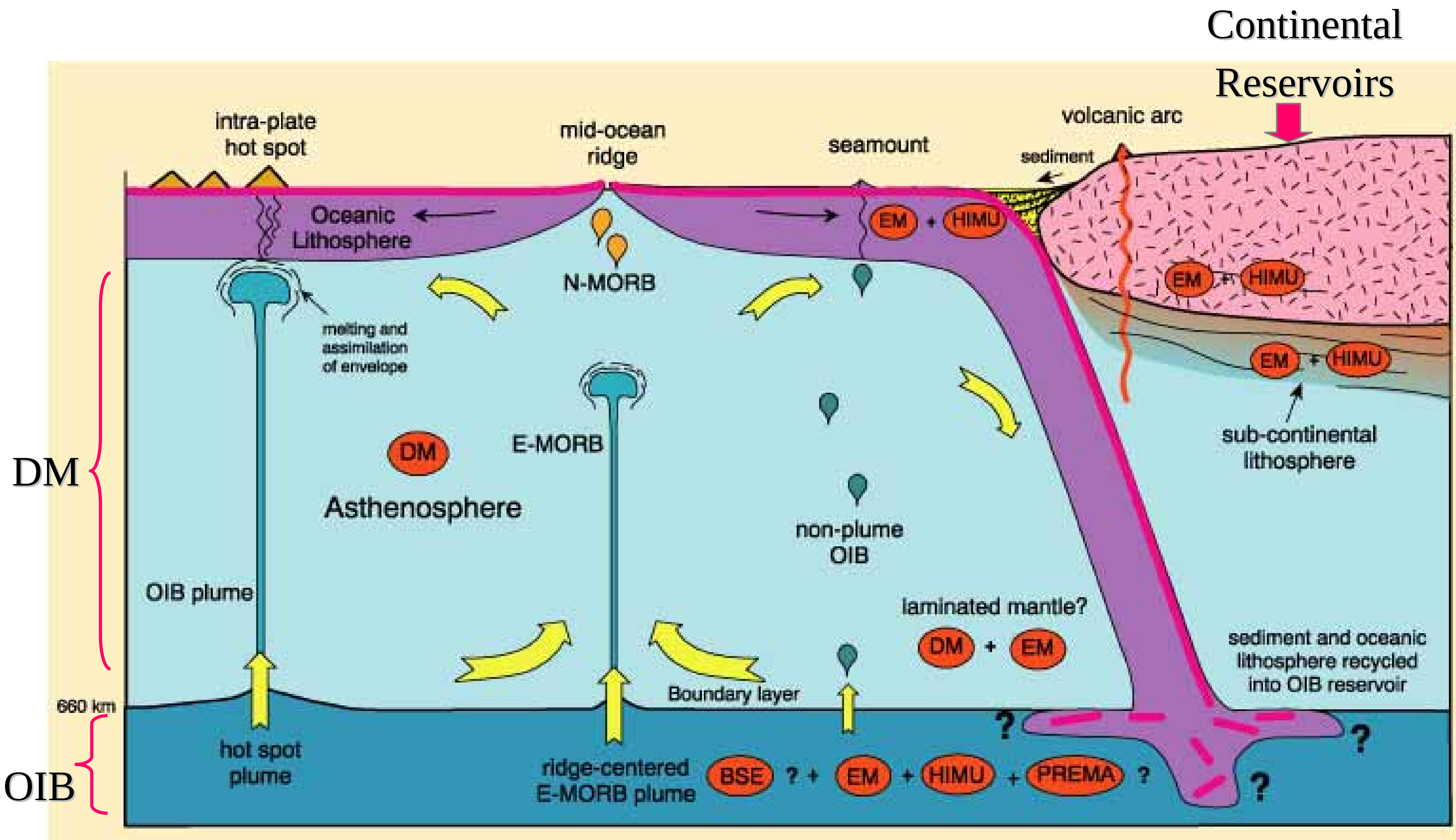


Figure 14-7. After Wilson (1989) Igneous Petrogenesis. Kluwer.

- Ratio $\mu = {}^{238}U/{}^{204}Pb$ (evaluate uranium enrichment)
- HIMU reservoir has a very high ${}^{206}Pb/{}^{204}Pb$ ratio, suggestive of a source with high U, yet not enriched in Rb, and old enough (> 1 Ga) to develop the observed isotopic ratios
- HIMU models:
  - subducted and recycled oceanic crust (possibly contaminated by seawater),
  - localized mantle lead loss to the core, and
  - Pb-Rb removal by those dependable (but difficult to document) metasomatic fluids

- The high Sr ratios in EMI and EMII also require a high Rb content and a similarly long time to produce the excess ^{87}Sr
  - This signature correlates well with continental crust (or sediments derived from it)
  - Oceanic crust and sediment are other likely candidates for these reservoirs

A Model for Oceanic Magmatism



EM and HIMU from crustal sources (subducted OC + CC seds)

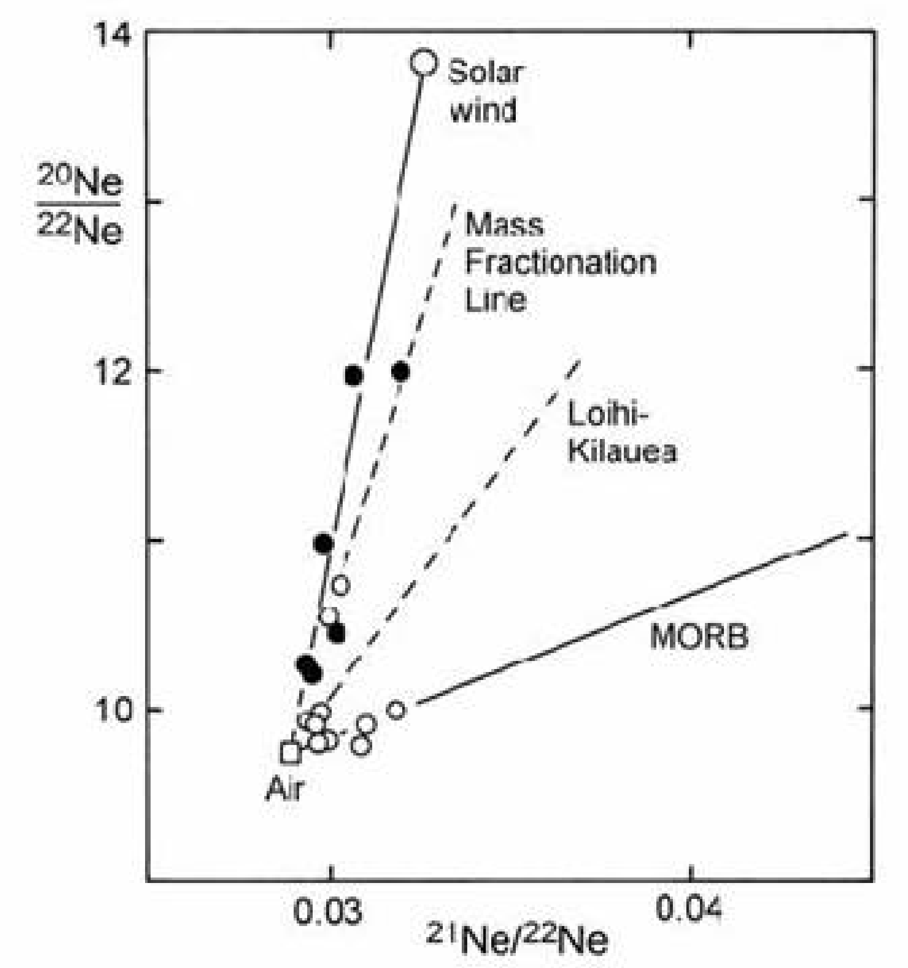
Figure 14-10. **Nomenclature from Zindler and Hart (1986). After Wilson (1989) and Rollinson (1993).**

More mantle components anyone? No thanks, I'm fine (Albarede)

- We described 6 possible mantle components today
- Petrologists have described up to 12 different components (add isotopic systems, need more components)

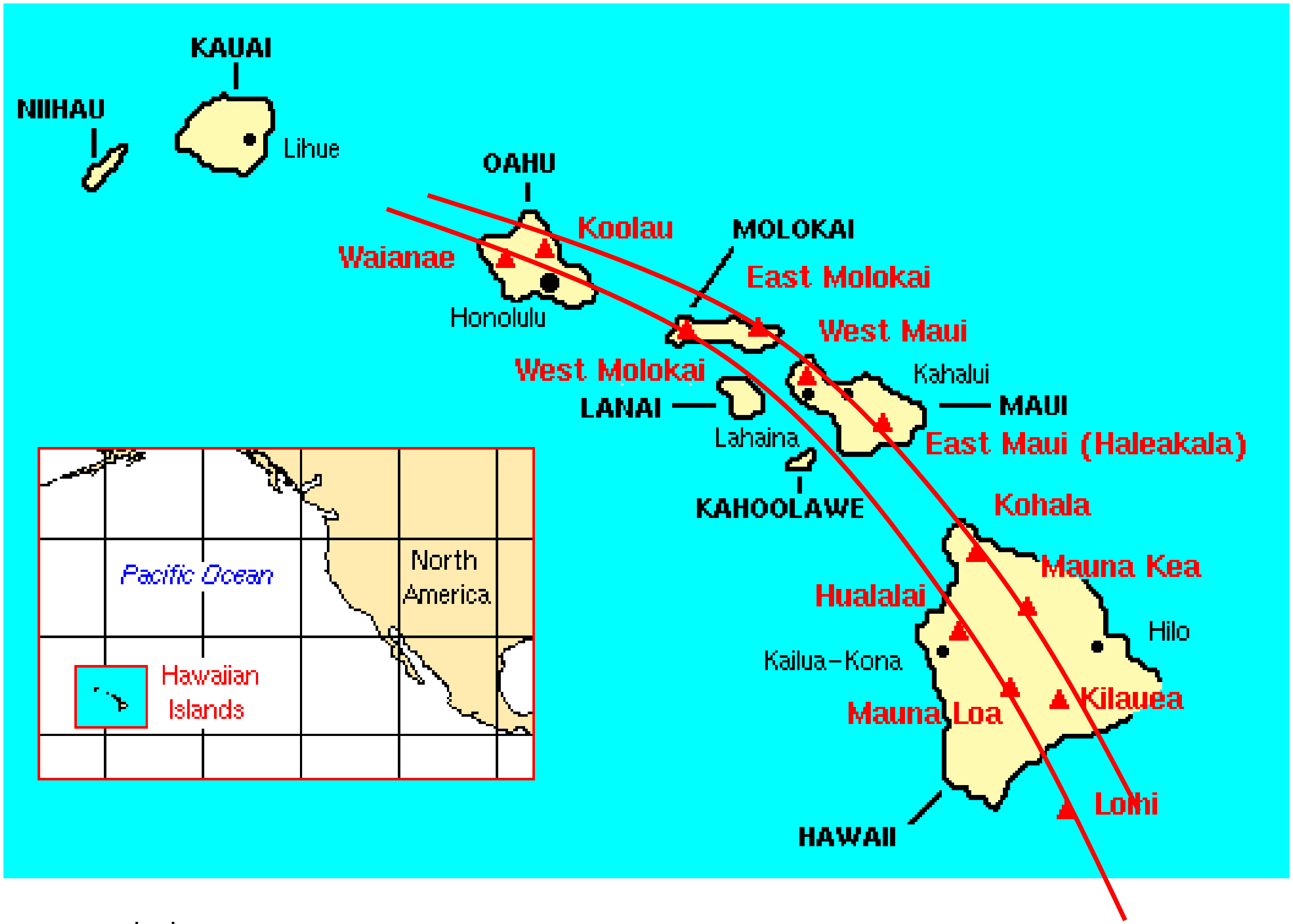
Ne isotopes

- MORB plus “Solar Wind” – primordial mantle



http://www.onafarawayday.com/Radiogenic/Ch11/Ch11-2.htm

Hawaii trends: Kea and Loa?



www.mantleplumes.org