

Sm-Nd metoda datiranja

Rijetke zemlje (RZ) ili lantanidi
(Rare earth elements, REE)

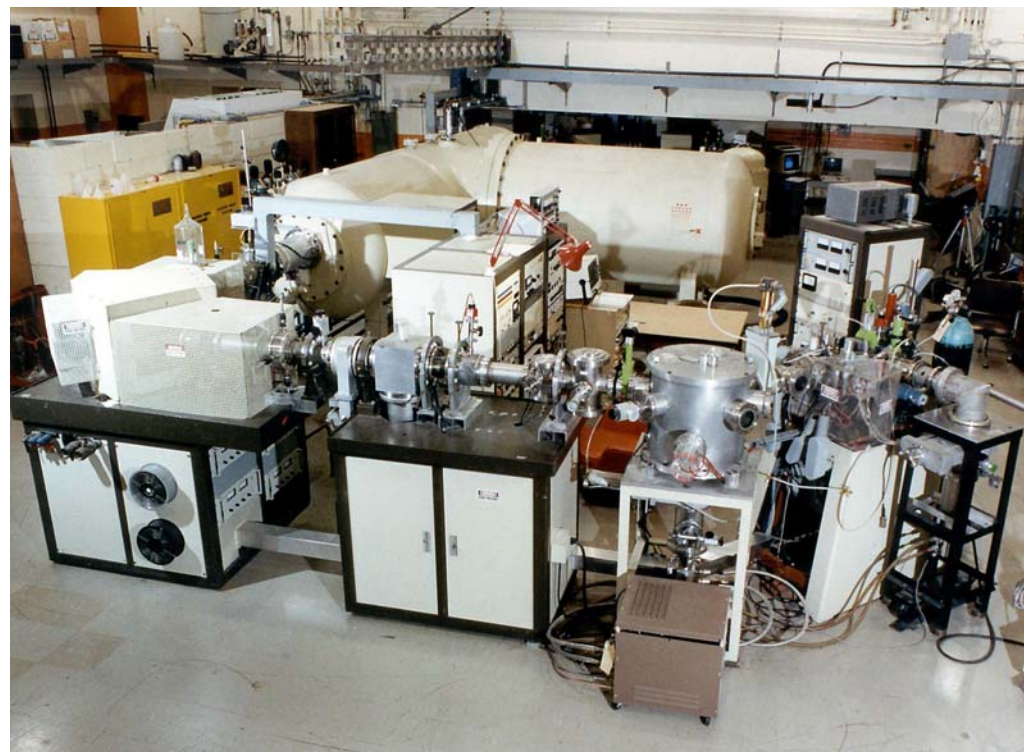
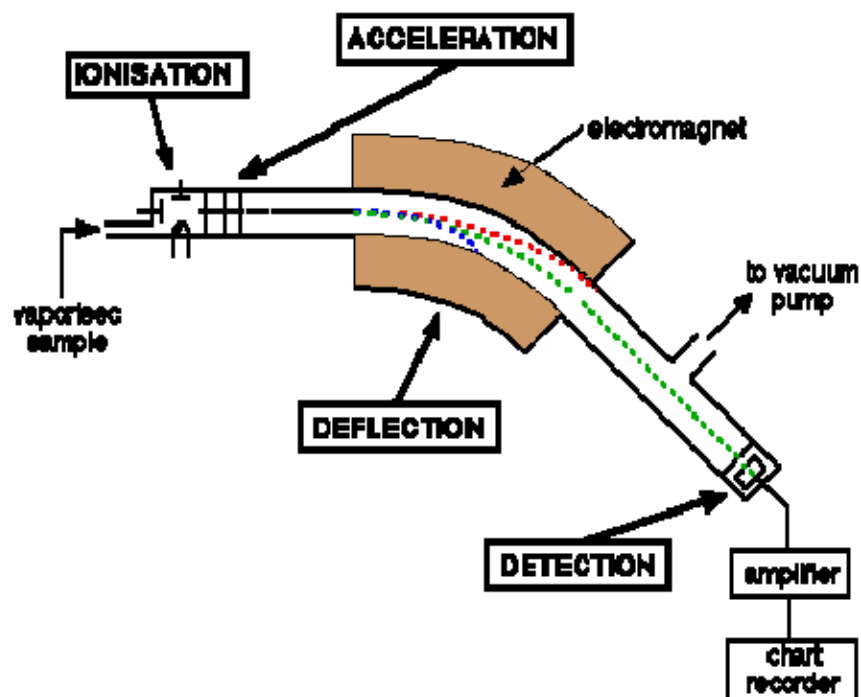


Manganske nodule na oceanskom dnu

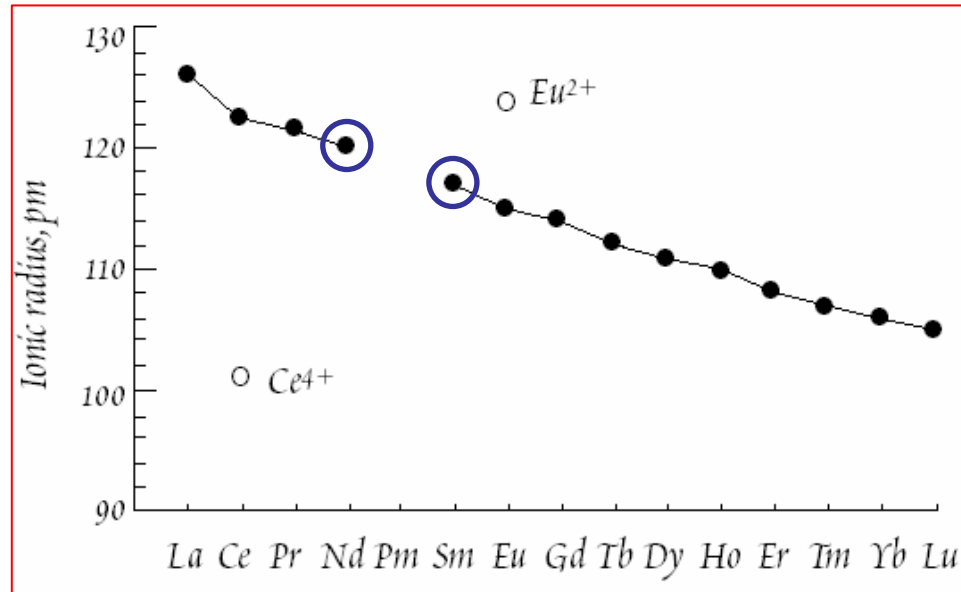
Rijetke zemlje (RZ) ili lantanidi

La, Ce, Pr, **Nd, Sm**, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

- Analitička osjetljivost mjerenja RZ bitno poboljšana uvođenjem visoko-preciznih masenih spektrometrijskih tehnika.
- Sve RZ su 3+ , osim Eu koji postoji također u stanju 2+ i Ce u stanju 4+. Ionski radijus pada sa porastom Z (atomskog broja, lantanidska kontrakcija).
- Sve RZ su inkompatibilne, a lake RZ su još inkompatibilnije (vole taljevinu).



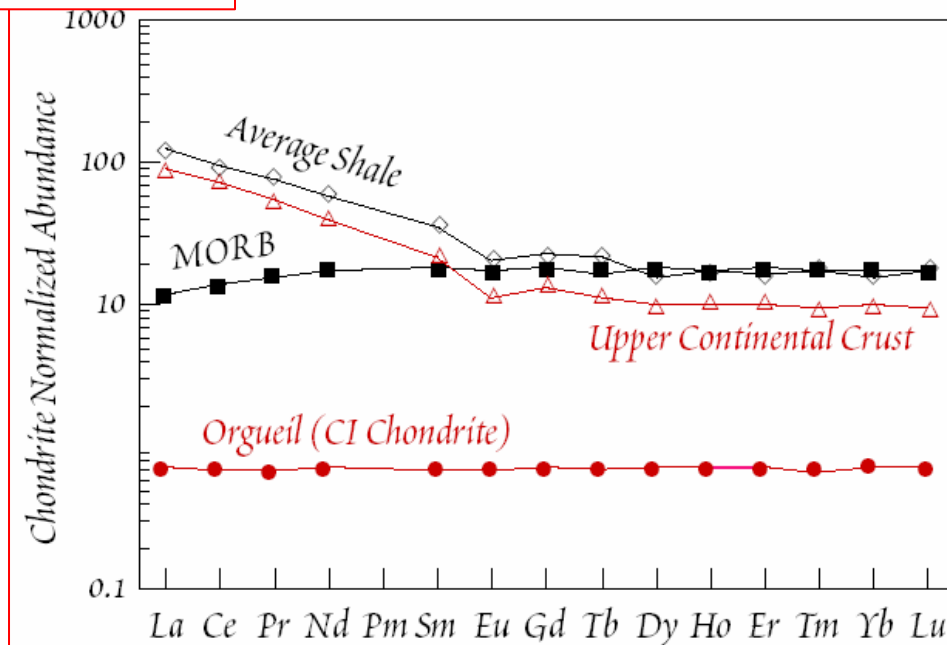
Rijetke zemlje (RZ) ili lantanidi



- REE so named because we could not measure them until high-precision mass spec techniques developed

- all REE have 3+ charge, ionic radii decrease with increasing Z

- all REE are “incompatible” (they prefer the melt), but light REE are more incompatible



What would the chondrite REE abundance look like?

^{147}Sm – ^{143}Nd radioaktivna shema

^{147}Sm = 15%; još četiri izotopa

^{143}Nd = 12.2 %; još šest izotopa



$T_{1/2} = 106 \text{ Ga}$

Sm/Nd odnos u terestričkim materijalima

garnet	0.539
MORB	0.32
seawater	0.211
Shale	0.209
Solar	0.31

Sm/Nd odnos u terestričkim materijalima

Nd im manji ionski potencijal (naboj/radijus) nego Sm, pa čini jače kemijske veze. Nd je koncentriran u taljevini, dok Sm ostaje u krutini.

Zaključak:

Visoki Sm/Nd u stijeni znači više ^{143}Nd

Niski Sm/Nd u stijeni znači manje ^{143}Nd

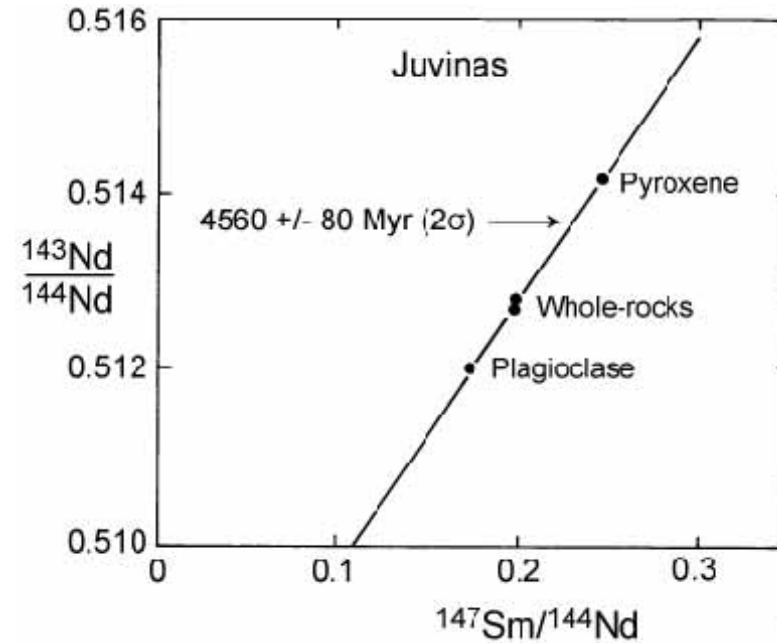
Opaska:

Sm će se obogaćivati u «osiromašenom» izvoru (na pr. MORB-u)
(suprotno nego u Rb/Sr sistemu)

$^{147}\text{Sm} - ^{143}\text{Nd}$ izokrone

$$\frac{^{143}\text{Nd}}{^{144}\text{Nd}} = \left(\frac{^{143}\text{Nd}}{^{144}\text{Nd}} \right)_i + \frac{^{147}\text{Sm}}{^{144}\text{Nd}} (e^{\lambda t} - 1)$$

- measured by isotope dilution and mass spectrometry
- arguments over the correction for isotopic fractionation during measurement led to the development of a **relative** reporting convention



Juvinas meteorit

If $x = (^{147}\text{Sm}/^{144}\text{Nd})_m$
 And $y = (^{143}\text{Nd}/^{144}\text{Nd})_m$
 We have $y = b + mx$

Where intercept $b = (^{143}\text{Nd}/^{144}\text{Nd})_i$
 And slope $m = (e^{\lambda t} - 1)$

CHUR modelna starost

CHUR (hondritski uniformni rezervoar)

- Nd isotope “model ages” can be calculated which represent the time of separation from CHUR evolution
- can also calculate an age from assuming a “depleted mantle” evolution (substitute DM Nd isotope values into equation below)

Present-day ratios:

	$^{147}\text{Sm}/^{144}\text{Nd}$	$^{143}\text{Nd}/^{144}\text{Nd}$
CHUR	0.1967	0.512638
DM	0.222	0.713114

“Model Age” calculation:

$$T_{CHUR}^{Nd} = \frac{1}{\lambda} \ln \left[\frac{(^{143}\text{Nd}/^{144}\text{Nd})_{\text{sample, today}} - (^{143}\text{Nd}/^{144}\text{Nd})_{CHUR, \text{today}}}{(^{147}\text{Sm}/^{144}\text{Nd})_{\text{sample, today}} - (^{147}\text{Sm}/^{144}\text{Nd})_{CHUR, \text{today}}} + 1 \right]$$

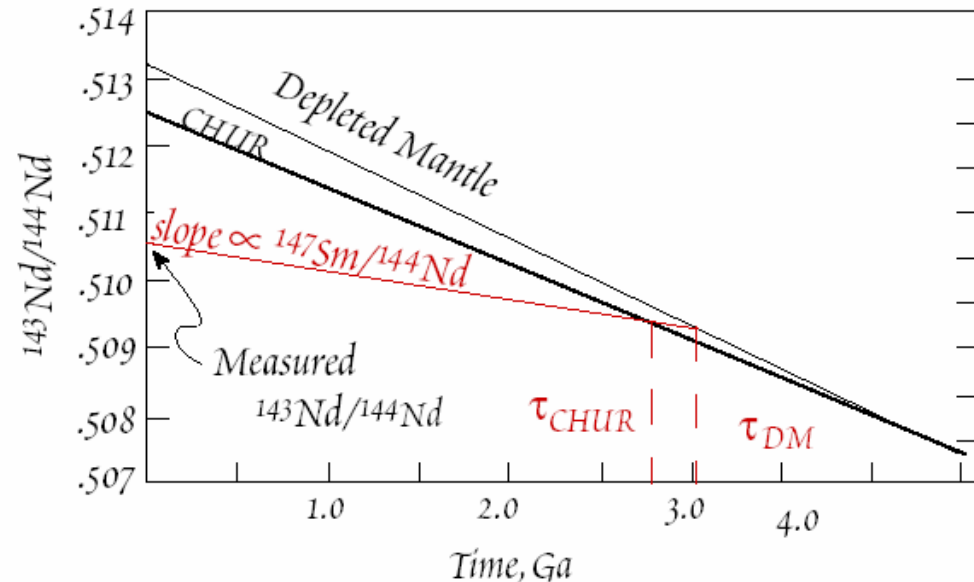
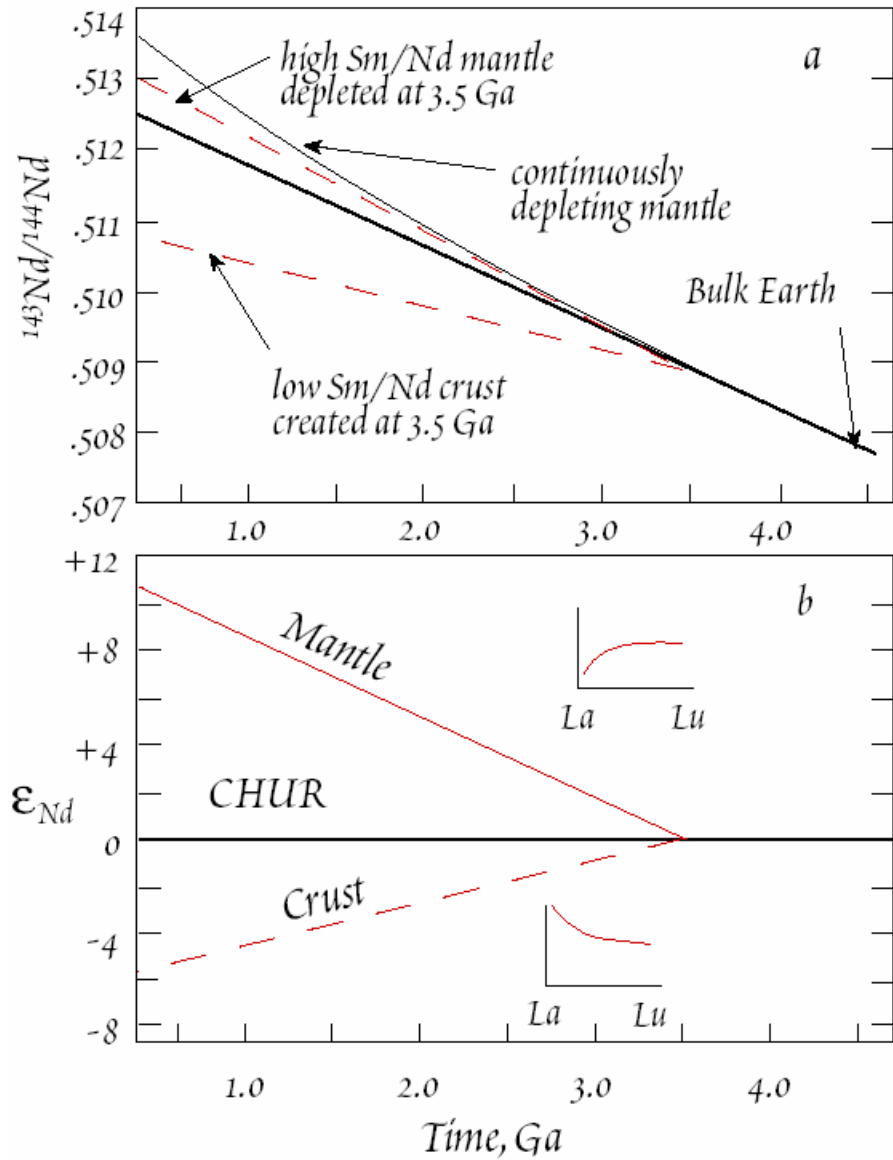


Figure 8.10. Sm-Nd model ages. The $^{143}\text{Nd}/^{144}\text{Nd}$ is extrapolated backward (slope depending on Sm/Nd) until it intersects a mantle or chondritic growth curve. In this example, the CHUR model age is 3.05 Ga while the depleted mantle model age is 3.3 Ga.

Epsilon Nd notacija

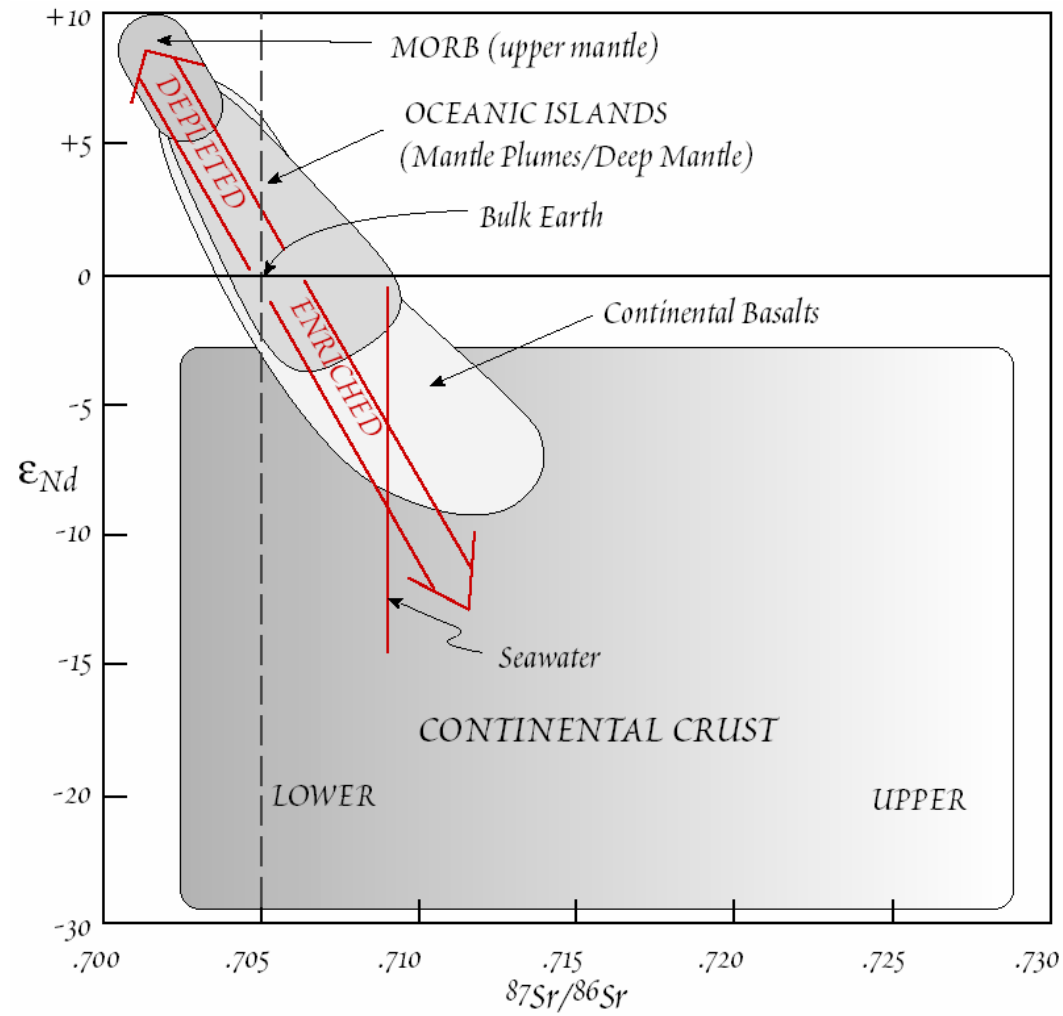


$$\epsilon_{\text{Nd,CHUR}} = \left[\frac{\left(\frac{^{143}\text{Nd}}{^{144}\text{Nd}} \right)_{\text{sample}}}{\left(\frac{^{143}\text{Nd}}{^{144}\text{Nd}} \right)_{\text{CHUR}}} - 1 \right] \times 10^4$$

“Chonritic Uniform Reservoir”

- typically measured on chondritic meteorites (DePaulo and Wasserburg, 1976a)
- If CHUR and samples are measured in the same lab, then regardless of normalization, one can compare ϵ_{Nd} values
- also practical way to report very small Nd isotope changes (~ 0.0001)

Sm-Nd i Rb-Sr dijagrami



Izotopna Nd evolucija morske vode

- Nd nije dobro miješan u oceanima zbog kratkog rezidencijalnog vremena.
- RZ su ekstremno otporne na metamorfizm, pa su pouzdani podaci Nd izotopa u vrlo starim sedimentima, zubima riba, željezno-manganskim nodulama.
- Nd izotopne varijacije reflektiraju globalnu tektonsku historiju.

Izotopna Nd evolucija morske vode

