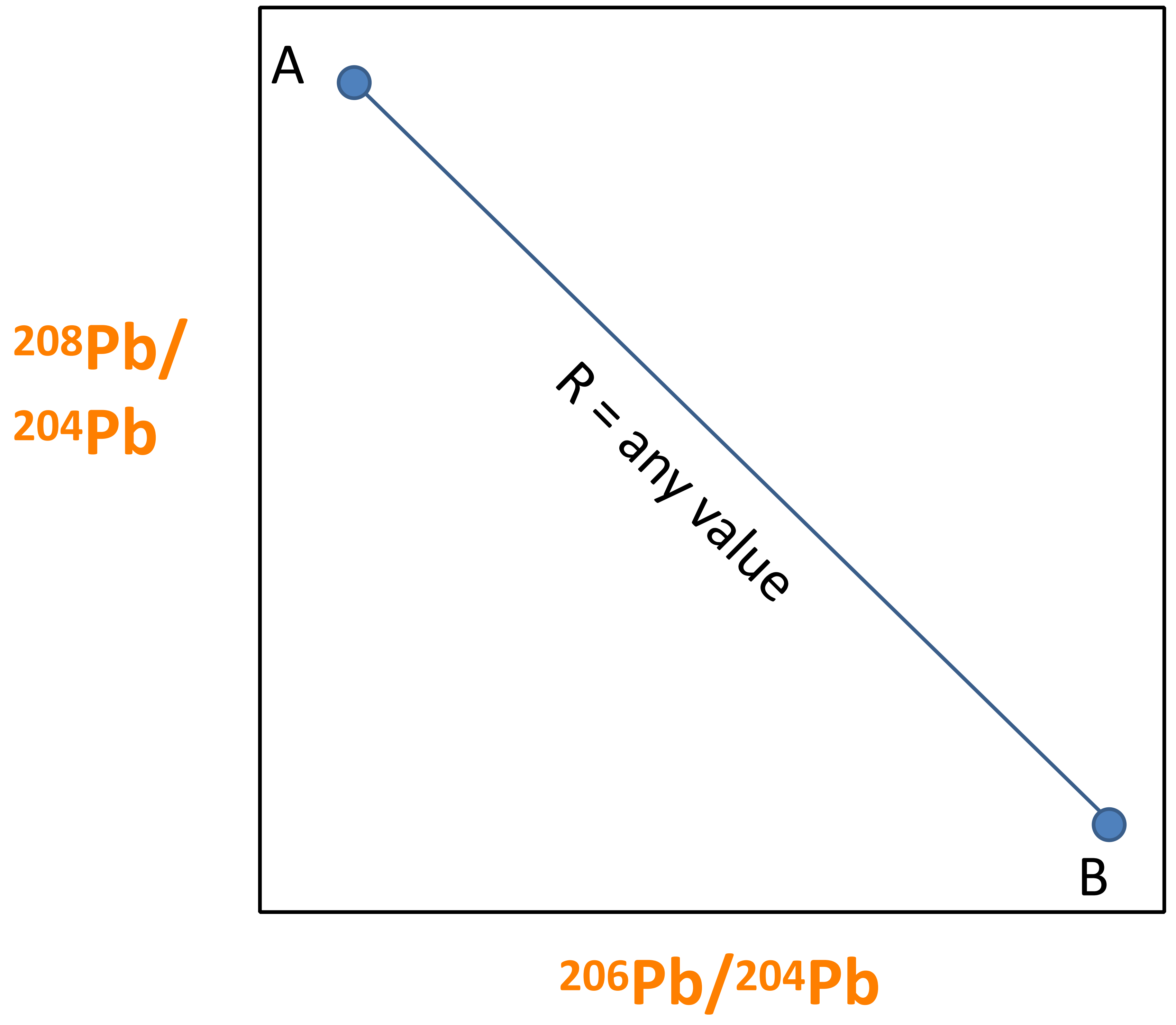
Isotope Ratios as Indicators of Mixing Processes

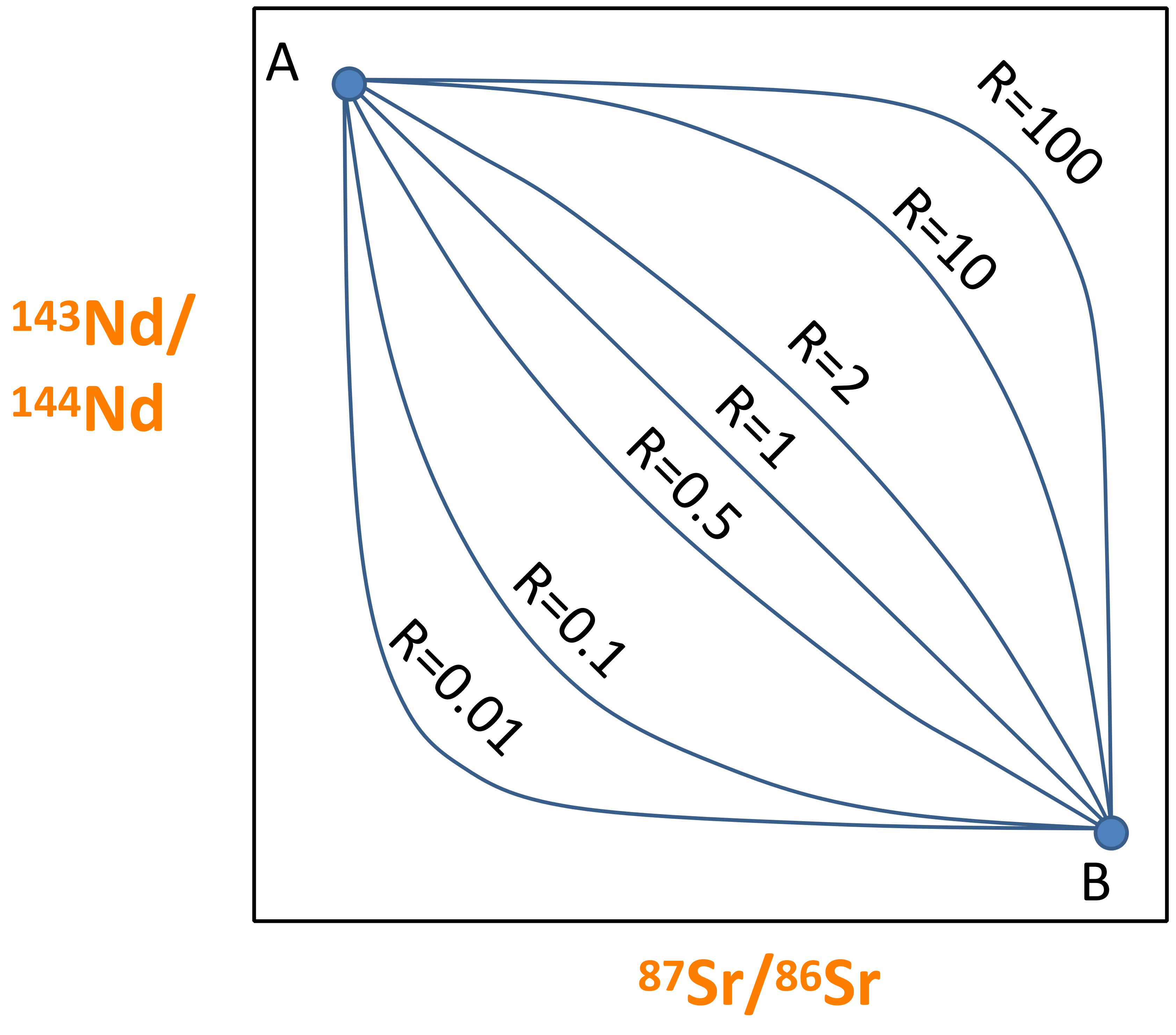
$$\left[\frac{^{87}Sr}{^{86}Sr}\right]_{MIX} = \frac{X_A[Sr]_A\left(\frac{^{87}Sr}{^{86}Sr}\right)_A + (1-X_A)[Sr]_B\left(\frac{^{87}Sr}{^{86}Sr}\right)_B}{X_A[Sr]_A + (1-X_A)[Sr]_B}$$

This is the mixing equation for Sr isotopes; similar equations exist for the other isotopic systems.

X_A and X_B are the wt. fractions of components A and B, Sr_A and Sr_B are the abundances of Sr in the two components, $(^{87}Sr/^{86}Sr)_A$ and $(^{87}Sr/^{86}Sr)_B$ are the isotopic ratios of the two components.

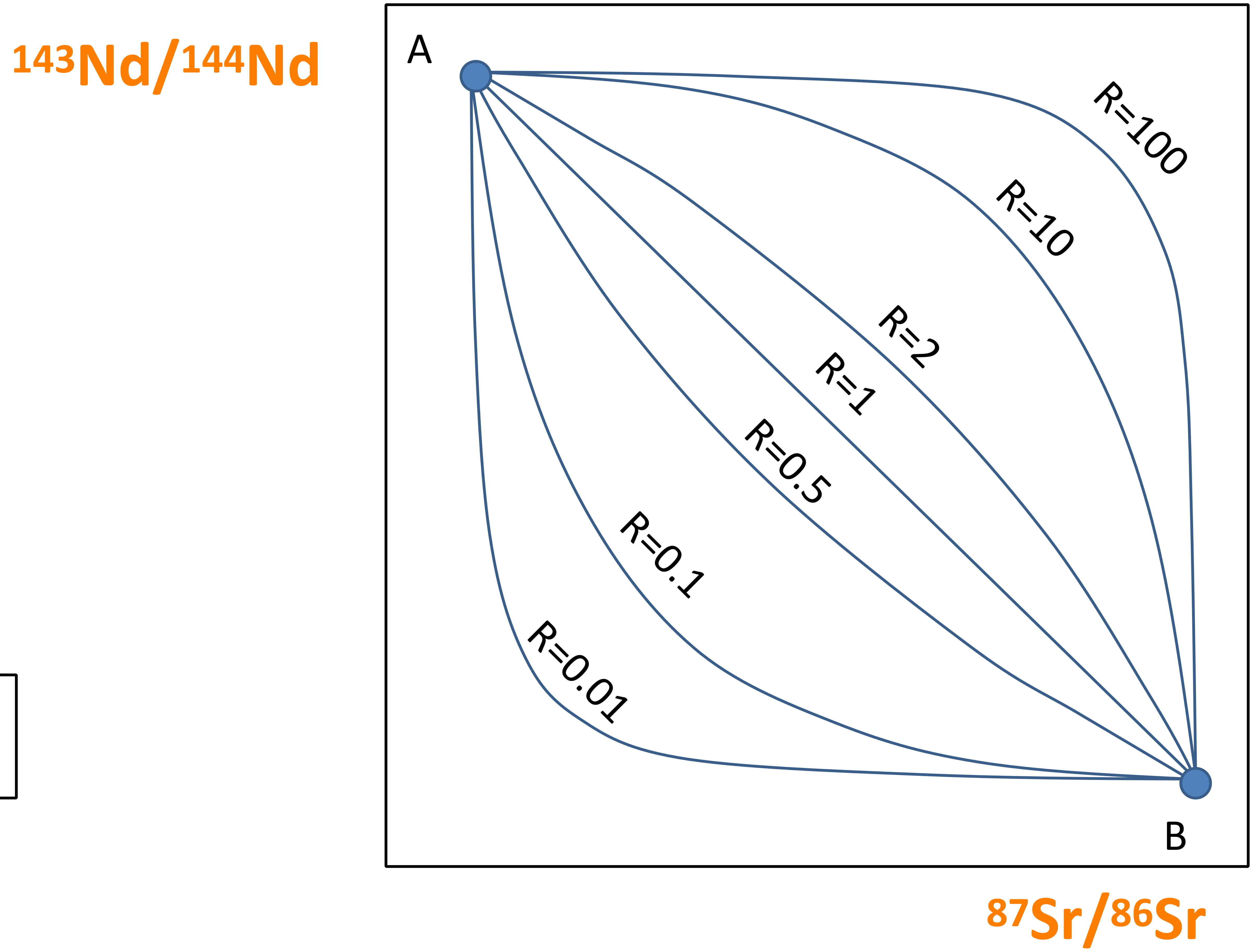
Mixing curves are straight lines ONLY if the x and y-axis denominators are the same. Otherwise, mixing curves are hyperbolas.





Isotope Ratios as Indicators of Mixing Processes

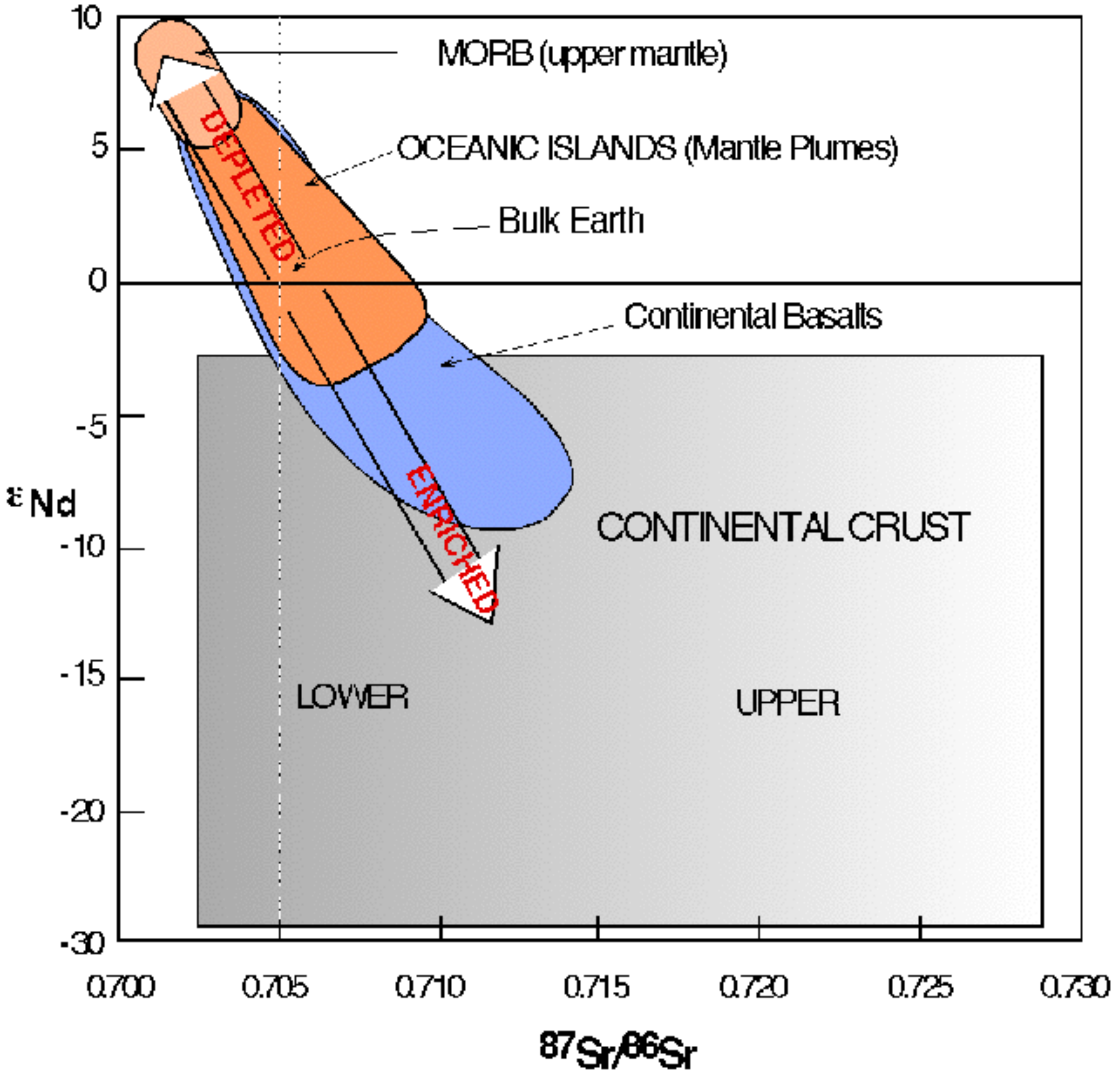
- $R = \dfrac{^{144}Nd_A * {}^{86}Sr_B}{^{144}Nd_B * {}^{86}Sr_A}$
- Since ^{144}Nd ~ total Nd and ^{86}Sr ~ total Sr,
- R ~ $(Nd_A Sr_B)/(Nd_B/Sr_A)$
- which simplifies to:
- **R ~ $(Sr/Nd)_B/(Sr/Nd)_A$**

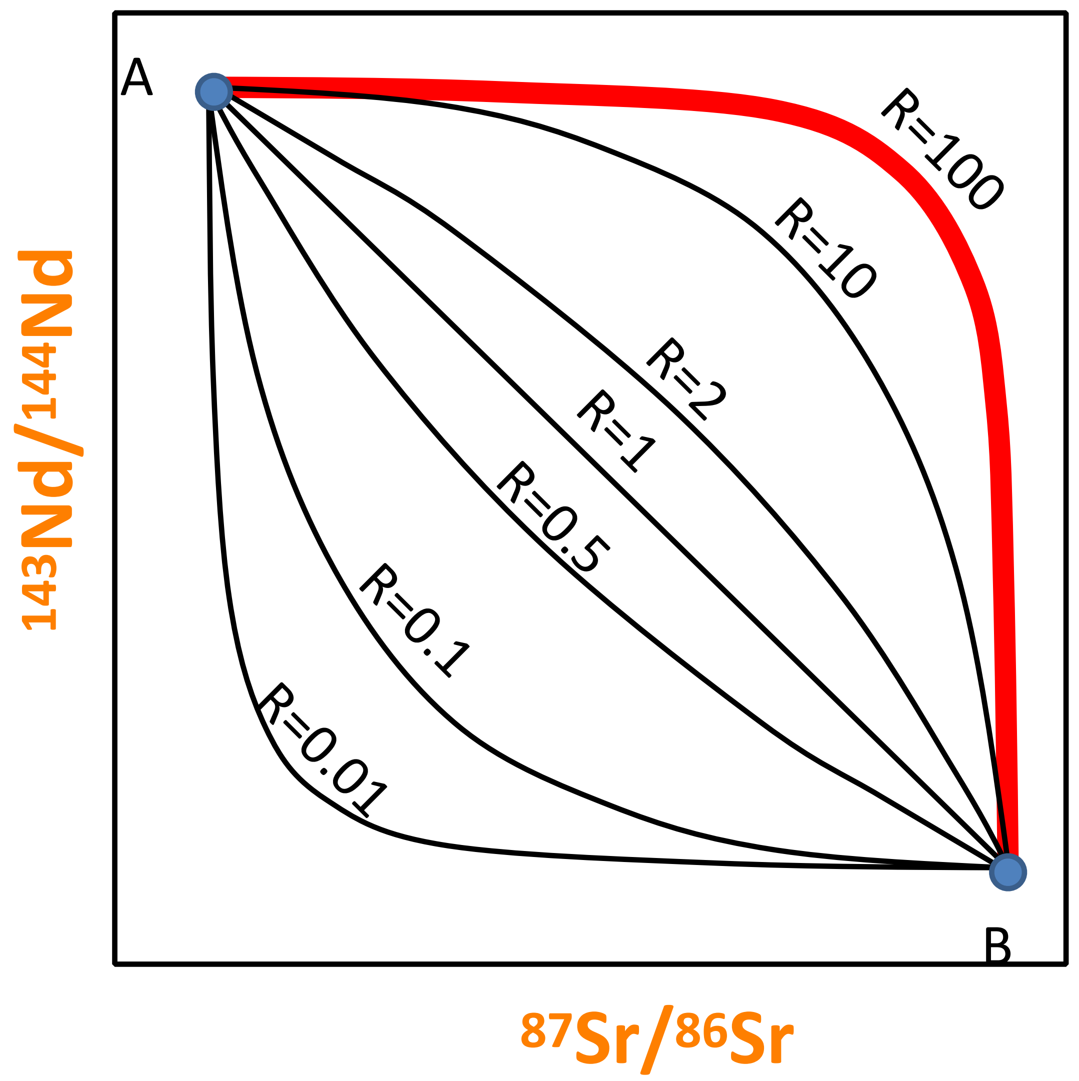


Sr-Nd Isotopes

Note that fields define mixing trends

These examples are from Island Arcs…
What happens in Continental Arcs?





After Winter (2001) Intro to Igneous & Metamorphic Petrology, Fig. 16-12

Sr-Nd Isotopes

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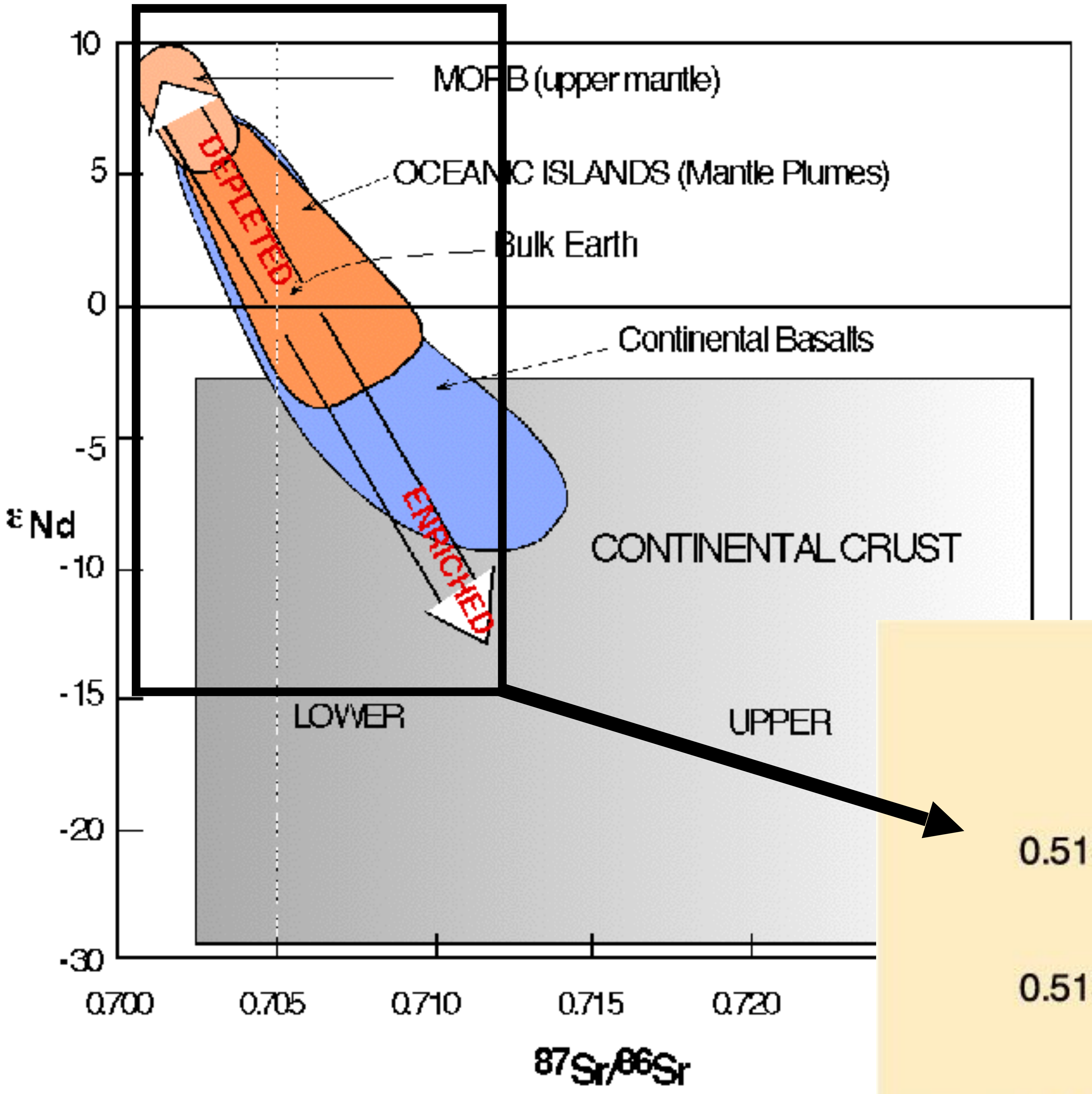
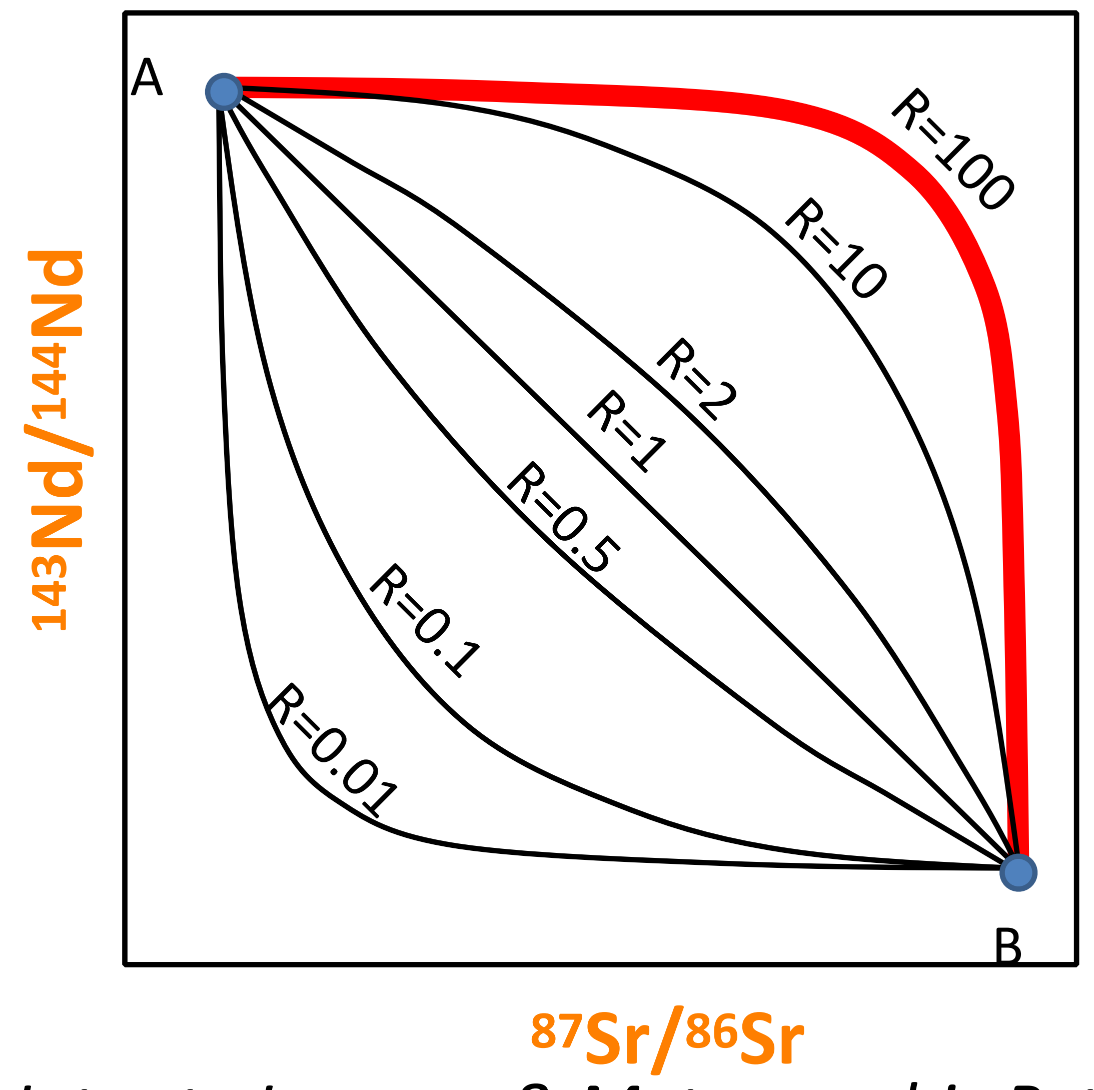
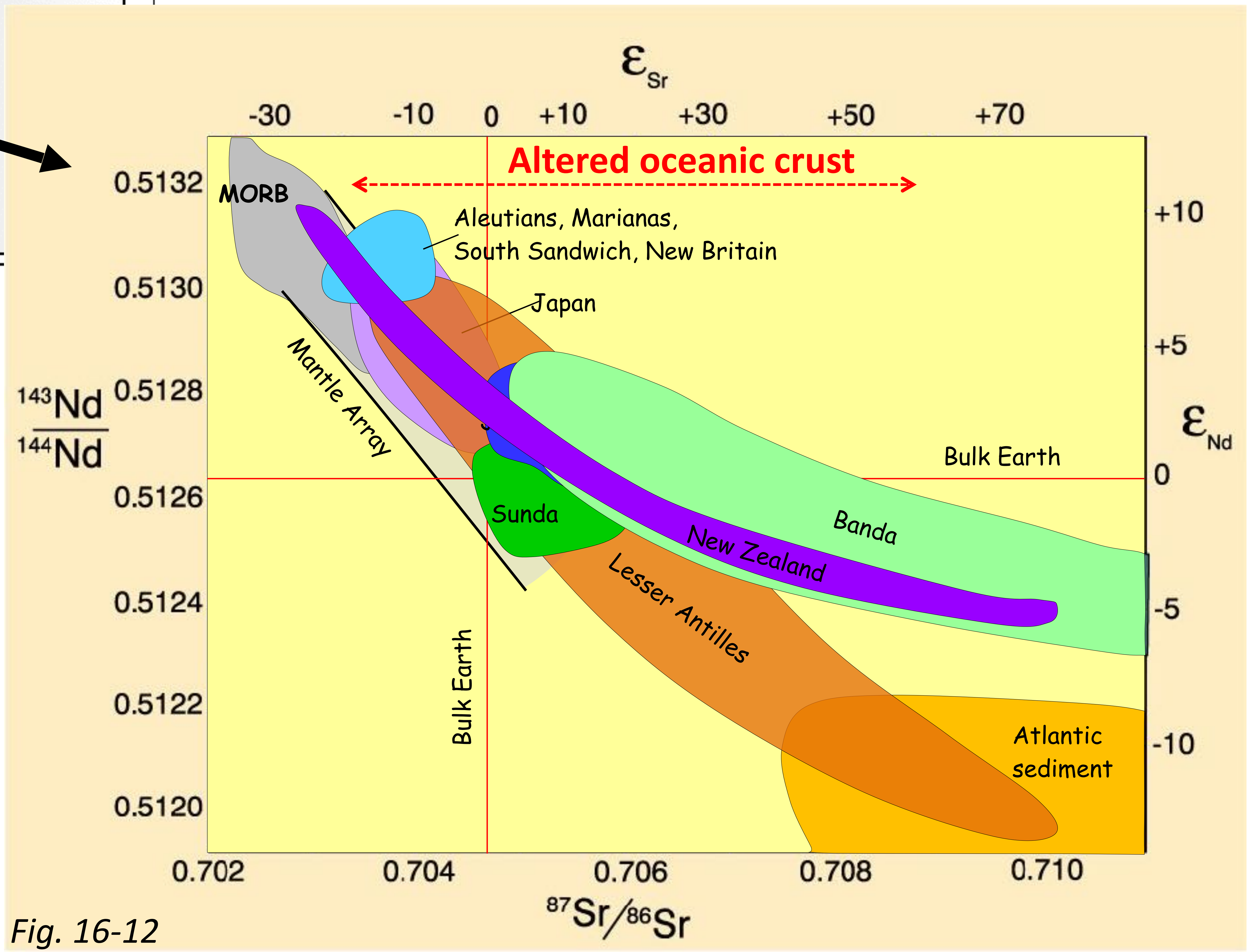
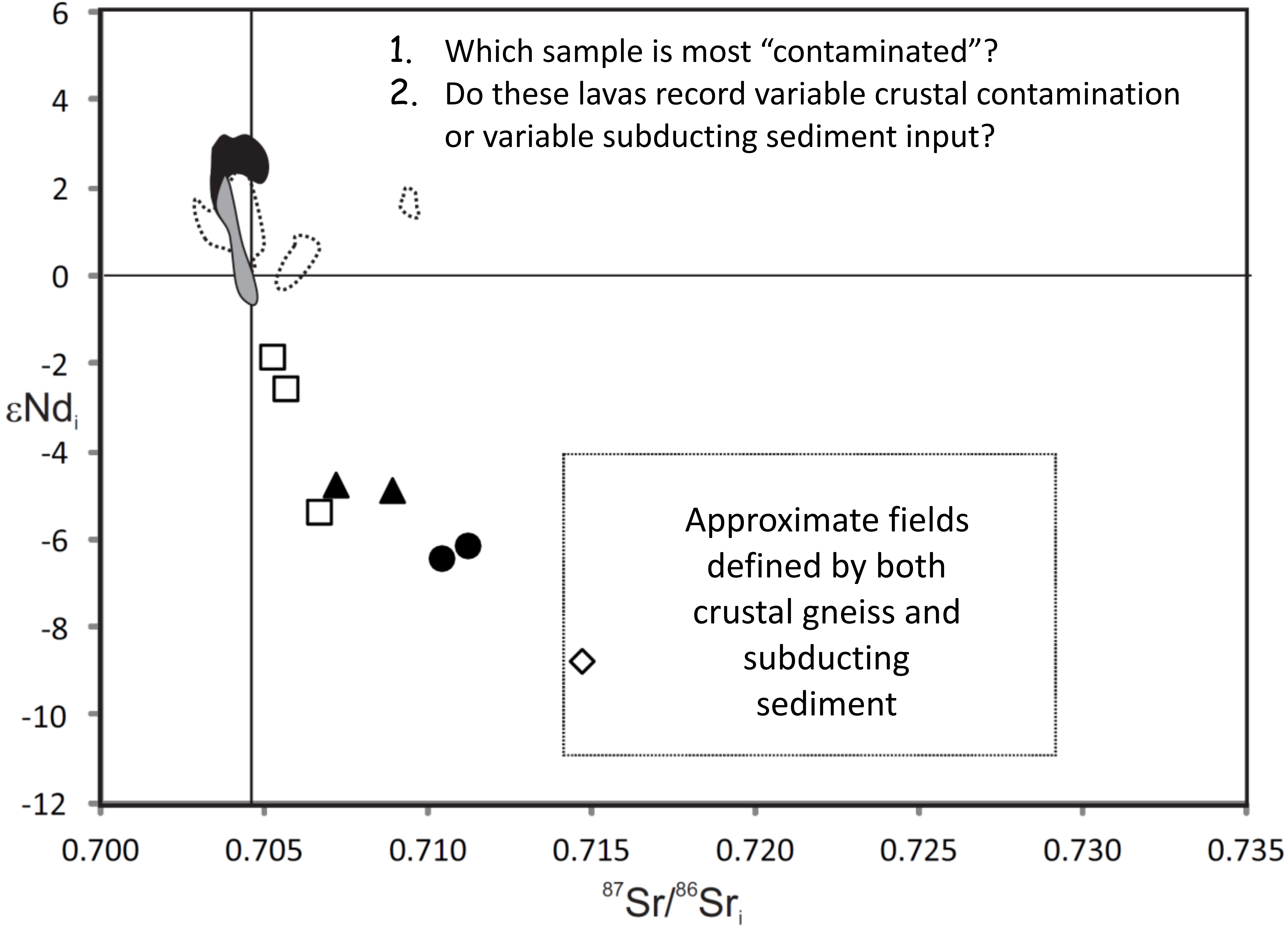






After Winter (2001) Intro to Igneous & Metamorphic Petrology, Fig. 16-12

1. Which sample is most "contaminated"?
2. Do these lavas record variable crustal contamination or variable subducting sediment input?



Possible sedimentary input

Trench	Colomb
Subd rate (mm/year)	70
Thickness (m)	270
Density (g/cc)	1.64
Water (%)	41.54
Trench length (km)	1050
Confidence level	3
SiO_2	35.70
TiO_2	0.04
Al_2O_3	1.49
FeO*	0.43
MnO	0.14
MgO	0.55
CaO	28.33
Na_2O	3.10
K_2O	0.13
P_2O_5	0.21
CO_2	22.26
H_2O+	6.92
Sc	2.15
V	17
Cr	5.1
Co	6.5
Ni	20.4
Cu	27.2
Zn	24.7
Rb	2.8
Cs	0.15
Sr	807
Ba	1658
Y	11.9
Zr	43
Hf	1.24
Nb	2.08
Ta	0.146
La	18.01
Ce	6.59
Nd	13.93
Sm	3.24
Eu	0.83
Gd	3.34
Dy	3.61
Er	2.33
Yb	1.19
Lu	0.350
Pb	0.89
Th	0.38
U	0.62

Plank & Langmuir, 1998

Least radiogenic mafic lava

Sample wt%	LC12
SiO_2	44.5
TiO_2	4.55
Al_2O_3	12.3
$Fe_2O_3^t$	12.9
MnO	0.17
MgO	8.06
CaO	9.10
Na_2O	2.86
K_2O	1.54
P_2O_5	0.74
CO_2	0.25
H_2O	2.57
LOI	2.83
Total	99.6
ppm	
Ba	532
Cr	157
Ga	16
Nb	51
Rb	33
Sc	21
Sr	550
V	230
Y	28
Zn	786
Zr	227
La	38.0
Ce	72.7
Pr	8.78
Nd	39.5
Sm	9.19
Eu	3.09
Gd	9.25
Tb	1.44
Dy	6.78
Ho	1.22
Er	2.78
Tm	0.37
Yb	2.08
Lu	0.26

Vasquez et al 2010

Possible crustal contaminants

Sample	Location	Sm (ppm)	Nd (ppm)	$^{143}Nd/^{144}Nd$	2σ	$^{87}Sr/^{86}Sr$	2σ	Rb (ppm)	Sr (ppm)
Argentine orthogneiss									
	Hombre Muerto								
6-84		*3.86*	*17.0*	0.512235	0.000010	0.919388	0.000103	196	22
Argentine paragneiss									
	Caldera Coranzuli								
xc-01	xenolith	*11.4*	*64.8*	0.511810	0.000009	0.723511	0.000024	289	209
	Salar Centenario								
FC-51		*5.33*	*28.1*	0.511988	0.000007	0.725339	0.000020	47	76
7/49		*6.18*	*31.0*	0.512053	0.000016	0.728630	0.000021	70	117
	Salar Hombre Muerto								
SK 1/55[a]		6.6	34.0	0.512091	0.000014	0.757668	0.000008	199	96
HM37									
	Sierra de Quilmes								
6/120		*5.11*	*25.8*	0.512069	0.000004	0.736172	0.000010	127	120
7/27		8.27	43.5	0.512056	0.000006	0.750406	0.000050	183	99
	Salar de Antofalla								
6-160		*7.44*	*40.1*	0.511989	0.000010	0.767946	0.000021	189	68
T2		8.01	34.8	0.512150	0.000005	0.738516	0.000006	74	55

Lucassen et al 2001