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Extended Abstracts

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The double stage Sm-Nd model age and aplications to Brazilian platform rocks

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Single stage Sm-Nd model age

The time corresponding to the point where the evolution curve of the sample $^{143}Nd/^{144}Nd(T)$ intersects the CHUR and DM curves are termed T_{CHUR} and T_{DM} (CHUR = Chondritic Uniform Reservoir; DM=depleted mantle).

The model ages can be calculated from equation:

$$T_x = \lambda^{-1} \ Ln\{1+ [\ (^{143}Nd/^{144}Nd)_s(t_0) - (^{143}Nd/^{144}Nd)_x(t_0) \ ] \ / \ [(^{147}Sm/^{144}Nd)_s(t0) - {}^{147}Sm/^{144}Nd_x(t_0)\} \qquad \text{(eq. 1)}$$

where x=CHUR or DM; s=sample and t_0= today ratio value;
$\lambda=6.54\times10^{-12}a^{-1}$; $(^{143}Nd/^{144}Nd)_{CHUR} = 0.512638$ and $(^{147}Sm/^{144}Nd)_{CHUR} = 0.1967$

The $^{143}Nd/^{144}Nd$ ratio also expressed here as $\varepsilon_{Nd}(t)$, the deviation from the value expected in a chrondritic reservoir (CHUR), and is (DePaolo 1981):

$$\varepsilon_{Nd}(T) = 10^4\{[^{143}Nd/^{144}Nd_s(T) \ / \ ^{143}Nd/^{144}Nd_{CHUR}(T)] - 1\} \qquad \text{(eq. 2)}$$

where $(^{143}Nd/^{144}Nd)_x(T) = (^{143}Nd/^{144}Nd)_x(t_o) - (^{147}Sm/^{144}Nd)_x[(\exp\lambda T)-1]$

The magnitude of the ε_{Nd} value for crustal rocks depends on the product of time and chemical fractionation parameter $f_{Sm/Nd}$:

$$f_{Sm/Nd}=[(^{147}Sm/^{144}Nd)_s - (^{147}Sm/^{144}Nd)_{CHUR}] \ / \ [(^{147}Sm/^{144}Nd)_{CHUR}] \qquad \text{(eq. 3)}$$

The ε_{Nd} of the model depleted mantle and crustal rock sample are given accurately by (DePaolo 1981):

$\varepsilon_{Nd}(T)=0.25T^2-3T + 8.5$ (DM - deplete mantle evolution). (eq. 4)
$\varepsilon_{Nd}(T)= \varepsilon_{Nd}(t_o) - 25.09f_{Sm/Nd}T$ (rock sample at a time T). (eq. 5)

The T_{DM} model age is otained by equating $\varepsilon_{Nd}(T)$ mantle and $\varepsilon_{Nd}(T)$ rock ($\varepsilon_{Nd}(T)$rock = $\varepsilon_{Nd}(T)_{DM}$.

Double stage Sm-Nd model age

In some cases if the $^{147}Sm/^{144}Nd$ ratio is very different from 0.09 - 0,125 mainly for granitic rocks, then Sm-Nd model age can be unrealistc. When the Sm/Nd ratios of a crustal rock are fractioned very late (>0.4Ga) after the mantle-continental differention the single stage model cannot be used.

A simple two stage history for magma source is ilustrated in Fig. 1, where T_{DM2} represents a model age of the magma source and T_{fe} represents a fractionation events.

In many cases such an age (T_{fe}) can be estimated from other geochronological relationships especially in the particular case of large crustal provinces of known age.

The depleted mantle model age in double stage is defined as:

$$T_{DM2}=\lambda^{-1}Ln\{1+[(^{143}Nd/^{144}Nd)_{DM}-[(^{143}Nd/^{144}Nd)_{s}-(e^{\lambda T(fe)}-1)[(^{147}Sm/^{144}Nd)_{s}-(^{147}Sm/^{144}Nd)_{f1}]]] / [(^{147}Sm/^{144}Nd)_{DM} - (^{147}Sm/^{144}Nd)_{f1}]\} \quad \text{(eq. 6)}$$

where $(^{147}Sm/^{144}Nd)_{DM}=0.2188$; $(^{143}Nd/^{144}Nd)_{DM}=0.513151$ (Millisenda et. al. 1994) and $(^{147}Sm/^{144}Nd)_{f1}$ = the average value for the crustal rock source (in general ~= 0.11 for TTG and granitic rock).

The equation T_{DM2} (double stage) can be applied if T_{DM1} (single stage) > Tfe and $(^{147}Sm/^{144}Nd)_{s} < 0.2188$ or if $T_{DM1} < T_{fe}$ and $(^{147}Sm/^{144}Nd)_{s} > 0.2188$.

The model age, T_{CHUR2}, in two stages can be calculated by DePaolo (1988) 3-14 equation:

$$T_{CHUR2} \approx T_{fe} + \varepsilon_{Nd(fe)} / 25.09 f_{Sm/Nd(f1)} \quad \text{(eq. 7)}$$

where the $\varepsilon_{Nd(fe)}$ value is calculated for the fracionation event (T_{fe}); $f_{Sm/Nd(f1)}$ can be estimated using source average values. As an example, a typical crustal rock such as TTG and granite might have $f_{Sm/Nd(f1)} \approx -0,44 \pm 0.06$. If the $f_{Sm/Nd}$ value measured today is very different from $-0,44 \pm 0.06$, mainly for granitic rocks with $\varepsilon_{Nd(fe)} < 0$, then the equation above can be applied with success.

Applications of two stage Sm-Nd model ages in mineral:

mineral /rock	identi cation	T_{DM2} (Ga)	$^{143}Nd/^{144}Nd$	$^{147}Sm/^{144}Nd$	Sm ppm	Nd ppm	$f_{Sm/Nd}$	$\varepsilon_{Nd}(t)$	t (Ga)	rf
plag.	JB 7B	2.70	.511578	.1386	22.4	97.7	-.30	-16	.61	5
pyrox.	JB 7B	2.71	.511409	.0976	4.6	28.5	-.50	-16	.61	5
biotite	JB 7B	2.73	.511540	.1341	4.9	22.1	-.32	-17	.61	5
wr/gnl	JB 7B	2.71	.511523	.1279	1.1	5.2	-.35	-16	.61	5
plag.	JP 48	1.54	.512350	.1693	2.1	7.5	-.14	-3.6	.58	5
biotite	JP 48	1.52	.512248	.1395	0.6	2.6	-.29	-3.4	.58	5
garnet	JP 48	1.56	.513124	.3721	2.4	3.9	+.89	-3.5	.58	5
wr/gns	JP 48	1.54	.512162	.1223	5.4	26.7	-.38	-3.8	.58	5

Table 1: Sm-Nd data for mineral of the Itatins Complex. The model ages, T_{DM2} are based on equation 6 using $(^{147}Sm/^{144}Nd)_{f1}$ = .1279 and .1223 (wr = wall rock); T_{fe} = 0.61Ga and .58Ga (Sm-Nd mineral isochron) for samples JB 7B (wr = granulite) and JP 48 (wr=gneiss) respectively. Isotopic data reference: 5 = Picanço (1995).

Applications of Sm-Nd model ages in two stage in wall rocks:

rock	identication	T_{DM2} (Ga)	$^{143}Nd/^{144}Nd$	$^{147}Sm/^{144}Nd$	Sm	Nd	$f_{Sm/Nd}$	$\varepsilon_{Nd}(t)$	t (Ga)	rf
vulc.	MP64[A]	0.97	.513204	.2320	1.37	3.57	.18	+6.9	.93*	7
granite	MP47B[A]	1.19	.512608	.2050	8.0	23.6	-.04	-1.1	.49*	6
granite	MP478D[A]	1.23	.512561	.1904	7.4	23.5	-.03	-1.1	.55*	6
granite	MM99D[B]		.511612	.1651	.86	3.15	-.16	-12.3	1.9*	3
granite	MM99H[B]		.512039	.1910	.48	1.52	-.03	-10.3	1.9*	3
granite	ABP63D[C]		.511765	.1474	5.92	24.3	-.25	-13	.62*	8
gneiss	MJ137[D]		.512573	.1683	---	---	-.14	0.9	.59#	9
granite	BR-92.48[E]	2.60	.511156	.0768	14.0	110.	-.61	-20	.60$	10

Table 2: Sm-Nd data for wall rock of the Complexes and Province: [A] = Center Goiás; [B] = Cont. Mirante - S.Francisco Craton; [C] =. Cunhaporanga - Paraná; D = Curitiba - Paraná; [D] = Borborema. The model ages, T_{DM2} are basead by equation 6 using $(^{147}Sm/^{144}Nd)f1 = 0.11$ and $T_{fe} = t($ * =Rb-Sr isochron; # =Sm-Nd mineral isochron; $ =U-Pb). Isotopic data reference: 7 = Pimenterl et. al. (1992); 6 = Pimnetel and Charnley (1991); 3 = Marinho (1991); 8 = Reis Neto (1994); 9 = Siga Jr. (1995); 10 = Van Schmuss et. al. (1995).

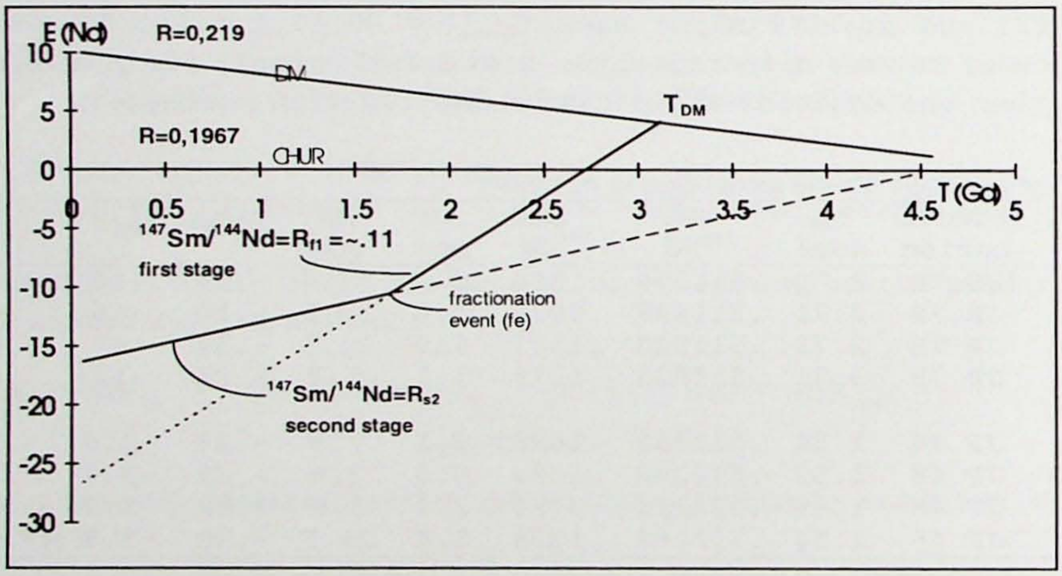

Fig. 1

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