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"Paleosols and paleoenvironments of early Mars"

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Table DR1. Transfer Functions used to interpret Martian paleosols

Equation	Variables	Coefficient of variation (R^2)	Standard error	Reference
$\tau_{j,w} = \left[\frac{\rho_w \cdot C_{j,w}}{\rho_p \cdot C_{j,p}}\right][\varepsilon_{i,w}+1]-1$	$\tau_{w,j}$ (mole fraction) = mass transfer of a specified (j) element in a soil horizon (w); ρ_w (g.cm^{-3}) = bulk density of the soil; ρ_p (g.cm^{-3}) = bulk density of parent material; $C_{j,w}$ (weight %) = chemical concentration of an element (j) in a soil horizon (w); $C_{p,w}$ (weight %) = chemical concentration of an element (j) in the parent material (p): $\varepsilon_{i,w}$ (mole fraction) = strain due to soil formation	not applicable	not applicable	Brimhall et al., 1992; Amundson et al., 2008
$\varepsilon_{i,w} = \left[\frac{\rho_p \cdot C_{i,p}}{\rho_w \cdot C_{i,w}}\right]-1$	$\varepsilon_{i,w}$ (mole fraction) = strain of a soil horizon (w) with respect to a stable chemical constituent (i); ρ_w (g.cm^{-3}) = bulk density of a soil horizon; ρ_p (g.cm^{-3}) = bulk density of parent material; $C_{i,w}$ (weight %) = chemical concentration of stable element (i) in a soil horizon (w); $C_{p,w}$ (weight %) = chemical concnetration of stable element (i) in the parent material (p)	not applicable	not applicable	Brimhall et al., 1992; Amundson et al., 2008
$A = 3.987G + 5.774$	A (kyrs) = duration of soil formation; G = percent gypsum in gypsic (By) horizon	0.95	±15 kyrs	Retallack, 2013
$A = 802468\ln S+299697$	A (kyrs) = duration of soil formation; S = Antarctic soil weathering stage of Campbell and Claridge (1987)	0.62	±672,809 yrs	Retallack et al., 2001; Campbell and Claridge, 1987
$B = \frac{-0.62}{\frac{0.38}{e^{0.17k}}-1}$	B (fraction) = compaction of Aridisol due to burial; k (km) = depth of burial	not applicable	not applicable	Sheldon and Retallack, 2001
$P = 87.593e^{0.0209 \cdot D}$	P (mm) = mean annual precipitation; D (cm) compaction-corrected depth to gypsum (By) horizon.	0.52	±129 mm	Retallack and Huang, 2010
$T = 0.21I - 8.93$	T (ºC) = mean annual paleotemperature; I (mole fraction) = chemical index of weathering $(I = \frac{100Al_2O_3}{(Al_2O_3 + CaO + Na_2O)})$	0.81	±0.5ºC	Óskarsson et al., 2009

Gaussian error propagation of molar weathering ratios

Analytical results on the Viking rovers had large error bars (McSween and Keil, 2001), which affect the precision of calculated molar weathering ratios to the extent that they are nearly meaningless. Curiosity rover in contrast has returned high precision analyses (McLennan *et al*., 2014). Gaussian error propagation of both sets of data have been calculated for comparison using the following partial derivatives.

1. Soda/potash molar ratio (F) for salinization

$$F = \frac{\frac{Na}{61.98}}{\frac{K}{94.2}}$$

Gaussian error propagation combining errors of *Na*, and *K*

$$S_{\overline{F}} = \sqrt{(\frac{\partial F}{\partial Na} \times S_{\overline{Na}})^2 + (\frac{\partial F}{\partial K} \times S_{\overline{K}})^2}$$

$$\frac{\partial D}{\partial Na} = \frac{1.51985}{K}$$

$$\frac{\partial D}{\partial K} = \frac{-1.51985 \times Na}{K^2}$$

2. Alkaline earths/alumina molar ratio (*E*) for calcification

$$E = \frac{\frac{Ca}{56.08} + \frac{Mg}{40.32}}{\frac{Al}{101.96}}$$

Gaussian error propagation combining errors of *Ca*, *Mg* and *Al*

$$S_{\overline{E}} = \sqrt{(\frac{\partial E}{\partial Al} \times S_{\overline{Al}})^2 + (\frac{\partial E}{\partial Ca} \times S_{\overline{Ca}})^2 + (\frac{\partial E}{\partial Mg} \times S_{\overline{Mg}})^2}$$

$$\frac{\partial E}{\partial Ca} = \frac{1.81812}{Al}$$

$$\frac{\partial E}{\partial Mg} = \frac{2.52877}{Al}$$

$$\frac{\partial E}{\partial Al} = \frac{-1.81812Ca - 2.52877Mg}{Al^2}$$

3. Alumina/silica molar ratio (*C*) for clayeyness

$$C = \frac{\frac{Al}{101.96}}{\frac{Si}{60.09}}$$

Gaussian error propagation combining errors of *Si* and *Al*

$$S_{\overline{C}} = \sqrt{(\frac{\partial C}{\partial Al} \times S_{\overline{Al}})^2 + (\frac{\partial C}{\partial Si} \times S_{\overline{Si}})^2}$$

$$\frac{\partial C}{\partial Al} = \frac{0.589349}{Si}$$

$$\frac{\partial C}{\partial Si} = \frac{0.589349Al}{Si^2}$$

4. Alumina/bases molar ratio (A) for base loss

$$A = \frac{\frac{Al}{101.96}}{\frac{Ca}{56.08} + \frac{Mg}{40.32} + \frac{K}{94.2} + \frac{Na}{61.98}}$$

Gaussian error propagation combining errors of *Ca*, *Mg*, *K*, *Na* and *Al*

$$S_{\overline{A}} = \sqrt{(\frac{\partial A}{\partial Ca} \times S_{\overline{Ca}})^2 + (\frac{\partial A}{\partial Mg} \times S_{\overline{Mg}})^2 + (\frac{\partial A}{\partial K} \times S_{\overline{K}})^2 + (\frac{\partial A}{\partial Na} \times S_{\overline{Na}})^2 + (\frac{\partial A}{\partial Al} \times S_{\overline{Al}})^2}$$

$$\frac{\partial A}{\partial Ca} = -\frac{1.5519Al}{(K + 2.33631Mg + 1.51985Na + 1.67974Ca)^2}$$

$$\frac{\partial A}{\partial Mg} = -\frac{0.765007Al}{(Ca + 0.595329K + 0.904808Na + 1.39087Mg)^2}$$

$$\frac{\partial A}{\partial K} = -\frac{0.337443Al}{(Ca + 1.39087Mg + 0.904808Na + 0.595329K)^2}$$

$$\frac{\partial A}{\partial Na} = -\frac{0.497662Al}{(Ca + 0.595329K + 1.39087Mg + 0.904808Na)^2}$$

$$\frac{\partial A}{\partial Al} = \frac{0.55002}{Ca + 0.595329K + 1.39087Mg + 0.904808Na}$$

5. Sulfite/alumina molar ratio (*U*) for gypsification

$$U = \frac{\frac{S}{80.07}}{\frac{Al}{101.96}}$$

Gaussian error propagation combining errors of *S* and *Al*

$$S_{\overline{U}} = \sqrt{(\frac{\partial U}{\partial S} \times S_{\overline{S}})^2 + (\frac{\partial U}{\partial Al} \times S_{\overline{Al}})^2}$$

$$\frac{\partial U}{\partial S} = \frac{1.27339}{Al}$$

$$\frac{\partial U}{\partial Al} = \frac{-1.27449S}{Al^2}$$

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