DATA REPOSITORY ITEM 2009041

Appendix DR1

The mass loss rate of a mineral species per unit ground surface area via chemical weathering ($\partial m/\partial t$, with the dimensions of $ML^{-2}T^{-1}$) is described as:

$$\frac{\partial m}{\partial t} = -RA_s w_m \quad . \qquad \text{(A1.1)}$$

where m is the mass of mineral per a given ground surface area (ML^{-2}), t is the time that the minerals are exposed to chemical weathering reactions, R is the chemical weathering rate in moles reacted per mineral surface area per time (mol L^{-2} T^{-1}), A_s is the mineral surface area per ground surface area (unitless), and w_m is molar weight of the mineral (M mole^{-1}),

The surface area of the minerals per ground surface area (A_s) is related to the mineral grain roughness by (White and Brantley, 2003):

$$A_s = \frac{6\gamma}{D\rho_m} m \quad , \qquad \text{(A1.2)}$$

where D is the grain diameter (L), γ is the mineral surface roughness (unitless), and ρ_m is the density of the minerals (ML^{-3}).

Both the mass and the surface area of minerals may evolve due to chemical weathering. In the model presented here we adopt the White and Brantley (2003) weathering model, which describes the chemical weathering rate per mineral surface area and the mineral grain roughness as a function of the mineral’s exposure time to chemical weathering as

$$R = at^{\alpha} \quad , \qquad \text{(A1.3a)}$$

and

$$\gamma = bt^{\beta} \ , \qquad \text{(A1.3b)}$$

where *a, b, α,* and *β* are empirical coefficients specific to individual mineral species. Note that *a* in A1.3a is the weathering rate constant presented in White and Brantley (2003).

Equations (A1.2 and A1.3) can then be inserted into equation (A1.1) to yield Eqn. (3) in the text ($dm/dt = -mKt^{\sigma}$) where, from Yoo and Mudd (2008),

$$K = \frac{6abw_m}{D\rho_m} \qquad \text{(A1.4a)}$$

and

$$\sigma = \alpha + \beta \qquad \text{(A1.4b)}$$

where *σ* is a unitless coefficient. It is important to note that the rate constant *K* in this derivation is not the same rate constant as in White and Brantley (2003). We use parameter values for potassium-feldspar; these parameters are statistically similar for other primary minerals reported by White and Brantley (2003). Table DR1 lists the parameter values for several minerals.

Table DR1. Parameter values for several minerals. Data for *a*, *α*, *b*, and *β* from White and Brantley (2003). Potassium feldspar is assumed to be of orthoclase composition, plagioclase is assumed to be of albite composition, and hornblende is assumed to be of magnesiohornblende composition. Note that *α* is the slope value, *b*, from Table 8 in White and Brantley (2003).

Parameter	K-feldspar	Plagioclase	Hornblende	Biotite
a (mol m^{-2} y^{-1}),	1.020 x 10^{-5}	1.093 x 10^{-5}	0.674 x 10^{-5}	1.509 x 10^{-5}
α (unitless)	-0.647	-0.564	-0.623	-0.603
b (unitless)	13.6	13.6	13.6	13.6

β (unitless)	0.2	0.2	0.2	0.2
w_m (kg mol^{-1})	0.2782	0.2630	0.8212	0.4335
ρ_m (kg m^{-3})	2600	2600	3200	3000
σ (unitless)	-0.447	-0.364	-0.423	-0.403
$K*D$ (m y^{-1})	0.891x10^{-7}	0.902x10^{-7}	1.412x10^{-7}	1.780x10^{-7}

Appendix DR2

In our approach, we seek to determine a relationship between chemical weathering and denudation. To test our model against field data, we need to isolate the role of erosion as the sole control on weathering rate and, thus, any climatic effects must be removed. The data compiled by West et al. (2005) for kinetically dependent weathering rates can be normalized by climate (i.e., annual precipitation and average temperature) according to their five parameter model. Rewriting their Eqn. (7) yields

$$\frac{1}{K\left(1+\frac{\delta\Gamma}{\Gamma_0}\right)^{\beta}\left[e^{-\left(E_a/R\right)\left(1/T-1/T_0\right)}\right]}=\frac{\left(1+\frac{\delta\varepsilon}{\varepsilon_0}\right)^{\alpha}}{W_K-C} \tag{A2.1}$$

where K is a weathering coefficient, Γ is runoff, E_a is activation energy, R is the gas constant, T is temperature, ε is total yield, and W_K is the measured kinetically dependent weathering rate. Alpha, β, and C are fitting constants. The subscript ‘0’ refers to the log-mean of the specified parameter and δ is the difference between the log-mean and the parameter value (see West et al. 2005 for further details). Examination of West et al.’s (2005) Eqn. (7) reveals that the right-hand-side of Eqn. (A2.1) above is equivalent to the weathering rate normalized by climate. To calculate the normalized kinetically dependent weathering rates, we used their values for α (0.42) and C (0.34). Finally, so that the kinetically dependent weathering rates could be expressed relative to the supply-limited rates, the log-mean denudation rate (ε_0) was determined from the supply-limited weathering data and found to be 17 t km^{-2} y^{-1}.

REFERENCES

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