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Hydrology and Earth System Sciences Discussions

Interactive comment on "Coupled modeling of hydrologic and geochemical fluxes for prediction of solid phase evolution in the Biosphere 2 hillslope experiment" *by* K. Dontsova et al.

Anonymous Referee #2

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General comments

This manuscript presents the results of a modelling exercise of a coupled geochemical transport simulations at steady state flow taking into account weathering reactions of dissolution and precipitation with potential feedback of secondary minerals changing the soil hydraulic properties. The mathematical assumptions are valid while rather large simplifications have been allowed for.

No biological influence is present, no water uptake by plants is allowed for and steady state flux is assumed throughout the whole modelling period. The authors are very

sparse with explanations of the mathematical equations that underlie their hydraulic model equations and the chemical reactions. I would request an electronic attachment that displays at least some of the governing equations with regards to hydrology and to geochemical reactions considered. The authors do not clearly present the concept of reactive surface area and no information is given on the reactive surface area development of the secondary minerals formed. Too little information on species distributions considered in the aqueous phase is presented. Did the authors check for saturation states of other potential forming phases such as imogolite or amorphous silica? The calculated weathering rates are very high! There are plenty of field based weathering rates in the literature some of which the authors could cite and compare to their own rate. It has been demonstrated that Al3+ activity has a significant effect on the weathering rate of basaltic glass [Wolff-Boenisch, et al., 2004] and feldspar ([Gautier, et al., 1994]) . Did the authors choose to incorporate this effect according to their equation 3? What about temperature effects ? The authors mention some climate scenarios but do not present data on the temperature profile in the soil and its effect on weathering! How are the redox process controlled ? Why did the authors not choose to impose a constant but realistic element or at least water uptake by plants too? Finally for comparison purposes with other weathering rates at other sites a general average weathering rate in terms of keq m-1 year-1 would be very helpful!

Specific comments:

The authors have a quite complete list of relevant references. To my opinion some other references that are very relevant are missing. What about adding the following references too?

a) [Godderis, et al., 2006] (use of a coupled weathering model to estimate weathering rates including the precipitation of secondary minerals) b) [Sverdrup, et al., 1995] (some earlier but comparably complete model to estimate non-steady state weathering rates) c) [Gerard, et al., 1998] (this paper besides others demonstrates the effect of Al3+ activity on the weathering rates in the filed)

P 4453 Line 16 The reader is interested in the actual data, what about sulphur content ? How good is the fit between the XRD data and that calculated from the software?

“These concentrations were verified by quantitative X-ray diffraction analysis (XRD) using a PANalytical X’Pert Pro MPD X-ray Diffractometer (PANalytical B.V., Almelo, the Netherlands) with Cu-K_ radiation that gave bulk values for the composition of the crystalline minerals and by image”

P 4457 Line 2 As the authors discuss later these assumptions are far from realistic.

“with a steady state water infiltration for that period that gives a total rainfall equivalent to that expected over the course of the 14 to 18 year (depending on selected climate) B2 hillslope experiment.”

P 4457 Line 8 Interesting for the reader is which species were chosen !

“of total concentrations was obtained by “sweeping” the EQ3 database for all relevant species”

P 4459 Line 14 why not check geometric surface area too ? There are a number opf paers that demonstrate that geometric surface area is a fair estimate for reactive surface area for a number of minerals.

“but several additional lower values (10, 100 and 1000-fold lower than the measured N2 BET) were also used”

P 4461 Line 5 As mentioned earlier the effect of Al3+ activity on weathering reactions has probably been incorporated, but the reader does not know when and how?

“or the indirect effects of bio-produced organic acids, on the weathering process (Berner et al., 2003; Hinsinger et al., 2001; Neaman et al., 2005)”

P 4461 Line 10 This software may only be known to some of the readers. I would propose that the authors give at least some two to three sentences in describing how the software transforms texture to hydraulic conductivity as there are quite a number of

ways how to perform this task.

“To assess the feedback effects of mineral transformation on hillslope hydrology, we estimated hydraulic parameters from soil texture evolution using Rosetta software (2001). Rosetta is a computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions.”

Table 1

Why should the solubility constants be displayed with 4 digits ? The precision and uncertainty is probably much higher !

All Fe is displayed as Fe(II) except when mentioned otherwise as in goethite. I would propose to follow the same nomenclature also for Mn and display Mn as Mn(II) and then for pyrolusite as Mn(IV)O2

REFERENCES:

Gautier, J.-M., et al. (1994), Experimental study of K-feldspar dissolution rates as a function of chemical affinity at 150° C and pH 9, Geochimica et Cosmochimica Acta, 58, 4549-4560. Gerard, F., et al. (1998), General implications of aluminium speciation-dependent kinetic dissolution rate law in water-rock modelling, Chemical Geology, 151, 247-258. Godderis, Y., et al. (2006), Modelling weathering processes at the catchment scale: The WITCH numerical model, Geochimica Et Cosmochimica Acta, 70, 1128-1147. Sverdrup, H., et al. (1995), Modeling Recent and Historic Soil Data from the Rothamsted-Experimental-Station, Uk Using Safe, Agriculture Ecosystems & Environment, 53, 161-177. Wolff-Boenisch, D., et al. (2004), The effect of fluoride on the dissolution rates of natural glasses at pH 4 and 25[degree sign]C, Geochimica et Cosmochimica Acta, 68, 4571-4582.

Technical comments:

Fig. 7. Removal of lithogenic elements (% of original content) from the hillslope cross-section as a function of time for two climates: Lucky Hills Climate an d Sky Island

Climate.

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