Development of a soil profile model

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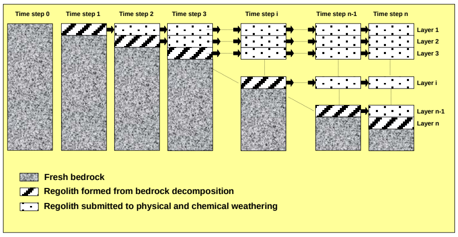
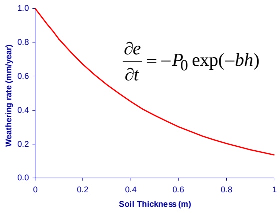
Introduction

The need for a better understanding of soil-landscape relationships is becoming an important topic as a response to increasing environmental problems. Quantitative modelling is the only means to evaluate the long-term impact of human activities and climate change on the soil and landscape. Most landscape evolution models only consider processes of erosion and deposition of the regolith as a whole. However the direction and rate of landscape processes are strongly influenced by soil properties and vegetation. Thus a realistic landscape evolution model needs to incorporate soil-forming processes. We present a model simulating in-situ soil profile development.

The Model

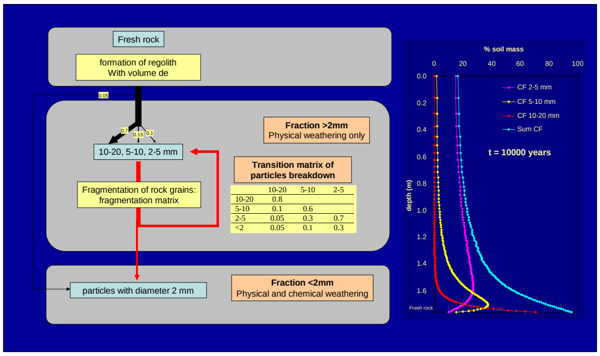
Overall structure



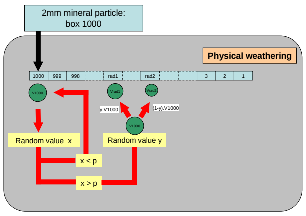


Regolith formed at each 'layer' is submitted to weathering

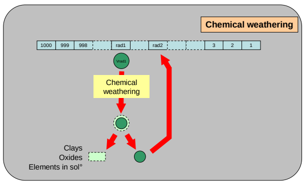
Evolution of coarse fraction



Physical & Chemical weathering



Physical weathering of minerals (Legros and Pedro, 1985)



Chemical weathering of minerals (White et al., 1996):

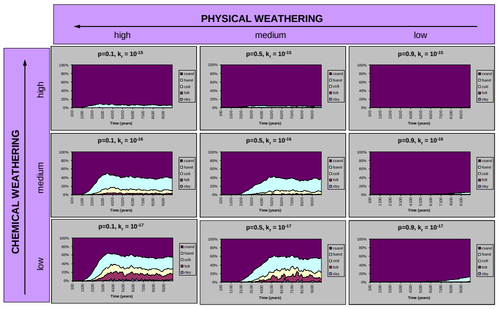
$m_t = k_r \cdot S_t$

m_t: moles primary silicate mineral dissolved (mole. yr^{-1})

k_r: reaction rate constant (mole. m^{-2}. yr^{-1})

S_t: surface area of the mineral (m^2)

Evolution of particle size of hornblende

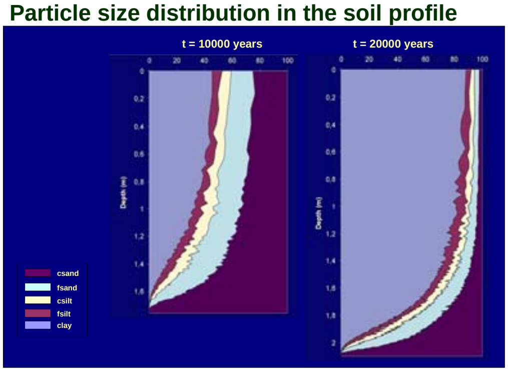


Example

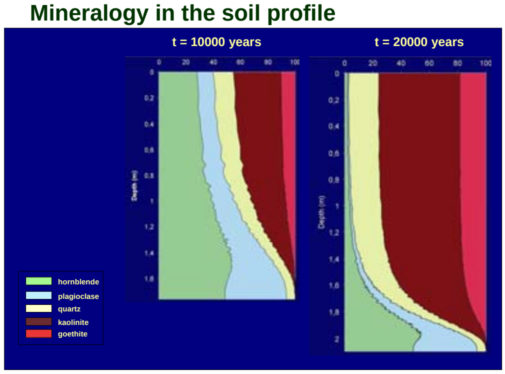
Meta-gabbro:
- 49% plagioclase
- 44% hornblende
- 7% quartz

Weathering pathways (+ stoichiometry):
dissolution plagioclase →
0.71 kaolinite group
- dissolution hornblende →
1.02 kaolinite group + 2.18 goethite
- quartz considered un-weatherable
- secondary reactions not taken into account

Particle size distribution in the soil profile



Mineralogy in the soil profile



Conclusion

The simple in-situ, no-translocation profile model allows us to follow the evolution of mineralogy, particle size, and chemical composition of regolith with time.

Improvements to the model required are organic matter evolution and redistributions (leaching), and expansion of the model to the catena & landscape scale to consider erosion processes

References

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White, A.F, Blum, A.E., Schulz, M.S., Vivit, D.V., Stonestrom, D.A., Larsen, Matthew, Murphy, S.F., Eberl, D., 1998, Chemical weathering in a tropical watershed, Luquillo Mountains, Puerto Rico: I. Long-term versus short-term weathering fluxes. Geochimica et Cosmochimica Acta 62, 209-226.