Geophysical Research Abstracts
Vol. 16, EGU2014-4393, 2014
EGU General Assembly 2014

Meteoric ^{10}Be as a tool to investigate human induced soil fluxes: a conceptual model

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The use of meteoric ^{10}Be as a tool to understand long term landscape behavior is becoming increasingly popular. Due its high residence time, meteoric ^{10}Be allows in principle to investigate in situ erosion rates over time scales exceeding the period studied with classical approaches such as ^{137}Cs. The use of meteoric ^{10}Be strongly contributes to the traditional interpretation of sedimentary archives which cannot be unequivocally coupled to sediment production and could provide biased information over longer time scales (Sadler, 1981).

So far, meteoric ^{10}Be has successfully been used in geochemical fingerprinting of sediments, to date soil profiles, to assess soil residence times and to quantify downslope soil fluxes using accumulated ^{10}Be inventories along a hill slope. However, less attention is given to the potential use of the tracer to directly asses human induced changes in soil fluxes through deforestation, cultivation and reforestation. A good understanding of the processes governing the distribution of meteoric ^{10}Be both within the soil profile and at landscape scale is essential before meteoric ^{10}Be can be successfully applied to assess human impact.

We developed a spatially explicit 2D-model (Be2D) in order to gain insight in meteoric ^{10}Be movement along a hillslope that is subject to human disturbance. Be2D integrates both horizontal soil fluxes and vertical meteoric ^{10}Be movement throughout the soil prolife. Horizontal soil fluxes are predicted using (i) well studied geomorphical laws for natural erosion and soil formation as well as (ii) human accelerated water and tillage erosion. Vertical movement of meteoric ^{10}Be throughout the soil profile is implemented by inserting depth dependent retardation calculated using experimentally determined partition coefficients (*Kd*). The model was applied to different environments such as (i) the Belgian loess belt, characterized by aeolian deposits enriched in inherited meteoric ^{10}Be, (ii) highly degraded and stony Spanish farmlands and (iii) strongly weathered Brazilian soils, relatively recently taken into cultivation. Model results confirm the hypothesis that meteoric ^{10}Be can be a useful tracer to investigate human induced soil fluxes. However, interpretation of meteoric ^{10}Be inventories along the profile must be performed with sufficient care: it is of utmost importance to jointly interpret meteoric ^{10}Be inventories and depth dependent concentration. Long periods of human disturbance are clearly recognizable in the modeled meteoric ^{10}Be signatures whereas the recognition of shorter periods of human impact critically depends on the boundary conditions. A sensitivity analysis points towards the essential role of soil chemistry in controlling depth dependent meteoric ^{10}Be concentrations and associated lateral meteoric ^{10}Be movement. The Be2D model is a step forward in unraveling the dynamic interplay between vertical meteoric ^{10}Be migration and horizontal soil fluxes and is therefore very suited to underpin empirical work. In a first phase the Be2D model can be used as an exploration tool to select sampling locations whereas in a later phase, the model may be used to extrapolate experimental observations to the broader landscape scale.

Sadler, P., 1981. Sediment accumulation rates and the completeness of stratigraphic sections. J. Geol. 89, 569–584.