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The fate of SOC during the processes of water erosion and subsequent deposition: a field study.

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Globally soils are the largest terrestrial pool of carbon (C). A relatively small increase or decrease in soil carbon content due to changes in land use or management practices could therefore result in a significant net exchange of C between the soil C reservoir and the atmosphere. As such, the geomorphic processes of water and tillage erosion have been identified to significantly impact on this large pool of soil organic carbon (SOC). Soil erosion, transport and deposition not only result in redistribution of sediments and associated carbon within a landscape, but also affect the exchange of C between the pedosphere and the atmosphere. The direction and magnitude of an erosion-induced change in the global C balance is however a topic of much debate as opposing processes interact: i) At eroding sites a net uptake of C could be the result of reduced respiration rates and continued inputs of newly produced carbon. ii) Colluvial deposition of eroded sediment and SOC leads to the burial of the original topsoil and this may constrain the decomposition of its containing SOC. iii) Eroded sediment could be transported to distal depositional environments or fluvial systems where it will either be conserved or become rapidly mineralized. iv) Increased emission of CO2 due to erosion may result from the disruptive energy of erosive forces causing the breakdown of aggregates and exposing previously protected SOC to microbial decomposition.
The above-mentioned processes show a large spatial and temporal variability and assessing their impact requires an integrated modeling approach. However uncertainties about the basic processes that accompany SOC displacement are still large.
This study focuses on one of these large information gaps: the fate of eroded and subsequently deposited SOC. A preceding experimental study (Van Hemelryck et al., 2008) was used to identify controlling factors (erosional intensity, changes in soil structure,...). However this experimental research needed to be complemented by field measurements, to achieve a better quantification and understanding of SOC dynamics in real field situations after a relatively important erosion event.
This study was conducted on an agricultural field in Belgium, located on a convex-concave hill slope. The field was planted with potatoes in parallel ridges, running up-and-down slope along the length of the field. As such a set of elongated miniature watersheds was delineated, in which water and eroded sediment were rapidly directed down slope, where a perpendicular potato ridge obstructed the sediment-laden runoff water, thereby inducing deposition. During one high-intensity rainfall event, a serious amount of soil material was eroded from the sideslopes of the ridges (avg. 28 ton ha-1) and deposited down slope. The C enrichment ratios of the deposited sediment were low (0.99) and hinted at the absence of selectivity with respect to SOM erosion and deposition. This probably resulted from the transport of eroded soil in aggregated form.
Subsequently, three measurement sites (two replicates) were delimited: i) a footslope position where soil was deposited (DEPO), ii) a similar footslope position on locations where no soil deposition occurred (NON-DEPO) and iii) a linear slope segment of the field (SLOPE). On each measurement site non-steady state gas sampling chambers were installed in triplicate. During a 5-month period, CO2-efflux (as a measurement of heterotrophic soil respiration) was measured at regular time intervals (from 2-3 times a week to biweekly). Soil moisture and temperature were monitored as well. Additionally, intact cylindrical soil cores were sampled at each measurement site. The soil cores were incubated at 25 ºC while moisture was kept constant. Using this setup, information on SOC dynamics could be collected in the sediment source areas (SLOPE) as well as in the sink areas (DEPO). By including NON-DEPO sites we were able to distinguish the effects of erosion from the effects of landscape position.
From the incubation experiment, significant differences in SOC decomposition were found between the measure-

ment sites. The average SOC decomposition rate was significantly higher for the deposited sediments (DEPO) but decreased rapidly thereafter. Lower but continued decomposition of SOC was measured on the NON-DEPO soil cores.

For the CO2-efflux measurements on the field, roughly two distinct environmental periods could be distinguished: a wet, colder period and a dry warm period. The CO2-efflux is highly influenced by environmental factors, nevertheless repeated measures ANOVA revealed significant differences between the measurement sites. During the wet period, CO2-efflux was very low on the footslope soils (DEPO and NON-DEPO) as high moisture contents impeded the diffusion of substrate and oxygen (above water-filled pore spaces of 76 and 60 % for both sites respectively). During the subsequent dry period, NON-DEPO soils respired at rates equal to those measured on the SLOPE sites. On the deposited sediments, however, high peaks of CO2-efflux were measured for a consecutive 20-day period.

From both field measurements and lab experiments, a conceptual model comes forth: erosion leads to a source of rapidly mineralizable C, which decomposes after deposition (permitting favorable environmental conditions). However, this erosion/deposition effect is only important in the short-term which results in a limited overall effect. During this study, only 74.3 g CO2-C additionally respired from the deposited sediments, representing a mere 1.6 % of eroded C.