From seconds to millennia: Weathering and erosion of the highly dynamic soils of Alpine areas

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Alpine areas are very fragile ecosystems and are strongly sensitive to changing environmental conditions (such as climate warming and land-use change). Soil erosion in the Alps is a well-recognized problem and its temporal scale varies from seconds to millennia. It is identified as a priority for action within the EU (European Union) soil protocol of the Alpine Convention. Steep slopes, extreme climate, fragile soils and the often intensive use of agricultural land characterise the environment of the Alps. There are several approaches to estimating erosion rates in these areas such as modelling using the Universal Soil Loss Equation or empirical determinations using radiogenic isotopes such as Cs or Be or even stable isotopes ($\delta^{13}C$). Recent results show that heavy-rainfall events as well as erosion processes during wintertime and early spring have a considerable influence on the erosion rates. This explains the often-observed failure of common erosion models for alpine areas - the measured rates are too low. The counter-part to erosion is weathering, keeping the sensitive process of soil formation in balance. Weathering in cold regions has often focused on the notion of 'cold'. As a result of this approach, the process focus has been that mechanical processes predominate and that chemical weathering is temperature-inhibited, often to the point of non-occurrence or extremely slow. Recent investigations show that in cryic, ice-free environments, chemical weathering can be a very active process leading to substantial leaching of chemical components and the formation of secondary weathering products (such as clay minerals). Contrary to popular belief, weathering in cold Alpine regions, including chemical weathering, is not strictly temperature-limited but is rather limited by moisture availability. As a consequence of warming, additional areas will become ice-free in high Alpine areas and subject to weathering, soil formation and erosion. Obvious soil changes must be excepted in proglacial areas and at low- to mid altitude sites. Concepts of weathering mechanisms, erosion processes and an overview of recent results from Alpine regions will be presented.

Tracing molecular proxy signals from biological source to sedimentary sink

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The abundances, distributions, and isotopic signatures of biomarker compounds preserved in aquatic sediments are increasingly being used to derive a diverse array of paleoenvironmental and paleoclimatic information. With analytical advances and development of streamlined methodological approaches, there is growing emphasis on biomarker-based reconstructions of past climate at high temporal resolution, and as part of multi-proxy investigations. Crucial to the accurate interpretation of such records is a robust understanding of the provenance of these molecular signals, as well as the timescales associated with signal transfer from biological source to sedimentary sink. While there is often an implicit assumption that the delivery of these signals to the sedimentary archive is virtually instantaneous. there is growing evidence from biomarker-specific ^{14}C measurements that transport may take several hundred to several thousand years. In the case of markers of vascular plant vegetation, storage in soils and at other locations within terrestrial drainage basins may induce significant temporal lags, while in the marine environment episodes of sediment resuspension and redistribution prior to burial have also been inferred to create significant temporal offsets in sedimentary records. The magnitude of such temporal lags may also vary as a function of climate, potentially yielding complex age relationships between proxy records through time. This presentation will describe studies using molecular isotopic ($\Delta^{14}C$, $\delta^{13}C$, δD) measurements that seek to explore the interplay between biomarker provenance and signal transmission times in the context of drainage basin properties and past climate variability. The results will be discussed in terms of implications for interpretation of biomarker records and carbon cycling on the continents.