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Stable isotopes in clay minerals from the North Alpine Molasse basin as proxies for Alpine paleoelevation

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The paleoelevation of a mountain belt is an important parameter to understand its geodynamic evolution and provides constraints on uplift and erosion rates and also on regional paleoclimate. A quantitative tool to determine the combined impact of these processes is the altitude effect on the stable isotope composition of precipitation, as the δ^{18}O and δD values of precipitation decrease with elevation. This climate and elevation signal can be preserved in different types of mineral proxies. Because the regional and global climate conditions may change over time, the isotope composition of the precipitation (as recorded in the mineral proxies) should be examined in both high elevation as well as low elevation material.

This study aims at reconstructing the changes in isotopic composition of precipitation and thus paleoelevation of the central European Alps during the Miocene. One of the possible archives to be examined are clay minerals, which contain both oxygen and hydrogen due to their high water content. In the circum-Alpine environment, they form through weathering of rocks (e.g. soils, regolith, floodplain environments, volcanic deposits) or in fault gauges by interaction with meteoric fluids within fractured rocks. In the Molasse basin, the sedimentary foreland basin of the Alps, clay minerals occur in sufficient abundance to be separated and can be used to obtain a low-elevation reference for climatic variations. Furthermore, clays that have been transported into the foreland basin are part of the detrital archive that may record orogenic weathering, erosion and material transport. We will explore, whether they preserve their initial hydrogen and oxygen isotope composition in order to reconstruct the isotope signal of precipitation within the individual catchments from which these clay minerals were sourced.

The first analyses were carried out on samples that have already been used for previous studies on changes of the paleoclimate by measuring the stable isotope composition of included fossils (foraminifera, ostracods, fossil mammal remains and fish and shark teeth). The sample provenance includes the North Alpine region and some parts of the Vienna and the Pannonian Basins, hence sediments with a sedimentation age of 8 to 20 Ma.

After refining the methods for sample preparation and measurement, different grain size fractions of clay minerals were extracted by centrifugation. Oxygen isotope compositions were analyzed using a CO2-laser fluorination line and hydrogen isotopes by TC/EA. Routine X-ray diffraction (XRD) and scanning electron microscopy (SEM) measurements were also performed to determine the mineralogy of the separates.

SEM images support a detrital origin of the clay minerals. The δ^{18}O and δD values vary from 14.8 to 21.5‰ and -114 to -134‰, respectively, over the sampled profiles. There is no apparent linear dependence between the oxygen and hydrogen isotope composition, which indicates that both tectonic and climatic variations may have influenced the isotopic compositions. The results are being combined with previous conclusions from fossil remains in the same samples to resolve this problem and will also be compared to other paleoclimate studies for the given time frame.

Future investigations will include further, higher density sampling of the Molasse sediments, as well as analyses of present soil horizons to further examine the local effects on isotopic compositions of clay minerals during their formation at different altitudes and prevailing climates.