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Past soil erosion history recorded by lake sediments in mountain areas (north and south French Alps): complex interactions with climatic and human activities

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Erosion rates and patterns are influenced both by hydrological activity and the evolution of soil-vegetation cover. This soil-vegetation cover is in turn impacted by climatic changes and human activities through deforestation, grazing and agriculture. Such land uses are reported in mountain areas since several millennia (the Neolithic or Bronze Age in the Alps). The effects of these activities and climatic changes on erosion and above all on soil cover are relatively few documented. However, a good knowledge of these processes is important to better evaluate the future evolution of soils and the sustainability for agricultural practices, in the context of global change.

Because lakes act as traps of erosion products, lake sediments represent interesting continuous archives of past soil evolution and erosion. They provide a unique opportunity to reconstruct at high resolution the soil history over long time periods and thus to determine the timing of changes in response to climate and/or anthropogenic pressures. As a result of the Pygmalion research program, we present the study of two small mountain catchment in north (Lake Anterne, 2063 m asl) and south French Alps (Lake Lauzanier, 2285 m asl), covering the Holocene and the last 1000 years, respectively. To trace the past soil erosion erosion history and bring arguments about the origin of changes, mineral and organic geochemical analyses were performed and combined with quantitative reconstructions of terrigenous inputs. To emphasize our assumptions about the origins of recorded changes, a pluridisciplinary approach (palynology, archaeology...) was also adopted.

The study of Lake Anterne shows the second half of the Holocene is characterized by four important phases of erosion. These phases are underlined by high flood frequencies and different geochemical composition of sediments. These geochemical signatures reveal changes of sediment sources related to different erosion patterns. In particular, the first phase, at 5450 cal. BP affects both leptosols and developped soil surface horizons (podzols. It is thus interpreted as mainly reflecting the climatic reversal toward colder and wetter conditions, known during this period. Likewise, during the end of Iron Age and the begin of Roman period, the most important erosion phase of the Holocene firstly affects developed soil (cambisol)surface horizons (during 300 years) and then attacks the deepest horizons (during 250 years). This suggest an intensification of grazing activity. Our interpretations are also supported by palynological and archaeological data.

The preliminary results of Lake Lauzanier show high terrigenous inputs during the Little Ice Age (LIA), probably due to wetter climatic conditions, as it is observed for Lake Anterne. However, during the last 1000 years, the most important phase of erosion is recorded just after the LIA, between AD 1900 and Ad 1960. This phase is interpreted as the result of intensification of human activities (probably grazing) affecting the soil stability in the catchment.