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Multi-proxy sedimentary record from Lake Ghirla (N-Italy) reveals hydro-climatic variations and periods of anthropogenic activities during the past 13 kyrs

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Lake Ghirla is a small lake that lies in the southern foothills of the Central Alps near the Swiss-Italian border. Climatically, the region is influenced by North Atlantic and Mediterranean weather systems and is frequently affected by severe storm tracks causing heavy precipitation. The catchment with Permian granites and gneisses contains Pb in amounts significant for mining as well as less important concentrations of Cu, As and U. This sensitive setting makes Lake Ghirla a promising site to reconstruct hydro-climatic variations and to track human activity by means of elevated heavy metal concentrations in the lake sediments.

The recovered sediment core comprises the entire Younger Dryas-Holocene time period and was analyzed for (i) sedimentological changes to identify flood deposits, for (ii) the hydrogen isotopic composition of terrestrial plant waxes (plant-wax D/H) to constrain hydro-climatic changes, and for (iii) variations of the elemental composition (XRF core scanning, ICP-MS) to understand anthropogenic impacts.

During the past 13 kyrs, we observe a high variability of floods with peak periods appearing at ∼11, 10.6–8.2, 6–4.9, 2.8–2.7, 2.6–2.4, 1.2–1 and 0.4–0.1 (LIA) cal kyr BP. From a hydro-climatic perspective, the most remarkable result from the plant-wax D/H data is that the Younger Dryas is characterized by no significant change and that the 2.8–2.7 kyr BP and LIA intervals show an increase of plant-wax D/H values. Hence, during these three cool climatic periods temperature effects cannot be solely responsible for plant-wax D/H variation. The southward migration of the westerly storm tracks above the North Atlantic due to climate cooling must have led to a more southern and thus isotopically enriched moisture source for the southern Alps. This moisture-source change likely counter-balanced or even over-rode the temperature-driven isotope effect.
Increased sedimentary Cu concentrations at 3.8–3.3 kyr BP are the first evidence for the presence of humans from our data. The Roman Period (2.1–1.5 kyr BP) is characterized by elevated Pb concentrations (110 ppm). During the last millennium we find conspicuous spikes of Cu at 800 and 700 yr BP, probably due to mining activities, as well as elevated Pb concentrations at about 800, 400 (100 ppm) and after 50 yr BP (180 ppm). Arsenic shows high sedimentary concentrations of up to 500 ppm in the course of the past 13 kyrs. Elevated values seem to be related to periods with high detrital input due to floods as well as to intervals probably deposited under anoxic bottom-water conditions. Phases of elevated Cu and Pb concentrations show no relation with flood occurrence, which might indicate that human activities in the Lake Ghirla area were not importantly influenced by hydro-climatic variations.

In conclusion, the sediments of Lake Ghirla offer a comprehensive archive for studying post-glacial climate, environmental changes and human activities.