Catchment vegetation and erosion controls soil carbon cycling in SE Australia during two Glacial-Interglacial complexes

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Soil Organic Carbon (SOC) represents with up to 80% the largest part of the terrestrial's carbon pool. However, it is still highly debated if soil-carbon is a net atmospheric carbon source or sink. This is mainly due to a paucity of information on the SOC's fate during soil erosion, which controls the interplay between SOC oxidation during soil storage, transportation, and final storage in a sedimentary sink. The southern hemisphere landmasses have the potential to play a dominant role in the SOC - atmosphere carbon cycle, since wetter (drier) climates can cause the expansion (contraction) of terrestrial biomass in vast continental areas, such as for example in temperate to semi-arid SE Australia.

We herein investigate the interplay between catchment erosion (quantified by means of uranium isotopes), vegetation density (pollen), the wetland's response (diatoms), and catchment-wide carbon and nitrogen cycling (carbon and nitrogen isotopes) on glacial/interglacial time scales in SE Australia. The analyses are applied to the sediments of Lake Couridjah, which is part of the Thirlmere Lake system located approximately 100 km SE of Sydney. A previous study has shown that Lake Couridjah and its catchment vegetation are highly sensitive to local and regional climate change. Radiocarbon and luminescence dating revealed that recovered lake sediments cover the time interval between ~140 ka and 100 ka, and between ~17.6 cal yr BP and present day. Lake Couridjah is thus one of the very few sedimentary archives providing a continuous archive for the previous interglacial complex in SE Australia, and thus offers an outstanding opportunity to study SOC cycling in a small catchment across different interglacial boundary conditions. The sedimentary analyses are supported by uranium, carbon, and nitrogen isotope analyses of a soil pit from the vicinity of the lake.

Statistical analyses revealed robust phase-relationships between catchment erosion, vegetation density, and carbon and nitrogen cycling during both glacial-interglacial complexes. The data implies that the density of the catchment's sclerophyll woodland and mid- to understory
vegetation - and not the amount of rainfall - has major control on catchment erosion, and, thus, on SOC storage in the catchment. Overall wetter and warmer peak interglacial conditions promote the expansion of dense sclerophyll vegetation, reducing catchment erosion while simultaneously increasing SOC storage as well as lake productivity and lake carbon-storage. The later post-Eemian phase of the preceding interglacial reveals overall cooler climates and a more open sclerophyll vegetation, resulting in faster catchment-wide erosion and reduced SOC and lake-C storage, conditions that are amplified in glacial periods (post-LGM, penultimate glacial period).