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Source to sink element geochemistry and clay mineralogy in Lake Towuti, Indonesia: understanding climate-induced controls on sediment composition during the past 60 kyr BP

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Lake Towuti is a large (560 km^2 surface area; 198 m max. water depth) ultraoligotrophic lake hosted in the East Sulawesi ophiolite, characterised by high iron and very low sulphur contents. The lake is surrounded by several 10s of metres thick deeply weathered laterite soils and closed-canopy rainforest. In May-July 2015, we recovered more than 1000 m of sediment core capturing the entire sediment infill to bedrock in the course of the ICDP Towuti Drilling Project.

In the tropics very little is known about the influence of climatic changes on weathering and erosion on glacial-interglacial time-scales. It is expected that varying hydroclimatic conditions will lead to changes in the weathering and erosion rates and greatly influence terrestrial elemental cycling. The direction of change and more quantitative estimates of the rates of changes are, however, unknown.

In order to characterise modern erosional processes and element cycling in the lake and its catchment, we collected catchment-characteristic bedrock samples and profiles of their overlying laterites, riverine sediments, and 85 samples of surface sediments from the lake. All samples were analysed for their geochemical and clay-mineralogical (<2 μm) composition in order to define the composition of erodible substrates, trace source-to-sink changes in sediment composition, and assess the spatial variability in Lake Towuti. The relationships found in the modern system were then applied to two sediment cores, dating back 30,000 and 60,000 years BP, respectively.

The laterite soils in the catchment show a characteristic zonation with high concentrations of Al, Ti, Fe, and Cr in the uppermost horizon, while Mg is enriched in the saprolite zone directly above bedrock. Weathering intensity increases from bedrock (least weathered) across river bedload of the 15 inlets to the sediments in the deepest basin of the lake (most weathered). The largest inlet to Lake Towuti, the Mahalona River, supplies sediments with low Al and high Mg concentrations and exerts a dominant control on the present-day sediment composition of Towuti's northern basin. This indicates that the Mahalona River and its tributaries cut deep into the laterite soils, transporting relatively unweathered material to the lake.

In the past 60,000 years, the Al/Mg ratio is lowest between 35,000 and 15,000 years BP, and kaolinite is the dominant clay mineral during this period. During most of the Holocene and $>$35,000 years BP, Al/Mg is comparable to today and smectites (Holocene) and illites (MIS 3) are the most abundant clay minerals. The clay mineralogy suggests deeper soil erosion during wet interglacials and more surficial erosion during dry glacial climate conditions. These findings imply that erosion and element cycling are mainly driven by changes in precipitation amount and terrestrial runoff in Towuti's catchment. The Al/Mg ratio on the other hand points to a stronger (lesser) contribution of relatively unweathered sediments sourced from the Mahalona River catchment during dry (wet) phases, likely as a result of lake-level changes and associated changes in shoreline proximity to our coring sites.