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Color reflectance spectroscopy of profundal lake sediments: a novel moisture-balance proxy for tropical East Africa

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Investigations of the continuous sediment record from Lake Challa, a deep freshwater crater lake on the eastern slope of Mt. Kilimanjaro, are expanding our knowledge about past climate and environmental changes in equatorial East Africa. During a field campaign in 2005 a 20.65-m long composite sediment sequence was retrieved from the center of the lake, covering the past 25,000 years. Unlike many other East African lakes, Lake Challa never dried out during this period and therefore provides one of the few continuous and high-resolution regional climate-proxy records since before the LGM.
Continuously taken digital line-scan images (GeoTek MSCL core logger) revealed systematic colour variation from greenish to yellow-brownish sediments throughout the core sequence. To characterize the origin of these colour variations, high-resolution colour reflectance spectrometry was carried out.
The relative absorption band depth (RABD) at different wavelengths was calculated to distinguish between sediment components with distinct absorption/ reflection characteristics. RABD660/670 can be used as a proxy for chlorophyll and its derivates, and RABD610 as a proxy for carotenoids and their derivates. Comparison of RABD660/670 with independent reconstructions of rainfall (the Branched and Isoprenoid Tetraether (BIT) index of bacterial lipids) and seismic lake level reconstructions showed a positive correlation between these proxies. During times of wetter climate and higher lake level, e.g. the early Holocene, the RABD660/670 value is higher than during times of inferred dry conditions and low lake level, e.g. the early late-Glacial period (during which no chlorophyll or its derivates were detected). We attribute this positive correlation to reduced preservation of chlorophyll contained in the settling remains of dead phytoplankton during lowstands, when bottom waters may have been better oxygenated. This data is supported by the variation in fossil pigment concentration and composition analyzed by high performance liquid chromatography (HPLC). During humid/highstand episodes, chlorophyll and carotenoids are more diverse and abundant than during dry/lowstand episodes.
Our data confirm the utility of reflectance spectroscopy as a tool for rapid, non-destructive and cost-effective analysis of long sequences of lithological change at high temporal resolution. They also support the previously published BIT-index record of Lake Challa as proxy for regional moisture-balance history.