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Advanced hyperspectral analysis of sediment core samples from the Chew Bahir Basin, Ethiopian Rift in the spectral range from 0.25 to 17 µm: support for climate proxy information

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This paper reports on the application of advanced hyperspectral analysis to support the non-destructive study of samples from long sediment cores (up to 280 m coring depth) collected under the Hominin Sites and Paleolake Drilling Program (HSPDP) in the Chew Bahir region of southern Ethiopia. For this purpose, the bidirectional reflectance of 35 core samples from different core depths in the wavelength range from 0.25 to 17 µm was measured. It can be directly compared with spectral remote sensing data of the corresponding land surface areas. We examined the relationship between the derived mineralogical and geochemical properties of the core samples to test for linkage to the hydroclimate history of the region. Using XRD and µXRD methods, it has been shown that an illitization of the smectites and an octahedral Al-to-Mg substitution occurs in the phyllosilicate materials present during phases that have been associated with increased salinity and alkalinity due to enhanced evaporation (Foerster et al., 2018). These processes are found to be accompanied by potassium fixation and they are associated with the increase of the layer charge due to the authigenic changes of the octahedral composition. Reflection spectroscopy is a suitable method for studying such mineralogical properties.

We investigated the spectral properties over a wide spectral range from UV to MIR. This enables detection of absorption bands of crystal field transitions of transition metal ions in the UV/VIS range and to detect the characteristic bands of OH, H_2O, M-OH lattice vibrations in the NIR. It also allows the study of the fundamental vibration bands as well as other typical MIR features like the Christiansen band or transparency features of silicates and thus helps to reconstruct weathering paths.

The results show that the main mineralogical components are clays of the smectite group. The samples are rich in montmorillonite and show variable concentrations of calcite. The clays are composed of tetrahedral coordinated, corner-connected SiO_4 for which Si is partially substituted

by Al and of edge-linked Al $(OH)_6$ octahedrons in which part of the Al is substituted by Mg and which are layered by OH and H_2O groups. Thus all reflectance spectra show the characteristic absorption bands at 1.4 µm (OH), 1.9 µm (H_2O), 2.2 µm (Al-OH), and 2.3 µm (Mg-OH). Their band depth ratios derived from continuum removed spectra have been used to characterize the clay structure within different climate periods. The results support the model of illitization and potassium fixation during dry climate intervals. In addition, the spectral indicators determined in the MIR can be used to specify the mineralogical properties of silicates and other materials in terms of their geochemical composition. In summary, the method is suitable for examining the main mineralogical components of Chew Bahir core samples and enables confirmation of climate-driven wet and dry weathering processes in the formation of phyllosilicates.

Foerster, V. et al., (2018) Towards an understanding of climate proxy formation in the Chew Bahir basin, southern Ethiopian Rift. Palaeogeography, Palaeoclimatology, Palaeoecology, 501, 111-123.