Identification of the mineralogy and organic materials of the Cretaceous and Middle Eocene ironstones by means of FTIR and micro-Raman spectroscopy

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In this study we are dealing with two different Egyptian Phanerozoic ooidal ironstone deposits. The first one is the Middle Eocene ironstone deposits of the Bahariya Depression, which are located in the northern part of the Western Desert. The second is the Cretaceous ironstone deposits, which are located in the Eastern part of Aswan area.

The Bahariya ironstones are subdivided into two marine shallowing-upward sequences separated by unconformities along which pedogenic and lateritic iron ore were formed. Four shallow marine ironstone facies are recorded in the Bahariya area including lagoonal manganiferous mud-ironstone, storm-related fossiliferous ironstone, intertidal stromatolitic ironstone and shallow subtidal-intertidal nummulitic-ooidal-oncoidal ironstone facies. Two shallow marine ironstone facies are recorded in Aswan area including tidal flat mud and ooidal ironstone facies, which are arranged in four main shallowing-upward cycles.

The different ironstone facies from both areas are investigated by means of FTIR and Raman spectroscopy. The samples are prepared for FTIR measurements by mixing of (1-2 mg) powdered sample with 200 mg KBr pellets. The FTIR measurements are made by Nicolet iS10 FT-IR spectrometer. The Raman measurements are made on the freshly broken sample surface. Raman spectra are recorded with a micro-Raman setup (HR Lab Ram inverse system, Jobin Yvon, Horiba). Raman scattering was excited by a frequency doubled Nd: YAG laser at a wavelength of 532 nm with a laser power between 50 and 500 µW incident on the sample surfaces. The acquisition time per spectrum was between 60 and 300s. The laser beam was focused by means of a Leica PL Fluoar x100/0.75 microscope objective down to a spot diameter of approximately 1 mm. The reference spectra of the identified minerals and organic materials are compared with the Rruff Raman database.

The black manganiferous mud-ironstone and fossiliferous ironstone types consist mainly of iron and manganese oxides and oxyhydroxides (hematite, goethite, todorokite, birnessite, aurorite, manjiroite, romanèchite, hollandite and pyrolusite), detrital and authigenic minerals (quartz, rutile, microcline, orthoclase and kaolinite) and late cement minerals (barite, anglesite, calcite, anhydrite and gypsum). The yellowish-brown microbially-mediated stromatolitic and nummulitic-ooidal-oncoidal ironstone types consist of iron oxyhydroxides and sulfates (goethite and jarosite), romanèchite, hollandite, pyrolusite, apatite, quartz, rapidcreekite, nitratine, calcite, gypsum and anhydrite. Organic materials such as proteinaceous compounds, lipids, celluloses and carotenoids are also detected inside these facies. These organic materials represent biomarkers of bacteria, including cyanobacteria, algae and fungi. On the other hand; the Cretaceous ooidal ironstones of Aswan area consist mainly of hematite, goethite, apatite, kaolinite, anhydrite and calcite. Limited fatty acids were detected by FTIR.

The application of FTIR and Raman spectroscopy is considered as powerful techniques for the identification of both organic and inorganic substances of the studied ironstone deposits. Raman spectroscopy is an effective tool in the identification of the less abundant and dispersed minerals such as manganese minerals.