
The Role of Sepiolite-Palygorskite in the Decay of Ancient Egyptian Limestone Sculptures

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Abstract: An ancient Egyptian limestone sculpture was found to be undergoing major structural decay when stored in a museum environment. Mineralogical and petrographic analysis of the limestone showed a high proportion of clay ($\geq 10\%$ by weight) that was concentrated along bedding planes. The clay fraction consisted mostly of sepiolite ($> 90\%$) and palygorskite ($< 10\%$). Minor quantities ($\leq 1\%$) of soluble salts (NaCl and NaNO₃) were also found. Wetting/drying with distilled water and relative humidity cycling resulted in the same delamination cracking damage as that observed in the museum environment. Thermomechanical analyses (TMA) confirmed that the damage was due to expansion ($> 4.5\%$) parallel to bedding planes when the limestone was immersed in water. The expansion due to swelling of the clays was directly observed at high magnification in an environmental scanning electron microscope (ESEM) when wetting/drying cycles were performed. X-ray diffraction (XRD) analysis showed that crystalline swelling of sepiolite occurred. This was determined by a shift of (*110*) reflection (from 12.07 to 12.20 Å) and a decrease of (*060*) reflection (4.47 Å, to 4.44 and 4.41 Å), when in contact with ethylene glycol (EG) and dimethyl sulfoxide (DMSO), respectively. Swelling also occurred due to hydration of the clay surfaces and to electrostatic forces between clay particles, which, it was assumed, was promoted by the presence of Na counterions in water solution. Possible treatments for the conservation of these artistic objects are proposed and discussed.

Key Words: Clays • Egyptian Sculptures • ESEM • Limestone Decay • Palygorskite • Sepiolite • Swelling

Clays and Clay Minerals; August 1998 v. 46; no. 4; p. 414-422; DOI: [10.1346/CCMN.1998.0460405](https://doi.org/10.1346/CCMN.1998.0460405)

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