

Testing the (time)^{1/4} Quartic Root Diffusion Law of Ceramics Rehydroxylation

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Determining the absolute chronology of ceramic artifacts has significant implications for archaeological and historical research. Wilson, Hall et al. [1,2] recently suggested a new technique for direct absolute dating of archaeological ceramics based on a moisture-induced chemical reaction, called rehydroxylation (RHX) dating. RHX dating proceeds by measuring the mass of chemically combined water in the ceramics in the form of OH hydroxyls, and the mass gain rate at the Effective Lifetime Temperature (ELT) that the ceramics experienced over its lifetime. The ELT can be precisely determined using a method developed by Moinester et al. [3], based on RHX rate measurements at two temperatures of two ceramic samples having the same age. The RHX reaction continues over the ceramics lifetime, causing it to expand and to increase in mass, the older the material, the more hydroxylated the ceramics and the greater the mass gain. RHX reaction kinetics are proportional to the quartic root of time, (time)^{1/4}, so the amount of hydroxyl chemically combined with the ceramic material provides an 'internal clock' that can be read by precision weighing to determine the elapsed time since it was fired. It has been suggested that the quartic root time dependence is due to a restricted diffusion process; that diffusing H₂O in ceramics follows a very complex and constrained path to their RHX sites. In particular, Wilson, Hall et al. suggested a possible connection to Single File Diffusion, for which the microscopic root-mean square displacement goes as t^{1/4}. But there is no known microstructural evidence in ceramics for such restricted pathways. We plan to test the (time)^{1/4} quartic root diffusion law by carrying out diffusion measurements at the very beginning of the rehydroxylation process; since due to the t^{1/4} dependence, the largest RHX rates of change are expected near t=0. Possible measurements include [4]: (i) the options of high-resolution NMR with aluminum and silicon as well as with protons (hydroxyls, water) for exploring structure and dynamics and of pulsed field gradient NMR for exploring water/proton diffusivities; (ii) micro-imaging by IR and interference microscopy for exploring the spatial-temporal dependence of rehydroxylation of fired clay; (iii) structural investigations by high-resolution electron microscopy and X-ray diffraction. The eventual success of these efforts requires forming an appropriate collaboration, and acquiring funding by preparing an adequate research proposal. This poster comprises an invitation to join this collaboration.

References

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