Sedimentary origins of an 8000 year-old rock shelter through Particle Size Analysis and X-ray Diffraction

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Introduction and Objectives

This geoarchaeological study was designed to determine the sedimentary and anthropogenic origin of an 8000 year-old Warren Point sandstone rock shelter on the Domain of the University of the South following a 2.5 month excavation during the summer of 2009. Analyzed sediments were collected at 10cm increments from an excavated trench 70 cm in depth (7 samples). Particle Size Analysis (PSA) was utilized to separate sediment into three size classes – sand, silt and clay. X-ray Diffraction (XRD) of clay fraction provided mineralogical analysis of clays present – illite, montmorillonite, kaolinite and chlorite. At present, the origins of the clay found in sandstone rock shelters on the Tennessee Cumberland Plateau have not been well studied. This study seeks to begin researching these origins, with special regard to anthropogenic influence.

Figure 1. 8000 year-old rock shelter studied

Materials and Methods

a)PSA

PSA was run 3 times on each sample, for a total of 3 trials. Samples were crushed and mixed with sodium hexametaphosphate to deflocculate. HCl was used to remove organics. Samples were then run through sieves to separate sand fraction from silt and clay fractions. Silt and clay fractions were obtained by settling in a 1000 mL beaker over 5 hours. Samples were then dried in an oven and weighed to obtain final percent compositions of each sample.

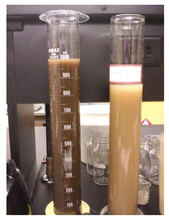

Figure 2. Comparison of suspended sediment before removal of organics (left) and and after treatment with HCl to organics (right)

b) XRD

XRD was conducted using a Siemens D5000XRD. Clay samples were put in suspension and a sonifier was used to disaggregate and align particles from coagulated masses to individual aligned particles. 3 slides of each sample were made (for a total of 21 slides), each with a different treatement: air – dried, glycolated with ethylene glycol and heated to 550° C. Samples were initially x-rayed for 2 hours each, and later for 22 hours each to obtain better results.

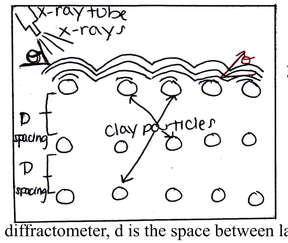

Figure 3. Schematic diagram X-ray Diffractometer. The diffractometer operates under Bragg's Law: $n\lambda=2d\sin\Theta$ where n reflection number, λ wavelength of the diffractometer, d is the space between layers and Θ is the angle between the x-ray beam and the layer surface.

Results

a) PSA

Percent Composition/ 100%	Trial 1- HCl	Average of all 3 trials
Sample 1		
Sand	0.610536025	0.661090449
Silt	0.244696116	0.133668751
Clay	0.144767859	0.2052408
Sample 2		
Sand	0.59092526	0.645294437
Silt	0.065214814	0.052535041
Clay	0.343859926	0.302170521
Sample 3		
Sand	0.549946691	0.613790976
Silt	0.104568195	0.065637946
Clay	0.345485114	0.320571078
Sample 4		
Sand	0.584612189	0.561239911
Silt	0.084231417	0.102879853
Clay	0.331156394	0.33609152
Sample 5		
Sand	0.608979469	0.510202195
Silt	0.053859577	0.101823424
Clay	0.337160954	0.343471787
Sample 6		
Sand	0.669831728	0.616667874
Silt	0.033016827	0.0467624
Clay	0.297151445	0.292786889
Sample 7		
Sand	0.59876406	0.608145276
Silt	0.024452052	0.052657371
Clay	0.376783888	0.339197353

Table 1. PSA results by percent

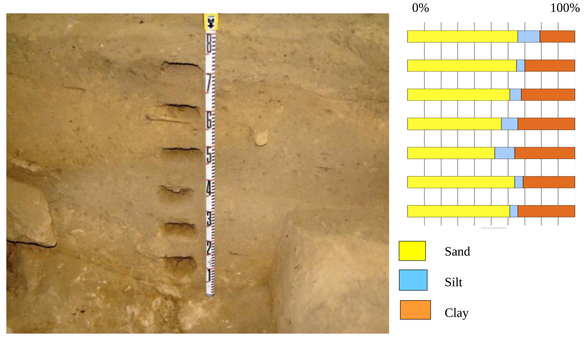

Figure 4. (Left) Profile where sediment samples were collected. (Right) Breakdown of size fraction by percent composition.

b) XRD

Percent composition/100%	22 hour run	2 hour run
Montmorillonite	58.99	59
Illite	12.01	6
Kaolinite	23.27	35
Chlorite	1.51	?
(Qtz)	4.21	?

Table 2. Mineralogical composition of clay by percent. Note unknowns in 2 hr run. Interlayering of clays caused poor results, and so entire process of XRD was repeated at 22 hrs each. Results improved significantly at 22 hrs/sample.

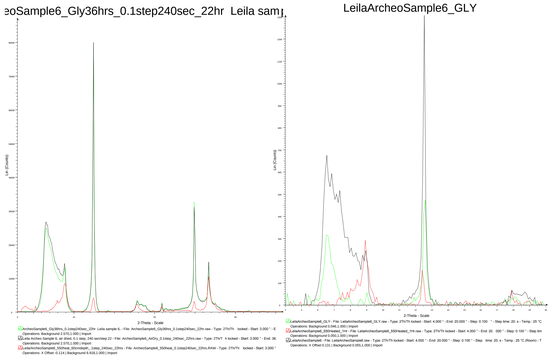

Figure 5. Comparison of patterns from 22hr run (left) and 2 hr run (right). Peaks are significantly more well-defined at 22hrs. Green is glycolated, black is air-dried and red is heated.

Results and Discussion

Particle Size Analysis results show little correlation between sample composition and depth, but several general trends are evident. X-ray diffraction indicates that mineralogical composition of the clay fraction is very similar across all depths. Sand is present in abundance, which makes sense because the rock shelter is in the Warren Point Sandstone. Silt is present in a small amount, probably having been transported as loess. Clay is present in a high percentage, possibly due to the presence of anthropogenic organic material. Further research is needed to assess the mineralogy of the parent material (rock) and soil above the rock shelter. If the mineralogy of these samples does not closely match the mineralogy of the parent material, then it is highly likely that anthropogenic organics play a large part in the rock shelter mineralogy.

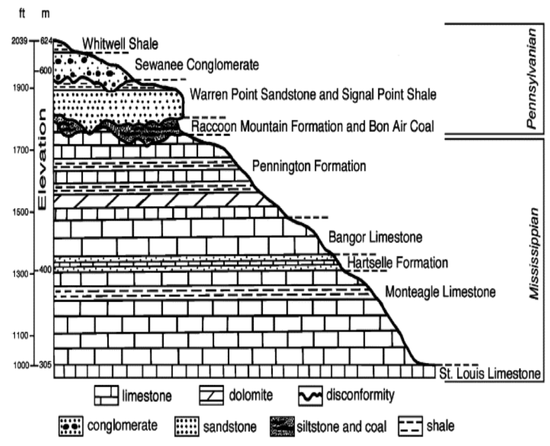

Figure 6. Cross-section of stratigraphy in Sewanee, TN. Note Warren Point and surrounding formations.

Acknowledgements

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