Geoarchaeology and the Hydrometer at the Bequette-Ribault Site, Ste. Genevieve, Missouri

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ABSTRACT

Excavations at the Bequette-Ribault site in Ste. Genevieve, Missouri, revealed cultural deposits incorporated within a matrix of homogeneous sediments with strong uniformity in color, characteristics and layering. A grain size analysis of sediments from Ste. Genevieve employs a hydrometer to assess origins, types and characteristics of sediments as well as continuity or transformations in sediment deposition over time.

Introduction

Ste. Genevieve, Missouri is claimed to be the first permanent European settlement west of the Mississippi River (Ekberg 1996). Scott (2006) conducted fieldwork at the Bequette-Ribault House site (23SG271) (Figure 1) in Ste. Genevieve during the 2004 and 2005 field seasons. Her excavations revealed cultural deposits incorporated within a matrix of homogeneous sediments with strong uniformity in color, characteristics, and layering. Possible origins for sediment deposition in this region include regular flooding of the Mississippi River, colluvial wash from the higher elevations on the western side of the site, or loess accumulation that continues to occur along the Mississippi River (Eden and Furkert 1988; Saucier 1994). The following paper provides a grain size analysis of sediments from Ste. Genevieve using a hydrometer to assess origins, types, and characteristics of sediments as well as continuity or transformations in sediment deposition over time. Sediment types can be dated with time-diagnostic artifacts to provide a depositional history and environmental context for site occupants. A final intent of this research is to illustrate the interpretive potential of sediments and other geoarchaeological analyses for historic sites archaeology.

Site Context and Stratigraphy

Named after the patron saint of Paris, Ste. Genevieve was founded no later than 1753 and possibly as early as 1735 according to local historians (Ekberg 1996). Perhaps the most important resource of the town was the fertile agricultural land along the Mississippi labeled "The Big Field." The rich alluvial soil of this area allowed Ste. Genevieve to become the breadbasket of the French colonies, with its surplus of wheat going to New Orleans and the fledgling settlement of St. Louis (Belting 1976).

In the spring of 1785, the Mississippi flooded. Still known as *L'anne des grandes eaux* (the year of the great waters), the 1785 flood inundated Ste. Genevieve and completely destroyed the settlement of Kaskaskia on the Illinois side of the Mississippi. It forced the colonists of Ste. Genevieve to relocate their town to higher ground three miles north at *Nouvelle Ste. Genevieve* (Belting 1976; Franzwa 1990; Norris 1991).

The present house at the Bequette-Ribault site was built using French *poteaux-en-terre,* or post-in-ground construction, between 1807 and 1808, based on dendrochronological dating. A wall trench held the posts in place, with intervening spaces filled with *bousillage*, a mixture of clay and straw and/or grass (Scott 2006). This house is one of five *poteaux-en-terre* houses still standing in the United States; two others are also in Ste. Genevieve (Franzwa 1990).

Scott's excavations at the Bequette-Ribault site were carried out in 2004 and 2005. Ten 5 x 5 ft. units in an area behind the house were excavated to sterile subsoil. Numerous artifacts including ceramics, glass beads, bottle fragments, worked catlinite, and machine cut nails were recovered. Ceramic types are similar to those from other French colonial sites in the region, including Fort Joseph (Scott 2006). Several of the test units incorporated massive sediment layers that could not be explained easily by the known historical occupations of the site (Scott 2006). Figure 2 shows a typical profile of the test units excavated. The lack of change in sediment color is unusual for a site with any appreciable amount of human occupation. Possible origins of this sediment include deposition from the regular flooding of the Mississippi River, colluvial wash

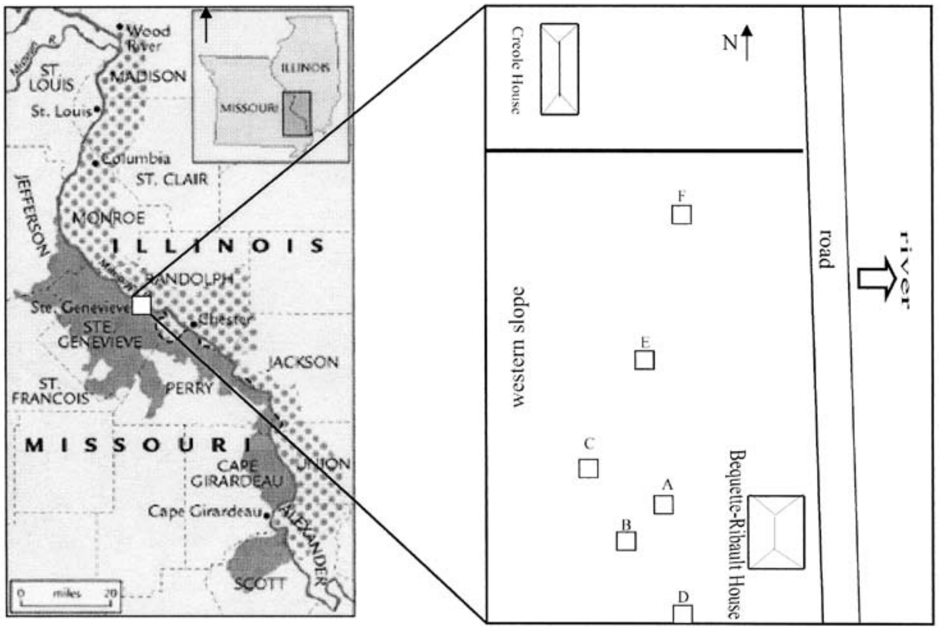

Figure 1. Map of Ste. Genevieve and surrounding region (Missouri's Terroir d'Exception, www.missouriwinecountry.com 2007) and site map of 23SG271 (by author).

Figure 2. East profile of unit F (Photo by Richard Young, 2004).

from the higher elevation on the western side of the site, or loess deposition (Ruhe 1969; Saucier 1994).

Methodology

Field observations failed to recognize visible stratigraphy for different episodes of sedimentary deposition. An initial test of grain size in the field indicated that most sediments were silt. Sediments also appeared well sorted with little internal stratigraphy, both being characteristic of loess-type deposition. Because these sediments are extremely fine-grained they are difficult to grade employing standard soil sieves. A hydrometer analysis of sediment cores is the most efficient way to extract the grain size distribution of silt-sized particles (Shackley 1975). Variation in type or origins of the sediments may relate to specific environmental or geological events such as floods, dust storms, or slope erosion. The hydrometer has been well-employed in grain size analyses to document flooding events (Paster *et*. al 1982) or where vegetation and landscape development are under investigation (Hopkins 1951; Mason and Begét 1991; McClain and Ebinger 2002); more limited application has occurred for interpretation of cultural stratigraphy (Waters 1996; Rapp and Hill 1998).

Core Samples

Grain size analysis was carried out on 20 cores taken from various locations across the site (Figure 3). All samples were taken with a 1 ft. long, 0.75 in. diameter Oakfield sampler, and then wrapped in aluminum foil for transport. Because maximum core length was only 1 ft., consecutive cores were taken from the same locale to increase sample depth. In all cases these extended cores were taken into deposits below occupation layers, which were in a range of 2–2.5 ft. beneath the surface (Scott 2006).

Cores were designated as having come from one of five excavation units labeled A through D and F (Figure 1); an additional area that was cored but not excavated was labeled E. A lower case sub-designation then was employed for multiple core locations within a unit (Aa, Ab, Ba, Bb, etc.). An attempt was made to take three stratigraphically consecutive 1 ft. cores from individual locations, with each of these also given a numeric designation. Cores were separated into three 0.33 ft. sub-sections that could be correlated with arbitrary levels used in Scott's excavations. This process resulted in an easily identifiable but unique provenience system for each of the core subsections (for example Ca1_1, Ca1_2, and Ca1_3.)

Core	Elevation
Aa1_1	394.03'
Aa1_2	393.53'
Aa2_1	393.03'
Aa2_2	392.78'
Aa2_3	392.53'
Aa2_4	392.28'
Aa3_1	392.03'
Ba1_1	394.32'
Ba1_2	393.82'
Ba2_1	393.32'
Ba2_2	392.99'
Ba2_3	392.66
Bb1_1	394.33'
Bb1_2	394.03'
Bb1_3	393.83'
Bb2_1	393.23'
Bb2_2	392.73'
Bb3_1	392.23'
Bb3_2	391.90
Bb3_3	391.57'
Ca1_1	394.48'
Ca1_2	393.98'
Ca2_1	393.48'
Ca2_2	393.38'
Ca3_1	392.98'
Ca3_2	392.65'
Ca3_3	392.32'
Cb1_1	394.57'
Cb1_2	394.24'
Cb1_3	393.91'
Cb2_1	393.58'
Cb2_2	393.25'
Cb2_3	392.92'
Da1_1	394.38'
Da1_2	393.88'
Fa1_1	394.38'
Fa1_2	393.88'

Figure 3. Cores and elevations (Table by author 2008).

Hydrometer Analysis

A hydrometer analysis for grain size sorting is based on Stokes' Law for falling spheres in a viscous fluid. The terminal velocity of fall depends on the grain diameter and the densities of the grain in suspension and of the fluid. The grain diameter can then be calculated by knowing the distance and time of fall. The hydrometer also determines the specific gravity (or density) of the suspension, and this enables the percentage of particles of a certain equivalent particle diameter to be calculated (Boggs 2005). Using a logarithmic function, the collected data can be graphed and assigned a sediment classification by weight, which can be correlated to a specific depositional process of the sediment. The American Society for Testing and Materials (ASTM) standard D422-63 method was used for the hydrometer analysis (Bowles 1997). Samples were mixed in an industrial blender for 15–20 seconds and then mixed with 125 ml of a 4% solution of Calgon detergent to break apart colloids. The resulting solution was transferred to a graduated cylinder that was filled with distilled water to a total volume of 1000 ml (Figure 4). A control hydrometer

Figure 4. Hydrometer set up (Photo by Maik Pertermann, 2005).

was filled with distilled water and a thermometer placed in the water to ensure temperature consistency. Once sediments were agitated in the graduated cylinder, the hydrometer was inserted. Readings were taken first at 15 seconds, and the time was doubled after each reading. The length of time each sample was allowed to settle varied due to density and mass of sediment, though this variation is corrected for in later calculations. Data were recorded on a standard hydrometer data form (Bowles 1997).

The formula for ϕ was employed to calculate grain size. The logarithm allows for statistical comparisons of grain size (Folk and Ward 1957; Boggs 2005). The formula for skewness of grain size distribution also was employed (Boggs 2005). Both formulas are shown in Figure 5. Grain size, under hypothetically random conditions, would conform to a bell curve; the highest percentage would be mid-range sand with lesser but equal distributions of coarse and fine sediment. This provides a baseline example against which real samples can be compared. The extent to which a sample varies from the hypothetical distribution is a measure of the degree of asymmetry of the grain size sample. Potentially this relates to variation in depositional environments and the transport process (Boggs 2005).

Results

The grain size distribution of the Bequette-Ribault site is an expression of the nature of the sediment deposition. Appendix A lists the raw data for all the hydrometer analyses. Sub-samples were randomly picked for the calculation of skewness. All are strongly negative with a high ϕ indicative of very small grain sizes. Figure 6 graphs grain size skewness for sub-sample Aa1_1. The sample has a skewness value (ϕ) of −0.32 which is typical of loess-type sediment deposition. This graph can be taken as representative of the analyzed sub-samples as a whole. Of the 58 samples

$$SK = \frac{(\phi_{84} + \phi_{16} - 2\phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{(\phi_{95} + \phi_{5} - 2\phi_{50})}{2(\phi_{95} - \phi_{5})}$$

$$\%\text{finer} = \left(\left(Gs \div Gs - 1\right) * \left(100{,}000 \div Ws\right)\right)\left(R - 1\right)$$

Figure 5. Hydrometer and skewness calculations (Bowels, 1997).

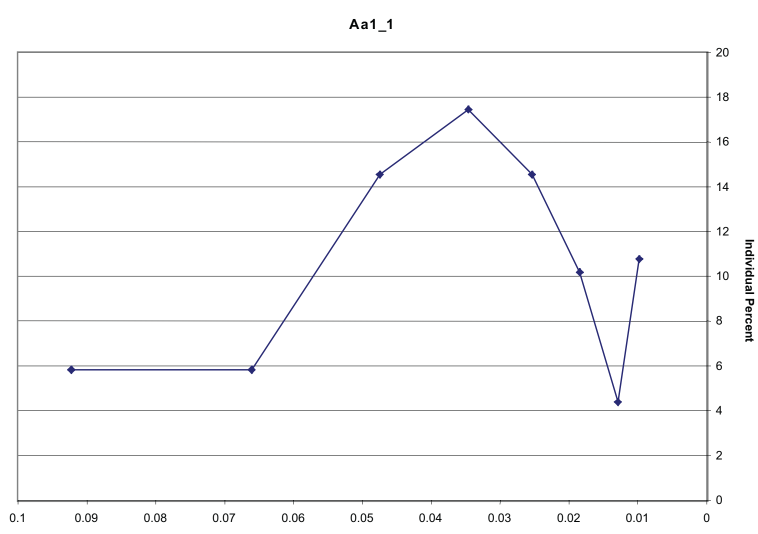

Figure 6. Skewness curve of sub-section Aa1_1 (Pertermann 2006).

analyzed, 55 had similar grain size distributions. The three cores that did not fit this trend, Ac2, Cb1, and Da1, can be related to anthropogenic and later impacts at the site, not the least including 20th-century road-building with large-scale movement of site matrices.

Hydrometer samples from units C and D (Figure 7) were graphed together to compare differences between grain size distributions in areas known to have stratigraphic integrity (unit C) and one that is chronologically mixed (unit D). There is similarity in grain size distribution among some of the sub-samples (for example Ca2_1 and Da1_1), which illustrates a consistent deposition of loess throughout the site's occupation and after abandonment. The absence of visible cultural layers, therefore, does not necessarily correlate with the absence of cultural activity.

Figure 8 graphs grain size distributions of each core taken at location Aa to compare grain size with sub-sample depth. Core Aa2 was recovered 1 ft. below core Aa1, core Aa3 was 1 ft. below Aa2, and core Aa4 was 1 ft. below Aa3. The samples are from the 20th century and from culturally sterile layers below the 20th-century layers. Two Native American pottery sherds are present, but very few of Scott's (2006) artifacts predate the 19th century. In this case grain size remains consistent for the three cores. This uniformity suggests a very thick deposit of loess, though the rate of deposition is difficult to calculate. It also implies that loess deposition is ongoing, as indicated in comparison of unit C and D sub-samples above.

A loess deposition rate can be estimated for cores with temporal ranges based on diagnostic artifacts. Potentially, this provides some understanding of the environment in which site occupants lived. Nineteenth-century artifacts occur 16 in. below the surface at location Cb. Taking these artifacts to represent A.D. 1801, then a rate of 0.078 in.

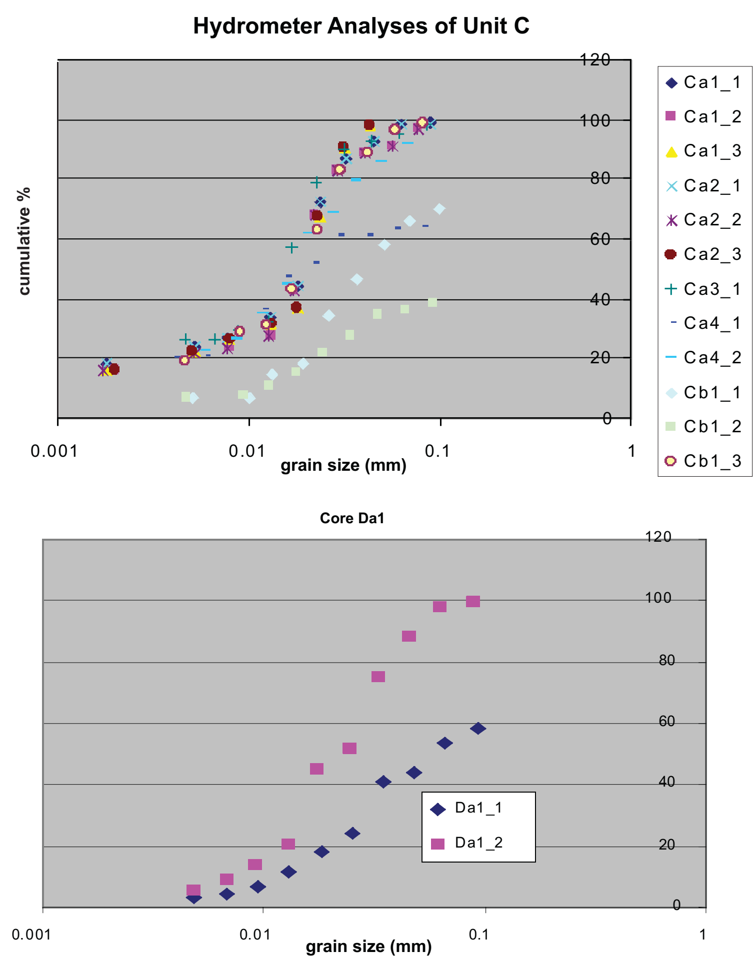

Figure 7. Hydrometer samples from units C and D (Pertermann 2006).

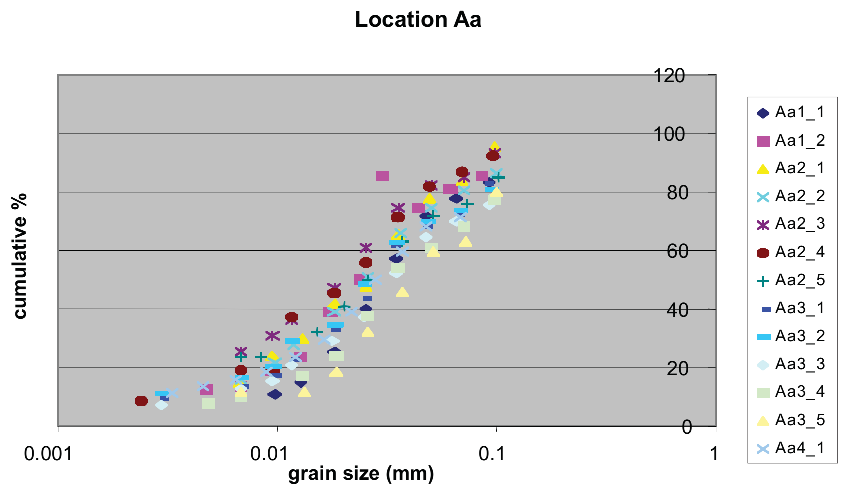

Figure 8. Graph of core samples at location Aa (Pertermann 2006).

per year of loess accumulation has occurred. This number is an average for a 206-year span and does not take into consideration a potentially accelerated rate in later years as anthropogenic impacts on the landscape took place. This number, however, is consistent with Figure 6, showing slow loess accumulation at the site over time.

Conclusions

Hydrometer analysis of sediments from Ste. Genevieve indicates consistent deposition during the time the site was occupied. Figures 6 and 8 show the consistency of grain size throughout the area, except for rare cases in which the soil can be shown to have been disturbed in the late 20th century (Scott 2006). The skewness of the cores, as well as the range of grain size for 93% of the samples is indicative of loess deposition (Boggs 2005), which could be either from water erosion off the terrace or wind transport from the bank. Colluvial deposits can occur as secondary sediment deposition from a slope (Eden and Furkert 1988).

It is equally possible that the sediment deposition on the Bequette-Ribault site comes from the reworking of the sediment from the terrace on the western side of the site. This could have occurred either by simple erosion or by water transport, as the site has significant rainfall coupled with a high water table. This type of deposition is referred to as colluvial loess due to its small grain size as compared to conventional colluvium. It cannot be distinguished from wind-blown loess deposition using available methods (Catt and Paepe 1988). Only careful measurement of air particles and particles washing down from the slope would allow determination of the predominant deposition method.

Finally, sediment analyses such as those employed here are of importance to historic sites archaeology. Significant changes can be measured in millimeters, providing a depositional history and environmental context for site occupants that cannot be explored in any other fashion.

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