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Independent Research Project: A Proposal for instrumental neutron activation analysis of ceramics and soil samples from Vésztő 20, Körösladány 14, Vésztő-Mágor, and Örménykút 13 in Bekés County, Hungary

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With nuclear pioneering in the 1960s and the raw statistical computing power of the ‘80s, Instrumental Neutron Activation Analysis (INAA) hit the archaeological scene some twenty years ago. However, the technique, which is capable of compositionally analyzing over thirty elements down to the parts per million (even billion!), has been slow to find its way onto many archaeological projects, even ones in which the sourcing of materials is key to understanding trade, migrations, and cultural exchange. Part of this may be due to the sheer cost and inconvenience brought on in part by the decrease of governmental subsidies regarding nuclear based research. But these hindrances aside, the access to a research reactor is a great advantage, especially when analysis can be incredibly precise and is able to detect the smallest variation within two or more very similar materials.

It is the former advantage that proves worthy in the Great Hungarian Plain, in which the study area is located. Spanning across much of the eastern half of Hungary, and crossing the Romanian border, the plain has been a staging ground for cultural immigration and habitation since the Paleolithic and extends through the Neolithic, Copper Age, Bronze Age, and through the modern era. The plain is topographically almost totally flat, broken by only slight rises, rivers, and cultural features. This is due to the geological history of the region, in where at the end of the Pleistocene heavy alluviation covered the region with sediment. (Parkinson, 1999) Hence, according to soil maps, the entire plain has a uniform soil surface that extends well into the earth. Clays are based on the parent materials in which they from, therefore the assumption has been made that if the parent materials are uniform across the Plain, so to must the clays. However, this does not take into effect small differences in clay composition, such as small amounts of trace elements that may distinguish Site A for Site B that may for a variety of reasons be present in an area.

The ability to distinguish between different clay sources is important to the area of study, which includes four sites in northern Békés County in southeastern Hungary: Vészt_ 20, Körösladány 14, Vészt_ -Mágor, and Örménykút 13. The first three sites are located very close to each other near the Körös river, whereas the forth site, Örménykút, is in the west near the Maros river. All the sites date to the Early Copper Age (4500-4000 BC). The use of compositional analysis on both ceramic sherds from each site and their surrounding natural clay sources has the possibility to answer important questions that will facilitate the understanding of this time period of which we know very little. These include the following: What can INAA tell us about the relationship between the sites of Vészt_ 20, Körösladány 14, and Vészt_ -Mágor? Is there any variation of the clay sources in the Great Hungarian Plain? Would creating a database be a useful framework for further projects? How localized was the procuring and possible manufacture of clay? If at all possible can we understand the relationship with other more distant Tiszapolgár people on the Great Hungarian Plain? These questions and their possible outcomes will be discussed further in this paper.

The need for compositional studies on sites from the Plain is not a new idea. Parsons and Galaty (2002) performed petrographic analysis on sherds from the four sites in question, finding that the sherds from the three sites near the Koros were almost exactly alike, creating a very homogeneous picture. This further strengthens the possibility that regional clays are so similar that clay-sourcing studies may prove to be fruitless in their efforts. However, the one outlier, Örménykút , which lies further west on the sandy Maros fan, looked quite different, shedding some light on regional variation. The study concluded with the hope that further compositional work would continue to find a verdict. Petrographic analysis is a technique in which grain size and numbers are counted in a thin-sectioned piece of a material. Although it can say much, it does not indicate which types of trace elements are present, elements that may be very small in concentrations and would only be detected by INAA. (Michelaki, 1999) It is with this hope that this project's analysis will yield different results, or if the answers match the petrographic homogeneity, at least strengthen that argument.

Methodology

Four sites were selected for sampling: Vészt_ 20, Körösladány 14, Vestzo-Mágor, and Örménykút 13. Each site includes a number of ceramics to be run through INAA and two clay samples taken from the soil of the site.

	Number of Sherds	Number of Soil Samples
Vészt_ 20	17	2
Körösladány 14	1	2
Vészt_ -Mágor	5	2
Örménykút 13	2	2

For the ceramics, each site varied in the number of sherds that could be analyzed: Vészt_ 20 is an extensive site that has been excavated for the past three years by American archaeologists, hence there are more sherds than Vészt_ -Mágor, which was uncovered years ago and has very protected collections. The kinds of sherds that were picked to be analyzed are important for many reasons. Pedestal bases were chosen because they accurately date which time period these ceramics are from (this type of base is unique to the Early Copper Age) and they keep a control to the sampling strategy.

The sites themselves sit in clay sediment, hence the natural clay soil samples were derived either from within the site (as in the case of Vészt_ 20 and Körösladány 14) or nearby (Vészt_ -Mágor, Örménykút 13). These were taken by simply removing soil from under the surface. These samples were bagged and shipped back to the United States, where they will be wetted, picked clean, molded into bricks, and sun dried. They will then be taken to the Material Sciences laboratory at the University of Michigan where they will be heated up to 800 degrees Celsius in a kiln to burn of organics and match as much as possible the matrix of fired ceramics.

To prepare for INAA sampling, each piece of ceramic must first be have its outer layer ground off with a carbide burr, a piece snipped from the whole, this piece washed in de-ionized water, and dried. This is then ground up to a fine powder with a mortar and pestle and then put into a jar where it is dried in a low temperature oven for 48 hours. Only after this preparation can the sample be taken to the Ford Nuclear Reactor at the University of Michigan, where it is weighed, and put into small quartz tubes.

In short, Instrumental Neutron Activation Analysis is a process where a material is radiated for a period of time in a nuclear reactor, being bombarded by the neutrons that trigger and sustain a nuclear reaction. When a neutron collides with an element, is makes that element become unstable. This new unstable isotope begins to emit energy in the form of gamma rays. Fortunately, different elements emit different gamma ray energies, hence with a good enough detector, we can measure all of the energies from an irradiated material, knowing what elements it is comprised. (Neff, 1988)

Eventually this material is immersed in the reactor pool where it sits for twenty hours next to the core. After a process of moving the sample from the core and allowing time for it to "cool off" can two sets of readings be taken with a detector. These results will be run through a statistical package called JMP where the data will be analyzed.

Interpreting the Results

No matter how much exceptional data one gets from compositional analysis, it means nothing without inserting it into some sort of archaeological framework and trying to interpret the results. The following will be a presentation of the different questions that are being asked and some attempts to explain how the future INAA data will answer them. Although there are always unexpected scenarios or problems, I hope to prove that compositional analysis could and will be a worthwhile step in understanding the Great Hungarian Plain in the Early Copper Age (ECA).

Is there any variation of clay sources in the Great Hungarian Plain, and would creating a compositional regional clay database be useful for future projects?

This question, although the most straightforward, is also possibly the most important, for it defines if clay-sourcing techniques are feasible in the region. Simply put, if all the clays are homogeneous, than most other questions are answered before they are asked. To answer this question, a quick look at the scatter plots comparing the soil samples from the four sites will do. If all the clays are very similar and overlap each other, than homogeneity is a good answer. However, if there are a couple groups that vary, or even if there is a single outlier, we can see that there is some variation, even at a regional level. Either one of these answers pose to be interesting, for if there is variation, further study must be done, but if there is none, than we know that in fact the geologists were correct in the assumption that the whole Plain is covered with one alluvial parent material that created a single uniform clay.

What can INAA tell is about the relationship between the sites of Vészt_ 20, Vészt_ - Mágor , and Körösladány 14?

The first step into understanding the relationship between the three sites is to analyze the chemical compositions of the local clays (6 total, 2 for each site) and see in which way they relate to each other. If all three clays are very similar, than the area is homogeneous on a micro-local level. This cannot tell us more than what was answered in the previous question: that all sherds that originate from the local clay will look homogeneous as well. However, if the local clay is not all the same, and there is variation, than things begin to get more interesting.

Assuming that the there is variation within the local clays, the comparison with the data from the sherds from each site will begin to complete the picture. If the sherds from two or more of the sites look similar and the clay is variable, than this means one of two things, either a) the clay from the sherds are either coming from outside of the region, or b) that the sherds match with one of the sites local clay sources. Both scenarios pose an interesting answer. If the local Tiszapolgár people are not procuring their own local clay, this could mean that either the clay was not to the standards of making a decent pot or that the potters simply liked another distant clay better. But if one site procured clay from another site's area, this could mean that either the clay was better here, they were in a sharing, peaceful relationship, or this site with the clay had some sort of distributor status and perhaps some prestige that came with having the clay mine to itself. Regardless, it is an intriguing model.

Another possibility is that within the bounds of a heterogeneous clay assemblage, each site's sherd composition varied from each other. This could indicate two things, that either once again, each site was going out of the local area to procure clay (which is highly unlikely) or that each site is procuring its own local clay. This would make sense if the trace element signatures matched up for the site's sherds and local clays. However, I will talk more about this in the next section. Either way, this shows a independence between sites that would be more likely during a tense time, and not a time of peace.

The relationship between these three sites is interesting in itself, but also in the larger context of the region during the transition time of the ECA. During this time, the large tell sites of the Late Neolithic were giving away to the much more numerous and widespread Tiszapolgár settlements, meaning that studying the relationship between close sites of the same period has the potential to shed light on the settlement patterns of the whole. (Sherratt, 1982)

Vészt_ -Mágor is a large tell site that has a ECA Tiszapolgár cultural layer. There were not many tell sites present during the ECA which makes this an important anomaly. Did this site hold some sort of high esteem amongst the other (possibly) contemporaneous smaller sites, such as Vészt_ 20 and Körösladány 14? Parkinson presents two different models for the relationship between the tell site compared to the smaller sites. Either sites like Vészt_ 20 are satellite sites off of the bigger Mágor tell, or in fact the two sites are just the result of settlement movement over the 500-year period. (Parkinson, personal communication) This may become more apparent as we analyze the compositional data. Assuming that there is variation amongst local clays, if the chemical compositions of both Vészt_ 20 and Vészt_ -Mágor match up, this could indicate that Vészt_ 20 is a satellite site. The thinking is that clay would be procured and manufactured at either site but then shared between the two, as if they were a single entity. Of course, this does not prove this conclusion, but it lends more ammunition for an argument that way. On the other hand, if the compositions of the sherds are different, this would swing the argument the other way, that either the two sites were independent of each other, or that they were not contemporaneous in time.

Another relationship that can be looked in the one between Vészt_ 20 and Körösladány 14. Although these are categorized as two different sites, they are actually in close proximity to each other. Although in modern times the sites are separated by an canal, this man made waterway is only a century old. Both sites have been excavated in recent years, with good Tiszapolgár material coming out of both. However, extended excavation of K-14 has been put aside this past year. With excavation planned for upcoming field seasons, it would be helpful to know its relationship to the bigger Vészt_ 20. The way this can looked at with compositional analysis is the same as was done for Mágor . If the local clays are heterogeneous, and the sherds from both sites match, then chances are they are either the same site, or have a close sharing relationship. Conversely, if there is no similarity, there is a possibility that these are different sites.

How localized was the procuring and possible manufacturing of clay?

This question arises with Parkinson's work (1999) that discusses his theory of where the Tiszapolgár people are procuring their clay. The idea is that they are digging their clay on site and keeping the whole procuring and manufacturing operation on a very domestic level, where once the clay is gathered, it is produced at the household level. This idea can be tested by comparing the clay and sherd samples acquired from each of the four sites to each other. Of course, like the problems stated before, if all the clay samples are homogeneous, it is almost impossible to answer this question. However, if there is local variation, answers can be produced. For example, I will compare the clay samples at Örménykút 13 to the pedestal bases found on site. If there is an equal compositional match between the two, then an argument could be made for a domestic procuring strategy. However, if there is not, it may mean that either clay is being procured outside the region, or that the sherds are being traded in, both interesting scenarios.

If at all possible can we understand the relationship between Tiszapolgár people across the Great Hungarian Plain?

This is the hardest question to answer, for our sample size is so small and we are only testing four sites, three of which are very localized. However, if there are some types of regional clay variation, such as the petrographic analysis found at Örménykút , it may be possible to test for this, at least as an aside. For this question we need to compare both the sherds and clays from Örménykút to the other three sites, and try to find similarities. A slight possibility is that there would be a sherd in either location with a compositional signature of the other, indicating trade. However, this would be only a question that could be answered if variation in clays was found, and than only in future research.

Conclusion and The Future

Petrographic analysis has shown that the ceramics from the sites are show a very similar compositional pattern – a strong argument for the homogeneity of the Great Hungarian Plain. However, the possibility that there are trace elements in local clays at a very micro-regional level exists, and needs to be tested using a chemical compositional analysis. INAA is the method available, and the samples will be run as soon as possible back in the United States. All signs point toward a homogeneous, and hence confusing, conclusion, but if there is any type of variation in local clays or ceramics, the project will take off on a new trajectory. For to be able to explain procuring and manufacturing of ceramics is to show social relationships, and to show these relationships is to begin to understand broad questions that may clarify research in the settlement patterns of the Early Copper Age.

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