

The course of archaeological research never did run smooth ...

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We share our research in *Heritage Turkey* to celebrate the results of our endeavours in a more approachable manner than formal research publications allow. Those technical, comprehensive reports also enable us to gloss over the bumps along the way. The reality is that sometimes, perhaps more often than we might care to admit, research projects do not go to plan. This is one such tale.

Way back in May 2016, I received a Small Research Grant from the British Institute at Ankara (BIAA) to undertake non-destructive chemical analysis on part of the Institute's pottery collection. I was interested in a class known generally as Southwest Anatolian Ware (SWA). This type is ill-defined beyond being the primary painted ceramic output of the uplands of southwestern Anatolia during the first few centuries of the first millennium BCE, the period known generally as the Iron Age. SWA is characterised by geometric designs, particularly parallel bands, wave lines and concentric circles, although other motifs appear, such as star, hook or meander patterns, and occasionally natural designs (for example birds and fish).

My interest in this class was stimulated by an observation I had made a few years earlier during the course of fieldwork at another BIAA-supported project, the Çaltılar Archaeological Project. Between 2008 and 2010, we undertook the intensive survey of Çaltılar Höyük, a small upland site equidistant between Fethiye and Antalya via the mountain route (published in *Anatolian Studies* 2011: see Momigliano et al.). In the course of classifying the Iron Age pottery in the dry heat of this Lycian *yayla*, I observed a group of related sherds decorated with slip and paint layers applied so thickly that it was possible to determine their application order just from feeling the sherds with my fingertips. One group had a thick white slip, with matt-black motifs and added red decoration. Another group had a red slip with black motifs and added white decoration. A third group had a distinctive thick pink slip, with black motifs. Only by feel could these differences be noted on the sherds. To the naked eye, they all looked like the same output, with the white and pink being potentially attributable to firing differences in production. Subsequent petrographic analyses established that the three groups were discrete from one another, however. In other words, their clays were each derived from different sources. This was the first indication of diverse production centres for this type of ware.

When it comes to pottery of the Iron Age, we are often dazzled by the spectacular designs on the decorated types produced by the Phrygians, Lydians and Anatolian Greeks. They are well studied, and often well dated. When examples

are found beyond their production zones, therefore, we use them to date local contexts, which are usually less well understood in terms of absolute dating. Local productions often appear to be more long-lived than the flashy imports, and less innovative in terms of motif developments. The appearance of a well-dated import therefore can offer us a temporal window, but one that is somewhat removed from its origins: how long did it take for that vessel to reach its final destination?

Nevertheless, the evidence of different production centres for SWA was too tantalising for me to let go easily. Where was this type produced, then? Would I be able to, quite literally, feel the same differences I could on the Çaltılar assemblage? To address these questions, I would need to examine SWA from a number of sites. Therefore, knowing that the BIAA has a substantial pottery collection from southern and western Anatolia, I approached the Institute for permission to study the collection.

Normally, petrography is the first analytical means of assessing where a piece of pottery was made. This is because petrography provides an understanding of the materials in the clay itself – what makes up the clay naturally and what might have been added by the potter – which can then be tied to geographic locations through comparison with clay sources. This requires a thin slice of a sherd to be taken to examine under a microscope; it is a destructive method of analysis.

I did not want to undertake destructive analyses on the BIAA's collection for various reasons. Therefore, I needed a non-destructive method of compiling comparative data. So I turned to portable X-ray fluorescence (pXRF). This technique, used to identify the chemical composition of a sample, involves firing X-rays at a sample to excite electrons in the compound's elements. The energy rates reflected by those electrons are specific to each element. This enables us to build a picture of the elements in a clay. Samples with similar elemental profiles can therefore be deemed to be of the same group. It does not tell us what makes up the clay or inclusions, however, so it cannot pinpoint the geographic origin of ceramic material. Nevertheless, it can identify material with common elemental characteristics, thereby allowing a means to establish ceramic groups to compare with visual assessments. It can then be used to show distributions of the groups between different sites, which may highlight production centres, especially if it is assumed that the predominant fabrics at a site will be locally produced. Such a pXRF study therefore can compensate for the lack of stratified contexts in a broad region, and petrographic knowledge. I needed someone who knew about pXRF.

As luck would have it, at the same time as I was mulling over my application, the BIAA appointed a postdoctoral fellow, Orlene McIlfratrick, who was a ceramic-production expert. Orlene was developing pXRF analytical expertise in collaboration with several field projects. We decided to embark upon a pXRF study of the BIAA's collection of SWA together.

The broad region known to use SWA extends roughly from the Upper Meander valley at its northernmost limit and incorporates the modern provinces of Muğla, Denizli and Burdur, with parts of Aydın, Antalya and Isparta provinces. Its western extent merges into the Aegean coastal territories of the Greeks during the first millennium BCE. In a research visit timed to coincide with the Institute's annual Christmas party, Orlene and I spent three days examining material from the 100+ sites in the BIAA's pottery collection that lie within this zone. Nearly half of these had enough SWA material suitable for inclusion in the study, from which we selected 415 sherds to assay with the pXRF machine.

Orlene then began to calibrate the machine and undertake preliminary testing to establish an appropriate number of targets to measure on the surface area of each sherd. After assessing measurement deviations and mean values, she soon commenced gathering data from the sherds. Meanwhile, I started the task of cataloguing our selection, including writing up fabric, paint and motif descriptions for each sherd and taking multiple photographs. I also combed the library shelves for published material from additional sites to compare with the BIAA's assemblage. As we entered our second working week, progressing at a rate of nearly 50 sherds per day, we appeared well on target to finish the pXRF data gathering the day before I was due to return to the UK. With a little under half the sherds to go, however, Orlene's pXRF machine decided it had had enough, and it refused to play any longer with us. Or with anyone. It simply refused to continue to chirp 'ping'.



SWA sherd from Çaltılar.

The machine had been on loan from the manufacturer, who had a programme to encourage take up of the technology by providing loan machines free of charge to convince organisations of the utility of pXRF and therefore to purchase the equipment – an approach Tom Lehrer would surely characterise as 'today's young, innocent faces will be tomorrow's clientele'. Frantic calls to the manufacturer about our loan machine's non-active state made it clear very quickly that the machine would need to be sent back to the UK for repair. With the UK beginning to close down for Christmas, however, we knew a replacement could not be obtained before the new year. Therefore, we organised the remaining material in a way that would enable Orlene to finish the job on her own when she could get hold of a replacement/repaired machine, while also leaving the pottery lab where we had been working available for others to use in the meantime. Sherds from which data had been collected were put back in their original boxes on the shelves. The sherds not yet analysed were bagged up and returned to their site boxes, which we placed on the window sill of the pottery lab for easy access for Orlene in due course.

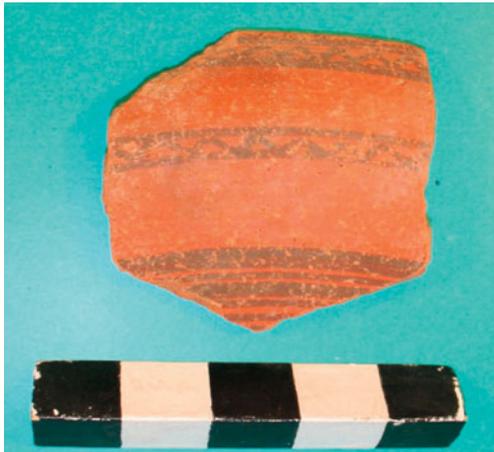
The loan machine was returned to Ankara several months later, in time for Orlene to use it on an extended project during March and April 2017. She promised to finish off my sherds on her days off from that excavation. Knowing that excavation is an all-consuming undertaking, I did not expect to hear from Orlene for the duration of that dig. Therefore, in late April, I emailed her to ask how it had all gone. In her reply to me, it was obvious that she was beside herself with dismay. The loan machine had failed early in the season in exactly the same way as it had for us in December. This time, however, she was able quickly to borrow the same model from a professional colleague who had a lull in his own contract work. However, this machine developed a fault before the end of the field season, so she was unable to complete her work for that project, not to mention mine. To make matters worse, the manufacturer had since declared it was discontinuing its free loan programme (the manufacturer ceased marketing the model after 2016 and ended its service in 2019; we had been using machines nearing the end of their working lives unknowingly all along). The only way for me to finish the project would be to hire another machine. This required additional money. The application deadline for the BIAA's 2017 Small Research Grant round was a mere three days away.

I have never written a grant application so quickly, and I am extremely grateful to the late Jim Coulton for providing a reference for me within 24 hours. The BIAA very generously awarded me the amount necessary to hire another machine for ten days to undertake the work.

By this time, Orlene was moving on to other research projects, so I also needed to find a new pXRF expert. I reached out to various contacts, and eventually I became connected to Ümit Guder, a pXRF expert known for his



Bichrome body sherd from Gencer.



Black on red rim sherd from Kızıllıhisar.

metallurgical analyses, including on material I had excavated myself at Kinet Höyük in the 1990s. Our various academic commitments meant we would not be able to start for some time, though. In fact, it was not until May 2018 that Ümit, his assistant, Tolga Özak, and I met in Ankara over a weekend to commence work. Ümit and Tolga immediately set up and calibrated their machine, which was from a different manufacturer altogether. In the meantime, I had to reassemble the collection that Orlene and I had first selected eighteen months before, most of which had been returned to its original storage in the pottery storeroom, as well. I reidentified and retrieved from their site boxes all 415 sherds, which I then laid out and numbered on planks carefully stacked in one of the aisles in the pottery store. Once the material was ready, as Orlene had done, Ümit and Tolga assessed the best way to compensate for the limitations of the assemblage itself: since we still could not create any fresh breaks, and taking into account the irregularity of the extant surface geometry, which can cause measurement changes, they had to determine how many targets on each surface to measure, check deviations between measurements and calculate the mean values of the measured compositions. Very quickly, Tolga found his rhythm and was underway ...

It is now late 2020. For over the past year, Ümit and I have had lengthy email discussions about the data. As no two

sherds are the same, we have had to determine an acceptable level of variability to distinguish one cluster as a distinct group from another. We chose specific elements in the compositions and we applied principal component analysis to create 3D graphs in which we could observe the clustering of sherds from diverse sites. As a result, we have identified six different clusters.

We have also played around with the best ways of showing our clusters. 3D static graphs make the groups clear in most cases, but sometimes a different angle is necessary to illustrate a cluster more effectively. I find myself wondering now if we can use rotating imagery such that the viewer could choose to rotate the image to see the clusters from all angles. This would require the final digital repository of the images to be able to host software that supports active content, which I have yet to investigate.

Then there are the results themselves. Five main styles have been distinguished by surface paints (black on red; black on buff; brown on buff; red on buff; bichrome). Each of the six clusters was used to produce more than one of the five style groups. This suggests there were multiple producers for each style group.

In terms of distribution, some sites appear to be selective in terms of where they acquired their styles from, whereas other sites appear to be more indiscriminate. Some obtained a particular style from several producers; others chose material primarily from one producer (and perhaps was the producer). Sometimes a site accepted certain styles from one producer and other styles from another. Currently, we are experimenting with machine learning algorithms to identify likely distribution routes.

An article will see the light of day in due course. When it comes out in *Anatolian Studies* (I am an optimist), I hope that those of you who have read this far will share the sense of accomplishment that I will feel. It has been a very long journey, and you are now privy to its true course. My aim in this narrative has been to share some aspects of how the road of research is not always smooth, even if the final publication does not mention the bumps along the way.



Too many sherds at Çaltılar!