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Ten seconds in the field: rapid Armenian obsidian sourcing with portable XRF to inform excavations and surveys

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ABSTRACT

Armenia has one of the most obsidian-rich natural and cultural landscapes in the world, and the lithic assemblages of numerous Palaeolithic sites are predominantly, if not entirely, composed of obsidian. Recent excavations at the Middle Palaeolithic cave of Lusakert 1 recovered, on average, 470 obsidian artifacts daily. After sourcing more than 1700 artifacts using portable XRF (pXRF) in our field house, our team sought to shift pXRF-based obsidian sourcing into the field itself, believing that the geological origins of artifacts would be useful information to have on-site during an excavation or survey. Despite increasing use of portable instruments, previous studies have principally focused on collections in museums and other archives, and as a result, obsidian sourcing has remained embedded in post-excavation studies. One critical factor in the uptake of obsidian sourcing in the field is the time needed to measure each artifact, frequently 2–6 min in previous studies. Here we report our two methods of obsidian sourcing, including source matching done automatically by the pXRF instrument's onboard software, in only 10 s. Our tests with Armenian geological specimens and Palaeolithic artifacts demonstrate the high efficacy of our two methods, which are sufficiently fast to become syncopated with our excavation and survey activities. By reducing measurement times from a mode of 300 s in recent studies to just 10 s, here we show how (and why) to shift pXRF-based obsidian sourcing from the context of "white lab coats" to that of "muddy boots."

1. Introduction

Although smaller than Belgium or the state of Maryland, Armenia has more than a dozen obsidian-bearing volcanic centers, resulting in one of the most obsidian-rich natural and cultural landscapes in the world. At numerous Palaeolithic sites, obsidian comprises the majority, if not the entirety, of the lithic assemblage. This is the case at two sites recently excavated by the Hrazdan Gorge Palaeolithic Project (Adler et al., 2012): Nor Geghi 1, an open-air Lower Palaeolithic site, and Lusakert 1, a Middle Palaeolithic cave site (Fig. 1). Their lithic assemblages are more than 99% obsidian. At Lusakert 1, in particular, after four excavation seasons (2008–2011), 13,970 obsidian artifacts have been recovered (excluding 5970 fragments smaller than 25 mm) from 11.9 m^3 of sediment. That is, 1174 obsidian artifacts were recovered per cubic meter. On average, 470 obsidian artifacts were excavated daily with spatial data recorded by two Leica total stations.

In 2011, the project began a new program of obsidian studies, including artifact sourcing as well as source surveys and characterization. During the 2012 season, we analyzed over 1700 artifacts in our field house using portable X-ray fluorescence (pXRF). We established that the Nor Geghi 1 and Lusakert 1 assemblages were both approximately 93% obsidian from Gutansar (sometimes spelled as Gutanasar), the nearest volcanic center with abundant obsidian resources. The remainder came from numerous sources throughout Armenia, including Hatis, Pokr and Mets Arteni, Pokr Sevkar, Geghasar, and the Tsakhkunyats sources. Publications on these findings, included detailed source and spatial data, are currently in preparation. The focus of this paper is a methodological development that arose out of our work, specifically a desire to have obsidian source information available on-site. The methods we document here will be deployed in future seasons, becoming a

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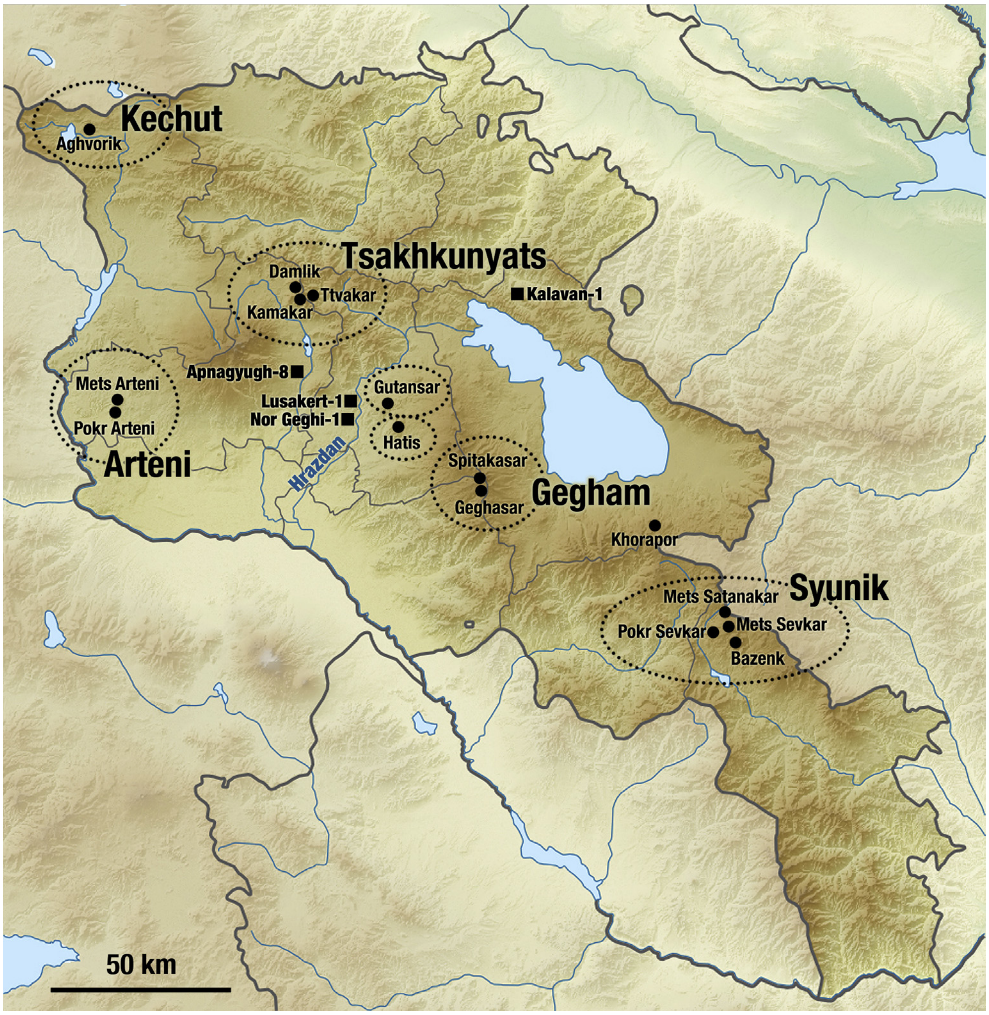

Fig. 1. Armenia obsidian sources (black circles) included in this study, archaeological sites referenced in the text (black squares), and source complexes (dashed lines) as conceptualized in the tests. Localities with different names but identical compositions are represented by a single dot (e.g., Djraber, Gyumush, Fontan, etc. localities of Gutansar). No attempt is made here to precisely represent the full primary and secondary distribution of the obsidians. For this study, Syunik complex specimens did not include sources only recently surveyed by our team, such as Mijnek Satanakar, Pokr Satanakar, and Merkasar. Although not conceptualized as such for this study, Gutansar and Hatis can be considered the Hrazdan-Kotayk group, while Khorapor is part of the Vardenis group. Apnagyugh-8 is unofficially known as Kmlo-2. Digital elevation data from SRTM3 (Shuttle Radar Topography Mission dataset version 3), and base map shared and modified under Creative Commons terms from Wikimedia Commons.

routine component of our excavation toolkit and constituting a key strategy in our approach to site surveys and assessments.

As hundreds of artifacts were sourced in our field house during the 2012 season and the results compared to the spatial data, it became clear to us (for reasons discussed in Section 2) that an artifact's geological origin would be useful information to have on-site during an excavation or survey. Our tests of visual classification yielded little success. Gutansar obsidian is highly variable in appearance, and as Table 1 shows, any "exotic" artifacts from other sources were overlooked and grouped into types with Gutansar artifacts. Thus, we began our efforts to develop methods for shifting pXRF from our field house into the field itself. As discussed in Section 2.4, pXRF-based obsidian sourcing has hitherto been largely conducted in laboratories, museums, and field houses. Although our colleagues are using dust- and waterproof instruments with 10-h batteries, obsidian sourcing remains embedded in post-excavation studies and is rarely, if ever, done in the field.

A critical factor in the uptake of obsidian sourcing in the field is the time needed for each measurement. In recent pXRF-based obsidian studies (Table 2), analyses took 2–6 min. The most common duration is 5 min, corresponding to 12 artifacts per hour. Our excavations at Lusakert 1 yielded, on average, 70–80 artifacts per hour. Although this suggests a need for 45-s measurements, we aimed for 10 s so that these analyses could become syncopated with the excavation activities. Additionally, we deemed it was insufficient simply to conduct a measurement in that time. After 10 s, we wanted the instrument's built-in LCD to display an artifact's source so excavators and surveyors could instantly know the result.

Reducing measurements from a mode of 300 s to just 10 s and having the instrument's onboard software automatically do the data analysis is bound to raise challenging assumptions about the validity and reliability of our approach. We show that the technological capability to source obsidian artifacts rapidly on-site exists, but the methods to do so effectively were previously undeveloped. Our tests with Armenian geological specimens and Palaeolithic artifacts demonstrate the high efficacy of the two methods we report here.

2. Rationale for field-based sourcing

Obsidian artifact sourcing conducted rapidly on-site can transform the ways in which our discipline approaches subjects involving raw-material procurement, transport, and use as well as the organization of space and the identification of activity areas.