PROCEEDINGS OF THE TWENTY-EIGHTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2015
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TOM BARTLETT, Colgate University
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GEOCHEMICAL INVESTIGATION OF LITHIC TOOLS AND FLAKES FROM THE ISLANDS OF FOUR MOUNTAINS, AK: DETERMINING SOURCES LOCATIONS AND INFERRING DISTRIBUTION METHODS

TOM BARTLETT, Colgate University
Research Advisor: Martin Wong

INTRODUCTION

Stone tool technology was an essential component of life in prehistoric Unangan (Aleut) society of the Aleutian Islands. Hatfield (2006) recorded changes in lithic materials across five Aleutian sites, which date between 8000 and 3000 uncalibrated yBP and pointed to a major decrease in the use of obsidian throughout the prehistory of the Unangax. However, obsidian was coveted because it is easy to flintknapp and results in a fine, sharp edge ideal for projectile points and knives (e.g., Davis and Knecht, 2010; Dumond and Knecht, 2001).

Although obsidian was an ideal material for points and knives, the central and western Aleutians lack any obvious geologic source because rhyolitic obsidian flows are uncommon in oceanic arc settings (Nicolaysen et al., 2012; West et al., 2012). Consequently some recovered tools are made of lower quality, fine-grained lavas or other rare rock types. This raises intriguing questions about where the source(s) of obsidian and other lithic materials were located, how homogeneous or heterogeneous the sources were, and how far the Unangan people traveled or traded to obtain this material, which have important social and resource implications.

The primary objective of this study is to describe the geochemical signatures of stone tools and flakes discovered throughout the Island of the Four Mountains (IFM, Fig. 1) with the ultimate goal of linking these to the geographic distribution of tool-suitable material. Geochemical analysis of stone tools by portable X-ray fluorescence (pXRF) and of worked flakes by electron probe microanalysis (EPMA) is employed as now common in the field of archaeometry (e.g., Millhauser et al., 2011; Reuther et al., 2011). The geochemical analysis of these tools and flakes are compared to the geochemical signatures of four known types of obsidian in the Aleutian Islands (Reuther et al., 2011). We conclude that obsidian was a commonly used material for lithic tools in the IFM and may be derived from multiple sources; these best match the Okmok and Group D obsidian types. Moreover green jasper and fine-grained lavas were also used; evaluating potential local sources is a goal shared with Fulton, 2015 (this volume).

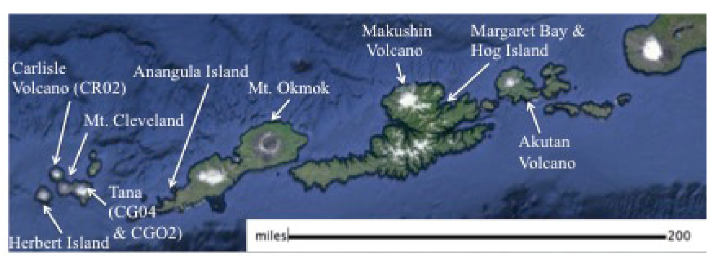

Figure 1. Samples were collected from sites on the flanks of Tana Volcano on Chuginadak Island and Mt. Carlisle. Known regional obsidian sources are from Okmok on Umnak Island and Akutan Island (e.g., Reuther et al., 2011; Nicolaysen et al., 2012). An obsidian type "Group D" is from an unknown location.

METHODS

Geochemical analysis was conducted on twenty flakes of obsidian and thirty-nine lithic tools collected from midden and house pits from sites CR02 (Carlisle), CG02 (Tana), and CG04 (Chuginadak). Non-destructive pXRF analysis was conducted on lithic tools using a Niton XL3t GOLDD+ Series X-Ray Fluorescence spectroscope at Whitman College. The device was operated in soil mode using standard parameters (40 kV and current of 20μA). Repeated measurements of SPHM and LGBO obsidian standards plus powdered GSP-2 USGS standard checked accuracy and precision for the pXRF analysis (Millhauser et al., 2011). The flattest surfaces of tools were wiped with ethanol prior to placing the flat face directly over the detector window. Three replicate measurements were made on the same spot for each tool. If measurements of a particular element for all three standards agreed with the known composition of the standard and had low variance (≤10% difference from mean and from standard value), then we accepted analyses of these elements (Zr, K) in the unknowns as reliable and averaged the measurements. The following elements returned highly reproducible results for standards and unknowns: Zr, Rb, Zn, Fe, Mn, Ti, Ca, K, Ba, Nb, Al, Si. If measured values of the standard were precise but consistently inaccurate with respect to the known values, a calibration curve was created to correct the elemental values of unknown samples.

For electron probe microanalysis (EPMA), seventy flakes (1-2-mm dia.) were impregnated into 1-inch epoxy mounts, polished, and carbon-coated (thickness ~250 Å). Of these, the matrix glass for twenty obsidian flakes was measured at the University of Alaska Fairbanks using a JEOL JXA 8530F electron microprobe. A 15 keV, 10 nA, 10 μm-diameter beam was utilized. Nine distinct analyses on each flake were averaged. Na and Al were analyzed first with time-dependent intensity correction to reduce the effect of volatilization. Major oxides were recorded in wt.% with all Fe reported as FeO. As a measure of a typical analytical uncertainty, a CCNM standard reference material was analyzed repeatedly during the analytical session. The following elements were analyzed: Si, Ti, Al Fe, Mn, Mg, Ca, Na, K, and Cl.

RESULTS

Lithology of flakes

The 70 collected flakes can be divided into four main lithic groups based on their visual appearance. The most common flake lithology (n=22) is a black to gray obsidian with a vitreous luster and rare small (~2 mm) phenocrysts of feldspar and minor titanomagnetite. Eighteen collected obsidian flakes were from House Pit 1 at CG02. Three of these are from level A, seven from level B, two from level C, three from level D, and two are from level E. Three obsidian flakes were recovered in House Pit 17 of CG02. One obsidian flake was found in the south blow out of CG04.

Another common flake lithology (n=14) is fine-grained gray-green jasper with small black inclusions. Twelve of the jasper samples were found in House Pit 1 CG02. Four of the samples were collected from level E, two from level B, one from level C, and five from level A. Additionally, two jasper samples were collected from the West Ravine profile at CGO2 (see Loopesko, 2015, this volume, for profile information). One large flake was found at the surface of a sandy devegetated blow out at CG04.

Fifteen of the flakes are likely basaltic andesite with sparse plagioclase phenocrysts up to 1 mm in length in a dark grey to black cryptocrystalline matrix. The rock cleaves in a staircase manner so it is not as smooth as the green grey jasper, yet it still breaks conchoidally. Eleven of the flakes were discovered in House Pit 1, CG02, two from level E, two from level B, two from level D, three from level C and two from level A. Three of the samples were found on Chuginadak in House Pit 17, floor number 1. Additionally, one originates from the south blow out of CG04.

Ten flakes are andesitic in composition with abundant plagioclase and some amphibole phenocrysts in a coarsely crystalline groundmass. These flakes range in color from light grey to pink (weathered) and are fairly porous. A subset of nine flakes for analysis was selected from House Pit 1 of CG02. Eight are from level C and one is from level E. Additionally, one flake is from the south beach blow out (CG04).

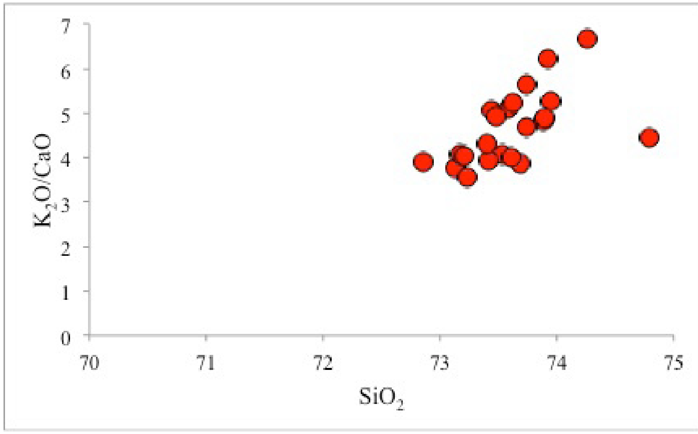

Figure 2. Geochemical data from the electron microprobe on the 20 obsidian flakes. These flakes have a narrow range in SiO but vary by roughly a factor of 2 in KO/CaO. Thus, the obsidian flakes are derived from rhyolititc obsidian. 19 of the flakes were found at CG02 and 1 flake was found at CG04.

Geochemistry Results

The EPMA analysis of both the black and gray obsidian flakes shows a rhyolitic compositions (72.9–78.4 wt.% SiO_2) with a factor of 2 variation in K_2O/CaO (3.6–6.7 wt. %; Fig. 2). After consideration of analytical error, obsidian flakes show little variation in other major elements (Fig. 3) and are relatively high in K (33,808±986 ppm) and Fe (16,297±1365 ppm) and low in Mn (658±48 ppm).

In total 39 lithic tools were analyzed using the pXRF, 25 of which were identified as obsidian, 9 as basaltic andesite or fine-grained lava, 3 as jasper, 1 argillite, and 1 as flow-banded rhyolite. A comparison of obsidian flakes and tools produce similar Si/Al and different Fe/Mn element ratios (Fig. 4). The flakes have Si/Al that range from 4.7–4.9 ppm (mean=4.8 ppm) whereas the obsidian tools have a slightly broader range of 1.8–4.3 ppm (mean = 3.7 ppm). Flakes have Fe/Mn that range from 13.1–34.7 ppm (mean=25.3 ppm) and tools range from 29.6–42.1 ppm (mean=33.9).

Trace element ratios such as Zr/Nb, Fe/Mn and K/Rb are valuable comparisons because they have the potential for distinguishing among obsidian groups with similar major element compositions. The obsidian tools from CG02, CR02, and CG04 are indistinguishable, within error, for Zr/Nb (Fig. 5). Fe/Mn and K/Rb ratios, however, do show that some of the tools are compositionally distinct.

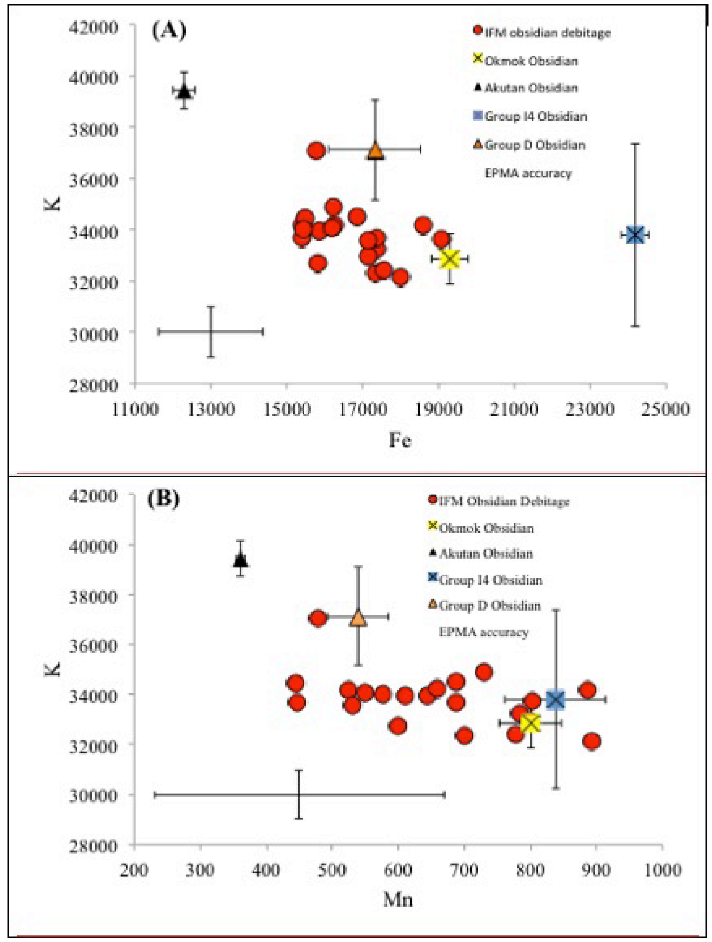

Figure 3 a., Figure 3b. Geochemical data from the electron microprobe on the 20 obsidian flakes compared to the known obsidian types from Reuther et al., 2011, Nicolaysen et al., 2012. Estimated error based on standards is shown in the lower-left of each graph. (A) K vs Fe from some flakes overlaps with Group D obsidian type and some with Okmok type. (B) Mn vs. K showing IFM flakes could overlap compositionally with three different sources. The accuracy of Mn by EPMA is much lower (see error bar at lower left). EPMA is not an ideal method for trace element analysis therefore nondestructive pXRF analysis was used on the tools.

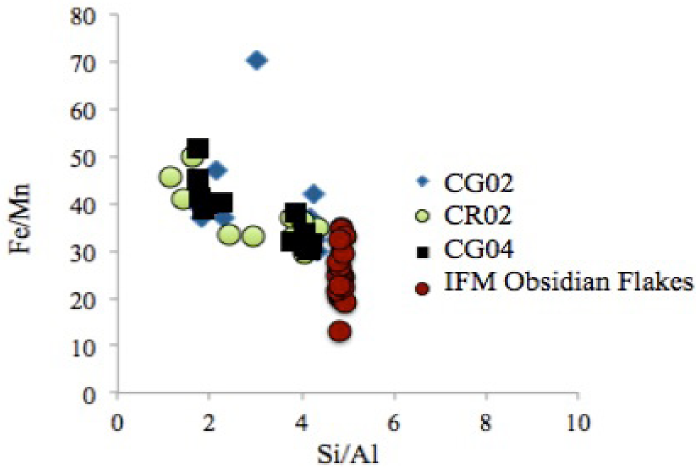

Figure 4. pXRF analyses of Si/Al versus Fe/Mn for IFM tool data compared to EPMA data on the IFM obsidian flakes. Some tools (diamonds, green circles, squares) overlap with the flakes (red circles) in Si/Al values but others appear to have distinctly lower Si/Al. The variation in Fe/Mn for the flakes may stem primarily from the relatively wide range of Mn values but the low precision means that these may essentially be a single obsidian type. These results are not entirely surprising as tools of at least 3 distinct lithologies – obsidian, sparsely plagioclase phyric lava, and jasper – were identified visually.

DISCUSSION

Determining how homogeneous or heterogeneous the nature of materials used by the IFM Unangax to make tools, and which type of lithology was prevalent is central to understanding what role obsidian played in lithic tool production. Based on the major element geochemistry of the obsidian debitage flakes (Figs. 2, 3), the obsidian used for tool production appears to be fairly homogeneous, perhaps suggesting the obsidian is from a single source. However, the major element geochemistry of the obsidian tools appears more variable, especially in Si/Al (Fig. 4), with one cluster overlapping with the flake geochemistry in Si/Al vs. Fe/Mn and one cluster of tools with distinctly lower Si/Al. One possible explanation of these data is that there were two distinct obsidian sources around the IFM, each used for tool production. However, other geochemical ratios suggest little variation in the tool values (Fig. 5). An alternate explanation is that the obsidian flake and tools may have similar Si/Al ratios but pXRF analyses may yield somewhat different Si/Al values than EPMA because pXRF integrates over a larger area and may incorporate phenocrysts as well as the glass matrix.

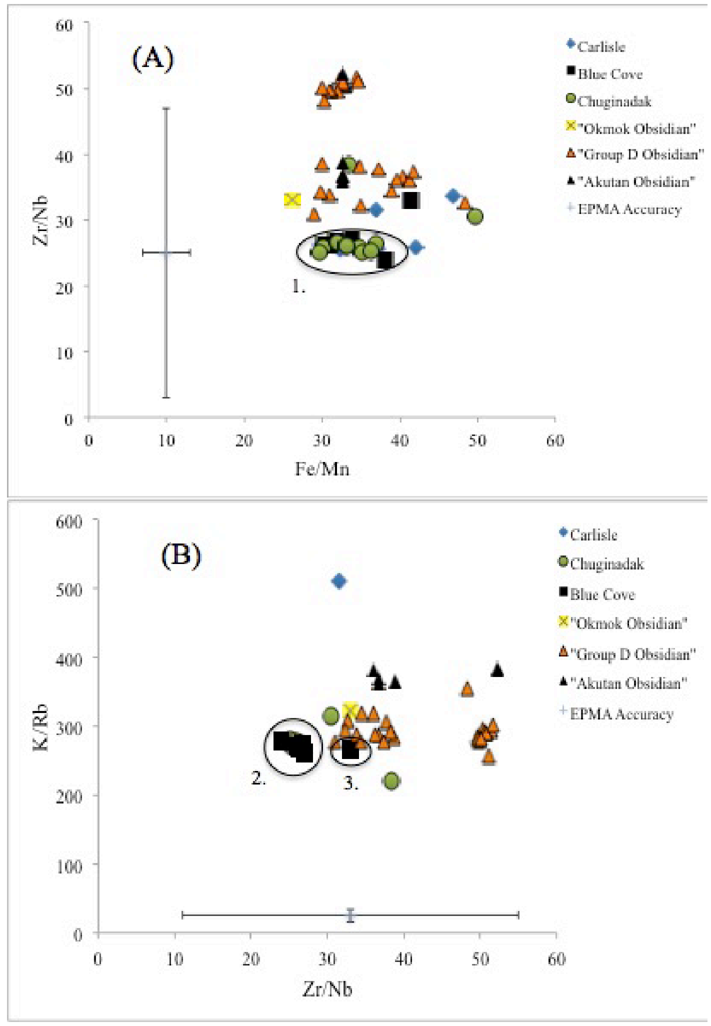

Figure 5a., Figure 5b. pXRF geochemical plots for the obsidian tools from all three sampled sites. (A) Fe/Mn versus Zr/Nb plot shows IFM samples overlap partially with the Okmok and Group D obsidian, although the majority of tools (circle 1) may have lower Zr/Nb and may represent a distinct group. (B) Zr/Nb versus K/Rb plot indicates that some IFM tools overlap with Group D or the Okmok source (circle 3), but some of the samples may be distinct (circle 2). The error bars represent the most conservative propagated standard deviation (1 sigma). We plan to complete a principle components analysis to evaluate these data more robustly.

These data present the opportunity to examine the source region for the obsidian for IFM tools. Individual obsidian flows and glassy welded tuffs have distinct chemical fingerprints (Reuther et al., 2011) and can provide valuable insight into the obsidian origin, distances involved in trade, and the preferred lithic materials of a region (Millhauser et al., 2011). Identified sources of obsidian and/or geochemical groups in the region include the Okmok source, located on Umnak Island ~129 km east of the IFM and the Akutan Island source, ~290 km east of the IFM (Nicolaysen et al., 2012, Fig. 1). Obsidian

Group 14 and Group D have been identified as distinct geochemical groups of obsidian tools, but their source region is still unknown (Glascock et al., 1998).

IFM flakes appear consistent with the Okmok source and Groups I4 and D, while Fe vs. K values appear to match only the Okmok and Group D obsidian due to lower Fe values (Fig. 3). Fe/Mn, Zr/Nb, and K/Rb values for the tools yield similar results to the flake data in that the IFM tools plot close to the Okmok source and Group D (Fig. 5). However, some of the tool data does not appear to match any of the known sources or groups convincingly, opening the possibility that the IFM tools came from a new source or group.

Nicolaysen et al. (2012) found that obsidian was transported from Okmok to Adak Island located 630 km west. The results of this study are consistent with an Okmok source for both obsidian flakes and some tools; it is quite plausible that the IFM Unangax used the closest available source (Okmok ~130 km east of the IFM) even though this would have been an arduous trek by baidarka (Unangan kayak). Moreover the compositional overlap of tools from all three sites (CR02, CG02, CG04; circles 1 and 2 in Fig. 5) shows people in all three villages used the same resources starting ~2990 radiocarbon yBP (Loopesko, 2015, this volume).

The fact that a majority of the tools found were crafted of obsidian suggests either (1) obsidian was the most desirable material for tool production or (2) sampling of the IFM is limited by the size of the excavation sites. Basaltic andesite lavas dominate the volcanic islands of the central Aleutians, including the IFM, though conchoidally-fracturing clasts of dacitic domes and flows have been found in several locations in the IFM (Fulton, 2015, this volume). Thus, obsidian, though originating in only a handful of isolated locations in Kamchatka, Alaska and the Aleutian Islands, appears to have been a highly valuable resource, regardless of harsh circumstances needed to collect it.

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