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The cultural nature of tephra: 'Problematic' ecofacts and artifacts and the Barú volcano, Panamá

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ABSTRACT

This paper presents data from archaeological stratigraphy and lacustrine core samples containing tephra from the Barú volcano in western Panama. The discussion seeks to refine the understanding of medial tephra deposits near Barú in relation to the eruption history indicated by geological, palaeoecological, and archaeological data. A primary goal of this fieldwork is the identification and correlation of tephra from major Barú eruptions encountered in archaeological contexts by their lithology, stratigraphic position, and mineralogy without resorting to geochemical fingerprinting. The intention is to develop a cost efficient and reproducible means of utilizing tephra as a chronostratigraphic marker in archaeological contexts and examine the intersection of human life with volcanic events and dynamic environments. Tephra in archaeological contexts can have ambiguous placement between ecofact and artifact, as is the case with a small number of crude tephra sculptures in my excavated material and that of a seminal prior study. While the research project utilizes visible tephra layers, not cryptotephra, by all means the tephra data prove to be cryptic. Engagement with the imperfection entailed in meshing multidisciplinary data sets and different scientific communities with interests in tephra, particularly in lesser studied regions, is posited as a 'total' view of tephra.

1. Introduction

If geoarchaeology is a nexus science (Dugmore and Newton, 2012; Nicoll and Murphy, 2014), then tephra can be seen as a nexus material via its importance in a growing number of scientific subfields. Tephra studies are increasingly important components of Quaternary research and provide a unique means to address palaeoenvironmental and archaeological chronologies (Lowe, 2011; Lowe and Alloway 2014). The precise relationship between key volcanic eruptions and the archaeological and environmental record can be highly problematic, however, even for heavily studied volcanic events such as the Bronze Age eruption of Santorini/Thera (e.g., Manning, 1999; Pearson et al., 2005; Friedrich et al., 2006; Manning et al., 2006). For lesser studied contexts, such as those of Central America, the challenges are compounded. The accumulation of further data in such contexts is requisite for a multidisciplinary consideration of volcanic eruption and materials.

This paper presents data from archaeological stratigraphy and lacustrine core samples containing tephra from the Barú volcano in western Panamá. The discussion seeks to refine the understanding of medial tephra deposits near Barú in relation to the eruption history indicated by geological, palaeoecological, and archaeological data. A primary goal of the study was the identification and description of tephra from major Barú eruptions encountered in archaeological contexts by their lithology, stratigraphic position, and mineralogy. Innovative new technologies that are more cost-efficient than geochemical fingerprinting and permit the creation of a visual archive of tephra particles are suggested as possible ways to further examine and identify volcanic materials from Central American archaeological sites.

1.1. Central American tephrochronology

Relative to the well-developed tephrochronologies of Iceland, New Zealand, and elsewhere, Latin American tephras have received a lesser degree of attention. This is disadvantageous, as tephra can provide important horizon markers for the post late-glacial history of the area. A majority of the foundational Latin American tephrochronology studies are in México (Rabek et al., 1985; Newton and Metcalfe, 1999; Newton et al., 2005; Luhr et al., 2010; Gonzalez et al., 2014), and central Mexico is the only context from the

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Americas represented by data in Tephrabase (www.tephrabase.org). The southern Andes and Patagonia have garnered a fair number of recent tephrochronology studies (e.g., Kilian et al., 2003; Haberzettl et al., 2007; Bertrand et al., 2008; Watt et al., 2011; Daga et al., 2014; Fontijn et al., 2014) while the central Andes (e.g., Breitkreuz et al., 2014) and northern Andes (e.g., Rodbell et al., 2002; Hansen et al., 2003; Le Pennec et al., 2008; Tonneijck et al., 2008) are also becoming better represented in the published literature. Central America, by comparison, has a paucity of recent tephrochronology studies despite its highly volcanic context. The majority of Central American tephra studies are of Arenal volcano in Costa Rica (e.g., Cole et al., 2005; Alvarado et al., 2006; Bolge et al., 2006; Soto and Alvarado, 2006) or other volcanoes and offshore deposits (e.g.; Clift et al., 2005; Shaw et al., 2006). Tephrochronology studies of Ilopongo volcano in El Salvador, which stem from the archaeological work of Payson Sheets, provide an important example of recent Central American tephrochronology (Dull et al., 2001; Mehringer et al., 2005).

2. Regional setting: Barú volcano

2.1. Geological setting of Barú

The Barú volcano, located near a complex junction of seismically active tectonic plates, forms the southern terminus of the arc of Central American volcanoes created by the subducting Cocos plate. The Barú cone volcano covers 280 km^2 and represents an overlapping series of pyroclastic flows, lahars, and lava flows (Sherrod et al., 2007: 10). Barú's current form, as estimated from 90-m resolution Shuttle Radar Topography Mission (SRTM) data, has a volume of roughly 140x km^3 and an area of approximately 394 km^2 (Van Wyk de Vries et al., 2007: 135). The palimpsest of forms, flows, and deposits prevent the earliest part of the volcano from being accessible or dateable.

Barú was the site of what was potentially the largest volcano debris avalanche in Central America, resulting in a 6 × 10 km horseshoe-shaped caldera that is breached to the west (Siebert et al., 2004, 2006). The more eroded western flank is characteristic of isthmian area volcanoes due to the higher rainfall on the Caribbean-side slopes (Van Wyk de Vries et al., 2007: 128). The large amount of water from both rainfall and streams makes lahars a common phenomenon of Barú eruptions, and a ~40 km wide radial lahar extends across the forearc of western Panamá (Morell et al., 2008).

The <12.4 ka maximum date (IRHE, 1987) estimated during geothermal analysis and the 2860 ± 50 BP date from the lowest sediment layer of a lake core examined by Behling (2000) may provide rough bounding dates for the collapse in the assessment of Siebert et al. (2006). Sherrod et al. (2007: 4, 13), however, believe that the avalanche occurred earlier than the 8740 ± 90 14C BP (9540 cal BP) date of silt found below a terrace where a redirection of the Río Chiriquí Viejo cut into an alluvial fan and date the debris avalanche at more than 50 ka in age.

2.2. The role and timing of Barú eruptions during human occupation

Evidence from lake-sediment cores in central and eastern Panamá (La Yeguada and Cana) point to extensive forest clearance by roughly 7000 BP (Cooke, 2005: 140–42; Piperno, 2006). This clearance was directly related to the dispersal and intensification of food production. Many of the tropical plants that subsequently became New World staples – such as maize (*Zea mays*), cassava (*Manihot esculenta*), yams (*Discorea* spp.) and squash (*Cucurbita*) - were being widely planted in Panamá by the Late Preceramic period of 7000–4500 BP (Piperno et al., 2000a, 2000b; Dickau et al., 2007). The use of fire and clearance of vegetation for agriculture related to permanent settlements is evident in highland western Panamá, near the Barú volcano, after ~2860 BP (Behling, 2000; Cooke, 2005).

The United States Geological Survey (USGS) Open File Report 2007-1401 by Sherrod et al. (2007) provides the most syncretic and accurate published assessment of Barú's eruption history to date. Using data from paleosols and eleven new AMS dates, Sherrod et al. (2007) synthesize data from palaeoecological studies and archaeological research to suggest the occurrence of four eruptions during the period for which archaeological evidence suggests permanent settlements in the Barú region. A 400–500 year dormancy separates the current landscape from the first and most recent episode, which Sherrod et al. (2007) place between 420 and 540 cal BP. Roughly 250 years of dormancy divide episode one and episode two, which is undated. Another roughly 250 year dormancy divides episodes two and three, which is interpreted between 690 and 950 cal BP. A roughly 230–620 year dormancy then separates their episodes three and four, interpreted to have occurred sometime between 1180 and 1310 cal BP.

Sherrod et al. (2007) do not accept the radiocarbon date used by Linares and Ranere (1980) to propose that an AD 600 eruption of Barú prompted significant settlement changes in the region and depopulation of the Barú area. In tandem with Anchukaitis and Horn (2005), the USGS researchers agree that the radiocarbon date from the Linares and Ranere (1980) project (I-7236; 740 ± 150 BP uncalibrated date, AD 988–1450 calibrated calendar year, 2δ) is associated with volcanism. The large analytical error of this date, however, makes its attribution to a particular eruption too uncertain (Sherrod et al., 2007: 17). The Sherrod et al. (2007) assessment accepts all three AMS dates used to date tephra layers in a lake-sediment core from Behling (2000). The USGS assessment also accepts AMS dates utilized by Clement and Horn (2001) and Anchukaitis and Horn (2005) to date lake-sediment cores containing Barú tephra. The three palaeoecological studies, which examine the presence of maize (*Z. mays*) pollen and palynological evidence for forest burning or regeneration, link only the most recent eruption of Barú to significant decreases in human occupation of the area.

3. Material and methods: examining Barú tephra

Tephra formed an important data component in the Linares and Ranere (1980) interpretations of how volcanism impacted pre-Columbian populations, though minimal description of the tephra was published. Dahlin (1980: 276–7) describes tephra from the Barriles site as follows:

> Throughout the survey area the culture-bearing strata are capped by a more or less thick layer of pumice with a contemporary humic layer on top … Using the sondage technique enabled us to tentatively assess the variable effects of the pumice fall. In recording the amount, size, and angularity of the pumice particles and the nature of their deposition at any and all locations within the survey area, we were able to identify the source of the pumice as Volcán Barú and conclude that it affected the entire survey area.

Dahlin (1980) does not provide details regarding how the tephra was sourced to Barú and morphological data are not included. Linares et al. (1975) describe the uppermost tephra layer as 'part pumice, part soil; medium yellow pumice', which Sherrod et al. (2007: 29) interpret as 'slightly weathered pumice lapilli admixed with soil … .' Rosenthal (1980: 290–1) provides stratigraphic