The Origin of Cinders in Wupatki National Monument: Lay Report[1]

The eruption of the Sunset Crater Volcano in the mid-to-late eleventh century A.D. has long played a prominent role in archaeological models of northern Arizona prehistory. Starting with the work of Dr. Harold S. Colton and his colleagues at the Museum of Northern Arizona in the early 1930s, and continuing into the modern period, the eruption has played a significant part in interpretations of prehistoric settlement and subsistence. For example, to explain the dramatic increase in site density in the general Flagstaff area at the end of the eleventh century, Colton (1932, 1946) proposed that thin layers of deposited cinders and ash acted as a water-retaining mulch, allowing previously unfertile areas to be farmed. In Colton's view, the opening up of new lands resulted in large-scale migration (a prehistoric "land rush"), which dramatically changed the nature of the groups living in the Flagstaff area. Colton's theory has been adopted, with some modifications, by more recent researchers, such as Christian Downum and Alan Sullivan (1990), who suggest that the cinder mulch was a very important factor in the initial settlement and subsequent population growth evident in Wupatki National Monument. The beneficial nature of a thin layer (less than 15-25 cm or 6-10 inches) of cinders acting as a water- and heat-retaining mulch has been demonstrated by three agricultural experiments in the general Wupatki and Flagstaff areas (Colton 1965; Mahle 1963; Waring 2001), as well as by data from the 1943 eruption of the Parícutin Volcano in central Mexico (Luhr and Simkin 1993).

Although other archaeologists, most notably Peter Pilles (1979, 1996), suggest that it was not the cinder mulch that allowed new lands to be farmed, but changing climatic regimes from dry to wet conditions, all researchers agree that the eruption of Sunset Crater had an enormous impact on the prehistoric inhabitants of the Flagstaff and Wupatki areas, and probably the greater northern Southwest. Some 900 years later, Hopi accounts of the eruption are still passed from

generation to generation as a part of traditional clan knowledge, underscoring the significance of this event (Ferguson and Lomaomvaya 2000; Malotki and Lomatuway'ma 1987).

Purpose and Objectives of this Study

Previous research has shown that settlement in the Wupatki area increased dramatically in the period following the eruption. Both tree-ring and ceramic temporal data indicate that the greatest population increase was in the early-to-mid twelfth century (circa A.D. 1130-1160), several generations after what is believed to be the initial eruption and period of cinder deposition. This lag in occupation has been suggested to represent a regeneration period, when "the local flora and fauna were recovering from the eruption, and when the area's farmers began experimenting with the agricultural productivity of the Sunset Crater ash" (Sullivan and Downum 1991:279). However, because at least eight eruptive periods of unknown length have been documented for Sunset Crater (Amos 1986:57), it is also possible that significant cinder and ash deposition at Wupatki did not occur until the twelfth century.

Numerous investigators have assumed that the black cinders and ash blanketing the Wupatki National Monument region originated from the eruption of Sunset Crater, but no previous research has conclusively demonstrated that these deposits are Sunset Crater in origin. In fact, Sunset Crater cinders cannot be visually separated from cinders stemming from the eruption of nearby Merriam Crater, now dated around 15,000 years ago. Determining the source of the Wupatki cinders is critical to any understanding of the prehistoric settlement in the region; if these cinder deposits are not from Sunset Crater, but in fact from some other, older source, then the mulch effect may not have occurred in the eleventh century, and alternative models for Wupatki settlement and population growth must be considered.

Whole-rock and trace element geochemical analyses provide highly accurate means of distinguishing between cinders and ash of different volcanoes or eruptions. The objective of this study is to derive a chemical signature for the volcanic material in Wupatki National Monument and determine whether these cinders and ash originated from Sunset Crater, or whether they were deposited in earlier (Pleistocene) times.

Methods of Analysis

The methods employed to carry out this analysis were three fold. First, several reconnaissance trips focused on identifying the general extent and distribution of volcanic ash and cinders in the Wupatki National Monument vicinity. This phase of the project was intended to help locate ideal sampling locations and determine how many different types of tephra (tephra is a collective term for all fragmental materials ejected from a volcano and transported through the air) may exist in the study area. Second, 19 sections of cinder and ash deposits were measured and described using both natural cuts and shallow holes dug using shovels and spades. An archaeologist was present for all subsurface investigations to ensure that no prehistoric deposits were disturbed. At each section, the thickness and physical characteristics, including shape, size, sorting, vesicularity, and bedform, of the tephra were described. In addition, each section was sampled for geochemical analyses. The third stage of the project involved submitting eight of the tephra samples for X-ray fluorescence and inductively coupled plasma mass spectrometry analysis. These geochemical analyses determine the major and trace elements present in a sample and are used to characterize the distinguishing traits or "fingerprints" of the various tephras. Single tephra samples from three other nearby volcanic sources, Merriam, Strawberry, and Doney craters, were also analyzed to determine their geochemical signature. The samples from these other volcanoes

were analyzed because they may have been potential sources for tephra deposition in the Wupatki vicinity. All of these samples were then compared to chemical data from Sunset Crater tephra samples analyzed by previous researchers.

Results of this Study

Two primary types of ash and cinder can be visually distinguished in the Wupatki area. The most common type, is black, and highly vesicular. This black tephra is very similar, in grain size, sorting, and physical character, to the ash and cinder products erupted from Sunset Crater, and is the material that previous researchers have suggested to be Sunset Crater in origin. Much of the black tephra present today in the Wupatki area, particularly in the northern portion of the monument, has been reworked by eolian (wind) action.

The second type of tephra found in the monument is reddish brown, highly oxidized, and vesicular. This material is restricted to an area surrounding the Doney Craters chain. This tephra layer thins and the cinders and ash get smaller in size away from Doney Craters out to a maximum lateral extent of approximately 2.5 km. This is consistent with a Doney Craters source for this material. The Doney Craters chain is considerably older (probably young Pleistocene) than Sunset Crater, and therefore this red tephra was deposited before the Sunset eruption.

In the Doney Craters area, the black, glassy, cinders are present as thin veneers capping the surface of the thick red cinder deposits. This indicates that the black cinders must postdate the Doney Craters eruption and possibly be Sunset Crater in origin. A Sunset Crater source for the black cinders was confirmed through geochemical analyses of the eight samples from Wupatki National Monument (all of the black, vesicular cinder variety) and one sample each from Merriam Crater, Strawberry Crater, and the Doney Craters chain. As noted above, previous

researchers had already determined the chemical signature of Sunset Crater tephra (Arculus and Gust 1995; Moore 1974; Moore and Wolfe 1987). Geochemical analyses confirmed that samples from Merriam, Strawberry, and Doney craters are distinct from all but one of the samples collected in Wupatki National Monument. The samples from Wupatki closely resemble the chemical signatures of the previous analyzed Sunset Crater material. The single exception contained a chemical signature transitional between Sunset Crater, Strawberry Crater, and Doney Craters, and the origin of this sample is unknown.

Conclusion

The two types of cinder visible in Wupatki National Monument come from two very different sources. The first, and most abundant, is a black, glassy cinder that covers much of the southern end of the Monument, and forms a thin veneer over the older volcanic rocks of the Doney Craters chain. This black tephra has geochemical attributes similar to Sunset Crater, and was transported into the Wupatki area either during the eruption of the volcano or through subsequent wind-reworking of the Sunset Crater deposits. The second variety of cinder is a red, oxidized tephra that is geochemically distinct from the Sunset deposits and localized to the Doney Craters vicinity. These deposits were erupted from the Doney Craters chain, recording an earlier phase of eruptive activity in the Wupatki area. Tephra from the eruption of Strawberry and Merriam craters are not present in the Wupatki region today and it is unknown if these tephras were present in the past.

Sunset Crater eruptive products dominate the current volcanic materials found in Wupatki National Monument. While much of this ash and cinder was blown by wind into the region after the eruption, our examination of these deposits indicates that the entire Wupatki area was

blanketed with a minimum of 5-10 cm (2-4 in) of ash during the eruption of Sunset Crater. The thickness of this layer would have been ideal for a water-retaining mulch. Because the Sunset Crater tephra was deposited in a region that was largely devoid of any previous ash deposits, the sudden addition of this material must have had an impact on the prehistoric peoples inhabiting the Wupatki area. The evidence presented in this study does not distinguish whether it was the eruption or climatic change that influenced prehistoric settlement and population growth. However, the timing of the Sunset Crater eruption, and the sudden addition of new materials (cinders) that could benefit agricultural practices, corresponds with known periods of increasing site and population density in the general Wupatki area. The data presented in this analysis confirms that the majority of the tephra in Wupatki National Monument is Sunset Crater in origin, and was deposited, in part, during the eruption of this volcano.

Endnotes

1. Lay report abstracted from:

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