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Holocene tephra stratigraphy in four lakes in southeastern Oregon and northwestern Nevada, USA

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ABSTRACT

To better understand the regional tephra stratigraphy and chronology of northern Nevada and southern Oregon, tephras in archived cores, taken as part of the Steens Mountain Prehistory Project from four lakes, Diamond Pond, Fish and Wildhorse lakes in southeastern Oregon and Blue Lake in northwestern Nevada, were reexamined using more advanced electron microprobe analytical technology. The best preserved and most complete core from Fish Lake along with Wildhorse Lake hosted two tephras from Mt. Mazama (Llao Rock and the Climactic Mazama), a mid-Holocene basaltic tephra from Diamond Craters, Oregon, two Medicine Lake tephras and an unexpected late Holocene Chaos Crags (Mt. Lassen volcanic center) tephra which was also found in the other lakes. Blue Lake was the only lake that hosted a Devils Hill tephra from the Three Sisters volcano in west central Oregon. Another tephra from the Three Sisters Volcano previously reported in sediments of Twin Lakes in NE Oregon, has now been confirmed as Rock Mesa tephra. The Chaos Crags, Devils Hill and Rock Mesa tephras are important late Holocene stratigraphic markers for central and eastern Oregon and northwestern Nevada.

Introduction

A three-pronged multidisciplinary approach (excavation, surface survey and paleoecology/geochronology) guided the Steens Mountain Prehistory Project (Aikens et al., 1982). Overall, archeologists focused on recognizing and explaining human responses to >12,000 years of recurring climate shifts and unique catastrophic events (e.g., Mt. Mazama climactic eruption) that could have wrought environmental challenges and cultural responses. Archeological excavations at occupation sites in caves and sand dunes revealed occupation and artifact sequences, whereas extensive surface surveys established the broad past distribution and styles of comparable artifacts from mountain top to desert floor.

In 1977 Mehringer initiated paleoenvironment and chronology studies by obtaining multiple cores from Fish (42°44.22′ N, 118°38.70′ W, elevation 2165 m) and Wildhorse (42^{0}37.72′ N 118^{0}35.18′ W, elevation 2700 m) lakes on Steens Mountain, Oregon and Diamond Pond in Malheur Maar (43°6.24′ N, 118°35.18′ W elevation, 1265 m) at nearby Diamond Craters (Fig. 1) along with pollen analyses of cores, woodrat midden, plant macrofossil studies focused on Diamond Craters (Wigand, 1987; Mehringer and Wigand, 1990). By 1982 stratigraphic sequences, radiocarbon ages and major element (Fe, Ca, K) concentrations in the tephra glasses allowed correlation of all tephra layers in the sediment cores from each of the Steens area lakes. Mehringer (1987) recognized and ^{14}C-dated six stratigraphically distinct tephra layers in Fish and Wildhorse lakes and the upper four of these in Diamond Pond. Hereafter, they are identified down-core by Roman Numerals (I to VI, Table 1). In 1986, cores were collected from Blue Lake, Nevada (41°40.76′ N, 118°43.01′ W, elevation 2432 m) for comparison with the dated Steens tephras. Though 107 km south of Steens Mountain, we anticipated that Blue Lake studies could confirm, improve or challenge some of the Steens area findings and, at the least, enhance knowledge of regional tephrochronology. Still, excepting Mt. Mazama, the tephra sources remained uncertain.

Major advances in electron microprobe technology over the past few decades allow for the identification and sourcing of compositionally very similar tephras. This coupled with the very detailed radiocarbon chronology warranted reexamination of the tephras in these cores, especially those in the well-preserved cores from Fish Lake.

Reexamination of the cores from the 1970s and 1980s provided a wealth of new information on the eruption history and tephra airfall distribution of Cascade volcanoes making a strong case for the archiving of cores for future study using more advanced analytical techniques. Detailed tephrochronologic data are especially useful and important in the arid western United States where dateable organic carbon is often nonexistent.

Archeologists often have to rely on the tephra stratigraphy of a site to gain insight into the age and duration of human occupancy (e.g.,

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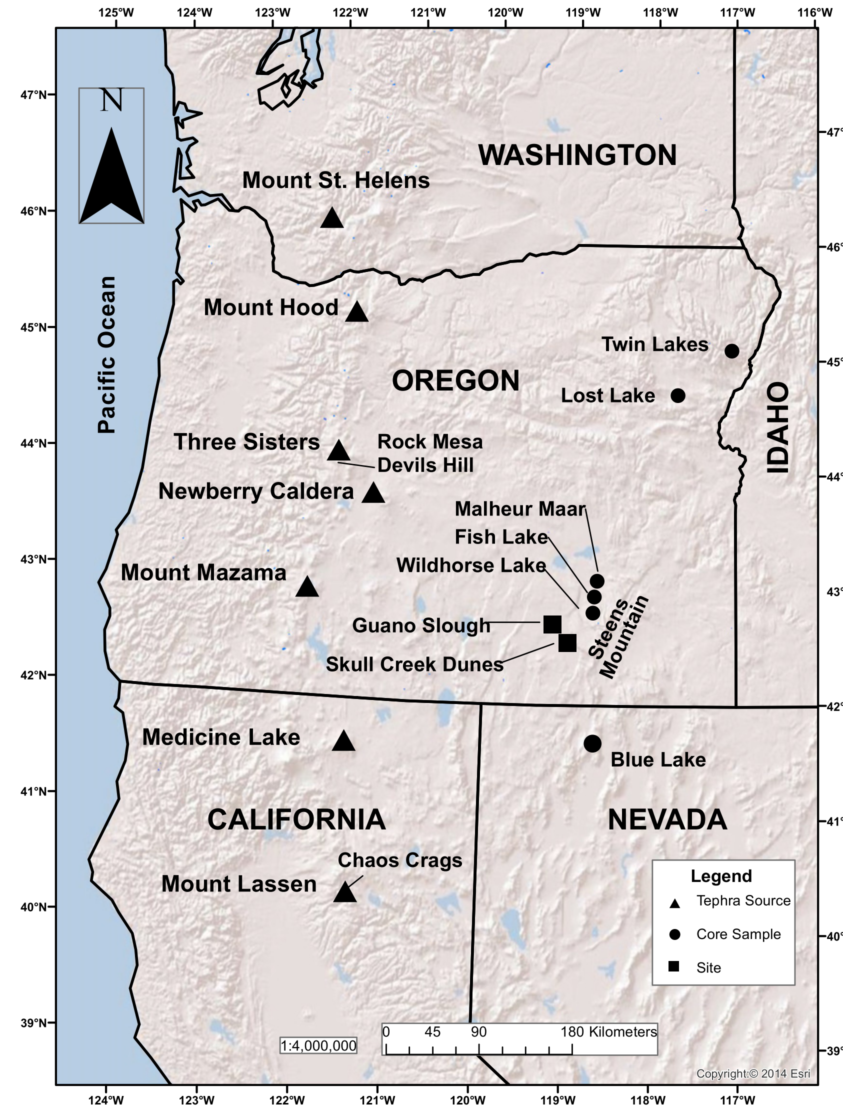

Figure 1. Map of Oregon, California, and Nevada showing the locations of the lakes cored (circles), Catlow Valley geoarchaeological sites (squares) and major Cascade volcanoes (triangles).

Rimrock Draw Rockshelter in south central Oregon). Geomorphologists and soil scientists use tephrochronology to determine rates of landscape evolution and soil formation (Busacca et al., 1992; Clague et al., 2003). Tephrochronologic studies, like the one presented here, help refine eruption age estimates and tephra airfall distributions, both of which are important in volcanic hazards assessment. For example, the presence of Mazama tephra in sag ponds in the foothills of the North Cascades has been recently used to estimate the age of regional fault reactivation (Sherrod et al., 2013). Thus, a broad spectrum of scientific studies greatly benefits from the availability of detailed tephrochronologic data.

Methods

Lake cores

Multiple, overlapping cores of lake sediments were collected in 10 cm diameter PVC core barrels from near the center and deepest parts of the lakes (core lengths: Fish Lake 8.9 m, Diamond Pond 15.0 m, Wildhorse Lake 4.2 m, Blue Lake 4.5 m). All cores with exception of Blue Lake bottomed out in bedrock. The Blue Lake core bottomed out in a meter plus layer of re-deposited (slope wash) Mazama tephra. The core barrels, split on opposite sides with a circular saw, exposed undisturbed sediments. Once logged, the cores provided samples for sediment, botanical, radiocarbon, and tephra analyses. Cores stored in a cold room in the Anthropology Department at Washington State University allowed resampling of some for more detailed tephra analyses.

Tephra analysis

Initial correlations of tephras from the Wildhorse Lake, Fish Lake and Diamond Pond (Malheur Maar) cores (Mehringer, 1987) were made using three element (Ca, Fe, K) analyses by Charles Knowles on an ARL-EMX electron microprobe (EMP) housed at the University of Idaho's Department of Geology. Although these analyses proved useful in the correlation of the tephras from the different lake cores, several tephras could not be identified as to their source. Beginning in the late 1980s and continuing to the present, those cores still available were resampled and the tephras analyzed using more advanced instrumentation (Cameca Camebax and JOEL JXA 8500F microprobes) in the GeoAnalytical Laboratory located in the Geology Department (currently the School of the Environment) at Washington State University.

The quality of the lake cores remaining in cold storage in the Anthropology Department at Washington State University varies considerably.