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ORIGINAL ARTICLE

Multiple dendrochronological responses to the eruption of Cinder Cone, Lassen Volcanic National Park, California

Paul R. Sheppard[a,*], Michael H. Ort[b], Kirk C. Anderson[c], Michael A. Clynne[d], Elizabeth M. May[a]

[a]*Laboratory of Tree-Ring Research, University of Arizona, Tucson, Arizona 85721, USA*
[b]*Departments of Environmental Sciences and Geology, Box 4099, Northern Arizona University, Flagstaff, Arizona 86011, USA*
[c]*Bilby Research Center, Northern Arizona University, Box 6013, Flagstaff, Arizona 86011, USA*
[d]*Volcano Hazards Team, United States Geological Survey, Menlo Park, 345 Middlefield Road, MS 910, California 94025, USA*

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Abstract

Two dendrochronological properties – ring width and ring chemistry – were investigated in trees near Cinder Cone in Lassen Volcanic National Park, northeastern California, for the purpose of re-evaluating the date of its eruption. Cinder Cone is thought to have erupted in AD 1666 based on ring-width evidence, but interpreting ring-width changes alone is not straightforward because many forest disturbances can cause changes in ring width. Old Jeffrey pines growing in Cinder Cone tephra and elsewhere for control comparison were sampled. Trees growing in tephra show synchronous ring-width changes at AD 1666, but this ring-width signal could be considered ambiguous for dating the eruption because changes in ring width can be caused by other events. Trees growing in tephra also show changes in ring phosphorus, sulfur, and sodium during the late 1660s, but inter-tree variability in dendrochemical signals makes dating the eruption from ring chemistry alone difficult. The combination of dendrochemistry and ring-width signals improves confidence in dating the eruption of Cinder Cone over the analysis of just one ring-growth property. These results are similar to another case study using dendrochronology of ring width and ring chemistry at Parícutin, Michoacán, Mexico, a cinder cone that erupted beginning in 1943. In both cases, combining analysis with ring width and ring chemistry improved confidence in the dendro-dating of the eruptions.

Keywords: Cinder Cone; Lassen Volcanic National Park; Dendrochronology; Dendrochemistry; Volcano; Dating

Introduction

In order to date a cinder-cone eruption using dendrochronology, several requisites must be satisfied (Brantley et al., 1986): (1) trees with visible, dateable growth rings must be growing near the cinder cone. (2) tephra must deposit over soils where trees are growing and affect ring growth of those trees; the thickness of tephra needed to change tree-ring growth might vary with other environmental factors. (3) The eruption must have occurred during the lifespan of affected trees.

Volcanic eruptions can affect ring width in trees (Yamaguchi and Lawrence, 1993), but interpreting ring-width changes alone as evidence of an eruption is not straightforward because many forest disturbances can cause similar changes (Sheppard et al., 2005). In

*Corresponding author. Tel.: +1 520 621 6474; fax: +1 520 621 8229.
E-mail address: sheppard@ltrr.arizona.edu (P.R. Sheppard).

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addition to ring width, variability in elemental concentrations in tree rings can reflect environmental changes caused by an eruption (Hughes, 1988). Dendrochemistry is the measurement and interpretation of elemental concentrations in tree rings (Smith and Shortle, 1996), and it has been applied widely in environmental research, including regional-, hemispheric-, and global-scale explosive volcanic eruptions (Hall et al., 1990; Padilla and Anderson, 2002; Ünlü et al., 2005; Pearson et al., 2005; Battipaglia et al., 2007). Dendrochemistry has not worked well on Mount Etna, a volcano with frequent, persistent eruptions, but dendrochemistry might fare better with volcanoes having single eruptions and lacking other confounding pollution (Watt et al., 2007), which accurately describes remote cinder cones. For example, dendrochemical responses to the 1943 eruption of Parícutin, a cinder cone in Michoacán, Mexico (Luhr and Simkin, 1993), include increases in tree-ring sulfur and phosphorus at the start of the eruption (Sheppard et al., 2008).

Parícutin is a single case of combining dendrochemistry with ring-width analysis to demonstrate multiple dendrochronological responses to a cinder cone eruption, but replication at other sites is needed to validate this concept. As an additional case, cinder cone in Lassen Volcanic National Park in northeastern California (Fig. 1) meets the criteria listed above and was investigated for multiple dendrochronological responses, including tree-ring chemistry. Cinder Cone is thought to have erupted in the mid 1600s (Clynne et al., 2000; Clynne et al., 2002). Key evidence for dating Cinder Cone is a 4-year period beginning in AD 1666 of below-average ring width in one tree found 0.2 km west of the crater (Finch, 1937). However, the tree used to date Cinder Cone to AD 1666 has another 4-year period of below-average ring width beginning in AD 1567 (Finch, 1937). The date of AD 1567 is not possible for the eruption of Cinder Cone (Clynne et al., 2000), so below-average growth at that time must have been caused by some other factor. The objective of this

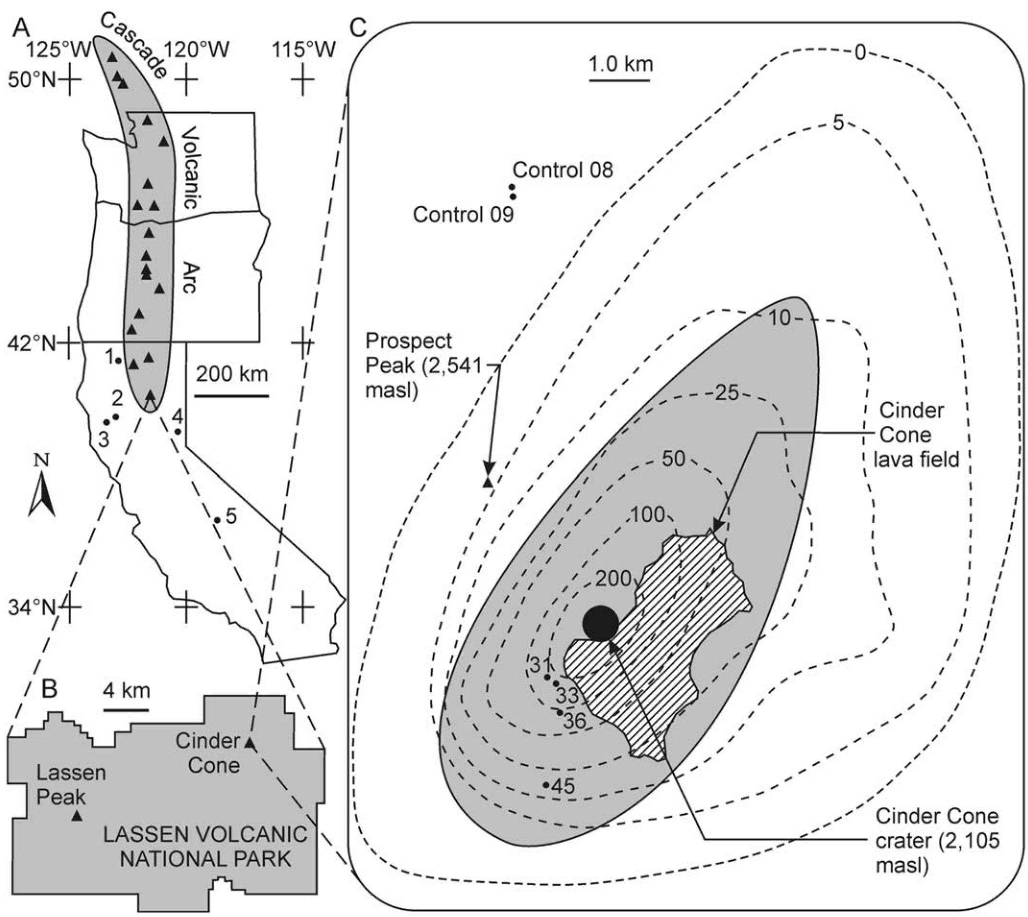

Fig. 1. Map of (A) Pacific Coast states of the US showing location of the Cascade Volcanic Arc and selected Jeffrey pine tree-ring chronologies from the International Tree-Ring Data Bank (dots with numbers), (B) Lassen Volcanic National Park showing location of Cinder Cone, and (C) Cinder Cone showing tephra isopach depths (dashed contours, in cm, Heiken, 1978), area searched for old trees (shaded area), and trees analyzed herein (dots with numbers). Control Trees 08 and 09 are located on ~15,000-year-old lava on the north side of Prospect Peak, away from tephra of Cinder Cone. The 0-cm isopach line indicates where no discrete tephra layer exists in the soil, but it does not necessarily mean that no tephra at all was deposited outside that line.