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Sense of Place in the Practice and Assessment of Place-Based Science Teaching

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ABSTRACT: We teach earth, ecological, and environmental sciences in and about *places* imbued with meaning by human experience. Scientific understanding is but one of the many types of meanings that can accrue to a given place. People develop emotional attachments to meaningful places. The *sense of place,* encompassing the meanings and attachments that places hold for people, has been well characterized in environmental psychology. Its components, place attachment and place meaning, can be measured psychometrically. *Place-based* science teaching focuses on local and regional environments and synthesizes different ways of knowing them, leveraging the senses of place of students and teachers. Place-based teaching has been advocated for its relevance and potential to attract underrepresented groups to science. We posit that sense of place is a measurable learning outcome of place-based science teaching. We developed an Arizona-based, culturally inclusive, meaning-rich introductory geology course, and used published surveys to assess place attachment and meaning in students who took the course. We observed significant gains in student place attachment and place meaning, indicating that these instruments are generalizable and sensitive enough for use in this context. Sense of place should be engaged by teachers of place-based science, and further explored as an assessment measure.
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INTRODUCTION

The earth, ecological, and environmental sciences are taught in and by means of physical localities in nature that are also *places* imbued with meaning by human experience (Tuan,

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RESEARCH ARTICLE

Eruptive conditions and depositional processes of Narbona Pass Maar volcano, Navajo volcanic field, Navajo Nation, New Mexico (USA)

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Abstract Phreatomagmatic deposits at Narbona Pass, a mid-Tertiary maar in the Navajo volcanic field (NVF), New Mexico (USA), were characterized in order to reconstruct the evolution and dynamic conditions of the eruption. Our findings shed light on the temporal evolution of the eruption, dominant depositional mechanisms, influence of liquid water on deposit characteristics, geometry and evolution of the vent, efficiency of fragmentation, and the relative importance of magmatic and external volatiles. The basal deposits form a thick (5–20 m), massive lapilli tuff to tuff-breccia deposit. This is overlain by alternating bedded sequences of symmetrical to antidune cross-stratified tuff and lapilli tuff; and diffusely-stratified, clast-supported, reversely-graded lapilli tuffs that pinch and swell laterally. This sequence is interpreted to reflect an initial vent-clearing phase that produced concentrated pyroclastic density currents, followed by a pulsating eruption that produced multiple density currents with varying particle concentrations and flow conditions to yield the well-stratified deposits. Only minor localized soft-sediment deformation was observed, no accretionary lapilli were found, and grain accretion occurs on the lee side of dunes. This suggests that little to no liquid water existed in the density currents during deposition. Juvenile material is dominantly present as blocky fine ash and finely vesiculated fine to coarse lapilli pumice. This indicates that phreatomagmatic fragmentation was predominant, but also that the magma was volatile-rich and vesiculating at the time of eruption. This is the first study to document a significant magmatic volatile component in an NVF maar-diatreme eruption. The top of the phreatomagmatic sequence abruptly contacts the overlying minette lava flows, indicating no gradual drying-out period between the explosive and effusive phases. The lithology of the accidental clasts is consistent throughout the vertical pyroclastic stratigraphy, suggesting that the diatreme eruption did not penetrate below the base of the uppermost country rock unit, a sandstone aquifer ~360 m thick. By comparison, other NVF diatremes several tens of kilometers away were excavated to depths of ~1,000 m beneath the paleosurface (e.g., Delaney PT. Ship Rock, New Mexico: the vent of a violent volcanic eruption. In: Beus SS (ed) Geological society of America Centennial Field Guide, Rocky Mountain Section 2:411–415 (1987)). This can be accounted for by structurally controlled variations in aquifer thickness beneath different regions of the volcanic field. Variations in accidental clast composition and bedding style around the edifice are indicative of a laterally migrating or widening vent that encountered lateral variations in subsurface geology. We offer reasonable evidence that this subsurface lithology controlled the availability of external water to the magma, which in turn controlled characteristics of deposits and their distribution around the vent.

Keywords Phreatomagmatic · Maar · Narbona Pass · Minette · Pyroclastic · Base surge · Navajo volcanic field

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Introduction

Phreatomagmatic eruptions occur when rising magma mixes with shallow surface water or groundwater (Sheridan and Wohletz 1983). Controlled experiments demonstrate