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Research paper

In situ cosmogenic nuclide production rate calibration for the CRONUS-Earth project from Lake Bonneville, Utah, shoreline features

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ABSTRACT

Well-dated bedrock surfaces associated with the highstand and subsequent catastrophic draining of Pleistocene Lake Bonneville, Utah, during the Bonneville flood are excellent locations for *in situ* cosmogenic nuclide production rate calibration. The CRONUS-Earth project sampled wave-polished bedrock and boulders on an extensive wave-cut bench formed during the Bonneville-level highstand that was abandoned almost instantaneously during the Bonneville flood. CRONUS-Earth also sampled the Tabernacle Hill basalt flow that erupted into Lake Bonneville soon after its stabilization at the Provo level, following the flood. New radiocarbon dating results from tufa at the margins of Tabernacle Hill as part of this study have solidified key aspects of the exposure history at both sites. Both sites have well-constrained exposure histories in which factors such as potential prior exposure, erosion, and shielding are either demonstrably negligible or quantifiable. Multi-nuclide analyses from multiple labs serve as an ad hoc inter-laboratory comparison that supplements and expands on the formalized CRONUS-Earth and CRONUS-EU inter-laboratory comparisons (Blard et al., 2015; Jull et al., 2015; Vermeesch et al., 2015). Results from ^{10}Be, ^{26}Al, and ^{14}C all exhibit scatter comparable to that observed in the CRONUS-Earth effort. Although a ^{36}Cl inter-laboratory comparison was not completed for Jull et al. (2015), ^{36}Cl from plagioclase mineral separates exhibits comparable reproducibility. Site production rates derived from these measurements provide valuable input to the global production rate calibration described by Borchers et al. (2015). Whole-rock ^{36}Cl concentrations, however, exhibit inter-laboratory variation exceeding analytical uncertainty and outside the ranges observed for the other nuclides (Jull et al., 2015). A rigorous inter-laboratory comparison studying the systematics of whole-rock ^{36}Cl extraction techniques is currently underway with the goals of delineating the source(s) of this discrepancy and standardizing these procedures going forward.

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1. Introduction

Nuclide production rates are key parameters in the application of *in situ* cosmogenic nuclides; e.g., the accuracy of exposure ages is directly related to the accuracy of the production rates. The ability to infer temporal and spatial variation in production rates at a given location impacts the inferences that can be made using cosmogenic nuclide data. The goal of the CRONUS-Earth project is to improve our understanding of global cosmogenic nuclide production systematics. A major part of this effort is to derive cosmogenic nuclide production rates directly from measurements of samples collected from carefully selected sites with well-constrained exposure histories.

Well-dated bedrock surfaces in northwestern Utah and southern Idaho associated with Pleistocene Lake Bonneville provide a robust opportunity for cosmogenic nuclide production rate calibration (Oviatt et al., 1992). In the past, these surfaces were used to estimate late Quaternary production rates for several nuclides, including ^{3}He (Amidon and Farley, 2011; Cerling, 1990; Cerling and Craig, 1994; Goehring et al., 2010), ^{21}Ne (Poreda and Cerling, 1992), ^{10}Be (Gosse and Klein, 1996), ^{36}Cl (Phillips et al., 1996; Stone et al., 1996; Zreda et al., 1991), and ^{14}C (Handwerger et al., 1999; Lifton et al., 2001; Miller et al., 2006). To provide a basis for intercomparison between the production rates for commonly measured cosmogenic nuclides, and to ensure that the most current techniques are employed in both sampling and laboratory procedures, key locations within the Lake Bonneville basin were re-sampled by CRONUS-Earth (Fig. 1).

The lake-level chronology of Lake Bonneville is well-constrained by numerous radiocarbon ages (Reheis et al., 2014, and references therein). The Lake Bonneville highstand (known as the Bonneville level) is well preserved as the Bonneville shoreline. This highstand is constrained in age by several radiocarbon dates ranging between 18.9 and 18.0 cal ka, including new ones generated during this study. The Bonneville shoreline is unique in that it was abandoned essentially instantaneously due to a catastrophic failure of the lake threshold at Red Rock Pass in southern Idaho, resulting in the Bonneville flood. The resulting ~100 m drop in lake level (model

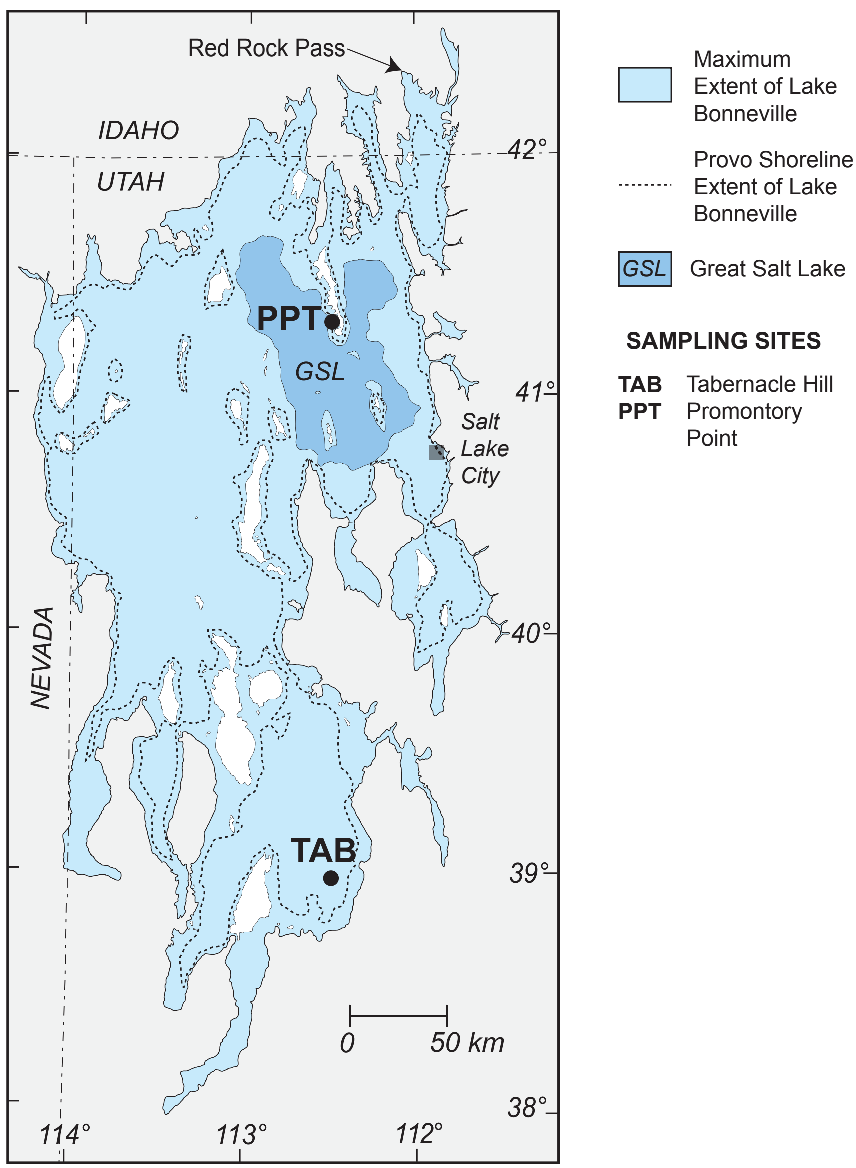

Fig. 1. Location of Lake Bonneville in relation to the current Great Salt Lake and the sampling locations (TAB = Tabernacle Hill, PPT = Promontory Point). Also shown is the Red Rock Pass threshold. Modified after Miller et al. (2012).