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Timing of the last glaciation and subsequent deglaciation in the Ruby Mountains, Great Basin, USA

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ABSTRACT

The timing of the last Pleistocene glaciation in western North America is becoming increasingly well understood, largely due to improved methods of obtaining numerical ages of glacial deposits and landforms. Among these, cosmogenic radionuclide surface-exposure dating has been widely applied to moraines of mountain glaciers, providing the framework for understanding terrestrial climate change during and since the last glaciation in western North America. During the Late Pleistocene, the Great Basin of the western United States hosted numerous mountain glaciers, the deposits of which can provide valuable records of past climate changes if their ages can be precisely determined. In this study, twenty-nine cosmogenic radionuclide ^{10}Be surface-exposure ages from a suite of moraines in Seitz Canyon, western Ruby Mountains, limit the timing of the last glacial episode in the interior Great Basin, known as the Angel Lake Glaciation. Results indicate that deposition of a terminal moraine and two recessional moraines began just prior to ~20.5 ka and continued until ~20.0 ka. Retreat from the next younger recessional moraine began at ~17.2 ka, and final deglaciation began at ~14.8 ka. These ages are broadly consistent with cosmogenic surface-exposure ages from the eastern Sierra Nevada and the western Wasatch Mountains, in the western and eastern extremes of the Great Basin respectively. Furthermore, these ages suggest that the valley glacier in Seitz Canyon was at or near its maximum extent before and during the hydrologic maxima of Pleistocene lakes in the Great Basin, supporting previous suggestions that a cool and wet climate persisted in this region during the early part of the last glacial–interglacial transition.

1. Introduction

The surficial geology and geomorphology of the Great Basin, a broad area of internal drainage in the southwestern United States, have long been recognized as key records of environmental changes during the late Quaternary (e.g., Gilbert, 1890; Blackwelder, 1931; Sharp, 1938). Numerous studies aimed at understanding paleoenvironmental changes in this region have focused on deposits of large Pleistocene lakes (e.g., Benson and Thompson, 1987) and on records of glaciation in mountain ranges that border the Great Basin (e.g., the Sierra Nevada in California, and the Wasatch and Uinta Mountains in Utah, Fig. 1). The record of Pleistocene glaciations in the interior mountains of the Great Basin (Blackwelder, 1931; Osborn and Bevis, 2001) is also valuable for understanding paleoenvironmental changes but has been generally overlooked.

The glacial geology of the Great Basin features deposits of former mountain glaciers (Blackwelder, 1931, 1934) in more than forty individual ranges (Osborn and Bevis, 2001). The Ruby and East Humboldt Mountains (Fig. 1) hosted the largest system of mountain glaciers of all the interior ranges (Munroe and Laabs, 2011). Here, the glacial record in these mountains is interpreted as representing two major glacial episodes, the Lamoille (penultimate) Glaciation, named for a broad, hummocky terminal moraine complex at the mouth of Lamoille Canyon in the western Ruby Mountains, and the Angel Lake (last) Glaciation, named for nearly continuous lateral and terminal moraines in the valley that hosts Angel Lake in the northeastern East Humboldt Mountains (Sharp, 1938). Osborn and Bevis (2001) summarize the record of these two glaciations throughout the Great Basin and emphasize the exceptional preservation of the glacial record in the Ruby and East Humboldt Mountains in particular. Reconstructions based on glacial-geomorphic evidence indicate that, during the Angel Lake Glaciation, these mountains hosted more than 130 discrete valley glaciers within a north–south distance of 150 km (Osborn and Bevis, 2001; Laabs et al., 2011; Munroe and Laabs, 2011). Throughout

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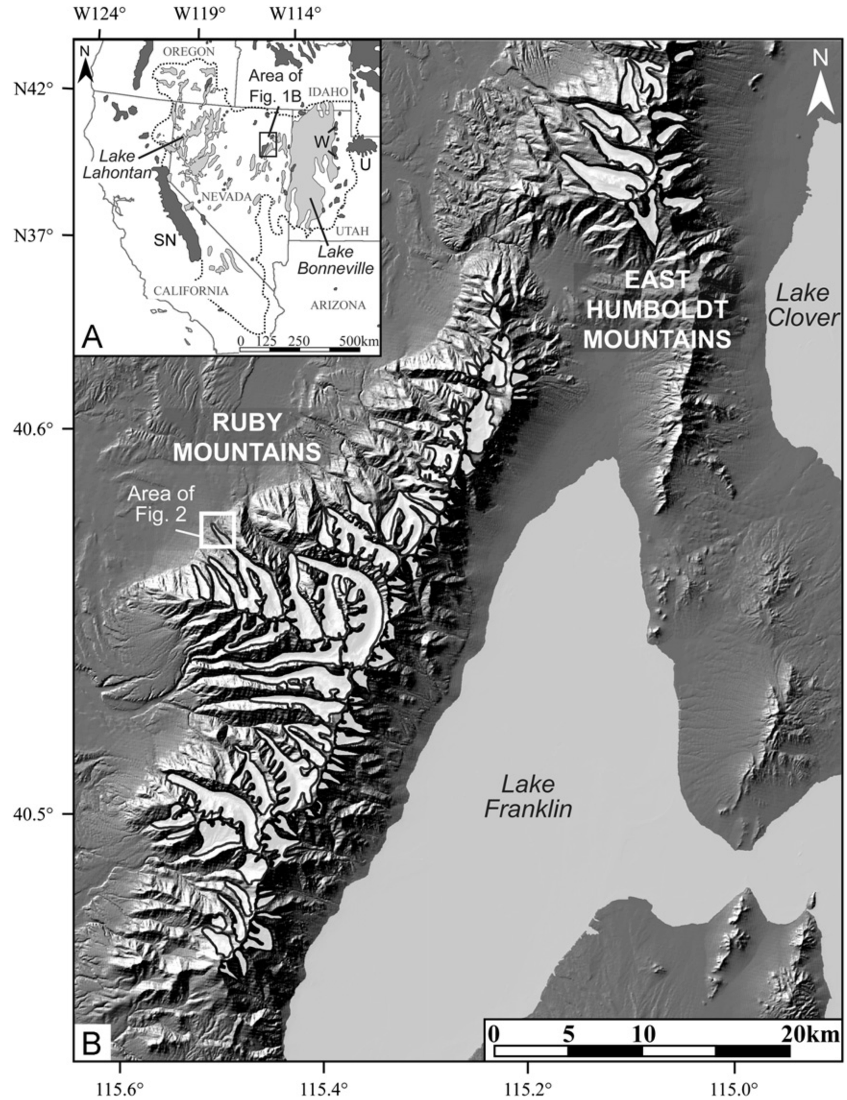

Fig. 1. (A) Map of a portion of the southwestern United States. Dashed line indicates the Great Basin region. Pleistocene mountain glacier systems (modified from Porter et al., 1983) and paleolakes (from Reheis, 1999) are shown in dark and light gray, respectively. SN=Sierra Nevada, U=Uinta Mountains and W=Wasatch Mountains. (B) Shaded-relief map of the Ruby and East Humboldt Mountains and adjacent valleys. Extents of valley glaciers for the Angel Lake Glaciation are shown in white with black outline. Lakes Franklin and Clover are Pleistocene lakes that were adjacent to the mountains.

these mountains, moraine sequences suggest a dynamic history of ice advance and retreat during the Angel Lake Glaciation.

Given its excellent preservation, the glacial record of the Ruby and East Humboldt Mountains offers great potential for understanding the magnitude and timing of the Angel Lake Glaciation. However, in the context of developing a chronology of glaciation, these mountains have received considerably less attention than the Sierra Nevada (e.g., Burke and Birkeland, 1979; Phillips et al., 1990; Phillips et al., 2009; Rood et al., 2011) and the Wasatch and Uinta Mountains (Madsen and Currey, 1979; Munroe et al., 2006; Laabs et al., 2009, 2011), which are nearer to major population centers. Developing a glacial chronology for the interior Great Basin is important for several reasons. First, the Ruby Mountains are centrally located among well-dated Pleistocene glacial locales in the interior of the western US, including the Sierra Nevada (e.g., Phillips et al., 1990, 2009), the Northern and Middle Rocky Mountains (e.g., Gosse et al., 1995; Licciardi and Pierce, 2008), and the Colorado Plateau (Marchetti et al., 2005). Given the apparent variability in the timing of mountain glacier maxima among these areas (Thackray, 2008), data from the Great Basin can fill a significant gap in the understanding of mountain glaciation and may help identify the causes of this variability. Additionally, the Ruby Mountains lie between areas occupied by the two largest Pleistocene lakes in the Great Basin, Bonneville and Lahontan (Fig. 1A), both of which have well-dated hydrographs based on radiocarbon dating of lacustrine deposits (e.g., Oviatt, 1997; Benson et al., in press). Setting clear limits on the relative timing of glaciation in the mountains and of lake highstands on valley floors provides a framework for understanding (1) the hydrologic relationship of mountain glaciers and lakes, (2) differences in the sensitivity of mountain glaciers and lakes to climate changes during the last glaciation, and (3) the timing of regional-scale climate changes that affected lake highstands and glacier maxima. Finally, given the relatively small size (~1–15 km in length) of the valley glaciers that occupied the Ruby Mountains, these glaciers were undoubtedly sensitive to both millennial- and centennial-scale climate changes during the Angel Lake Glaciation, which may be reflected in their moraine records.

In this paper, a suite of cosmogenic radionuclide ^{10}Be surface-exposure ages (hereafter referred to as "surface-exposure ages") from one of the best-preserved moraine sequences in the Ruby Mountains provides the first direct numerical age limits on glacial