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Short Paper

A glacial chronology for the Fish Creek drainage of Boulder Mountain, Utah, USA

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Abstract

Boulder Mountain, located in South Central Utah, is one of several mountain ranges on the Colorado Plateau that was glaciated during the late Pleistocene. Using ^{3}He exposure-age dating (corrected for non-cosmogenic ^{3}He with shielded samples), we determined ^{3}He exposure-ages for boulders from the most well-preserved moraines in the Fish Creek drainage of Boulder Mountain. ^{3}He exposure-ages indicate a last glacial maximum (LGM) advance ~23,100 ± 1300 to 20,000 ± 1400 yr ago and a later and smaller advance ~16,800 ± 500 to 15,200 ± 500 yr ago. This chronology is very similar to other cosmogenic glacial chronologies from the Western U.S. and suggests that the timing of glacial advance and retreat on the Colorado Plateau was generally in phase with the rest of the Western U.S. during the late Pleistocene.

Keywords: Cosmogenic; He-3; Colorado Plateau; Glacial geology; Pinedale glaciation

Introduction

Several mountain ranges and high plateaus on the Colorado Plateau supported valley glaciers and small ice caps during the late Quaternary. The White Mountains, located in east-central Arizona, have a record of four Quaternary glacial advances with the last advance possibly occurring in the Holocene (Merrill and Péwé, 1977). The San Francisco Peaks of Northern Arizona have a record of three glacial advances (Péwé and Updike, 1976; Sharp, 1942). Grand Mesa, in west central Colorado, also has a record of three glacial advances (Yeend, 1969). In Utah, the La Sal Mountains had several valley glaciers in the middle and northern mountain groups during at least two different glacial advances (Richmond, 1962; Shroder and Sewell, 1985), while the Fish Lake Hightop (Hardy and Muessig, 1952), Wasatch Plateau (Spieker and Billings, 1940) and Boulder Mountain (Aquarius Plateau) (Flint and Denny, 1958; Gould, 1939; Osborn and Bevis, 2001) all had small ice caps with associated outlet glaciers during the last glacial maximum (LGM) and perhaps the penultimate glaciation. It is likely that many of the pre-LGM surficial deposits of these ranges are the product of large-scale mass movement rather than glaciation, as has been demonstrated in the La Sal Mountains (Shroder and Sewell, 1985) and on Boulder Mountain (Marchetti, 2002; Waitt, 1997; Williams, 1984).

The glacial records for all these ranges have been studied to some degree, but only three quantitative age determinations (radiocarbon ages) have been reported for glacial deposits on the Colorado Plateau (Merrill and Péwé, 1977; Richmond, 1962; Yeend, 1969). Most of the age assignments for these deposits are based on relative dating techniques including stratigraphic relationships, degree of boulder and deposit weathering, and soil development. Typically, the Colorado Plateau glacial deposits have been correlated to the Pinedale (late Wisconsin Glaciation, MIS 2) and Bull Lake (Illinoian Glaciation, MIS 6 (Gosse and Phillips, 2001; Sharp et al., 2003)) glaciations of the Wind River Range, Wyoming (Blackwelder, 1915). Although relative dating techniques can be quite robust at distinguish-

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ing till units of significantly different ages (e.g., Pinedale vs. Bull Lake), these techniques are much less reliable when applied to younger till units (early Pinedale, late Pinedale, Younger Dryas, Neoglacial). Determining the timing of LGM and subsequent ice advances on the Colorado Plateau is essential for understanding the response of this unique physiographic province to climatic shifts during the late Pleistocene.

In this study, we use cosmogenic ^{3}He exposure-age dating to determine emplacement ages of boulders from the most prominent moraines in the Fish Creek drainage of Boulder Mountain. We develop a simple correction for our exposure-ages using samples shielded from cosmogenic radiation to account for inputs of non-cosmogenic ^{3}He. Finally, we compare our exposure-age determinations with other glacial chronologies from the Western U.S.

Geographic and geologic setting

Boulder Mountain is located on the western edge of the Colorado Plateau in South central Utah (Fig. 1). It is the easternmost salient of the Aquarius Plateau, one of the High Plateaus of Utah that characterize the transition between the Colorado Plateau and the Great Basin. The top of Boulder Mountain is a broad, high tableland ~180 km^2 (~70 mi^2) in area, ranging in elevation from 3323 m (10,900 ft) to 3449 m (11,312 ft) (Fig. 1). The bedrock underlying most of the summit surface is a porphyritic basaltic andesite approximately 150 m thick, that has been dated at 25 ± 1 myr by K-Ar analysis (Best et al., 1980; Mattox, 1991). These rocks were derived from the Marysville volcanic center and are genetically related to the volcanic and volcaniclastic rocks on the nearby Fish Lake, Markagunt and Paunsagunt Plateaus (Best et al., 1980).

Glacial geology of Boulder Mountain

Dutton (1890) first described evidence for glaciation on the mountain's flat summit. Gould (1939) studied the moraines deposited by outlet glaciers spilling off the summit as well as the erosional features on the mountaintop. He suggested that the most recent ice cap and associated moraines were late Pleistocene in age and that only deposits related to the most recent glacial advance were preserved.

Flint and Denny (1958) mapped and described evidence for glaciation on the summit as well as most of the boulder deposits around the flanks of the mountain. They inferred ages for three "drift" (till) units deposited by outlet glaciers, based on stratigraphic relationships, soil development and degree of clast weathering. From oldest to youngest, these units are the Carcass Creek drift (Bull Lake glaciation), Donkey Creek drift (early Pinedale stage) and Blind Lake drift (late Pinedale stage). They also mapped numerous relict rock glaciers preserved beneath the high volcanic cliffs of northeast facing slopes and assigned them a Holocene age.

Osborn and Bevis (2001) included Boulder Mountain in their review of Great Basin glaciation. They suggested that the mapping of Flint and Denny (1958) may be in error with regard to the origin of the Carcass Creek drift unit, the

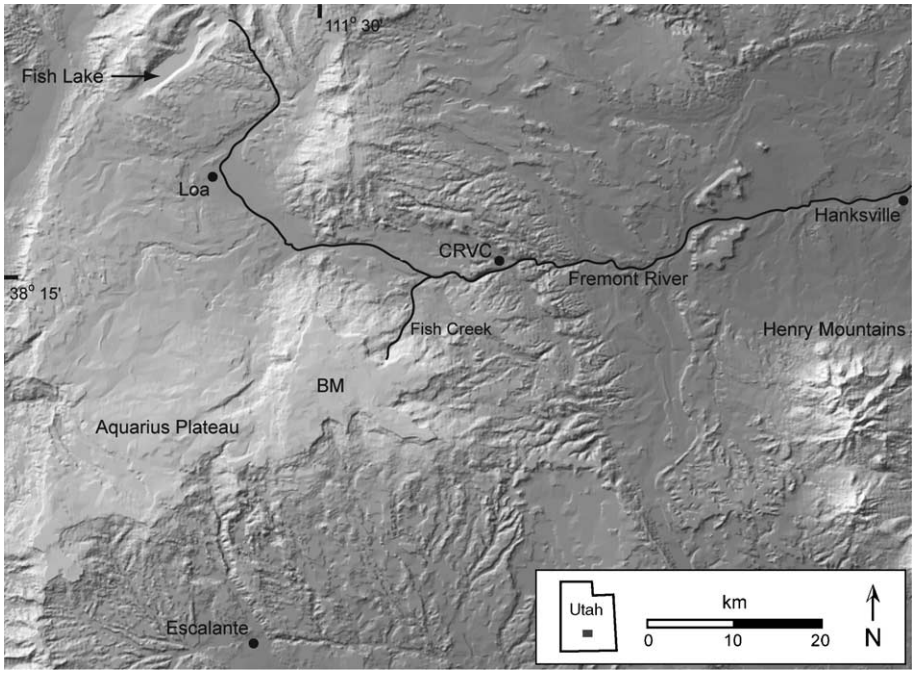

Figure 1. 30-m DEM of the Northwestern Colorado Plateau and Colorado Plateau to Basin and Range transition zone (illumination at 315 and 30°). CRVC = Capitol Reef National Park visitor center, BM = Boulder Mountain.