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Investigation of late and post-Fremont alluvial stratigraphy of Range Creek, east-central Utah: Use of OSL when radiocarbon fails

Tammy M. Rittenour [a, *], Larry L. Coats [b], Duncan Metcalfe [c]

[a] 4505 Old Main Hill, Department of Geology, Utah State University, Logan, UT 84322, USA
[b] Department of Geography, University of Utah, 260 South Central Campus, Salt Lake City, UT 84112, USA
[c] Natural History Museum of Utah, University of Utah, 301 Wakara Way, Salt Lake City, UT 84108, USA

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ABSTRACT

Range Creek in east-central Utah hosts a unique abundance of Fremont-aged archaeological sites. Although good age control is available for cultural artifacts and sites, radiocarbon ages from alluvial sequences along the valley floor have generally produced age overestimates. In order to provide an alternative dating technique and test the reliability of the radiocarbon results, samples for single-grain quartz optically stimulated luminescence (OSL) dating were collected from three alluvial profiles where 18 radiocarbon samples of charcoal and aggregated pollen had been analyzed. While AMS radiocarbon age results were more precise, the single-grain OSL ages were stratigraphically consistent and suggest radiocarbon age overestimation of up to 2–6 ka, with the greatest divergence observed in the results from aggregated pollen samples. OSL results and geochemical analyses suggest that hydrocarbon contamination may have affected the accuracy of the radiocarbon results; age overestimates are likely due to contribution from oil-shale deposits within the catchment.

OSL and stratigraphic results suggest fluvial deposition began prior to 0.88 ka (AD 1130) at the site. Floodplain aggradation continued by conformable deposition of tabular flood packages, commonly capped with charcoal and ash-rich sediments, until interrupted by channel (arroyo?) entrenchment prior to 0.34 ka (AD 1670). Sandy flood packages filled this channel and re-aggradation continued until historic arroyo entrenchment of Range Creek in the late AD 1800's. OSL age constraints indicate that the alluvial sediments at the study sites were deposited during and immediately following Fremont occupation of Range Creek at AD 1000–1200 and may contain valuable archives of environmental conditions leading up to and following the abandonment of Fremont peoples from the region. Moreover, OSL results point to the importance of the use of multiple chronometers to date alluvial deposits, as the radiocarbon chronology alone would suggest that the study sites contained pre-Fremont-aged deposits and may lead to the misinterpretation of associated cultural and environmental records.

1. Introduction

Range Creek, a tributary to the Green River in east-central Utah, hosts a unique preservation and abundance of Fremont (ca. 200–1350 AD) archaeological sites and artifacts (Metcalfe, 2008). Limited public access prevented looting and destruction of the unusual high-density of granaries, residential sites and rock art along the rugged sandstone ledges of this bedrock valley, leading to its archaeological significance and current protection. While radiocarbon dating of maize and wood from archaeological sites has been highly successful, obtaining age control from the sediments that make up the valley floor has proven difficult. These alluvial sequences contain valuable archives of environmental conditions leading up to and following the peak in Fremont occupation of Range Creek, justifying the need for better age control for these environmental archives.

The purpose of this paper is to develop a chronology of Range Creek alluvium. Results from AMS (accelerator mass-spectrometry) radiocarbon dating of charcoal and aggregated pollen and single-grained optically stimulated luminescence (OSL) dating of quartz sand are discussed with respect to stratigraphic context and potential sources of error and contamination. Finally the alluvial

* Corresponding author.
E-mail address: tammy.rittenour@usu.edu (T.M. Rittenour).

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stratigraphy is interpreted in relation to the timing of the intense but short-duration Fremont occupation of Range Creek.

2. Physiographic, climatic, and geologic setting

Range Creek occupies a NNW-trending bedrock canyon carved within the relatively flat-lying Tertiary strata of the Book Cliffs and Roan Cliffs of the Tavaputs Plateau in east-central Utah (Fig. 1). The catchment area is 376 km^2 and elevations range from 3084 m at its headwaters to 1290 m at its confluence of the Green River at the mouth of Desolation Canyon. Climate in the region is semi-arid with spring (May) and winter (December) peaks in precipitation. Mean annual precipitation is 328.4 mm and mean annual temperature is 10.9 °C, recorded 5 km east of Range Creek at Sunnyside, UT (1993 m asl) (Global Historical Climatology Network USC00428476, AD 2008–2013). Range Creek is not gauged, but observations indicate it is ephemeral in its headwaters and perennial in its lower reaches due to groundwater discharge. Peak flows in the spring and late summer to early fall are driven by snowmelt and late-season convective storms.

The stream channel of Range Creek currently occupies a steep-walled, 3–5 m deep and 5–30 m wide arroyo entrenched within a relatively narrow (0.2–0.5 km wide) alluvial valley. Riparian vegetation lines the entrenched channel, with grasses (Poaceae), sagebrush (*Artemesia* sp.), rabbitbrush (Asteraceae) and occasional juniper (*Juniperus* sp.) on undisturbed regions of the alluvial valley. Forest communities vary by elevation and aspect along the steep rocky hillslopes and range from juniper (*Juniperus osteosperma* and *Juniperus scopulorum*) and pinyon pine (*Pinus edulis*) at lower elevations to Douglas fir (*Pseudotsuga mensizii*), white fir (*Abies concolor*) and quaking aspen (*Populus deltoides*) at higher elevations and north-facing slopes.

Range Creek is located in the northern portion of the Colorado Plateau physiographic province. Bedrock strata are largely undeformed and are deeply eroded by local streams forming steep-walled canyons and regionally named benches (cliffs) due to breaks in erosional competence of rock units. The Book Cliffs, directly to the west of Range Creek, are formed at the erosional break between the more resistant Blackhawk Formation (sandstone) and underlying Mancos shale, both Upper Cretaceous (Witkind, 1988; Weiss et al., 2003). The Roan Cliffs bound Range Creek to the east and are composed of inter-bedded sandstones and shales of the fluvial Colton Formation overlain by mudstones, marlstones, oil-shale beds and thin sandstones of the lacustrine Green River Formation, both Eocene. Differential erosion of the inter-bedded quartzose sandstones and shales of the Colton Formation has produced steep, step-like canyon slopes that were sought-out by the Fremont for protected sites that sheltered granaries (Metcalfe, 2008; Towner et al., 2009).

3. Fremont culture and preservation of sites in Range Creek

Fremont-affiliated cultural sites are found within the eastern-most Great Basin and Colorado Plateau of Utah, USA, and the edges of adjoining states. Fremont subsistence consisted of hunting and foraging augmented with farming of maize and other cultigens adopted from their Anasazi neighbors to the south (Madsen and Simms, 1998; Simms, 2008) and may have included slash and burn farming strategies (Barlow, 2002). Throughout the region, occupation of Fremont sites range from AD 200–1350, with the majority of sites dating between AD 700 and 1200 (Marwitt, 1986; Talbot and Wilde, 1989; Massimino and Metcalfe, 1999). Studies within Range Creek, however, suggest that the canyon hosted an intense occupation around AD 1000–1200 during late Fremont time, based on the two-sigma ranges of >30 calibrated radiocarbon ages from maize and wood from cultural contexts (Arnold et al. in press). To date, surveys have identified nearly 470 archaeological sites within the Range Creek catchment, which are typically located on the toes of ridges and benches above the alluvial plain (Metcalfe, 2008). These include remains of residential structures, well-preserved rock art on sandstone faces, and intact rock and mud granaries on high bedrock ledges, some still containing evidence of food storage.

Perhaps more unique than the abundance of archaeological sites at Range Creek is their state of preservation. Unlike many locations, archaeological sites in Range Creek have been protected from

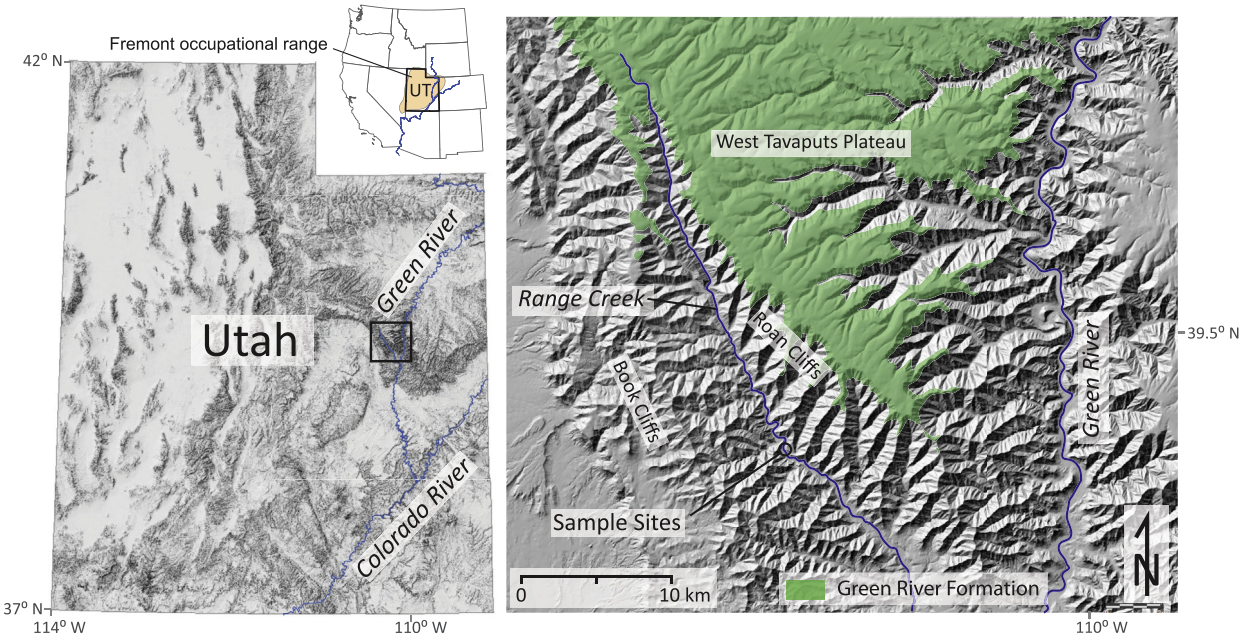

Fig. 1. Location map of study site within Range Creek, east central Utah. The Fremont occupational range, as determined by locations of characteristic sites and artifacts, and the regional extent of the Eocene Green River Formation are shown.