



A loess record of pre-Late Wisconsin glacial outburst flooding, Pleistocene paleoenvironment, and Irvingtonian fauna from the Rulo site, southeastern Washington, USA



Nicholas E. Bader^{a,*}, Patrick K. Spencer^{a,*}, Alexandra S. Bailey^{a,1}, Karen M. Gastineau^{a,2}, Emily R. Tinkler^{a,3}, Christopher J. Pluhar^b, Bruce N. Bjornstad^c

^a Department of Geology, Whitman College, 345 Boyer Ave., Walla Walla, WA 99362, USA

^b Department of Earth & Environmental Sciences, California State University Fresno, 2576 E San Ramon Ave., Fresno, CA 93740, USA

^c 1918 Harris Ave., Richland, WA 99354, USA

ARTICLE INFO

Article history:

Received 3 June 2016

Received in revised form 26 August 2016

Accepted 31 August 2016

Available online 2 September 2016

Keywords:

Loess
Palouse
Paleosols
Fossils
Vertebrates
Missoula floods

ABSTRACT

Worldwide, loess-paleosol sequences are archives of terrestrial Quaternary paleoenvironment data. The Rulo site is a newly described site in the Palouse loess of southeastern Washington State, USA. The site reveals a 19 m thick deposit of loess and flood sediment, preserving a total of 30 m of reconstructed stratigraphic section. Five unconformity-bound sequences of sediment are exposed at the site, the lowest two of which have yielded fossil remains, including the first reported occurrence of flat-headed peccary (*Platygonus compressus*) in northwestern North America. The unconformities, two diamicts bearing extrabasinal clasts, and a number of clastic dikes provide evidence for pre-Wisconsin glacial outburst floods in southeastern Washington. More than a dozen paleosols are preserved at the site. These soils are relatively unweathered and therefore primarily record periods of slow sedimentation accumulation in the Palouse, rather than changes in weathering rates. A paleosol near the base of the sequence is unusually weathered for Palouse paleosols, and records a period of increased weathering during the Middle Pleistocene. All units above the sand are normal paleomagnetic polarity; additional age control is provided by a tephra in the upper third of the sequence that matches a ca. 220 ka tephra from Newberry Volcano, and by stratigraphic correlation of later units to other sites in the Palouse. The Rulo site adds to the record of Irvingtonian fauna in North America, and supports accumulating evidence for pre-Late Wisconsin glacial outburst floods in the Pacific Northwest.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

Worldwide, Quaternary loess deposits have been used successfully for paleoenvironmental reconstruction (see Muhs, 2013 for a review). The Palouse loess deposits of the northwestern United States, which include the Pleistocene Palouse Formation and the overlying Holocene loess, cover up to 50,000 km of southeastern Washington and parts of Oregon and Idaho (Fig. 1; McDonald and Busacca, 1992; Bettis et al., 2003) to a depth of up to 75 m (Ringe, 1970). The depositional history of the Palouse loess is unique among Late Wisconsin (last glacial) loess deposits because of factors peculiar to the Pacific Northwest,

including a series of catastrophic glacial outburst floods that provided the sediment that later accumulated to form the loess (Bjornstad et al., 2007; McDonald et al., 2012). This makes the Palouse loess a particularly interesting Quaternary terrestrial record.

The Palouse loess is composed primarily of quartzofeldspathic loess deposited by prevailing southwesterly winds (Lewis, 1960) in the distinctive rolling hills of the Palouse region. Following pioneering work by Fryxell and Cook (1964), most of what we know about the significance of the Palouse loess is from the work of Alan Busacca and colleagues. Busacca (1989) established that deeper parts of the Palouse loess predate the Late Wisconsin glaciation, and at least some of the loess predates Brunhes-Matuyama reversal at 781 ka (Gradstein et al., 2012). The uppermost strata can be regionally correlated on the basis of paleosol stratigraphy (McDonald and Busacca, 1992), interlayered tephra deposits (Busacca et al., 1992), and fossils (Spencer and Knapp, 2010). Thermoluminescence ages for the upper part of the sequence (Berger and Busacca, 1995; Richardson et al., 1997) have revealed that loess accumulation rates were lower during cold periods (Sweeney et al., 2004). The Palouse loess has yielded fossil remains, from small rodents (Spencer, 1989) to Columbian mammoth (*Mammuthus columbi*)

* Corresponding authors.

E-mail addresses: baderne@whitman.edu (N.E. Bader), spencerp@whitman.edu (P.K. Spencer).

¹ Present address: Department of Geological Sciences and Geological Engineering, Queen's University, 36 Union Street, Kingston, Ontario K7L 3N6, Canada.

² Present address: Broadbent & Associates, Inc., 5450 Louie Ln., Suite 101, Reno, NV 89511, USA

³ Present address: U.S. Geological Survey, P.O. Box 25046, Mail Stop 980, Denver, CO 80225, USA.

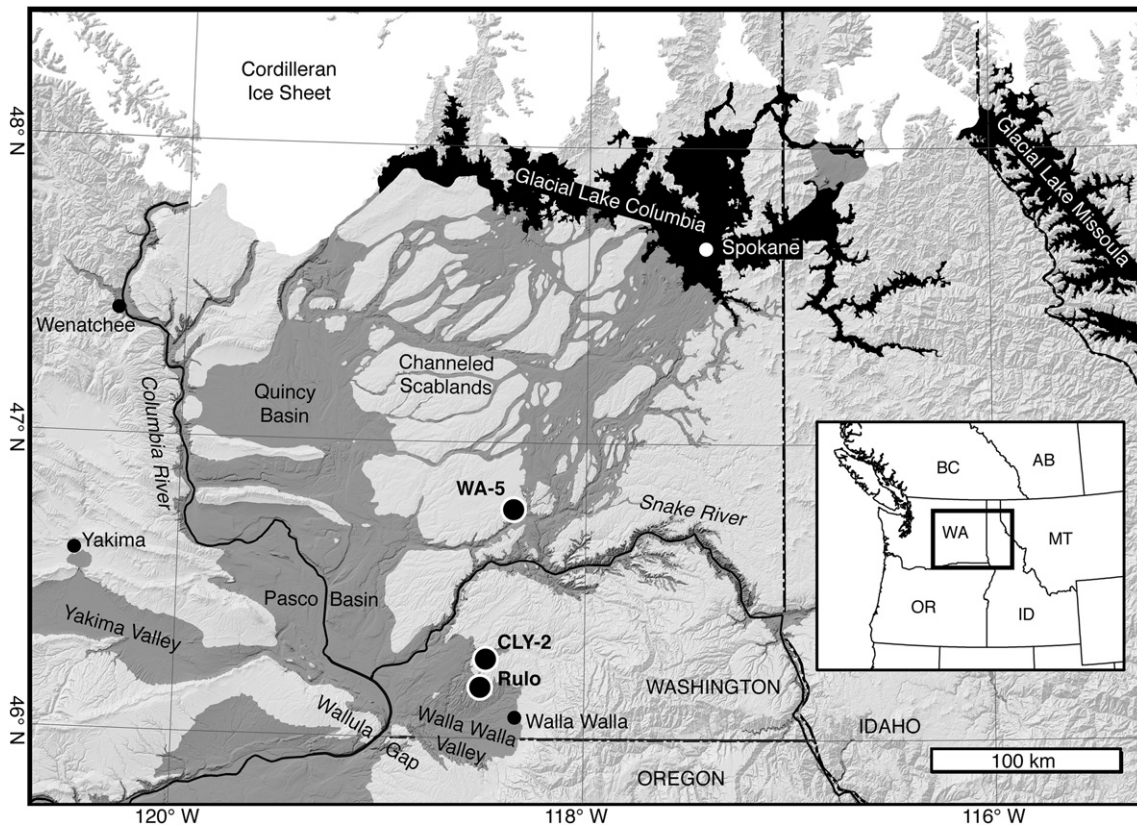


Fig. 1. Overview map showing the areas of eastern Washington State affected by Late Wisconsin glacial outburst flooding, including the position of the Cordilleran ice sheet (white) and the boundaries of glacial lakes Columbia and Missoula. Floodwaters scoured channels in the Channeled Scablands, then temporarily ponded in the Pasco Basin and the Walla Walla Valley due to the constriction of the channel at Wallula Gap. Eolian deposits of Palouse loess dominate the “islands” in the Channeled Scablands and the region to the east. Rulo, CLY-2, and WA-5 are sites in the Palouse loess mentioned in this paper. Late Wisconsin data is from Silkwood (1998), cited in Ehlers et al. (2011).

(Bryan, 1927). Paleosols (Busacca, 1989; McDonald and Busacca, 1992), phytolith records (Blinnikov et al., 2002), and cicada burrows (O’Geen and Busacca, 2001; O’Geen et al., 2002) generally paint a picture of a landscape that was a cold, dry sagebrush steppe during the Late Wisconsin glaciation, becoming a grassland environment with stronger winds and more rapidly-accumulating loess during the current interglacial period (Sweeney et al., 2004). However, our record for earlier loess deposited before ca. 75 ka is incomplete, because most sites in the Palouse either preserve only the most recent deposits, or are too thin to be useful for paleoenvironmental reconstruction.

The Palouse loess also records evidence of repeated Pleistocene glacial outburst floods. Regional variation in deposit thickness and grain size (Busacca and McDonald, 1994) and geochemical similarities (McDonald et al., 2012) indicate that the loess in southeastern Washington was probably sourced from slackwater sediments deposited during glacial outburst floods in the Pasco Basin and Walla Walla Valley to the south and southwest, especially near Wallula Gap (Fig. 1; Sweeney et al., 2007). These catastrophic floods have been studied extensively (see Baker et al., 2016 for a review), and there is evidence for at least 40 Late Wisconsin flood events (Waitt, 1980), each separated by perhaps 80 years (Hendy, 2009), with later floods coincident with the eruption of the Mount St. Helens S Set tephra at about 15.4 ± 0.1 ka (Mullineaux, 1996, recalibrated age from Sweeney et al., 2004). However, there is a growing body of evidence for earlier (pre-Wisconsin) episodes of flooding. For example, Bjornstad et al. (2001) and Pluhar et al. (2006) found reversed-polarity deposits in flood-deposited gravel bars. Using evidence from unconformities, fining-upward sequences, and flood-deposited sediments preserved in the loess, McDonald and Busacca (1988) and McDonald et al. (2012) demonstrated that the Palouse loess preserves evidence of pre-Late Wisconsin glacial outburst floods. Spencer and Jaffee (2002) found similar evidence in the Walla

Walla Valley from both loess deposits and slackwater flood deposits. Despite these efforts, our understanding of these earlier floods remains inadequate, because of the comparative rarity of sites that preserve these earlier sediments and their stratigraphic relationships.

The Rulo site is one such site. It is a deep (ca. 19 m) roadcut in the Palouse loess, located on Sudbury Road in central Walla Walla County in southeastern Washington (Fig. 2), at $46^{\circ} 9' 53.79''$ N, $118^{\circ} 30' 10.33''$ W, with an elevation of about 295 m at the base of the outcrop. The roadcut exposing the site was created in 2003, and the 19 m-deep cut exposes more than a dozen paleosol horizons and their stratigraphic relationships (Fig. 3), making the Rulo site a valuable new source of pre-Late Wisconsin paleoenvironmental information. The site is located near the boundary separating eolian from primarily flood-deposited sediments to the south (Fig. 2), which probably made Rulo site sediments more responsive to flood events. Major unconformities, clastic dikes, and extrabasinal clasts record apparent pre-Wisconsin flood events. Finally, vertebrate remains have been recovered from deep in the section, associated with earlier flood deposits. In this study, we report sedimentological, pedological, stratigraphic, fossil, and paleomagnetic observations from the Rulo site, and we discuss the implications of the site for expanding the record of Irvingtonian fauna and providing new evidence for pre-Late Wisconsin glacial outburst floods in the Pacific Northwest. Supplementary data is available online at <https://doi.org/10.1594/PANGAEA.860969>.

2. Methods

2.1. Field and lab methods

Individual units in the Rulo outcrop were distinguished on the basis of major changes in grain size or of pedogenic horizons distinguishable

Download English Version:

<https://daneshyari.com/en/article/4465509>

Download Persian Version:

<https://daneshyari.com/article/4465509>

[Daneshyari.com](https://daneshyari.com)