Quaternary Research 85 (2016) 94–106

Contents lists available at ScienceDirect

Quaternary Research

journal homepage: www.elsevier.com/locate/yqres

The micromorphology of Younger Dryas-aged black mats from Nevada, Arizona, Texas and New Mexico

Erin Harris-Parks

Department of Geosciences, University of Arizona, 1040 E 4th St., Tucson, AZ 85721, USA

ARTICLE INFO

Article history:
Received 11 December 2014
Available online 5 January 2016

Keywords:
Micromorphology
Black mats
Younger Dryas
Desert sediments
Paleoclimate
Thin sections
Fluorescence microscopy

ABSTRACT

Black mats are organic-rich sediments and soils that form in wet environments associated with spring discharge. Micromorphological and geochemical analyses of 25 black mats dating to the Younger Dryas Chronozone (12.9–11.7 ka) and early Holocene were conducted to determine their composition and depositional environment. Samples were collected from Arizona, New Mexico, Texas and Nevada. Micromorphological analyses were conducted on thin sections using polarized and blue fluorescent light. These analyses determined that black mats contain humic acids, fine (5–20 μm) plant fragments, diatoms, phytoliths, and gastropods. The dominant type of organic matter in black mats is derived from herbaceous plants, contradicting previous studies that supported algal or charcoal sources. Differences in the micromorphological characteristics of the samples revealed that black mats formed as three different types, organic horizons, moist soils and, ponded sediments, depending on their topographic position in relation to the water table. The microscopic evidence found in black mats supports the presence of widespread wet environments in Nevada and Arizona during the Younger Dryas Chronozone, clearly indicating a sustained period of greater effective moisture, optimal for spring discharge and black mat formation.

Introduction

Black mats are organic-rich sediment layers and soils preserved in late Pleistocene and early Holocene stratigraphic sequences throughout central and western North America (Quade et al., 1998; Haynes, 2008; Pigati et al., 2009, 2012). The term "black mat" has been applied to a wide variety of soil and sediment types including Mollisols (organic-rich grassland soils), Aquolls (wet-meadow soils), pond sediments, algal mats, diatomites and marls (Haynes, 2008). Black mats form in wet environments associated with spring discharge and elevated water tables (Quade et al., 1998; Haynes, 2008; Pigati et al., 2009). Because black mats are commonly associated with moist settings, their presence in present day arid to semi-arid environments suggests that they formed under different environmental conditions compared to today.

Studies in the southwestern United States documented dramatic increases in black mat formation associated with the Younger Dryas Chronozone (YDC). Quade et al. (1998) determined that black mat formation in southern Nevada peaked from 11,200 to 10,000 ^{14}C yr BP (~13.0–11.7 ka). Haynes (2008) called black mats the "stratigraphic manifestation of the Younger Dryas" after identifying 57 YDC-aged black mat sites in North America. The YDC was a brief period that lasted from 12.9 to 11.7 ka (11,000 to 10,000 ^{14}C yr BP) and marked a return to cooler conditions following a general warming trend after the end of the last glacial maximum (Mangerud et al., 1974; Alley et al., 1993; Anderson, 1997; Steffensen et al., 2008). Greenland ice cores provide high-resolution records of colder and dryer conditions in the North Atlantic for the YDC, including evidence that shows temperatures may have been 15 ± 3°C colder than present in the North Atlantic (Severinghaus et al., 1998).

Most of North America did not experience these glacial-like conditions. Paleoclimate studies in the southwest, for example, indicate moister conditions associated with the YDC, including speleothem growth and paleolake expansion (Broughton et al., 2000; Polyak et al., 2004; Briggs et al., 2005; Wagner et al., 2010). Further, other records indicate drying and warming trends on the Great Plains and in the Midwest during the YDC (Holliday, 2000; Wang et al., 2000, 2012; Mandel, 2008; Holliday et al., 2011). Additionally, the disappearance of the Clovis culture, the earliest widespread culture to occupy all of North America, and the extinction of an estimated 35 genera of large mammals appear to coincide with the onset of the YDC (Fiedel, 1999; Anderson and Faught, 2000; Lovvorn et al., 2001; Haynes, 2002, 2008; Faith and Surovell, 2009; Polyak et al., 2012). Therefore, the peak in black mat formation and the onset of the YDC mark major cultural and biological changes.

Adding to the significance of black mats is the hypothesis that an extraterrestrial impact caused YDC climate changes, megafaunal extinctions and the demise of the Clovis culture (Firestone et al., 2007). Many of the proposed "impact markers" found in black mats, such as elevated levels of charcoal from widespread wildfires, have since been

E-mail address: ehparks25@gmail.com.

http://dx.doi.org/10.1016/j.yqres.2015.11.005
0033-5894/

questioned by others citing misidentification, presence in younger, or older black mats, or non-reproducibility (Marlon et al., 2009; Surovell et al., 2009; Daulton et al., 2010; Haynes et al., 2010; Scott et al., 2010; Pinter et al., 2011; Pigati et al., 2012).

Despite the numerous associations between black mats and significant Late Pleistocene environmental, faunal and cultural changes, there has never been a systematic study of the microscopic contents or characteristics of black mats. To inform debate on the ultimate cause(s) of environmental changes observed during the YDC, this study aims to quantify the organic content and mineral composition of black mats to better understand how they formed. Here, I present a thorough description of the microscopic and geochemical composition of 25 black mat samples, from Arizona, Nevada, Texas, and New Mexico, with an emphasis on the types and forms of organic matter present. The overall goal of this study is to provide an in-depth understanding of the composition and origins of black mats in order to relate their formation to environmental changes associated with the YDC and early Holocene.

Sampling locations

Murray Springs and the San Pedro Valley, Arizona

The San Pedro Valley is a 240 km long valley, located in the Basin and Range Province of southern Arizona on the border between the Sonoran and Chihuahuan Deserts (Pigati et al., 2009) (Fig. 1). Many of the archaeological sites there contain evidence of Clovis hunting (Haury et al., 1959; Hemmings and Haynes, 1969; Haynes, 2007d). At many locations, the black mat, referred to as Stratum F_{2a} or the Clanton Ranch Member of the Lehner Ranch Formation, directly overlies the Clovis age strata (Haynes, 2007c). The black mat also formed at the same time as Stratum F_{2b}, a marl, called the Earp Member of the Lehner Ranch Formation (Haynes, 2007c). Radiocarbon ages on the organic matter in the black mat indicate that it formed from 10,950 ± 50–9800 ^{14}C yr BP (Haynes, 2007a).

Murray Springs is an archaeological site in Curry Draw, a tributary of the upper San Pedro Valley. Excavations, which began there in June 1966, uncovered mammoth and bison remains associated with Clovis artifacts, and a Clovis campsite (Haynes, 2007d). The black mat directly overlies the Clovis surface and is described as an organic-rich, silty, smectitic clay with fine angular blocky structure (Haynes, 2007c). Combined pyrolysis and thin layer chromatographic analysis of black mat samples from Murray Springs led Haynes (2007b) to conclude that it was primarily composed of algal organic matter.

For this study, micromorphology and bulk samples were collected from Trench 22, Area 4, and Profile B at Murray Springs (Table 1, Fig. S1a). Four sediment block samples were collected from black mat outcrops along a 35 km stretch of the upper San Pedro Valley (Fig. S2). The basal contact of the black mat was included in all of these samples. Four additional thin section samples from sites in the San Pedro Valley were provided by Jesse Ballenger (Statistical Research Inc., Tucson, AZ). None of the black mat samples from the San Pedro Valley that were collected outside of the Murray Springs archaeological site have been radiocarbon dated. However, these deposits are likely YDC-aged based on similarities in their observed stratigraphic position to that of the well-dated black mat at Murray Springs.

Lubbock Lake, Texas

Lubbock Lake is located in Yellowhouse Draw, a tributary of the Brazos River, on the Southern High Plains of northwestern Texas (Fig. 1). Lubbock Lake is a well-stratified archaeological site, discovered in 1936, that contains evidence of occupation by Native American populations beginning as early as 11,100 ^{14}C yr BP (Holliday, 1985a; Johnson, 1987; Hatte et al., 2010). The Paleoindian-aged archaeological deposits are associated with alluvial, spring, marsh, and lacustrine sediments, and include Rancholabrean faunal remains with evidence of butchering (Johnson and Holliday, 1981; Stafford, 1981; Holliday, 1985a).

The black mat at Lubbock Lake is called stratum 2A and is described as interbedded laminations of pure diatomite, sapropelic silt, clay, and, phytoliths (Stafford, 1981; Holliday, 1985a). The lithologic variability of the black mat is interpreted to reflect alternating periods of standing water and marsh sediments (Holliday, 1985a). Radiocarbon ages on stratum 2A show that it formed from ~11,000 to 10,000 ^{14}C yr BP (Holliday, 1985a; Haas et al., 1986). For this study, a sediment block including the black mat and its overlying and underlying contacts was collected from Trench 65 (Table 1, Fig. S1c).

Blackwater Draw, New Mexico

The Blackwater Draw Locality No. 1 archaeological site is located on the Southern High Plains of northeastern New Mexico in a basin that flows into Blackwater Draw proper, another tributary of the Brazos

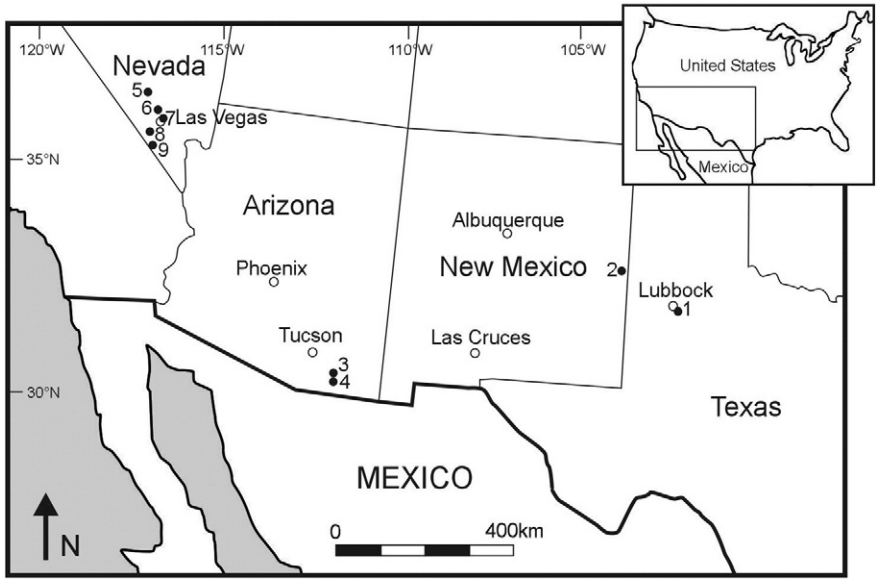

Figure 1. Generalized map of sample locations. Black dots indicate sampling locations. 1) Lubbock Lake. 2) Blackwater Draw. 3) BM 3. 4) Murray Springs, BM6, BM5, SP13-1, SP13-2, SP14-3, SP14-4. 5) Cactus Springs. 6) Corn Creek Flat. 7) Gilcrease Ranch. 8) Browns Spring, Stump Spring. 9) Sandy Valley.