Earth and Planetary Science Letters 434 (2016) 141–150

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Atlantic Ocean modulated hydroclimate of the subtropical northeastern Mexico since the last glacial maximum and comparison with the southern US

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ARTICLE INFO

Article history:
Received 28 August 2015
Received in revised form 23 November 2015
Accepted 27 November 2015
Available online 8 December 2015
Editor: M. Frank

Keywords:
paleoclimate
geochemistry
deglaciation
Holocene
northeastern Mexico
Atlantic Ocean

ABSTRACT

Proxy records generated from chemical composition and radiocarbon dating of a sediment sequence collected from the El Potosi Basin provide information about variable hydroclimate of the subtropical northeastern Mexico since the last glacial maximum (LGM). Minimal amounts of runoff and more carbonate deposition during >19 ka represent the LGM. The deglaciation was wetter compared to the LGM and enhanced runoff during ~19–12 ka transported more Ti-bearing clastics from a relatively humid watershed. Over the deglaciation, the basin received more runoff during the Bølling-Allerød compared to the Heinrich Stadial 1 and Younger Dryas. Reduction in the amount of runoff during ~10–1 ka and deposition of unweathered Si-bearing clastics during ~4–1 ka suggest that the Holocene was drier compared to the deglaciation. Hydroclimates of the northeastern Mexico and southern US were synchronous during the LGM as well as deglaciation. Change from the drier LGM to wetter Bølling-Allerød occurred as the Gulf of Mexico became warmer and the region received more summer precipitation. However, the dissimilarities observed in regional hydroclimates of the Holocene need further evaluation.

1. Introduction

The subtropical northeastern Mexico receives most of the modern era precipitation during the summer and autumn months (Fig. 1). This bimodal precipitation has a mid-summer dry spell known as *caniculas* (Comrie and Glenn, 1998). The early summer precipitation is associated with transportation of moisture from the Caribbean Sea and Gulf of Mexico by northward branch of the Caribbean Low Level Jet (Mestas-Nuñez et al., 2005, 2007). Tropical cyclone originating in the Atlantic Ocean provides the autumn moisture (Jones et al., 2003; Wang et al., 2006, 2011). Amounts of the winter and spring precipitations are related to the El Niño Southern Oscillation (ENSO) and tropical Atlantic meridional gradient variability (Wang et al., 2006). Tree-rings from the region registered more droughts in the last century compared to the previous five centuries (Villanueva-Diaz et al., 2007). Similarly, the drought of AD 2010–2011 associated enhanced aridity in the subtropics with the anthropogenic global warming (Wang et al., 2011; Seager et al., 2014). In such a scenario, it is necessary to reconstruct the past climate and understand the dynamics of precipitation and aridity during different intervals of the global climate change.

Lacustrine sediment, aeolian deposit and packrat midden located in the northwestern Mexico registered the late Quaternary hydroclimate of the subtropical Mexico (Murillo de Nave et al., 1999; Lozano-García et al., 2002; Metcalfe et al., 2002; Palacios-Fest et al., 2002; Caballero et al., 2005; Castiglia and Fawcett, 2006; Blanchet et al., 2007; Ortega-Rosas et al., 2008; Holmgren et al., 2014; Roy et al., 2010, 2012, 2013, 2014a, 2014b; Chavez-Lara et al., 2012, 2015). These proxy records along with paleohydrological information obtained in the southwestern US (Anderson et al., 2002; Holmgren et al., 2003, 2007; Kirby et al., 2005, 2006, 2013; Asmerom et al., 2007, 2010; Wagner et al., 2010; Lyle et al., 2012; Lachniet et al., 2014) deciphered dynamics of moisture sourced from the Pacific Ocean. The North American Monsoon, tropical cyclones and winter storm had different regional coverages during different intervals (Barron et al., 2012; Lyle et al., 2012; Antinao and McDonald, 2013; Kirby et al., 2013; Roy et al., 2013, 2014a, 2015; Metcalfe et al., 2015). However, the

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http://dx.doi.org/10.1016/j.epsl.2015.11.048
0012-821X/

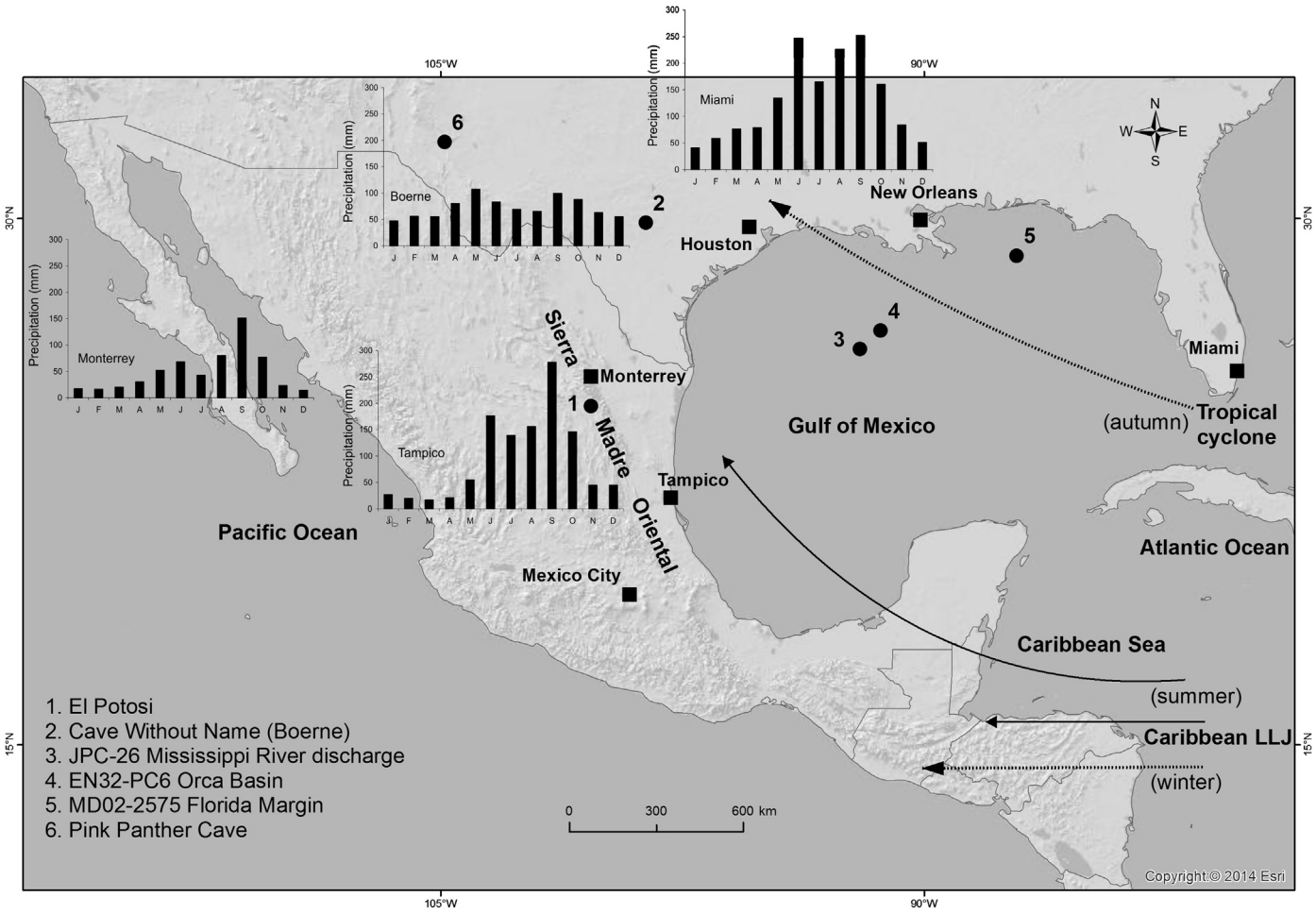

Fig. 1. El Potosi Basin is located in rain shadow of the Sierra Madre Oriental Mountains in the northeastern Mexico. Modern era precipitation data (source: www.weatherbase.com) from different sites shows that both the northeastern Mexico and southern US receive precipitation during the summer as well as autumn. The early summer moisture flux is transported by northward branch of the Caribbean Low Level Jet (LLJ) and tropical cyclone provides the autumn moisture. Regional hydroclimate is evaluated by comparing proxy records from the El Potosi Basin with different paleoclimate records from the southern US and the Atlantic Ocean.

northeastern Mexico lacks paleoclimate information and there is limited knowledge about dynamics of moisture sourced from the Atlantic Ocean.

In this study, we present millennial-scale proxy records of runoff, lake water salinity and watershed aridity reconstructed from chemical (organic carbon, carbonate and elemental concentration) and physical (magnetic susceptibility) characteristics of a sediment sequence collected from the El Potosi Basin of the northeastern Mexico. Influences of different forcings on paleohydrological variations that occurred since the last glacial maximum (LGM) are inferred by comparing the new proxy records with insolation, mean position of the Intertropical Convergence Zone (ITCZ), ENSO activity and sea surface temperature (SST) of the Atlantic Ocean. Similarly, the regional hydroclimate is evaluated by comparing runoff record of the El Potosi Basin with precipitation in the southern US (Feng et al., 2014), discharge of the Mississippi River into the Gulf of Mexico (GoM) (Tripsanas et al., 2013) and sea surface salinity in the Orca Basin of GoM (Flower et al., 2004).

2. Material and methods

2.1. El Potosi Basin and geology

The endorheic El Potosi Basin (24°50′N, 100°19′W, 1880 m asl) is located within a semi-graben in rain shadow of the Sierra Madre Oriental Mountains (Fig. 1). It is present in the Nuevo León state (Mexico) and located at distances of ∼240 km from the GoM and ∼700 km from the Pacific Ocean. This lacustrine basin is NW–SE oriented, has a maximum length of ∼7 km and maximum width of ∼3 km (Fig. 2). Jurassic to Neogene sedimentary rocks (i.e., limestone, sandstone, siltstone and conglomerate) are exposed in ∼3500 m and ∼2500 m high hills present to the immediate east and west of the basin (Eguiluz et al., 2000; Servicio Geológico Mexicano, 2000). Limestones are abundant in the eastern watershed and an association of non-carbonate rocks (i.e., sandstone–siltstone, siltstone and conglomerate) constitutes the second important lithology. The western watershed is dominated by conglomerate and has minor exposures of limestone, siltstone and sandstone. The Quaternary deposits consist of lacustrine sediment and alluvium.

2.2. Climate

A meteorological station at the eastern margin of the basin (Fig. 2) recorded annual precipitation between 90 mm and 800 mm during AD 1950–2011 (source: Servicio Meteorologico Nacional, Mexico). The average annual precipitation was ∼330 mm and it occurred in a bimodal distribution with peaks during the early summer and early autumn. Average temperature was 20 °C during