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Preliminary results from Laguna Minucúa a potentially annually resolved record of climate and environmental change for the past ~5000 years in the Mixteca Alta of Oaxaca, Mexico

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ABSTRACT

Despite several decades of research focusing on prehispanic human ecology, debate continues over the impact of climatic and anthropogenic landscape change on human populations in Mesoamerica. One problem in identifying the cause of this change is the lack of high-resolution paleo-environmental data from many regions. The southern Mexican highlands, in particular, have yielded few paleoenvironment data, yet have a rich and diverse cultural history.

The sedimentary record from Laguna Minucúa, located within the Sierra Madre del Sur, Oaxaca, offers an exceptional opportunity to address human and environmental interactions in the region. Minucúa is a small (~0.25 ha), currently shallow pond with no apparent inlets or outlets. We retrieved two sediment cores from the site (3.5 m and 5.6 m long). The cores are highly laminated. Core chronology was developed with paleomagnetic secular variation data and compared with couplet counts and limited radiometric measurements. These data indicate that the Minucúa record at least spans the last ~4500 ± 100 years. We discuss preliminary results that assess long-term environmental change for the region through examination of geochemical and magnetic susceptibility data. In particular, we discuss in more detail a 500 year time slice which encompasses the period known as the "Classic Collapse." The record indicates overall dry conditions but with two extended wet periods experienced between 1160 and 1120 cal yr BP and 1060–1000 cal yr BP We place our findings in the context of current archaeological and paleoclimatological research in Oaxaca.

1. Introduction

Mesoamerica, broadly defined as extending from central Mexico south to El Salvador and Honduras, has long been the focus of geographical and archaeological investigation (e.g., Holmes, 1897; Maudslay, 1889–1902; Sauer, 1941, 1957). Paleoecological research began in the 1940s and 1950s (e.g. Deevey, 1943; Sears, 1952) and has become increasingly important in understanding human impacts and land use change (e.g. Bernal et al., 2011; Deevey et al., 1979; Joyce and Goman, 2012), and more recently, climatic change and how it impacted prehispanic peoples (e.g. Bhattacharya et al., 2015; Hodell et al., 1995; Jones et al., 2015; Rodríguez-Ramírez et al., 2015). In particular, climate has been implicated as a causal factor in major periods of cultural change, especially the transition to agriculture and the Classic period collapse (e.g.

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Bhattacharya et al., 2015; Haug et al., 2003; Hodell et al., 1995; Rodríguez-Ramírez et al., 2015).

Paleoclimatological studies, however, have tended to be concentrated in two regions in Mesoamerica (Fig. 1): the volcanic highlands of central Mexico (e.g. Bradbury, 1989; Conserva and Byrne, 2002; Lozano-García et al., 1993; Metcalfe and Davies, 2007; O'Hara et al., 1993) and the Maya lowlands (e.g. Brenner et al., 2002; Curtis et al., 1996, 1998; Deevey et al., 1979; Dull, 2004, 2007; Hodell et al., 2001, 1995; Jones, 1994; Leyden, 2002; Wahl et al., 2006). The geographic area between these two regions has generally poor coverage in terms of environmental and especially high-resolution climate reconstructions (Fig. 1). Research in this area has tended to focus near the coastal zone in areas below an elevation of 100 m (Goman et al., 2010, 2013, 2014; Gonzalez-Quintero and Mora-Echeverría, 1978; Jones and Voorhies, 2004; Rust and Sharer, 1988; Siemens et al., 1988; Sluyter, 1997) and to a lesser extent at higher elevations (Berrío et al., 2009; Byrne and Horn, 1989; Goman and Byrne, 1998; Lozano-García et al., 2007; Piperno et al., 2007; Piperno and Flannery, 2001). The significant lack of climate data and in particular, data of a high temporal resolution prevents a rigorous assessment of the role of climate on prehispanic cultural change in these areas. In this paper we present and discuss the climatological and environmental archives held in the sediments of Laguna Minucúa, located in the Mixteca region of Oaxaca, southern Mexico. Minucúa offers the potential for high resolution reconstructions as the sediment is composed of dark and light seasonal couplets that repeat throughout the majority of the sedimentary sequences recovered.

2. Environmental setting

The study site, Laguna Minucúa (17° 04′ 46.64N; 97° 36′ 33.30W: Fig. 1), is located in the Sierra Madre del Sur at an elevation of 2510 m. It was chosen for coring as it is one of the few extant natural lake bodies that remain in the region. The nearest weather station is located at Chalcatongo (~6 km to the southeast). Annual temperature ranges from 11 to 16 °C. Overall annual precipitation is approximately 900 mm a year; however, precipitation is highly seasonal with the rainy season running from May to October, when ~90% of all precipitation falls (Fig. 2: http://smn.cna.gob.mx).

Between elevations of 2000–2600 m the natural vegetation for the region, is dominated by various species of pine (*Pinus oaxacana, P. teocote, P leiophylla, P. lawsoni,* and *P. pringlei*) with occasional occurrences of juniper (*Juniperus* spp.), madrone (*Arbutus* spp.), and oak (*Quercus* spp.). At elevations between 2500 and 3500 m more mesophytic conditions are found, which are characterized by fir (*Abies hickelli*) in association with pine (*P. pseudostrobus*), oak, and madrone (Bersain Ortiz Jiménez, 2007). The local geology is predominantly Late Cretaceous and Tertiary arc volcanic rocks and marine forearc sediments (Moran-Zentano et al., 2007; Nieto-Samaniego et al., 2006). Soils in the area are dominated by rendzinas (Bersain Ortiz Jiménez, 2007).

Laguna Minucúa has no inlets or outlets and appears to have formed in a carbonate sink. The pond is about 0.25 ha in size. The site is surrounded on three sides by a calcareous outcrop, which has stands of *P. oaxacana* and *Quercus* spp. growing on the slope. The land slopes toward the lake from the northwest and here the vegetation has been cleared for maize agriculture. The pond surface was clear of aquatic vegetation at the time of coring and low grasses and sedges were present around the periphery. At the time of coring the water depth was ~45 cm.

3. Cultural history

The Mixteca is a mountainous region with peaks reaching 3000 m broken by a series of small highland valleys with floor elevations ranging from 1500 to 2500 m asl. The mountains descend abruptly to the Pacific Ocean in a steep escarpment, often forming a high, rugged coastline, which is interrupted in places by lowland river valleys and short stretches of coastal plain. The region was inhabited largely by Mixtec-speaking peoples in the prehispanic era as it is today. Major centers of prehispanic population and socially complex societies developed in the highland valleys, which offered the most productive agricultural land, as well as in a number of coastal lowland valleys.

Occupation in the Mixteca dates to the Paleoindian period with early sedentary villages emerging by ca. 3550 cal yr BP. (Joyce, 2010; Pérez Rodríguez, 2013). Evidence for anthropogenic erosion due to land clearance for cultivation begins as early as 3950 cal yr BP. in the highlands (Mueller et al., 2012). Between 2250 cal yr BP. and 1850 cal yr BP. perhaps a dozen urban or proto-urban hilltop centers emerged in the Mixteca at sites including Río Viejo,

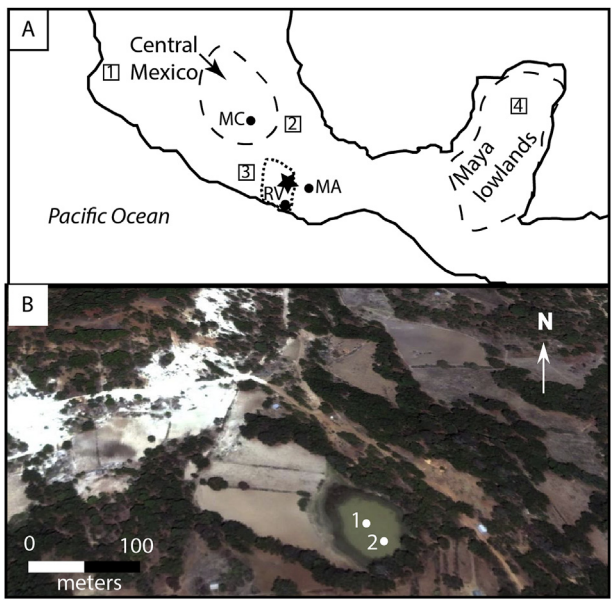

Fig. 1. A. Location of Minucúa, major archaeological sites in Oaxaca and selected high-resolution climate records. Dashed line shows Mixteca region. (Image Source: Google, Landsat). The black star indicates the location of Laguna Minucúa; RV = Río Viejo; MA = Monte Albán; MC = Mexico City; 1: Juanacatlán (Jones et al., 2015); 2: Aljojuca (Bhattacharya et al., 2015); 3: Juxtlahuaca (Lachniet et al., 2012); 4: Chichancanab (Hodell et al., 1995). B. Laguna Minucúa and its immediate vicinity. Numbers 1 and 2 show the approximate location of core locations (Image Source: Google, Digital Globe).

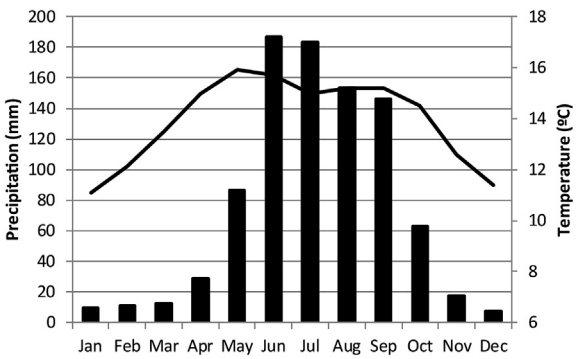

Fig. 2. Climograph for Chalcatongo (station 20178) for the period 1951–2010 (Data from Mexican Meteorological Service: http://smn.cna.gob.mx). The solid line represents temperature and the bar graph precipitation.

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