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Late Holocene anthropogenic and climatic influences on the regional vegetation of Mexico's Cuenca Oriental

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ABSTRACT

Scholars continue to debate the relative magnitude of pre- and post-Conquest anthropogenic landscape transformation in many regions of Mesoamerica. These debates have important implications for our understanding of the role of anthropogenic practices in the development, or at times degradation, of regional environments. Paleoecological records that provide long-term perspectives on climate change and human land-use patterns are critical to addressing these uncertainties. However, many regions of Mexico including the Cuenca Oriental, a semi-arid basin in the rain shadow of the Sierra Madre Oriental, remain poorly studied. We present a new paleoecological record from sediment cores recovered from Lake Aljojuca, located in the southern part of the basin. Stable isotope analyses of authigenic carbonates provide an independent record of past climate, while pollen and microscopic charcoal provide insights into past vegetation and fire history. The Aljojuca record is one of the only well-dated multi-proxy paleolimnological records from the Cuenca Oriental, and is one of few charcoal studies from highland Mexico. *Zea mays* pollen and increased fire activity at 2700 calendar years before present (cal yr. BP) suggest Formative period human settlement around the lake. Between 1700 and 800 cal yr BP, a drying climate combined with human uses of fire likely resulted in increases in the extent of xeric scrub vegetation. The Aljojuca record also documents important landscape changes during the historic period (~430 cal yr. BP–present) likely related to the introduction of invasive species and agricultural intensification. The Aljojuca record provides a unique perspective on human–environment relationships and highlights differences between landscape transformations in the pre- and post-Conquest periods.

1. Introduction

Researchers have long debated the magnitude of human landscape transformation in the Americas prior to European arrival. This debate has important implications for our understanding of the evolution of environments in the Neotropics, modern landscape management practices, and historic carbon cycle dynamics (Butzer and Butzer, 1997; Lentz, 2000; Dull et al., 2010). Studies from lowland tropical regions of Mesoamerica have made strides in providing evidence of past human landscape management (Goman et al., 2010; Wahl et al., 2013; Walsh et al., 2014). In highland Mexico, paleoecological research has also clarified patterns of past human settlement in the Western Highlands and the Basin of Mexico (Arnauld et al., 1997; Almeida-Lenero et al., 2005; Metcalfe and Davies, 2007; Metcalfe et al., 2007; Figueroa-Rangel et al., 2008; Figueroa-Rangel et al., 2009; Metcalfe et al., 2010; Park et al., 2010; Vazquez et al., 2010). However, significant uncertainties still exist about the nature of anthropogenic landscape transformation in many regions of highland Mexico.

One important area of debate focuses on the environmental impact of pre-Columbian versus historic land use. Evidence from the central highlands of Mexico shows pulses of erosion in response to both pre- and post-Conquest period land-use (Heine, 2003; Davies et al., 2004). Some researchers argue that the historic period resulted in unprecedented landscape change and degradation (Simpson, 1952; Fernández, 1985; O'Hara et al., 1994; Fisher, 2005; Elliott et al., 2010), while others suggest much more modest landscape changes following Spanish Conquest (Butzer and Butzer, 1997). Historic period landscape changes may have largely resulted from post-Conquest demographic changes and the abandonment of traditional pre-Conquest agricultural systems (Butzer and Butzer, 1995; McClung de Tapia, 2000). Resolving these debates requires detailed knowledge of the chronology and magnitude of both pre- and post-Conquest land use.

The eastern sector of highland Mexico offers a particularly important setting in which to address questions about the character of long-term anthropogenic landscape transformation. While some geomorphological and paleolimnological research has shed light on vegetation and erosion in this area, few of these records are precisely dated (Straka and Ohngemach, 1989; Caballero et al., 2003; Heine, 2003). The area known as the Cuenca Oriental is located in the rain shadow of the Sierra Madre Oriental (Gasca-Duran, 1981)(Fig. 1). This dry, semi-arid zone is

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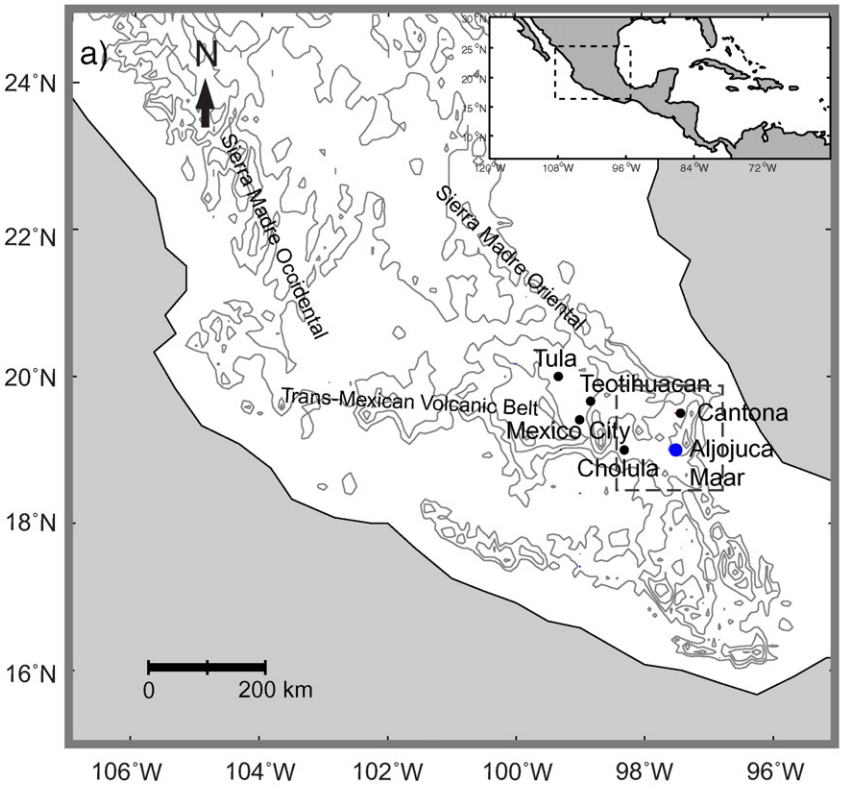
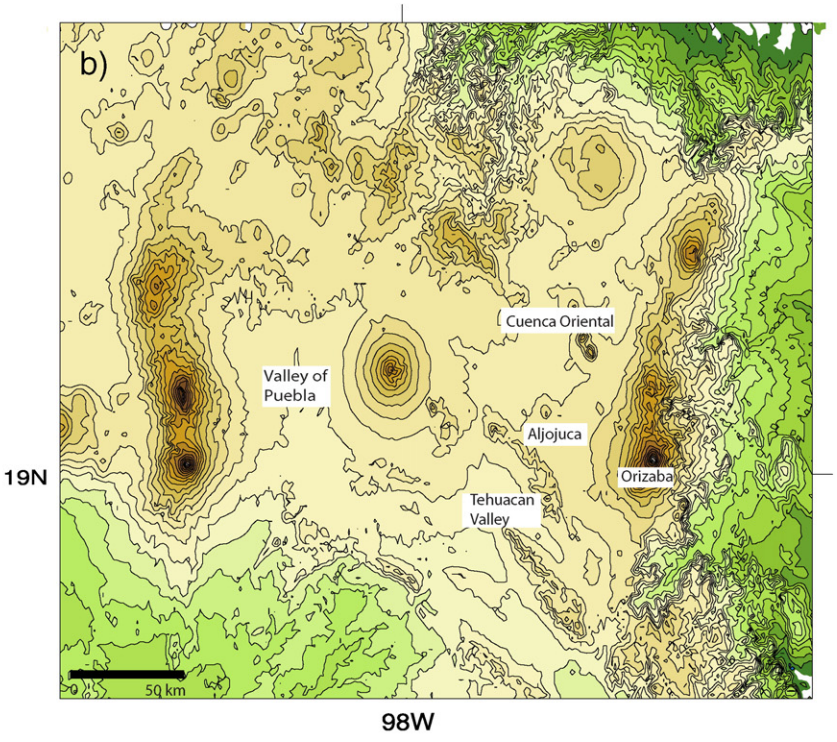
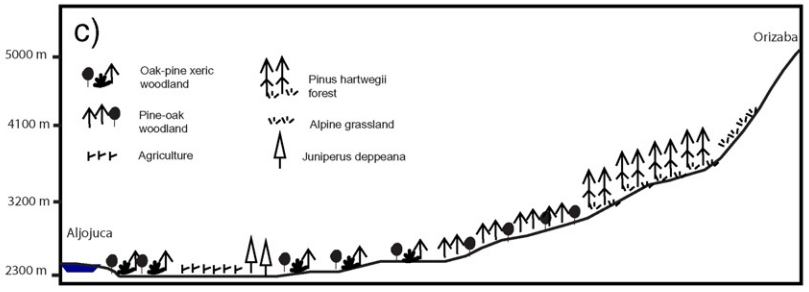

a)
N
Sierra Madre Occidental
Sierra Madre Oriental
Trans-Mexican Volcanic Belt
Tula
Teotihuacan
Cantona
Mexico City
Aljojuca
Cholula
Maar
0
200 km
24°N
22°N
20°N
18°N
16°N
106°W
104°W
102°W
100°W
98°W
96°W


b)
Cuenca Oriental
Valley of Puebla
Aljojuca
Orizaba
Tehuacan Valley
0
50 km
19N
98W


c)
Orizaba
5000 m
4100 m
3200 m
2300 m
Oak-pine xeric woodland
Pine-oak woodland
Agriculture
Pinus hartwegii forest
Alpine grassland
Juniperus deppeana
Aljojuca