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Climate, agriculture, and cycles of human occupation over the last 4000 yr in southern Zacatecas, Mexico

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ABSTRACT

Scholars attribute the growth and decline of Classic period (AD 200–900) settlements in the semi-arid northern frontier zone of Mesoamerica to rainfall cycles that controlled the extent of arable land. However, there is little empirical evidence to support this claim. We present phytolith, organic carbon, and magnetic susceptibility analyses of a 4000-yr alluvial record of climate and human land use from the Malpaso Valley, the site of one such Classic frontier community. The earliest farming occupation is detected around 500 BC and appears related to a slight increase of aridity, similar to the level of the modern day valley. By AD 500, the valley's Classic period Mesoamerican settlements were founded under these same dry conditions, which continued into the Postclassic period. This indicates that the La Quemada occupation did not develop during a period of increased rainfall, but rather an arid phase. The most dramatic changes detected in the valley resulted from the erosion associated with Spanish Colonial grazing and deforestation that began in the 16th century. The landscape of the modern Malpaso Valley is thus primarily the product of a series of intense and rapid transformations that were concentrated within the last 400 yr.

Introduction

Climatic conditions in the northern frontier zone of Mesoamerica (today's states of Guanajuato, Zacatecas, Aguascalientes, San Luis Potosí, and Durango) during the Classic period (AD 200–900) have interested archeologists, geographers, and geologists for more than 40 yr. Several scholars have posited that Mesoamerican peoples colonized these semi-arid highlands after an increase in annual rainfall allowed farming in a region that was previously too arid (Armillas, 1964; Palerm and Wolf, 1957). The abandonment of the zone by AD 900 is attributed to drought that caused significant environmental degradation, still visible today.

These ideas have significantly affected interpretations of Mesoamerican culture history (e.g., Gunn and Adams, 1981; Coe, 1994; Braniff and Hers, 1998). Subsequent research to test this hypothesis of decreased rainfall for the northern frontier zone in the Late Classic period has been carried out primarily in central and west Mexico. A pattern of increased aridity and significant anthropogenic impacts is observed for the Late Classic to Early Postclassic periods at a number of sites, particularly the Pátzcuaro and the Upper Lerma Basins (Metcalfe et al., 1991; O'Hara et al., 1993; Sugiura et al., 1994; Fisher et al., 2003). This pattern is also reported at sites in southern Guanajuato that border the western portion of the northern Mesoamerican frontier zone (Metcalfe et al., 1989; Metcalfe and Hales, 1994; Metcalfe et al., 1994). In contrast, pollen data from Hidalgo in the eastern portion of the frontier zone do not indicate increased aridity in the Late Classic (Conserva and Byrne, 2002). The few investigations carried out north of the Rio Lerma-Santiago indicate little evidence for climate change but significant evidence that anthropogenic impacts have had long-term effects on these northern landscapes (Brown, 1992; Frederick, 1995).

Thus, further investigation is necessary to evaluate the role that climate played in the cultural development of northern Mesoamerica, with a combination of paleoecological and archeological data collected from the frontier zone itself to control not only for regional climate changes but also for the localized effects of human land use, which can mitigate difficult climatic conditions. To this end, we present an alluvial record covering the past 4000 yr of landscape and cultural change in the Malpaso Valley of southern Zacatecas. Through settlement survey, geomorphology, environmental magnetism, and phytolith analysis of the alluvial record, we seek to understand how

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the landscape of the valley has changed throughout the Prehispanic and historic/modern periods, and when the most significant changes occurred. If the hypothesis of rainfall driving settlement is true, the data should indicate higher rainfall leading up to the Classic period occupation of the Malpaso Valley and drier conditions correlating with its later occupation and collapse. We also investigate the degree to which environmental change in the valley was the result of large-scale, regional climate change and to what degree it resulted from localized human land use.

Environmental background

The Malpaso Valley (22°25′N, 102°50′W) is located 2000 m amsl in the basin and range province of northwestern Mexico within the modern state of Zacatecas (Fig. 1). A northern tributary of the Río Lerma-Santiago, the valley is dissected by several perennial drainages and formed from uplifted rhyolite domes, ash flow tufts, and excised rhyolite plugs. Valley topography includes steeply sloped sides grading to a gently sloped floodplain. Today precipitation decreases progressively to the north with a mean annual rainfall of about 400 mm (Secretaría De Programación y Presupuesto, 1981). Rain-fed farming is undertaken, but pronounced precipitation fluctuations, both excesses and deficiencies, create agricultural difficulties.

The valley lies at a transition from Chihuahuan Desert to low mountain steppe including riparian, crassicaulescent scrub grassland, and piedmont zones (Matson and Baker, 1986; Rzedowski, 1981). Today mesquite (*Prosopis* sp.), acacia (*Acacia farnesiana*), and nopal cactus (*Opuntia* sp.) are the only arboreal species except in the floodplain, where cottonwoods (*Populus* sp.) and willows (*Salix* sp.) occur. The nearest pine forests are approximately 25 km to the east in the Sierra Fría Mountains.

Only one prior study of paleoenvironmental proxies has been published for the Malpaso Valley (Trombold and Israde-Alcantara, 2005). Analyses of pollen, phytoliths, and diatoms from sediment collected from man-made terraces on the southeast edge of the valley's principal center, La Quemada, suggest maize and agave were grown here, irrigated with water carried from the river below. Although the study lacks chronometric dating to confirm these deposits are Prehispanic, the assemblage of grass short-cell phytoliths suggests an arid environment that remained stable through time and likely reflects the Epiclassic period (AD 500–900).

Summary of prehistory

The Malpaso Valley was dominated in the Classic period by La Quemada, the best known example of a large frontier ceremonial center with associated clusters of habitation sites. The La Quemada polity also includes more than 200 much smaller settlements in a 10×12 km area (Trombold, 1991). The site of La Quemada is 40 ha in extent; the next largest is Los Pilarillos at 5 ha, strongly suggesting a degree of political centralization. The settlement system is maximally three-tiered with estimates for the total valley population ranging between 2500 and 9155 (Nelson, 1995; Trombold, 2005).

Research within the valley has characterized the nature, timing, and spatial extent of occupation, making the region an ideal place to examine climatic flux and socio-landscape evolution (Elliott, 2005;

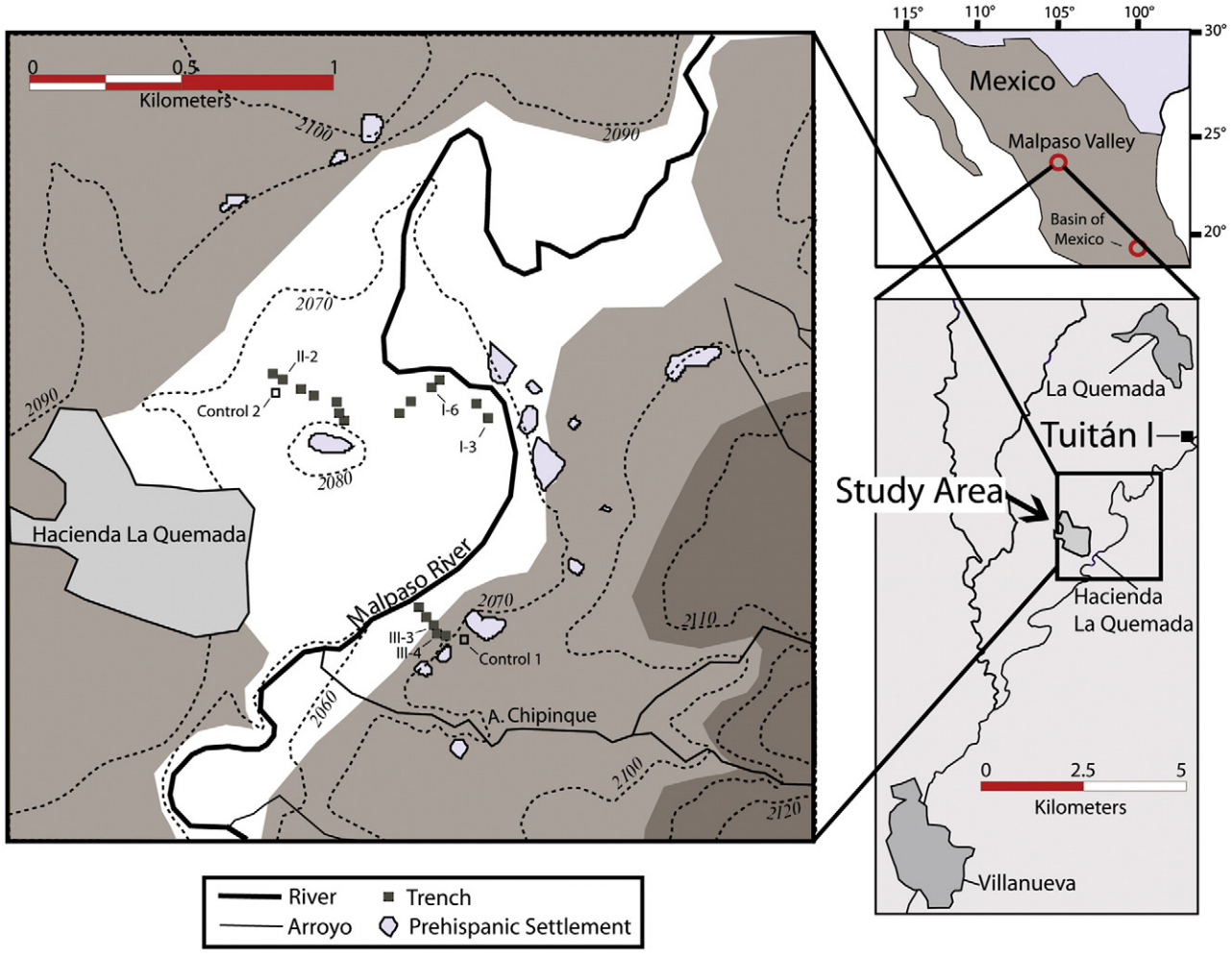

Figure 1. Location of the Malpaso Valley and the study area.