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Millennial-scale cycles of aridity as a driver of human occupancy in central Spain?

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ABSTRACT

Human settlements around the fluvial wetland of Las Tablas de Daimiel (central Spain) have been related to the water availability in this area for nearly 5500 years; however the relationship of the hydrology of the wetland to climate change remains uncertain. Whilst archaeological and pollen data provide contradictory arguments, statistical empirical mode decomposition of geochemical data from core S-1 reveals arid periods *ca.* 1.8 cal. ka BP, *ca.* 3.3 cal. ka BP and *ca.* 5.5 cal. ka BP between which periods both Bronze Age and Iberian-Roman settlements developed. These periods can be identified in other records of the Iberian Peninsula and around the western Mediterranean. Comparison of these records points to a complex spatial pattern that evolved in time and, despite a number of forcings (volcanism, solar activity, atmosphere-ocean interactions) being invoked to explain such periods, there is no clear mechanism to explain their spatial pattern and the changes that have taken place since 2.5 ka BP.

1. Introduction

The relationship between climate change and the rise or fall civilizations has been attracting the interest of the general public and researchers for a long time (Weiss et al., 1993; Binford et al., 1997; Cullen et al., 2000; Stanley et al., 2003; Staubwasser et al., 2003; An et al., 2005; Bar-Matthews and Ayalon, 2011). Bond cold events (Bond et al., 1997, 2001) or rapid climate changes (RCCs) (Mayewski et al., 2004) are representative of these episodes that took place during the Holocene.

However, the heterogeneous distribution of the records and their different time scales or resolution, among other factors, make it difficult to estimate the representativeness in time and space of such events and their frequency (Mayewksi et al., 2004; Wanner et al., 2015) and obtain tools for prediction. Consequently, more information is necessary to be able to understand these patterns and their controlling mechanisms.

Human occupancy in central Spain, during the mid-to-late Holocene, occurred under wetter conditions than today but with fluctuating conditions of water availability.

Geochemical data derived from sediments can provide valuable information about the hydrological conditions of the basin that can be used for climate reconstruction. In this paper, we derive this palaeo-hydroclimatic information from wetland sediments and we analyse their temporal structure in the millennial time scale for the last 5500 years in central Spain. This region is rich in settlements linked to water courses and we explore their relationship with hydroclimatic periods. In addition, we compare this record with other records around the western Mediterranean to determine the spatial extent of these periods and relate them to regional and global climatic episodes during the Holocene. We tentatively compare our resulting series with global forcings in order to determine if there is a clear relationship between these forcings and the local signal or, on the other hand, if more complex processes should be invoked.

2. Study area

The Las Tablas de Daimiel National Park is a Mediterranean fluvial wetland located at 605 m a.s.l. in central Spain (Fig. 1a). From

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a geological point of view, the wetland is near the northern boundary of the morphostructural unit of the Mancha Plain, of Pliocene age, which is mostly composed of limestone and marls. In detail, the reliefs to the north of the wetland are composed of quartzite and schist of Ordovician age surrounded by alluvial and colluvial gravel deposits with some sparse carbonate crusts of ages ranging from Pliocene to Holocene that supply the clastic material. The wetland itself is encased upon karstified limestone of Pliocene age or Pleistocene fluvial terraces of siliciclastic composition (Mediavilla et al., 2013a).

Until 1983, the wetland was fed, from the NE, by the Gigüela River (sulphated waters) and, from the SE, by the Guadiana basin groundwater and other small rivers (carbonated waters). As result of the combination of these water supplies and the low slope of this area the water flow slowed enough to generate wetlands with an annual renewal of water (both surface and groundwater). Since 1984, due to intensive water abstraction, the groundwater table has become disconnected from the surface and the water supply to the wetland has come from the scarce water of the Gigüela River, rainfall and human regulated supplies (from wells and channels) (Mediavilla et al., 2013a).

The climate is continental Mediterranean, with an average annual precipitation of 412.6 mm and annual average temperature of 14.3 °C (for the 20th century), with dry, hot summers and cold winters. The marked seasonality is responsible for the strong fluctuations shown by the water table of the wetland (data supplied by the Spanish Meteorological Agency, AEMET; Santisteban and Mediavilla, 2013).

Present vegetation is dominated by heliophytes, mainly *Phragmites australis*, *Claudium mariscus* and *Typha domingensis*, distributed across the banks and in some patches within the wetland, in the 'tablas' (open water zones with a depth from centimetres up to 4 m) dense masses of charophytes appear, and the surrounding areas are dominated by Tamarix, halophytes and crops composed mainly of grapevines, olives and cereals.

Three main sub-environments make up the wetland: 1) mudflats related to the Gigüela River, where clay and gypsum carried by the surface waters are the main components, 2) vegetated margins

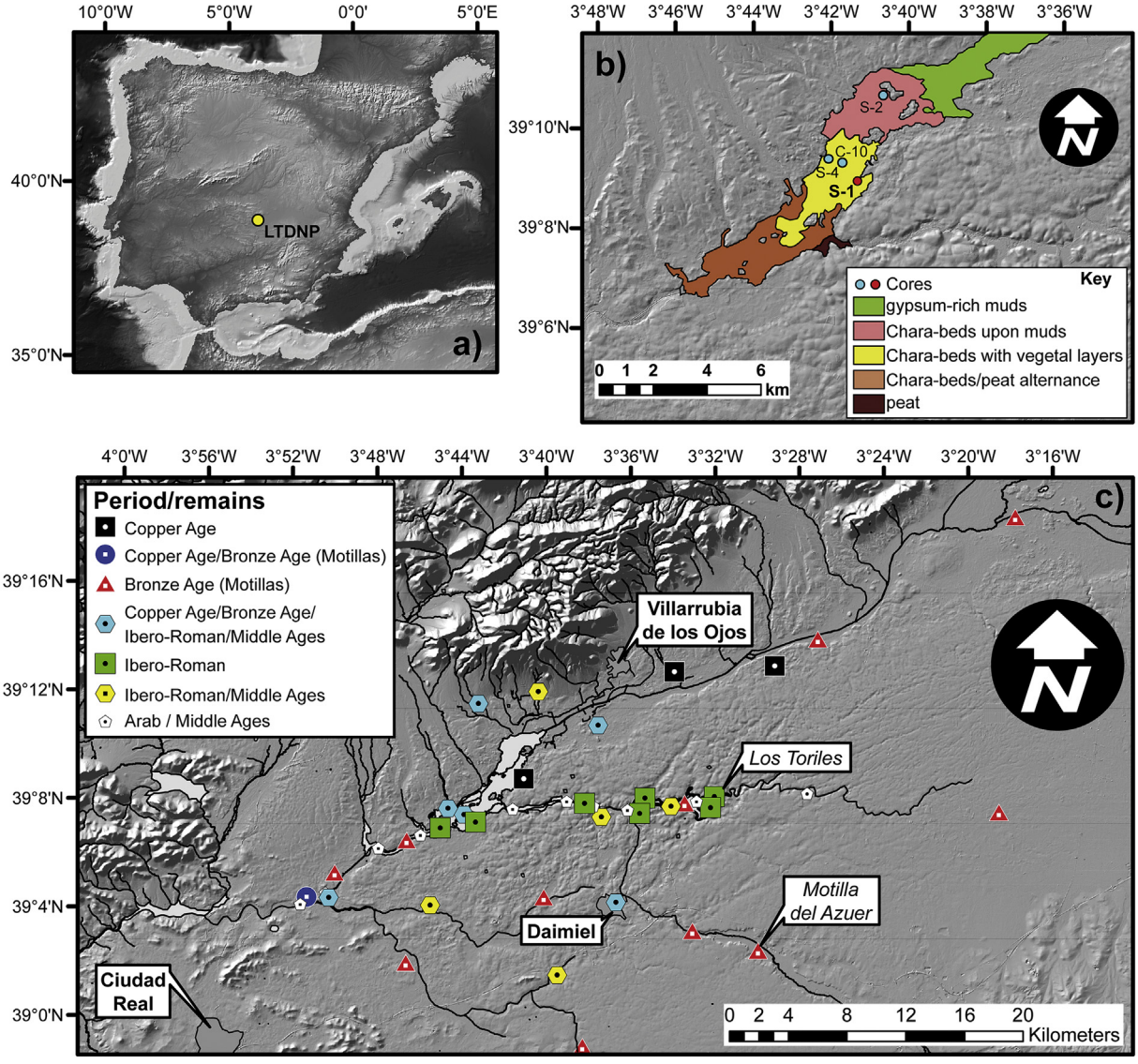

Fig. 1. a) Location of Las Tablas de Daimiel National Park (LTDNP). b) Present day distribution of surface sediments and location of cores mentioned in this paper (S-1: main core; S-2, S-4 and C-10: cores used for developing the age model). c) Settlements from the Copper Age up to the Middle Ages in relation to water courses.