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Palaeoenvironmental reconstruction based on charophytes and sedimentology: Can the mid-Holocene Optimum be recognised in western Argentina?

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ABSTRACT

We sought to recognise to which extent the mid-Holocene Optimum can be identified in the Río Jarilla region of western Argentina, situated at the boundaries of the South American Arid Diagonal. The palaeoenvironmental conditions of the Arco del Desaguadero Formation, formed by a sedimentary sequence of late Pleistocene to middle Holocene age, were reconstructed based on charophyte assemblages and sedimentology. Three fluvio-lacustrine cycles were recognised with evaporitic layers at the top of each, reflecting the high temperatures that characterise the Holocene. For the second cycle, three ^{14}C dates were obtained, ranging from ca. 11 to 7 ka BP which, together with sedimentology and the palaeontological record allowed us to infer a warm and semiarid period assigned to the mid-Holocene Climatic Optimum. The gyrogonites found in the sediments belong to *Chara* cf. *contraria*, *Chara* cf. *papillosa*, *Chara halina* and *Chara hornemannii*, species related to extant species from Argentina. The presence of *C. hornemannii* imbedded in sedimentary rocks (evaporites) reflects higher temperatures in the past, although further research is needed to establish the significance of this species for reconstructing Quaternary climate.

1. Introduction

The reconstruction of Late Pleistocene and Holocene environmental variability across the key climatic boundary of the Arid Diagonal in South America is poorly understood (Fig. 1A). Although the last decade has seen an increase in palaeoclimatic studies in South America, continuing palaeoenvironmental research clearly shows the necessity to analyse past climate variability from a more regional perspective (Piovano et al., 2009). Climatic changes during Late Pleistocene and early Holocene affected the characteristics of sedimentary deposits of the fluvial basins directly connected with the Andes, and therefore related to deglaciation of central west Argentina.

In southern South America, climatic archives show a complex pattern of timing and even antiphase climate responses. For example, arid conditions have been proposed for western Argentina, during the middle Holocene. By contrast, for the Pampean region, Iriondo and García (1993) suggested warm and moist conditions from 8 to 3.5 ka with the development of a mid-Holocene Optimum soil. The Desaguadero-Curacó-Salado basin (our study area) is situated in central western Argentina, where the palaeontological record is poor compared to that of the Pampean region and mostly confined to fluvio-lacustrine systems. Accordingly, multiproxy data are necessary for a more accurate understanding of the region's past climates. This study investigates the sedimentology and charophyte associations from the Río Jarilla section in order to reconstruct the palaeoenvironmental history of central western Argentina.

Charophytes inhabit most types of non-marine habitats, from fresh to hypersaline waters, between the coast to inland lakes and they are sensitive to environmental change. Each genus and species can indicate different ecological conditions, such as ephemeral or permanent waterbodies, pH, depth, temperature, substrate types, and principally salinity (García, 1994). The aim of this work is to

Abbreviations: AD, Arid Diagonal; AMS, accelerator mass spectrometry; OM, organic matter; RJ, Río Jarilla.

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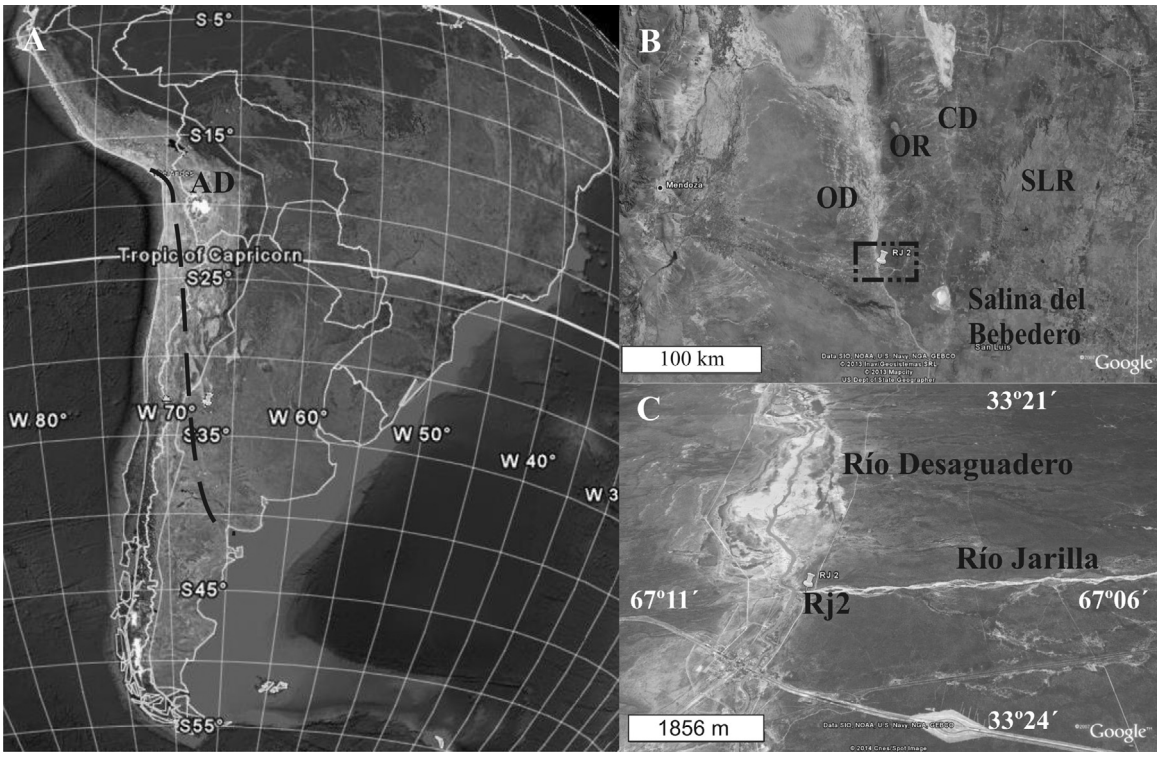

Fig. 1. (A) Position of the South American Arid Diagonal (AD). (B) Geomorphological units. Occidental depression (OD), Occidental range (OR), Central depression (CD), San Luis range (SLR) and study area (within the square). (C) Detail of the study area, with latitude and longitude coordinates.

recognise whether the mid-Holocene Optimum from this area of central-west Argentina can be characterised by reconstructing the palaeoenvironmental conditions inferred from charophytes and sedimentological evidence.

2. Materials and methods

2.1. Study site

The study area forms part of the arid-semiarid region of central west Argentina (Fig. 1A and B), which according to its vegetation communities is considered an ecotone between the Chaco and Monte-Espinal provinces, in the Chaco domain (Cabrera, 1976) assigned to the Occidental Plains by Costa et al. (2001). The terrain is flat, only interrupted by the channel and aggradational plains of the Río Desaguadero, which flows from north to south. The outcrop studied is located at the Junction of the Río Desaguadero and the Río Jarilla which originates in the western Sierras Pampeanas and flows westerly (Fig. 1C). The Río Desaguadero has been the major fluvial system of the Central Andes throughout the Quaternary (last 2.6 Ma) and constitutes the main sediment-transport system from that region to the Atlantic Ocean. Currently, the climatic conditions are arid to very arid, with the volume of water transported by the river being small, with insignificant flow and, at times, the river is completely dry. However, sedimentological, stratigraphical and geomorphological data indicate that were periods, particularly in the Pleistocene, when the volume of water was similar to that of the current Río Paraná, which rises in Brazil and flows along the eastern margin of Argentina to join the Río de La Plata, which has an average flow of 17,100 m^3/s (Bello et al., 2009). The Río Desaguadero, fed by snowmelt precipitated in the Andes by direct influence of the Pacific Anticyclone, is at present 1518 km long, and occupies a basin area of 248,000 km^2 extending from ~27°35″ S to ~38°50″ S.

The study site is located within the Arid Diagonal (AD) (Fig. 1A), a narrow band in South America with precipitation less than 250 mm/year which extends from Ecuador (west coast) to the Patagonian Atlantic coast (Argentina, east coast). The AD is at the boundary or transition between two different atmospheric circulation systems driven by the Atlantic and Pacific dominant moisture sources. Numerous palaeohydrological reconstructions suggest dominantly wet conditions during cold phases in regions located west and south of the AD, like Patagonia or the Central Andes, with a dominant Pacific source of moisture. During the same climate phase, dry conditions have been proposed across the subtropical lowlands east of the AD, under the influence of an Atlantic summer precipitation regime. Conversely, extensive dryness across Patagonia and wet conditions in the Pampas can be inferred during warm climate phases (Piovano et al., 2009).

2.2. Methods

A stratigraphic survey of the basin was performed during several fieldtrips, with the analyses of an outcrop from Río Jarilla. Palaeontological sampling was performed each 10 cm through the profile and 200 g of sediment were washed with tap water through 500 μm, 250 μm and 125 μm sieves and dried at ambient air exposure. All gyrogonites that were complete or almost complete (lack of apex) were isolated by picking, analysed by stereoscopic microscope and a few specimens separated for scanning electron microscopy (SEM) undertaken at the Laboratorio de Microscopía y Microanálisis (LABMEM), Facultad de Química, Bioquímica y Farmacia, Universidad Nacional de San Luis (UNSL). The systematic recognition of gyrogonites was made using the contributions of Soulié-Märche (1989) and García (1990, 1993a, b, 1996, 1999).

All charophyte species recognised had extant representatives, so reference information about some of the ecological factors affecting their distribution was available. The salinity classification of waters proposed by Hammer et al. (1983) was used, who considered fresh as 0–0.5 $g\,L^{-1}$, subsaline as 0.5–3 $g\,L^{-1}$, hyposaline as 3–20 $g\,L^{-1}$, mesosaline as 20–50 $g\,L^{-1}$, and hypersaline as >50 $g\,L^{-1}$. Gyrogonite