

The Holocene Climatic Recovery in South-Western Iberia as Recorded in Limestone Tuff Deposits

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Abstract Data on continental limestone shows that following the cold climate of the Younger Dryas stadial, conditions for carbonate sedimentation settled in south-western Iberia, leading to the development of the Asseca River (Tavira) limestone tuffs. This formation, deposited over a period of ca. 7.5 kyr, preserves a detailed record of the climatic conditions of the area as well as of the vegetation cover.

Keywords Holocene · Climate · South-western Iberia

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Introduction

In south-western Iberia (Algarve), several deposits of continental limestones are found. Between Loulé (Guerreiro et al. 2011, 2013) and Tavira (Ribeiro et al. 2009, 2011), multiple examples of pedogenic calcretes have developed on top of the Mesozoic sedimentary formations as well as on fluvial carbonate deposits. The fluvial deposits correspond to the development of limestone tuffs or the cementation of siliciclastic sediments.

The mineralogy of the limestone tuffs is dominated by the presence of the calcite, with some iron oxides, clay minerals, and quartz, being essentially inherited from the clastic fluvial sediments exposed along the streams. This mineralogy is suitable for the use of stable isotopes (carbon and oxygen) as a proxy for past climatic conditions (Pentecoste 2005).

The Asseca River, near Tavira, is a W–E-trending stream running along the contact between the lower Mesozoic sediments from the Algarve Basin and the upper Carboniferous metasediments from the South Portuguese Zone. The northern slope is carved into the upper Carboniferous metasediments whereas the southern slope is carved into the Mesozoic sediments. Along the river, the carbonate precipitation has led to the development of three dams that constitute morphological features where the flow of the water increases. In all three dams, the limestone tuffs have layers of centimetric to decimetric width that result from seasonal precipitation. Upstream of each dam, a low-energy pond has developed, in which fine-grained, clay-rich sediments have been deposited.

This continental formation was studied from a multidisciplinary perspective to establish: (1) a detailed petrographic and mineralogical characterization (using SEM–EDS, X-ray diffraction, and confocal RAMAN spectroscopy); (2) a characterization of the pollen content; (3) a characterization of the malacofauna assemblages present in the associated mudstones; (4) an exhaustive analysis of the stable isotope signature of the carbonate fraction; and (5) radiocarbon dating of the limestone tuffs. A broad picture of the climatic evolution in this region during the period of active limestone tuff deposition and its influence on the living communities was attained by synthesising all the aforementioned data.

Results

The mineralogical and petrographic results for the limestone tuffs can be summarized as follows: (1) X-ray diffraction data show that the main mineralogical component is calcite, with quartz and clay-minerals also present as minor constituents; (2) the calcite usually grows in millimetre-scale regular bands due to its seasonal precipitation; (3) sporadically, textures due to microbial activity are found, pointing to the importance of biological mediation on the precipitation of carbonates in some cases; (4) a residue of organic molecules (RAMAN data) of

dark colour is commonly preserved between the calcite layers, attesting to periods of particular high productivity in the system.

The pollen content of the limestone tuffs is uniform through the entire stratigraphic sequence, indicating an array of vegetation similar to the current. The slopes of the valley were occupied by a typical meso- to thermo-Mediterranean association comprising *Quercus faginea*, *Olea europaea sylvestris*, *Ceratonia siliqua*, *Quercus coccifera*, *Arbutus unedo*, *Pistacia lentiscus*, *Phillyrea*, *Jasminum*, *Rhamnus*, *Daphne gnidium*, and *Erica arborea*, whereas the low and more humid areas were covered by *Alnus glutinosa*, *Fraxinus*, *Salix*, *Frangula alnus*, *Vitis*, *Myrica*, and *Nerium oleander*. In close association with the fluvial system, several aquatic genera were identified: *Lemna*, *Callitriche*, *Ranunculus*, *Asplenium*, *Botrychium*, *Filicales*, *Alisma*, *Lotus*, *Myosotis*, and *Isoetes* (Queiroz and Mateus 2011).

The carbon stable isotope record of the limestone tuffs is remarkably homogeneous throughout the stratigraphic sequence, ranging between -10 and -7.5 ‰ (PDB) with no trend of regular increase or decrease in the $\delta^{13}\text{C}$ values. This is due to the homogeneity through time of the two main sources of carbon to the system, namely, the Mesozoic formations and the vegetation cover.

The oxygen stable isotope record presents values between -5.3 and -2.8 ‰ (PDB) with a slight but regular increase towards the top of the limestone tuff sequence as revealed by decomposition of the time series. Accompanying this trend is a remarkable increase in the dispersion of the data, with more marked transitions between the positive and negative peaks.

Radiocarbon dating of the stratigraphic sequence points to a time interval for the sedimentation of between 10.2 and 2.6 ka. These results on the age of the Asseca River limestone tuffs point to the existence of stable conditions for the carbonate sedimentation for a period of 7.5 kyr during the climatic recovery following the Younger Dryas cold period.

Acknowledgments This work was supported by the FCT funding to the project HOLOCLIMA (PDTCT/CTE-GEX/71298/2006). C. Ribeiro acknowledges the funding provided by the Évora Geophysics Centre, Portugal, under the contract with FCT, PEst-OE/CTE/UI0078/2011.

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Chemoschimidica Acta 73(13), A1096–A1096. 19th Annual Goldschmidt Conference, Davos.
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Ribeiro, C., Terrinha, P., Voelker, A., Candeias, A., Azevedo, M. R., Ribeiro, S., & Rosado, L. (2011). Climate change towards more arid conditions in SW Iberia during the Holocene. *Geophysical Research Abstracts* 13, EGU2011–11411, EGU General Assembly 2011, Wien.

This paper is also a contribution to the Project CAVE (PTDC/CTE-GIX/117608/2010), cofunded by Fundação para a Ciência e Tecnologia (FCT) and the European Operational Competitiveness Programme (COMPETE).