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Late Pleistocene and Holocene palaeoenvironments in and around the middle Caspian basin as reconstructed from a deep-sea core

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ABSTRACT

Late Pleistocene and/or Holocene high-resolution palynological studies are available for the south basin of the Caspian Sea (CS), the world's largest lake. However, the north and middle basins have not been the object of high-resolution palynological reconstructions. This new study presents the pollen, spores and dinoflagellate cysts records obtained from a 10 m-long sediment core recovered in the middle basin, which currently has brackish waters and is surrounded by arid and semi-arid vegetation.

An age–depth model built based on six radiocarbon dates on ostracod shells indicates that the sequence spans the period from 14.47 to 2.43 cal. ka BP. The present palaeoenvironmental study focuses on the top 666 cm, or from 12.44 to 2.43 cal. ka BP.

At the vegetation level, the Younger Dryas is characterised by an open landscape dominated by desert vegetation composed by Amaranthaceae with shrubs and salt-tolerant plants. However, although the Early Holocene is also characterised by desert vegetation, it is enriched in various shrubs such as *Ephedra* and *Calligonum*, but tree expansion is not important at the Holocene onset. After a major shift at 8.19 cal. ka BP, the Middle Holocene displays now both the character of desert and of steppe, although some trees such as *Quercus* and *Corylus* slightly spread. The Late Holocene records steppe vegetation as dominant, with more tree diversity.

Regarding the lacustrine signal, the dinocyst assemblage record fluctuates between slightly brackish conditions highlighted by *Pyxidinopsis psilata* and *Spiniferites cruciformis*, and more brackish ones – similar to the present day – with the dominance of *Impagidinium caspienense*. The Late Pleistocene is characterised by low salinities, related to the Khvalynian highstand. From 11.56 cal. ka BP, slightly more saline waters are reconstructed with an increase of *I. caspienense* for a period of 1000 years, which could be attributed to the Mangyshlak lowstand. From 10.55 cal. ka BP, low salinity conditions return with remains such as *Anabaena* and *Botryococcus* abundant until 8.83 cal. ka BP, followed by a slow, progressive decrease of *P. psilata* and *S. cruciformis* until 4.11 cal. ka BP, which is the main assemblage change at lacustrine scale. Since then, higher salinities, similar to the present one, are reconstructed. Finally, *Lingulodinium machaerophorum* starts its development only at 2.75 cal. ka BP, in the Late Holocene.

The present research revealed fundamental differences from previously published sea-level curves, in that a 6000 yr-long highstand suggested by low salinities is shown between 10.55 and 4.11 cal. ka BP. Amongst other arguments, using a comparison to a similar palynological regard but in the south basin, a N–S salinity gradient that is the reverse of the present one across the CS, suggests that the Amu Darya was flowing in the CS. Hence the CS levels during the Late Pleistocene and Holocene were influenced by a combination of precipitation over the high European latitudes and the indirect influence of the Indian summer monsoon over the Pamirs.

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1. Introduction

The Caspian Sea (CS) forms a natural geographical border between Europe and Asia at 50° east of longitude. It is the world's largest inland water body, with a current size equivalent to Norway (Fig. 1). Its level has changed dramatically over various timescales, causing rapid modifications in the volume and the area of the water body (Kazancı et al., 2004). During the 20th century, the CS water levels have fluctuated suddenly, a hundred times faster than recent global sea level rise (Kroonenberg et al., 2007). This caused serious environmental and economic damages and adversely affected oil and gas exploration and exploitation, agriculture and fishing (such as sturgeon for caviar). In addition, it caused major risks in areas used for storage of nuclear wastes and for nature conservation of international importance. Despite the importance of this area, no enough in-depth high-resolution palaeoenvironmental research has been performed on the CS sediments and the precise timing of these changes and even their causes remain not well understood yet. They have been suggested to be a combination of climate, human impact and tectonic activity (e.g. Shiklomanov et al., 1995; Froehlich et al., 1999), with a large role played by the precipitation over the Volga drainage basin (Arpe et al., 2012). However, the picture seems to be more complex, as not only the abovementioned factors affect the CS levels, but also the CS itself has an effect on the sub-tropical jet-stream speed via a lake effect on over-lake temperature, transferred to altitude. Hence its correct representation over time, especially its changing area during lowstands (such as the Mangyshlak lowstand at the beginning of the Holocene) and highstands (such at the Late Khvalynian highstand during the last period of melting of the Eurasian icesheet), in the general circulation models is essential (Farley Nicholls and Toumi, 2013).

The rare studies available so far on the palaeoenvironment of the CS during the Late Pleistocene and Holocene have been made on coastal sequences (e.g. Leroy et al., 2013a and references in it; Richards et al., in press) or in the shallow North basin (Bezrodnykh et al., 2004) and suffer from deposition hiatuses during periods of low sea levels and sedimentation starvation. Only one sequence provides continuous pollen and organic-walled dinoflagellate cysts (dinocyst) records of changes in the south basin from the Late Pleistocene to the Middle Holocene (Leroy et al., 2013c). Hardly anything is known for the middle basin, besides a preliminary pollen study by Kuprin and Rybakova (2003), but with a timescale based on a chronology built from bulk radiocarbon dates. No palynological studies (pollen and dinocysts) have been carried out on continuous, long sequences in the north basin.

The aim of this investigation is to partially fill this research gap by reconstructing changes in terrestrial vegetation and lake levels, mostly via salinity changes, that occurred in the middle basin of the

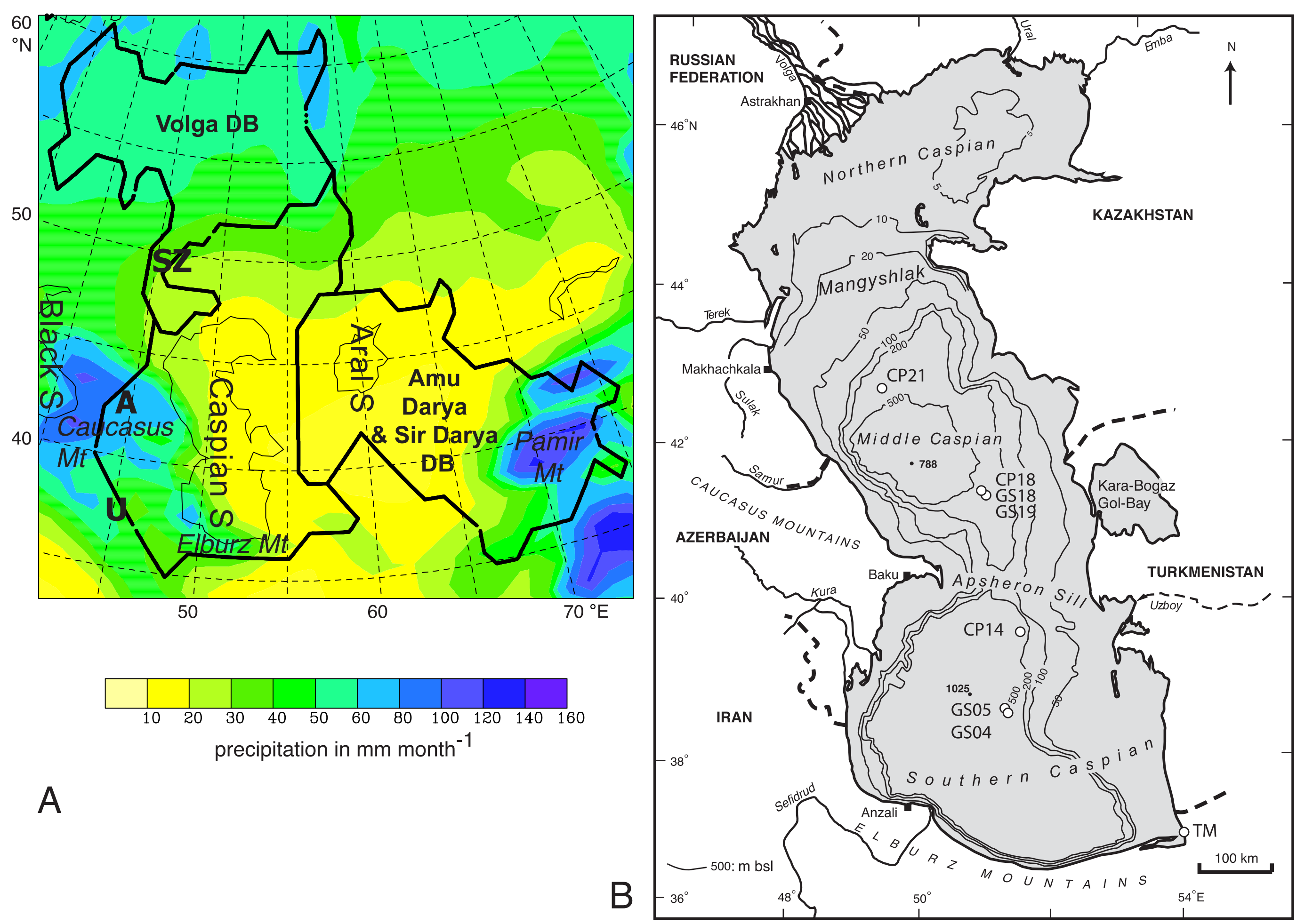

Fig. 1. Location map of the main inflows to the Caspian Sea (1A) and the cores (1B). For 1A: Black dashes lines are borders. Grey lines are rivers, continuous line for permanent, dashed line for temporary, SZ: Lake Solenoye Zaimishche, A: Lake Aligol, U: Lake Urmia, DB: drainage basin, S: Sea, Mt: Mountain. For 1B: Grey circles for core locations. Adapted from: Leroy et al. (2013c).