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HOLOCENE LACUSTRINE CARBONATE FORMATION: OLD IDEAS IN THE LIGHT OF NEW RADIOCARBON DATA FROM A SINGLE SITE IN CENTRAL HUNGARY

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ABSTRACT. Lacustrine carbonate deposition in Hungary has been traditionally interpreted as the outcome of the dry, hot climate prevailing between 7500 and 5000 ^{14}C yr BP (hereafter BP) (~6400 and 3800 BC), triggering the partial desiccation of minor ponds and lakes. A comparative analysis of 5 ^{14}C results from the site of Csólyospálos, central Hungary, with those of other Hungarian lacustrine carbonates yielded stunning new results. According to these new dates, carbonate deposition must have initiated much earlier, possibly around 10,000–11,000 BP (9500–11,000 BC) in the Carpathian Basin. Furthermore, the formation of lacustrine carbonates must have come to an end at very different times in different parts of the basin, contrasting previous views on the uniform and synchronous cessation of lacustrine carbonate formation in Hungary. According to the newest results presented here, carbonate deposition in the southern and southeastern parts of the basin ceased around 6000 BP (~4900 BC). Meanwhile, in the central parts, deposition continued as long as the terminal Bronze Age (~1300 BC).

INTRODUCTION

The deposition of lacustrine marls and formation of freshwater carbonates have been traditionally linked to the Boreal phase of the Early Holocene in Hungary. This was based on assumptions that the dry, hot climate of the Hazelnut stage (between 7500 and 5000 ^{14}C yr BP; hereafter BP) favored a partial desiccation of minor ponds, leading to the precipitation of carbonates and the formation of extensive lacustrine carbonate beds (Mucsi 1963).

The first ^{14}C studies, implemented on samples of buried lacustrine carbonates in northeast Hungary (Bátorliget; see Figure 1), yielded the first comprehensive paleoecological, sedimentological, geochemical, and environmental historical results—and brought highly contrasting results (Sümegi and Gulyás 2004). From this time onward, the formation of these sequences could not have been unequivocally linked to the Boreal phase of the Holocene. In addition, the partial desiccation of minor ponds in Hungary could not have been blamed for the formation of lacustrine marls alone. In order to corroborate these initial assumptions, new sites were investigated from the central and western parts of the Carpathian Basin. The present study details the findings from one of these sites in central Hungary and tries to put the newly gained information into a wider context to corroborate or refute the initial presumptions mentioned earlier.

MATERIALS AND METHODS

A comparative chronological analysis of a lacustrine carbonate sequence was carried out based on recently obtained ^{14}C results. The sequence is found in the vicinity of the village of Csólyospálos in the central part of the Great Hungarian Plain (Figure 1). A general geological plan of the site of Csólyospálos is shown in Figure 2. The site itself is located in a small sandy depression among the hummocks of the plains. Here, the bedrock is derived from Pleistocene wind-blown sands overlain by sandy lacustrine carbonates and lacustrine marl of Holocene age. In some cases, the precipitated lacustrine marl was transformed syngenetically into magnezito-calcite or dolomite. The samples derive from the geological profile created at the site (Figure 3).

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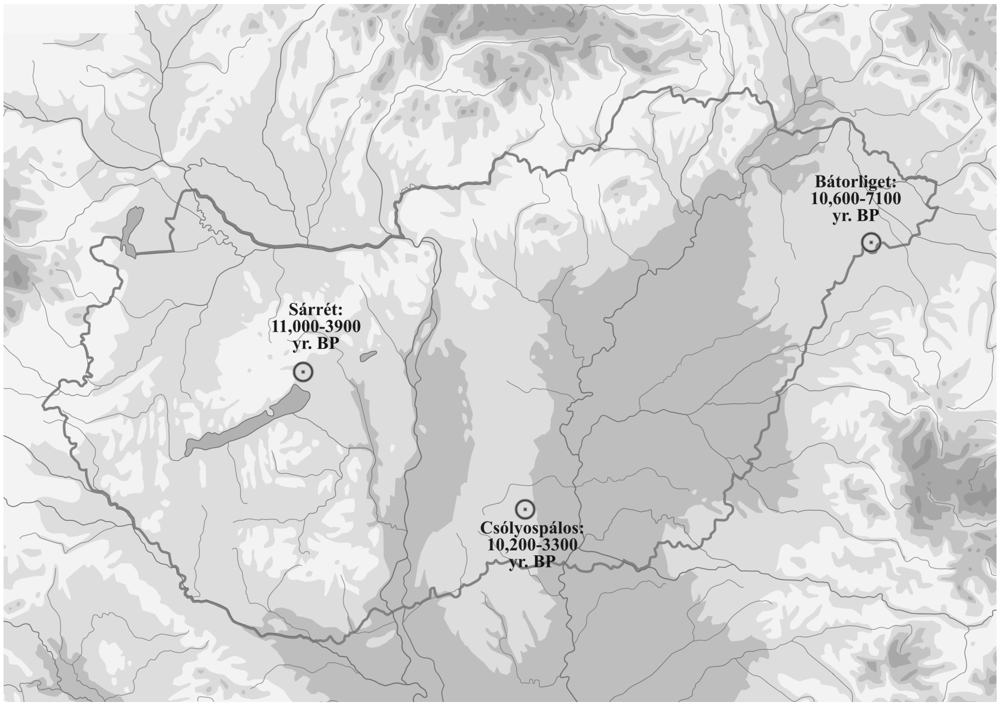

Figure 1 Geographical location of the studied lacustrine carbonate sequence and other sequences mentioned in the text, with the approximate ^{14}C dates of the cessation of carbonate precipitation.

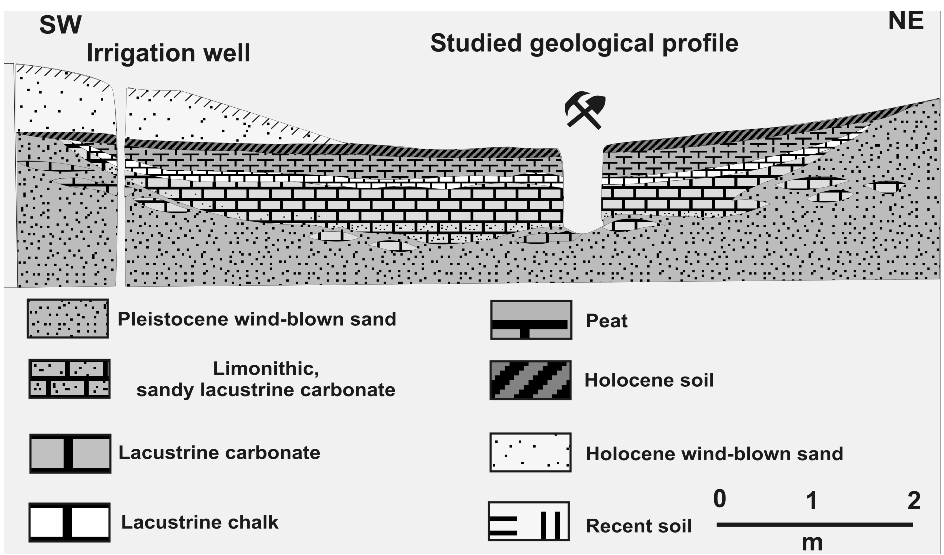

Figure 2 Geological profile of the Csólyospálos outcrop

^{14}C measurements were obtained from the Laboratory of Environmental Studies of the Institute of Nuclear Research of the Hungarian Academy of Sciences in Debrecen, Hungary (lab code: Deb). Twenty grams of cleaned mollusk shells were used. Shell fragments were boiled in distilled water and cleaned with diluted H_2O_2 before the acid pretreatment (Hertelendi et al. 1989, 1992). The physical parameters and the steps of ^{14}C measurements on carbonates using the gas proportional counting (GPC) technique are detailed in Hertelendi et al. (1989). In order to minimize or eliminate the bias deriving from the presence of exogenous carbonate, only herbivorous gastropod shells of *Helix lutescens*, *Cepaea vindobonensis* (Frömming 1954; Grime and Blythe 1969), and those of the bivalve *Pisidium* have been used, in accordance with the proposal of Preece (1991), to avoid carbon derived from sources not in isotopic equilibrium with the surface seawater. It is important to emphasize that none of the ^{14}C measurements implemented on mollusks and charcoal deriving from Hungarian profiles dating to the end of the Quaternary yielded controversial dates, i.e. younger ages within the deeper parts of the sections. Furthermore, the multiple measurements of samples deriving from several horizons of the individual profiles yielded reliable dates after comparison with each other (Sümegi 1989; Hertelendi et al. 1992; Sümegi et al. 1992; Szöőr et al. 1992; Krolopp et al. 1995). Consequently, mollusk shells retrieved from freshwater carbonates and carbonate muds seem to be suitable for ^{14}C measurements and dating temporal alterations within the embedding geological profiles or sediments.

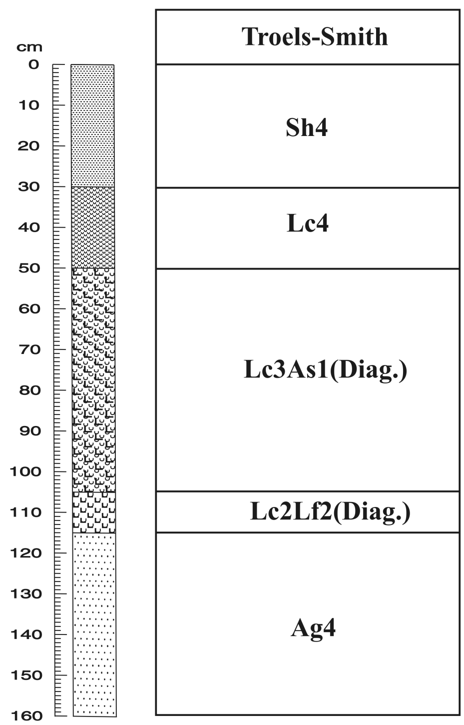

Figure 3 The studied geological profile

The dates were calibrated with CALIB v 4.0 (Stuiver and Reimer 1993) (Table 1). The previously gained paleoecological findings as well as environmental historical reconstructions regarding the time and causes of lacustrine carbonate formation were reinterpreted in light of these new ^{14}C dates and the calculated sedimentation rates.

Table 1 ^{14}C dates from the outcrop of Csólyospálos.

Lab code	Depth (cm)	^{14}C age (BP) (1 σ)	cal BC
Deb-2635	30–40	3391 ± 80	1890–1490
Deb-1067[a]	60–65	8040 ± 200	7600–6500
Deb-3303	70–75	8603 ± 90	7950–7480
Deb-3282	80–85	8747 ± 70	8200–7550
Deb-3290	90–85	9237 ± 80	8640–8270
Deb-3286	105–115	10,119 ± 81	10,400–9350

[a]From Szöőr et al. (1992).

RESULTS

According to the detailed ^{14}C analyses, the accumulation of carbonate sediments in the lacustrine basin of Csólyospálos must have begun in relatively deeper and colder waters between 9500–11,000 BC (10,000–11,000 BP) (Table 1). By about 8400 BC (~9200 BP), the terrestrial habitat had been highly altered; it was accompanied by a similarly large-scale change in the aquatic habitat around 7500 BC (~8500 BP). These alterations are characterized by an expansion of plant taxa dwelling in deciduous woodlands and an increase in water temperatures—reaching values similar to modern summer temperatures—for the majority of the growth season (Sümegi 1989, 1996, 2004; Sümegi et al. 2005). This milder climate must have been preserved until ~3800 BC (~5000 BP) and was followed by a relative cooling. Parallel with these climatic changes, an intensification of erosion accompanied by a more rapid shoaling of the pond could have been observed in the studied area from the Late Neolithic (around 3000 BC) (Hertelendi et al. 1996; Bálint 2003; Sümegi et al. 2005). Precipitation of calcareous muds must have continued until the end of the Bronze Age (~1300 BC). The end of the Bronze Age also marked the complete cessation of lacustrine carbonate precipitation in the pond of Csólyospálos. Furthermore, the appearance of tell cultures and a more dense population, as well as the technical advancement of agricultural production, must have initiated an intensified and more rapid soil erosion, contributing to an increase of the organic content of the sediments accumulating in the lacustrine basin and, thus, the cessation of carbonate formation in this area (Csányi et al. 1992; Poroszlai 1988, 1992).

According to the earliest of the ^{14}C dates, the formation of lacustrine marls composed of dolomite, magnezito-calcite, and calcite must have begun between 9500 and 11,000 BC (10,000 and 11,000 BP) in the central parts of the Carpathian Basin. While the precipitation of lacustrine carbonates was exchanged by the deposition of eutrophic, clayey, silty lacustrine sediments around 6000 BP (~4900 BC) in the southern and southeastern parts of the basin (Figure 1) (Sümegi and Gulyás 2004; Sümegi et al. 2005), this process came to an end only at a later stage here. In the site of Csólyospálos, as shown by our new results, the deposition of carbonates ceased only during the terminal Bronze Age (~1300 BC).

CONCLUSION

The new ^{14}C results refute traditional assumptions that the start of lacustrine carbonate formation in Hungary must be linked to the dry, hot climate of the Hazelnut stage of the Early Holocene. As shown by our new data, the cessation of carbonate formation is also diachronous within the area of Hungary. The cessation of carbonate formation in smaller ponds covering an area of a couple of hectares can be linked to the appearance of the first food-producing human communities, triggering intensified soil erosion and acidification of water bodies. In the southern, southeastern, and northeastern parts of the country, where more fertile soils are found, this process was relatively rapid, leading to an early cessation of lacustrine marl precipitation by ~6000 BP (~4900 BC). In the area of the Danube-Tisza interfluve, located in central Hungary and characterized by less fertile soils, this process ended only at a later stage, during the terminal Bronze Age (~1300 BC). Here, the water bodies also tended to be larger in expansion than in the other areas of Hungary. Thus, the acidification attributable to the transportation of eroded organic matter and soils into the lacustrine basins must have been much slower as well.

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