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# Stable isotope geochemical and petrographic studies on travertines from Tata, Porhanyó-Quarry (Hungary)

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In the area of the Tata town (Hungary) there are several Quaternary travertine outcrops of which the Porhanyó-Quarry is the best exploited one. The former archaeological studies of the Porhanyó-Quarry resulted in the reconstruction of the Middle Paleolithic Mousterian culture of the site. The principal goal of this work is to define the depositional environment of the Tata travertine by studying the petrographical and microfacies features and stable carbon and oxygen isotope compositions.

The 15 m thick lacustrine travertine can be divided to six units. Unit 1 (14.7-12.4 m) consists of massive, thick bedded, phytoclastic travertine with some gastropods, and covered by a sharp discontinuity surface, parallel to the bedding. Unit 2 (12.4-11.8 m) comprises the archaeological „culture layer" and is build up by a palaesoil horizon at the bottom and siliciclastic fluvial channel deposits at the top. Both are rich in bones, in Palaeolithic human tools, artefacts and show fragments of charcoal. A new discontinuity surface separates the bedded phytoclastic and gastropods bearing travertines of the Unit 3 (11.8-4.5 m) from the „culture layer" (paleosoil layer). 20 to 250 cm wide, from SW to NE directed and mainly open fissures cut the rocks of Units 1, 2 and 3. Some of these fissures represent minor spring vents and cones, filled by vertically and upward conical laminated travertines. The lower boundary of the soft, laminated, phytoclastic travertine of Unit 4 (4.5-2.5 m) is formed by a new discontinuity surface, which covers the vents and cones. Top of Unit 4 is covered by the loose clastic travertine bearing horizon of Unit 5 (2.5-1.0 m), which is imbedded in fluvial-eolian sand. Eolian sand of Unit 6 (1.0-0.0 m) terminates the section.

Eighteen samples were collected from one vertical section for paleoclimatological evaluation. Besides we sampled the most typical carbonate vent as well the other carbonate like forms. Eight samples were taken from one undetermined form which can be either carbonate vent or cascade. At the same time samples were collected from Kőpite-Hill (carbonate cone?) travertine occurence which situated north from Tata town. Petroghraphic and microfacies analyses of on thinsections were performed combined with stable carbon and oxygen isotope measurements. Detailed XRD studies were conducted on bulk samples and on insoluble residue collected in the vertical section and on samples collected from the palaeosoil horizon. Paleomagnetic measurements of the vertical sections were also used to determine the timing of travertine formation.

Algal and other phytoclastic grainstone, boundstone and floatstone are considered dominant microfacies types of travertines. Among the bioclasts fragments of gastropods, ostracods and charas may occur. Travertines are composed mainly of pure, magnesium-free calcite, with traces of dolomite. Low proportion of siliciclastic insoluble residue of Units 1-4 (0,53 %) increases upward unto 2,29 % in Unit 5. Quartz, feldspar and few muscovite represent the scare extraclasts.

The depositional environment was a shallow (1-3 m), plant-dominated lake, dissected by spring cones and vents, which are indicators of the ancient spring activity. These vents appear on the wall of the quarry and NE from the quarry, next to the Öreg-lake. The lake, fed by thermal springs formed in a siliciclastic floodplain or delta system. The springs bought quartz grains with the thermal water from the Pannon siliciclastic bedrock to the surface. These grains are reversed in the centre of the carbonate vents.

The three main lacustrine phases of the lake evolution were interrupted at first by a palaeosoil formation and flooding event, followed up by an fluvial-eolian event and finally finished by eolian sedimentation. The lacustrine phases represent intensive spring activity generating relatively high water levels, while the fluvial to eolian phases are to be connected to reducted spring activity with waterlevel-drops.

Based on the stable isotope investigations the values of the samples taken from the carbonate vents ($\delta^{13}C$ (-5,34)-(-5,57 ‰) and $\delta^{18}O$ (-12,31)-(-12,87 ‰) differ from the mean isotope values of samples ($\delta^{13}C$= - 5,43 ‰, $\delta^{18}O$ = -11,40 ‰) collected from the vertical section and from samples collected from cascades ($\delta^{13}C$ (-4,9)-(-5,5 ‰) and $\delta^{18}O$ (-10,6)-(-12 ‰) relative to V-PDB. Because of the former intensive spring activity, many carbonate vent were preserved in the quarry. Among the flow path of the water outgassing and evaporation controlled the stable isotope compositions of travertines precipitated. The different facies (vent, cascade, pond) migrated during the evolution of the travertine complex due to changes in morphology and flow direction. Thus, it is not possible to use a simple vertical section to conduct paleoclimatological evaluation on the base of stable isotope measurements. However, distinct isotope compositions characterize the vent and cascade facies that can be used to study the evolution of the complex.

The Tata travertine complex ($\delta^{13}C_{mean}$= -5,3 ‰) show marked $\delta^{13}C$ difference from the travertine occurrences of the Buda Mts. (Buda-Vár-hegy: $\delta^{13}C_{mean}$= 1,5 ‰; Budakalász: $\delta^{13}C_{mean}$= 2,0 ‰), while the stable oxygen isotope compositions are the very similar. Although other processes like upwelling of mantle-derived or metamorphic $CO_2$ may also produce $\delta^{13}C$ changes, these are shown to be regionally occurring in the Carpathian-Pannonian Region, and thus, the large $\delta^{13}C$ variations at close localities (within about 50 km) are rather attributed to local effects. Presumably the ascending solutions from which the Tata travertine deposited infiltrated through bedrocks rich in organic matter and could have carried dissolved C enriched in light ($^{12}C$) stable carbon isotope.