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High resolution paleotemperature proxy obtained from clastic sediments in cave environment (Example from Divje Babe 1 Palaeolithic site)

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There have been a lot of attempts to reconstruct the chronology of paleoclimate changes in Palaeolithic sites filled with clastic sediments (caves and rock-shelters). Of all deposits found in sedimentary sequences, the rock fragments are the most abundant and continuous. For this reason, high resolution paleoclimate proxies can be obtained only by study of rock fragments. But variable rate of sedimentation is the main problem to obtain high resolution paleoclimate proxy in caves. Missing data which occur due to depositional hiatuses or erosion of cave sediments is another problem.

Problem of variable rate of sedimentation may be solved with new sedimentary morphogenic analysis, which was carried out at the Divje Babe 1 cave. 280 cm thick sedimentary sequence was arbitrarily divided into 28 levels (samples), each of which was around 8-10 cm thick. According to ESR dates, the studied sedimentary sequence was deposited in the period from 80,000 BP (the base part) to 40,000 BP (the top part). In each level, 300 to 400 clasts in the 10-40 mm size range were collected and studied (coarse clasts of this size range are the most abundant in Divje Babe 1). Only post-depositional morphogenic characteristics of coarse fragments of rocks in all of 28 levels were studied. Methodology is based on fact that after the deposition, corners of clast were rounded or semi-rounded by chemical weathering and (or) clasts were broken to more pieces by frost wedging (physical weathering). The most important is that both processes alternate and that they take place only at the cave topsoil (relatively thin top layer). When topsoil sediments become buried by a new sedimentary sequence of sufficient thickness, all weathering processes stop and the morphology of the clasts remains preserved in the form acquired prior to burial. According to this fact, clasts which have one or more freshly broken surfaces with sharp edges, were shattered by frost action by relatively recent cold event in the cave topsoil before being buried by a new layer of sediment and consequently protected from further (chemical) weathering. We call these clasts congelifracts. The time period in which these congelifracts (broken clasts with sharp edges) were exposed to further post-depositional (mainly chemical) weathering in the topsoil is presumed to be short and approximately equal in all levels. For this reason the affect of variable rate of sedimentation in different levels on post-depositional frost-wedging may be minimized by this approach. Majority of other clast were also post-depositionally shattered by frost action, but later they were exposed to the post-depositional chemical weathering at the cave topsoil for significant period of time. Consequently broken surfaces were blurred and edges became rounded, before the burial. We call these clasts semi-rounded clasts.

Paleotemperature reconstruction is based on interpretation that levels in which there is a higher percentage of congelifracts (clast which were post-sedimentary frost-shattered by relatively recent cold event before the burial) were modified in colder climate conditions than levels that contain a lower percentage of congelifracts.

Divje Bave 1 paleotemperature proxy shows two very distinctive cool climate phases in the period between 80,000 and 40,000 BP. At least two depositional hiatuses appear. Two cool climate phases correlate well with the GRIP record. We placed them to 67,000-62,000 BP and 61,000-58,000 BP. The temporal resolution of the Divje babe I paleotemperature record is estimated to be 1,000±500 years, assuming an average rate of sedimentation.