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# Cryogenic cave carbonates as an archive of Late Pleistocene permafrost in the Ural Mountains: preliminary results

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A specific type of cave deposits, cryogenic cave carbonates (CCCs), was discovered in the late 1980s in several caves of Central Europe. Unlike "common" speleothems that form primarily due to degassing of $CO_2$ from $Ca^{2+}$ and $HCO_3^-$ -rich waters, CCCs form by freezing-induced segregation (Žák et al., 2004). The formation of CCCs, hence, requires the presence of both liquid water and freezing temperatures. The latter combination may occur in caves in two situations: (1) freezing-thawing cycles in cave entrance zones; and (2) degrading permafrost conditions, when the active layer reaches the cave ceiling, whilst the deeper parts of the cave remain frozen. The latter situation is associated with a particular type of CCCs, which can be used as a marker for permafrost conditions. Because cave carbonates can be accurately dated using the U/Th method, CCCs may be used to identify events of (degrading) palaeo-permafrost conditions.

In this study, CCCs were identified and sampled in four caves, located along a 1000 km-long transect from the northern to the southern Ural Associating the CCCs to permafrost conditions was possible on the basis of field observations (locations deep inside the cave, far from entrance zones) and stable isotope properties (strongly depleted $\delta^{18}$O values, inverse correlation between $\delta^{18}$O and $\delta^{13}$C).

Chaikovskiy et al. (2014) reported five U/Th analyses of CCC from three caves: 16.7 ka and 104.8 ka (Divja Cave, northern Ural); and 13.4 ka, 86.5 ka and 125.3 ka (Rossijskaya and Usvinskaya Caves, central Ural). In this study we report 25 additional U/Th ages from northern and central Ural, as well as the first CCC age from southern Ural (Shulgan-Tash Cave).

Most of the younger ages (<ca. 450 ka) cluster near Terminations V, II and I. One date corresponds to the optimum of the Last Interglacial (Marine Isotope Stage 5e). Another age from the northern Ural corresponds to the early part of the last glacial. Ages older than ca. 450 ka have large analytical uncertainties and cannot be attributed to specific stages of the Pleistocene glaciation.

References: Chaykovskiy et al., 2014, Geochemistry International, 52, 4, 336–346. Žák et al., 2004, Chemical Geology, 2006, 119-136.