Burial age dating of clastic cave sediments from the Southern Calcareous Alps, N Slovenia

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The presented work constitutes the start of an ongoing FWF project which aims to compare valley incision rates across a N-S transect of the Eastern Alps during the Pliocene and Pleistocene, based on cave sediments in both the Northern (Austrian) and Southern (Slovenian) Calcareous Alps.

Theoretical aspects

Speleogenesis and surface landscape development are linked processes which, especially in mountainous areas, are driven by interplay of tectonic uplift and climate-controlled erosion. In karst regions, gradual lowering of valley floors and local base levels by river incision or glacial erosion promotes cave development at lower elevations resulting in the formation of multi-level karst systems (Audra et al., 2007). Dating sediments from various cave levels can provide information about the pace of landscape development, and in particular valley incision rates, provided that a relative chronology can be established between the morphogenesis of the cave and the deposition of the studied sediments (Häuselmann, 2007).

Ages for sediments deposited over the past 5 Ma can be obtained by using the burial age dating method, which relies on the differential radioactive decay of the 26Al-10Be isotope pair. The two isotopes form inside quartz grains at or close to the surface of the Earth, under the influence of high energy cosmic radiation (Gosse & Phillips 2001). The dating method can be applied as long as (1) the investigated sediment contains quartz which was exposed to radiation long enough for the two isotopes to accumulate, and (2) the sediment was effectively shielded from further radiation at the moment of its deposition.

Audra ,P., Bini, A., Gabrovšek, F., Häuselmann, P., Hobléa, F., Jeannin, P.Y., Kunaver, J., Monbaron, M., Šušteršic, F., Tognini, P., Trimmel H., Wildberger, A. (2007). Cave and Karst evolution in the Alps and their relation to paleoclimate and paleotopography, Acta Carsologica, 36(1), p.53-67.
Häuselmann, P. (2007).How to date nothing with cosmogenic nuclides, Acta Carsologica, 36(1), p. 93-100.
Gosse, J.C., Phillips, F.M. (2001). Terrestrial in situ cosmogenic nuclides: theory and application, Quaternary Science Reviews, 20, p.1475-1560.

Sample preparation

Heavy liquid separation of minerals with different density than quartz (~2.65 g/cc)

In order to get pure 26Al and 10Be concentrations, the quartz has to be purified, dissolved, and the other elements removed. The sediment is cleaned, crushed, and decarbonatized. The Al-bearing silicates are removed by leaching with weak HF. A 9Be carrier is added to the quartz which is then dissolved in concentrated HF. Evaporation of the HF, conversion of the remaining fluorides to sulfates or nitrates is followed by dissolution of the sample in HCl. Anion chromatography, removal of Ti by selective precipitation, and cation chromatography results in Al and Be separates. These hydroxides are then oxidized, mixed with metal powder, and pressed into targets for measurement on an accelerator mass spectrometer. The AMS measurement gives 26Al/27Al and 10Be/9Be ratios which can be converted in nuclide concentrations per gram of quartz. These concentrations are then used following Granger & Muzikar (2001) in order to get a burial age of the sediment.

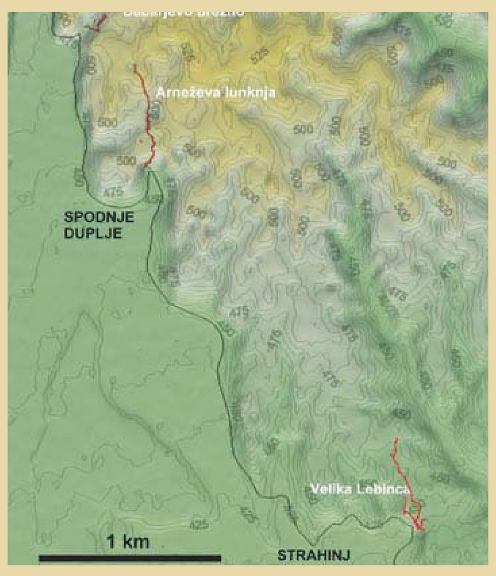
Granger, D.E., Muzikar, P.F., (2001), Dating sediment burial with in situ produced cosmogenic nuclides: theory, techniques and limitations, Earth and Planetary Science Letters, 188, 269-281

Al/Be separation by cation exchange

Sample locations in Slovenia

Udin Borst

Caves in the Udin Borst area are mostly developed at the contact between supposedly Pleistocene carbonate conglomerates and impermeable Oligocene shales. Samples taken from Arneseva luknja, the longest cave in the area, will be used to determine the depositional time of the conglomerate and obtain information about valley incision rates prior to deposition and to changes in the landscape after deposition.

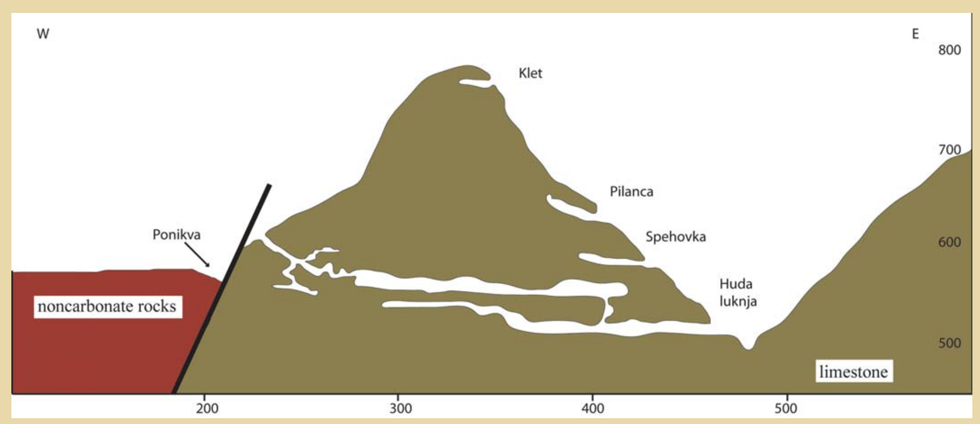


Digital relief model with ground plans of the longest caves in Udin Borst (Gabrovsek, 2005)

Gabrovsek, F., 2005, Caves in conglomerate: case of Udin Borst, Slovenia, Acta Carsologica, 34 (2), p. 504-519

Huda Luknja & Spehovka (Tisnik Mountains)

The caves of Tisnik Mountain are located just south of the periadriatic lineament, north of the Velenje basin, NE Slovenia. The caves present evidence of a genesis in different phases, of which the lowermost one is still active. Due to the non-carbonate rocks upstream of the calcareous Tisnik mountain, quartz-rich sediment is washed into the caves. Two conglomeratic samples, one from Spehovka, and one from the upper passage of Huda luknja will de used to determine the time at which speleogenesis occurred in the respective levels.



Schematic cross section showing the five recognizable speleogenetic phases in the Tisnik Mountains

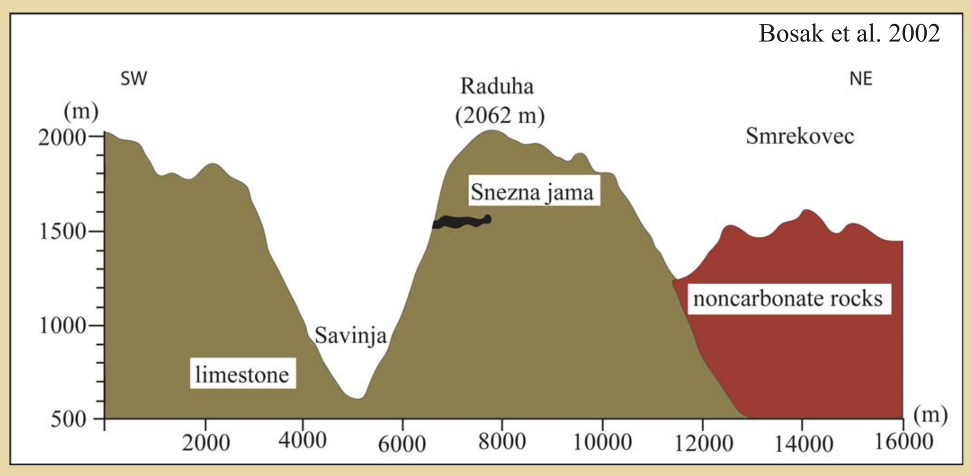
Digital elevation data from CGIAR Consortium for Spatial Information (http://srtm.csi.cgiar.org/)

Jama pri planina pri jezero (Julian Alps)

Satellite image of the area north of Lake Bohin, showing the aproximate location of Jama pri planina pri jezero (Google Earth)

Jama pri planina pri jezero is located north of Bohin lake in the Julian Alps. The very short cave, below a limestone plateau, is filled with well-sorted fluviatile quartz sands. Dating of the cave sediment will determine weather the plateau was formed during the Pliocene, or has a much older, Oligocene - Miocene age, comparable to similar features from the Austrian Alps.

Snezna jama (Kamnik Alps)



Schematic cross section of the Raduha Massif, with the position of Snezna jama

In Snezna jama, the fluviatile sediment that was sampled consists of mixed pebbles and fine sand. It predates flowstone which is at least 1.7 Ma old (Bosak et al. 2002). Dating of the sediment not only gives the incision rate of the valley in front of the cave, but (because the pebbles came from Oligocene andesitic tuffs that are presently lowered below the cave's altitude) also the erosion rate in the hinterland. Erosion and uplift is connected to movements of the periadriatic lineament some 10 km to the North of Snezna jama.

Bosak, P., Hercman, H., Mihevc, A., Pruner, P., 2002, High resolution magnetostratigraphy of speleothems from Snezna Jama, Kamnik-Savinja Alps, Slovenia, Acta Carsologica, 31 (3), p. 15-32