

VALLEY INCISION IN THE NÍZKE TATRY MTS. (SLOVAKIA) ESTIMATED BASED ON PALEOMAGNETIC AND RADIOMETRIC CAVE SEDIMENT DATINGS

**Jaroslav Kadlec¹, Pavol Bella², Kristýna Čížková¹, Darryl E. Granger³, Helena Hercman⁴, Peter Holúbek⁵,
Martin Chadima^{1,6}, Monika Orvošová⁵, Petr Pruner¹, Petr Schnabl¹, Stanislav Šlechta¹**

¹*Institute of Geology AS CR, v.v.i., Rozvojová 269, 165 00 Praha 6, kadlec@gli.cas.cz*

²*Správa slovenských jaskýň, Hodžova 11, 031 01 Liptovský Mikuláš*

³*Earth and Atmospheric Sciences, Purdue University, West Lafayette, Indiana 47907*

⁴*Institute of Geological Sciences PAS, Twarda 51/55, 00-818, Warsaw*

⁵*Slovenské múzeum ochrany prírody a jaskyniarstva, Školská 4, 031 01 Liptovský Mikuláš*

⁶*Agico spol. s r.o., Ječná 29a, 621 00 Brno*

Up to eleven horizontal cave levels occur at different altitudes in Jánska, Demänovská and Mošnická karst valleys in the Nízke Tatry Mts. Most of the caves are filled with allochthonous sediments transported from the area formed mostly by granite. The cave levels were filled with fluvial sediments in dependence on the valleys incision caused by Neogene and Pleistocene uplift of the mountain range. The fluvial sediments are intercalated with, or capped, by flowstone layers in the caves. The paleomagnetic polarities measured both in clastic and chemogenic sediments indicate the age of deposition. Based on obtained polarity data we are able to distinguish cave sediments deposited during the Brunhes, Matuyama and Gauss chrons. The paleomagnetic interpretation was partly verified by U-series datings of flowstones preserved in the sedimentary sections. Except for the horizontal cave levels located in the karst valleys, additional large cave systems were found at extremely high altitudes in the Nízke Tatry Mts. 600–700 m above the lowest horizontal cave level.

1. Introduction

An estimation of deposition time of inner cave sediments is possible based on measurement of paleomagnetic polarity record preserved in fine clastic and chemogene deposits. The paleomagnetic interpretation can be verified by U-series dating of speleothems intercalated into the sedimentary sections (e.g., Bosák and Pruner 2011).

2. Geography and geology

Triassic carbonate rocks forming the northern slopes of the Nízke Tatry Mts. in Slovakia are hosting cave systems developed in eleven levels (Droppa 1966). Cave passages located in different altitudes were filled with fluvial, flood and chemogenic deposits during the Demänovská and Jánska karst valleys incision. Except for the horizontal cave levels located in these karst valleys, additional cave systems were developed at high altitudes in the Nízke Tatry Mts. in Krakova Hoľa, Kozie Chrbty, and Ohništie Plateau.

3. Methods

Paleomagnetic polarities recorded in both fine clastic and chemogenic cave deposits were acquired by thermal or alternating field demagnetization. Directions of magnetization vector were measured using both spinner and superconducting rock magnetometers. Magnetostratigraphic inter-pretations were verified by U-series (²³⁰Th/²³⁴U and ²³⁴U/²³⁸U) dating of speleothems deposited in the sedimentary sections. The paleomagnetic age of sediments preserved in the high altitude cave systems was verified based on cosmogenic isotope activity (¹⁰Be and ²⁷Al) measured in quartz pebbles.

4. Results and discussion

Based on obtained magnetostratigraphic pattern we are able to distinguish cave sediments deposited during the Gauss (2.588–3.58 Ma), Matuyama (0.781–2.588 Ma), and Brunhes (<0.781 Ma) paleomagnetic chrons. The paleomagnetic record extracted from the high altitude cave systems indicates deposition between 3.1 and 1.75 Ma ago. The sediments had to be deposited during a period of tectonic stability when only shallow valleys were developed on both sites of the mountain range. The tectonic uplift in this area was accelerated since 1.7 Ma. The valley incision rate can be estimated based on paleomagnetic polarity and elevation data as follows: 6 cm.ka⁻¹ during 1.7–1.1 Ma; 32 cm.ka⁻¹ during 1.1–0.78 Ma; and 4 cm.ka⁻¹ since 0.78 Ma. The remarkable increase of the valley incision during the latest Early Pleistocene corresponds with results of valley incision study performed in the Swiss Alps reaching twice to four times faster rate in comparison with the Nízke Tatry Mts. (Haeuselmann et al. 2007). The periods of alluvial aggradation in the caves were also correlated with terraces deposited by the Váh River running 10 km North from the karst area. Paleomagnetic polarity of the fluvial deposits filling the largest 4th cave level show the age of sediments younger than 0.78 Ma which is in agreement with stratigraphic conclusion of the most extensive Váh River terrace to the early Mid-Pleistocene (Droppa 1966).

5. Conclusions

The cave levels in the Nízke Tatry Mts. were filled with fluvial sediments in dependence of Neogene and Pleistocene uplift of the mountain range. Sediments preserved in the large cave systems developed in extremely

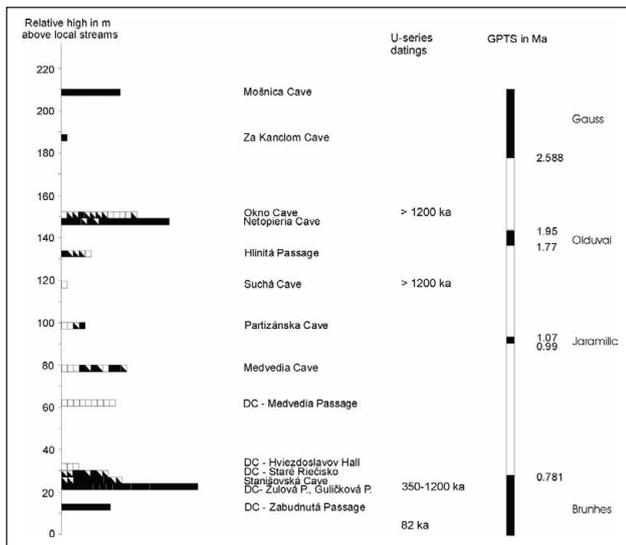


Figure 1. Magnetostratigraphic pattern of cave sediments in the Nízke Tatry Mts. karst valleys. Black (white) squares represent normal (reverse) magnetization of sample, black-and-white squares represent transitional character of sample. DC – Demänovská Jaskyňa Slobody Cave.

high altitudes in the Nízke Tatry Mts. Were deposited between 3.1 and 1.75 Ma ago (paleomagnetic chrons Gauss and Matuyama). Sediments deposited in cave levels developed in Demänovská, Jánská and Mošnica karst valleys in a relative elevation above 185 m are older than 2.588 Ma (Gauss chron). Fluvial sediments found in the

cave levels in the relative elevations 30–185 m were deposited 2.588–0.781 Ma ago (Matuyama chron). Fluvial sediments deposited in lower elevation cave levels are younger than Brunhes/Matuyama paleomagnetic boundary (0.781 Ma). After relative tectonic stability period between 3.1 and 1.7 Ma the tectonic uplift was accelerated since 1.7 Ma. The valley incision rate can be estimated based on paleomagnetic polarity and elevation data as follows: 6 cm.ka⁻¹ during 1.7–1.1 Ma; 32 cm.ka⁻¹ during 1.1–0.78 Ma; and 4 cm.ka⁻¹ since 0.78 Ma.

Acknowledgments

The research is supported by grants No. IAA3013201 and IAA30013001. The institutional funding is provided by the Institute of Geology AS CR, v. v. i. (AV0Z30130516).

References

- Bosák P, Pruner P, 2011. Magnetic rekord in cave sediments. In Petrovský E, Herrero-Bervera E, Harinarayana T, Ivers D (Eds.) The Earth's magnetic interiér, 343–360.
- Droppa A, 1966. The correlation of some horizontal caves with river terraces. Stud. Speleol., 1(4), 186–183.
- Haeuselmann P, Granger DE, Jeannin P-Y, Lauritzen S-E, 2007. Abrupt glacial valley incision at 0.8 Ma dated from cave deposits in Switzerland. Geology, 35(2), 143–146.