

The first radiocarbon dating of a cave lion fossil from the Slovakian Western Carpathians

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Abstract: So far, no fossils of cave lion (*Panthera spelaea*) from Slovak sites were dated by the radiocarbon method (AMS – ¹⁴C dating). The rib fragment of cave lion prime adult from Medvedia jaskyňa Cave in the Západné Tatry Mts. is the first cave lion fossil from Slovakia dated by this method in the Curt-Engelhorn-Centre Archaeometry (CEZA) in Mannheim. The analysis showed its age 44,350 ± 730 yrs BP, what is in good agreements with age of cave bear fossils from the same site, dated at the Vienna Environmental Research Accelerator Laboratory in Vienna. The obtained date corresponds well with the MIS 3 period, the warmer climate of which allowed also the cave lion penetration into the mountains areas.

Key words: *Panthera spelaea*, AMS – ¹⁴C dating, Last Glacial, Medvedia jaskyňa Cave in the Západné Tatry Mts., Slovakia

1. INTRODUCTION

Radiocarbon dating (¹⁴C dating), which is most commonly used in archaeological Palaeolithic research (Neruda & Kaminská, 2013; Kaminská, 2014), has been used in the Slovak Quaternary palaeontology predominantly for precise age determination of cave bear fossil remains (Schmidt & Chrapan, 1970; Pomorský, 1993; Sabol & Višňovská, 2007; Sabol et al., 2008; Ábelová & Sabol, 2009), but also for chamois (Vlček, 2010) and small mammal (Obuch, 2006) osteological remains. However, no cave lion fossils from Slovak sites have previously been dated by this method.

The cave lion fossil record in Slovakia is relatively scarce (Sabol, 2011; Čeklovský & Sabol, 2012; Čeklovský, 2018; Sabol et al., 2018). While there have been known the isolated finds of dentition and cranial and postcranial remains from more than 13 sites, the most important fossil record is the prime adult male lion skeleton from Medvedia jaskyňa Cave in the Západné Tatry Mts. (Sabol et al., 2018). Its age was determined only indirectly from dated cave bear remains found in the same (sub-)surface layer (Tab. 1).

2. LOCALITY

Medvedia jaskyňa Cave ('Bear Cave') in the Západné Tatry Mountains is a part of the Suchý potok cave system (Benický, 1953). The cave is the highest and the most significant cave lion site in the Slovak part of the Western Carpathians. Its 9 x 4 metre entrance portal at the altitude of 1,133 metre on the left slope of the Suchá Valley near Liptovský Trnovec village in northern Slovakia (49° 44' N, 19° 35' E) (Fig. 1) is leading to the 160 metre long fluviokarst-collapse cave (Droppa, 1972; Bella et al., 2007). The fossil record from this cave consists primarily of cave bears, with the occasional wolf and a few cave lion remains. The prime adult cave lion male skeleton was discovered in the Levia sieň (Lion Hall) (Sabol et al., 2018).

Table 1. Radiometric dates of cave bear fossils from Medvedia jaskyňa Cave in the Západné Tatry Mts. by ¹⁴C-AMS in the VERA-Laboratory, Vienna (Austria).

Lab. Nr.	sample name	d ¹³ C* [‰]	¹⁴ C-age* [BP]
VERA-4395	femur sin.	-21.8 ± 0.6	>46.000
VERA-4396	femur sin. (juv.)	-21.7 ± 0.6	>47.600
VERA-4810	humerus dext.	-17.6 ± 0.8	>47.500

*) 1σ

3. MATERIAL AND METHODS

The prime adult cave lion skeleton (P 14359) is housed in the Slovak Museum of Nature Protection and Speleology in Liptovský Mikuláš and the requirement of its direct dating arose because only the cave bear remains had previously been dated from this site under study. For these purposes, a rib fragment from this skeleton (Fig. 2) was selected and sent to the Curt-Engelhorn-Centre Archaeometry (CEZA) at the Reiss-Engelhorn-Museen in Mannheim, Germany. The bone sample (MC-WT1, Lab. Nr. MAMS-34510) was radiocarbon-dated using the MICADAS Accelerator at the subsidiary institute Klaus-Tschira-Laboratory in CEZA.

The development of the accelerator mass spectrometry (AMS) allowed to significantly minimise the quantity of samples required and considerably increase measurement speed and accuracy (Rosendahl & Döppes, 2016). The collagen extracted from the bone samples was ultra-filtered to remove molecules with chain length less than 30kD and freeze-dried. In the final step, this organic sample was converted to carbon dioxide and subsequently converted to solid graphite form. The milligram-sized graphite sample was bombarded with cesium ions to obtain carbon ions and these were accelerator-separated into their different masses. Age was determined from the ratio of ¹⁴C to ¹²C, and ¹³C was used as the control in the separation processes.

By default, radiocarbon data is reported as conventional ¹⁴C or AMS ¹⁴C age BP, but this is not a calendar age. The convention



Fig. 1. Medvedia jaskyňa Cave in the Západné Tatry Mountains, Slovakia. A –location of the cave (white circle); B –ground plan of the cave (modified according to Droppa et al., 1966 ex Droppa, 1972).

originates from ^{14}C data being converted to age by the radioactive decay equation, radiocarbon half-life and the assumption that the atmospheric ^{14}C content is constant over time. Unfortunately, the atmospheric content is not constant and radiocarbon in the atmosphere is produced by interaction of neutrons with nitrogen, while the neutrons are produced by galactic cosmic rays entering the atmosphere. To cope with this, a calibration curve was established using independent dating methods including dendrochronology, varve counting, and speleothem and coral uranium-thorium dating. This method also has limits because less than 1 per mille of the original ^{14}C remains after 10 half-lives (half-life of $5,730 \pm 40$ years). Therefore, no material older than 50,000 years can be reliably dated with this method (Olsson, 2009; Reimer et al., 2013). Calibrated raw dates are indicated by calBP.

The ^{14}C age is normalised to $\delta^{13}\text{C} = -25$ ‰ (Stuiver & Polach, 1977). This emanates from the measurement of the isotopic ratios in the accelerator; with approximate error of 2–3%. This value can differ from the sample material's true value because

of isotope separation during the sample preparation and the accelerator ion source. Consequently, this value is used only to correct fractionation effects. It is not comparable with the measurement in a mass spectrometer for stable isotopes (IRMS) and should not be used for further data interpretation.

4. RESULTS

The lion rib AMS dating established $44,350 \pm 730$ yrs BP age, what is in good accord with the ^{14}C age of cave bear fossils from the same cave, dated to the MIS 3 stage. Accompanying data is highlighted in Table 2. The sample's collagen preservation is very good, and the C/N ratio and extracted collagen carbon content fall within the normal range (van Klinken, 1999). The calibrated ages are normally quoted with a 1-sigma error range and while this corresponds to 68.3% confidence probability, it rises to 95.5% for 2-sigma (Fig. 3). The calibration here was performed by the SwissCal 1.0 programme with INTCAL 13 dataset.

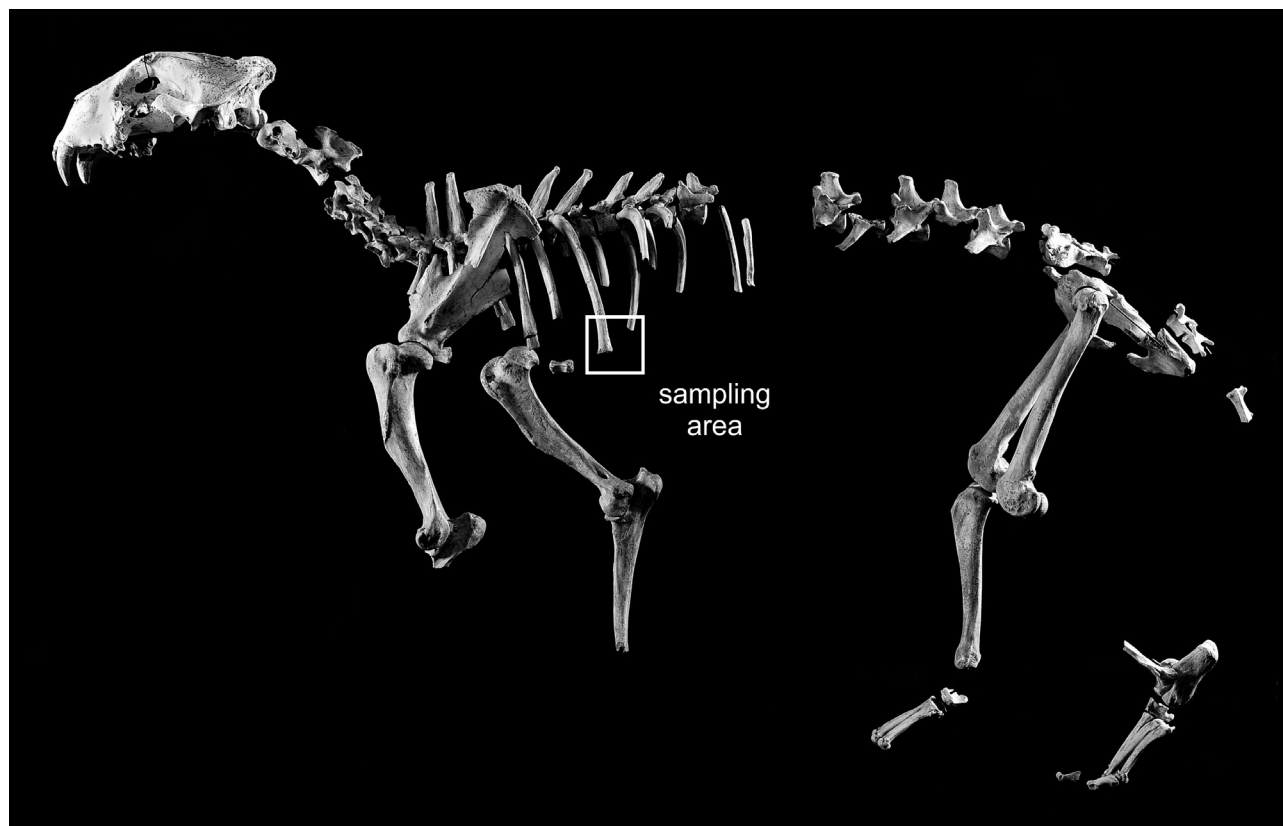


Fig. 2. The skeleton of prime adult cave lion male from Medvedia jaskyňa Cave in the Západné Tatry Mts. with the marked area from which the sample was submitted for the AMS dating to the CEZA in Mannheim, Germany.

Table 2. Result of the AMS dating of the cave lion fossil from Medvedia jaskyňa Cave in the Západné Tatry Mts.

Lab. Nr. MAMS 34510	
¹⁴ C Age	44,350 ± 730 yrs BP
δ ¹³ C (AMS) (per mille)	-27.8
Cal 1-sigma	48,440–46,740 cal BP (with INTCAL 13)
Cal 2-sigma	49,330–46,080 cal BP (with INTCAL 13)
C:N Ratio	2.9
C (%)	24.7
Collagen (%)	2.8
Material	bone (rib)

5. DISCUSSION & CONCLUSIONS

The oldest European fossil record of cave lion (*Panthera spelaea*) most likely comes from Repolusthöhle in Austria, where felid fossils have been found in late Middle to Late Pleistocene deposits (Mottl, 1951; Schütt & Hemmer, 1978; Döppes et al., 2008; Pacher, 2014). On the contrary, one of the European cave lion terminal date is 12,375 ± 50 yrs BP from Zigeuenerfels, Sigmaringen in Germany (Stuart & Lister, 2007, 2011). Most cave lion fossil remains, found across the whole Europe (except of Ireland and Fennoscandia) are, however, dated to the Last Glacial period in the 25–50 kys BP time span (MIS 3).

The AMS dating of the cave lion sample from Medvedia

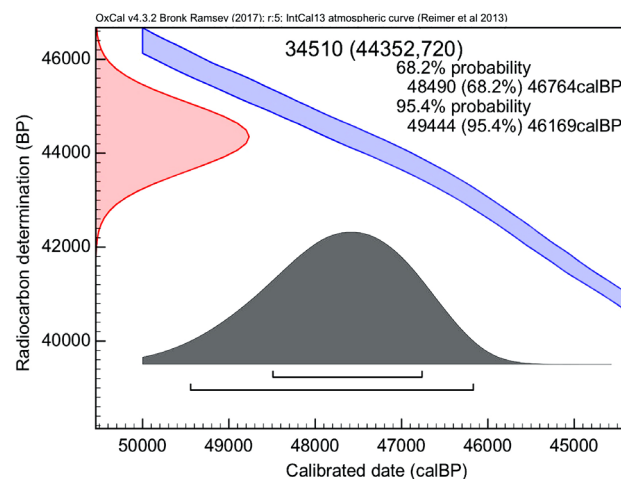


Fig 3. Calibration graph for the radiocarbon determination of cave lion sample MAMS 34510 from Medvedia jaskyňa Cave in the Západné Tatry Mts. created with the software OxCal v4.3.2. For calibration, the pMC (percent Modern Carbon) input option was used (corresponding to a symmetric uncertainty of the uncalibrated ¹⁴C age).

jaskyňa Cave in the Západné Tatry Mts. corresponds well with this time range and also agrees with the dated age of the cave bear remains at the same site. The warmer interstadial climate during this period enabled the penetration of lion-like felids into the higher mountain areas, what is documented not only from the Western Carpathians, but also from the Alps

(Pacher, 2018) and the Caucasus (Baryshnikov, 2011). Their presence in this mountain environment is discussed in Sabol et al. (2018).

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