

JEDINEČNÉ JASKYNE V PLAVECKOM HRADNOM VRCHU, MALÉ KARPATY

**Pavel Bella^{1,2} – Pavel Bosák³ – Petr Mikysek³ – Juraj Littva¹
– Helena Hercman⁴ – Šimon Kdýr³ – Petr Pruner³ – Jozef Minár⁵
– Michał Gradziński⁶ – Wojciech Wróblewski⁶ – Marek Velšmid⁷**

¹ Štátna ochrana prírody Slovenskej republiky, Správa slovenských jaskýň, Hodžova 11,
031 01 Liptovský Mikuláš, Slovenská republika

² Katedra geografie, Pedagogická fakulta, Katolícka univerzita v Ružomberku, Hrabovská cesta 1,
034 01 Ružomberok, Slovenská republika

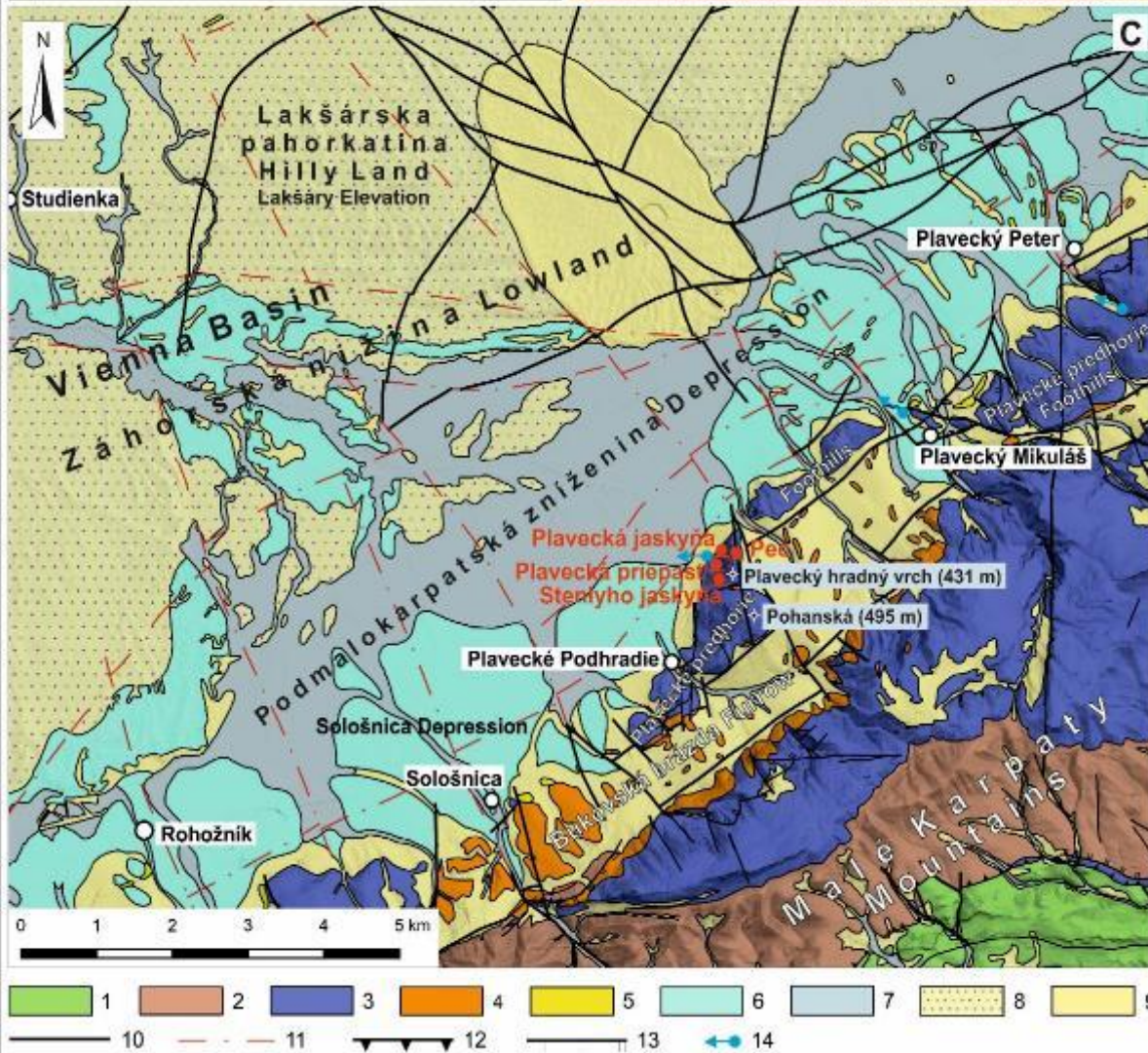
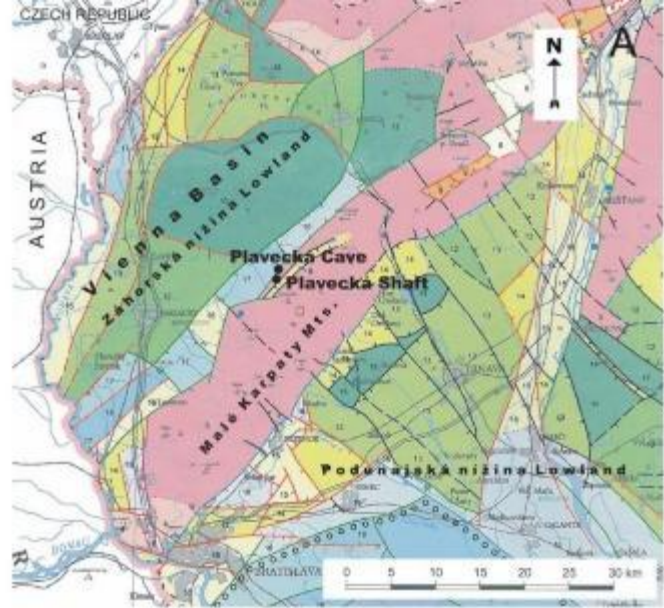
³ Geologický ústav AV ČR, v. v. i., Rozvojová 135, 165 00 Praha 6-Lysolaje, Česká republika

⁴ Institute of Geological Sciences, Polish Academy of Sciences, ul. Twarda 51/55,
00 818 Warszawa, Poland

⁵ Katedra fyzickej geografie a geoinformatiky, Prírodovedecká fakulta, Univerzita Komenského,
Mlynská dolina, Ilkovičova 6, 842 15 Bratislava 4, Slovenská republika,

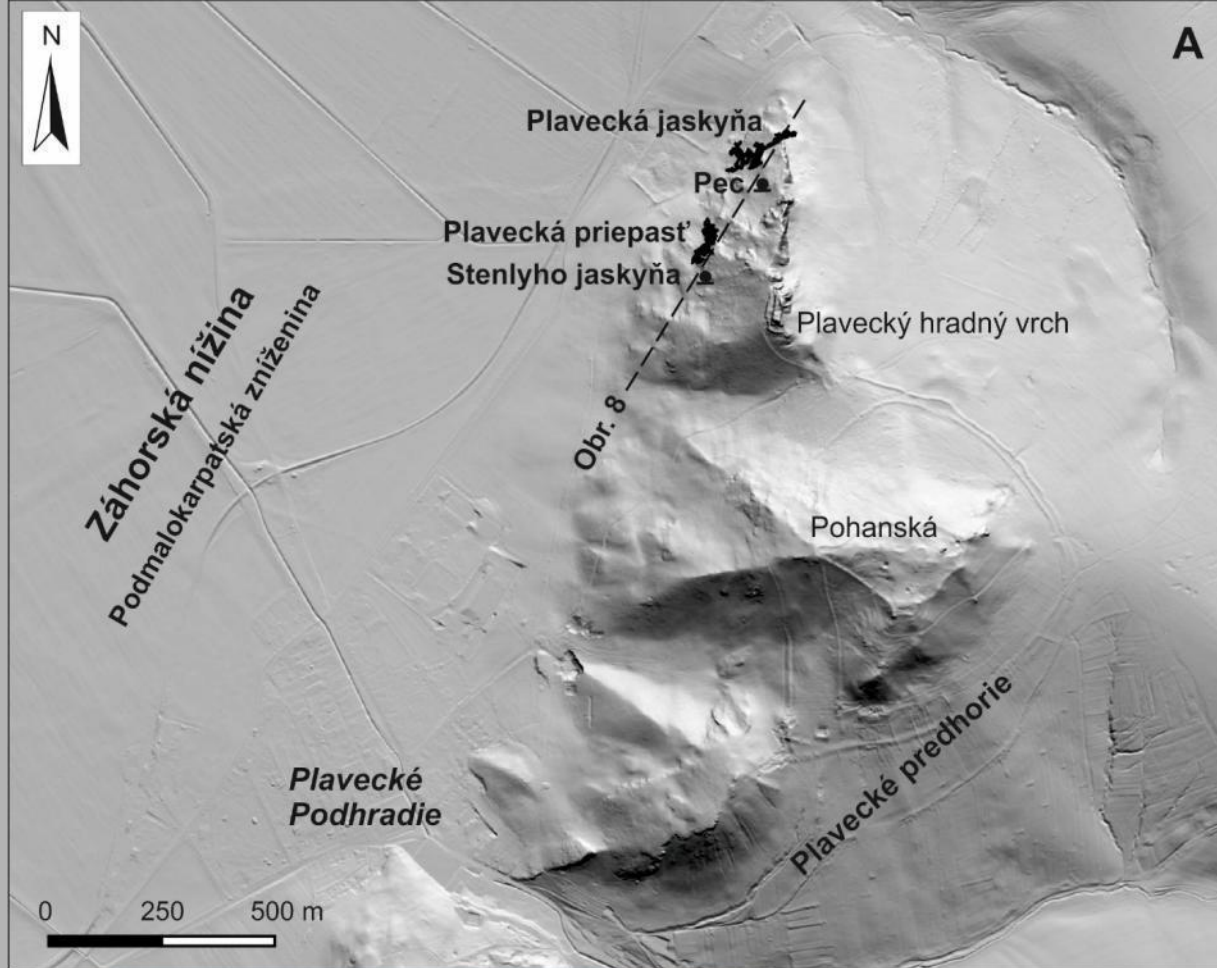
⁶ Institute of Geological Sciences, Jagiellonian University in Kraków, Gronostajowa 3a,
30-387 Kraków, Poland

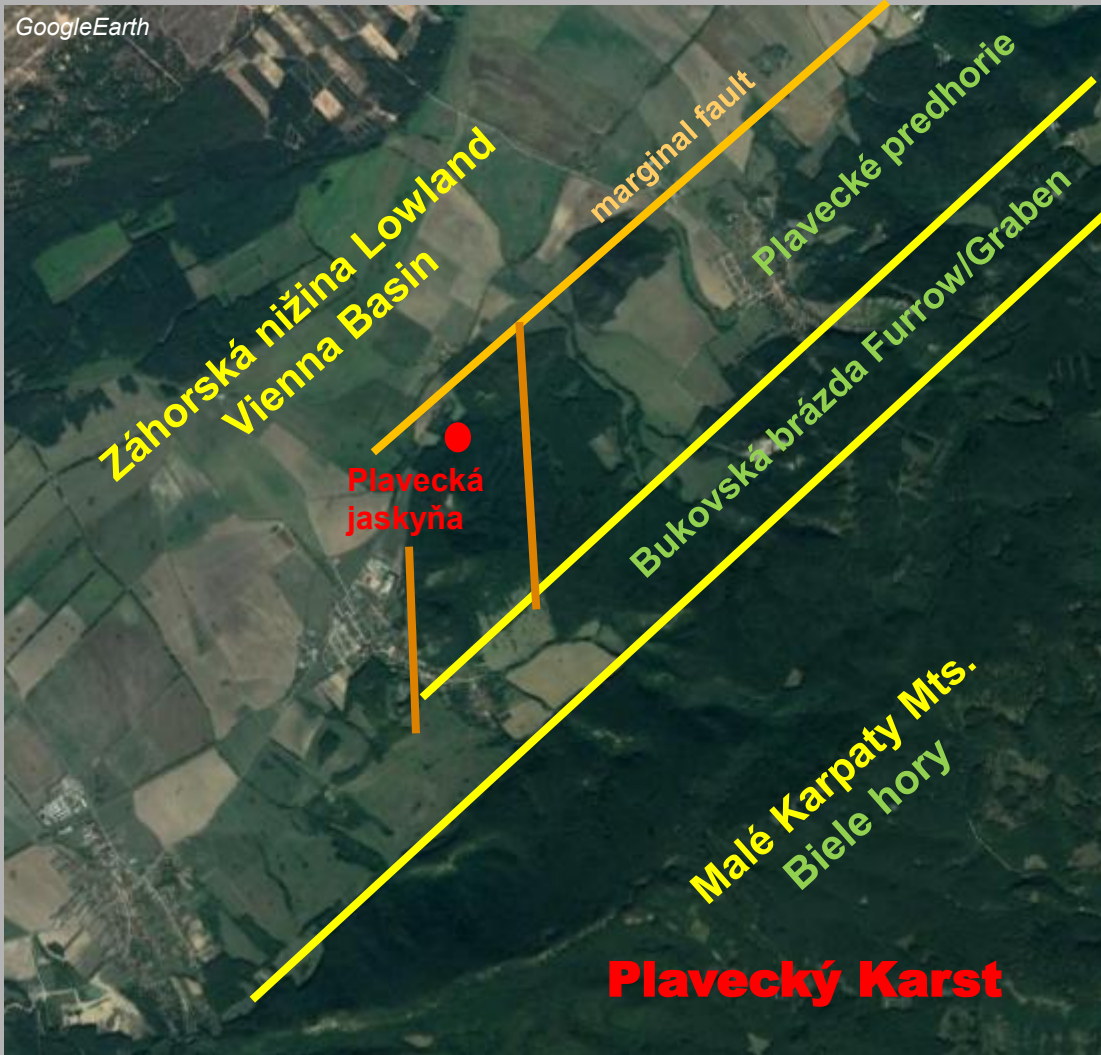
⁷ Jaskyniari Plavecké Podhradie, o. z., 906 36 Plavecké Podhradie 284, Slovenská republika



from Bella and Bosák (2012); map: Maglay et al. (1999)

Hypogene caves in the Plavecký hradný vrch Hill (Western Slovakia, Central Europe) were formed by waters ascending along faults in fractured Triassic carbonates related to the horst-graben structure at the contact of the Malé Karpaty Mountains and the NE part of the Vienna Basin.

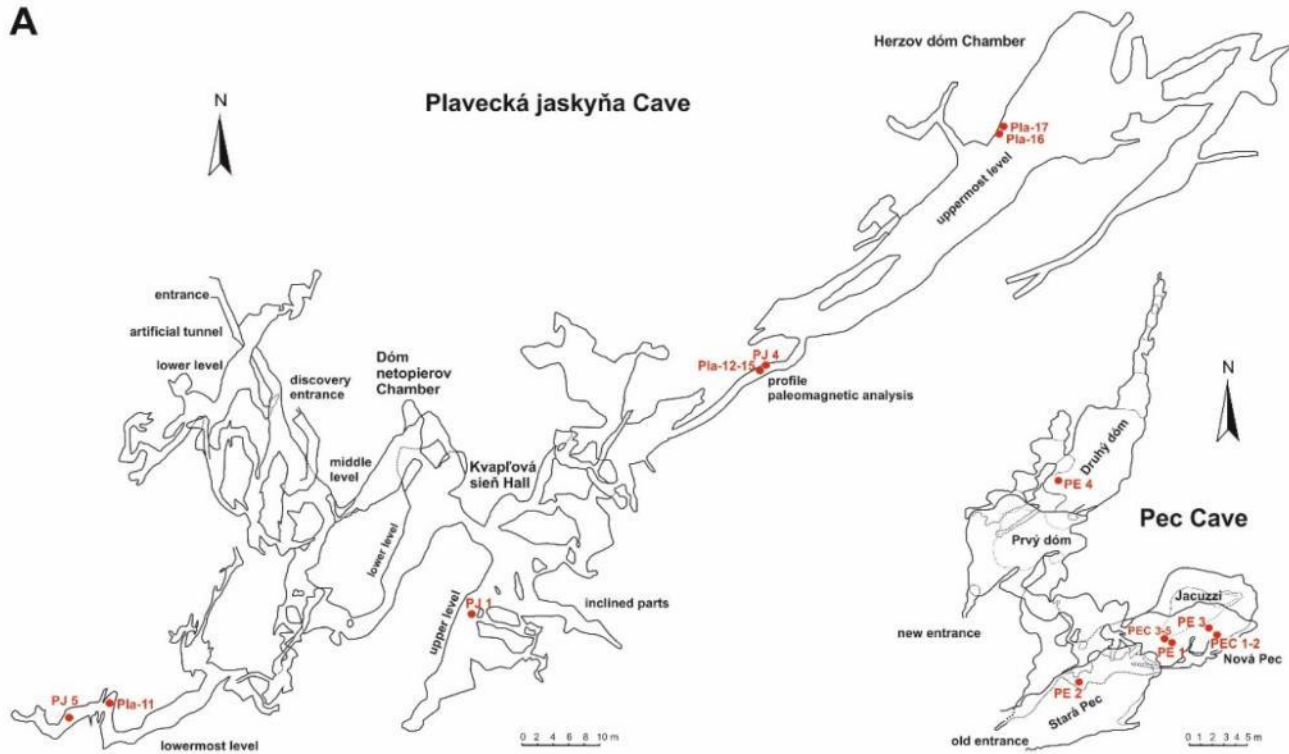
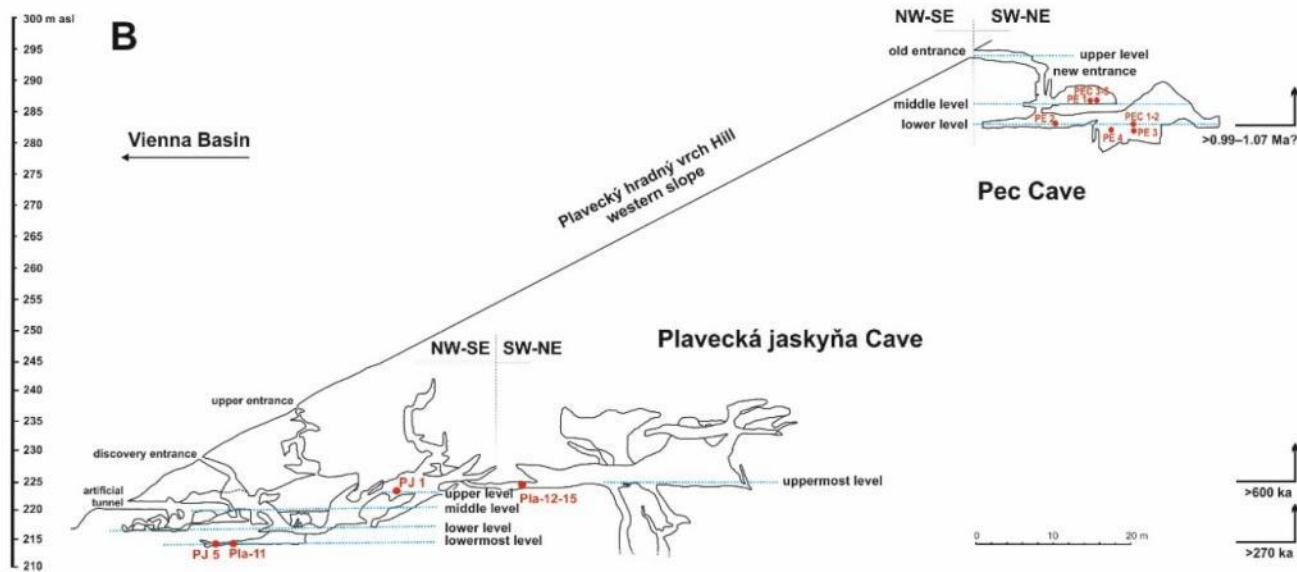


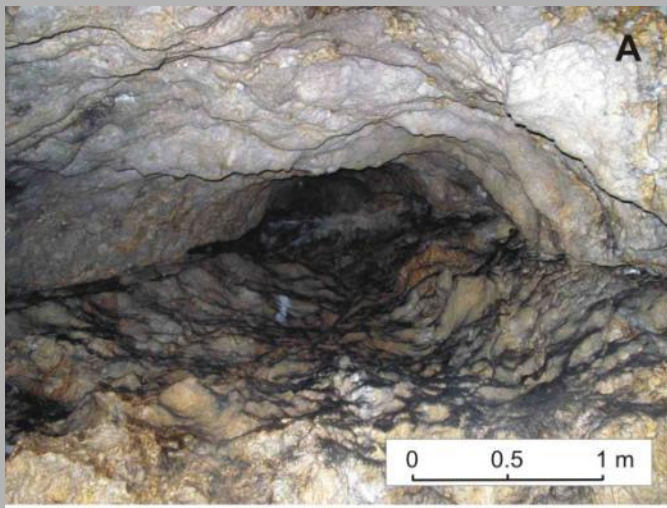


Plavecká jaskyňa belongs to the warmest caves in Slovakia with air temperature of **11 to 12.8 °C**

Karst spring – water temperature **11.6 to 13.6 °C**

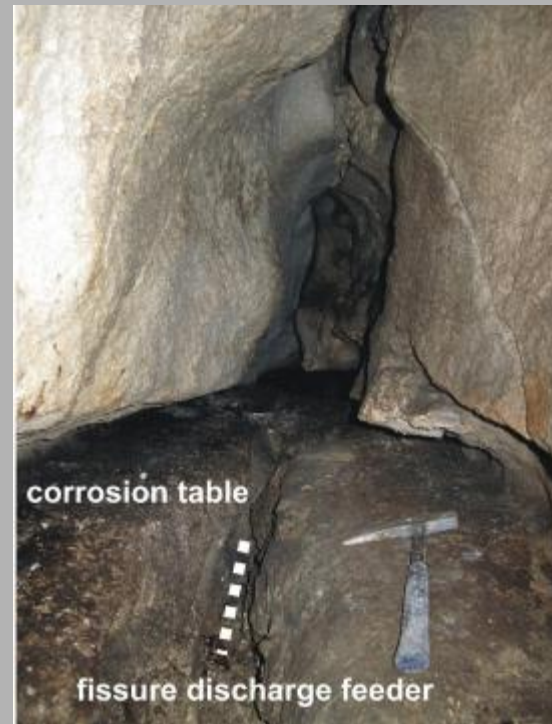


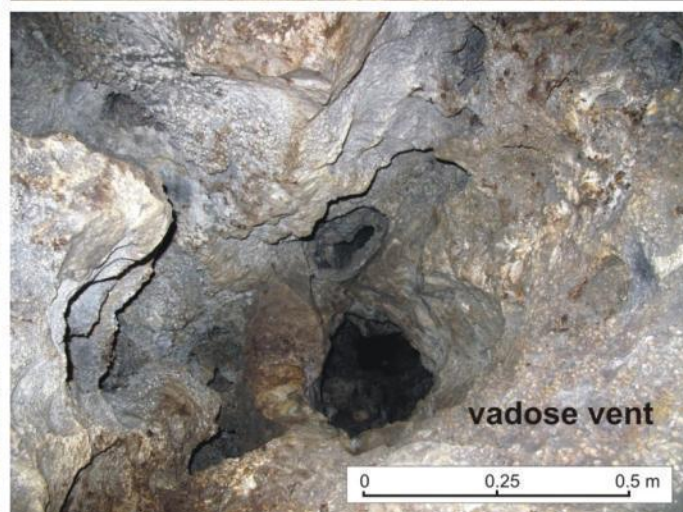
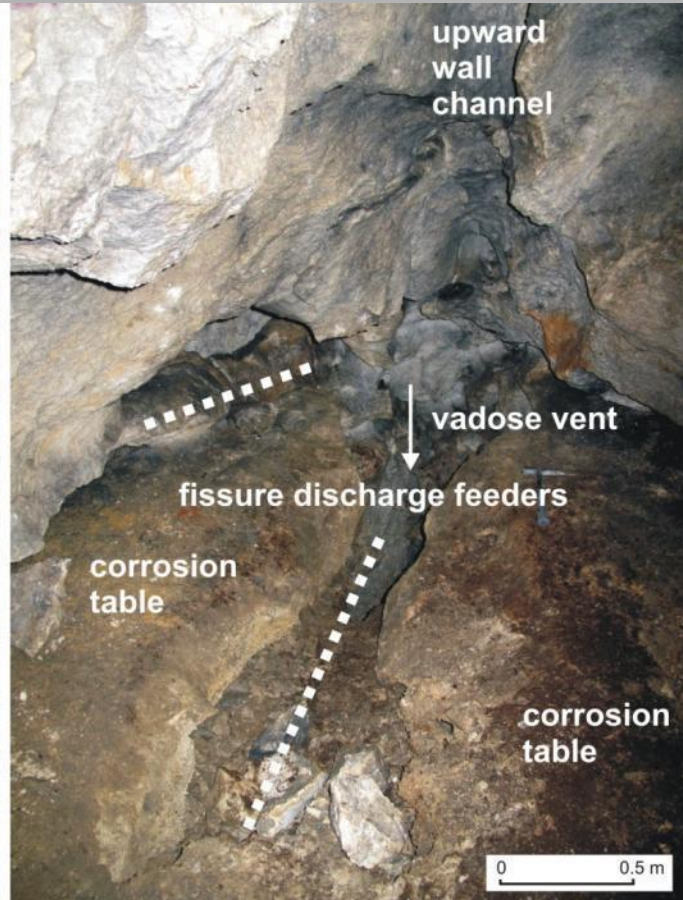
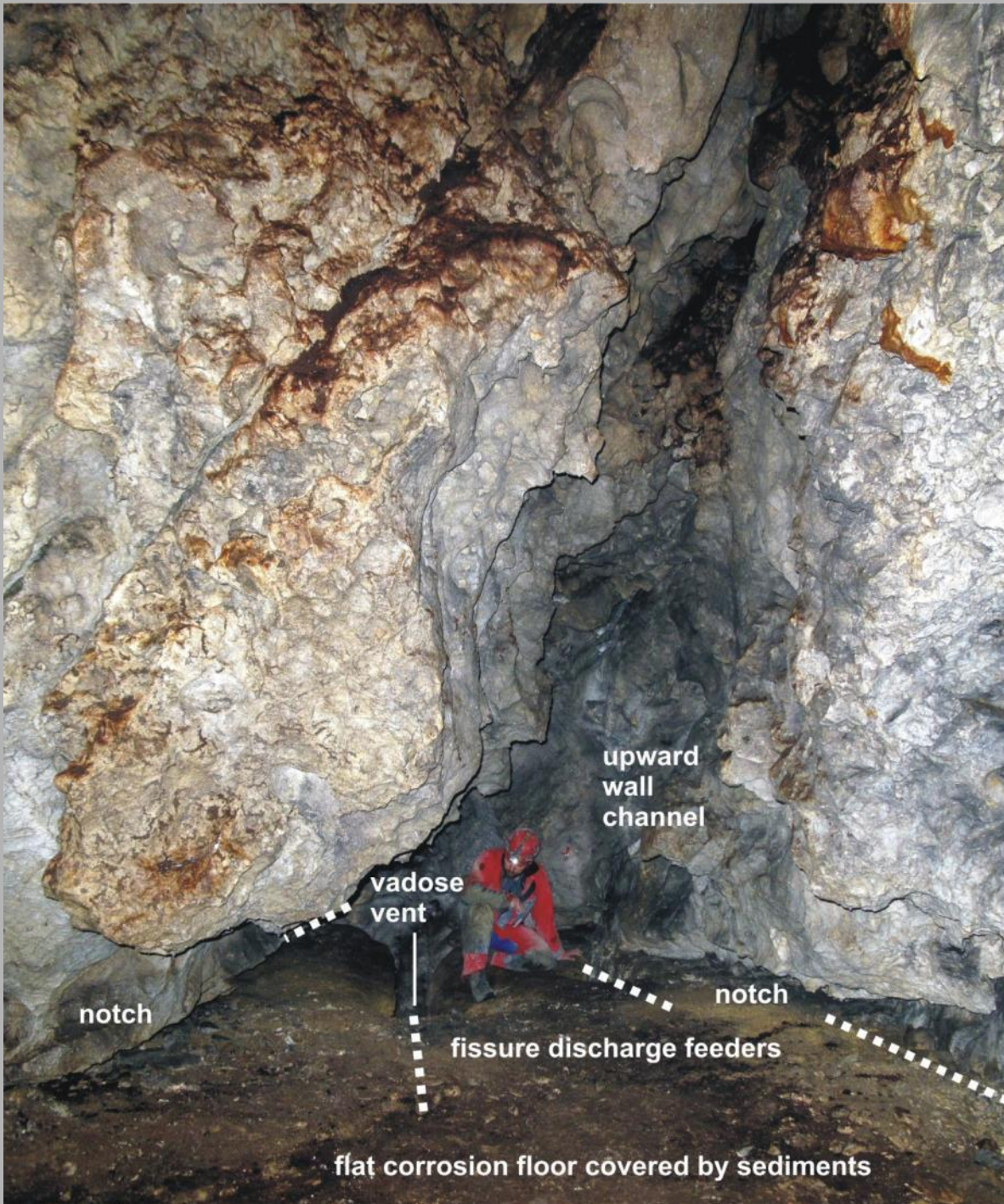
A**B**





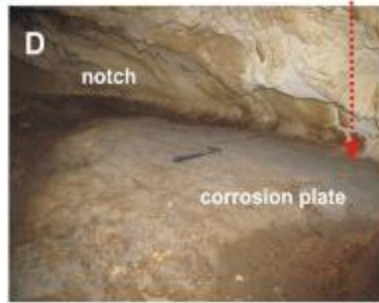
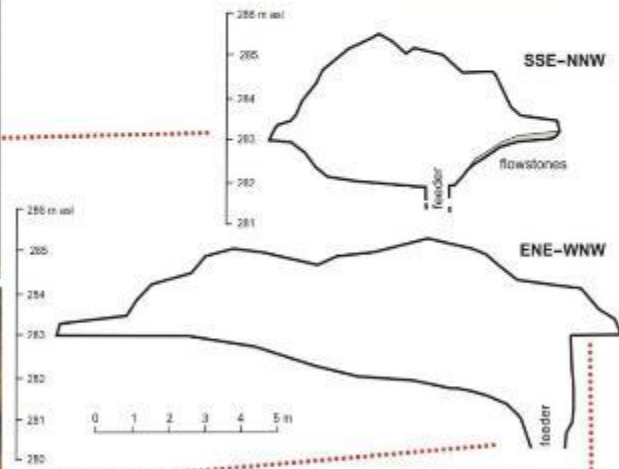
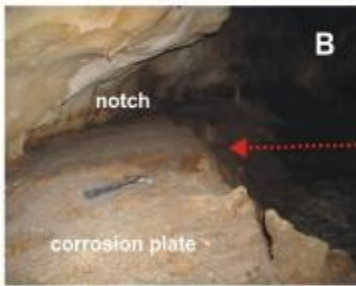
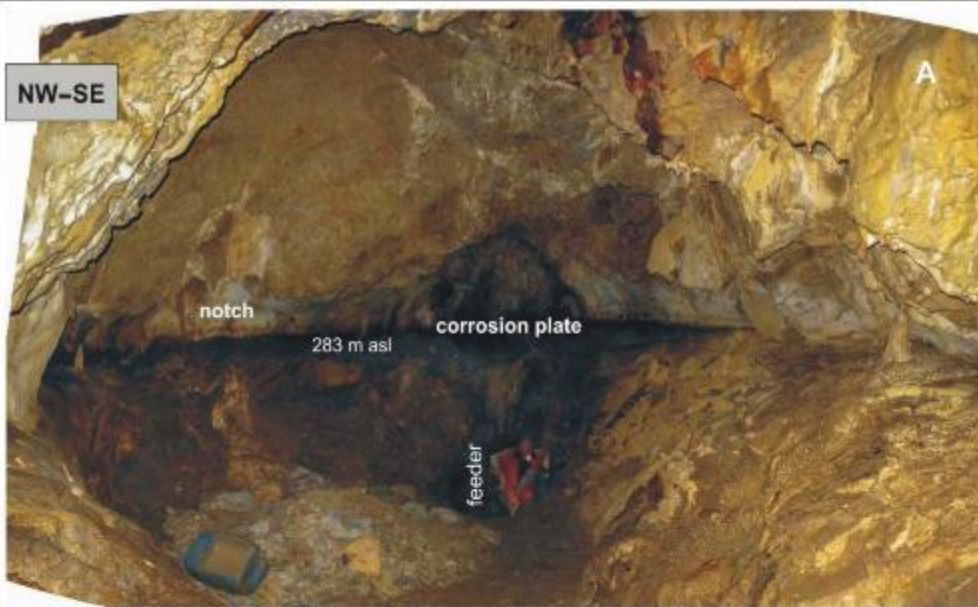
The Plavecká jaskyňa and Pec caves mostly contain mostly horizontal passages and chambers with flat corrosion bedrock floors, fissure discharge feeders, wall water-table notches, replacement pockets, and as well as some a few other speleogens associated with sulfuric acid speleogenesis.

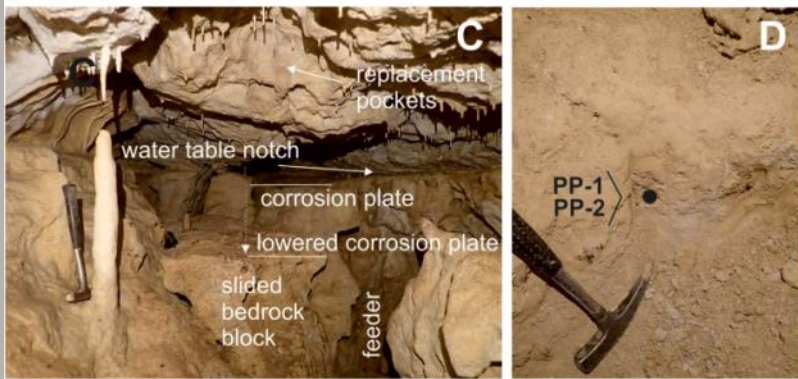
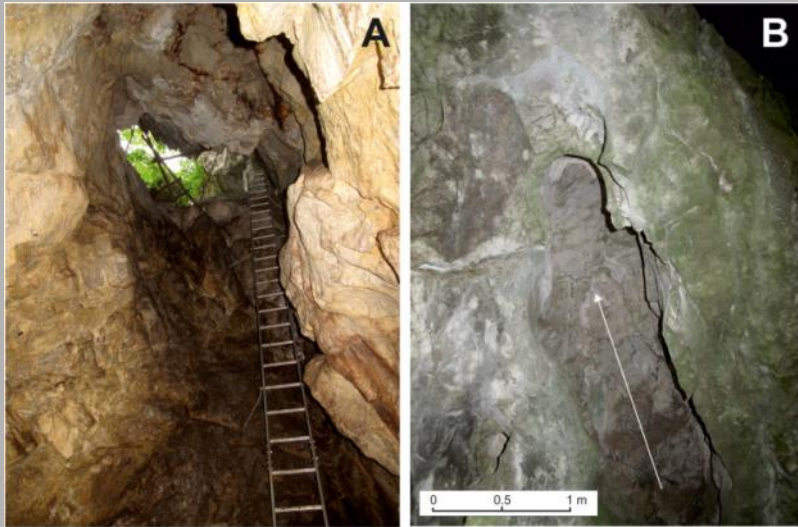




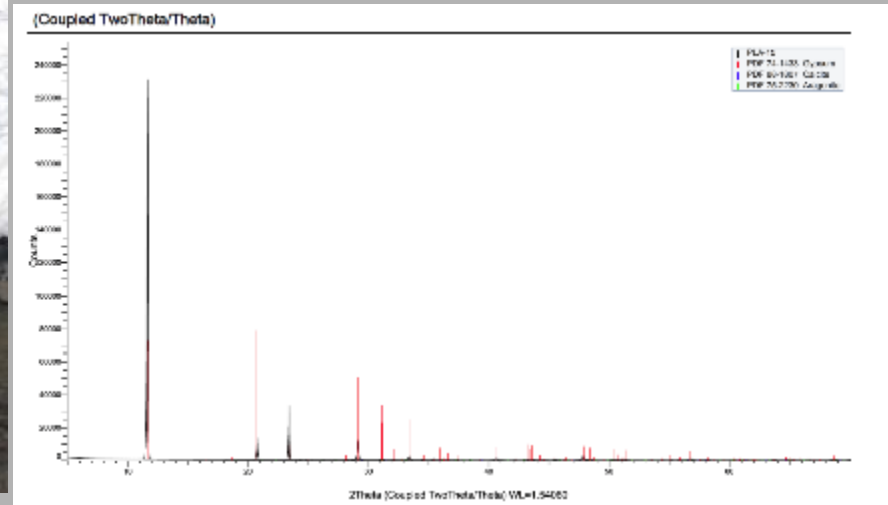


Jaskyňa Pec Cave

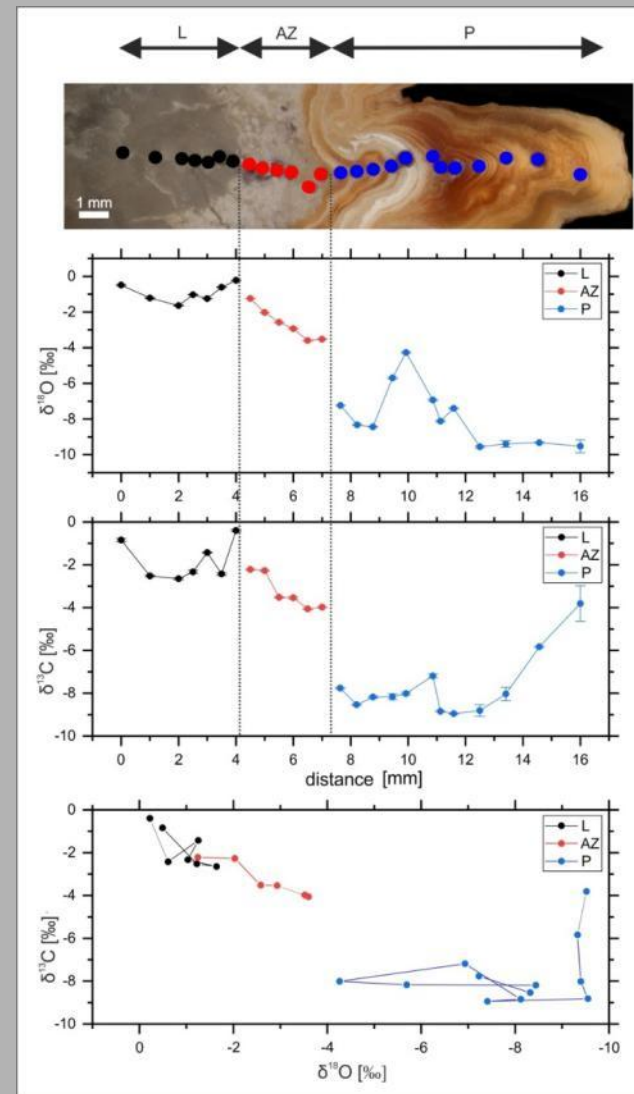
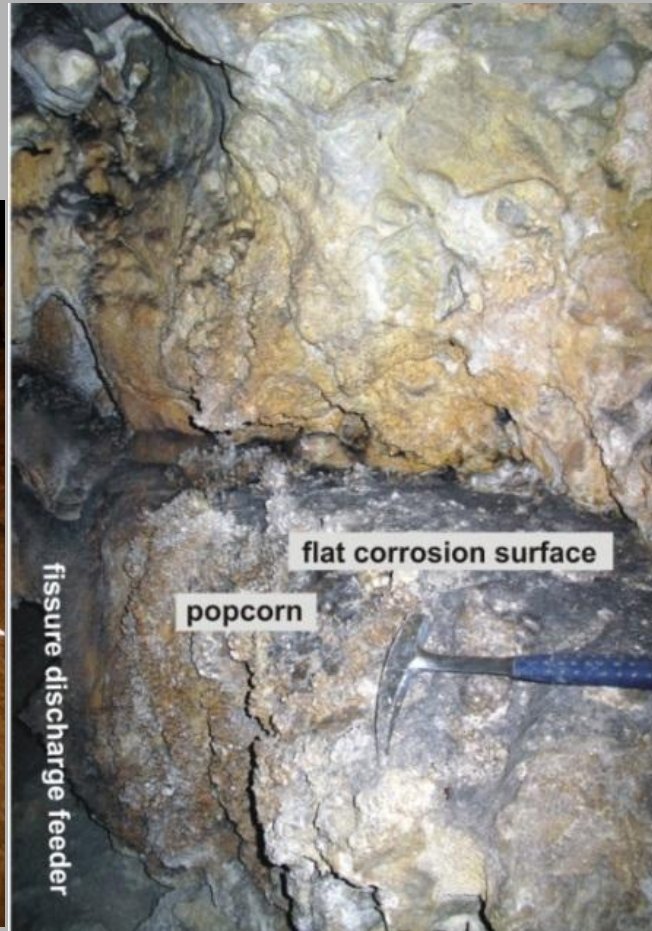




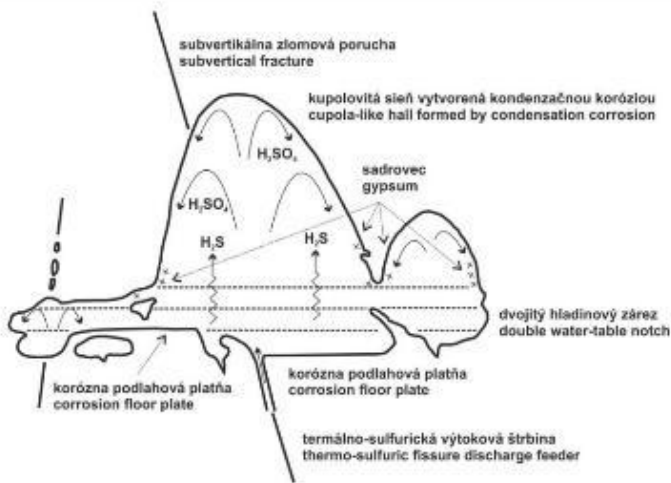
The sulfuric low-temperature sulfuric acid development phases of the Plavecká Jjaskyňa are also indicated by the presence of sulfate minerals (i.e., gypsum and jarosite).



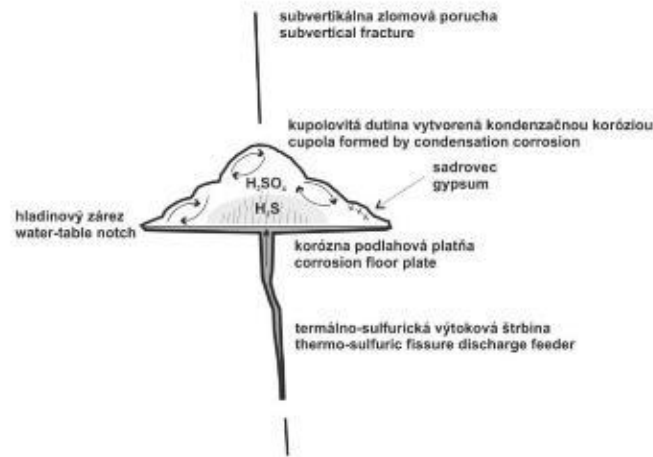
Subaerial calcite popcorn rims were precipitated from water condensation water at the edges of feeding fissures that were still active as thermal vents when the water table dropped.



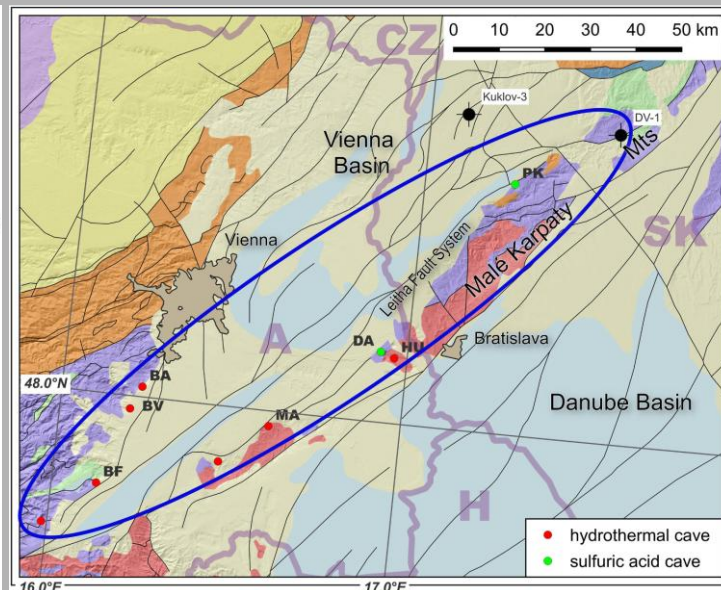
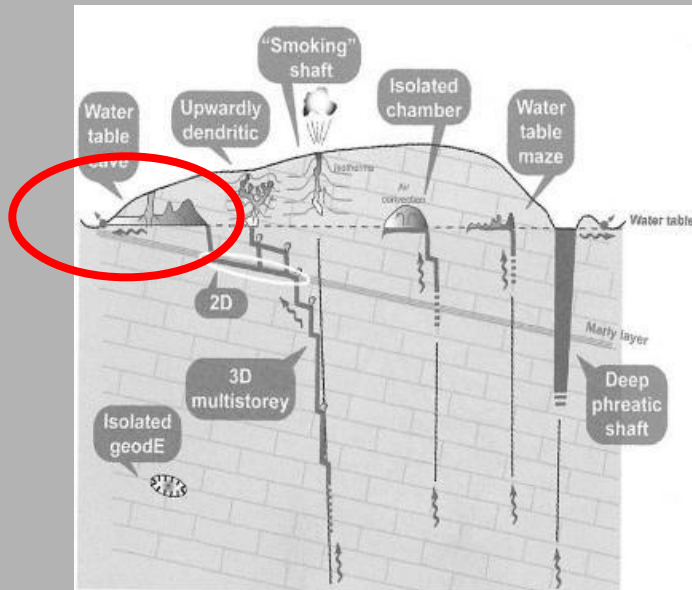
Lab. no.	Sample	U cont. [ppm]	$^{234}\text{U}/^{238}\text{U}$	$^{230}\text{Th}/^{234}\text{U}$	$^{230}\text{Th}/^{232}\text{Th}$	Age [ka]	Corrected age [ka]
1072	Pla-11 Plavecka/popcorn: upper part	0.743±0.004	1.0673±0.003	0.146±0.002	4.08±0.05	17.2±0.2	13.9±0.3
1071	Pla-11 Plavecka/popcorn: lower part	0.424±0.003	1.1017±0.003	0.957±0.006	4.14±0.03	+9 293 -8	+17 270 -10



Audra (2008), Audra et al. (2009), De Waele et al. (2016)

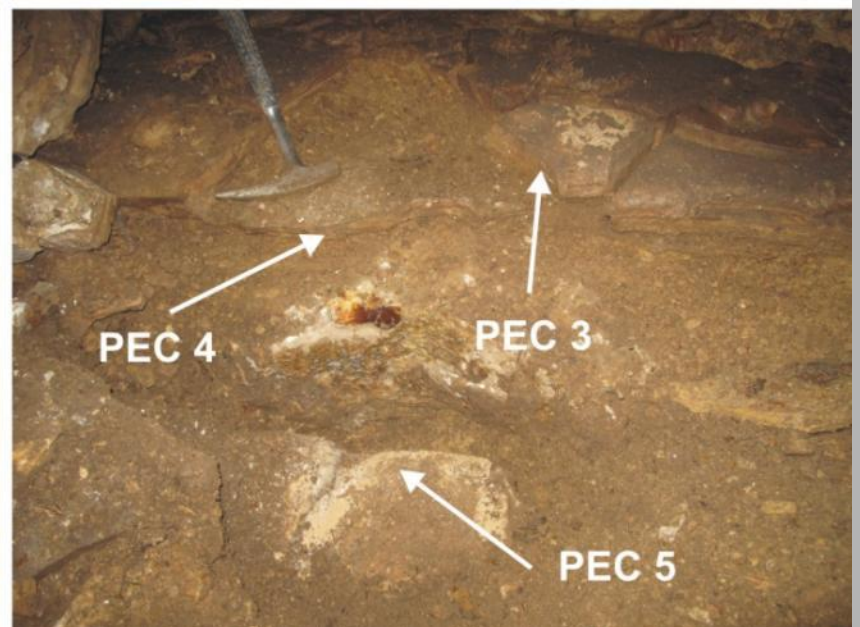
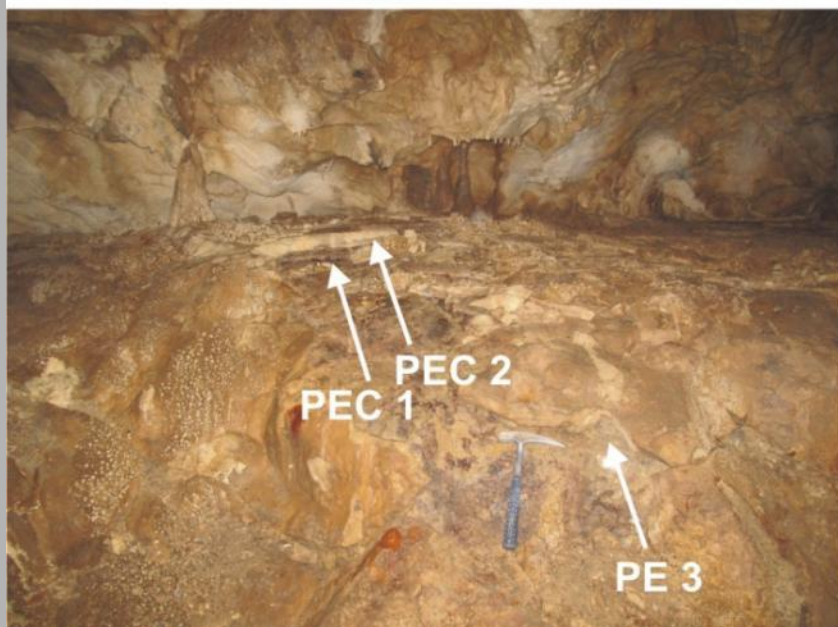
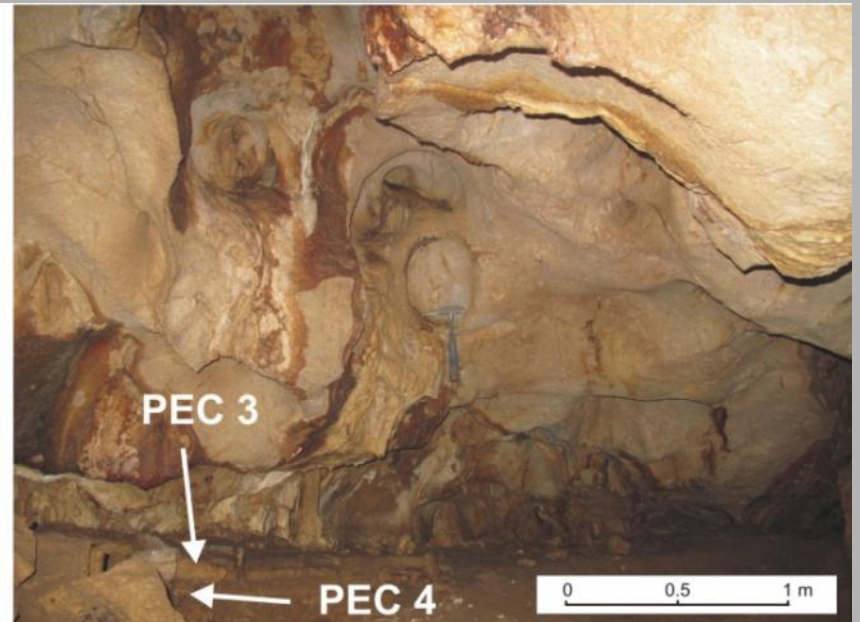
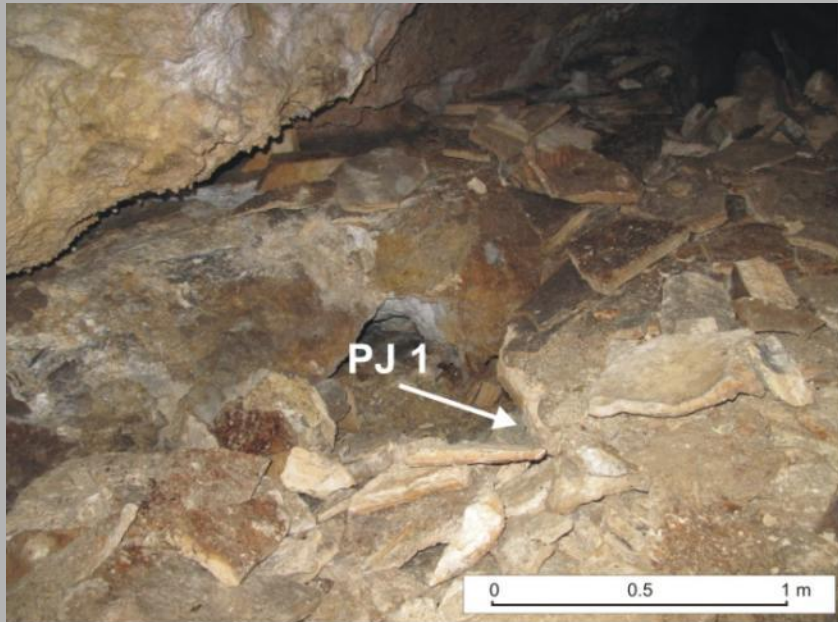


Vattano et al. (2012, 2013)

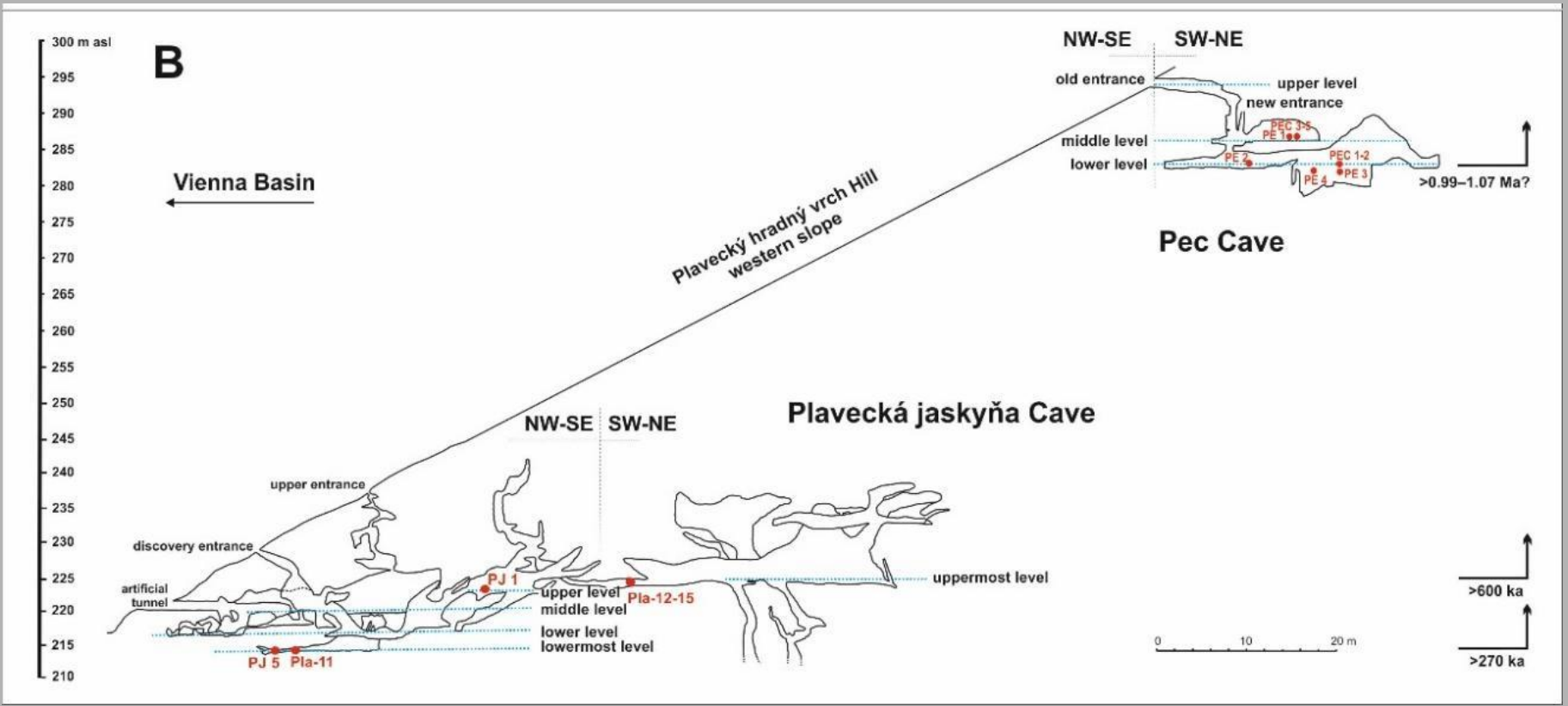


Hydrogen sulfide involved in the sulfuric acid speleogenesis was probably likely derived from anhydrites and/or hydrocarbon reservoirs with sulfate-saline connate waters in the fill of the adjacent Vienna Basin. It ascended to the surface along deep-rooted sub-vertical fault zones at the contact of the Vienna Basin with neighboring mountains.

Jaskyňa Pec Cave

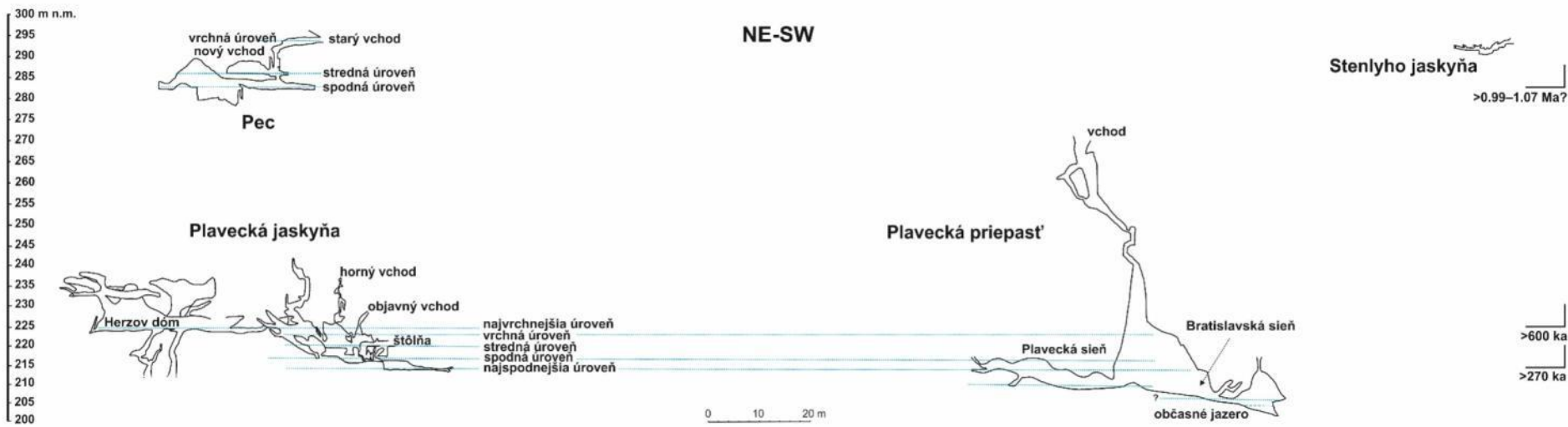


Lab. no.	Sample	U cont. [ppm]	2 σ error	²³⁴ U/ ²³⁸ U AR	2 σ error	²³⁰ Th/ ²³⁴ U AR	2 σ error	²³⁰ Th/ ²³² Th AR	2 σ error	Age [ka]	Corrected Age* [ka]	Initial ²³⁴ U/ ²³⁸ U AR**	2 σ error
1072	Pla-11 Plavecka/ popcorn: upper part	0.743	0.004	1.0673	0.0030	0.146	0.002	4.08	0.05	17.2±0.2	13.9±0.3	1.070	0.023
1071	Pla-11 Plavecka/ popcorn: lower part	0.424	0.003	1.1017	0.0030	0.957	0.006	4.14	0.03			1.216	0.077
1334	PE 1/1	0.0943	0.0006	1.0420	0.0079	1.138	0.040	25.49	0.89	open system?			
1335	PE 1/2	0.0990	0.0006	1.0438	0.0067	0.958	0.028	6.65	0.19			1.10	0.15
1336	PE 1/3	0.0272	0.0002	0.9878	0.0082	0.919	0.039	7.38	0.31			0.97	0.17
1320	PE 2/1	0.1746	0.0012	1.0254	0.0059	1.035	0.025	27.24	0.63	>600 (< 1.2 Ma)			
1331	PE 2/2	0.2343	0.0015	1.0344	0.0046	0.5486	0.0073	20.36	0.26	86.7±1.7	84±2	1.044	0.025
1351	PE 2/3	0.2340	0.0013	1.0240	0.0036	0.897	0.018	16.22	0.32			1.046	0.097
1352	PE 2/4	0.1897	0.0010	1.0397	0.0039	0.997	0.036	23.71	0.87			1.14	0.31
1353	PE 2/5	0.3430	0.0018	1.1613	0.0032	0.9674	0.0057	14.856	0.081			1.355	0.039
1354	PE 2/6	0.4402	0.0024	0.9887	0.0024	0.7988	0.0053	37.02	0.24	176.9±2.7	174.2±3.2	0.982	0.018
1377	PE 3-1	0.1565	0.0009	1.1394	0.0036	0.8785	0.0093	23.43	0.24			1.248	0.038
1367	PE 3-2	0.1131	0.0006	1.1396	0.0051	1.0515	0.0098	54.25	0.45	>600 (< 1.2 Ma)			
1376	PE 4/1-1	0.0878	0.0005	1.1250	0.0060	0.722	0.018	49.89	1.20			1.181	0.057
1333	PE 4/2/2	1.3149	0.0075	1.0270	0.0017	0.9558	0.0031	13.932	0.044			1.065	0.024
1349	PEC 1	0.1408	0.0008	1.0192	0.0047	1.061	0.020	6.00	0.11	>600 (< 1.2 Ma)			
1365	PEC 1-1A	7.430	0.046	0.9594	0.0023	0.768	0.002	2232.12	5.79			0.9358	0.0050
1356	PEC 2-1	0.2298	0.0013	1.0274	0.0038	0.8900	0.0082	180.60	1.55			1.053	0.036
1357	PEC 2-2	0.0988	0.0006	1.0353	0.0051	0.953	0.023	15.17	0.36			1.08	0.15
1358	PEC 3-1	0.1324	0.0007	1.0511	0.0040	1.179	0.027	29.67	0.68	open system?			
1359	PEC 3-2	2.408	0.014	1.1366	0.0029	0.8808	0.0033	889.35	2.96			1.247	0.012
1360	PEC 3-2A	1.786	0.011	1.1732	0.0025	0.9386	0.0057	2024.11	12.68			1.352	0.026
1361	PEC 3-3	0.1317	0.0007	1.0266	0.0040	0.961	0.010	64.62	0.64			1.067	0.071
1321	PEC 4/1	0.2087	0.0012	1.0468	0.0045	1.031	0.016	17.99	0.27	>600 (< 1.2 Ma)			
1364	PEC 4/1-2	0.1008	0.0007	1.0453	0.0070	0.956	0.016	27.88	0.44			1.11	0.10
1322	PEC 4/2	0.2464	0.0014	1.0517	0.0032	0.9656	0.0080	120.82	0.95			1.129	0.059
1323	PEC 4/2/1	0.1128	0.0006	1.0551	0.0048	0.9529	0.0099	13.74	0.13			1.129	0.063
1324	PEC 5/1	0.2732	0.0016	1.0563	0.0033	0.9364	0.0068	17.07	0.12			1.121	0.038
1325	PEC 5/2	0.3349	0.0021	1.0770	0.0031	0.9039	0.0066	14.78	0.10			1.148	0.037
1350	PJ 1/1	0.1004	0.0005	1.0714	0.0046	1.066	0.026	6.472	0.160	>600 (< 1.2 Ma)			
1330	PJ 1/2	0.1043	0.0006	1.0730	0.0055	0.9831	0.013	10.906	0.130			1.19	0.10
1366	PJ 5-rafts	0.2463	0.0013	1.3588	0.0033	0.9570	0.0053	4.834	0.025			1.678	0.059



PJ 5-rafts
228 ka

The water table in the lowermost cave level probably dropped after the tectonic reactivation of the Podmalokarpatská znížena Depression just in the front of a marginal horst structure of the Malé Karpaty Mountains.



Three cave levels at 295 to 283 m asl in the Pec Cave, and five levels at 225 to 214 m asl in the Plavecká jaskyňa corresponded to phases of stable local erosional base levels in the bordering part of the Vienna Basin, most likely during periods of strongly decelerated and/or interrupted subsidence. Cave levels separated by vertical differences of only a few meters may be also be related to the Pleistocene climatic cycles.

The subhorizontal parts of the Pec Cave are probably of late Early Pleistocene age (>0.99–1.07 Ma?). The two highest levels of the Plavecká jaskyňa developed during the early Middle Pleistocene (>600 ka). Fine-grained sediments in the passage at 225 m asl with the normal magnetic polarity contain jarosite. The middle level of the Plavecká jaskyňa at 220 m asl was formed in the mid-Middle Pleistocene, while the lower and lowermost levels formed in the late Middle Pleistocene (>270 ka).

NW-SE

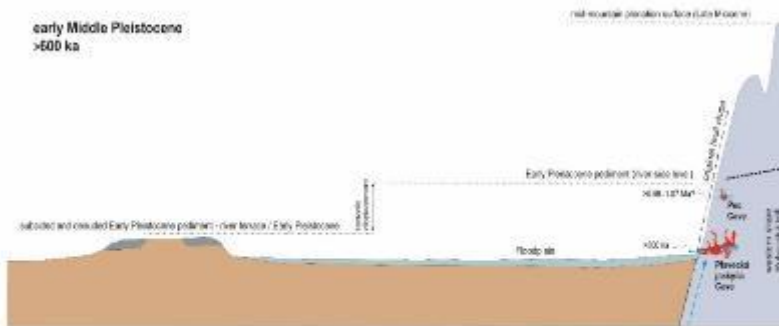
Malé Karpaty Mountains

late Early Pleistocene
>0.99–1.07 Ma?

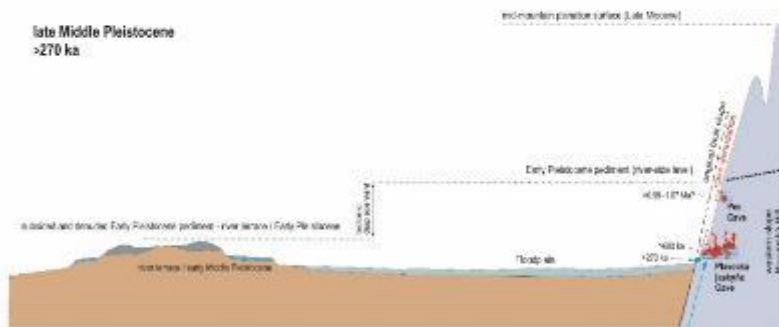
Vienna Basin
Záhorská nížina Lowland



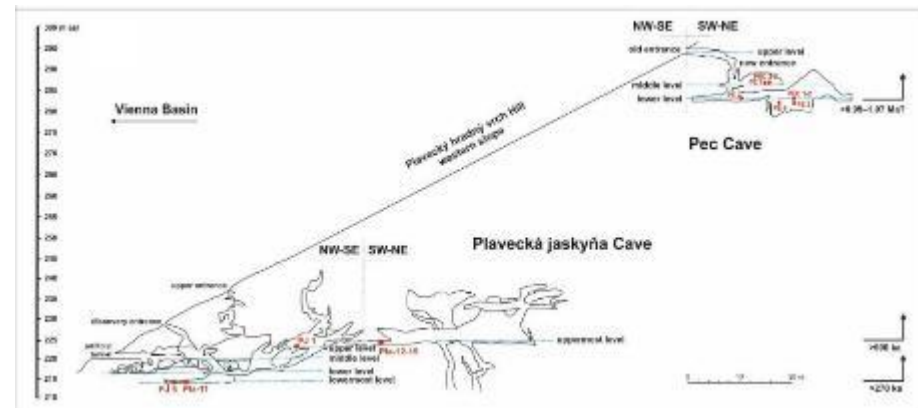
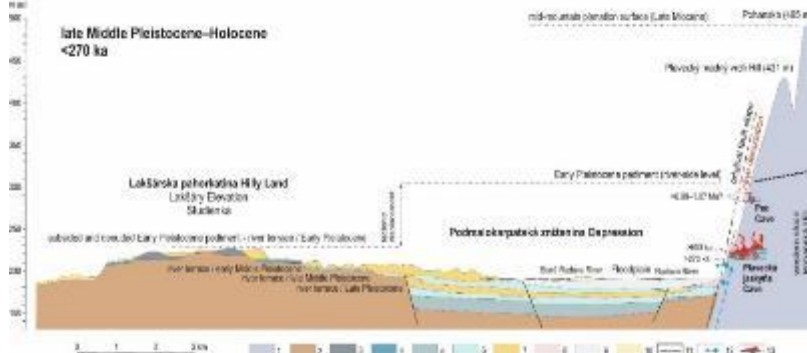
early Middle Pleistocene
>600 ka



late Middle Pleistocene
>270 ka



late Middle Pleistocene–Holocene
<270 ka



Hypogénne jaskyne v Plaveckom hradnom vrchu, Plavecký kras, Malé Karpaty

- úrovňové časti jaskýň vytvorené pôsobením kyseliny sírovej (vznikala oxidáciou H_2S na vodnej hladine)
- jedinečný genetický typ jaskýň na Slovensku

