

Sedimentary Deposits in Kittl's Bear Gallery in Križna Jama Cave (Slovenia)

by

Polona Kralj ¹⁾

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Zusammenfassung

Die Križna jama ist eine Karsthöhle, die durch fließendes Wasser und somit durch die Dominanz fluviatiler Sedimente geprägt wird. In trockenen Galerien, wie eben Kittl's Bärenhöhle, kommen typischerweise extrem schlecht sortierte und schwach stratifizierte Höhlensedimente vor. Sie entstehen durch Deckenbrüche und von den Höhlenwänden brechendem Material, episodische Überflutungs-Events, authigenische Calcit-Ausfällung und der Ablagerung von Höhlenbärenresten.

Während der Überflutungs-Events wurden neue, feinkörnige fluviatile Sedimente in die Galerie eingebracht und die davor abgelagerten Sedimente wurden erodiert und ausgeschwemmt oder umgelagert. Die Höhlensedimente in Kittl's Bärenhöhle erinnern damit stark an die zuvor untersuchten Sedimente aus der Potočka zijalka, der Herkova jama, und vor allem an die aus der Ajdovska jama.

Schlüsselwörter: Höhlensedimente, Karst, fluviatile Sedimente, Bärenhöhle, Slowenien

Abstract

Križna jama is a karstic cave, characterised by flowing water and dominating fluvial sedimentation. In dry galleries – like Kittl's Bear Gallery – typical, extremely poorly sorted, and massive to faintly stratified cave sediments occur. They developed by free-fall from the cave walls and ceiling, episodic flooding events via conduits, authigenic calcite precipitation, and settling of cave bear remains. During flooding events, new fine-grained fluvial material was brought in the gallery, and the pre-existing deposits were eroded and redistributed. Cave deposits in

the Kittl's Bear Gallery resemble to previously studied cave sediments from the Potočka zijalka, Herkova jama, and particularly Ajdovska jama caves.

Keywords: cave sediments, karst, fluvial sediments, cave bear site, Slovenia

Izvleček

Križna jama je kraška jama, ki jo odlikujeta tekoča voda in značilna rečna sedimentacija. V suhih dvoranah kot je naprimer Kittlova medvedja dvorana, se pojavljajo značilni jamski sedimenti, ki so ekstremno slabo sortirani ter masivni do nejasno plastoviti. Nastali so s prostim padom odlomkov prikamnine s stropa in sten, z epizodičnimi poplavami preko kraških ponorov in požiralnikov, z izločanjem kalcita ter s kopičenjem kostnih ostankov jamskega medveda. Poplavni dogodki so v sicer suho dvorano prinašali nov rečni material, hkrati pa so erodirali in presedimentirali stare sedimente. Jamski sediment v Kittlovi medvedji dvorani je zelo podoben tistim, ki smo jih našli v drugih jamah – Potočki zijalki, Herkovi jami in predvsem Ajdovski jami.

Gljučne besede: jamski sedimenti, kras, rečni sedimenti, medvedja jama, Slovenija

1. Introduction

The Križna jama cave at Lož (Fig. 1) is one of several attractive phenomena developed in the area of classic karst in Southern Slovenia. The cave consists of the main gallery and several smaller galleries and channels attaining all together a length of over 8 km. The main gallery is characterised by flowing water whilst the smaller ones are »dry« most of the time, and may be flooded only in the periods of heavy rains. The cave is hydrologically connected to the main recharge area of the Bloška polica plateau in the north-east, and to the westward positioned discharge area of the Cerknjsko polje carstic lowland with the Lake of Cerknica in its

¹⁾ Dr. Polona KRALJ, Geological Survey of Slovenia, Dimičeva 14, 1000 Ljubljana, Slovenia. e-mail: polona.kralj@geo-zs.si

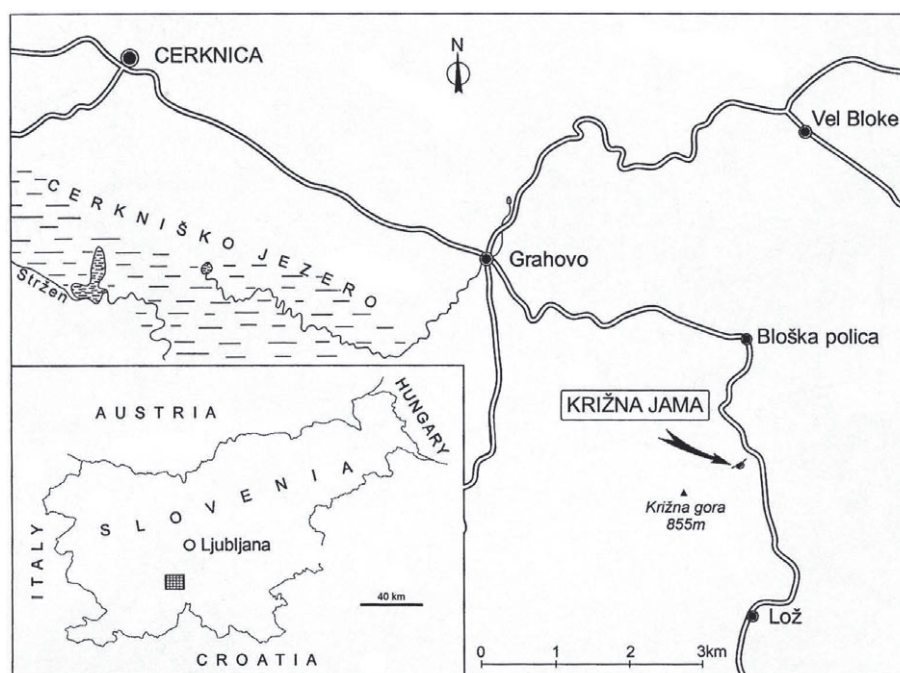


Figure 1: Geographic position of the Križna jama cave.

central part (PRELOVŠEK et al., 2008). Flowing waters running through the cave are the most important agent in sedimentation process forming channel-lag, levee, point bar and swale-fill deposits. During high-water regimes, flood suspensions reach »dry« galleries via conduits and form fine-grained laminated and thinly stratified deposits. Free-fall material detached from the wall ceiling and walls is significant, too, and can be distinguished from fluvial deposits by essentially extremely angular shape. After deposition, free-fall material can be subjected to mechanical decomposition and eventual redistribution and rounding by fluvial currents. Bauxite and limonite ooids occur mainly in the granule size and are reworked clastic material in origin.

Authigenic mineral deposits are dominated by stalactites, stalagmites and aragonite and calcite sinter precipitating from waters leaking through fracture systems in the cave walls and ceiling. Small-scale dams in fluvial channels slow-down the flow and produce small lakes. Their bottom is covered by fragile aragonite sinter which is still growing. Phosphates occur as an alteration product of bone material. When replacing bones, they are commonly crystallised as apatite, carbonateapatite or fluorapatite. Redistributed phosphates are scarce, and as amorphous or very poorly crystallised colloidal material form thin lenses in clayey and silty deposits. Manganese oxides are rare in occurrence and commonly poorly crystallised, too.

This contribution is focused on sedimentary deposits in Kittl's Bear Gallery which was the most important excavation site in our 1999 campaign. Sediment composition, structure and texture were studied in order to recognise transporting agents, depositional environment, and syn- and post-sedimentary reworking processes that influenced redistribution of fossil bone material.

2. Cave Deposits

Cave deposits in Križna jama were previously extensively studied by GOSPODARIČ (1974). Quaternary fluvial sand and silt prevail. Average sandy sediment contains up to 10 wt. % of silt and clay. The composition is dominated by carbonate (about 70 wt. %), whilst quartz (20 wt. %) and limonite ooids (10 wt. %) are subordinate constituents. Only locally, quartz- and limonite ooid-dominated sands (Plate 1, figs. 1, 2) occur, containing less than 10 wt. % of carbonate only. The sands are the most widespread levee and point bar deposits in the water-dominated galleries. Lithification of sands is not very common. Cement consists of bauxite (Plate 1, fig. 3) or carbonate – calcite or aragonite (Plate 1, fig. 4).

In »dry« galleries, finer-grained sand occurs. It commonly contains higher proportions of silt, although its composition is similar to the coarser varieties. Carbonate is the main constituent; quartz, limonite and illite/muscovite follow in a decreasing abundance order.

Gravel and conglomerate are channel deposits. Sporadic erosional remains of conglomerate occur between Dežman's Gallery and Mt. Crystal, and along the shoreline of the First Lake. In the first locality it consists of bauxite ooids up to 1 cm sized (about 65 wt. %) that are set in a sandy-silty matrix (about 22 wt. % of sand and 13 wt. % of silt). Carbonate cement may partially fill primary pores. Conglomerate occurring in the second locality contains less than 30 wt. % of ooids in average, the rest are mainly the grains of dolomite.

Bauxite and limonite ooids are common in the water channels (Plate 1, figs. 5, 6). Being heavier than the rest of the load, they can not be flooded over the sinter dams but are concentrating as the channel lag deposit. They are eroded from some pre-existing sedimentary deposits that

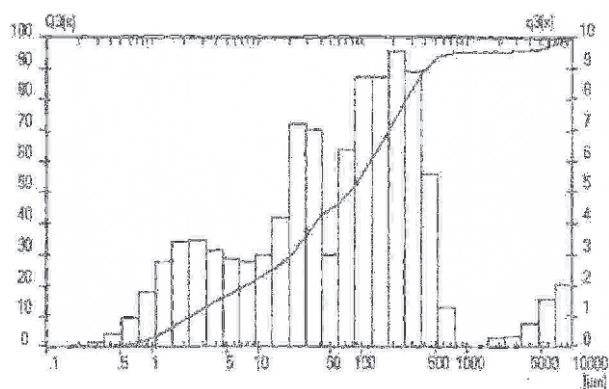


Figure 2: Bulk sediment distribution for the sample KJ 03.

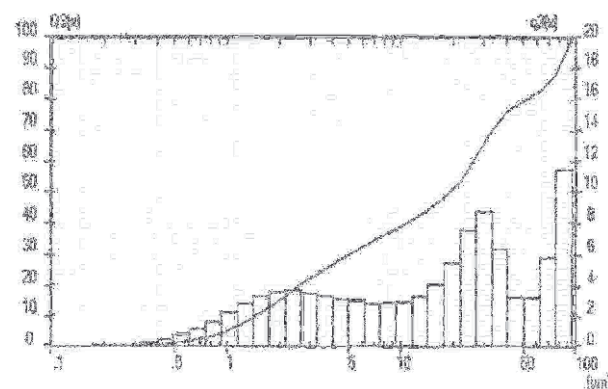


Figure 3: 0–100 μm fraction distribution for the sample KJ 03.

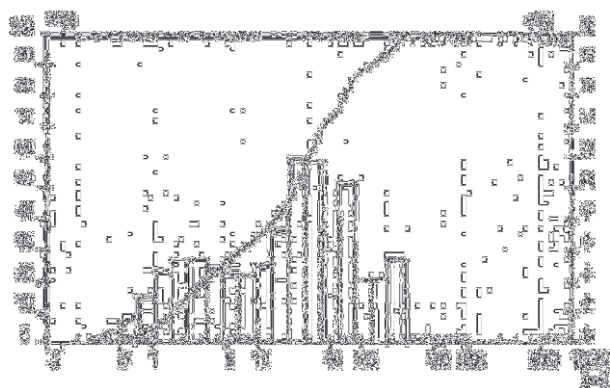


Figure 4: Bulk sediment distribution for the sample KJ 06.

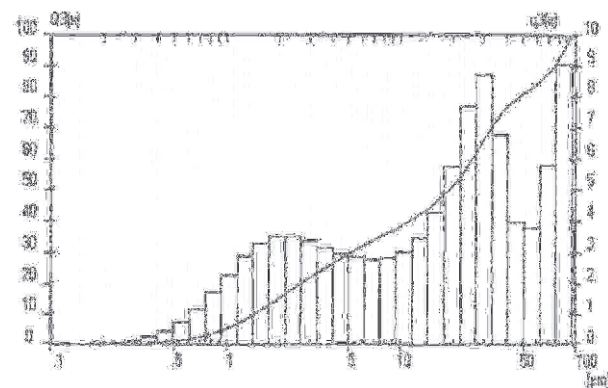


Figure 5: 0–100 μm fraction distribution for the sample KJ 06.

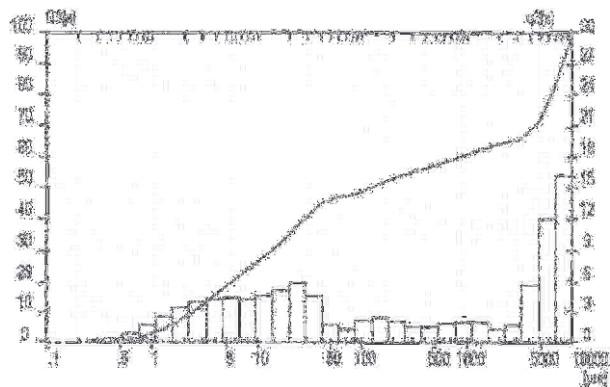


Figure 6: Bulk sediment distribution for the sample KJ 13.

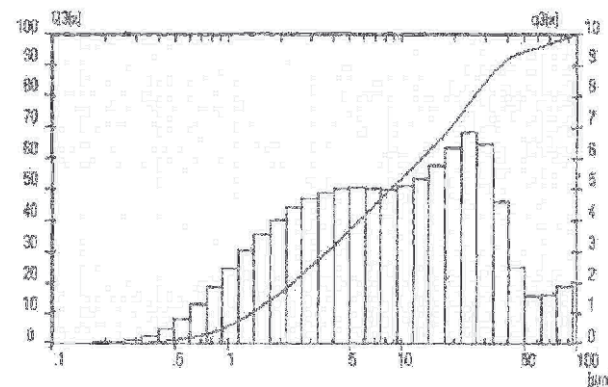


Figure 7: 0–100 μm fraction distribution for the sample KJ 13.

underwent erosion and reworking, and are not authigenic formations in the cave environment. If flooded in a small sink (Plate 1, fig. 7) exposed to constant dripping from the leaking walls and ceiling, they may become concentrically coated by aragonite or calcite (Plate 1, fig. 8).

3. Sediments in Kittl's Bear Gallery

Kittl's Bear gallery is one of smaller galleries situated close to the cave entrance. Today, the gallery is essentially dry.

The water invades the cave during high water regimes via narrow conduits. The sediments are faintly laminated and thinly to medium bedded. Lamination and bedding is mainly related to a slight change in the grain-size, and very rarely, to the content of the sediment constituents. Grain-size analysis (Table 1) indicates that the sediments are mixtures of silt, sand, gravel and clay. The actual amount of gravel fraction is uncertain as the sampling in the profile did not permit to gather the quantity sufficient for a reliable analysis. Nevertheless, the majority of the analysed samples are silts, most commonly sandy silts, or

Sample	Station	Depth (cm)	Clay < 2 μm	Silt 2 – 63 μm	Sand 63 μm – 2 mm	Gravel 2 – 63 mm
KJ 03	1	50–65	8.3	38.4	48.6	4.7
KJ 04	1	65–70	10.9	56.4	32.7	0
KJ 05	1	70–90	10.6	61.4	28.0	0
KJ 06	2	150–160	13.3	63.8	22.9	0
KJ 07	2	140–150	11.3	68.8	19.9	0
KJ 08	2	175–185	9.3	77.8	12.9	0
KJ 09	3	0–20	7.5	45.4	30.7	16.5
KJ 10	3	20–30	13.5	65.5	20.0	1.0
KJ 11	3	30–40	3.1	33.8	26.2	36.9
KJ 12	4	180–215	7.2	43.0	15.0	34.8
KJ 13	5	20–50	7.9	39.1	17.0	36.0
KJ 14	5	50–70	4.0	26.9	10.0	59.1

Table 1: Grain-size distribution for the studied samples from the Križna jama cave.

Sample	Station	Depth (cm)	Clay < 2 μm	Silt 2 – 63 μm	Sand 63 μm – 2 mm
KJ 03	1	50–65	8.7	40.3	51.0
KJ 04	1	65–70	10.9	56.4	32.7
KJ 05	1	70–90	10.6	61.4	28.0
KJ 06	2	150–160	13.3	63.8	22.9
KJ 07	2	140–150	11.3	68.8	19.9
KJ 08	2	175–185	9.3	77.8	12.9
KJ 09	3	0–20	9.0	54.2	36.8
KJ 10	3	20–30	13.6	66.2	20.2
KJ 11	3	30–40	4.9	53.6	41.5
KJ 12	4	180–215	11.0	66.0	23.0
KJ 13	5	20–50	12.3	61.1	26.6
KJ 14	5	50–70	9.9	65.6	24.5

Table 2: Gravel-free grain-size distribution for the studied samples from the Križna jama cave. The gravel fraction was sieved-off from the bulk sample and the grain-size distribution recalculated to 100 wt. %.

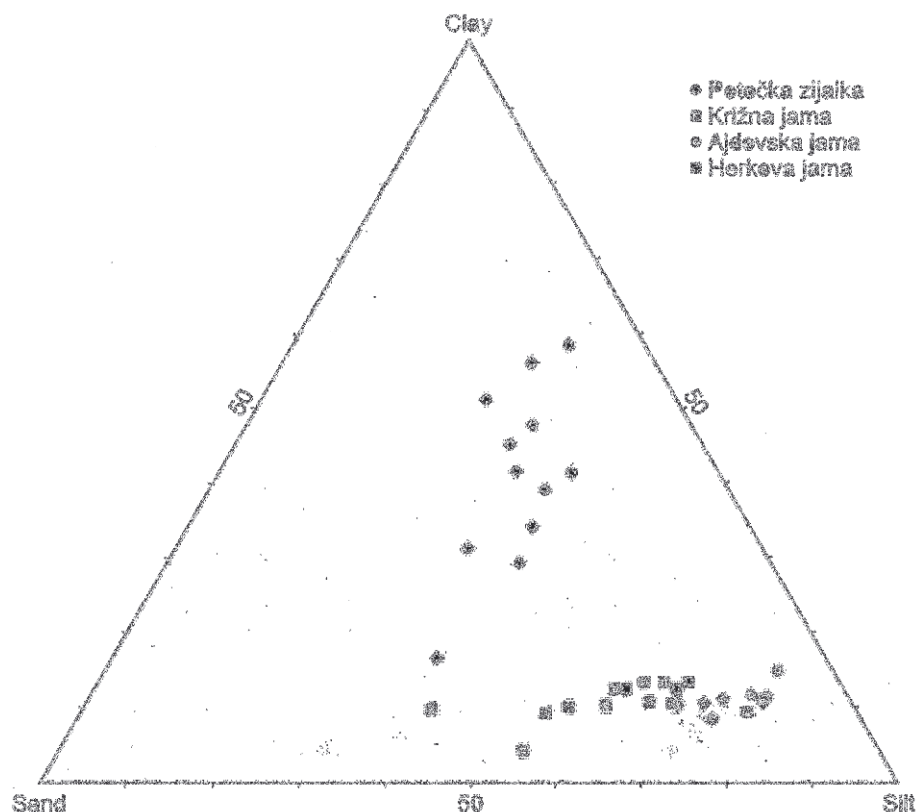
more rarely, gravelly (sandy) silts. Only one of 12 samples is sandy silty gravel.

The content of gravel fraction is not representative owing to insufficient availability of the sediment sampled in the profiles in our digging stations. The gravel mainly originates from the walls and ceiling and forms a unique population. The remaining sand, silt and clay fractions represent fluvial material, and also, the material developed by mechanical decomposition of the wall and ceiling rock and/or by authigenic calcite and limonite growth. Uneven grain-size distribution indicating the presence of different populations has been observed for both, bulk and gravel-free samples. Sorting is extremely poor for the bulk samples and somewhat better for the gravel-free samples (Table 2, Figs. 2–7). Clay and very fine to fine silt (0.3–10 μm) population is very uniform for the majority of the studied samples and has the median of

about 2.2 μm . Medium and coarse silt population has the median of about 30 μm , and very fine sand at about 80 μm . Medium- to fine-grained sand is typically composed of fluvial and reworked free-fall material, and for that reason, the population is very commonly bi-modal. Coarser populations have a less uniform distribution and median values, and mainly originate from free-fall from the cave walls and ceiling.

Mineral composition recognised by X-ray diffraction method is relatively uniform. In bulk samples, calcite is the most abundant mineral, the amount ranging from 50 wt. % to 85 wt. %. The other very variable component is hydroxyl-carbonate apatite which originates from the alteration of bone material; fluorapatite is less abundant and replaces fossil teeth. Some laminae in silty layers consist of authigenic apatite, but it is poorly crystallised, gelatinous and non-detectable by X-ray diffraction. In

Figure 8: Clay-Silt-Sand triangle with the position of samples studied in Slovenian karstic caves with cave bear remains.



the sand and silt fraction, quartz is the most abundant mineral although its amount is variable – from 30 wt. % to over 60 wt. %. Calcite is still an important constituent and commonly ranges from 25 wt. % to 40 wt. %. Muscovite/illite amounts up to 20 wt. %, whilst chlorite is less abundant, commonly below 10 wt. % of the bulk sample. In the sand and silt fraction, limonite particles also occur in the form of xenomorphic and poorly crystallised grains. The clay fraction may still contain up to 20 wt. % of calcite, although the most abundant constituents are illite and mixed layered illite/montmorillonite and chlorite/montmorillonite. The clay fraction was studied in oriented and glycolised samples. In suspended form, clay minerals underwent extreme coagulation, very possibly owing to the presence of phosphate colloidal particles.

4. Conclusions on Transport and Post-sedimentary Redistribution of Sediments in Kittl's Bear Gallery

Based on sedimentological analysis of cave deposits in the Stations 1 – 5 in the Kittl's Bear Gallery, in average about 20 wt. % originates from free-fall, about 70 wt. % was derived by fluvial currents during flooding periods, about 5 wt. % is authigenic – mainly calcite sinter, and about 5 wt. % are fossil remains.

Predominant massive structure, grain-size distribution indicating the presence of up to six populations, extremely poor sorting, coexistence of very angular and rounded grains, as well as the sediment composi-

tion reveals a complex formation history. The majority of fine-grained sediment (clay, silt and fine sand) was transported by ephemeral flooding episodes that entered the gallery via conduits. The bulk of coarse sediment (gravel) originates from free-fall – the detachment of the cave walls and ceiling. Along geochemical boundaries, calcite precipitates and forms thin sinter veneers. Flooding episodes brought new clastic material in the gallery, but also disturbed the existing deposits owing to a turbulent current character. Free-fall material, broken sinter veneer, bone material and eroded old flood deposits were redistributed and settled again as reworked sediment mixture that lacks of internal stratification and is extremely poorly sorted.

Although the majority of Križna jama cave is characterised by flowing water and fluvial sedimentation, typical cave sediments have been developed in the dry Kittl's Bear Gallery. They closely resemble the sediments studied in some other Slovenian karstic caves with Pleistocene fossil fauna remains, like Potočka zijalka (KRALJ, 2004), Herkova jama or Ajdovska jama (Fig. 8). The closest resemblance can be identified for the Ajdovska jama cave (KRALJ, 2011) as it is strongly influenced by flooding events via conduits and has mineralogically similar source rocks.

5. Acknowledgements

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PLATE 1

- Fig. 1** Fluvial pebbly sand with bauxite ooids and fragments of broken sinter. The ooid sizes range from about 1–3 cm.
- Fig. 2** Partially lithified pebbly sand.
- Fig. 3** Bauxite-cemented sandy conglomerate.
- Fig. 4** Calcite-cemented sandy conglomerate.
- Fig. 5** An underground lake dam covered by aragonite.
- Fig. 6** Concentration of eroded bauxite ooids (pebbles) in the dam fronts.
- Fig. 7** Authigenic aragonite forming covering the dam surfaces. Aragonite crystal sizes attain up to some mm.
- Fig. 8** Authigenic aragonite ooids, 1–2 cm sized.

Photos: © by Alojz Troha (Bloška Polica, Slovenia)

PLATE 1



