Fossil remains of a cave tube worm (Polychaeta: Serpulidae) in an ancient cave in Slovenia

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Abstract

Calcareous tubes, matching those of the modern cave tube worm *Marifugia cavatica* Absolon & Hrabe (Polychaeta: Serpulidae) in shape and dimensions, were found attached to the wall of a fossilised cave on the Kras plateau, W Slovenia. Due to (1) the supposed absence of any marine influences in that cave, (2) the fact that *Marifugia* is the only freshwater serpulid known at all, and (3) the mentioned similarity, we suppose that the fossil tubes belonged to the same species or its ancestor. The exact datation would give the first direct data about the minimum "cave age" of an animal species.

Towards the end of its hydrological activity, the passage was filled with clay and flowstone. The roof of the passage has been removed by karst denudation and cave is now exposed to the surface.

Paleomagnetic datation of the sediment fill shows minimal possible age of 1,7 Ma which is in accordance with the geomorphological observations.

Introduction

During the geomorphologic research of the Kras plateau in past years we focused our attention to the unroofed caves. This are segments of caves, which were formed in the depth but they are exposed to the surface as a result of the karst denudation which dissolved and removed all the rock layers above them. They are the oldest remains of caves in this area and the oldest sediments have been preserved in them (MIHEVC, 1996; MIHEVC & ZUPAN 1996; MIHEVC *et al.*., 1998; BOSAK *et al.*., 2000).

In the Črnotiče limestone quarry, we studied a large unroofed cave, filled with speleothems and allochtonous alluvial sediments. The quarry is situated on the S edge of the Kras, on the Podgorski kras plateau, W Slovenia (45° 33' 57" N, 13° 52' 48" E). The surface of the plateau is levelled at about 450 m a.s.l., dismembered only by numerous dolines. The deepest cave is 150 m deep, but no active flow can be reached trough it. Karst springs with maximum discharge of several $m^3s^{-1}$are few km away, at the foot of the plateau, at elevation of about 50 m a.s.l.

The quarry exploitation opened the fossilised cave step by step, making study of the former cave passage and its sediments possible. A profile of the sediment was dated with paleomagnetic method. Its minimum age was 1.77 Ma (BOSAK *et al.*., 1999).

New, side passage of the cave was quarried out in the year 2000. In this passage, which was also filled with sediments, we found calcareous tubes that were attached to the cave wall. These tubes are very similar to those of the Dinaric cave tube worm *Marifugia cavatica* (MIHEVC, 2000). The clay deposit in the cave obviously protected the fragile tubes since the time when an underground river flowed through the cave.

Description of the profile and fossils

The uncovered side passage profile with fossil tubes is 4-8 m wide and more than 17 m high. Laminated clays were deposited in its lower part. In the middle, there is an erosional discordance of the sediment above which quartz sands and some layers with pebbles are deposited. Sand and pebbles, brought in the cave by a sinking river originate from Eocene flysch rocks. Above them 7 m thick layer of flowstone was deposited.

The calcareous tubes are attached to the wall in the lower part of the passage between 426 and 427 m a.s.l. They are placed separately or in groups of up to several hundred individuals. Unfinished ones accompany tubes of supposedly grown up animals. The end parts of tubes, which were perpendicular to the wall, were broken off, probably when we were removing the clay sediment from the wall; anyway, we were able to wash them out of the sediment.

The remains of the fossilised tubes attached to the cave wall were removed together with the rock they were attached to. Tubes could also be picked out of the sediments that were in the contact with the wall. A profile of the sediment was taken for the paleomagnetic datation. The tubes were compared with the recent tubes of the serpulid *Marifugia cavatica.*

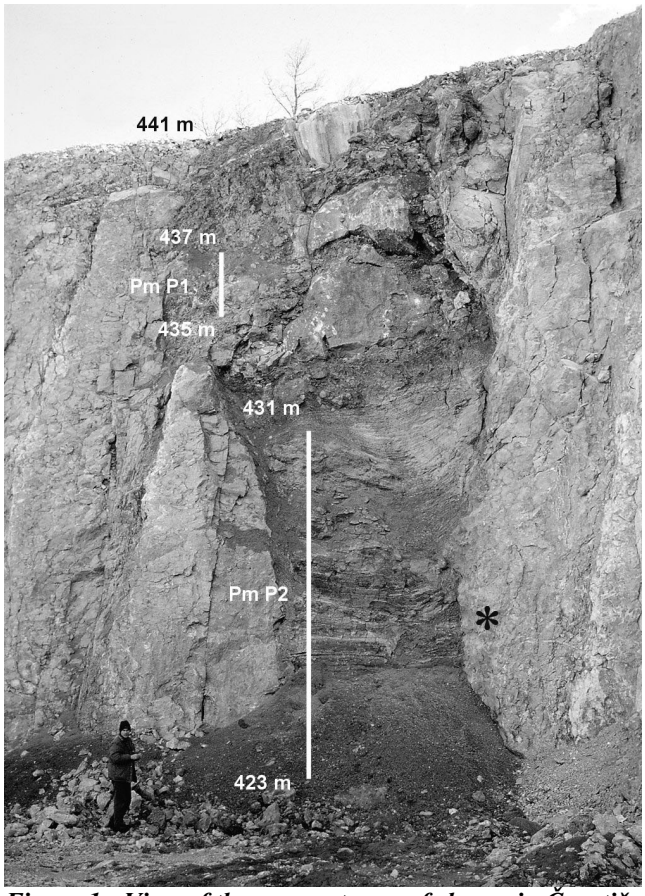

Figure 1 - View of the crosscut unroofed cave in Črnotiče quarry. Legend: * the position of the tubes; PmP, PmP2 levels of the paleomagnetic profiles.

Datation of the sediments

There are two profiles of cave sediments dated by the paleomagnetic method, i.e., (PmP1) profile in main passage composed of laminated cave (algal) limestones with intercalations of red clays, (BOSAK *et al.*., 1999), and (PmP2) profile in a side passage, 20 m distant, with finds of worm tubes composed of numerous typical cave fluvial cycles (conglomerate to claystone).

Within the first profile, elevation between 435 and 437 m, the long normal magnetozone was interpreted in the lower half of the log. The top part of the profile shows reverse palaeomagnetic direction interrupted by two normal magnetised zones.

The magnetostratigraphic investigation of the second profile, elevation between 423 and 431 m, proved two short reverse magnetozones within the dominant normal magnetic polarisation.

The arrangement of the distribution of normal and reverse polarity magnetozones depends on abundant unconformities of unknown duration in both profiles. According to the arrangement of individual magnetozones in a standard scales, we can assume that the top of the highest normal polarised magnetozone in our first profile could be correlated with the top of the Olduvai event (1.77 Ma) as the youngest possibility, and therefore the rest of profile must be older.

The second profile is clearly older that Brunhes/Matuyama boundary (0.78 Ma), but the arrangement of individual magnetozones indicate much higher age, very similar to the interpretation of the first profile.

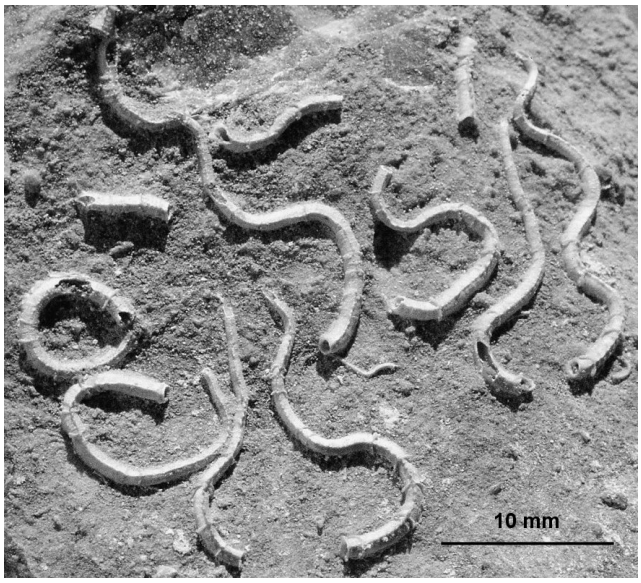

Figure 2 - A group of tubes of the cave serpulid from the profile of the unroofed cave in Črnotiče quarry. Corrosion damage to the limestone can also be observed; the tube itself is less damaged.

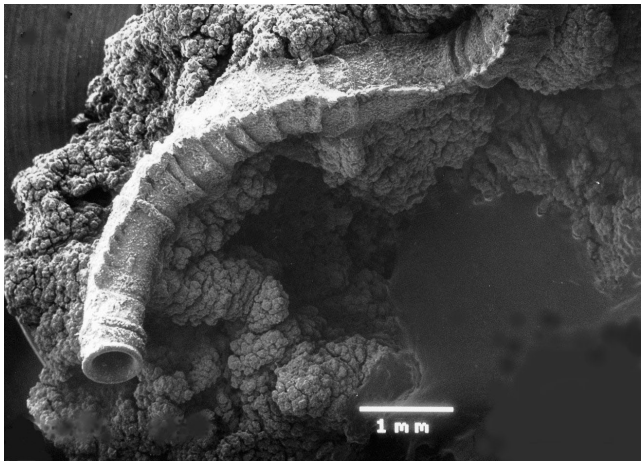

Figure 3 - The tube of the recent cave Marifugia cavatica from the cave Jama pod Krogom. The longitudinal toothed crest and the collar-like rings can be seen.

Comparative data about the recent *Marifugia cavatica*

Marifugia cavatica Absolon & Hrabe, 1930, is recently the only truly freshwater member of the family Serpulidae (Annelida: Polychaeta) and the only known tube worm inhabiting continental caves. It is widely, although patchily, distributed within the Dinaric Karst, from the Carso in NE Italy through southern parts of Slovenia, Croatia, Hercegovina and in western Bosnia (SKET, 1970b). Biogeographically it belongs to so called holo-Dinaric elements (*sensu* SKET, 1994).

Figure 4 - Fragments of the fossilised serpulid tubes from the sediment in the roofless cave in Črnotiče quarry. Their variability is remarkable.

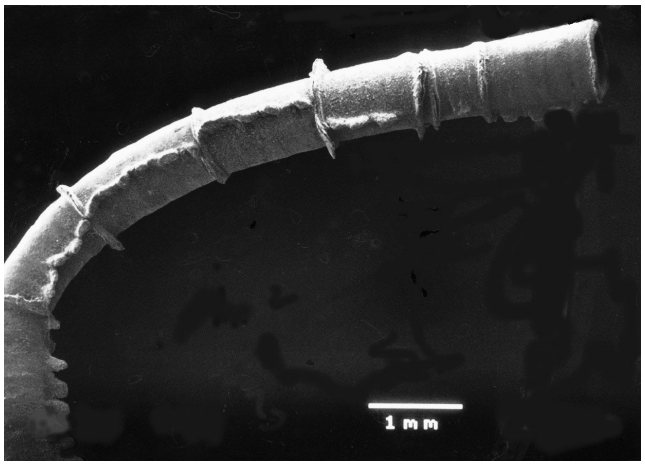

Figure 5 - The tube of a recent cave worm Marifugia cavatica from spring Tounjčica. Variability of the shape of the serrated crest and of the rings is clearly seen.

Although it was originally considered a marine element colonising fresh cave waters directly from the sea (ABSOLON & HRABE, 1930) it is nowadays supposed to have colonised cave waters from ancient (Pliocene or Pleistocene) freshwater lakes in the region (SKET, 1997). This is a parallel to some similarly distributed stygobionts: the amphibian *Proteus*, the cockle *Congeria*, and the cnidarian *Velkovrhia*.

Marifugia is an explicitly fresh water animal, it has never been found even in brackish waters (compare SKET, 1986). It is a filter feeder with a free-swimming larva (MATJAŠIČ & SKET 1966). It can be very sparsely settled in clear and fast flowing streams while it may aggregate to very dense colonies in backwaters where larvae are not swept away by the current and where particulate organic matter can be richer. Thick masses of many layers of tubes (as described by ABSOLON & HRABE 1930) are nevertheless a unique exception.

The calcareous tube of *Marifugia* is curved and attached to substratum in its initial centimetres while detached and more or less perpendicularly erect and straight when the worm grows up. The accreted part of the tube may be flattened beneath while the vertical part is perfectly cylindrical. There is an irregular and interrupted and serrate crest along the tube, however feebly developed or even absent along the erect part. On the contrary, circular pleats are very scarce and less distinctive along the accreted part while denser and very wide along the erect part. The finished tube evidently regularly ends with such a pleat. The broken off erected parts of tubes are very often found in the sand of karst springs, together with shells of stygobiotic gastropods.

The outer diameter of erect parts of tubes is 0.65 – 0.85 mm, while it diminishes towards the thinnest parts at least down to 0.2 mm. The first part of the tube at the young animal, before it gets incrusted, is only 1 mm long and 0.1 mm wide (MATJAŠIČ & SKET 1966). The maximal width of the collar-like pleats varies among specimens and populations. However, it varies as well along the individual tube; the maximal diameter measured was 1,5 mm and its width was 0.35 mm. They may be very densely packed or very distantly set, intervals in an individual tube are also variable. The tube's walls are approximately 0.05 mm thick.

Discussion and conclusions

The comparison of fossilised calcareous tubes from the fossil cave in Črnotiče with tubes of the recent *Marifugia cavatica* from its western localities reveals no differences surpassing those among the recent tubes themselves. They widely match in their shape and dimensions. The fossil tubes do not surpass any measures of the recent ones. Even the wall thickness is nearly equal which eliminates a possibility of corrosion in the clayey sediments.

The fossil locality is also within the general distribution area of *Marifugia* and even surrounded by some of its factual localities in the Rižana and Osapska reka spring areas, near Movraž and in the underground Reka system; they are all only 3-10 km away of Črnotiče. Since *Marifugia* is also the only known builder of such a type of tubes in freshwaters and there is no indication that the fossilised cave could have ever been flooded by the sea; therefore the identity or close relations of the fossil

with the extant cave tube worm is the only parsimonious solution.

From the dimensions of the cave profile, scallops on the walls of the passage, and the sediment filling we can conclude that a large underground river formed the cave. Scallops that formed on the walls indicate a slow current. We suppose that the sessile serpulid tubes were buried step by step when the passage was partly filled with fine sediment. Later the fine sediments in the upper part of the profile were eroded and replaced by coarser sediments. In that part of the cave wall no serpulid tubes were found. This seems to have been followed by a longer dry phase when more than 7 m thick flowstone layer was deposited. Finally, the karst erosion removed the rock above the cave, ceiling and part of the cave walls, so the flowstone fill is now exposed on the surface.

Paleomagnetic dating of the two sediment profiles in the cave because of the incomplete profiles and uncorformities in them gave the minimum possible age only; the sediment from the upper part of the cave fill is at least 1.7 Ma old, therefore the sediments below it, and the fossil tubes are most probably older.

This age is in accordance with geomorphologic observations: the estimated rate of karst denudation in the area is about 60 m/Ma (GAMS, 1974) and judging from the massive flowstone now exposed to the surface, there was at least 100 m of the rock removed by karst denudation from above the cave. Also, the present water caves and springs are about 370 m below the level of the unroofed cave with the fossilised serpulid tubes.

So, according to the minimum age of those sediments we may with some certainty suppose that at the beginning of Pleistocene epoch well developed karst with large water caves populated by animals adapted to cave life existed in the Podgorski kras plateau.

The main parts of the Dinaric cave fauna had been calculated to be of the Pliocene age (SKET, 1970a). However, recent studies revealed that even some important members of it could have been retarded in colonising cave waters till quite recently, postglacially (SKET, 1997). Since also a polytopic and polychronous immigration of surface species (let alone of surface faunas) underground has been supposed, both hypotheses are not necessarily in contradiction.

The new finding is a strong argument towards the high age of the Dinaric cave fauna although a direct datation of the fossils' age would add some certainty.

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