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NEW PLEISTOCENE VERTEBRATE ASSEMBLAGES IN THE BREITSCHEID-ERDBACH CAVE SYSTEM (IBERG LIMESTONE, DILL BASIN, GERMANY)

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A substantial cave system developed in Devonian reef carbonates at the eastern foothills of the Westerwald Mountains (Hessen, Germany) was first opened in 1993 by limestone quarrying. The system is split into 4 karst levels that appear to represent stages of cyclic karst formation. All accessible levels are presently in the vadose state. Clastic sediments filling fossil voids have preserved two rich Pleistocene vertebrate assemblages. Most specimens are identified as bats or the cave bear Ursus spelaeus*. The assemblages are at least partly allochthonous. The significance of the accumulations lies in the preservation of an undisturbed surface assemblage, which most likely has not been disturbed since the late Pleistocene.*

During quarrying activities under the so-called “Hohes Feld”, the entrances of the Breitscheid-Erdbach Cave system (also called Herbstlabyrinth-Adventhöhle-System; KNr: 5315/51; Hülsmann 1996) were blasted open in the fall of 1993. Initial investigations by cavers from the Speleologische Arbeitsgemeinschaft Hessen e.V. (SAH) (Grubert 1996a, b, c; Hülsmann 1996), revealed a system divided into different karst levels. In the upper levels of this system, rich fossil vertebrate faunas are preserved. Due to the early recognition, the unique fossil inventory was subject to only a little modern alteration. These assemblages offer the rare opportunity to study the formation process of fossil accumulations in central European caves in a protected environment. They further provide the rare opportunity to document and study a undisturbed Pleistocene cave-floor thanatocoenosis (death assemblage) by applying non-contact methods of documentation. The current research program therefore has the character of a pilot study, introducing non-contact methods into cave paleontology.

GEOLOGIC SETTING

Speleogenous carbonates are common in the Dill Basin (Kayser 1907; Lippert *et al*. 1970). The cave system is developed in the Iberg Limestone, a complex of Late Devonian, predominantly biogenetic reef carbonates, exposed in the vicinity of Breitscheid-Erdbach (central Hessen). The outcropping carbonates belong to a formerly extensive reef complex, outcrops of which now are restricted to an area of only 3 km² (Fig. 1). Despite its limited extent, the carbonate complex of Bereitscheid demonstrates all the characteristics of deep karstification (Becker 1925; Böhm *et al*. 1985; Kayser 1907; Stein 1995; Stengel-Rutkowski 1968). Since the complex is bordered and partly overlain by non-speleogenous volcanics and slates (Lippert *et al*. 1970; Nesbor *et al*. 1993), it probably has to be considered as a “karst barré”, *sensu* Pfeffer (1984).

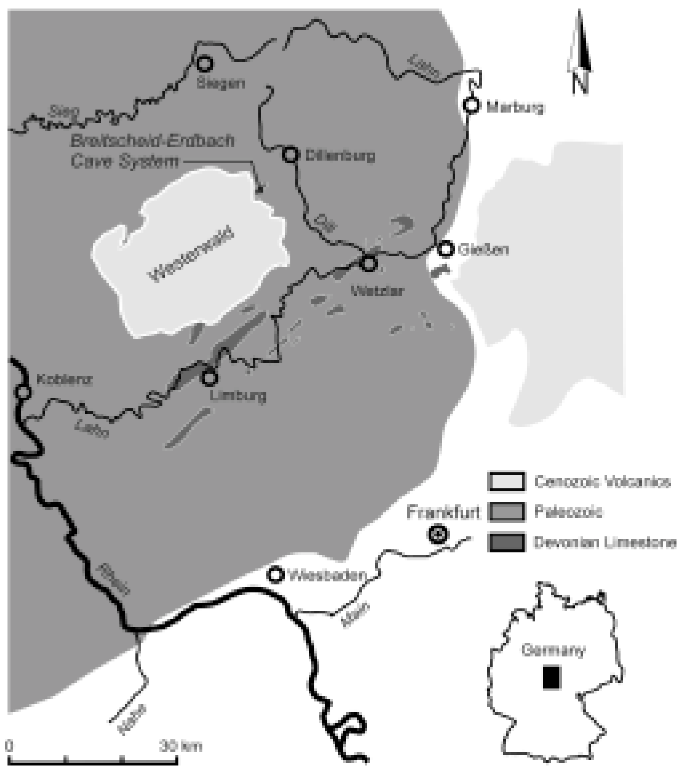

Figure 1. Location of the Breitscheid-Erdbach Cave System, at the north-eastern foothills of the Westerwald Mountains (after Kaiser et al. 1999).

Exposures in the Breitscheid Limestone complex are presently restricted to some dolines and limestone quarries operated by the Kalksteinwerk Medenbach Co. (Bachwinkel 1979).

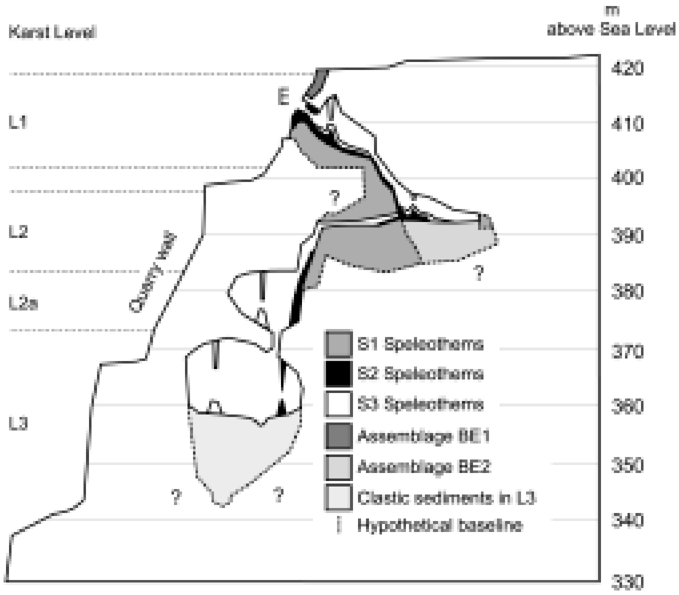

Figure 2. Generalized cross-section of the known parts of the Breitscheid-Erdbach Cave System (altitudes with kind permission of Barbara Rohstoffbetriebe Co.) showing karst levels, speleothem generations, fossil assemblages and clastic sediment bodies.

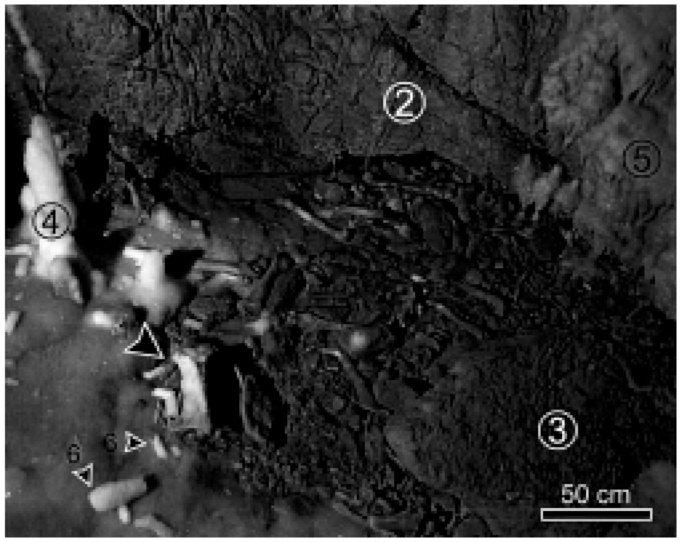

Figure 3. Surface exposure in the BE2 assemblage. A skull of *Ursus spelaeus* (1) and isolated cranial and post-cranial skeletal elements of a Pleistocene vertebrate fauna exposed in close proximity of the southern cave wall (2). (3) Collapsed boulder of S1 sinter; (4) S2-S3 stalagmite; (5) S3 sinter crust; (6) S3 stalactites fallen due to blasting activities in the quarry.

METHODS

Surveys for karst level correlation were conducted using a Leica-DistoMemo handheld lasermeter. Speleothem generations are distinguished morphologically. The vertebrate assemblage contained by L2 is considered unique in Europe due to its undisturbed preservation. Investigators therefore agreed to ensure maximum site protection. Fossil sampling was restricted to a small area previously disturbed. A fossil assemblage outcropping in the quarry wall was sampled, providing isolated blocks of fossiliferous deposits. From this assemblage, fossils embedded in flowstone were prepared with 5% acetic acid. The acid was changed daily and isolated specimens were subsequently hardened following Wadewitz (1977).

STRUCTURE OF THE CAVE SYSTEM

The Breitscheid-Erdbach Cave System extends over several levels that are in different stages of speleogenesis. Four levels (L1, L2, L2a, & L3) are distinguished in the presently known part of the cave. These levels (Fig. 2) are all in the vadose state (Kaiser *et al*. 1999).

L1 is the highest complex of preserved air-filled voids, which provides the present cave entrances. The voids show vadose features and are severely altered by collapse. L1 cavities, therefore, are fossil voids partly filled with clastic sediments. This level is cut by the present surface and entirely collapsed and blocked in places.

L2 voids show pronounced phreatic features, which are superimposed by vadose features. Collapse is of little importance. Coarse grained clastic sediment fills the basal part of the level and probably obscures many vadose features (Fig. 3). L2a is topographically intermediate between L2 and L3. The speleogenetic state corresponds to L2. L3 cavities show phreatic features with only a little vadose alteration. Thick bodies of fine-grained clastic sediment form the basal deposits (Fig. 4). A temporary cave creek is evident in this part of the system.

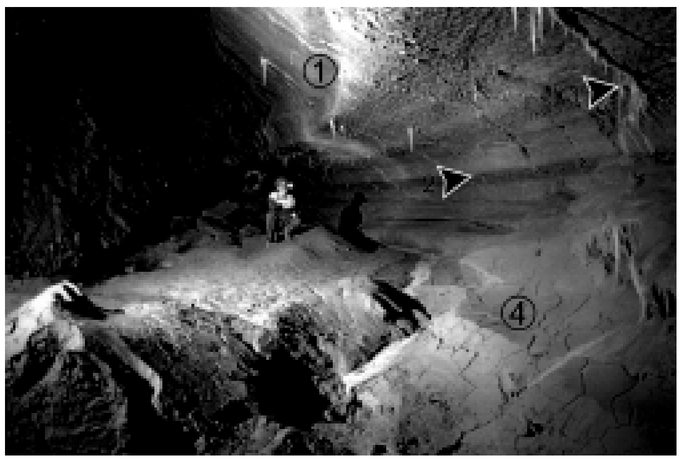

Figure 4. Principal gallery in L3, showing well preserved phreatic ceiling (1). Vadose features are water-level marks (2). Thick bodies of fine grained clastic sediment form the basal deposits (4). Some S3 speleothems are developed (3).

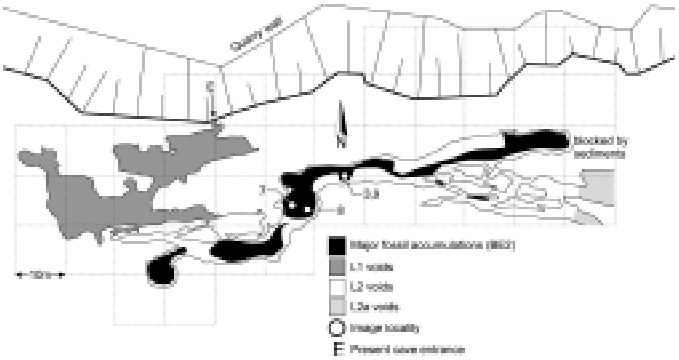

Figure 5. Plan view of cave levels L1-L2 and L2a, containing the BE2 fossil assemblage (cave topography after Thomas Hülsmann, unpublished map, and Barbara Rohstoffbetriebe Co., unpublished map). Spots indicate image localities of figures 3,7,8,9.

THE VERTEBRATE ASSEMBLAGES

Rich accumulations of vertebrate fossils are preserved in voids attributed to levels L1, L2, and L2a. The occurrence of these assemblages is bound to these karst levels. The uppermost complex of fossil accumulations BE1 (Breitscheid-Erdbach 1) crops out in the quarry wall. It is associated with sediment bodies attributed to the fossil level L1 (Fig. 2). The fossil accumulations in levels L2 and L2a are summarised as thanatocoenosis BE2 (Breitscheid-Erdbach 2). The BE2 complex is not exposed in the quarry. The faunal remains are components of a clastic sediment body, which forms the cave floor in a 105 m section of a principal gallery in L2 (Fig. 5). BE1 and BE2 have an average vertical spacing of 25 m. No fossils are yet recorded from L3.

BREITSCHEID-ERDBACH 1 (BE1)

The BE1 complex of fossil assemblages is exposed at an absolute altitude between 400 m and 420 m. Alternating bands of sinter and clastic facies composed of boulders, pebbles and vertebrate bones occur in a fine to coarse grained matrix, which in places is dominated by pelites. Incasion masses and surface detritus from the overlying units predominate. Fossils are enclosed in sinter bands and in the finer clastic lithofacies. Vertebrate fossils so far recorded are not yet identified fish vertebrae, several species of the Genus Myotis (Chiroptera), the lagomorph *Ochotona pusilla*, the rodent *Apodemus* sp., the marten *Martes* cf. *vetus* (Michael Morlo, pers. comm.; Anderson 1970), and the ursid *Ursus* sp. Bat remains (Fig. 6) predominate as well as individuals and also in species diversity. The bat assemblages are considered to represent a fragment of hibernating communities. Since the faunal record so far is considered to be fragmentary, a detailed faunal and taphonomic analysis will be dedicated to a later contribution.

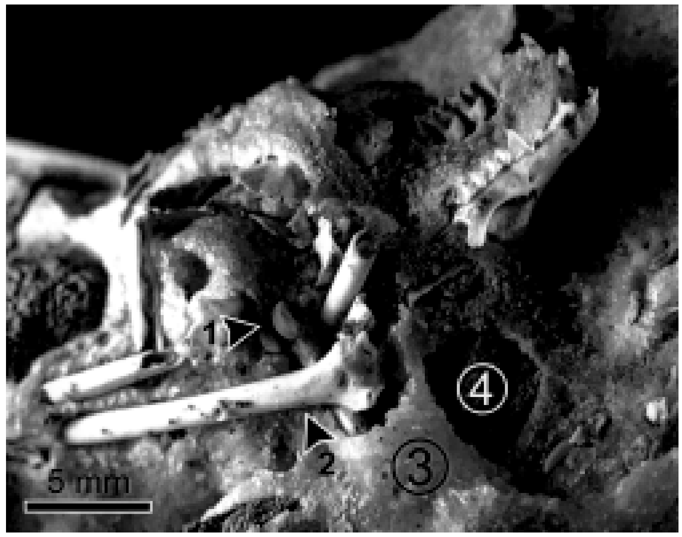

Figure 6. Bat remains predominate in BE1. Skull and long bones of *Myotis* sp., distal femoral (1) and ulna fragment (2), are embedded in calcitic matrix (3), which is intercalated with fine grained clastic material (4).

BREITSCHEID-ERDBACH 2 (BE2)

The underlying limestone floor is not accessible in any part of the gallery containing BE2 (Fig. 3,7,8). Thickness and volume of the sediment body is thus largely unknown. The clastic lithofacies is clay bound and contains inclusions of sinter fragments, limestone gravel, and collapsed boulders. Mammalian fossils are exposed covering the cave floor in large masses, partly lacking sedimentary cover (Fig. 3,7,8,9). Fossil inclusions are bone fragments and complete skeletal elements which predominantly are identified as *Ursus spelaeus* Rosenmüller. *Equus* sp., a rhinocerotid, and a large bovid recorded by isolated foot bones.

An initial sampling of bone specimens was undertaken in an previously disturbed area of assemblage BE2. It yielded the first evidence of a middle Würmian date for part of BE2 (Gernot Rabeder, pers. comm.). The superficially exposed fossils are in a state of preservation that is characterized by extensive loss of the organic bone matrix. Speleothems grow on superficially exposed bone specimens in a wide variety of forms (Fig. 5,6,8).

Strongly rounded limestone clasts are common in the surface exposures of BE2 (Fig. 9). Edge rounding is further evident in many fossil bone specimens. With the exception of isolated bat remains, no macroscopic postglacial components are recorded from the surface assemblage of BE2. This also applies to evidence for hominid presence or artifacts.

RELATIVE CHRONOLOGY OF SPELEOTHEM GENERATIONS AND VERTEBRATE ASSEMBLAGES

A minimum of three sinter generations (S1-S3) of different ages are proposed from the known parts of the system. Massive bodies of brown clay-encrusted speleothems block

Figure 7. Panoramic image of principal gallery in L2 containing the BE2 fossil accumulation. Dashed lines are match lines of the 360° panorama. SW extension of gallery (5); NE extension (4). Prominent S1 and S2 sinter masses are covered with white S3 sinter crusts (1). S2 (2) and S3 speleothems (3).

substantial galleries in places (Fig. 7). These speleothems are inactive, partly corroded, and form collapse masses (Fig. 3). They are regarded as the oldest speleothem generation (S1). S1 speleothems are common in L1-L2, but not yet identified in levels L2a and L3 (Fig. 2). A younger sinter population assigned to S2 superimposes S1. S2 sinter is white or yellowish. It forms massive stalagmites (Fig. 7), sinter columns, and massive flowstone formations. S2 speleothems are recorded from all known levels (L1-L3). The youngest speleothems of the system (population S3) are mostly clear white. They superimpose S1 and S2 speleothems as well as all clastic bodies in the system (Fig. 3,4,7,8). S3 is the presently active sinter population, which is recorded as soda straws, sinter draperies, helictites, slender stalagmites, and flowstone crusts. Speleothems grown on fossil specimens from BE2 probably belong to the generations S2 and S3 (Fig. 3, 8). S2 was probably already active when BE2 fossils were finally embedded. Recent sinter damage, mainly suffered by S3 soda straws and slender stalagmites (Fig. 3,8,9) is due to quarry blasting in the close vicinity of the cave.

The BE1 complex and the associated sediment body is interpreted as representing the infill of the collapsed and partly eroded karst level L1. Because BE1 and BE2 have a mean vertical distance of 25 m, it is likely that the related paleovoids are part of different karst levels (L1 and L2). It is thus regarded likely that these voids represent different stages of cyclic karst formation in the sense of Sawicki (1909). The voids associated with BE1, representing level L1, would then be older then L2 and L2a voids containing BE2.

Intense edge rounding of clastic inclusions and fossils in complex BE1 may evidence transport and resedimentation of clasts and fossils. Also in BE2, clasts with severe edge rounding suggest impact during transport prior to final emplacement.

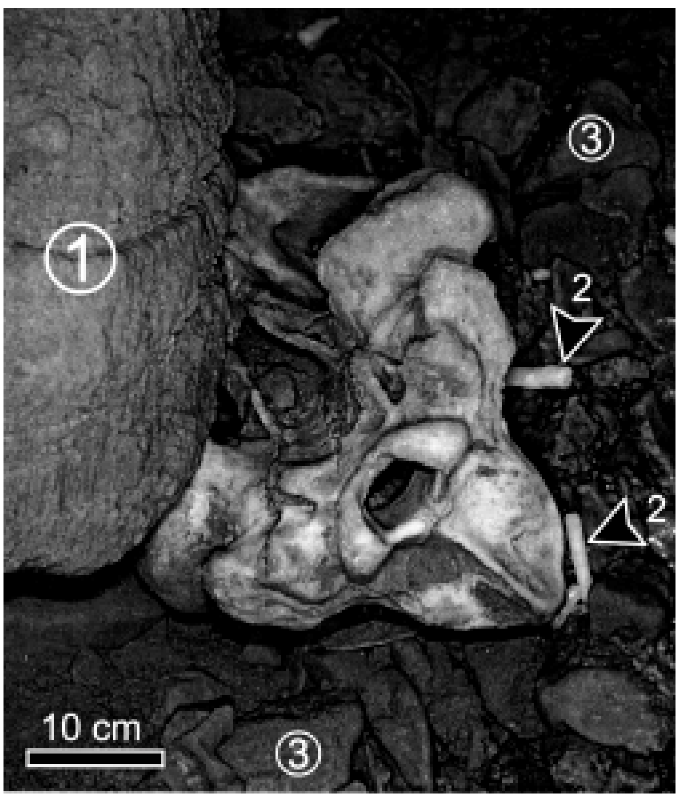

Figure 8. (1) Cranium of *Ursus spelaeus* underneath a collapsed boulder of S1 speleothems; (2) fallen S3 stalactites; (3) edge- rounded clasts of the BE2 sediment body.

Figure 9. Postcranial elements of *U. spelaeus* (1: femur), superimposed by S3 stalagmites (2). The stalagmites grow on the stumps of older fallen stalagmites (3). (4) S1 sinter mass; (5) bone specimen covered by S3 sinter crust; (6) S3 stalactites that fell due to blasting.

BE1 and BE2 are, therefore, interpreted as at least partly allochthonous complexes.

The primary depositional environment of part of the BE2 fossil assemblage may be located in level L1 or an even higher, hypothetical level L0. Horizontal fluviatile transport within level L2, however, seems more likely.

The undisturbed preservation of the Pleistocene cave floor, and the lack of Holocene components in the surface assemblage suggests that L2 was no longer accessible for larger vertebrates after the deposition of BE2. Today, the gallery containing assemblage BE2 is only accessible by vertical passages. If the fossiliferous part of the cave acted as hibernating shelter for larger mammals, the Pleistocene entrances would not be identical with the present entrance passage.

The easterly extension of the gallery containing BE2 is blocked by massive deposits of speleothems and clastic sediment (Fig. 5). The proposed Pleistocene cave entrance is tentatively considered to relate to this proposed extension of the cave.

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