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AN EARLY TRIASSIC VERTEBRATE ASSEMBLAGE FROM KARST DEPOSITS AT CZATKOWICE, POLAND

(WCZESNOTRIASOWY ZESPÓŁ KRĘGOWCÓW Z UTWORÓW KRASOWYCH STANOWISKA CZATKOWICE, POLSKA)

EDITED BY

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PREFACE

The Early Triassic (early Late Olenekian) fauna of small vertebrates presented in this volume comes from karst deposits developed in Early Carboniferous (Turnaisian to Mid Visean) limestone at the Czatkowice quarry near Kraków (Southern Poland). All the material comes from a single exposure, referred to as Czatkowice 1.

In Czatkowice quarry the bone-bearing breccia was first collected from waste-heaps, but was eventually discovered *in situ* by a team from the Institute of Geological Sciences of Jagiellonian University, Kraków (Paszkowski and Wieczorek 1982). Unfortunately, the geology of the site was only briefly studied, because of the rapid exploitation of the quarry. The original description of the geological setting is that of Paszkowski and Wieczorek (1982).

Through the kindness of colleagues from the Jagiellonian University (and notably Ryszard Gradziński), the material was transferred to Teresa Maryańska and Halszka Osmólska (Museum of the Earth and Institute of Paleobiology of the Polish Academy of Sciences, Warsaw, respectively), who took part in the exploration of the site and performed a preliminary paleontological examination.

The bone-bearing breccia was subjected to chemical preparation in acetic acid in the Museum of the Earth and the Institute of Paleobiology, Polish Academy of Sciences. However, more effective preparation started only in the 1990's and has now terminated. Around this time, Halszka Osmólska and Teresa Maryańska, both fully engaged in dinosaur studies, kindly offered the Czatkowice 1 material to one of us (MBB). A more detailed study then began in collaboration with Susan Evans from University College London, first under the British/Polish Joint Collaboration Programme funded by the British Council and Polish State Committee for Scientific Research (1993–1996), then only under the latter organization (2000–2003; 6 P04D 072).

We were later joined by colleagues who contributed to the study of particular groups. Michail Shishkin, a fossil amphibian expert from the Paleontological Institute of the Russian Academy of Sciences (Moscow), took over the temnospondyl material in collaboration with Tomasz Sulej (Institute of Paleobiology); Andriej Sennikov from the Paleontological Institute of the Russian Academy of Sciences (Moscow) contributed to the work on archosauriforms; and Mariusz Lubka, a PhD student from Wrocław University, contributed to the procolophonian paper.

This long and detailed project would not have been possible without the help and support of many people, especially the technical staff of the Institute of Paleobiology and Museum of the Earth who completed the time-consuming chemical preparation of the matrix and the recovery of bone fragments. We are particularly indebted to Ewa Hara for her exquisite preparation work, to Cyprian Kulicki for SEM micrographs, to Marian Dziewiński for photography, and to Aleksandra Hołda-Michalska for most of computer illustration work. In total, several hundred kilograms of Czatkowice 1 breccia were processed, yielding around 1500 catalogued specimens and many thousands of valuable unnumbered specimens.

Early Triassic tetrapod faunas are of particular interest in documenting the biotic changeover that took place on land at the Permo-Triassic boundary (Ochev 1993). In terms of Scythian paleogeography, these faunas are best known from the temperate latitudes of southern Gondwana (primarily in South Africa, Australia and Antarctica) and, in the northern hemisphere, from the areas adjacent to the circum-equatorial xeric belt (such as Eastern Europe and Greenland). The belt represented a vast arid/semiarid zone which included, in particular, most of Central and Western Europe (Lozowsky 1993). It was inhabited by impoverished tetrapod communities largely concentrated within and around freshwater basins. Accordingly, their fossil record is usually dominated by aquatic temnospondyl amphibians (Shishkin and Ochev 1993).

In this context, the Early Triassic tetrapod assemblage from Southern Poland, surveyed for the first time in its entirety in the present volume, deserves special attention. Although it came from the xeric belt, its structure differs notably from that of other assemblages from elsewhere in the same climatic zone (mostly in Central Europe and North American southwest). In contrast to them, the Polish fauna is dominated by a terrestrial component, with abundant archosauriform reptiles, while the bones of aquatic amphibians are much rarer. This "reversed" pattern of faunal preservation unquestionably resulted from the specific environmental setting and unusual mode of burial of the Czatkowice vertebrates (Shishkin and Sulej 2009). Their remains were accumulated in karst fissures developed within the upland relief rather than in the lowland floodplain deposits that typically host vertebrate fossils. As a result, unlike most other localities, there was no preferential burial of aquatic or subaquatic animals.

The unusual conditions under which the Czatkowice 1 locality developed were probably responsible for the presence of a number of exceptionally rare forms, such as stem-frogs, small lepidosauromorphs, and the earliest euparkeriid archosaurs, all hitherto unknown from the Early Triassic of Laurasia. On the other hand, the Czatkowice temnospondyl amphibians have been found to be readily comparable at generic level with those of East Europe, where they provide a basis for high resolution subdivision of the regional Triassic faunal succession (Shishkin and Ochev 1993; Shishkin *et al.* 2000). This correspondence is regarded as a decisive factor in dating the Polish assemblage. In summary, these new records and the often exquisite preservation of the material from which they are described, make a significant contribution to our current knowledge of early Mesozoic land vertebrates.

The Editors

THE EARLY TRIASSIC KARST OF CZATKOWICE 1, SOUTHERN POLAND

MARIUSZ PASZKOWSKI

Paszkowski, M. 2009. The Early Triassic karst of Czatkowice 1, southern Poland. *Palaeontologia Polonica* **65**, 7–16.

The Czatkowice 1 locality, that yielded a rich fossil assemblage of small tetrapods, is situated in the Dębnik area near Kraków as one of a number of karst forms developed within the Paleozoic Moravia-Małopolska carbonate platform. The fossiliferous deposits occurred in a funnel-shaped structure, about 4 m in width, and 6 m in depth, tapering downwards and passing into several subhorizontal corridors in the basal part. It probably represented a system of collapsed and coalescent paleodolines. The upper part of the main sinkhole was filled with a few meter thick sequence of yellow sands and silts, whereas the lower part contained green-brownish and variegated cave loams with gypsum intercalation and calcite concretions (hollow septarians) as well as calcite flowstones. The deepest 0.7 m of the cave was filled with fine cross-bedded calcareous sandstone as well as by spar-cemented layers and discrete lenses of bone breccia. The fallen blocks of early Permian rocks indicate a post-Autunian, probably early Triassic age for the breccia. Biostratigraphic evidence suggests the early Late Olenekian age of Czatkowice 1 bone bearing deposits. They underlie the cave loams with gypsum and stromatolites that may have been deposited under marine inundation of the late Late Olenekian Röt transgression.

Key words: Karst, Early Triassic, Czatkowice.

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INTRODUCTION

The karst deposits developed in host limestones of the Early Carboniferous (late Tournaisian to mid Viséan) at the Czatkowice quarry (Kraków Upland, southern Poland) are the source of the Early Triassic fauna of small vertebrates, which is a focus of the present volume. The quarry is located some 20 km to the WNW of Kraków in the area of Paleozoic exposures bordered by the young tectonic depression, the Krzeszowice Graben, to the south, by the Upper Silesian Coal Basin to the west, and by a large area of Kraków Jura to the east and north (Fig. 1). The Krzeszowice Graben extends nearly east-west and is filled with Miocene sediments.

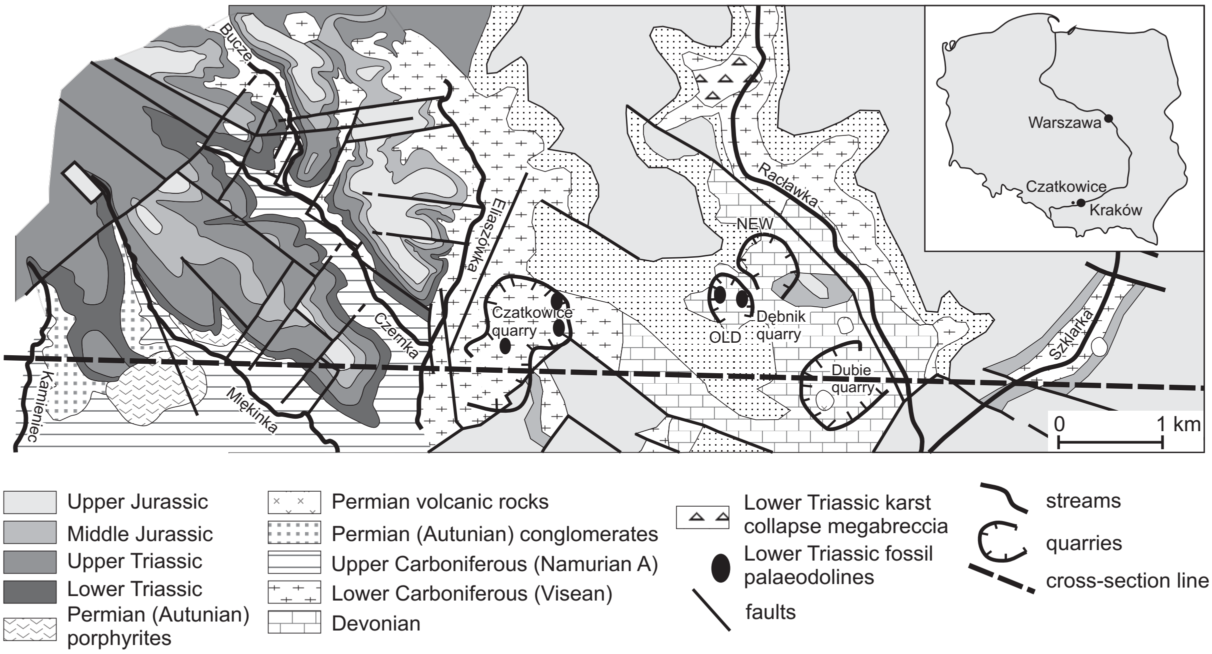

Fig. 1. Geological map of the Dębnik Anticline area (north of Krzeszowice town).

All the material described in the present volume comes from one of the numerous karst forms, of different ages, developed in the Czatkowice quarry (Paszkowski and Wieczorek 1982). This funnel-shaped megabreccia (Fig. 2B), referred to as the Czatkowice 1 locality, was discovered in late 1970's. It was briefly studied by Paszkowski and Wieczorek (1982) and then quarried out. The objective of this paper is to present a geological setting for the locality at Czatkowice 1, and to discuss the paleoenvironment of the Czatkowice 1 site.

The dating of the Czatkowice 1 deposits is based upon biostratigraphical criteria worked out for the East European (Cis-Uralian) Triassic tetrapod succession (Shishkin *et al*. 2000). This succession has been shown to include subsequent faunal groupings spanning the entire range of the Triassic (Ochev and Shishkin 1989; Shishkin and Ochev 1993). It was calibrated against the standard marine scale owing to marine intercalations with stratigraphically diagnostic fossils, such as *Parotosuchus*, which occurred in both continental Yarenskian deposits of Moscow syneclise and the marine Upper Olenekian sediments of Bogdo Mountain and Mangyshlak, Tethyan Province (Lozovsky 1993). The Czatkowice 1 assemblage correlates with the lower *Parotosuchus* faunal grouping of this scale (Fig. 5), and on this basis, the age determination of these deposits is early Late Olenekian (Shishkin and Sulej 2009). Attempts to extract spore/pollen material (S.E. Evans, unpublished data) gave no result, and no conchostracan remains have been found.

Karstification was a multiple process (polyphase karst) (Lis and Wójcik 1973; Paszkowski and Wieczorek 1982; Paszkowski 2000) that occurred several times in the basement of the Kraków–Silesia Laramide monocline, mainly in the host platform of Devonian and Carboniferous carbonates. The existence of the Permian–Triassic paleokarst has also been documented in the Holy Cross Mountains (*e.g.*, Głazek 1989;

Urban 2007). The best review of paleokarst investigation in the whole of Poland has been done by Głazek (1989 and references therein).

Outside of Poland, the Mesozoic paleokarst is best known from South Britain (Robinson 1957; Ford 1966; Fraser 1985; Fraser 1994; Wall and Jenkyns 2004; Whiteside and Marshall 2008), but is no older than the Late Triassic. The early Triassic karst is practically unknown except from unconformity-related early Triassic karst discovered in the Devonian carbonate host rocks of the Barrandian area in Bohemia (Bosák 1997; Žak *et al.* 2007).

Acknowledgments. — I am indebted to all the colleagues, who discussed with me the problems related to the topic of this account, for their valuable criticism and comments. Thanks are also due to Artur Kędzior (Institute of Geological Sciences, Polish Academy of Sciences, Kraków) and to Aleksandra Hołda-Michalska (Institute of Paleobiology, Polish Academy of Sciences, Warsaw) for preparing figures to this paper.

GEOLOGICAL SETTING OF CZATKOWICE 1 LOCALITY

The Czatkowice quarry (Fig. 2A) is a large active quarry of the Early Carboniferous limestones located in the western limb of the Variscan Dębnik Anticline (Kraków Upland, southern Poland), north of Krzeszowice area. The central part of the Dębnik Anticline is composed of dolomites and limestones of Givetian to Famenian age that pass into late Tournaisian to mid Viséan sediments towards the western limb of the anticline, where Czatkowice quarry is situated (Fig. 3). The whole complex of Devonian and Early Carboniferous limestones, up to 1600 m in thickness, belongs to the wide Moravia-Małopolska carbonate platform (corresponding to Bohemian–Vindelician Massif plus Pre-Carpatian Massif; Fig. 6).

To the west of Krzeszówka (Fig. 3B) and Eliaszówka faults the Carboniferous (Mississippian and lower part of the Pennsylvanian) rocks are continuously covered with continental or marine Triassic and Jurassic deposits (Fig. 3B). Further to the west, Carboniferous rocks are covered by an Early Permian succession of continental deposits, up to 600 m thick. The most characteristic deposits of the Permian complex in the described area are various volcanogenic rocks. Red clasts of these Permian rocks are found redeposited in some coarse grained Mesozoic karst infillings (*e.g.*, at the Czatkowice 1 site). In contrast, to the east of the Krzeszówka and Eliaszówka faults (Fig. 3B) there is no continuous cover of Permian and Triassic deposits,

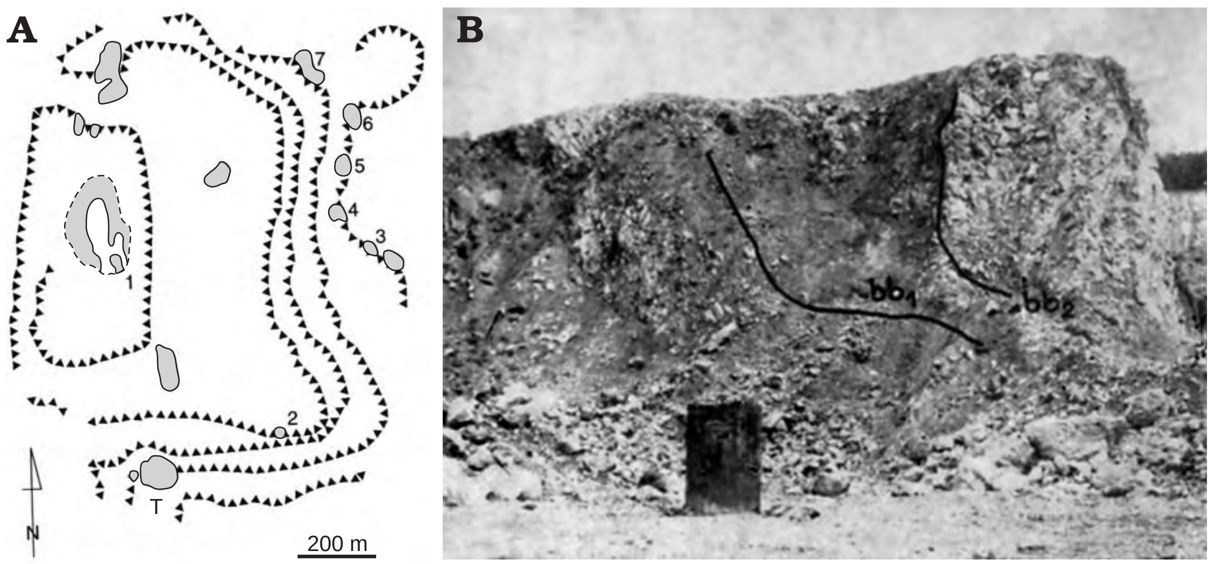

Fig. 2. **A**. Sketch map of Czatkowice quarry (in 1979) showing localizations of karst forms (1–7 and T after Paszkowski and Wieczorek 1982). **B**. View of the Czatkowice 1 karst form at the north wall of the Czatkowice quarry (level 310) according to original picture taken by J. Wieczorek in 1979 (after Paszkowski and Wieczorek 1982, phot. 1). The funnel-shaped outline of a preserved fragment of the cave with bone breccia in the lower part – bb1; a fragment of subhorizontal corridor covered by rubble heap – bb2.

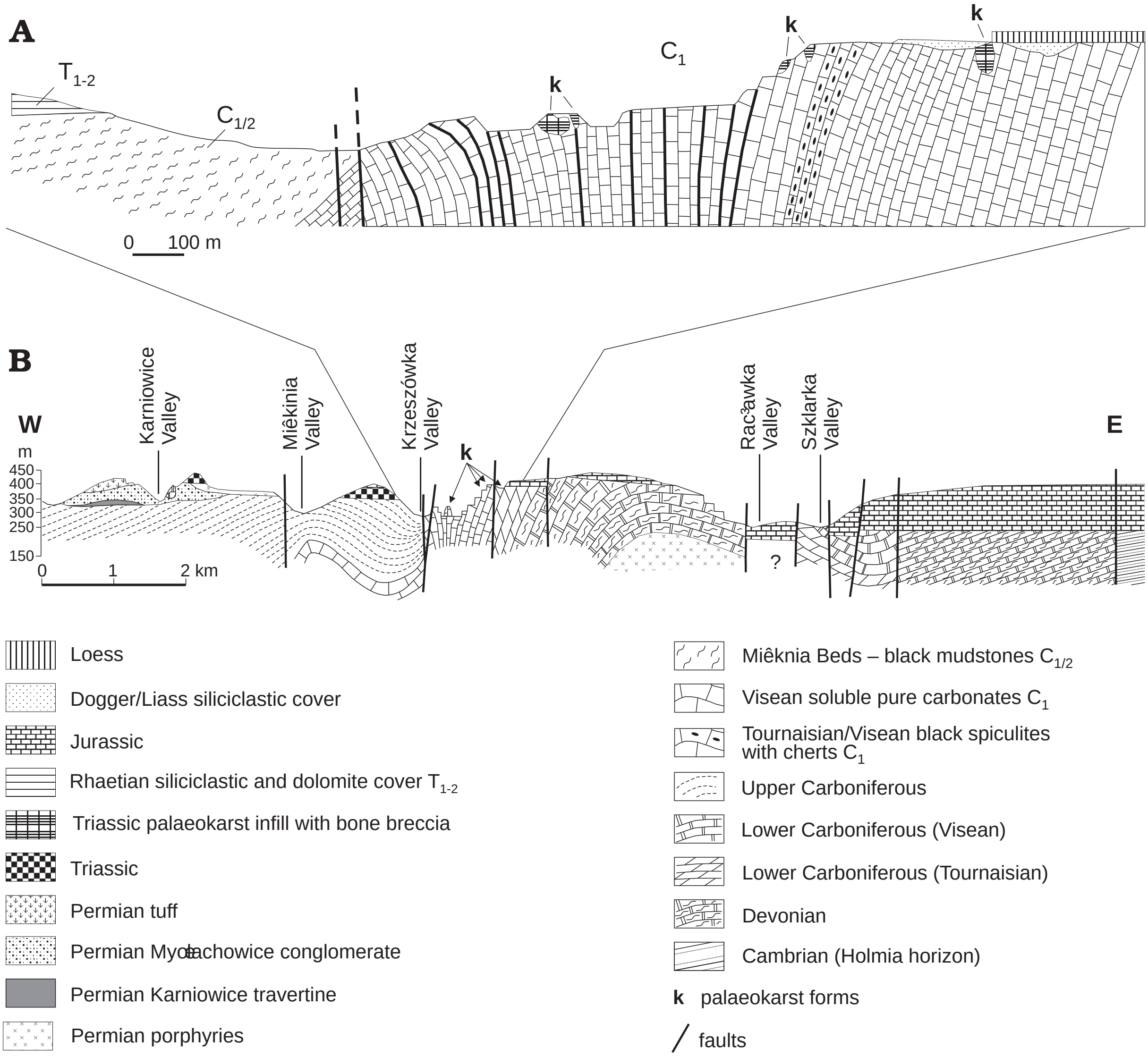

Fig. 3. **A**. WE cross-section of the Dębnik Anticline, crossing Czatkowice quarry. **B**. Regional geological WE cross-section of the Dębnik Plateau karstified area.

the older Paleozoic rocks (Cambrian to Early Carboniferous) being directly covered by Mid Jurassic deposits. The Early Permian, Early Triassic, Late Triassic and Jurassic pre-Callovian deposits occur as only local fillings of paleokarstic depressions in this region (Fig. 3A), including those in Czatkowice quarry (Paszkowski and Wieczorek 1982).

In the Czatkowice part of the Dębnik Anticline, the Carboniferous rocks display a very steep inclination, the dip changing from 50°–60° in the eastern part to about 90° in the central part of the quarry and then dipping to the east in the western part of the quarry (Fig. 3A). Resulting from Variscan tectonics, this subvertical bedding enhanced the development of very deep karst forms of different age beginning with the Late Paleozoic and continuing until the advance of the Callovian sea with an interruption during the Muschelkalk transgression (Paszkowski and Wieczorek 1982).

Several forms of a supposed Late Permian to Early Triassic karst have been discovered in the Dębnik anticline area. The main object of these studies, the Czatkowice 1 karst form, was preserved as a funnel-shaped structure (Fig. 2B), about 4 m in width, and 6 m in depth, tapering downwards and passing into several subhorizontal corridors in the basal part. It probably represents a system of collapsed and coalescent paleodolines (uvala). It was developed in the steeply oriented, light-colored Viséan thick-bedded limestone and was preserved, as a remnant left intact during the exploitation process, on the bottom of the quarry, at the

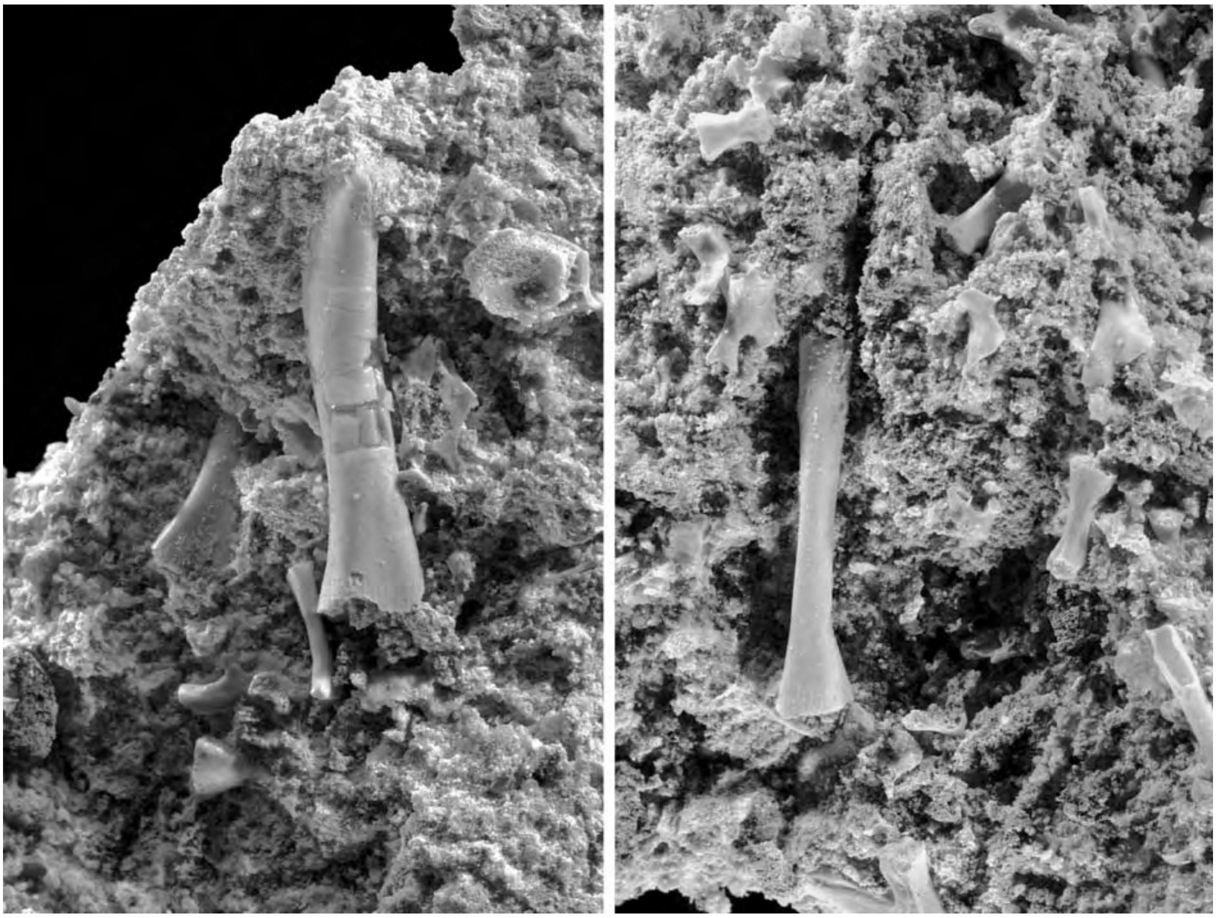

Fig. 4. Pieces of Czatkowice 1 bone-bearing breccia with bones exposed after treatment with dilute acetic acid.

altitude 310–330 m. Until the late 1970's, it still existed in the middle of the quarry floor (Fig. 2A), but was later completely quarried out.

The walls and especially the roof of the cave were covered in some places by coarse crystalline, brown and pink calcite flowstones, from 20–30 cm up to 1 m thick, strongly resembling and probably interconnected with the Early Permian hydrothermal onyx vein system of the neighborhood. The upper part of the main sinkhole was filled with a few meter thick sequence of yellow sands and silts, whereas the lower part contained green-brownish and variegated cave loams with gypsum intercalation and calcite concretions (hollow septarians) as well as calcite flowstones. An important constituent of this megabreccia, despite of host Mississipian limstones, are fallen blocks of Early Permian hydrothermal endokarst speleothems: red crystaloclastic carbonates with flowstones and red endostromatolite-bearing calcite-veins.

The bone breccia occupied only the deepest 0.7 m of the cave infill. This part of the cave was filled with fine cross-bedded calcareous sandstone as well as by spar-cemented layers and discrete lenses of bone breccia. The breccia was vertically cracked and the cracks were filled by cave loams. The bone breccia layers demonstrated a distinctive grading, and flute marks on the bottom surfaces. In some places they formed elongated gutter casts with bowl-shaped cross section.

Both in the calcite-cemented bone breccia, and calcareous sandstone above it, minor constituents are well-rounded quartz grains (0.2 mm in average diameter, reaching up to 1 mm), most probably recycled from adjacent Carboniferous and Permian deposits.

Layers and lenses of brittle sandstone and breccia may possibly have been broken into blocks by mass movements or earlier by compaction or liquefaction of karst loam and telescoping karstification. The edges of separated blocks of breccia were slightly rounded. Smaller fragments have fallen and slid into deeper parts of the cave. This supports a supposition that the Czatkowice 1 megabreccia represents a collapsed and coalescent paleodoline (uvala). This is also true of some other karst forms of Czatkowice quarry, as *e.g.*, the locality

T (Fig. 2A) filled mainly with Permian tuffites (Paszkowski and Wieczorek 1982, phot. 3) that bears traces of roof collapse.

The bone material collected from the Czatkowice 1 breccia (Fig. 4) was disarticulated and damaged, usually broken into pieces, but the fragments were generally finely, three-dimensionally preserved, with relatively little abrasion and polishing. Usually there is no stratification bedding or parallel orientation of the long bones.

STRATIGRAPHIC CORRELATION OF CZATKOWICE 1 BRECCIA

The fallen blocks of early Permian age rocks present in the karst form at Czatkowice 1, provide reliable evidence of a post-Autunian, probably early Triassic age for the breccia (Paszkowski and Wieczorek 1982). As the direct correlation of the Czatkowice 1 karst deposits with the transgression/regression cycles of the Buntsandstein is impossible, the dating of these deposits is based on biostratigraphic criteria of the east European faunal succession (Shishkin and Ochev 1985; Shishkin *et al.* 1995, 2000).

The Early Triassic age of the Czatkowice 1 karst fillings is supported by the studies of the included fauna, with a slight suggestion of a Late Olenekian age, mainly on the basis of the procolophonids (Borsuk-Białynicka *et al*. 1999). The diapsid taxa of the assemblage are less conclusive in this regard. Czatkowice 1 procolophonids display a mosaic morphology, their unicuspid, possibly paedomorphic (Borsuk-Białynicka and Lubka 2009) teeth being combined with a derived heterodonty and reduced tooth count, most compatible with the Olenekian. The rare teeth of *Gnathorhiza*, which is a dipnoan fish ranging up to the early Late Olenekian (Fig. 5), and the lack of *Ceratodus*, another dipnoan fish that already appeared and coexisted with *Gnathorhiza* in the early Late Olenekian (Minikh 2000), suggest an Early Olenekian age of the assemblage (Borsuk-Białynicka *et al*. 2003). However, the cooccurence of *Gnathorhiza* with temnospondyl index taxa of the Late Olenekian (*Parotosuchus* and *Batrachosuchoides*; Shishkin and Sulej 2009) allows still more exact dating of the Czatkowice 1 assemblage. An earliest Late Olenekian age thus seems most probable for the Czatkowice 1 bone bearing deposits.

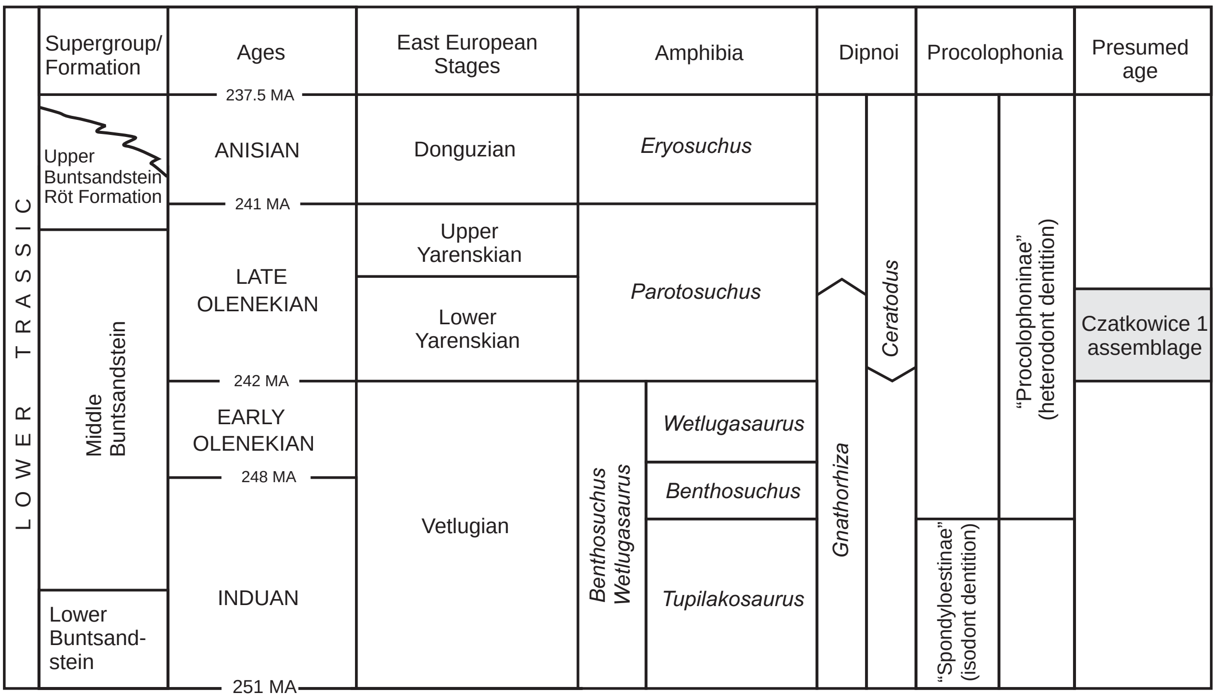

Fig. 5. Biostratigraphy of the Early Triassic of Eastern Europe mainly after Lepper and Röhling (1998) and Shishkin *et al.* (2000). Absolute ages compiled after Gradsten *et al.* (1995) and Becker *et al.* (2008).

DISCUSSION

In the early Triassic, the Dębnik area was situated in the SE part of the central European Buntsandstein or German Basin (Fig. 6) — a post-Variscan epicontinental depression, which extended from England to Poland and from the North Sea to southern Germany (Bachmann 1998). In the Triassic it was affected by syndepositional tectonism (Feist-Burkhardt *et al*. 2008), and by a transgression/regression cyclicity (Bachmann 1998). The seaways opened and closed at different times *via* hypothetical East Carpathian and Silesian-Moravian Gates (Lepper and Röhling 1998), first at the very beginning of the Middle Buntsandstein sedimentation (Szyperko-Teller *et al*. 1997), then at the advent of Röt trangression. The basin was surrounded by the Fennoscandic Baltic Massif to the north to northeast, by the Ardennian–Gallian Massif to the west, and the Bohemian–Vindelician Massif and Pre-Carpathian Massif (including the Dębnik Massif) to the south (Fig. 6). The elevated areas, and mainly those affected by the Variscan and post-Variscan tectonics (Paszkowski 1988), were subjected to karstification. The process occurred several times in a host platform of Paleozoic rocks of the Pre-Carpatian Massif, and particularly in the Devonian through Carboniferous Dębnik Anticline (Paszkowski and Wieczorek 1982; Paszkowski 2000), and notably in the Czatkowice part of the Anticline.

Two main phases of karstification have been recognized in Czatkowice and Dębnik quarries (Paszkowski and Wieczorek 1982). The first one occurred during one of synsedimentary Devonian or Early Carboniferous short emersions (Fig. 2A; locality T of Paszkowski and Wieczorek 1982) and continued through the Early Triassic (*i.e.*, around 243 Ma: Gradsten *et al*. 1995; Becker *et al.* 2008), under continental conditions after Variscan deformations and Late Carboniferous siliciclastic cover removal. It is the Early Triassic section of this phase that is represented by the karst form at Czatkowice 1 (Paszkowski and Wieczorek 1982). The second, distinctive Mesozoic phase began in the Late Triassic and ended in the Mid Jurassic, before the Callovian transgression. The locality Czatkowice 2 (Fig. 2A) and a waste-heap designated as Czatkowice H

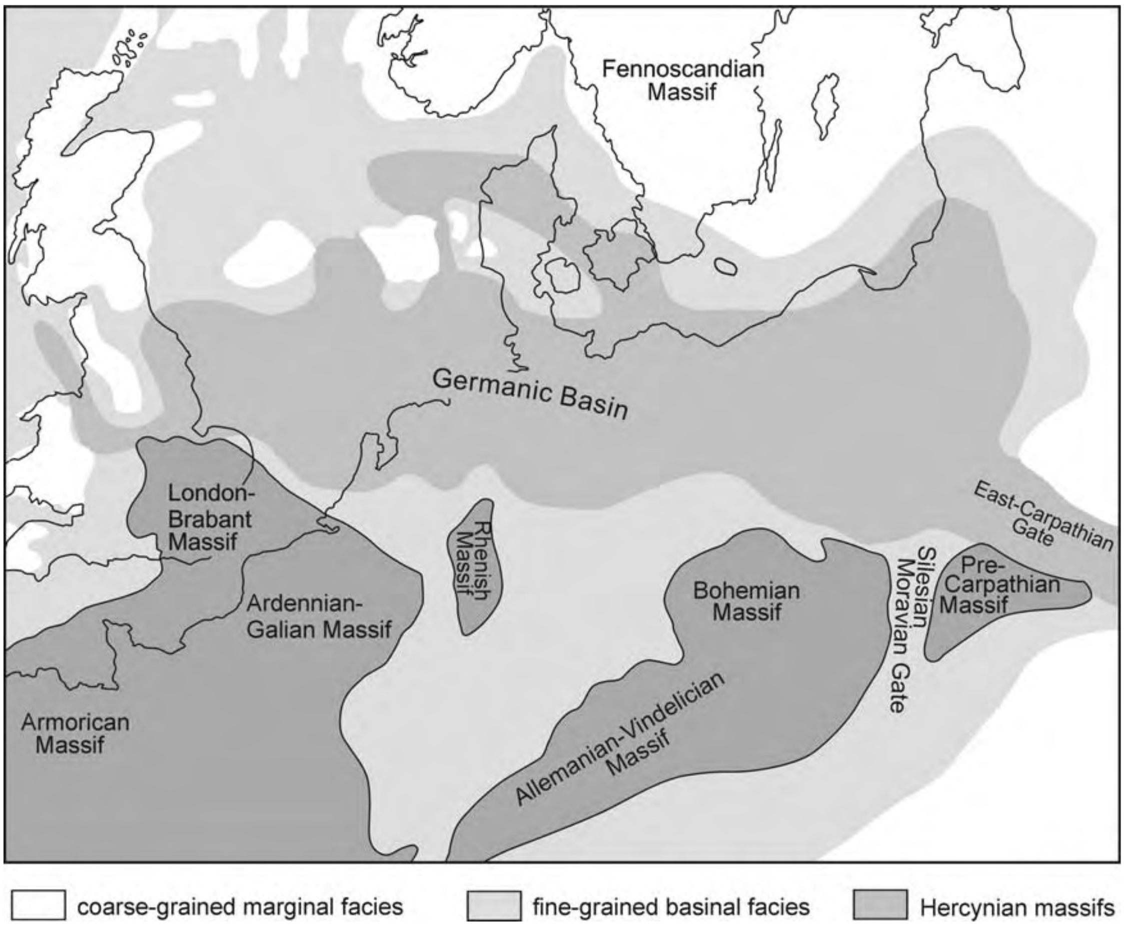

Fig. 6. Late Early Triassic (Röt) palaeogeography of Europe based on Lepper and Röhling (1998).

(Paszkowski and Wieczorek 1982), that yielded the early and middle Jurassic dipnoan fish *Ceratodus phillipsi*, represent this phase.

The Buntsandstein Basin was located within the subtropical zone of northern Pangea, under dry climatic conditions (Feist-Burkhardt *et al*. 2008), and was characterized by a predominantly continental sedimentation in a fluvio-lacustrine environment with restricted marine (two small transgressions prior to the Röt one, the first one coming from the boreal zone: Szyperko-Teller *et al.*1997), and local aeolian influences and a high rate of evaporation. This kind of sedimentation definitely ended with the Röt transgression which corresponds to the late Late Olenekian age (Lepper and Röhling 1998) of the Early Triassic. The transgressing sea, which entered the German Basin, came over the eroded surface of the Dębnik Massif and, most probably, ended the karstification process (Paszkowski and Wieczorek 1982). Apart from this premise, no other suggestion concerning the dating of Czatkowice 1 karst deposits can be deduced from the transgression-regression cyclicity that affected the early Triassic. Whether the process could have continued on partially submerged erosion resistant mogot/inselbergs and horsts, which formed an archipelago until the late Muschelkalk, is not definitely known.

Recent equivalents of the Triassic paleokarst environment of Dębnik area are known from different parts of the world, and notably from Serbia (Miroc Mountains), Spain, Albania, and western-central Anatolia, all of them situated in a classic region of Alpine lateral escape tectonics resulting from Arabian plate collision with Eurasia. They include tectonically uplifted, karstified plateaux penetrated by several sinkholes (dolines), some of them filled with impermeable *terra rossa* clay and fresh water ephemeral water reservoirs (Canik and Corekcioglu 1986), surrounded by alluvial plains, with fauna of small amphibians and fish. Grabens filled up with ephemeral salt lakes and playas contribute to this landscape. In contrast, the shallow marine-flooded Ha Long Bay karst area in northern Vietnam is an archipelago of partially submerged mogot/inselbergs of resistant rocks, and the host of extensive karstification processes. The drowned dolinas are filled with marine water, and include small biostromes and stromatolites.

In Czatkowice 1, the presence of gypsum (as indicator of marine waters evaporation) and stromatolites with coarse calcite crystal fan (pseudomorphs after aragonite), elsewhere known from shallow marine, both carbonate and siliciclastic Permian–Triassic passage sections (Peryt 1975; Szulc 2007), are suggestive of occasional invasions of marine waters on the karstified Dębnik plateau. Discrimination between the marine and fresh-water stromatolites is problematic (Peryt 1975; Paul and Peryt 2000), but the very low level of karstified Dębnik plateau in the Early Triassic, both relative and above sea level altitude (about 200 m above sea level), makes the invasions of highly sediment-charged, turbid flood waters or marine waters quite probable. The main question to be answered is whether the accumulation of the bone-bearing deposits at Czatkowice 1 occurred on an island surrounded and occasionally invaded by the Röt sea or did it occur prior to the Röt transgression?

The following premises support the second option:

The early Late Olenekian age determined for the Czatkowice 1 vertebrate assemblage provides evidence that it existed before the onset of the Röt transgression.

The bone-bearing deposits at Czatkowice 1 underlie, and are thus older than, the several meter thick sequence of cave deposits, such as sands, silts and cave loams with gypsum and stromatolites that may have been deposited under occasional marine inundations of the approaching Röt transgression (Fig. 5).

The vertebrate assemblage of Czatkowice 1 includes definitely terrestrial and fresh-water vertebrates, and no marine elements which would indicate sea shore proximity. In the early Late Olenekian, the region was situated in a low upland and probably well inland.

CONCLUSIONS

The Late Permian/Early Triassic fossil karst forms that occur in the Paleozoic Dębnik massif, are considered remnants of sinkholes (paleodolines). Czatkowice 1 megabreccia probably represents a collapsed paleodoline (uvala).

Variscan and post-Variscan strike-slip tectonics is considered an important agent behind the polyphase karstification of the Dębnik area.

The data inferable from the transgression/regression cyclicity of the Late Paleozoic–Mesozoic sedimentation in the Germanic Basin support the suggestion that the Czatkowice 1 karst deposits belong to the Early Triassic. Similarly, the presence of fallen blocks of Early Permian rocks in the karst form at the Czatkowice 1 locality provides evidence of post-Autunian, probably Early Triassic age of the deposits. This is consistent with the age determination of the Czatkowice 1 breccia as early Late Olenekian (Shishkin and Sulej 2009) based on a correlation with the Early Triassic tetrapod succession worked out for the Eastern Europe (Cis-Uralian) (Shishkin *et al.* 2000). According to this dating, the breccia was deposited prior to Röt transgression.

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