



## New data on the age of the bone breccia from the locality Czatkowice 1 (Cracow Upland, Poland)

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**Fissure deposits are notoriously difficult to date. But, determination of the age of assemblages they contain is crucial for the evolutionary conclusions based on them. The early Mesozoic karst infillings within the Lower Carboniferous limestone of the locality Czatkowice 1 (Southern Poland) containing a diverse terrestrial microvertebrate assemblage (see Borsuk-Białynicka et al. 1999 for review) were originally thought to be most likely Late Permian to Early Triassic in age. Subsequent study of the assemblage containing procolophonids, prolacertiforms, basal lepidosauromorphs, a basal archosaur and small amphibians (including a pre-frog) showed that it is Early Triassic, most probably Late Olenekian, in age because of the advanced dentition pattern of the procolophonids. The discovery of tooth plates of the lungfish *Gnathorhiza*, known to range from the Induan into early Late Olenekian (Vetlugian Superhorizon to Fedorovskian Horizon of the regional scheme) in Eastern Europe, has further enhanced the dating. The combination of procolophonid and dipnoan evidence now appears to restrict the age of the Czatkowice 1 assemblage to the Early Olenekian.**

**Introduction.**—The bone-bearing Mesozoic karst infillings of the Czatkowice locality (Southern Poland) were discovered in 1978 by a team from the Institute of Geological Sciences, Jagiellonian University (Paszkowski and Wieczorek 1982). Rock samples collected at that time were later generously forwarded to the Institute of Paleobiology and Museum of the Earth, Polish Academy of Sciences, Warsaw, for paleontological studies. The karst cavities yielding the bone-bearing breccia are present in the Lower Carboniferous (Tournaisian to Middle Viséan, according to Paszkowski and Wieczorek l.c.) limestone which is still actively quarried. The largest of these sites, designated Czatkowice 1, has yielded a microvertebrate assemblage comprising about ten terrestrial taxa (mostly not published as yet), which has been studied since nineties (Evans and Borsuk-Białynicka 1998; Borsuk-Białynicka et al. 1999, Borsuk-Białynicka and Evans 2002), and further study is in progress. Most of the rock infill from the Czatkowice 1 locality has been removed by the quarry workers, which now precludes more detailed study of the local stratigraphic profile. The breccia available for study has been broken into blocks which were given consecutive numbers before chemical preparation started.

The filling rock of Czatkowice 1 was originally dated on both geological and paleofaunistic premises by Paszkowski and Wieczorek (1982). According to these authors the deposits correspond in age to a karstification phase that lasted from the Early Permian through Spathian (Late Olenekian) until the Röt transgression, with the Late Permian–Early Triassic interval being regarded as the most appropriate dating. Subsequent study of the Czatkowice 1 tetrapod assemblage showed it to be Triassic (Borsuk-Białynicka et al. 1999), but the available data on its taxonomic content provided only limited grounds for a more precise dating. The most informative components of the assemblage were procolophonid parareptiles which show heterodont dentition with differentiated molariform teeth, and a reduced tooth count (6 maxillary to 8 teeth dentary teeth). Following the East European Early Triassic vertebrate biozonation (Shishkin 1995; Shishkin and Ochev 1985; Ochev and Shishkin 1989), this tooth pattern first appeared in procolophonoids in the Early Olenekian and characterizes the Late Vetlugian–Yarenskian time span, i.e., ranges through the entire Olenekian (Table 1). A primitive unicuspid structure of teeth of the Czatkowice 1 procolophonids, otherwise indicative of the earlier (latest Permian–Induan) taxa possessing a more uniform dentition (see Ivakhnenko 1979), may be reasonably interpreted as juvenile character of the preserved specimens. Hence, the heterodonty and reduced tooth count are regarded as decisive for the attribution of the Czatkowice 1 procolophonids and the whole assemblage to post-Induan (most likely Olenekian) part of the Triassic. This conclusion is not at variance with the presence of a proterosuchid—grade archosauriform (Borsuk-Białynicka and Evans in preparation), and of the prefrog *Czatkobatrachus polonicus* Evans and Borsuk-Białynicka, 1998. This species is similar to *Triadobatrachus massinoti* (Piveteau, 1936) from the Early Olenekian Middle Sakamena Group of Madagascar (see Kummel and Steele 1962: 651–652; Shevyrev 1990: 24).

**New data.**—The recent identification of tooth plates of dipnoan fish *Gnathorhiza* Cope, 1883 from samples 47 and 51 of Czatkowice 1 material, serves for further refinement of dating. This lepidosirenid genus, fairly common in the Late Carboniferous and Early Permian of North America, is so far unrecorded in most of younger part of the Permian, but reappears in the Late Tatarian of Eastern Europe as an extremely rare component of some vertebrate communities of the Vyatskian Horizon (Minikh

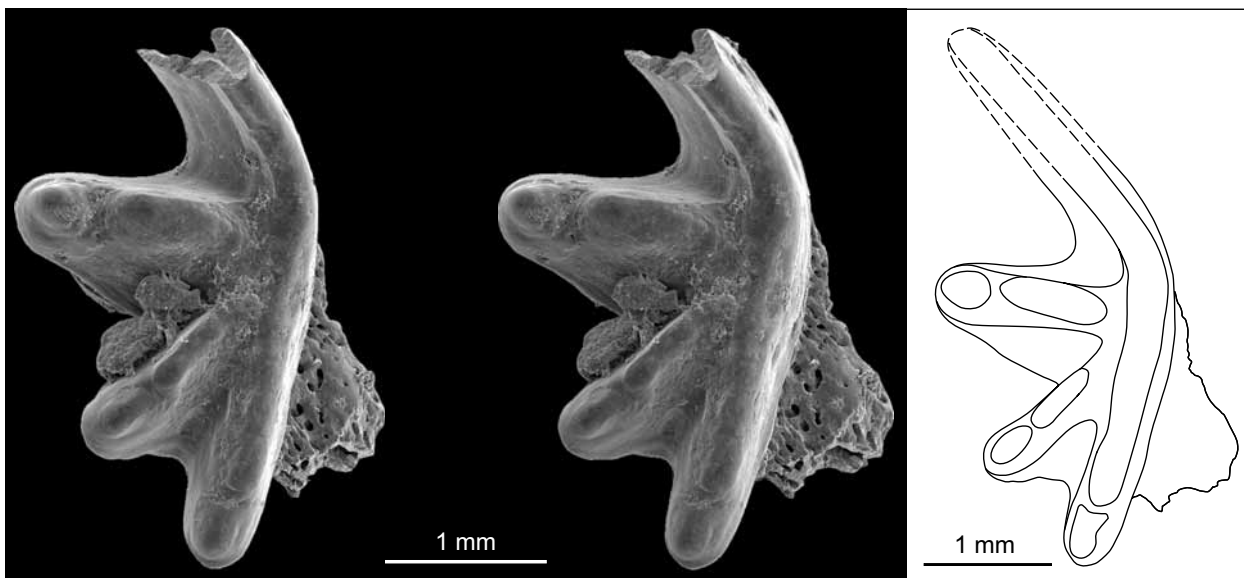


Fig. 1. Right pterygoid tooth plate ZPAL PVII/5 of a young individual of *Gnathorhiza* sp. **A.** SEM stereo-micrographs. **B.** Drawing of the same specimen before damage. Both in ventral view.

Table 1. Assessment of age of the Czatkowice 1 vertebrate assemblage based on the evidence from lungfish and procolophonoid remains. The name Spondylolestinae Ivakhnenko, 1979 is accepted conventionally to designate the primitive procolophonoids with undifferentiated unicuspid teeth. According to Spencer and Benton (2000), the taxon may prove to be a plesiomorphic grade.

	Stage/Substage	EASTERN EUROPE					Presumed age of Czatkowice 1 assemblage	
		Superhorizon/Horizon	Fauna/Grouping	Dipnoi	Procolophonia			
<b>LOWER TRIASSIC</b>	<b>UPPER OLENEKIAN</b>	Yarenskian	Gamskian	<i>PAROTOSUCHUS</i>		<i>Ceratodus</i>		
			Fedorovskian					
	<b>LOWER OLENEKIAN</b>	Vetlugian	Ustmylian	<i>Benthosuchus</i> <i>Wetlugasaurus</i>	<i>Gnathorhiza</i>			
			Sludkian					<i>Wetlugasaurus</i>
			Rybinskian					<i>Benthosuchus</i>
	<b>INDUAN</b>	Vokhmian	<i>Benthosuchus</i> <i>Wetlugasaurus</i>	<i>Tupilakosaurus</i>		<i>"Spondylolestinae"</i> (isodont dentition)		

1989). During the Early Triassic, *Gnathorhiza* becomes widespread in Eastern Europe, ranging from the base of the Vetlugian Superhorizon to Fedorovskian Horizon (Table 1), i.e., from the Induan to early Late Olenekian (Ochev and Shishkin 1989). In terms of abundance and diversity, *Gnathorhiza* is one of the principal index fossils of Vetlugian time (Table 1), during which it diversifies into five species and subspecies (*G. triassica triassica*, *G. t. beresnikiensis*, *G. lozovskii*, *G. bogdensis*, and *G. otschevi*) and remains the only lungfish genus known in the area

(Minikh 1998, 2001). During Fedorovskian (early Yarenskian) interval, just before *Gnathorhiza* became extinct, it coexisted with the ceratodontid *Ceratodus*, the commonest dipnoan genus of the younger Triassic vertebrate assemblages (Minikh 1998; Shishkin et al. 2001). In the typical terrestrial facies of the Fedorovskian Horizon, the presence of *Gnathorhiza* is limited to a single terminal subspecies, *G. triassica baskunchakensis*, which is usually by far outnumbered by *Ceratodus*. But the latter genus is not detected at Czatkowice 1. In contrast, all the dip-

noan tooth plate fragments identified hitherto from the locality Czatkowice 2 belong to *Ceratodus* (Rudzińska 1988), which suggests the later dating of its contained assemblage.

**Conclusions.**—Based on the evidence from *Gnathorhiza* only, it could be concluded that the age of Czatkowice 1 assemblage probably lies within the Induan–early Late Olenekian time span. However, the advanced evolutionary level of accompanying procolophonids (heterodonty and reduced tooth count) is incompatible with the assumption of their Induan age. On these grounds, the range of the assemblage under discussion cannot extend beyond the interval from the Early Olenekian to early Late Olenekian, i.e., from the upper part of the Vetlugian Superhorizon to Fedorovskian Horizon of the East European Triassic section. Further refinement of this dating depends on the identification of dipnoan material at the species/subspecies level. This may be complicated by the fact that the available *Gnathorhiza* tooth plates belong to juvenile or half-grown stages. However, as these finds are not accompanied by remains of *Ceratodus*, the Early Olenekian (Late Vetlugian) age of the assemblage appears to be most likely. It should be stressed that if the assumption on the Early Olenekian age of the Czatkowice 1 assemblage is correct, it would then provide the first piece of tetrapod fossil record detected for this level in terrestrial deposits of Euramerica outside the Cis-Urals and East European Platform.

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