Triassic Field Trip Guide

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IN KATOWICE

INTRODUCTION

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Triassic vertebrates are abundantly represented in the fossil record of Upper Silesia and the adjacent areas of Lesser Poland (Fig. 1). They include a variety of cartilaginous fishes, ray-finned fishes, lungfishes, temnospondyls, synapsids, lepidosauromorphs, sauropterygians, turtles, and archosauromorphs. The scientific research on the Silesian vertebrates began in the 19th century when palaeontologists and geologists such as Ferdinand Roemer and Heinrich Eck published the earliest classic works on the regional Triassic fossil record (Eck 1862, 1863, 1865; Roemer 1863, 1870). Among the most impactful studies from that time should be mentioned Georg Gürich's work on the articulated reptiles from the early Middle Triassic of Gogolin (e.g., *Dactylosaurus gracilis* Gürich, 1884), Hermann von Meyer's research on the Middle Triassic of the Tarnowskie Góry vicinity, including a specimen from the type series of *Tanystropheus conspicuus* von Meyer, 1852; and Friedrich von Huene's study, including a description of a fragmentary bone of a theropod dinosaur, *Velocipes guerichi* von Huene, 1932, from the vicinity of the Kocury village. After World War I, the interest in vertebrate palaeontology in this region declined and did not revive until the 1990s.

A notable turnover was the discovery of the Early Triassic vertebrate assemblage in Czatkowice Mariusz Paszkowski (Evans & Borsuk-Białynicka 1998; Borsuk-Białynicka et al. 1999). The second major find was the Late Triassic bone-bearing layer in the Krasiejów quarry. The spectacularly rich vertebrate assemblage in Krasiejów was known to the local community, particularly quarry workers, but it remained outside the scientific interest for a long time. Probably the first person related to the academic community to take serious notice of this site was Krzysztof Spałek, a local student who began his education in biology at the University of Wrocław. Several years later, Robert Niedźwiecki from the same university informed Jerzy Dzik about the locality. Following the preliminary reports in the non-scientific press, Jerzy Dzik launched a large-scale fieldwork campaign in the Krasiejów site. The first scientific paper on the Krasiejów assemblage was published in 2000 (Dzik et al. 2000). Since then, regular studies of the Triassic vertebrates have been conducted, including investigation of the material from both Czatkowice and Krasiejów (e.g., Dzik 2001; Paszkowski 2009; Shishkin & Sulej 2009; Dzik & Sulej 2007), findings of new assemblages (e.g., Miedary, Woźniki, Zawiercie-Marciszów; Sulej et al. 2010, 2011, 2012; Budziszewska-Karwowska et al. 2010), and rediscoveries of the historical and forgotten localities (e.g., Kocury; Czepiński et al. 2021). All these sites represent different environments and time frames that gradually uncover the patterns of vertebrate evolution and faunal turnovers spanning almost the entire Triassic period.

The record of Triassic sediments in present-day Upper Silesia is fairly continuous. This region was located in the north-eastern part of the Germanic Basin (Central European Basin, CEB), close to the Silesian-Moravian Gate, a lowland area situated between the Vindelican and Małopolska massifs, temporarily enabling the marine transgressions into the Upper Silesia area (Nawrocki & Szulc 2000; Szulc 2000). The general Triassic stratigraphic chart in the Silesia region is three-folded and constitutes of the predominantly continental Bundsandstein (Pol.: *pstry piaskowiec*), the marine Muschelkalk (*wapień muszlowy*), and the mainly continental Keuper (*kajper*). They roughly correspond to the Early, Middle, and Late Triassic, respectively. Each of these stages was characterized by distinct environmental conditions that favoured the preservation of vertebrate fossils.

Vertebrates from the continental Bundsandstein are primarily known from the above-mentioned Czatkowice locality, an active quarry located west of Kraków. The Triassic vertebrates from there are represented mainly by micro- and mesofossils preserved in karst infills within the Devonian carbonates. The identified taxa comprise several small tetrapods, e.g.: *Osmolskina czatkowicensis* Borsuk-Białynicka & Evans, 2003; *Sophineta cracoviensis* Evans & Borsuk-Białynicka, 2009; *Pamelina polonica* Evans, 2009; and the lungfish *Gnathorhiza*. The most remarkable find from this locality is one of the earliest frogs, *Czatkobatrachus polonicus* Evans & Borsuk-Białynicka, 1998. The marine Bundsandstein (Röt) is poorly exposed in the Silesia region; however, recent studies, benefiting from the road construction works, provide unpublished data about rich assemblages of fish and tetrapod microfossils, along with associated ichnocenoses.

Fossils of the Middle Triassic marine vertebrates occur mainly in the lowermost Muschelkalk (early Middle Triassic) and the uppermost Muschelkalk (late Middle Triassic). The main bone-bearing unit of the lower Muschelkalk is the Gogolin Formation, with its classic exposure in the eponymous locality, although it also crops out at numerous other sites across the whole region (e.g., Mikołów-Mokre, Nakło, and Żyglin). The vertebrate remains from the Gogolin site and its surroundings were described by, among others, Gürich (1884, 1891), Kunish (1885, 1888), Volz (1896, 1902), and Schrammen (1899). The fossils found from the bone-bearing deposits of the Upper Muschelkalk, historically referred to as the Rybna Limestone, were extensively studied for the first time by von Meyer (1847-1855, 1849-1851). The current position of this stratum can be correlated with the Wilkowice Beds and the Boruszowice Beds. This interval represents a restricted marine environment with increasing continental influence. Unfortunately, the historical vertebrate-bearing sites of this stratum, known from the vicinity of Tarnowskie Góry (e.g., Stare Tarnowice, Rybna), are no longer accessible. The vertebrate finds from the region include remains of numerous hybodontiforms, actinopterygians, and tetrapods, such as *Pistosaurus*, nothosaurids, placodonts (including the holotype skull of *Cyamodus tarnowitzensis* Gürich, 1884), as well as some isolated finds of *Tanystropheus* and the ichthyosaur *Pachygonosaurus* von Huene, 1916. This fauna is nearly identical in its composition to the roughly contemporaneous assemblage from the Bayreuth area in Germany (for an overview, see Klein et al. 2022 and references provided therein). The vertebrate fossils in the Upper Muschelkalk are usually concentrated in so-called bone beds – thin horizons of coarse-grained sediment, likely of storm origin. A recently discovered and currently intensively excavated site in the Tarnowskie Góry region is located nearby the Miedary village. Unlike other outcrops in the area, it is not correlated with the Upper Muschelkalk but with the Lower Keuper, and is therefore probably younger than the historical findings from this region. The faunal composition of the Miedary assemblage shares similarities with that of the 'Rybna Limestone' but with few notable differences, such as the abundance of temnospondyl amphibians.

The youngest Triassic unit in Silesia, rich in vertebrate fossils, is the Grabowa Formation. It is correlated with the late Carnian to late Norian, corresponding to the upper part of the Middle Keuper (Szulc & Racki 2015; Szulc et al. 2015a). It is dominated by fine-grained deposits of playa, floodplain and low-energy rivers, interbedded with coarse-grained sediments comprising mainly deposits of the high-energy rivers and reworked paedogenic lags (Jewuła et al. 2019). The Grabowa Formation is subdivided into the Ozimek and Patoka Members, which are depositional equivalents of the Wesser Formation (Upper Gypsum Beds) and Arnstadt Formation (Steinmergelkeuper) in the western part of the CEB (Szulc et al. 2015a). An interesting

feature of this formation is the common occurrence of lensoidal bodies of continental carbonates in its upper part, called the Woźniki Limestone (Woźniki Member; Szulc et al. 2006, 2015a). Their origin is regarded as related to the tectonic activity of Kraków-Lubliniec dislocation zone, causing a development of hot springs and related palustrine environments (Szulc et al. 2015a). So far, the vertebrate fossils have been found only in the Patoka Member, within six recognized paleontological sites: Kocury, Krasiejów, Lisowice, Poręba, Woźniki, and Zawiercie-Marciszów; and another site in Kierszula, which is currently under study. These sites have yielded numerous findings of fish, amphibians, reptiles, and synapsids. The most interesting are species either known primarily from Silesia or even considered endemic to this region, such as the lungfish *Ptychoceratodus roemeri* Skrzycki, 2016, amphibian *Metoposaurus diagnosticus* ssp. *krasiejowensis* Sulej, 2002, turtle *Proterochersis porebensis* Szczygielski & Sulej, 2016, aetosaur *Kocurypelta silvestris* Czepiński et al., 2021, dinosauriform *Silesaurus opolensis* Dzik, 2003, a large predatory archosaur *Smok wawelski* Niedźwiedzki et al., 2012, and dicynodonts *Lisowicia bojani* Sulej & Niedźwiedzki, 2019, and *Woznikella triradiata* Szczygielski & Sulej, 2023.

Each of the vertebrate-bearing sites of the Grabowa Formation represents a different faunal composition, hampering direct correlation between them, particularly due to the scarcity of index fossils. The first historical findings from this unit were recovered from coarse-grained, probably paedogenic-lag deposits near the Lisów village (Roemer 1870). The term 'Lisów Breccia' was a long-standing stratigraphic descriptor for the vertebrate-bearing deposits of the Late Triassic (Samsonowicz 1929; Znosko 1953; Szyperko-Śliwczyńska 1961; Kotlicki 1974, 1995); however, the subsequent studies on this strata revealed that vertebrate remains are not confined to the conglomeratic sediments, but also occur in fine-grained low-energy or stagnant water conditions (e.g., Krasiejów, Lisowice). Moreover, the coarse-grained fluvial horizons form multiple local insertions rather than a single continuous package (Jewuła et al. 2019). Two main models have been proposed to explain the stratigraphic distribution of the vertebrate sites within the Patoka Member. The dispersive model (e.g. Qvarnström, 2024) assumes different ages of all deposits with more or less contemporaneous sites in the Krasiejów and Woźniki (late Carnian), and Lisowice and Zawiercie-Marciszów (late Norian), with Poręba and Kocury localities being intermediate in age (middle Norian). In contrast, Szulc et al. (2015a) proposed a model of two bone-bearing levels: the early Norian 'Krasiejów level' (represented solely by the Krasiejów locality), and a middle Norian 'Lisowice level' (encompassing all other known localities).

Below, we are pleased to present the plan for our Triassic Field Excursion, highlighting the selected vertebrate-bearing sites, which represent a broad spectrum of depositional environments and stratigraphic horizons of the Silesian Triassic.

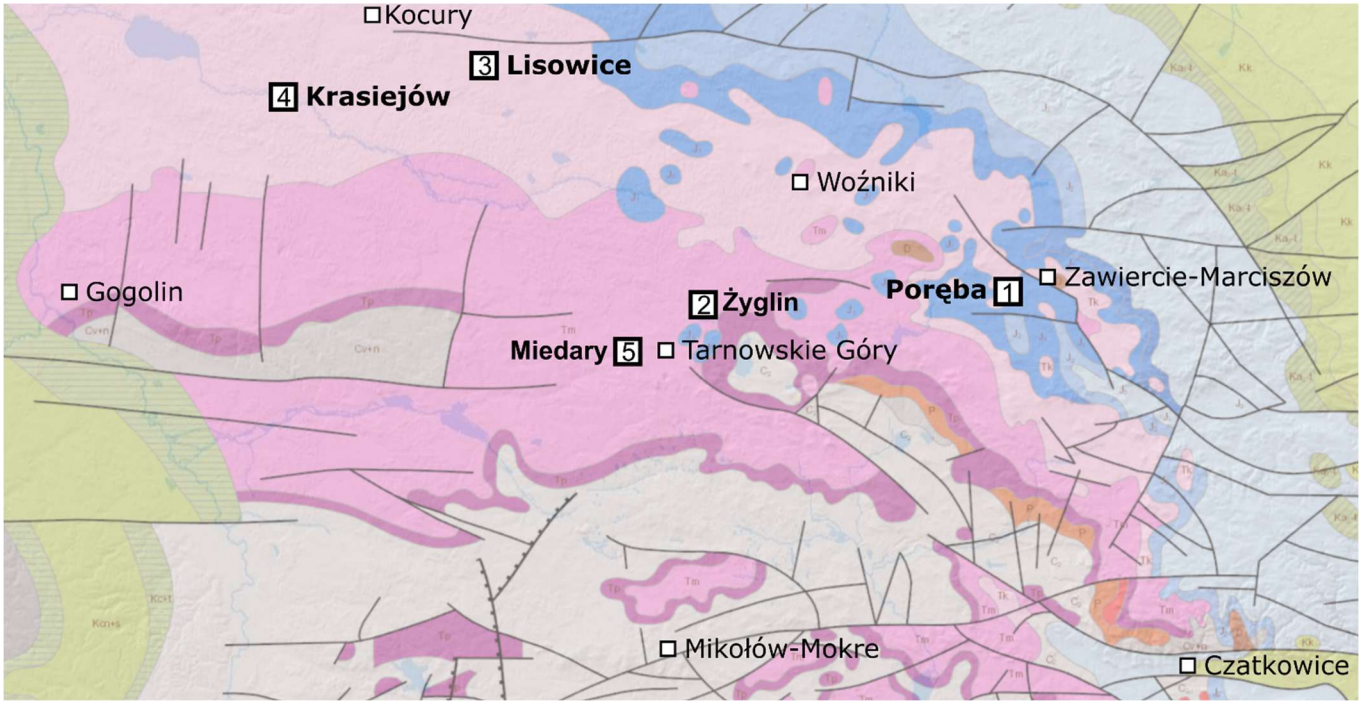

Fig. 1 – The Triassic vertebrate-bearing localities mentioned in this guide. The geological map background with the Cenozoic sediments removed. Map prepared thanks to data shared by Polish Geological Institute-National Research Institute: https://geolog.pgi.gov.pl/.

STOP 1
Poręba – the river of turtles
Tomasz Sulej

The age of the sediments exposed at the Poręba locality is middle Norian, as estimated by palynological studies (Sulej et al. 2012, Warzecha et al. 2024). A prominent feature of these deposits is the dominance of coarse-grained yellowish to greyish sediment composed of predominantly soft, clayish grains (Fig. 2). The conglomerates are interbedded by fine-grained grey mudstones. In both lithologies, can be found quite abundant, dark-coloured bones and various plant remains, ranging from tree trunks (Sulej et al. 2012), *Brachyphyllum-Pagiophyllum*-type leaves (Pacyna et al. 2024) to charcoal (Philippe et al. 2015), the latter being the most common fossil in the locality. Additionally, the site yields abundant oncoids, conchostracans, and unionid bivalves. The origin of the Poręba bone-bearing deposits is fluvial, and, as is typical for such environments, there is high lateral variability in lithology.

The site was accidentally discovered by the author in 2008. Since then, the excavations have been carried out using excavators. The sediment slabs removed from the trenches are left to be naturally washed by rainfall, which gradually reveals the fossil content. In this way, a diverse vertebrate assemblage was discovered. The remains are mostly isolated bones with few exceptions. The particularly common are finds of aetosaurs and turtles. The former were preliminarily described by Sulej et al. (2012). It is possible that the Poręba material represents more than one aetosaur species. Other taxa are very rare, and include hybodont sharks, ray-finned fish, lungfish, temnospondyls, and dinosaurs. So far, the temnospondyls are represented by a tooth, a sagittal part of the mandible similar to *Cyclotosaurus,* and a fragment of dermal bone with sculpture characteristic of plagiosaurids. The dinosaurs are represented by a proximal part of the femur, a scapula and a proximal head of fibula belonging to Herrerasauridae indet. A pelvic fragment was described as Theropoda indet., and a distal head of tibia as ?Neotheropoda indet. by Niedźwiedzki et al. (2014). A vertebra of the gliding archosauromorph *Ozimek* was found in the Poręba site this year.

The most abundant and iconic fossil from the Poręba site is *Proterochersis porebensis* – one of the earliest fully armoured turtles (Szczygielski & Sulej 2016). The most common finds are fragments of the shell, usually of a few centimetres in size. Whole shells are very rare; to date, only four specimens have been found, including one belonging to a juvenile individual. The latter specimen shows evidence of having survived a wildfire (Szczygielski & Słowiak 2022). The shells from Poręba show a rather high morphological variability (Szczygielski et al. 2018). Finds of the turtle limb bones are relatively rare (Szczygielski & Piechowski 2023; Szczygielski et al. 2023), and no skull bones have been discovered to date.

In addition to the skeletal fossils, the Poręba site yielded an abundant assemblage of bromalites, which have been attributed to sharks, turtles, large herbivore synapsids, and theropods (Zatoń et al. 2015; Bajdek et al. 2019).

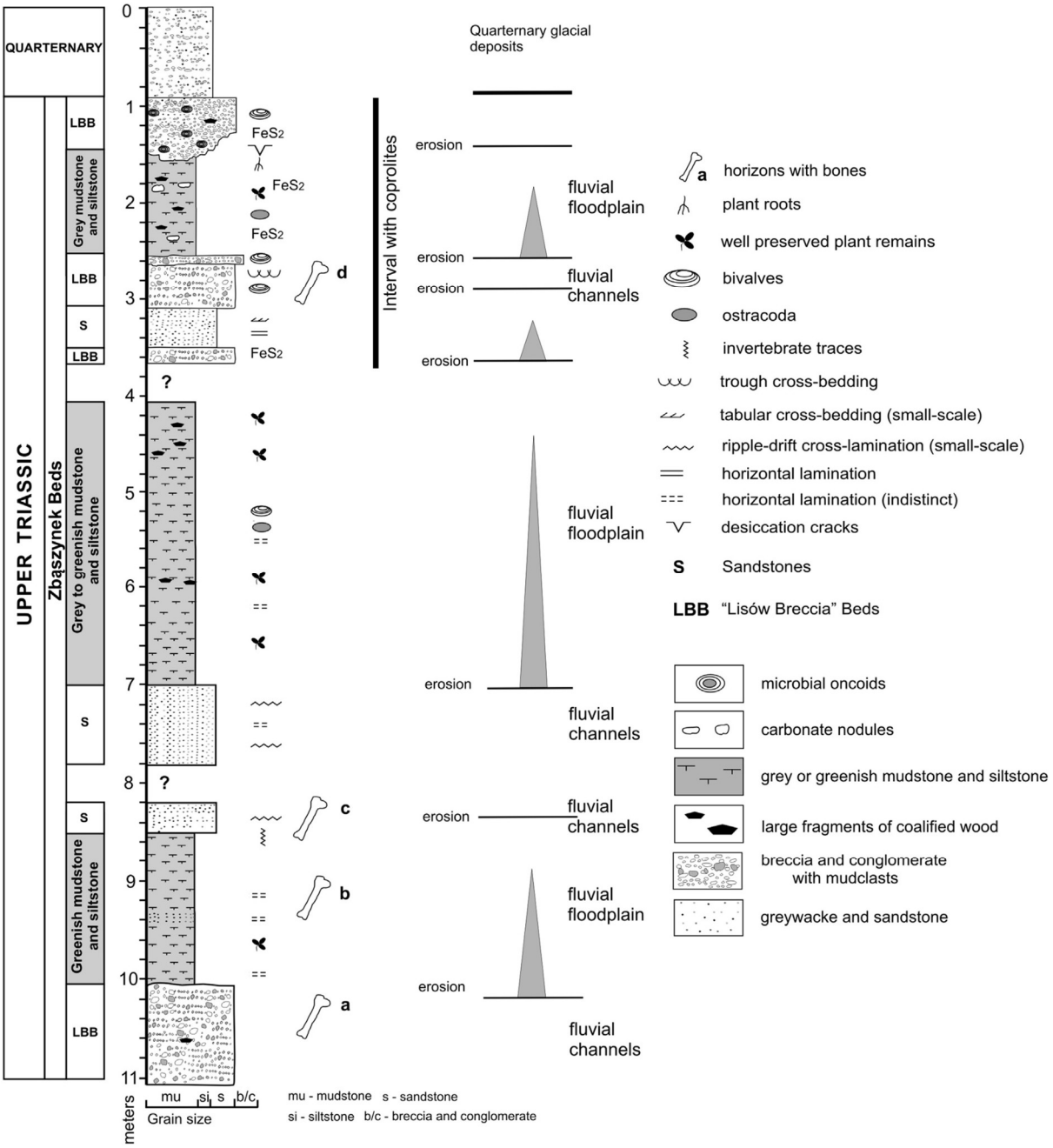

Fig. 2 – Geological section of Poręba locality (from Zatoń et al. 2015).

STOP 2
Żyglin – the Middle Triassic Sea realm
Adam Rytel, Dawid Surmik

Żyglin is a hamlet of the Miasteczko Śląskie town with two active quarries, where calcareous blocks are partially manually extracted on a small scale, allowing easy access to fossils (Fig. 3). The section cropping out in the Żyglin (Fig. 4) site represents the uppermost part of the Röt (Myophoria Beds) and the lowermost part of the Muschelkalk (Gogolin Formation; see Surmik 2010). These sediments date to the earliest Anisian, but some have suggested a slightly older, latest Olenekian age for their base (see the discussion in Skawiński et al. 2017). The Żyglin locality, first described in detail by Bardziński et al. (2008), is currently the most productive source of the Muschelkalk vertebrate macroremains in Poland.

Lithologically, the Gogolin Formation is composed predominantly of organodetrital limestones, marls, and intercalated dolomitic layers. They are rich in bioclasts, such as brachiopods, bivalves, gastropods, and especially crinoidal debris, reflecting a shallow, warm subtidal to intertidal marine environment with relatively high energy and episodic sedimentation. The characteristic alternation of hard limestones and softer marls, along with sedimentary structures such as bioturbation, ripple marks, and occasional oncoids, suggests frequent environmental fluctuations, including storm activity and minor sea-level changes. Due to their fossil richness and stratigraphic position, the Gogolin Formation has long served as a reference horizon in the Central European Triassic stratigraphy. Moreover, it provides valuable insights into paleoenvironmental conditions, carbonate platform development, and early diagenetic processes in the Germanic Basin, making it a crucial unit for both the regional geological correlation and the broader paleogeographic reconstructions.

In Żyglin, the two lowermost units of the Gogolin Formation are exposed: (1) the limestone with the bivalve *Entolium* and the crinoid *Dadocrinus,* and (2) the first horizon of the wavy-bedded limestone (Wellenkalk; see Kowal-Linka et al. 2014). The entire formation is approximately 45 m thick and was deposited on a tropical carbonate mid-ramp, situated in the southern part of a shallow epicontinental sea around 25°N paleolatitude (Kowal-Linka et al. 2014). The lower part of the limestone with *Entolium discites* and *Dadocrinus kunishi* consists of thick- to medium-bedded, cross-bedded bioclastic limestones representing shoals and barriers of the inner ramp (Kowal-Linka et al. 2014). The middle part of this unit is dominated by composite beds (bioturbated micritic limestones with erosionally truncated tops, covered by bioclastic limestones), which are interpreted as proximal tempestites deposited on autochthonous calcareous muds in the inner ramp zone. Finally, the upper part of the unit consists of alternating non-bioturbated micritic limestones and marls, with some debris-flow deposits (Kowal-Linka & Bodzioch 2011). The first horizon of the wavy-bedded limestone comprises several types of layers. The most common are thick beds of crumpled, highly bioturbated micritic limestones, which are interpreted as autochthonous sediments deposited in the mid-ramp zone (Kowal-Linka et al. 2014). The unit is completed by the platy to wavy-bedded, thin- to medium-bedded micritic limestones, medium-bedded bioclastic limestones, and sandy limestones (distal tempestites deposited on the autochthonous, semi-consolidated, usually bioturbated calcareous muds), as well as numerous marl intercalations.

The burial history of fossils from the Gogolin Formation is complex (Kowal-Linka et al. 2014; Kowal-Linka 2015; Kowal-Linka & Bodzioch 2017). The reptile and fish bones,

teeth, and scales are scattered in many limestone layers; however, a unique bonebed reported by Bardziński et al. (2008) and Surmik (2010) is especially rich in vertebrate remains. It most likely includes bones of different ages, reworked for an unknown number of times, and finally deposited together in result of storm activity (Kowal-Linka et al. 2014). Numerous fossil material consists largely of isolated bones and very rare semi-articulated skeletal fragments. The most abundant occurrence of disarticulated vertebrate remains is connected with the medium-bedded crinoid limestones (bioclastic calcarenites) deposited in the Limestone with *Entolium* and *Dadocrinus*, in high-energy settings. Ichthyoliths are the dominant vertebrate fossils from Żyglin, with isolated fish teeth, scales, and bones being relatively common. The ichthyofauna found therein consists of sharks (*Acrodus*, *Hybodus*), actinopterygians (*Colobodus*, *Gyrolepis*, *Nephrotus*, *Saurichthys*), as well as some rare coelacanths. The Żyglin quarry has yielded a tetrapod fauna typical for the Gogolin Formation – a diverse assemblage of sauropterygians, including nothosaurids (*Nothosaurus* sp.), pachypleurosaurs (*Dactylosaurus* sp.), placodonts (*Placodus* sp., cyamodontids), as well as some remains of more enigmatic taxa, such as a cervical vertebra of an archosauromorph tanysaurian *Protanystropheus antiquus* (von Huene, 1907), several jaw fragments of a possible saurosphargid *Hemilopas mentzeli* von Meyer, 1851, ichthyosaur vertebrae, and teeth of archosauriforms (Bardziński et al. 2008; Surmik 2010, 2016; Surmik & Brachaniec 2014; Surmik et al. 2016; Rytel et al. 2024). Coprolites containing shell fragments, phosphatic remains, and some possible nematode imprints have also been reported from the site, implying the existence of a multi-level trophic food web in the aftermath of the end-Permian extinction (Brachaniec et al. 2015).

Fig. 3 – Calcareous succession outcropping in Żyglin. Photograph courtesy D. Surmik.

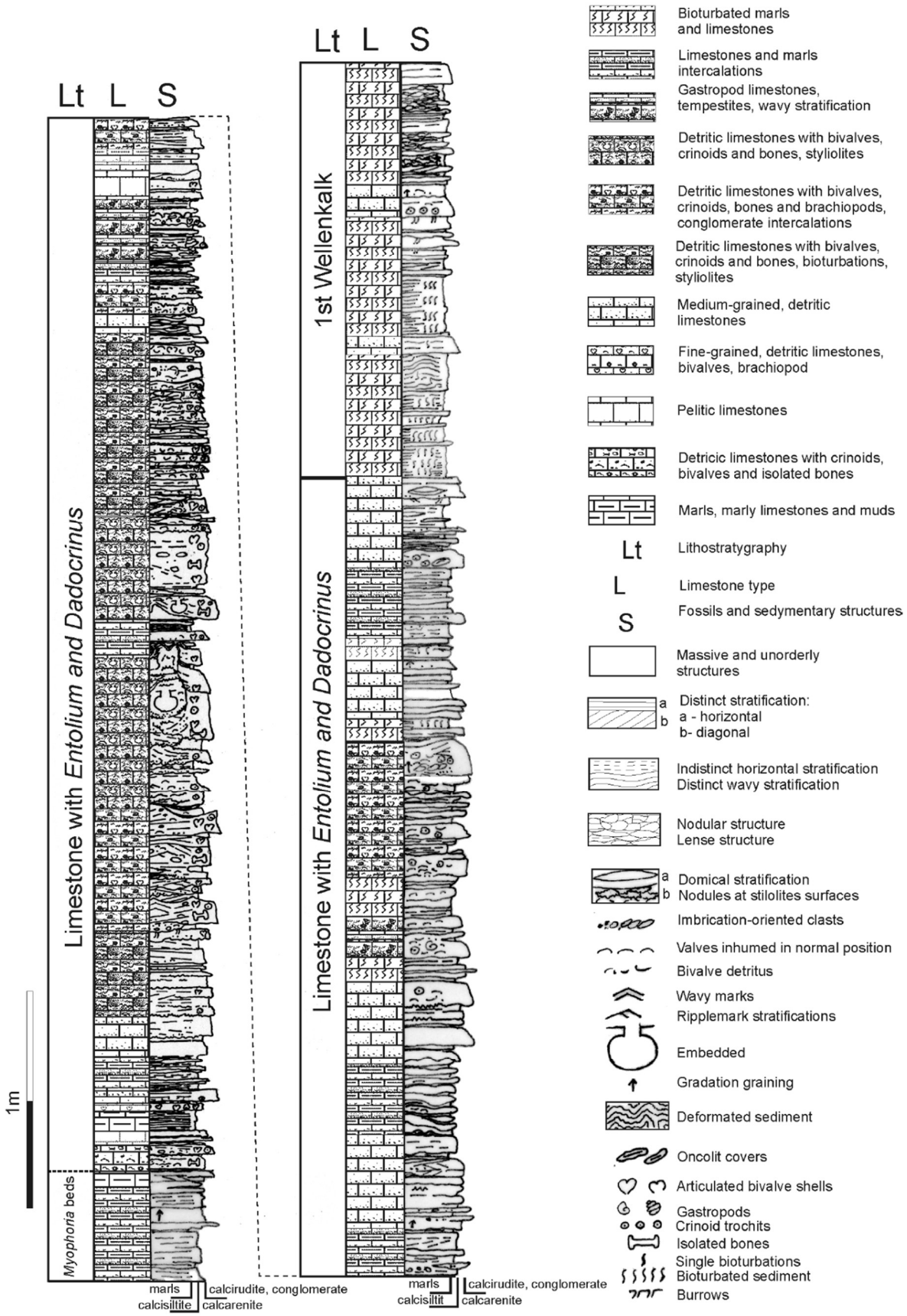

Fig. 4 – Geological section of the Żyglin locality (from Surmik 2010).

STOP 3
Lisowice–Lipie Śląskie – reign of *Smok* and *Lisowicia*
Tomasz Sulej

The locality is a former brickyard, which started exploration of the Triassic clays in 1924. The first reported fossils from there were macrospores (Fuglewicz & Śnieżek 1980). The first bones were found in the 1990s by Marek Błyszcz, a brickyard employee, but he initially identified them as plant remains. Then in 2005, the theropod dinosaur bones were discovered by Robert Borzęcki while searching for pyrite, which commonly occurs at the site. Around the same time, Piotr Menducki found the first dicynodont bones. In 2006, Grzegorz Niedźwiedzki and Tomasz Sulej began the scientific exploration of the site, including a large-scale campaign of annual excavations from 2007 to 2017. In 2008, Marek Błyszcz founded the Paleontological Museum in Lisowice.

The brickyard exposes a 12-meter-thick section (Fig. 5) composed mainly of grey to reddish clays and siltstones, formed under the floodplain to lacustrine/palustrine conditions, accompanied by fluvial channel sandstones (Szulc et al. 2015a; Pieńkowski et al. 2014; Tałanda et al. 2017). The latter have yielded tracks of three-toed dinosaurs. The layer with bones is about 1 meter thick and consists mainly of siltstone, although numerous breccia lenses are also present.

The age of the locality is unclear and often reported as late Norian to Rhaetian (e.g., Qvarnström et al. 2024). The Rhaetian age was proposed by Dzik (2008) and Pieńkowski et al. (2014) based on plant and conchostracan stratigraphy. In terms of palynostratigraphy, the strata would represent the IVc *meyeriana* subzone and V *tuberculatus* zone correlated with the late Norian to Rhaetian by Marcinkiewicz et al. (2014). This age was further supported by cuticle fragments from the typical Rhaetian seed-ferns (Staneczko 2007; Wawrzyniak & Filipiak 2023), conifers, and isoëtalean macrospores (Fuglewicz & Śnieżek 1980). Two horizons with conchostracans were identified: the lower with numerous *Shipingia sp.* and rare small *Euestheria* sp., and the upper one with *Gregoriusella polonica* Kozur & Weems, 2010. These conchostracan assemblages are correlated with the latest Norian and early (possibly also younger) Rhaetian deposits (Kozur & Weems 2010). However, the late Norian/Rhaetian dating was contested by Fijałkowska-Mader et al. (2015) and Szulc et al. (2015b), who highlighted uncertainties in previous floral interpretations. They recognized only the IVb *meyeriana* subzone, correlated with the middle Norian (Marcinkiewicz et al. 2014). Besides the biostratigraphical data, the maximum age of the Lisowice-Lipie Śląskie assemblage is constrained radiometrically by detrital zircons to 211±3 million years (late Norian; Kowal-Linka et al. 2019).

The aquatic fauna is represented by numerous teeth and fin spines of hybodont sharks (currently under study), scales and disarticulated bones of actinopterygians, rare isolated remains of plagiosaurid amphibians, and more common cranial and pectoral girdle elements of *Cyclotosaurus*.

The terrestrial assemblage includes the iconic, world's largest and stratigraphically youngest dicynodont, *Lisowicia bojani* Sulej & Niedźwiedzki, 2019. The excavated remains have allowed for the almost complete reconstruction of the skeleton, with the exception of most of the skull (Sulej & Niedźwiedzki 2019; Sulej 2024). Scattered remains of a single individual (including vertebrae, ribs, and pelvis) were found. *Lisowicia* was likely hunted by the large

archosaur *Smok wawelski* Niedźwiedzki et al., 2012 (Niedźwiedzki et al. 2011a, 2011b), whose precise systematic position remains unresolved. The assignment of three-toed tracks found in the Lisowice-Lipie Śląskie site to *Smok* suggests its close relationship with theropods (Niedźwiedzki 2013). Smaller predators included *Coelophysis*-like theropod dinosaurs, and an isolated find indicates the presence of ornithischian dinosaurs (Qvarnström et al. 2024). The smallest discovered vertebrates were insectivorous mammaliamorphs similar to *Hallautherium* (Świło et al. 2013). Additionally, abundant finds from Lisowice-Lipie Śląskie are bromalites attributed to terrestrial vertebrates (Bajdek et al. 2014; Qvarnström et al. 2024).

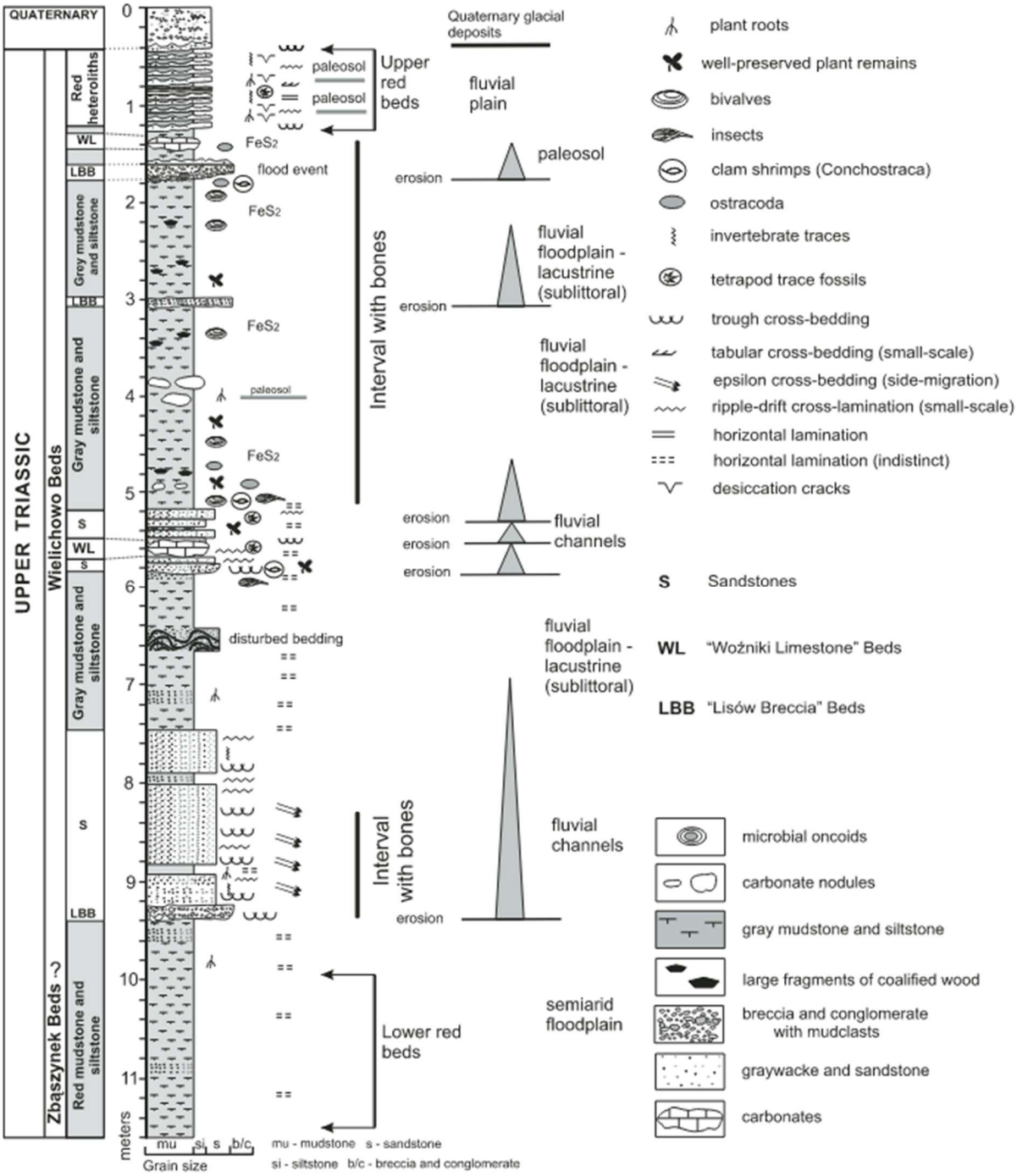

Fig. 5 – Geological section of Lisowice (from Pieńkowski et al. 2014).

STOP 4
Krasiejów – the Late Triassic graveyard
Wojciech Pawlak

The Krasiejów site is a former quarry located about 20 km east of Opole. It exposes an almost 15-meter-thick succession of the Late Triassic fine-grained deposits dominated by clays and muds, representing the lowermost part of the Patoka Member of the Grabowa Formation (Fig. 6). The gypsum-rich layers occur in the lowermost part of the quarry section, as well as under its surface, belonging to the evaporitic Ozimek Member (Szulc et al. 2015b). Two vertebrate-bearing levels occur in the upper part of the section, often undifferentiated in the paleontological literature (Dzik & Sulej 2007). Although the vast majority of vertebrate fossils derive from these two levels, some specimens were found outside them, e.g. incomplete remains of a phytosaur, a rauisuchian, and an aetosaur (Dzik & Sulej 2007).

The fossil accumulation in the lower level was described for the first time by Dzik et al. (2000). The long-term field campaign resulted in discovery of almost two dozens of vertebrate species: hydodont *Lonchidion* sp., coelacanth (Kowalski et al. 2019, 2025), lungfish *Ptychoceratodus roemeri* Skrzycki, 2015, amphibians *Metoposaurus krasiejowensis* (Sulej, 2002) and *Cyclotosaurus intermedius* Sulej & Majer, 2005, gliding reptile *Ozimek volans* Sulej & Dzik, 2016, aetosaur *Stagonolepis olenkae* Sulej, 2010, rauisuchian *Polonosuchus silesiacus* (Sulej, 2005), dinosauriform *Silesaurus opolensis* Dzik, 2003, and a synapsid *Polonodon woznikensis* Sulej et al., 2020. Additionally, microfossils suggest a high diversity of small rhynchocephalians (e.g., cf. *Planocephalosaurus*, cf. *Diphydontosaurus*) and pseudosuchians (e.g., cf. *Revueltosaurus*) unknown from the more complete remains (Kowalski et al. 2019). The least-studied group are ray-finned fish, which are relatively rare in the Krasiejów site. Early preliminary investigations identified a redfieldiiform *Dictyopyge* (Dzik & Sulej 2007), whereas the microfossil survey recognized four different scale morphotypes (Antczak & Bodzioch 2018; Kowalski et al. 2019). The studies of articulated specimens support the presence of at least four different taxa of Actinopterygii (Pawlak in prep.). The vertebrates are associated with numerous invertebrate taxa: five species of conchostracans (Olempska 2004), two ostracod species (Olempska 2011), a cyclid *Opolanka decorosa* Dzik 2008, a beetle *Triamyxa coprolithica* Qvarnström et al. 2021, and an extremely abundant bivalve *Silesunio parvus* Skawina & Dzik 2011. Plant remains are relatively common but rather poorly preserved. They include two identified taxa: *Neocalamites* and a fern *Sphenopteris* sp. (Pacyna 2019). At the microscale, charophyte oogonia are common (Zatoń et al. 2005). The upper fossiliferous level was reported for the first time by Dzik & Sulej (2007). The composition of a fossil assemblage in this level is depleted compared to the lower one, with only *S. opolensis*, , *C. intermedius*, *S. olenkae*, and *S. parvus* being reported (Dzik & Sulej 2007).

The quality as well as quantity of fossils occurring in Krasiejów enabled numerous specialistic studies on biomechanics (Konietzko-Meier et al. 2018, 2019), functional morphology and muscle reconstructions (e.g. Dróżdż 2018; Piechowski & Tałanda 2020), histology (e.g. Gruntmejer et al. 2016, 2021; Teschner et al. 2022, 2023; Błaszczeć & Antczak 2025), intraspecific variability (Sulej 2007; Skawina 2013; Piechowski et al. 2014), soft tissue preservation in invertebrates (Dzik 2008; Skawina 2010), paleopathologies (Surmik et al. 2022; Antczak et al. 2025), and particularly interesting coprolites (Qvarnström et al. 2017, 2019, 2021, 2024)

The origin of the lower level is controversial. It is composed mostly of a 1 meter-thick massive claystone, interbedded by thin grainstone horizons, and the bottom is particularly rich in plant remains, invertebrates, and fish encrusted by limonite. Several hypotheses have been proposed since the discovery of the locality, including debris flow (Szulc 2005), lacustrine (Dzik & Sulej 2007), ephemeral pond (Bodzioch & Kowal-Linka 2012), and multi-stage hypothesis (Kowalski et al. 2019). Outside the lower fossiliferous level, the upper part of the sedimentary succession in Krasiejów is predominantly fluvial, dominated by low-angle cross-bedded mudstone and siltstones, indicating the low-energy meandering fluvial system (Gruszka & Zieliński 2008). This interpretation applies both to the upper fossiliferous level and to the fossils found outside the main bone-bearing levels.

The age of the Krasiejów deposits is most likely late Carnian, as it is suggested by magnetostratigraphic data (Nawrocki et al. 2015), vertebrate (Dzik et al. 2000; Dzik, 2001, Dzik 2003, Lucas et al. 2007; Lucas 2015), and conchostracan biostratigraphy (Olempska, 2005; Kozur & Weems 2010). In contrast, Szulc (2005, 2007) and Szulc et al. (2015b) proposed an early/middle Norian age based on the lithostratigraphic correlation with the lower Arnstadt Formation (Steinmergelkeuper).

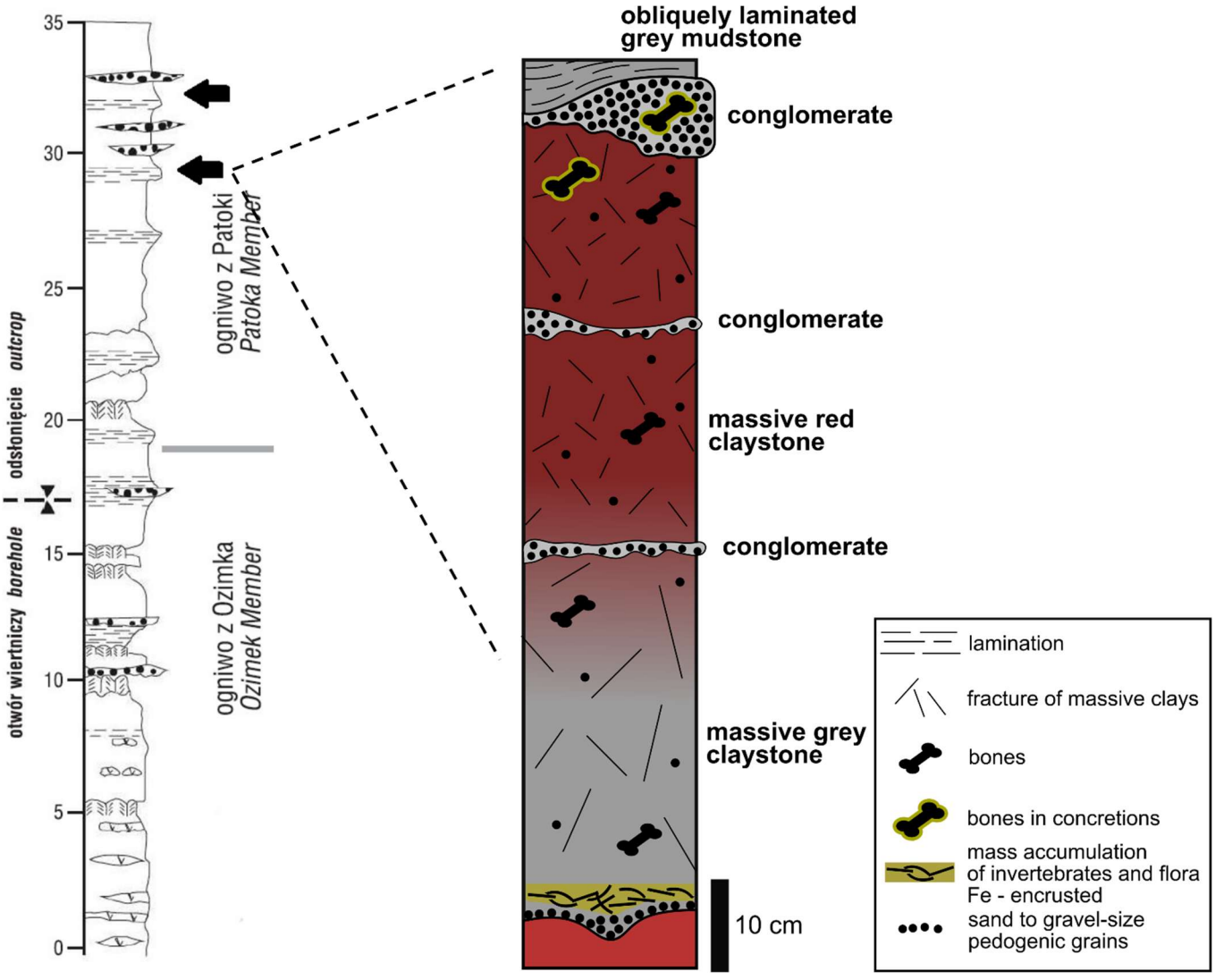

Fig. 6 – Geological section of the Krasiejów locality. The section on the left from Szulc (2005).

STOP 5
Miedary – the great transition
Łukasz Czepiński, Wojciech Pawlak

The Miedary site is an abandoned claypit located between the villages of Miedary and Laryszów in the Tarnowskie Góry region of southern Poland, about 1 km to the west of the historical outcrop of the Upper Muschelkalk in Laryszów. Vertebrate fossils were discovered at this site for the first time in the late 2000s by Michał Stachacz, a geology student at the time. The upper part of the stratigraphic section, comprising carbonates with sandstone intercalations containing a scarce record of both vertebrate and invertebrate remains, was first described by Sulej et al. (2011). In 2014, a previously undocumented lower unit was exposed at the Miedary site. This unit consists predominantly of claystones, mudstones, and sandstones rich in glauconites (Fig. 7), and it yields a significantly richer assemblage of vertebrate fossils. Preliminary descriptions of this fossiliferous lower unit were provided by Pawlak et al. (2022) and Czepiński et al. (2023).

The sedimentary succession at the Miedary site records depositional settings, fluctuating between storm-affected nearshore zones, tidal flats, and palustrine to subaerial erosion. In both the lower and upper units, the vertebrate fossils occur mainly within facies rich in the interbeds of storm origin, similarly to the 'bonebeds' typical for the Upper Muschelkalk. No index fossils were found in the Miedary site, except palynomorphs indicating the Ladinian age. Taking into consideration the proximity to the outcrop in Laryszów and regional models of the Upper Muschelkalk/Lower Keuper deposition, the age is estimated to be the early Ladinian (Fassanian; Pawlak et al. 2022).

Fossils recovered from the upper part of the section include invertebrate trace fossils, the bivalve *Costatoria goldfussi*, and various vertebrate remains. These include shark teeth (*Acrodus lateralis*, cf. *Palaeobates* sp., *Lissodus* sp.), actinopterygians *Saurichthys*, *Gyrolepis*, and isolated bones of nothosaurid sauropterygians (Sulej et al. 2011; Pawlak et al. 2022).

The lower unit at the Miedary site yields a remarkably diverse vertebrate assemblage comprising over 20 taxa, including chondrichthyans, actinopterygians, temnospondyl amphibians, and a wide range of reptiles. Some of these taxa are rare or previously unrecorded within the eastern part of the Germanic Basin. The fish fauna is diverse. Hybodontiform sharks are represented here by at least four species: *Acrodus* cf. *A. lateralis*, *Lissodus nodosus*, *Polyacrodus keuperianus*, and *Polyacrodus* cf. *P. polycyphus*. In addition, at least six actinopterygian taxa are present, including *Saurichthys*, *Gyrolepis*, *Serrolepis suevicus*, an indeterminate redfieldiiform, dipnoan *Ptychoceratodus*, and teleosteomorph cf. *Prohalecites* (Pawlak et al. 2022; Czepiński et al. 2023).

Temnospondyl amphibians are abundant in Miedary, with *Mastodonsaurus* sp. being the dominant taxon, whose well-preserved skulls and postcranial remains likely represent a new species comparable in size to the largest specimens from the German Keuper (Schoch 1999). Plagiosaur amphibians are also present, including cf. *Gerrothorax* sp., *Plagiosternum*

sp., and at least one more, yet indeterminate plagiosaurine. In addition to temnospondyls, an osteoderm of reptiliomorph chroniosuchian *Bystrowiella* cf. *B. schumanni* has been found.

The taxonomically diverse reptilian remains include isolated elements of an owenettid procolophonomorph, and vertebrae of the ?thalattosaurian *Blezingeria* sp. The sauropterygian *Nothosaurus* sp. is particularly well represented, including several nearly complete skulls and a number of postcranial elements.

Among archosauromorphs, *Tanystropheus* sp. is extraordinarily abundant. The site has yielded numerous cervical vertebrae, including the longest known for this taxon, preserved in exceptional three-dimensional detail. Miedary currently represents the richest global source of *Tanystropheus* material, surpassing even Monte San Giorgio in both quantity and some aspects of preservation quality (Spiekman et al. 2021; Czepiński et al. 2023). Additional remains suggest the presence of doswelliid *Jaxtasuchus* sp., and a range of archosauriforms represented by at least eight distinct tooth morphotypes. Of particular interest is the discovery of a partial skeleton of a medium-sized, heavily armoured archosauromorph with bizarre vertebral and osteoderm morphology, presumably representing a single individual of an enigmatic and previously unrecognized taxon.

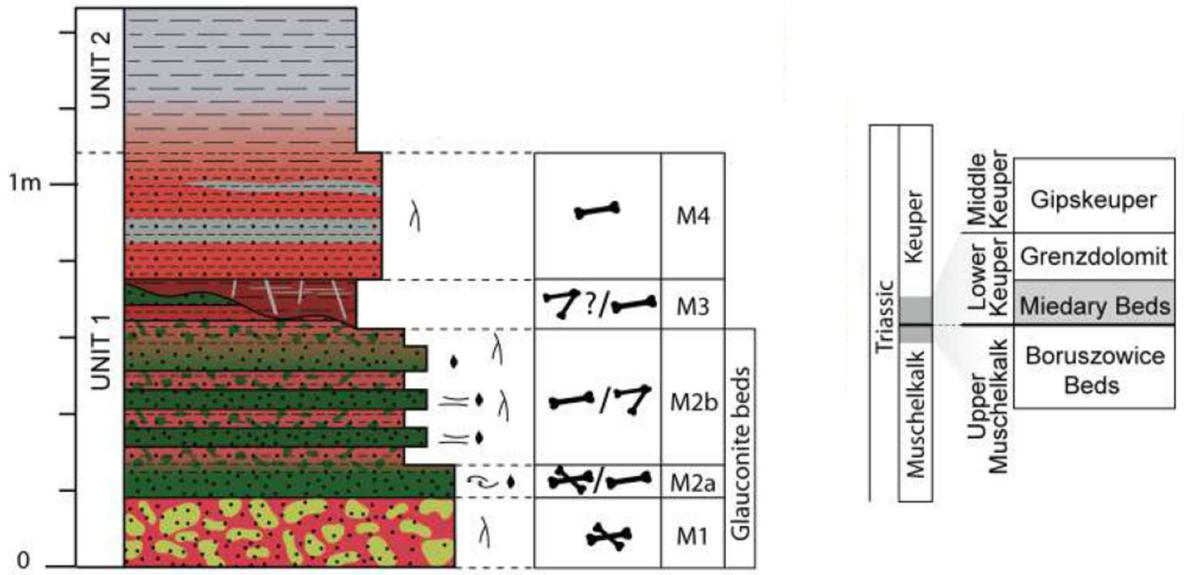

Fig. 7 – Geological section of the lower units exposed in the Miedary site and placement of the Miedary Beds within the Triassic lithostratigraphic units of Upper Silesia (from Czepiński et al. 2023).

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