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PALAEOHISTOLOGY OF RIBS AND CLAVICLE OF *METOPOSAURUS DIAGNOSTICUS* FROM KRASIEJÓW (UPPER SILESIA, POLAND)

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ABSTRACT: The microstructure of bones is affected by many factors, such as ontogeny, biomechanics and environment. Thanks to well-preserved histological integrity of fossil bones, studies of aspects of the life history of the extinct temnospondylid amphibian *Metoposaurus diagnosticus* is possible. The present note focuses on bone microstructures and tissue composition.

KEY WORDS: histology, bone microstructure, Temnospondyli, *Metoposaurus*

Introduction

Temnospondyli are a huge clade of extinct animals, which existed on Earth from the Early Carboniferous to the Early Cretaceous. *Metoposaurus diagnosticus* belongs to the Metoposauridae, a temnospondylid family which was widely distributed during the Triassic, with records from central Europe (Germany and Poland; Dzik *et al.* 2000), the southwestern United States, North Africa (Morocco) and Madagascar (Steyer 2004). In Poland, the locality "TRIAS" (Fig. 1) at Krasiejów is world famous for large accumulations of remains of Late Triassic vertebrates. Bones of *Metoposaurus diagnosticus* are the most abundant here; they usually are strongly disarticulated, yet often very well preserved.

There are only few papers concerning the histology of Temnospondyli (e.g. Steyer 2004; Ray *et al.* 2009; Konietzko-Meier *et al.*, in press). The bone histology of *Metoposaurus diagnosticus* was already briefly studied by Witzmann (2009); however, that author was not sure if the thin sections he studied came from the skull roof or from the dermal pectoral girdle. The present note focuses on the pectoral girdle (clavicle) and ribs.

Material and methods

The material studied comprised two types of rib and a single clavicle. These bones are deposited at Opole University, with catalogue numbers UOPB-01021 and UOPB-01022 (ribs) and UOPB-01023 (clavicle). They were cut in a cross and longitudinal planes, and subsequently ten thin sections were made. Eight thin sections are of ribs and two of the clavicle Observations were carried out using an optical microscope in polarised light and cross-polarised light. In addition, a scanning electron microscope (SEM) was used, by courtesy of the Institute of Geology of Adam Mickiewicz University at Poznań.

Histological description

One of the ribs is from the thorax, the other one from the lumbar region. Irrespective of the plane of sectioning, bones consist of distinctly spongy bone, surrounded by compact bone (cortex). The cortex of ribs is mostly lamellar; there is also parallel-fibred bone underneath the lamellar layer (Fig. 2A). The vascularisation is poor in the lamellar layer (Fig. 2A). It is represented by a small number of secondary osteons, which are assembled in groups of 5 or 6 osteons. The parallel-fibred layer is more vascular, and the diameter of the canals is larger. It is represented by secondary osteons, but in a relatively low number (Fig. 2B). Most vascular canals in ribs are oriented parallel to the bone surface. Most vascular canals are partially filled by laminae, similar to the lamellar tissue. In these ribs, there was no evidence of Haversian tissue. A large number of osteocyte lacunae occur in the ribs' cortex (Fig. 3A). These lacunae are elliptical, round or irregular in shape. Between them, there are microscopic canals (named canaliculi), which are arranged in canal networks connecting one lacuna to the other and to the bone's outer surface. The boundary between cortex bone and spongy bone is uneven, yet distinct. There are a large number of erosion cavities (Fig. 3B), which can even be seen with the naked eye. The thickness of the cortex decreases, and the percentage of spongy bone increases towards to the distal end of the rib. Ribs of *Metoposaurus diagnosticus* are very rich in bony structures known as Sharpey fibres. Generally, there are two types of such fibres, long ones and short ones. The former connected bone with muscles and ligaments, while the latter link the periosteum to the rest of the bone. The largest number of Sharpey fibres occur on the distal end of the rib (Fig. 3B).

The clavicle is a flat and elongated dermal bone from the pectoral girdle. This type of bone is ornamented on the ventral (external) side, and smooth dorsally (internally). The clavicle is characterised by a diploë structure (Fig. 4A), which means that it is composed of external cortex, middle region and internal cortex. The ratio between these is 0,75:1,5:0,5. The external cortex is composed of parallel-fibred bone. The vascular system is poorly developed, being composed of primary vascular canals. Sculptural ridges consist of avascular tissue. The number of vascular canals decreases in the direction of the external bone surface. Numerous osteocyte lacunae are either round or slightly elliptical in shape. Canaliculi are poorly visible. In sculptural valleys, large numbers of Sharpey fibres, arranged in groups, are seen. The external cortex changes gradually into the middle region which is composed of cancellous bone. There is a large number of secondary vascular canals, which occasionally form Haversian tissue. Many erosion cavities attain diameter of 0,1 mm to 1 mm. The internal cortex is thinner than the middle region and external cortex. It is distinguished from the middle region by a fine transition zone. The internal cortex consists mostly of parallel-fibred bone. Vascularisation is poor (Fig. 4B); there are only few primary vascular canals. Osteocyte lacunae are less abundant than in the external cortex; in shape they are similar to osteocyte lacunae in the external cortex.

Interpretation

The above observations allow to determine the age of these specimens as relatively young, in late adolescence or early adulthood. Rib vascularisation is mostly primary; secondary osteons do occur, but are rare. However, in the clavicle a large number of secondary osteons have been determined, which might imply that this specimen was older than the individuals from which the ribs were derived. Distinctive skeletochronological structures do not occur in any of the bones studied. For this, there are two possible explanations. The environment in which these metoposaurids lived may have been stable environment. However, the lamellar and parallel-fibred bone complex may imply that growth rate could fluctuate during the life of these animals, but it also have been triggered by physiological changes in their bodies, irrespective of environmental changes.

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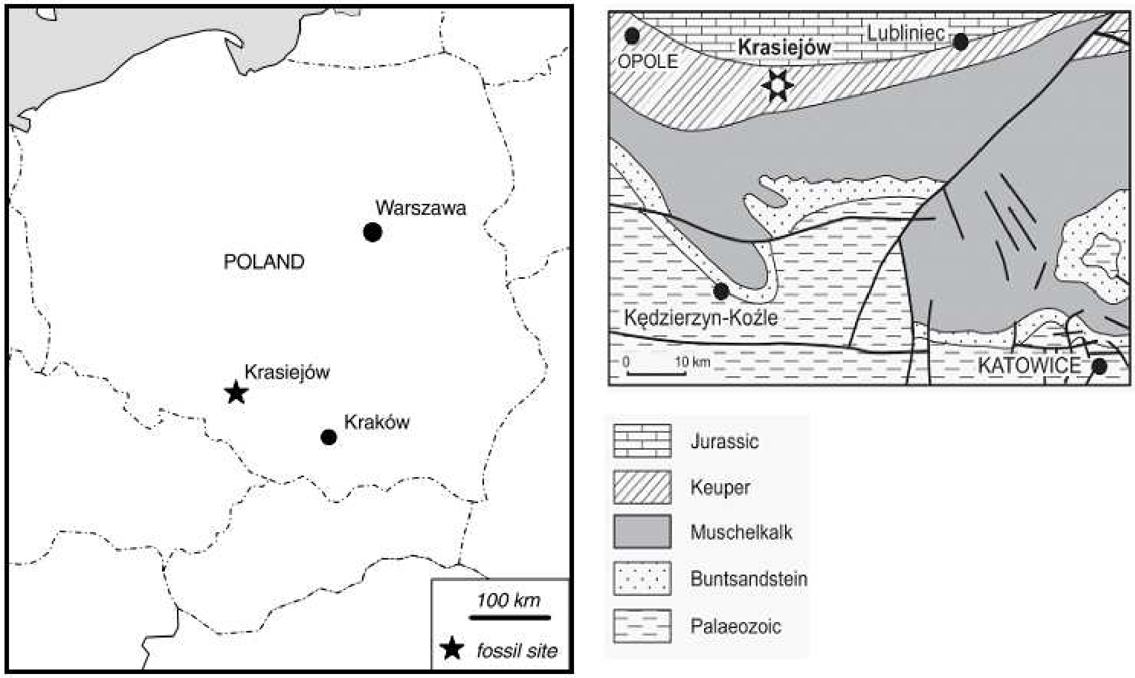

Fig. 1. Outline map of Poland showing the position of Krasiejów (**A**), simplified geological map of the Krasiejów area (**B**) (**A** – from Sulej 2002; **B** – from Olempska 2004).

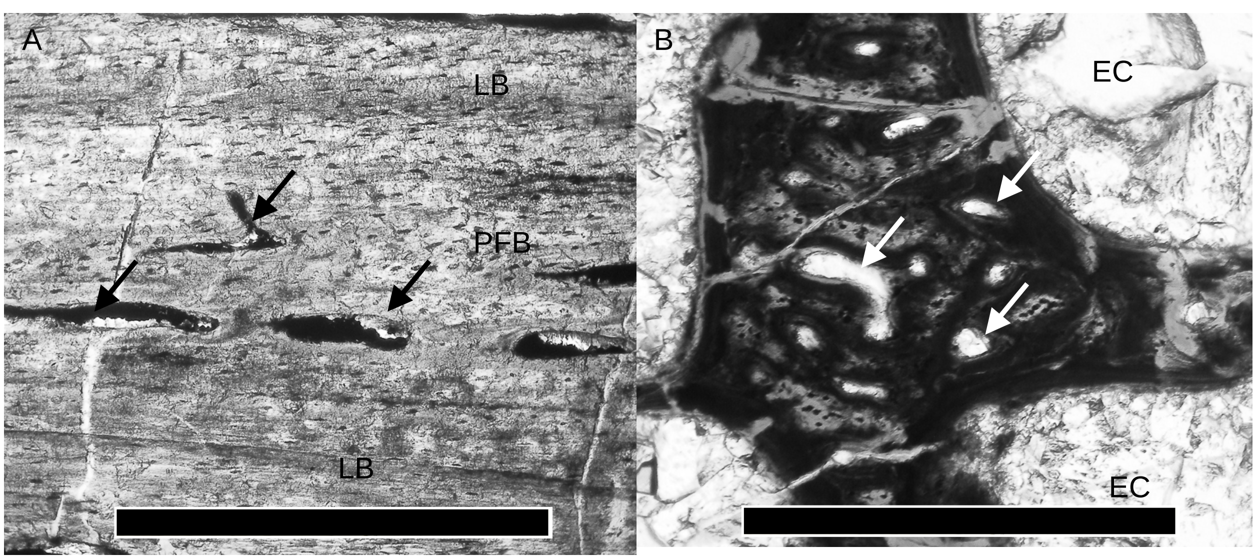

Fig. 2. Cross sections of ribs of *Metoposaurus diagnosticus*. (**A)** LB – Lamellar bone; PFB – Parallel-fibred bone; secondary vascular canals – black arrows. Scale bar – 1 mm. (**B)** Secondary osteons – white arrows; Erosion cavities – EC. Scale bar – 1 mm. Based on sample number 6 (A) and 4 (B).

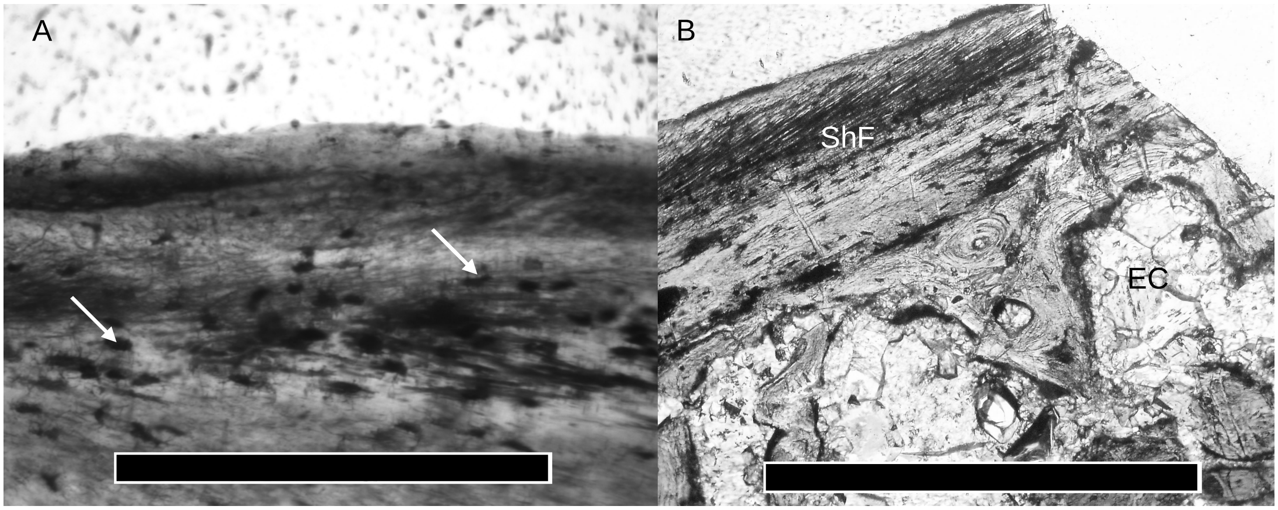

Fig. 3. Longitidunal sections of ribs of *Metoposaurus diagnosticus*. (**A)** Group of osteocyte lacunae – white arrows. Scale bar – 0.4 mm. (**B)** Sharpey fibres – ShF; Erosion cavities – EC. Scale bar – 1 mm. Based on sample number 5 (A and B).

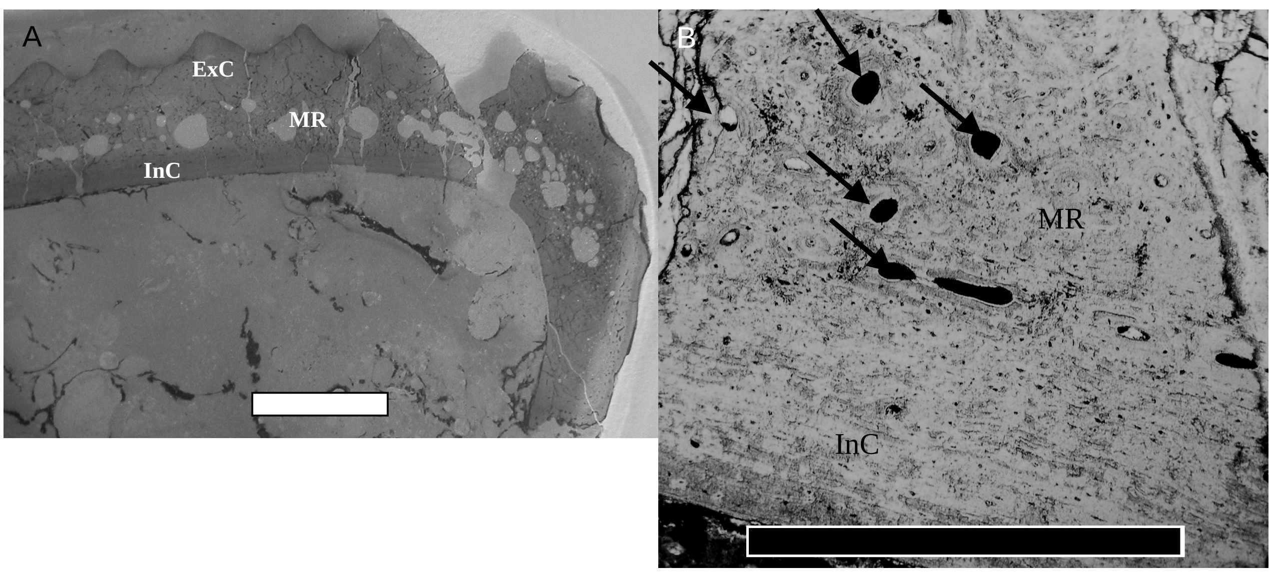

Fig. 4. Cross sections of clavicle of *Metoposaurus diagnosticus*. (**A)** Diploë structure of clavicle. ExC – External Cortex; InC – Internal Cortex; MR – Middle Region. Scale bar – 4 mm. (**B)** Internal cortex of clavicle an middle region. Black arrows indicate vascular canals; InC – Internal Cortex; MR – Middle Region. Scale bar – 1 mm. Based on sample number 10 (A and B).