GROWTH PATTERNS IN ROSTRA OF THE MIDDLE JURASSIC BELEMNITE *MEGATEUTHIS GIGANTEUS*: CONTROLED BY THE MOON?

ELENA DUNCA[1], LARISA DOGUZHAEVA[2], BERND R. SCHÖNE[3] and BAS VAN DE SCHOOTBRUGGE[3]

[1] *Department of Paleozoology, Swedish Museum of Natural History, Stockholm*
elena.dunca@nrm.se
[2] *Palaeontological Institute, Russian Academy of Sciences, Moscow*
ldoguzhaeva@rambler.ru
[3] *Institute for Geology and Paleontology, Increments Research Group, University of Frankfurt a. M.*
B.R.Schoene@em.uni-frankfurt.de, van.de.Schootbrugge@em.uni-frankfurt.de

Abstract: In order to determine the timing of growth of belemnite rostra, we analyzed microgrowth patterns of seven, excellently preserved specimens of *Megateuthis giganteus* (v. Schloth.) from the Middle Jurassic of the Hannover area, Germany. Spectral analysis (single spectrum analysis, continuous wavelet transformation) of microgrowth curves suggests that the microgrowth increments and lines formed on a lunar daily basis. Microincrements are arranged in fortnight bundles of 15. Based on this interpretation, we estimated that the ontogenetic age of the studied specimens (at least the well-preserved visible portions) ranged between one and two years. Furthermore, chemical (energy dispersive spectrometry) and structural (X-ray diffractometry, scanning electron microscopy) analyses and monochromatic cathodoluminescence were employed to study the degree of diagenetic alteration, interpret the original mineralogical composition of the guards and explain the reason for the distinct alternation of dark and light laminae (microgrowth lines or rings). We found that the alternation of dark and light laminae in the rostrum is caused by regular changes in density of calcium carbonate rather variable organic content. Orthorostra were originally composed of low-Mg calcite rather than aragonite. The overall high carbon content (35 to 65% higher amounts than expected for pure calcite) indicates the presence of pristine intra-crystalline (and perhaps inter-crystalline) organic matrix. Despite the overall mint preservation, some portions of the rostra (stained blue by Mutvei's solution) have undergone diagenetic alterations such as cementation and/or recrystallization.

Key words: Belemnites, microstructures, growth patterns, lunar periodicity, Jurassic

INTRODUCTION

Belemnite rostra have been used in numerous studies for the reconstruction of paleoenvironmental conditions (e.g., Urey et al., 1951; Podlaha et al., 1998; Price et al., 2000; Longinelli et al., 2002, 2003; McArthur et al., 2000, 2004; Niebuhr & Joachimski, 2002; Voigt et al., 2003; Florek et al., 2004; Rosales et al., 2004; Wierzbowski 2004; van de Schootbrugge et al., 2005). These studies focused on stable isotopes and trace and minor elements to infer ancient water temperatures, interpret seawater isotopic composition and paleoceanography. Yet, little is known about the structure and the growth periodicity of belemnite rostra. Urey et al. (1951) interpreted the oscillations of oxygen isotopes of the belemnite low-Mg calcite as annual temperature variations and used these cycles to estimate the ontogenetic age of these belemnites (four years of age). However, age determinations based on sclerochronological (growth pattern) studies of belemnite rostra have not been employed.

The rostra of most Jurassic and Cretaceous belemnites have three parts with different structures: (1) the primordial and early juvenile rostrum is considered to be organic-rich and often aragonitic in composition, (2) the orthorostrum is a solid calcitic structure that covers the primordial rostrum and (3) the epirostrum is covering the orthorostrum. Bandel and Spaeth (1988) stated that the epirostrum was originally composed of the aragonite polymorph. The ortho- and epirostrum show concentric laminae interpreted as alternating organic (*laminae obscurae*) and inorganic laminae (*laminae pellucidae*) (Müller-Stoll, 1936; Jeletsky, 1966; Barskov, 1970; Spaeth, 1971; Sælen, 1989). These laminae, also called microgrowth lines or microgrowth rings form a specific microgrowth pattern for each rostrum and are considered to have been formed periodically throughout the entire life-span. Similar microgrowth patterns are found in skeletons of many organisms including bivalve shells (e.g., Berry and Barker, 1968; Clark, 1975, 2005a; Evans, 1972; Richardson et al., 1979; Schöne et al., 2002), corals (e.g., Wells, 1963; Cohen and McConnaughey, 2004), fish otoliths (e.g., Pannella, 1971; Gutiérrez and Morales-Nin, 1986), squid statoliths (e.g., Archipkin and Murzov, 1986; Bettencourt and Guerra, 2001), beak and gladius of octopus (Hernández-Lopez et al., 2001; Perez et al., 1996) and have been interpreted as daily growth periodicities. In these organisms, precipitation of skeletal hard parts is regularly retarded resulting in the formation of distinct growth lines. Such structures might thus be useful in estimating precise ontogenetic ages and adding a time axis to geochemical analyses.

Two major reasons may explain the lack of sclerochronological studies of belemnite guards. Firstly, the poor preservation of most specimens prevents the recognition of