Palaeogeography, Palaeoclimatology, Palaeoecology 466 (2017) 326–333

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Gastropod egg capsules from the Lower Cretaceous of Russia preserved by calcitization

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ARTICLE INFO

Article history:
Received 9 June 2016
Received in revised form 18 November 2016
Accepted 29 November 2016
Available online 1 December 2016

Keywords:
Gastropoda
Egg capsules
Calcitization
Taphonomy
Ammonites
Cretaceous

ABSTRACT

Small-sized (0.8–1.6 mm in diameter), circular to oval, three-dimensionally preserved calcitized structures have been found embedded within ammonite body chamber moulds from the Lower Aptian (Lower Cretaceous) of Russia. The characteristic morphology, consisting of a flat attachment base and convex upper hemisphere possessing an apical, tiny, circular opening indicate that these structures represent gastropod (possibly Caenogastropoda) egg capsules. Originally, the egg capsules were attached to the empty shells of the ammonites *Deshayesites* and *Sinzovia* which later were embedded within carbonate concretions. The preservation of the egg capsules resulted from both their deposition within a suitable, cryptic habitat provided by the empty ammonite shells, and the quick cementation of the infilling sediment which not only sufficiently protected the capsules from external environment, but also created a suitable, closed microenvironment for fossilization. The calcitization of the egg capsules may have occurred under low pH conditions in an environment characterized by a very low concentration of phosphorous ions essential for phosphatization. So far, such structures are known from a few examples derived from different stratigraphic horizons and geographic locations. Those which are known have been reported in the form of pyritized, phosphatized, carbonaceous and even bioimmured fossils. The calcitized gastropod egg capsules presented here indicate, that such structures may in fact be preserved by a wide array of fossilization modes in different paleoenvironments/microenvironments. Thus, such fossils seem to be much more common in the fossil record than previously considered.

1. Introduction

Aquatic gastropods produce a variety of egg-containing gelatinous masses, strings, ribbons and tough capsules (e.g., Soliman, 1987; Rawlings, 1999; Przeslawski, 2004). However, only the latter ones have a chance to be fossilized and enter the fossil record (e.g., Zatoń et al., 2009; Zatoń and Mironenko, 2015a). The structures interpreted as fossilized gastropod egg capsules are relatively rare in the fossil record, and have a patchy distribution in both time and space, being mainly known from the Jurassic and Cretaceous of Europe. Unlike egg capsules from the Jurassic, which have been repeatedly reported, those from the Cretaceous are known only from two occurrences. Although such structures have been known for a long time (e.g., see Lundgren, 1878 for the examples from the Lower Jurassic of Sweden), they have not been paid sufficient attention until the work of Kaiser and Voigt (1977) who described small, circular fossils preserved on a bivalve shell from the Lower Jurassic (Pliensbachian) of Germany, interpreting them as remnants of gastropod egg capsules. Later, Kaiser and Voigt (1983) found more of these structures, differing from each other in morphology, preserved on the ammonite moulds from the Pliensbachian of Germany. They compared them to the egg capsules produced by extant neritimorph and columbellid (Neogastropoda) gastropods. Pyritized hemispherical structures preserved on fossil wood and similar to gastropod egg capsules were also reported from the Pliensbachian of Germany by Riegraf and Schubert (1991) and Schubert et al. (2008). Zatoń et al. (2009) described tiny, circular structures preserved in the form of carbonaceous impressions on cardiniid bivalves from the Hettangian deltaic deposits of Poland. Later, Zatoń et al. (2013) reported on the first gastropod (neritimorph) egg capsules preserved by bioimmuration. The latter find, detected on the mould of a large volutid gastropod from the Maastrichtian of the Netherlands, was also the first report of such structures from the Cretaceous. Recently, Zatoń and Mironenko (2015a), for the first time described egg capsules of caenogastropod affinity preserved by phosphatization from the latest Jurassic (Volgian) of Russia. These three-dimensionally preserved capsules are definitely the best preserved fossils of this kind, enabling the observation of both their exterior and interior parts. Zatoń and Mironenko (2015b) also reported neritimorph-like egg capsule remnants preserved on a Lower Cretaceous (early Aptian) ammonite mould from Daghestan in Russia. Possible gastropod egg capsules preserved as carbonaceous compressions on non-marine bivalve moulds

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http://dx.doi.org/10.1016/j.palaeo.2016.11.048
0031-0182/

are also known from the Miocene of Czech Republic (Mikuláš and Dvořák, 2001).

Here we report on an occurrence of structures most probably representing gastropod egg capsules from the Lower Cretaceous of Russia. However, unlike all such fossils mentioned above, these were preserved by calcitization.

2. Material and methods

2.1. Material and its provenance

The fossils interpreted as egg capsules were found in body chambers of five, out of a total of 225, Lower Aptian ammonites belonging to the species *Deshayesites volgensis* Sasonova (two specimens) and *Sinzovia sazonovae* Wright (three specimens). The ammonite specimens were found within carbonate concretions in the Lower Aptian shales outcropping at the Volga river bank, not far from the town of Khvalynsk, Saratov region, south-western Russia (Fig. 1A–B, see also Gavrilov et al., 2002). The carbonate concretions (20–50 cm in length) occur in black, bioturbated, bituminous shales of the *Deshayesites volgensis–Volgoceratoides schilkovkensis* ammonite Zone, 2.5–3 m above the noticeable horizon of the 'Aptian plate' (Fig. 1C, see also Gavrilov et al., 2002). The concretions contain only three ammonoid species: *Sinzovia sazonovae* Wright, *Deshayesites volgensis* Sasonova and small heteromorphic *Volgoceratoides schilovkensis* Mikhailova & Baraboshkin together with fish bones and scales, rare and small bivalve (pectinids, arcticids and inoceramids) and gastropod (actenoids, turbinids, cerithioids) shells, as well as ammonite aptychi.

The Lower Aptian shale layers crop out along the Volga river from Ulyanovsk almost to Saratov (Baraboshkin et al., 2003: Fig. 4), and occupy a large area from the Oka–Tsna swell in the North toward the northern Caspian Lowland (Gavrilov et al., 2002). The black shales formed mainly within the *Deshayesites volgensis* = *Deshayesites forbesi* ammonite Zone, and thus simultaneously with one of the episodes of the global OAE-1 event known as OASE-1a subevent (Gavrilov et al., 2002). The thickness of the shales varies greatly in different localities. The black shales, the thickness of which varies greatly in particular localities, consist of non-uniform layers differing in mineralogical, as well as paleontological characteristics (Gavrilov et al., 2002). It is clear that in that part of the basin, the anoxic conditions prevailed during the formation of the deposits below the 'Aptian plate', as bioturbation traces and benthic fauna are lacking (Gavrilov et al., 2002). Later on, during the sedimentation of the concretions-bearing deposits, the anoxia was infrequent as evidenced by the presence of bioturbations and periodically occurring benthic fauna.

2.2. Methods

The egg capsules were investigated using a binocular microscope and TESCAN VEGA SEM with a BSE detector at the Paleontological Institute of the Russian Academy of Sciences in Moscow, and the environmental scanning electron microscope (ESEM) Philips XL30 at the Faculty of Earth Sciences of the University of Silesia in Sosnowiec, Poland. In both cases, the specimens were inspected in uncoated state in low-vacuum conditions. Images were generated using secondary (SE) and back-scattered electrons (BSE).

In order to determine the exact composition of the egg capsules, three capsules were isolated from the ammonite *Deshayesites volgensis* (GIUS 9-3670/2) and analysed using WITec alpha 300R Confocal Raman Microscope equipped with an air-cooled solid laser (488 nm) and a CCD camera operating at −61 °C. The laser radiation was coupled to a microscope through a single-mode optical fibre with a diameter of 3.5 μm. An air Zeiss LD EC Epiplan-Neofluan DIC (100/0.75NA) objective was used. Raman scattered light was focused a broad band single mode fibre with effective Pinhole size about 30 μm and monochromator with a 600 mm^{-1} grating. The power of the laser at the sample position was 42 mW. Integration times of 3s with accumulation of 10 scans and a

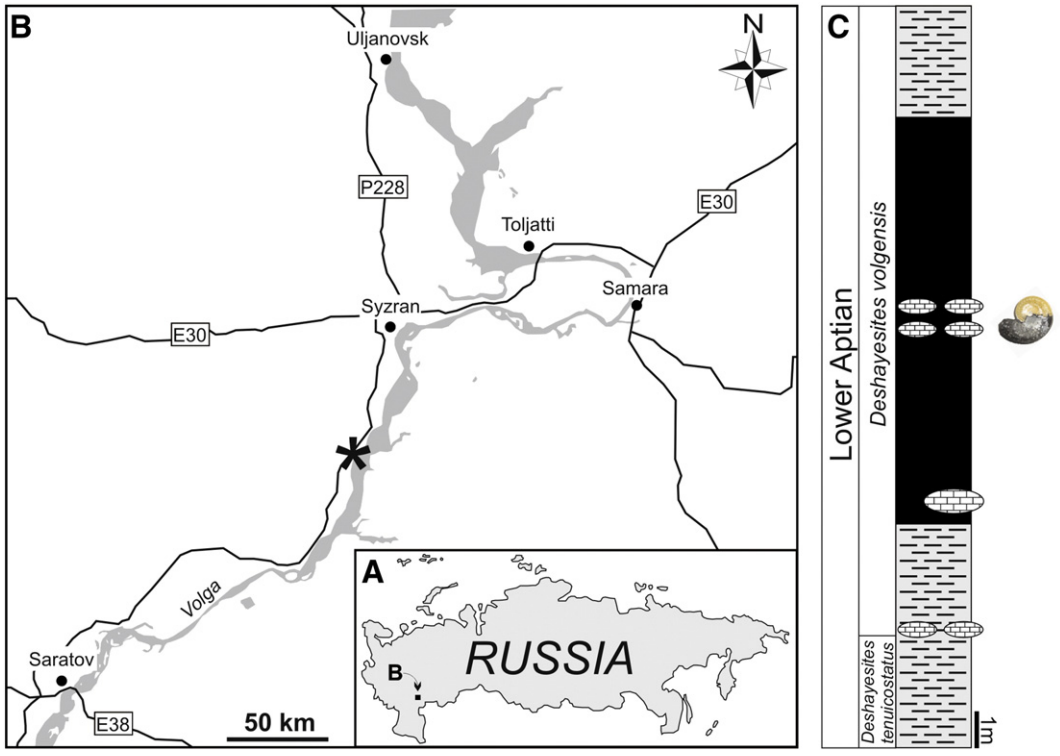

Fig. 1. Locality and lithostratigraphy. A–B. Sketch-maps showing the sampled locality (indicated by an asterisk) at the Volga River bank near the town of Khvalynsk in the Saratov region, south-western Russia. C. Schematic lithostratigraphical section of the ammonite-bearing Lower Aptian deposits. The egg-capsule-bearing ammonites come from the carbonate concretions (marked) occurring within the black shales (black) which are underlain and overlain by clays (grey) (simplified after Gavrilov et al., 2002).