Palaeogeography, Palaeoclimatology, Palaeoecology 457 (2016) 186–194

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Evidence for semi-sessile early juvenile life history in Cretaceous ammonites

Wolfgang Stinnesbeck [a,*], Eberhard Frey [b], Patrick Zell [a]

[a] Institut für Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany
[b] Staatliches Museum für Naturkunde, Erbprinzenhof 13, 76133 Karlsruhe, Germany

ARTICLE INFO

Article history:
Received 7 February 2016
Received in revised form 9 June 2016
Accepted 10 June 2016
Available online 11 June 2016

ABSTRACT

Here we present evidence for a semi-sessile early juvenile stage of ammonites. Our hypothesis is based on fossil evidence in early diagenetic limestone concretions discovered in platy limestone deposits of Cenomanian age in the northern state of Coahuila, Mexico. In these locations densely packed post-embryonic shell assemblages were attached to fossilized algal or bacterial mats and preserved in sediments deposited under permanently anoxic bottom conditions. Tiny ammonites, as well as gastropods and byssate pectinid bivalves are abundant and restricted to these mats. They do not occur elsewhere in the sediment. The ammonite hatchlings were apparently unable to escape from mats sinking to the hostile sea floor and must thus have been semi-sessile, similar to the associated gastropods and bivalves.

1. Introduction

Ammonites are among the most abundant fossils in Jurassic and Cretaceous marine sediments. While their morphological diversity is well studied and of outstanding importance to date rock strata (biochronology), the life cycles, ecology and ontogeny of these extinct cephalopods are subject to a wide range of speculation (e.g. Kennedy and Cobban, 1976; Shigeta, 1993; Tanabe et al., 1993; Lewy, 1996, 2002; Westermann, 1996; Saul and Stadum, 2005; Mapes and Nützel, 2009; Lukeneder et al., 2010; Kruta et al., 2011; Tanabe, 2011; Stephen et al., 2012; Arkhipikan, 2014; Zell et al., 2014; De Baets et al., 2015; Lukeneder, 2015; Zell and Stinnesbeck, 2016). For instance, recent authors majorly consider ammonites to have hatched directly without a post-hatching larval stage, and they suggest that hatchlings were initially planktonic or passively transportable (e.g. Kulicki, 1974; Tanabe and Ohtsuka, 1985; Landman, 1985; Shigeta, 1993; Westermann and Tsujita, 1999; Rouget and Neige, 2001; Saul and Stadum, 2005; Mapes and Nützel, 2009; Tajika and Wani, 2011; De Baets et al., 2015), based on the small size of protoconchs and wide dispersal of species. Reproductive strategies are largely speculative but a variety of possibilities are discussed, as in extant cephalopods. They include egg deposition on the seafloor, attachment to seaweed, floating egg masses, or even brood care up to hatching. These alternative scenarios are extensively discussed by De Baets et al. (2015) and Lukeneder (2015).

An important change in the mode of life from planktic into either nektobenthic of nektoplanktic was postulated for early juvenile (neanic) ammonites after reaching a diameter of 2–2.5 mm (Shigeta, 1993). This change in habitat is also indicated by internal shell morphology changes, i.e. the highly variable septal distances observed during this stage of growth (cf. Arai and Wani, 2012; De Baets et al., 2015; Zell and Stinnesbeck, 2016).

Dense concentrations of early juvenile (neanic) ammonoids have variously been reported from the fossil record and may provide important evidence for egg-laying behavior and the post-hatching mode of life of these extinct mollusks (e.g. Tanabe et al., 1993; Mapes and Nützel, 2009; Stephen et al., 2012; also see De Baets et al., 2015, and Lukeneder, 2015, for discussion).

Here we report on a mass occurrence of early juvenile ammonoids in platy limestone of early Late Cretaceous age (Cenomanian) in northern Coahuila, Mexico (Fig. 1). The paleoecological circumstances of the accumulation layers provide fossil evidence for a semi-sessile early ontogenetic stage of ammonites. The host sediment is a thin bedded and finely laminated platy limestone deposited under hemipelagic conditions (Stinnesbeck et al., 2005; Ifrim et al., 2008, 2014; Giersch et al., 2011). It contains vertebrate fossils with an excellent state of preservation, for instance of fins and soft tissues, characterizing these localities as conservation Lagerstätten in the sense of Seilacher et al. (1985). Vertebrate fossils in these localities are often phosphatised, often with a

* Corresponding author.

http://dx.doi.org/10.1016/j.palaeo.2016.06.019
0031-0182/

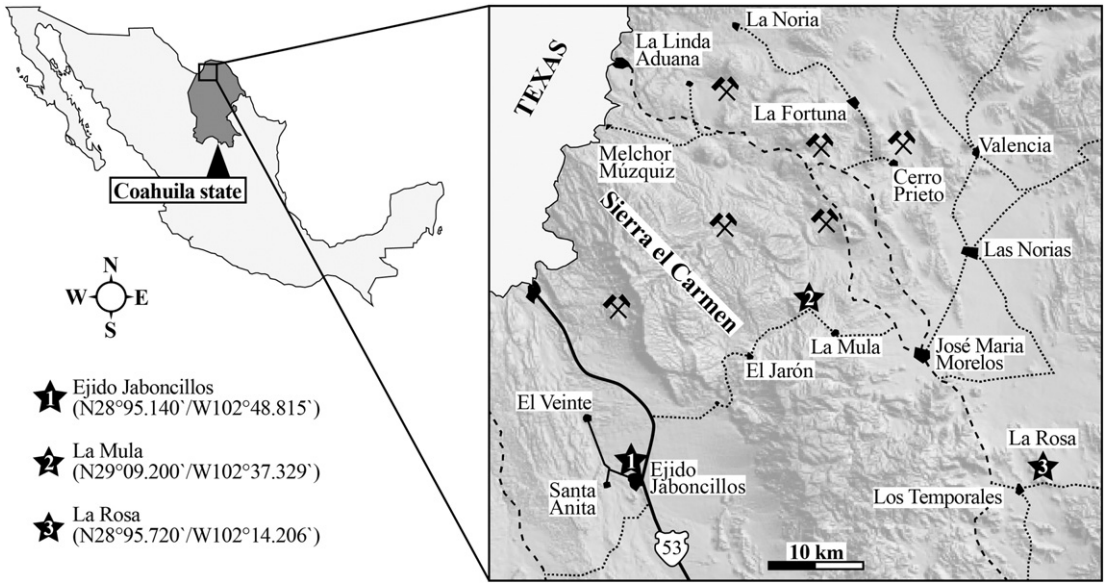

Fig. 1. Map of Mexico with inset of northeastern Mexico. Upper Cretaceous platy limestones are widely exposed north of Múzquiz in northern Coahuila, Mexico, along both the eastern and western slopes of the Sierra del Carmen. Dense concentrations of juvenile ammonoids described here were sampled at three localities (see asterisks); Topographic map from INEGI (2015).

three-dimensional preservation of soft-parts and bones (Stinnesbeck et al., 2005; Riquelme et al., 2013).

1.1. Platy limestone deposits north of Múzquiz

Upper Cretaceous platy limestones are widely exposed north of Múzquiz in northern Coahuila, Mexico, along both the eastern and western slopes of the Sierra del Carmen; they are locally quarried for flag stones, wall and floor tiles (Fig. 1, Fig. 2). From this area, only the upper Turonian–lower Coniacian El Rosario quarry section and its faunal assemblage have been documented to some detail (e.g. Stinnesbeck et al., 2005; Frey et al., 2006; Ifrim et al., 2014), but there are numerous other sections in the region that contain hemipelagic platy limestone as intermittent units in an open marine limestone-marl succession reaching from the Cenomanian to lower Campanian. The association of early juvenile ammonites documented here was identified in platy limestone of the Del Rio Formation of Cenomanian age (González Sánchez et al., 2007) at La Rosa, Ejido Jaboncillos and La Mula (Fig. 1). Fossils from these outcrops have only been described briefly, e.g. by Blanco-Piñón and Alvarado-Ortega (2005); Alvarado-Ortega et al. (2006); Giersch et al. (2011) and Riquelme et al. (2013).

2. Results

2.1. Limestone concretions and their faunal assemblage

The Cenomanian platy limestone unit at La Rosa, Jaboncillos and La Mula reaches an exposed thickness of about 5to 10 m and is formed by thin bedded pink to orange-colored marly limestone with intense lamination. It contains well preserved fishes, but also ammonites and inoceramid bivalves. The microfaunal assemblage is dominated by planktonic foraminifers (e.g. hedbergellids) and calcispheres, whereas benthic foraminifers are absent. Stratified limestone concretions within the unit reach diameters of between 100 and 300 mm. They contain the early juvenile ammonite assemblage that forms the base for this report, as well as abundant tiny, thin-shelled bivalves and gastropods (Fig. 3). The concretions are laminated and must have formed during early diagenesis prior to sediment compression, as is evidenced by three-dimensionally preserved fossils inside these concretions. Outside the concretions, the limestone is considerably more compressed and fossils are generally flattened and often preserved as external molds. Invertebrate fossils smaller than a few tens of millimeters are not preserved, likely because of diagenetic dissolution.

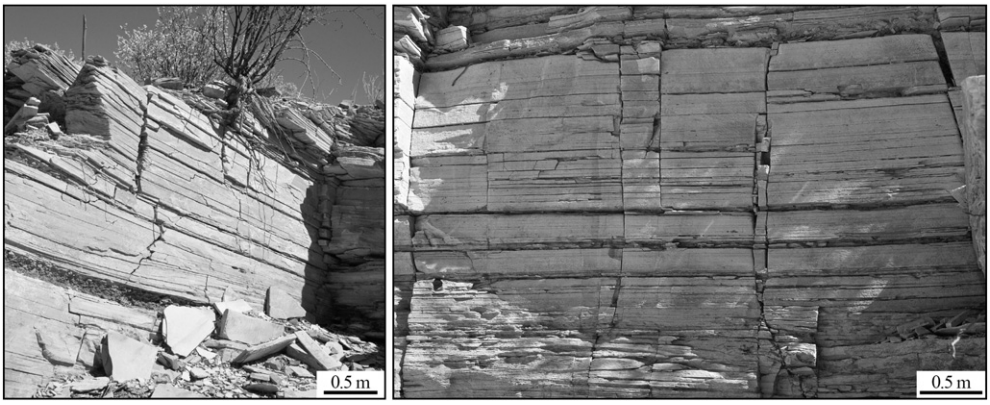

Fig. 2. Outcrop photographs of the platy limestone unit at La Rosa, northern Coahuila state. Dense concentrations of juvenile ammonoids occur in calcareous concretions within platy limestone tentatively assigned to the Del Rio Formation.