Palaeogeography, Palaeoclimatology, Palaeoecology 438 (2015) 364–378

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Sand spherules interpreted as crustacean feeding pellets from an Eocene shore environment (Western Carpathians — Slovakia)

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ARTICLE INFO

Article history:
Received 20 March 2015
Received in revised form 19 August 2015
Accepted 21 August 2015
Available online 29 August 2015

Keywords:
Fossil feeding spherules
Trace fossils
Intertidal palaeoenvironment
Eocene
Western Carpathians
Slovakia

ABSTRACT

Sand spherules from Eocene shallow-marine deposits are identified as crab (Brachyura) feeding pellets. Several points support this interpretation: (i) microscopic study of these structures shows the absence of fine-grained matrix; (ii) spatial distribution within shallow water deposits (foreshore to upper shoreface) is interpreted on the basis of well sorted, fine-grained sandstones and sedimentary structures, such as a low-angle wedge-shaped tabular type cross-bedded units, ripples, sand bars, and intercalated storm layers of coarser material, with trace fossils identified as belonging to the archetypal *Skolithos* to *Cruziana* ichnofacies and (iii) the sand spherules have a bimodal size distribution and all these structures have a regular spherical shape. Another argument that implies biogenic origin of spherules and supports the interpretation of them as fossil feeding pellets of crabs is their association with other crustacean trace fossils (*Ophiomorpha*) and the occurrence of identical structures interpreted as fossil feeding pellets associated with a comparable trace fossil assemblage from Miocene shallow water deposits in southwest Japan. The recognition of crustacean sandstone spherules in the sedimentary record is a good indicator of the shoreline palaeoenvironment.

1. Introduction

In this study, the origin, size, composition and morphology of spherical sandstone structures from upper Eocene deposits in the northern part of the Zvolenská Kotlina Depression of the Central Carpathian Paleogene Basin (Fig. 1) are analysed. Our data in a comparison with possible modern analogues of the spherules have been used for definition of the most probable interpretation of sandstone spherules.

The genesis of these structures as pellets produced by crustaceans is supported by analysis of associated trace fossils, sedimentology, palaeoenvironmental interpretation, structure of sandstone spherules and statistical analysis of spherule size. Only one previous record of fossil crustacean sand spherules (interpreted as feeding pellets) has been documented, from the Middle Miocene sandstone and laminated siltstone of Iriomote Island in southwest Japan (Noda, 1990).

Comparable modern sand spherules are described for instance as feeding pellets (e.g., Muñiz et al., 2010), excavation pellets (e.g., Gibert et al., 2013) or discard pellets (Unno and Semeniuk, 2008) and the producer and mechanism of formation of these structures are relatively well known from recent environments (e.g., Unno and Semeniuk, 2008; Muñiz et al., 2010). Feeding pellets are generally produced mainly by fiddler crabs and ghost crabs (Brachyura, Ocypodidae) (Muñiz et al., 2010), sand bubbler crabs (Brachyura, Dotillidae) (Chakrabarti et al., 2006; Wong et al., 2011) and soldier crabs (Brachyura, Myctiridae) (Davie et al., 2010) in the upper foreshore and backshore of tropical and subtropical regions. Dotillidae and Myctiridae are modern groups of crabs without any fossil record (Schweitzer et al., 2010). The oldest fossil record of Ocypodidae is dated as lower Miocene (Brito, 1972). The environments near the river mouth characteristically have a continuous supply of organic-rich sediment so they are largely colonized by animals foraging upon this material. Modern intertidal environments of tropical to subtropical regions near river mouths are often inhabited by crabs forming feeding pellets (Muñiz et al., 2010). Such structures, together with other traces, are described as an important indicator of the biogenic activity of crabs (Chakrabarti et al., 2006).

2. Geological and stratigraphical setting

The Central Carpathian Paleogene Basin lies within the Western Carpathians mountain chain (Fig. 1A) and it developed in the basinal system of the Peri- and Paratethys. The basin accommodated a forearc position on the destructive Alpine–Carpathian–Panonnian microplate margin and at the hinterland of the Outer Western Carpathian accretionary prism (Soták et al., 2001 and references therein). The basin is mainly filled with flysch-like deposits with a thickness of up to a thousand metres and they overlap the Palaeoalpine, pre-Senonian nappe structure. The deposits are preserved in many structural subbasins and the age of the sedimentary fill ranges from Bartonian (e.g., Samuel and Fusán, 1992; Gross et al., 1993) to latest Oligocene (e.g., Olszewska and Wieczorek, 1998; Soták, 1998, 2010; Soták et al., 2001, 2007).

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http://dx.doi.org/10.1016/j.palaeo.2015.08.023
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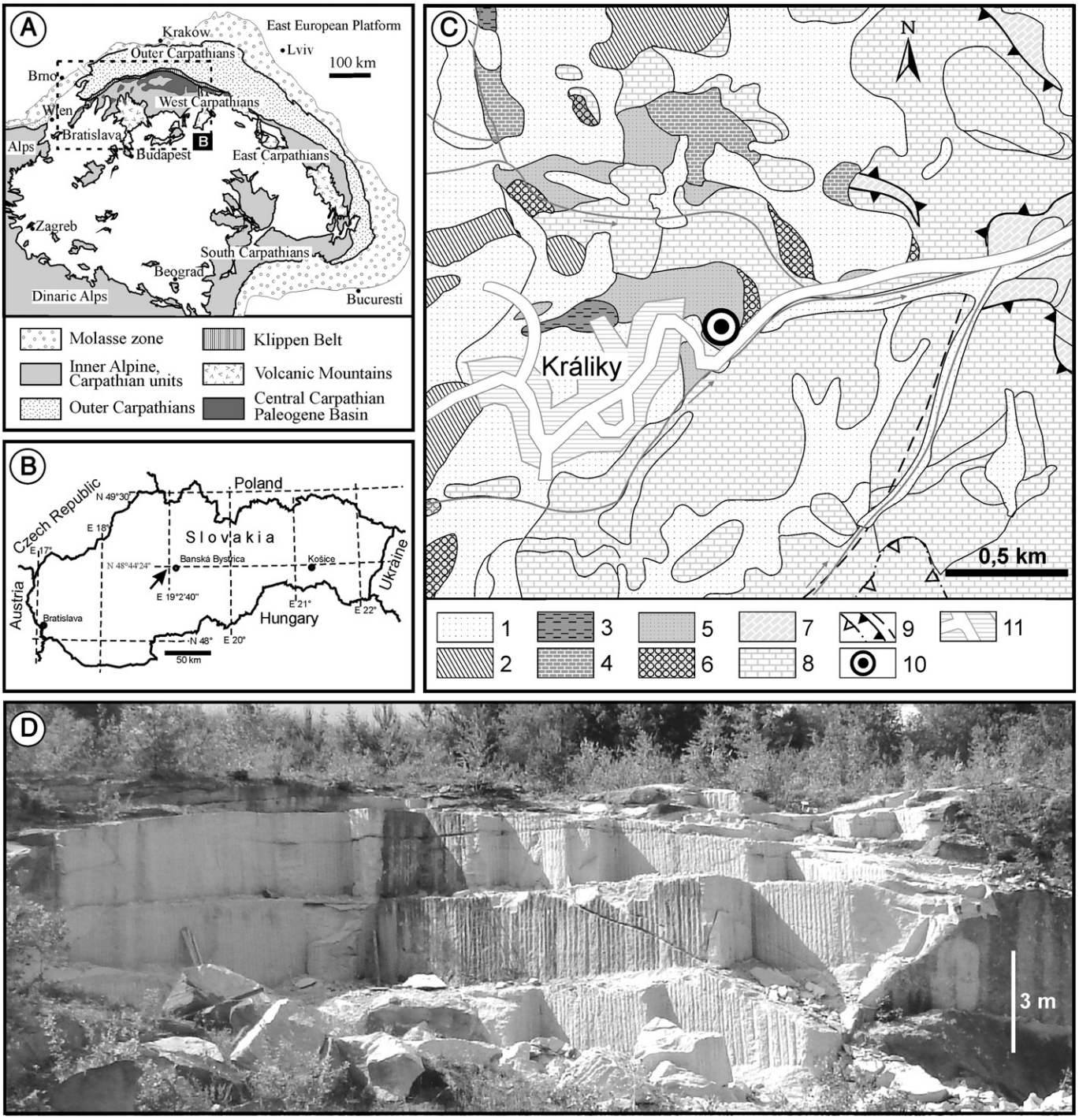

Fig. 1. A location of study area. A — a location of study area within the Alpine–Carpathian orogen; B — sketch map with GPS location of evaluated section; C — geological sketch of the wider surroundings of the locality. Key: 1 — Quaternary deposits (undivided); 2 — subaqueous lava flows and extrusions of pyroxenic andesites (Early–Late Badenian); 3 — claystones with layers of siltstones and sandstones (Kiscelian); 4 — organodetrital sandy limestones, sandstones, conglomerates (Bartonian–Early Priabonian); 5 — fine-grained calcareous sandstones (early Priabonian); 6 — dolomite conglomerates, breccias and sandstones (Middle Eocene–Early Priabonian); 7 — Mesozoic of the Central Western Carpathians–Veporicum Unit (undivided); 8 — Mesozoic of the Central Western Carpathians–Hronicum Unit (undivided); 9 — overthrust lines, faults; 10 — location of evaluated section; 11 — built-up area of village. D — sandstone deposits of the Králiky quarry.

The locality with occurrence of the sandstone spherules is situated in a sandstone quarry (Fig. 1D) near the village of Králiky 2 km west of the town of Banská Bystrica (Fig. 1B). The vicinity of the quarry includes middle to upper Eocene rocks consisting of dolomite conglomerates, breccias and sandstones, fine calcareous sandstones, organodetritic sandy limestones and carbonate conglomerates (Polák et al., 2003; Fig. 1C). These lithofacies are associated commonly with the Borové Formation (Gross et al., 1984). They are represented by basal terrestrial deposits of alluvial fan and fluvial systems (e.g., Marshalko, 1970; Baráth and Kováč, 1995; Filo and Siráňová, 1998) and by shallow-marine transgressive deposits (e.g., Kulka, 1985; Gross et al., 1993; Filo and Siráňová, 1996; Bartholdy et al., 1999). The Borové Formation