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Original article

Distinction between fill channels and abrasion furrows on ammonoid internal moulds

Distinction entre canaux de remplissage et sillons d'abrasion dans les moules internes d'ammonoïdes

Distinción entre canales de relleno y surcos de abrasión en los moldes internos de ammonites

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Abstract

Ammonoid sedimentary internal moulds can display grooves on the external or ventral region that have been formed by diverse taphonomic processes. In particular, draft-filling spiral channels and abrasion annular furrows are taphonomic structures useful as palaeoenvironmental indicators of turbulent waters and conditions of low rate of sedimentation, although they can show some common morphological properties that may lead to erroneous identifications. However, the morphological features, formation processes and palaeogeographic conditions in which the structures of these two types have been developed are very different. In consequence, it is important to keep in mind the distinctive characters of these taphonomic structures before using their occurrence in the palaeoenvironmental or palaeogeographic interpretations.

Résumé

Les moules internes formés par remplissage sédimentaire des coquilles d'ammonoïdes peuvent présenter des canaux et des sillons dans la région externe ou ventrale, qui ont été générés par divers processus taphonomiques. En particulier, les canaux spiraux de remplissage sédimentaire et les sillons annulaires d'abrasion sont des structures taphonomiques utiles comme indicateurs paléoenvironnementaux de régimes turbulents et de conditions de baisse de taux de sédimentation, bien qu'ils puissent présenter quelques propriétés morphologiques communes pouvant conduire à des identifications erronées. Néanmoins, tant les traits morphologiques que les processus de formation et les conditions paléogéographiques dans lesquelles se sont développées les structures de ces deux types sont très différentes. En conséquence, il est important de prendre en considération les caractères distinctifs de ces structures taphonomiques avant d'utiliser leur présence dans les interprétations paléoenvironnementales ou paléogéographiques.

Resumen

Los moldes internos de ammonites formados por relleno sedimentario de las conchas pueden presentar surcos y canales en la región externa o ventral que han sido generados por distintos procesos tafonómicos. En particular, los canales espirales de relleno sedimentario y los surcos anulares de abrasión son estructuras tafonómicas útiles como indicadores paleoambientales de regímenes turbulentos y condiciones de baja tasa de sedimentación, aunque pueden presentar algunas propiedades morfológicas comunes que pueden llevar a identificaciones erróneas. Sin embargo, tanto los rasgos morfológicos, como los procesos de formación y las condiciones paleogeográficas en las que se han desarrollado las estructuras de

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estos dos tipos, son muy diferentes. En consecuencia, es importante tener en cuenta los caracteres distintivos de estas estructuras tafonómicas antes de utilizar su presencia en las interpretaciones paleoambientales o paleogeográficas.

Keywords: Ammonoidea; Jurassic; Taphonomy; Fossilization; Sedimentary palaeoenvironments; Palaeogeographic analysis

Mots clés : Ammonoidea ; Jurassique ; Taphonomie ; Fossilisation ; Paléoenvironnements sédimentaires ; Analyse paléogéographique

Palabras clave: Ammonoidea; Jurásico; Tafonomía; Fosilización; Paleoambientes sedimentarios; Análisis paleogeográfico

1. Introduction

Fill channels and abrasion furrows occur on ammonoid internal moulds of complete shells as well as of incomplete phragmocones, and they show a number of properties in common. The features of some fill channels developed on the external region of ammonoid sedimentary internal moulds have been investigated by Seilacher (1968, 1971, 1973); Mundlos (1970); Duringer (1982); Hagdorn and Mundlos (1983) and Fernández-López (1997a). Similarly, the characteristics of some abrasion furrows have been studied by Fernández-López (1985, 1995) and Fernández-López and Meléndez (1994, 1995).

The purpose of this paper is to provide diverse criteria for a correct distinction between draft-filling spiral channels and abrasion annular furrows, taking into account their relevance for palaeoenvironmental and palaeogeographic interpretations of fossiliferous deposits in Mesozoic carbonate epicontinental platforms.

2. Fill channels

According to data from the fossil record, soft parts, periostraca and siphuncular tubes of ammonoids showed increasing values of durability during biodegradation-decay processes (Seilacher et al., 1976, 1985; Hagdorn and Mundlos, 1983; Maeda and Seilacher, 1996; Fernández-López, 1997a, 1999, 2000a, 2000b). All these organic components of ammonoid remains could be biodegraded and destroyed in well-oxygenated marine waters, before the burial of the shells. In contrast, ammonoid shells maintaining soft parts in the body chamber and periostraca during early diagenesis should be more common in poorly oxygenated environments, associated with more protected, restricted or deeper environmental conditions, as well as in environments of high rate of sedimentation and high rate of sediment accumulation.

Empty chambers of ammonoid shells could be filled with sedimentary particles before and after the burial. As a general rule, the sedimentary infill was introduced in the chambers by draft currents produced by outside turbulence (cf. Seilacher, 1963, 1966, 1971, 1973; Schindewolf, 1967; Mundlos, 1970; Seilacher et al., 1976; Duringer, 1982; Hagdorn and Mundlos, 1983; Maeda and Seilacher, 1996; Fernández-López, 1997a, 2000b). The generation of draft hydraulic currents inside the shells would require that the chambers were communicated with the exterior by some orifice and the existence of a turbulent regime in the proximity of the shell. According to Bernouilli's principle, if the outside turbulence could act on the orifice, a vacuum able to suck water with sedimentary particles in suspension into the shell could be produced in the phragmocone chambers. The stronger the turbulence, the greater the suction, and so the sedimentary particles would be transported farther up the phragmocone. On the contrary, unbroken chambers keeping the siphuncular tubes or soft-parts still articulated would in turn continue being empty of sedimentary fill.

However, the sediment transported by draft currents towards the interior of the shell chambers is a load deposit, carrying particles in suspension; therefore, other extrinsic factors such as the size of the available sedimentary particles, the rate of sedimentation (calculated by dividing the thickness of sediment by the total time interval including the gaps) and the rate of sediment accumulation (estimated by dividing the thickness of sediment by the time interval of positive net sedimentation) may also affect these filling processes of shells. In particular, the probability of shells to be filled with sediment will be inversely proportional to the rate of sedimentation and to the rate of sediment accumulation. Hollow ammonites (i.e., shells showing no sedimentary infill in the phragmocone) are dominant in expanded sections, formed in conditions of high rate of sedimentation and high rate of sediment accumulation, although they are usually compressed by gravitational diagenetic compaction (Fernández-López, 1997a, 1997b, 2000a, 2000b; Reboulet et al., 2003). Expanded deposits formed by turbulence events under conditions of high rate of sediment accumulation, such as tempestites or turbidites, even in environments of low rate of sedimentation and associated with condensed sections, often contain hollow ammonites too. In contrast, ammonoids displaying phragmocones with complete and homogeneous sedimentary infill are common in condensed sections formed by condensed deposits, resulting from low values of both rate of sedimentation and low rate of sediment accumulation, in distal and deep marine environments (Fernández-López, 1997a, 1997b; Fernández-López et al., 1999, 2000, 2002; Fernández-López and Meléndez, 2004a, 2004b). Conversely, empty phragmocones showing no sedimentary infill (i.e., hollow ammonites) or phragmocones with heterogeneous sedimentary infill are common in condensed sections, of low rate of sedimentation, formed by expanded deposits of high rate of sediment accumulation in proximal and shallow marine environments (Fernández-López and Gómez, 1990; Gómez and Fernández-López, 1994; Fernández-López, 1997a, 1997b, 2000a, 2000b).

One of the clearest indications of the performance of intracameral draft streams on ammonoid shells, from the body chamber towards the apical chambers and through the septal foramens, is the occurrence of a sinuous-shaped groove in, or a