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Foraminiferal evidence for paleogeographic and paleoenvironmental changes across the Coniacian–Santonian boundary in western Ukraine

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ABSTRACT

Planktonic and benthic foraminiferal assemblages, oxygen stable isotopes, calcium carbonate content and total sulfur and magnetic susceptibility have been studied from the middle Coniacian to middle Santonian interval of the Dubivtsi succession (western Ukraine). At the Coniacian–Santonian boundary significant changes took place in foraminiferal assemblages. Keeled, deep-water forms, which are a common to dominant group in planktonic foraminiferal assemblages in the late Coniacian decline in abundance in the Santonian, where the assemblages are dominated by heterohelicids and *Hedbergella*. Late Coniacian benthic foraminiferal assemblages dominated by large, calcareous epifaunal (oxic) forms in the early Santonian became dominated by small, thin-walled, infaunal (dysoxic) species with significant increase of agglutinated foraminifers within assemblages. Changes in foraminiferal assemblages correspond with lithological changes from upper Coniacian limestones to lower Santonian marls. An increase in total sulfur in the lower Santonian and increase in magnetic successibility values up the succession are recorded. Changes in foraminiferal assemblages along with decreasing calcium carbonate content and increasing magnetic susceptibility indicate that during the early and middle Santonian the Tethyan connection with the studied part of the south-central European epicontinental sea was partially limited by an area uplifted as a consequence of Subhercynian tectonic movements; thus it constituted a partially restricted basin with sedimentation in an oxygen depleted environment.

1. Introduction

During the Late Cretaceous the evolution of European sedimentary basins was influenced by the interplay of two main global processes: plate tectonics and eustatic sea-level changes (Voigt et al., 2008). The Late Cretaceous global plate tectonic reconfiguration caused modification of the tectonic stress field in Europe. Several alterations in the tectonic style, related to the onset of rift basin formation at the eastern margin of the Atlantic Ocean and convergence of the Alpine orogenic belt at the northern margin of the Tethys, have been responsible for a very complex basin history in Europe (Ziegler, 1990; Baldschuhn et al., 1991; Voigt et al., 2008). A counter-clockwise rotation of Africa was put in motion as a result of the opening of the South Atlantic, as well as the coeval closure of the Tethyan Ocean. These motions placed Europe in a transtensional stress field (Świdrowska et al., 2008). A major reconfiguration of sedimentary basins was then produced as a result of the onset of subduction at the northern Tethys margin and the opening of the Bay of Biscay (Scheck-Wenderoth et al., 2008).

The increased sea level in the Late Cretaceous, resulting from the high global rates of seafloor spreading, caused large areas of northwestern, Central and Eastern Europe to be covered by epicontinental shelf seas (Larson, 1991; Hardenbol et al., 1998). Commencing with the middle Cenomanian–early Turonian and ending in the late Maastrichtian various types of pelagic chalk, a new and unique type of lithofacies, was deposited over a large part of the European epicontinental sea. More siliciclastic lithofacies were deposited mainly along the southern margin of the Central European Basin System (Ziegler, 1990; Schwerd, 1996).

The benthic and planktonic foraminiferal assemblages of this sea were almost uniform in the whole epicontinental basin across northwestern and Eastern Europe (Koch, 1977; Hart et al., 1989; Bailey et al., 2009). Benthic foraminiferal assemblages in the greater part of the epicontinental Cretaceous are characterized by relatively high diversity with a high proportion of calcareous epifaunal morphotypes, accompanied by a smaller number of (though still relatively diverse) calcareous infaunal morphotypes as well as agglutinated forms (Peryt, 1988; Hart et al., 1989; Cetean et al., 2011). These assemblages are typical for a shelf sea with a high calcium carbonate precipitation potential and mesotrophic bottom water conditions, which did not change much during the Late Cretaceous. Since the Early Turonian a continual evolution and diversification of benthic foraminifera is observed which was not disturbed by any significant biological crisis until the end of the Maastrichtian. Nevertheless there are some exceptions that reflect

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significant paleoenvironmental changes: e.g., a sharp faunal turnover connected with the Cenomanian–Turonian boundary event (e.g. Peryt et al., 1994; Paul et al., 1999), high taxonomic impoverishment in the middle part of the upper Turonian (Dubicka and Peryt, 2012a), significant changes in planktonic and benthic foraminiferal assemblages during the mid-Maastrichtian event (Robaszynski et al., 1985; Dubicka and Peryt, 2012a, 2012b) or gradual extinction of benthic foraminifera at the Cretaceous/Paleogene boundary (e.g.Peryt et al., 2002). Quantitative changes in planktonic foraminiferal assemblages in the relatively shallow European epicontinental Upper Cretaceous sediments are more noticeable because they were strongly affected by eustatic changes.

Changes in foraminiferal assemblages recorded at the Coniacian–Santonian boundary are significant and comprise quantities and qualitative changes in planktonic and benthic foraminiferal assemblages at the same time. Thus they are exceptional and unique in comparison to other, more stable foraminiferal assemblages of the epicontinental European Upper Cretaceous. In addition they coincide with distinct changes in lithology, so they must reflect significant paleoenvironmental changes.

The Coniacian–Santonian time interval is the inferred time of oceanic anoxic event 3 (OAE3) (Wagreich, 2012). This event is known as a prolonged interval of large scale deposition of black shale mainly in the Atlantic domain and is the longest and last such event during the Cretaceous period (e.g. Wagner and Pletsch, 1999; Pletsch et al., 2001; Meyers et al., 2006; März et al., 2009; Friedrich, 2010; Jenkyns, 2010). OAE 3 is also one of the least documented of all of the Cretaceous OAEs and mechanism of its initiation is still poorly understood. Wagreich (2012) emphasized that OAE3 does not have a global occurrence but is regionally restricted to the low- to mid-latitudinal part of the Atlantic as well as adjacent basins, shelves and epicontinental seas. It is largely absent in the Tethys, the North and southern South Atlantic, and Pacific Oceans (Wagreich, 2012). Furthermore, Wagreich emphasized that it differs highly from other Cretaceous anoxic events because it is not represented by a single, short-lived black shale event; is not clearly defined; is neither global nor contemporaneous and is characterized, if at all, by only small positive carbon isotope excursions. Thus it is subject to a high degree of discussion (Wagreich, 2012) whether OAE3 should be regarded as a global oceanic event, or perhaps as a regional or Atlantic anoxic event.

Therefore, the aim of our study is to produce a detailed analysis of the nature of the foraminiferal assemblages, integrated with geochemical proxies (oxygen isotopes, calcium carbonate content, total sulfur) and geomagnetic (magnetic susceptibility) properties to reconstruct the paleoenvironment in the studied basin. Another goal of our analysis was to determine the causes of noticed paleoenvironmental changes and to what degree they are related to oceanic anoxic event 3. We also discuss the paleogeography of the region.

2. Geological setting and stratigraphy

In western Ukraine, Upper Cretaceous strata from the Cenomanian through basal Campanian are well-exposed in the area around Halych about 120 km southeast of Lviv (Kokoszyńska, 1931; Pasternak, 1959; Ivannikov et al., 1987; Pasternak et al., 1987; Gavrilishin et al., 1991; Vashchenko et al., 2007; Walaszczyk et al., in press). The studied Upper Cretaceous Dubivtsi succession is located a few km southeast from Halych, in the village of Dubivtsi (Fig. 1). The succession is exposed in two large quarries: a lower quarry named Dubivtsi 1 and an upper quarry named Dubivtsi 2 (Walaszczyk et al., in press) which are located a few kilometers apart from each other. The studied sediments are exposed in the Dubivtsi 2 quarry in the two lowest exploitation levels (1 and 2) and in one incomplete level which for the purpose of this paper is designated as level −1. Level −1 exposes inoceramid limestones and pelitic limestones also occurring at level 1. In the middle part of level 1, limestones pass into gray marls which continue almost up to the top of the studied part of the Dubivtsi succession (until the top of level 2) (Fig. 2). A detailed description of the lithology and faunal distribution of the Dubivtsi succession will be published by Walaszczyk et al. (in press).

Fig. 1. Geographical location of the Dubivtsi succession in western Ukraine.

Based on macrofossils (Walaszczyk et al., in press) the studied part of the succession (outcropping in levels −1, 1 and 2) represents the interval from the middle Coniacian to the lower part of the middle Santonian (Fig. 2). The Coniacian/Santonian boundary is placed at the lowest occurrence of *Cladoceramus undulatoplicatus* (Roemer) which occurs 4 m from the base of level 1. Consistent records of the "pill-box-like" morphotype of *Globotruncana linneiana* (d'Orbigny), a proxy for the Coniacian–Santonian boundary (CSB) (Lamolda et al., 2007) occurs in the Dubivtsi succession 2 m below the first appearance of

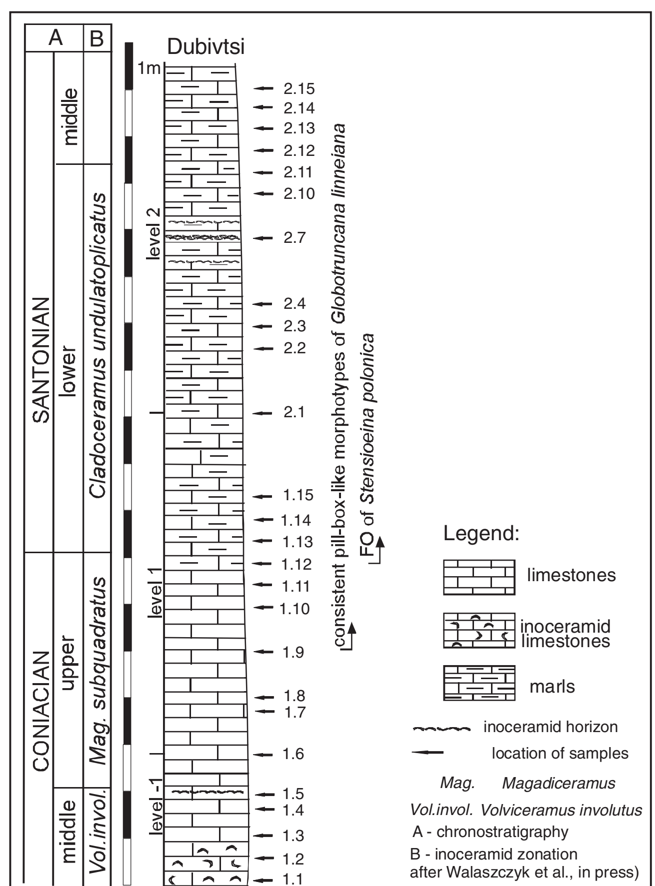

Fig. 2. Lithologic column of the Dubivtsi succession, inoceramid stratigraphy and FOs of stratigraphically important foraminifera.