HIGH RESOLUTION CARBON ISOTOPE STRATIGRAPHY OF LOWER CRETACEOUS PELAGIC LIMESTONES

O. LINTNEROVÁ[1] and J. MICHALÍK[2]

[1]*Comenius University, Faculty of Natural Sciences, Bratislava, Slovakia; lintnerova@fns.uniba.sk*
[2]*Geological Institute, Slovak Academy of Science; Bratislava, Slovakia; geolmich@savba.sk*

Abstract: West Carpathians Mt Rochovica section has been correlated on the basis of bio-, and sequence stratigraphy, high resolution $\delta^{13}C$ curve, with the Roter Sattel section in Swiss Prealps. Stable C isotopes curves are controlled by synchronous global processes, are related to marine primary productivity and can be used in stratigraphic studies and for basin correlations.

Key words: correlation, Western Carpathians, Alps.

Introduction

Subsidence and seal level fluctuation, continental sediment input, biological and chemical production and sediment transport generally control changes in sedimentary records. These factors depend on the tectonics, climate, water chemistry and nutrient ability and other local factors differently change in geological time. It has long been known that stable C isotopes are related to marine primary productivity and can be used in stratigraphic and petroleum exploration studies (Scholle and Arthur 1980). Generalized $\delta^{13}C$ curve at first for the period from Jurassic to Recent (Renard 1986) and later for the Phanerozoic has been presented (Holser et al., 1996, and others). The most detailed works in Cretaceous sediments have shown that $\delta^{13}C$ curves in far distant sections can be correlated. The similarity between isotope curves suggest, that they were controlled by synchronous global processes and can be used for high-resolution correlation (Mitchell et al., 1996, Holser et al., 1996, Jarvis et al., 2001, Strasser et al., 2001). The increase in background $\delta^{13}C$ values represents an increase in the area of ocean floor available for burial of marine organic carbon (Mitchell et al. 1996). Sedimentary relationships combined with stratigraphic variation in lithology and carbon isotope have been used to define not only global anoxic event (OAE) but also sedimentary sequence (Mitchell et al. 1996, Jarvis et al., 2001).

The aim of this paper is to demonstrate main aspects of high-resolution stratigraphy correlation of Lower Aptian black-shales in Rochovica and Roter Sattel sections that has been identified as

records of the OAE 1a - Selli event (Michalík et al 2002). We want to stress the importance of carbon isotope high-resolution analysis as an important part of integrated stratigraphic method.

Geological setting

During Early Cretaceous, the Tethyan domain formed part of European foreland: It was separated by the Penninic Oceanic Branch from the Central Carpathian - Alpine microcontinent, associated with the Adriatic microcontinental assemblage. The most complete uppermost Jurassic – Lower Cretaceous sequence as deposited along foot of the Czorsztyn Ridge slope - the southernmost European shelf edge. During Alpine collision, the sediments of this marginal area have transformed into a peculiar highly deformed linear structure, the Pieniny Klippen Belt. The Kysuca River narrows cut the Rochovica section in a large klippe of the Kysuca Unit. Lower Aptian Selli Event is recorded by the Koňhora Fm (Lintnerová 1999, Michalík et al. 1999, Lintnerová et al. 2000) intercalated in thick majolica limestone sequence (the Pieniny and the Brodno Fms).

The Rotter Sattel section is located in Swiss Romandes Prealpes (Menegatti et al. 1998, Strasser et al. 2001) situated originally on the same northern margin of the Penninic Oceanic Branch. The sequence was deposited in a marginal basin located on the Briançonnais Swell. The lower, pelagic nannoplanktonic limestone complex is represented by the "Calcaires Plaquettes", covered by marly hemipelagic Intyamon Formation with dark coloured interval of organic-rich sediments on the base. The latter is referred as the Livello Selli equivalent.

Correlation

West Carpathian Mt Rochovica section (Michalík et al. 1995; 1999; Lintnerová et al. 1997; 2000; 2001) has been correlated on the basis of bio-, and sequence stratigraphy, high resolution $\delta^{13}C$ curve, with the Roter Sattel section in Swiss Prealps. A striking confidence can be supplemented by the correlation of isotope, organic geochemistry, microelement and TOC distribution and mineralogical data sets obtained in both sections

Standard biozonation of the sections studied has been assigned using planktonic foraminifera, which are abundant in the limestones. The quantitative bio-stratigraphy investigation has been documented, that sudden change from light nannofossil limestones to black shales was connected with evolutionary breaks of many marine organisms and with production of shales enriched in organic carbon (Michalík et al 1999, 2002, Lintnerová et al. 2000, Strasser et al, 2001). The organic matter found in the both sections appears to have mixed marine and continental origin. Whereas total organic carbon (TOC) values are generally below 0,1 % in limestones, in the Koňhora beds reached up to 3 %. Higher TOC values have been referred in Roter Sattel (1- 6,75%) or other shales on the Selli level in around the Europe. It is interesting, that also diagenetic alteration of organic

mater both these profiles, one thousand kilometers apart each of other, is comparable.

It was appeared that facies evolution and stacking pattern of beds and sets of beds are base tools for correlation of discussed sections. Sequence boundary (SB) are placed at the base of the thickest limestone beds, or at the base of carbonate dominated interval, where break of stacking pattern occurred (Strasser et al., 2001). In the black shales interval of sections mainly short term sequence related to high frequency changes of sea level and climate are well documented. However, both sections are suitable to distinguish also higher order of sequence and in the certain intervals of sections hierarchy of beds bundling reflecting Milankovitch cycle (400ka). It is important that in comparison with well-established sequence in Roter Sattel section, we can document regional (or global) character of eustatic sea-level change in the Rochovica section. In the same time we can identify changes caused by tectonic activity or local sedimentary processes in the basin slope.

The positive $\delta^{13}C$ excursions indicate OAE (Scholle and Arthur 1980) and can be used to correlation of carbonates (Managetti et al., 1998, Mitchell et al. 1996, Jarvis et al., 2001). These OAE or black shale events can be characterized as short-timed perturbations of the carbon storage in the sediments or deep-sea waters.

High-resolution $\delta^{13}C$ curves of studied black shales events can be divided into eight segments (Menegatti et al., 1998) in order to detail comparison of it in studied sections. We can see, that $\delta^{13}C$ values decreases gradually from majolica limestones (range from 2,2 to 2,4 ‰) of the Vranie Member towards the Koňhora Formation (2.2 - 1.0 ‰). The"Selli" level is denoted by step-like $\delta^{13}C$ shifts (e.g. in Rochovica section from 1.4 to 3.3 and from 3.3 to 3.9 ppm, respectively) in the Planomalina (Globigerinelloides) blowi- and at the base of Leupoldina cabri zones. The relative clear $\delta^{13}C$ decrease visible in a basal part of black shales of Konňhora Fm. (first shale cycle) is obscure in the Roter Sattel $\delta^{13}C$ curve can indicated local sedimentary processes on the basin slopes. This can be verify by beds stacking, biofacies and quality of organic matter evolution. The interpretation of relative low TOC (to 0,5 %) and low $\delta^{13}C$ (about 1,0-1,5 ‰) values in this part of the Koňhora black shales can be based on dominance of strong oxidized continental organic matter in the beds. The organic matter was deposited in transgressive water regime and in relative euxinic condition. Increased support of nutrients from continent can leads to plankton overproduction and to increase of total amount of organic matter. TOC values fluctuation in dark layers (2.26 – 0.44 – 2.71% TOC), indicated, that organic matter storage in sediment is controlled by sea level fluctuation, however may be modify also other actions. Organic matter (oxidic or bacterial) degradation affect also relative acidity of water, dissolution and preservation of nanno- and micro-fossils. The relative abundance of pyrite in beds documented (early) diagenetic processes in the sediments, when organic matter reduced

sulfates in (and is degraded itself). On the other side, despite of TOC values fluctuation in dark layers general isotope trend remains high (3.3 to 3.9 ‰) here. Moreover, $\delta^{13}C$ values attain even 4 to 4.6 ‰ in the overlying limestone sequence. An increase in $\delta^{13}C$ is not simply connected with a significant accumulation of organic matter (TOC 0.3 to 3%). High-resolution analyses indicates rather a positive correlation between $\delta^{13}C$ excursion and disturbance of global C-regime (Menegatti et al. 1998, Weissert et al. 1998, Hochuli et al. 1999) resulted from sea-level rise which had been followed by climatic change. Observed remarkable synchronicity between the nannoplankton decrease, the increase of non-calcareous dinoflagellate cysts abundance and the $\delta^{13}C$ excursion suggest this interpretation (Michalík et al., 2002).

Lack of correlation between both $\delta^{13}C$ and $\delta^{18}O$ changes document any significant diagenetic alteration of isotopic ratios. Its was verify by organic matter and clay minerals study (Lintnerová et al 2000). The negative excursion of $\delta^{18}O$ is shifted towards lower values especially in the mentioned first black shale cycle of Koňhora beds and signalizing compositional (salinity), or carbonate producing water temperature change resulting from general sea level rise and greenhause climatic turnover (Michalík et al. 1999). During late Early Aptian humid climatic event terrigenous material was repeatedly transported from the Paleoeuropean continent towards the ocean. Sea level changes primary directed sediment deposition in the margin part of basin. From the point of view of sources of clastic material and of the global change interpretation, recognizing of paleogeographic proximality and distality trends is important.

Conclusion remarks

Black shales of Early Aptian age were inserted in lower Cretaceous pelagic limestone sequence deposited along European continental margin and in other parts of the Tethys tropical ocean. The Koňhora black shale Fm. is the first stratigraphic equivalent of this 1a OAE documented in the Western Carpathians (Lintnerová et al 199, Michalík et al., 1999). It has been studied in detail and correlated by high-resolution bio- and chemostratigraphic methods.

Close similarities in the Aptian sedimentary record of both, the Carpathian and Pre-Alpine sections documented high importance of black shale vent in the inter-regional correlation and identification of global change in the pelagic sediments. It is also important, that high-resolution stratigraphic data are enable to distinguish the differences of local tectonic and sedimentary evolution of the basins.

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