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The Valanginian history of the eastern part of the Getic Carbonate Platform (Southern Carpathians, Romania): Evidence for emergence and drowning of the platform

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ABSTRACT

Lower Cretaceous successions that crop out in the eastern part of the Getic Carbonate Platform (Southern Carpathians, Romania) preserve records of the Valanginian events in different settings of the platform. The integrated sedimentological, biostratigraphical, geochemical and mineralogical analysis of the upper Berriasian–Valanginian successions reveal successive stages in the evolution of the carbonate platform: (a) pre-drowning stage of the shallow-shelf and slope settings of the platform; (b) subaerial exposure and karstification; and (c) incipient flooding and drowning of the carbonate platform. Following the subaerial exposure, starting in the middle early Valanginian, the eastern part of the Getic Carbonate Platform experienced a drowning phase documented by iron oxyhydroxides, phosphate and glaucony mineralized discontinuity surface and glaucony-rich sediments disposed on the discontinuity surface. Recognition of the diachronous intra-Valanginian discontinuity surface within the studied successions is based on clear evidences (facies contrast, depositional and diagenetic features, biostratigraphic and taphonomic data, and geometrical relations). The negative–positive carbon isotope excursion is correlated with the global perturbations of the carbon cycle related to the Valanginian "Weissert" episode, and it is documented for the first time in the shallowest parts of the Getic Carbonate Platform. Tectonic activity and eustatic sea-level fluctuations were most probably the main factors that led to fault-block tilting, local emersion and subsequent drowning of the eastern part of the Getic Carbonate Platform during the Early Cretaceous. We infer that the eastern part of the Getic Carbonate Platform was affected by late Berriasian–early Hauterivian extensional tectonics that could be related to the Neo-Cimmerian movements with effects generally recognized in the northern peri-Tethyan areas.

1. Introduction

Within the Lower Cretaceous peri-Tethyan carbonate platforms a series of drowning unconformities (e.g. Schlager and Camber, 1986; Schlager, 1989) are associated with erosional truncations, stratigraphic condensation and diverse mineralized discontinuity surfaces (e.g. Föllmi et al., 1994; Hillgärtner, 1998; Godet et al., 2013). The drowning event of the Valanginian carbonate platforms coincides with the global palaeoenvironmental perturbations of the carbon cycle, corresponding to the onset episode of greenhouse climate (cf. Lini et al., 1992; Weissert et al., 1998) and to the "Valanginian Weissert Oceanic Anoxic Event" (cf. Erba et al., 2004). These episodes correspond to the most intense phosphogenesis during the Valanginian Oceanic Anoxic Event (cf. Föllmi et al., 2006).

On the Romanian territory, records of the Valanginian drowning event were observed within the carbonate deposits exposed in the eastern extremity of the Southern Carpathians. During the Middle

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Jurassic–Early Cretaceous, an extended and complex system of carbonate platforms developed along the northern passive margin of the Neo-Tethys between 19° and 24° N palaeolatitude (cf. Panaiotu, 1998) throughout the Getic Domain in the Southern Carpathians. This system of carbonate platforms was named by Patrulius (1976) and Patrulius and Avram (1976) the Getic Carbonate Platform. The Upper Jurassic–Lower Cretaceous deposits of the Getic Carbonate Platform crop out on large surfaces in the Dâmbovicioara zone, in the Braşov-Codlea zone, and on the western side of the Bucegi Mountains. In these areas, the Berriasian to early Valanginian time interval is usually represented by a thick succession (up to 900 m) of Štramberk-type limestones, whereas the late Valanginian–Hauterivian consists of different types of limestones and marly limestones with variable stratigraphic thickness.

The lithostratigraphy and biostratigraphy of these deposits have been studied since the middle of the 19th century; their detailed history was presented by Patrulius et al. (1980) and Avram and Grădinaru (1993, 2001). Outstanding works by Patrulius (1963, 1969, 1976), Patrulius and Avram (1976) and Patrulius et al. (1980) provided the general outline of the Jurassic–Cretaceous litho- and biostratigraphy from the Dâmbovicioara zone and the Bucegi Mountains, in the eastern margin of the Getic Carbonate Platform. Building on previous work, during the last decades a number of studies contributed to the detailed litho- and biostratigraphy of the Upper Jurassic–Lower Cretaceous carbonate successions located in these zones (Grădinaru and Bărbulescu, 1989; Avram and Grădinaru, 1993, 2001; Panaiotu et al., 1997; Melinte and Mutterlose, 2001; Barbu, 2007, 2013; Barbu and Melinte-Dobrinescu, 2008; Andrăşanu, 2009; Dragastan, 2010; Bucur et al., 2014).

The aim of the present paper is to decipher the ways global Valanginian events (emersion and drowning episodes) affected different parts of the Getic Carbonate Platform, using integrated analyses of facies contrast, geometrical relationships, depositional and diagenetic features, mineralogy and geochemistry, biostratigraphy and taphonomy of the most representatives Lower Cretaceous sequences exposed on the eastern part of the Southern Carpathians.

2. Geological setting

The research area is located in the eastern extremity of the Southern Carpathians (Fig. 1A) that structurally are part of the Alpine-Carpathian Fold Belt. The studied sections belong to the pre-Austrian (Triassic–Lower Cretaceous) sedimentary cover of the Getic Nappe and are composed of Lower Cretaceous shallow-water marine and hemipelagic deposits.

From north to south, the studied sections are located in the following zones:

- Braşov-Codlea zone – the studied carbonate sequence is exposed in the Piatra Mare Quarry located at about 2 km southwest from Codlea locality (GPS N 45°41′16″, E 25°25′28″, 226 m altitude) (Fig. 1B);
- Dâmbovicioara zone; here, four sections were studied in detail: Drumul de Care (GPS N 45°24′47,3″; E 25°13′9,7″; 927 m altitude), the southern slope of Sasului Hill (GPS N 45°24,516′; E 25°14,002′; 1020 m altitude), Gângului Valley, a right tributary of Dâmbovicioara Valley (GPS 45°25′10″; E 25°8′35″; 905 m altitude), and Pârâul Peşterii Valley, a left tributary of Dâmbovicioara Valley (GPS N 45°26′42″, E 25°13′29″, 1021 m altitude) (Fig. 1C);
- the southern part of the western flank of the Bucegi Mountains, with two sections: the first one located in the topmost part of the Lespezi Quarry (N 45°18′34″; E 25°23′57″; 1664 m altitude) and the second one is located about 1000 m north from the protected geological site Clăile de Piatră (GPS N 45°18′36″; E 25°24′25″; 1646 m altitude) (Fig. 1D).

3. Materials and methods

Seven stratigraphic sections were studied and a total of 200 samples were collected. The microfacies and diagenetic features were investigated in 250 thin-sections under petrographic microscope and stereomicroscope. Based on the textural descriptions, the microfacies types have been identified and described in percentage of grain size and grain-to-matrix ratios, according to the classifications of Dunham (1962) and Embry and Klovan (1971). The identified microfacies are presented in Table 1. Cathodoluminescence microscopy was applied for diagenetic studies on 40 polished slabs. The chemical and mineralogical composition was determined by X-ray fluorescence analysis (XRF) in more than 60 samples, using a Horiba XGT 7000 device for major elements, and X-ray diffraction data were obtained from 35 powdered samples using a PANalytical's X'Pert PRO (microXRD) diffractometer. The organic matter and carbonate content were quantified by calculation of the weight loss during the reactions, measured by weighing the samples before and after heating at 105 °C overnight to remove water, at 550 °C for two hours to remove organic matter, and at 950 °C for two hours to remove carbonates. The organic matter and carbonate content have been calculated using the equations: $LOI_{550} = [(DW_{105} - DW_{550})/DW_{105}] \times 100$ and $LOI_{950} = [(DW_{550} - DW_{950})/DW_{105}] \times 100$ (Heiri et al., 2001). In addition, carbon and oxygen stable isotope analyses of carbonate powder samples were performed at the isotope laboratories of the Iso-Analytical Limited, United Kingdom. All samples have been tested prior to isotope analysis with respect to potential diagenetic overprinting, using petrographic and cathodoluminescence microscopy as well as chemical data. Powdered samples were taken from polished slabs using a Dremel drill equipped with precision bits. The powdered samples were treated with 100% phosphoric acid at 75 °C, and the evolved CO_2 was analyzed by Continuous Flow-Isotope Ratio Mass Spectrometry (CF-IRMS). All isotopic results are reported relative to the PDB (PeeDee Belemnite) standard (standard deviation smaller than 0.04%).

Glaucony grain separates from three samples were used for K–Ca geochronology. Pure glaucony grains separates were spiked with ^{39}K and ^{43}Ca spikes described in Cecil and Ducea (2011), dissolved in a mixture of ultraclean HF and HNO_3 acids and put through conventional cation columns for K and Ca separation. K and Ca separates were dried-down and loaded for analysis on Re and Ta filaments, respectively. Procedural blanks for K and Ca in the clean laboratory were 150 pg and 180 pg, respectively. The isotopes of Ca and K were measured by ID-TIMS on a VG Sector mass spectrometer equipped with 6 Faraday collectors and a Daly photomultiplier (Otamendi et al., 2009).

4. Results

4.1. Description of the studied sections

4.1.1. The Braşov-Codlea zone: Piatra Mare Quarry section

The Lower Cretaceous deposits of the Codlea zone are represented by the limestones from the upper part of the Cheile Dâmbovicioarei Formation (Berriasian–lowermost Valanginian) (Fig. 2A). These are overlain by the Braşov Formation (upper Valanginian–Hauterivian–lowermost Barremian) (cf. Avram and Grădinaru, 1993, 2001). The reference section is exposed in the Piatra Mare Quarry, located near Codlea locality.