# $^{87}Sr/^{86}Sr$ isotope systematics on belemnites from the Pliensbachian of West Bulgaria

# $^{87}Sr/^{86}Sr$ изотопна стратиграфия по белемнити от Плийнсбахския етаж в Западна България

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## Introduction

Strontium isotope stratigraphy is relatively new technique for dating and correlating marine sediments. For the Jurassic, in particular, it can provide a resolution and precision superior to that obtainable by ammonites (e.g. McArthur et al., 2000). This is especially useful when strata are gaped and poor in guide-fossils. Here we report the first Sr-isotope curve for the Pliensbachian in Bulgaria. It comes from the well-known Jurassic section near the Berende Izvor Village (West Bulgaria). The section contains well-preserved and abundant belemnites, bivalves, brachiopods, as well as common ammonites that supply enough sampling density and material for doing parallel biozonation for each of the fossil groups.

## Background, material and methods

The belemnites were sampled from 35 m thick succession of the Ozirovo Formation (Fig. 1). It includes a suite of sandy bioclastic, micritic and spicule limestones and ironstones, grading upwards into an irregular alternation of silty marls and micritic limestones. Fossils occur as a series of successive clusters throughout the section. The great thickness of the sequence and the lack of biostratigraphic mixing illustrate that the fossil record is continuous. We analyzed belemnite rostra occurring from the base of the Maculatum Zone to the poorly defined upper part of the Margaritatus Zone. Forty belemnites were screened for burial and diagenetic reworking, and following careful leaching protocol, pristine Sr-extracts were obtained. The $^{87}Sr/^{86}Sr$ ratios were measured on Thermo-Finnigan Triton-series thermal ionization mass spectrometer, at the University of Leeds (UK). To attain maximum accuracy the $^{88}Sr$ signal was bracketed between 5 and 8V, delivering internal precisions for the $^{87}Sr/^{86}Sr$ measurements (2σ; n>180) between 2.6 and $6.6 \times 10^{-6}$. Repeated analysis of the $^{87}Sr/^{86}Sr$ in NBS-987standard gave values of 0.710254 (2σ, *n*=31). All $^{87}Sr/^{86}Sr$ reported have been normalized to NBS-987 value of 0.710248 (McArthur et al., 2000).

## Results and discussion

The Lower-Upper Pliensbachian boundary in the studied section was placed below the first incoming of the ammonite family Amaltheidae, and after the fading of the ammonites from the family Liparoceratidae. The proposed substage boundary coincides with the replacement of *Catateuthis-Brachybelus* belemnite complexes with *Passaloteuthis* assemblages. It also corresponds to a distinct reversal within the bivalve-brachiopod associations, by the complete disappearance of the infaunal elements from the Lower to the Upper Pliensbachian, as well as by the decreasing domination of the brachiopods.

The Sr-isotope ratios define a clear trend and range from 0.707247 at the bottom to 0.707122 at the top of the sequence (Fig. 1). In general, our dataset and the new Sr-isotope curve appear to be in good agreement with Sr isotope datasets from the coeval strata from Yorkshire, UK (McArthur et al., 2000). However, our Sr-isotope curve displays some distinct oscillations that are difficult to explain solely based on palaeoenvironmental fluctuations, because of the relatively large (~4 Ma) residence time of Sr in the oceans. It seems that the elevated Sr-isotope values are due to the reburial of diagenetically unaltered belemnites.

Assuming that calcite (and thus the $^{87}Sr/^{86}Sr$ ratios) from the belemnite rostra grew in equilibrium with seawater, McAtrhur et al. (2000), proposed a method to estimate the relative durations of the ammonite zones and have shown that contrary to common beliefs those are highly unequal.The excellent quality of our Sr-isotope dataset and the completeness of our strati-

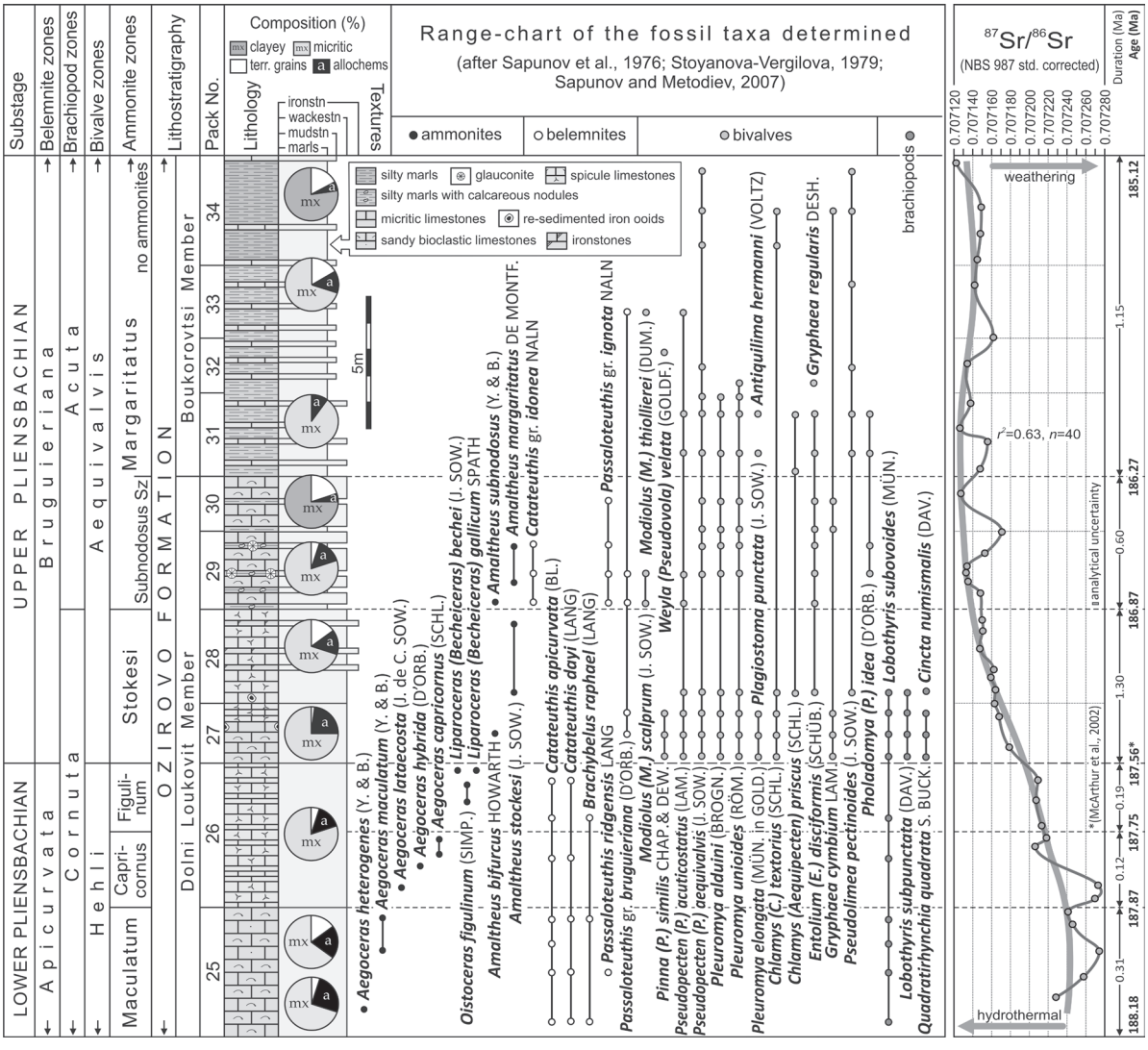


**Fig. 1.** Lithological section of the Ozirovo Formation at the Berende Izvor village (West Bulgaria), showing the fossil occurrence, strontium isotope trend and the ages of the Pliensbachian ammonite zones

graphic section allowed us to estimate the relative duration of the Pliensbachian ammonite zones. Using the approach of McAtrhur et al. (2000), $^{87}Sr/^{86}Sr$ isotope ratios were modeled by linear regression analysis and absolute ages have been assigned to every belemnite using 187.56 Ma as the lower boundary of the Upper Pliensbachian. We found that the durations of the Pliensbachian ammonite zones from West Bulgaria are concordant with the results obtained from the UK sections. They differed from each other by factor of up to 1.0, i.e. from 0.12 Ma (Capricornus Zone) to 1.30 Ma (Stokesi Zone). Our new Sr isotope dataset enabled us to calculate absolute ages from the non-ammonite bearing upper part of the section (186.27 to 185.12 Ma), i.e. covering the Gibbosus Subzone of the Margaritatus Zone.

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