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GEOLOGY

Assessment of Diachronism of Biostratigraphic Boundaries by Magnetochronological Calibration of Zonal Scales for the Lower Cretaceous of the Tethyan and Boreal Belts

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Complex bio- and magnetostratigraphic studies of Lower Cretaceous deposits in the central Volga region, Northern Caucasus, and other regions carried out by the authors of the present communication for more than 10 years resulted in the detailed correlation of biostratigraphic zonal scales between each other (mainly upper Hauterivian–Aptian) and with the "standard" scale of the Western Mediterranean [1, 2]. Paleomagnetic inversions are known to be synchronous for all rock sequences on the earth regardless of the latitude of their formation. Therefore, correlation of regional magneto- and biostratigraphic scales (magnetochronological calibration) allowed us to establish and assess quantitatively for the first time the asynchronous nature of the series of stratigraphic boundaries, which were regarded as synchronous for different paleogeographic belts.

The paleomagnetic correlation of Barremian–Aptian boundary deposits of the Russian Plate [7], Northern Caucasus [6], Mediterranean region [4], and England [9] makes it possible to assess the asynchronous nature of the *Deshayesites volgensis* Zone base in the lower Aptian (Fig. 1). In the Northern Caucasus, the boundary between the *D. weissiformis* and *D. volgensis* zones is confined to the subzone of the reversed sign (the analog of M0 Chron). In the central Volga region, the base of the *D. volgensis* Zone and its West European analog the *D. forbesi* Zone occurs above M0 within the direct polarity interval. The time shift obtained by interpolating the available isotopic dates is ~10^5–10^6 yr (Fig. 1) and is comparable with the duration of ammonite zones. A similar situation is possible for sections in England as well, but the dating of Wealden deposits underlying Aptian deposits remains problematic. The correlation of these data with the known curve of sea-level fluctuations [8] (Fig. 1) suggests that ammonites, which appeared at the northern margin of the Tethys, migrated further northward during the eustatic rise of the World Ocean level and the opening of the submeridional Caspian Strait [2].

A similar situation with the phase shift of zonal boundaries is outlined for the middle Aptian as well (Fig. 1).

The boundary between the lower and upper Barremian in the Volga region, which coincides with the boundary of *Aulacoteuthis descendens* and *Oxyteuthis brunsvicensis* belemnite zones established by analogy with sections of northern Europe [3], falls within the direct polarity interval of M1 Chron. In the Mediterranean region, this boundary correlated with the ammonite evolution is characterized by the reversed polarity and is located in the upper part of M3 Chron. Hence, the lower and upper Barremian boundaries in the Tethyan belt and Russian Plate (Subboreal belt), which were established by different fauna groups, show a time discrepancy of more than *one million years* (Fig. 2).

The boundary between the Hauterivian and Barremian is confined to the top of M4 Chron of the normal polarity in the Mediterranean region and the base of the orthozone of the reversed polarity (the M3 Chron analog) in the Volga region (Fig. 2). Thus, the asynchronism is recorded in this case as well, although its value does not exceed 10^5 yr. The comparison of Hauterivian subzones of the Volga region with magnetic chrons correlated with the zonal standard of the Western Mediterranean (Fig. 2) does not contradict the concept of correlation of the Tethyan and Boreal standards of the upper Hauterivian [1].

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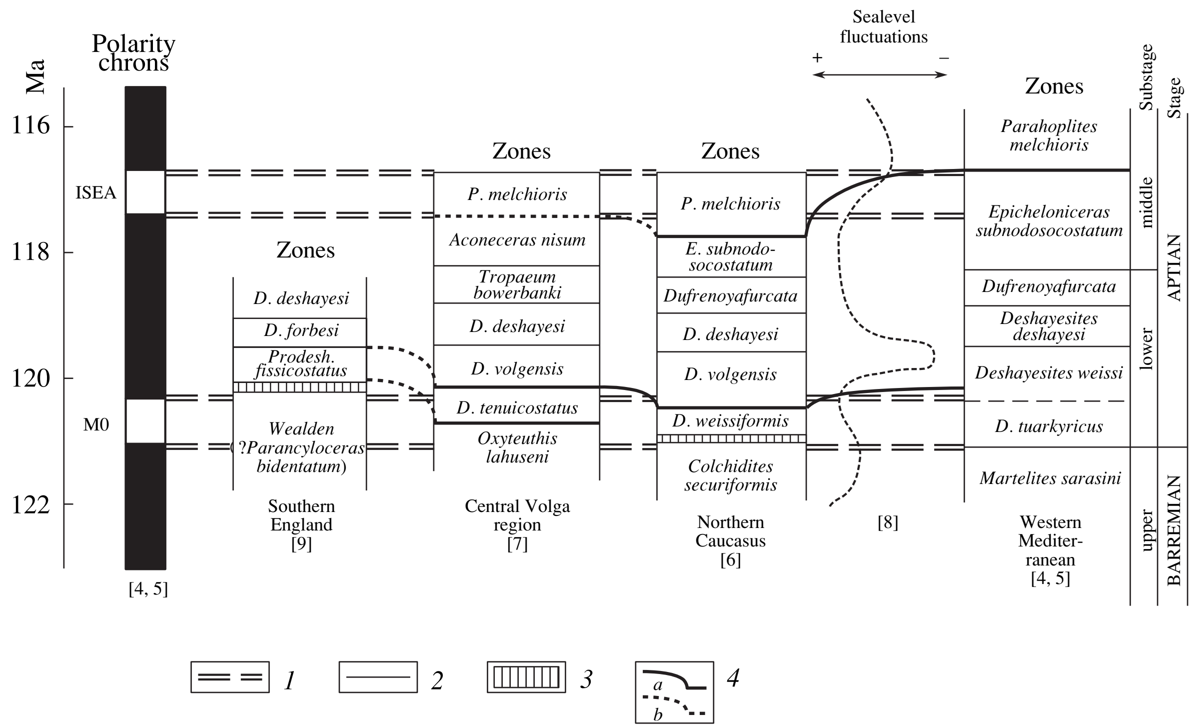

Fig. 1. Magnetochronological calibration of zonal scales for the lower–middle Aptian deposits of the central Volga region, Western Mediterranean, Northern Caucasus, and southern England. Boundaries of biostratigraphic zones within monopolar intervals are conventional. (*1, 2*) Isochronous (paleomagnetic) and biostratigraphic boundaries, respectively; (*3*) stratigraphic hiatuses; (*4*) stratigraphic correlation with the consideration of paleomagnetic data: (*a*) (proven), (*b*) inferred.

Despite many efforts, the correct correlation of the Boreal and Tethyan Barremian based on only the paleontological data with consideration of the paleogeographic isolation of the basins remains an extremely complicated and, probably, unsolvable problem [2]. (A similar problem also arises for other intervals, such as the lower Hauterivian, upper Aptian, and so on.) We believe that this problem can be reasonably solved by drawing the Hauterivian/Barremian boundary in the General Stratigraphic Scale (GSS) at the M3 Chron base; the Barremian substage boundary, at the M3 Chron top; and the Barremian/Aptian boundary, at the M0 Chron base. We have given preference to this version with consideration of the fact that the universally recognized stratotypes of the Hauterivian, Barremian, and Aptian are located in the Tethyan realm.

Any other isochronous events of a planetary scale (for instance, anomalies of stable isotopes) can be used for the same purposes instead of the paleomagnetic criterion. These events, however, are rare as compared to geomagnetic inversions, the number of which is comparable with the number of biostratigraphic zones. The current version of the global curve of sealevel fluctuations, which complies in detail with the condition formulated above, has a regional tectonic control. Therefore, eustatic cycles of the third order are not always identifiable. Moreover, the Haq–Vail curve is inapplicable to continental deposits. In terms of the accuracy of determinations, isotope dates are insufficiently accurate for detailed interregional correlations and the assessment of the synchronism of stratigraphic boundaries. Thus, no alternative to paleomagnetic methods is available at present for the establishment of synchronism of events and stratigraphic boundaries. Therefore, we should recognize the paramount role of paleomagnetic criteria for substantiating and tracing GSS units and should use them in combination with paleontological methods for the GSS construction.

Such precedents have already taken place, e.g., the proposal of the International Working Group on the Aptian [5] to use the M0 Chron base as the main criterion for establishing the Barremian/Aptian boundary. The data obtained on the diachronous nature of biostratigraphic boundaries in different paleobiogeographic belts give grounds for discussing the problem as to what unit should be the principal unit of the GSS (zone or stage).

The use of stages as principal stratigraphic units of the GSS is justifiable at present, because the time interval (10^5–10^6 yr) corresponding to asynchronism of stratigraphic boundaries is negligible as compared to the duration of ages (Fig. 3). When tracing substages by biostratigraphic methods, the diachronism of their boundaries can be comparable to the duration of substages themselves. This is unacceptable for GSS units. Therefore, substages cannot serve as GSS units until

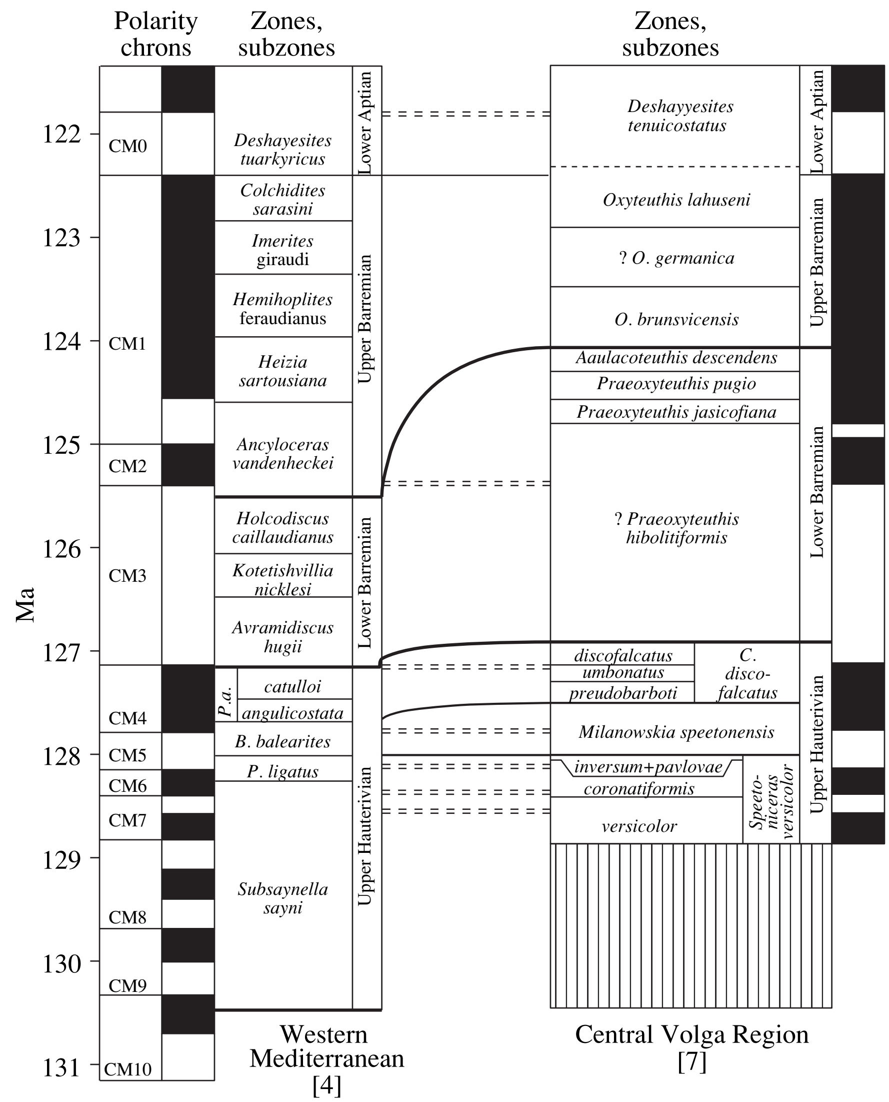

Fig. 2. Magnetochronological calibration of zonal scales for the Hauterivian–Barremian of the central Volga region and Western Mediterranean. See Fig. 1 for symbols.

methods providing isochronism of their boundaries appear. This conclusion is valid to a greater extent for biostratigraphic zones: diachronism of boundaries of ammonite and belemnite zones for the Lower Cretaceous can exceed their own duration (!).

Of course, the above statement does not mean that we should discard the zones (in the chronozone sense) as potential principal units of the GSS. If methods for the substantiation of isochronism of zonal boundaries that occur in remote sections and/or different paleoclimatic belts will be elaborated, such zones can successfully represent more detailed principal units of the GSS.

The results obtained suggest the following conclusions.

(1) Stage, substage, and zonal boundaries of the Hauterivian, Barremian, and Aptian in the Tethyan belt differ in the absolute age from analogous boundaries in the Boreal belt by a value of ~10^5–10^6 yr, which is comparable with the duration of Early Cretaceous ammonite zones.

(2) For the Hauterivian–Aptian interval of the GSS, it is expedient to propose the following intervals as references: (1) the M3 Chron base for the Hauterivian/Barremian boundary, (2) the M3 Chron top for the Barremian substage boundary, and (3) the M0 Chron base for the Barremian/Aptian boundary (according to [5]).

(3) A stage is the main stratigraphic unit of the GSS for integrated substantiation, since diachronism of its boundaries is negligible for remote correlations as compared to its duration. Units of the substage or zone rank cannot be adopted as principal units for the time being (at least, for the Lower Cretaceous).

4. When establishing a stage (substage, zonal) boundary relative to geomagnetic inversion (or another

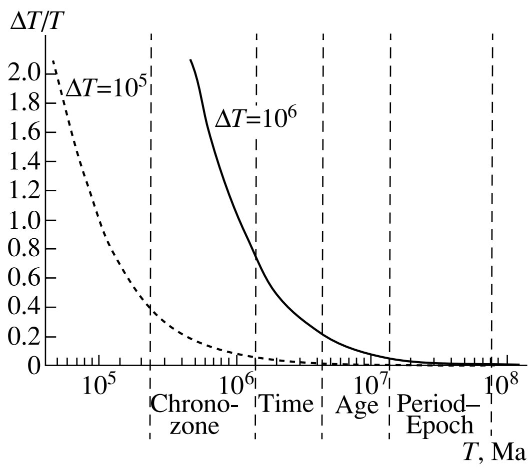

Fig. 3. The degree of diachronism ($\Delta T/T$) of biostratigraphic boundaries vs. the duration of a geochronological unit (T). (ΔT) The value of a possible phase shift during the correlation of biostratigraphic boundaries of different paleobiochores.

event), preference should be given to the inversion, which is (1) well identifiable and (2) best suitable for the biostratigraphic boundary in the stratotype.

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REFERENCES

1. E. Yu. Baraboshkin, Byull. Mosk. O-va Ispyt. Prir., Otd. Geol. **79** (5), 44 (2004).
2. E. J. Baraboshkin, in *Tethyan/Boreal Cretaceous Correlation* (VEDA, Bratislava, 2002), pp. 39–78.
3. E. J. Baraboshkin and J. Mutterlose, Acta Geol. Polon. **54**, 499 (2004).
4. J. E. T. Channell, F. Cecca, and E. Erba, Earth Planet. Sci. Lett. **134**, 125 (1995).
5. E. Ebra, R. Aguado, E. Avram, et al., Bull. Inst. Roy. Nat. Belgique, Suppl. 66, 31 (1996).
6. A. Guzhikov and V. Eremin, Geodiversitas **21** (3), 387 (1999).
7. A. Yu. Guzhikov, E. Yu. Baraboshkin, and A. V. Birbina, Russ. J. Earth Sci. **5** (6), 1 (2003).
8. B. U. Haq, J. Hardenbol, and P. R. Vail, Soc. Econom. Paleontol. Miner. Spec. Publ. **42**, 71 (1988).
9. M. Kerth and E. A. Hailwood, J. Geol. Soc. London, No. 145, 351 (1988).