Regional magnetic zonality scheme for the Berriasian-lower Aptian from the North Caucasus

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ABSTRACT
Palaeomagnetic research was carried out in the North Caucasus, Azerbaijan, Mountainous Mangyshlak and Central Kopetdag. The ten most complete marine sections of the Lower Cretaceous were selected. They provided opportunity to make reliable references of palaeomagnetic columns to the ammonite zones from the general stratigraphic scale. About 7500 oriented samples were selected from outcrops. The data on the Berriasian-lower Aptian deposits magnetism in the North Caucasus and the Western Central Asia combined with other authors data provide the material for revision of Neocomian palaeomagnetic structure.

KEY WORDS
Magnetostratigraphy, polarity, remanent magnetisation, Lower Cretaceous, Caucasus.

RÉSUMÉ
Zonation magnétique régionale pour le Bérriasien-Aptien inférieur du Nord Caucase.
Des recherches paléomagnétiques ont été poursuivies dans le Nord Caucase, en Azerbaïdjan, dans les montagnes du Mangyslhak et dans le Kopetdag central. Les dix coupes les plus complètes du Crétacé inférieur ont été sélectionnées. Elles offrent la possibilité de dresser des colonnes paléomagnétiques de référence, corrélables aux échelles standard d'ammonites. Environ 7500 échantillons orientés ont été prélevés. Les données sur le magnétisme des dépôts du Berriasien-Aptien inférieur dans le Nord Caucase et l'Asie centrale de l'Ouest, combinées avec les données bibliographiques, permettent une révision de la structure paléomagnétique du Néocomien.

MOTS CLÉS
Magnétostratigraphie, polarité, aimantation rémanente, Crétacé inférieur, Caucase.

INTRODUCTION

The materials obtained constituted the basis for a composite section of the Berriasian-lower Aptian of the North Caucasus; four relatively large magnetozones with alternating, normal and mainly reverse polarity were recorded within this section. Their stratigraphic ranges (stage, substage) correspond to the orthozones from the general palaeomagnetic scale (Anonymous 1992). Each orthozone is characterised by a rather complicated structure owing to subordinate sub- and microzones of opposite polarities.

Palaeomagnetic units, which contrary to palaeontological ones, are stable on global scale, in certain cases may be used as a measuring rule for parallelisations of stratigraphic scales from distant regions.

Magnetostratigraphic correlation of the Berriasian deposits from the Caucasus and the stratotype region has made it possible to reveal the interrelations between the ammonite scales from the two regions, and furthermore, to establish the approximate locations of calpionellid-zone boundaries in the sections on the Caucasus. Correlations of magnetostratigraphic sections from Mangyshlak, the northern Mediterranean and the English hypostratotype made it possible to consider the correlations between the ammonite and calpionellid scales of the Valanginian.

WORKING METHODS

The study was focused on the most complete Berriasian-lower Aptian marine sections from the North Caucasus and Central Kopetdag (Fig. 1) providing reliable referencing of the palaeomagnetic columns to the ammonite zones in the general stratigraphic scale.

The sections were commonly described in cooperation with biostratigraphers, which allowed strict geologic and palaeontologic control of the palaeomagnetic arrangements.

Frequencies of the oriented sample selection were determined by the thicknesses of the deposits studied. Sampling intervals varied from 0.5 to 3.5 m in the sections through folded areas and from 0.2 to 0.75 m in the platform.

As a rule, one sample was selected from each stratigraphic level; later on, it was sawed in 4-6 cubes, 24 or 20 mm on edges.

Palaeo- and petromagnetic studies were accompanied by the standard complex of laboratory work. Magnetic susceptibilities (k) and natural remanent magnetisation (NRM, Jn) were measured; magnetic cleaning was carried out with temperatures and alternating magnetic fields; normal magnetisation curves were drawn with subsequent measuring of the remanent saturation magnetisation (Jrs), determination of saturation fields (Hs) and destroying fields of remanent saturation magnetisation (H'cs). Thermomagnetic and differential thermomagnetic analyses (TMA and DTMA) were widely used to diagnose magnetic phases. A number of samples from each section were studied by means of optical mineralogy.

Remanent magnetisations were measured by ION-1, JR-3, JR-4 devices, magnetic susceptibilities – by IMV-2 and KT-5.

Temperature magnetic cleaning was performed in the non-magnetic furnaces within four or five-layer permalloy screens or within a Helmholtz ring unit. Successive heating was carried out in the range of 100-500 °C at temperature increment of 50-100 °C during one to four hours. To consider possible rock biasing, at least two cubes from each sample were put into the furnace: those with mutually antithetic orientations in all the three components of magnetisation vectors.

Some samples underwent cleaning with alternating magnetic field within Helmholtz ring system in the range of $16\text{-}40.10^{-3}$ A/m.

The analyses of normal magnetisation parameters (Hs, Jrs, H'cs) and the TMA and DTMA data (See fig. 2 *in* Guzhilov & Molostovsky, this volume) make it possible to conclude, that magnetisation of the rocks studied, was caused mainly by magnetite. Its presence is easily diagnosed by means of thermomagnetic curves: remanent magnetisation vanishes from the region of 580 °C (magnetite Curie point). The sample magnetic saturations have revealed the magnetically soft phase typical of finely dispersed magnetite (Hs = $32\text{-}64.10^{-3}$ A/m, H'cs = $24\text{-}50.10^{-3}$ A/m).

Zijderveld diagrams were constructed for com-

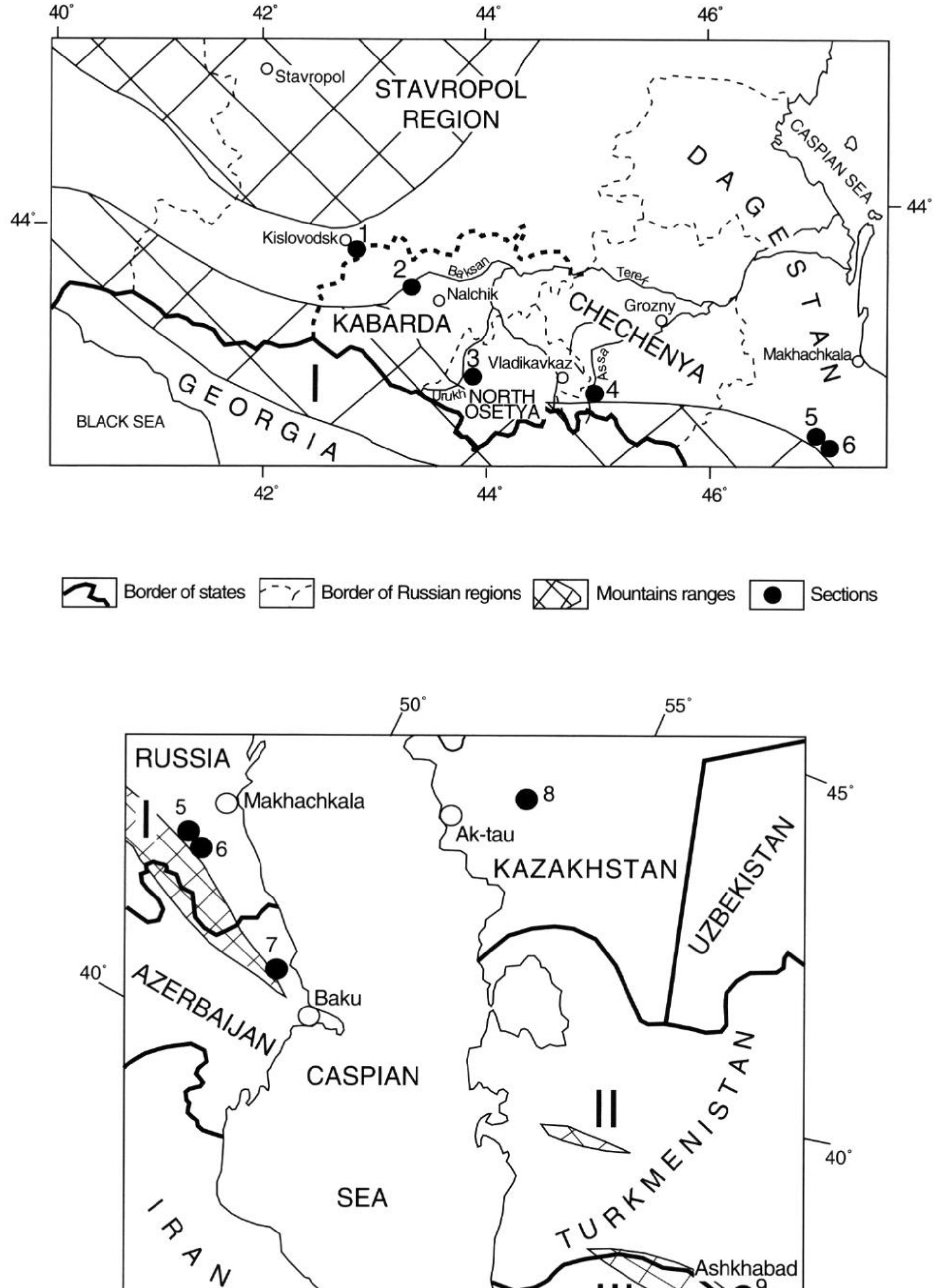


FIG. 1. — Location map. **I**, Great Caucasus; **II**, Balkhan; **III**, Kopet-Dag. Sections: **1**, Kislovodsk City; **2**, the Baksan River; **3**, the Urukh River; **4**, the Assa River; **5**, Gergebil Village; **6**, Akusha Village; **7**, Nardaran Village (Northern Azerbaijan); **8**, Tyuyesu Mountains (Mangyshlak); **9**, the Segiz-Yab River (Central Kopetdag).

ponent analyses of remanent magnetisation vectors. The typical diagram presented in Figure 3, testifies to the stability of resulting Jn trends: over the whole temperature interval after destruction of the secondary components, the vector changes along the straight line directed towards the centre of co-ordinates.

Magnetisation of the rocks considered, is characterised by two components: the primary one, revealing its trend after mild thermal cleaning and preserving it up to 500 °C (Fig. 2), and the secondary one, of probable viscous nature. The latter fact is affirmed by the majority of Jn vectors clustering after in situ measurements about the trend of rock remagnetisation by the present field (Appendix 1A). After a series of successive t°- and H-cleanings, the remagnetisation trends were regularly clustering in the first quadrant of the lower hemisphere or in the third quadrant of the upper one (Appendix 1B). These sets were interpreted as the normal and reverse polarity intervals, respectively.

To substantiate the Jn priority, numerous geologic-geophysics criteria and tests were applied, which made it possible to judge the age of magnetisation in major rock complexes. Some of these indications are considered below.

1. One of the important indications of a Jn sign being related with the polarity of an ancient field, consists in orientation independence of magnetisation vectors upon lithologic-mineralogic characteristics. In the majority of the sections studied, the magnetisation trends are obviously indifferent to various rock types (Appendixes 3-8).

2. Another evidence of magnetisation priority lies in the lack of interrelations between polarity signs and scalar magnetic characteristics. In many sections studied, several diverse-polarity zones were recognised within sequences undifferentiated with respect to k or Jn. Similar situation is observed, for instance, in the Valanginian beds on the Tyuyesu Mountain (Appendix 3). In the Barremian section near the village of Gergebil, on the contrary, a normal polarity zone embraces both, the weakly magnetised (k = 3-10.10^{-5} SI units, Jn = 0.5-1.2.10^{-3}/m), and strongly magnetised (k = 20-50.10^{-5} SI units, Jn = 2-4.10^{-3} A/m) intervals (Appendix 4).

3. The immersional analyses data show allothigenic magnetite to be present in the rocks. The coarsest Fe_3O_4 varieties have angular grains with obvious signs of transportation by water (scratches and grooves on faces and edges), which confirms their terrigenous origin. To a certain extent, this arguments for detrital nature of magnetisation. Firm grounding of this statement is identical to NRM priority proof.

Low values of Kenigsberger ratios (Q = Jn/Ji = 0.05-0.5) and low inter-sample clustering of the trends of stable NRM components (k = 5-30), characteristic of DRM (or PDRM), are regarded as the indirect palaeomagnetic evidences in favour of orientational (or postorientational) genesis of magnetisation.

4. Correlation of the palaeomagnetic structures of the similar-aged beds from distant heterofacial sections, may certainly serve as a strong argument for substantiating the geophysical nature of magnetozones. The overwhelming majority of the magnetozones recognised, meet this criterion and are laterally traced in certain stratigraphic intervals within various lithological-magnetic rock types that have been formed in diverse geochemical settings (Fig. 3). It is practically impossible to imagine, that self-reversal or secondary remagnetisation processes, able to result in distortion of NRM polarity, may be manifested synchronously over vast territories and in rocks of diverse types. The indication of exterior correlation becomes especially ponderable when similar magnetic polarity zones are recognised within similar-aged stratigraphic intervals from the regions characterised by different geologic histories. For example, the reverse polarity subzone R_1ap is recognised in the base of the lower Aptian substage, both in the North Caucasus and in the Kopetdag. The comparisons of the palaeomagnetic columns from the objects studied with the magnetostratigraphic sections from Siberia, Central Asia, West Europe and other regions lying apart (Fig. 3), have revealed good correlation of the palaeomagnetic data.

Each of the above criteria indirectly confirms, but does not prove priority of Jn. An important evidence in favour of this hypothesis, however, lies in the sum of independent observations conforming to the suggestion of the ancient nature of NRM.

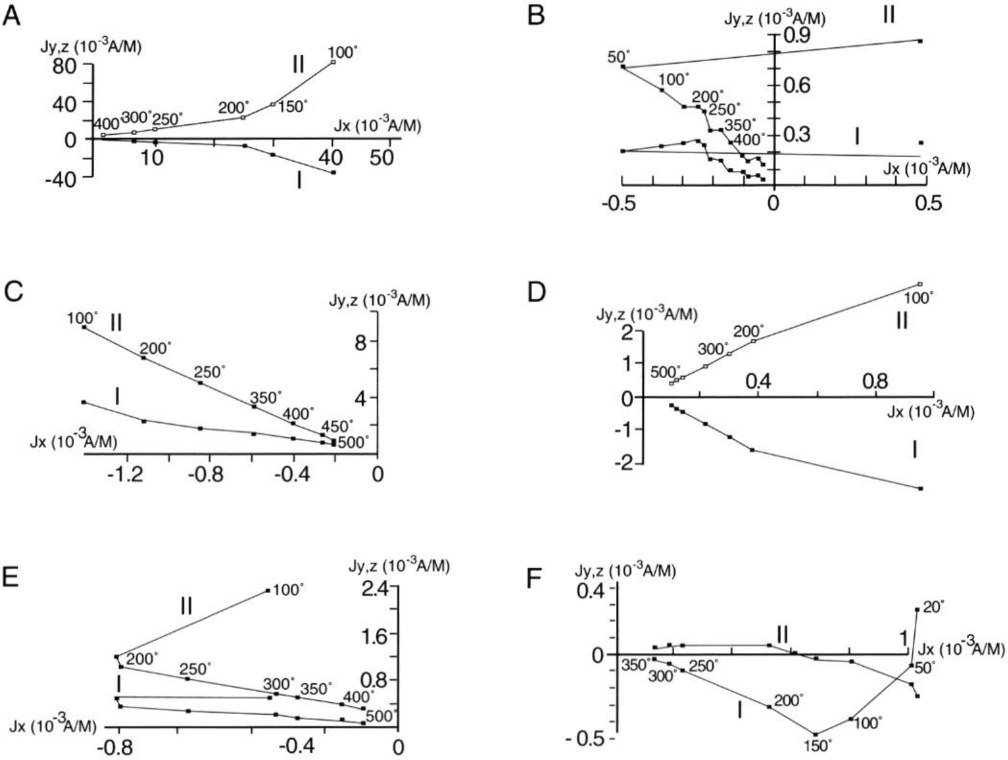


FIG. 2. — Zijderveld diagrams. NRM vector projection in horizontal (**I**) and vertical planes (**II**) within the sample coordinate system. Samples: **A**, clay (Hauterivian, Gergebil Village); **B**, limestone (Hauterivian, Gergebil Village); **C**, aleurolite (Berriasian, the Urukh River); **D**, aleurolite (Barremian, Gergebil Village); **E**, aleurolite (Barremian, the Segiz-Yab River); **F**, sandstone (Aptian, Kislovodsk city).

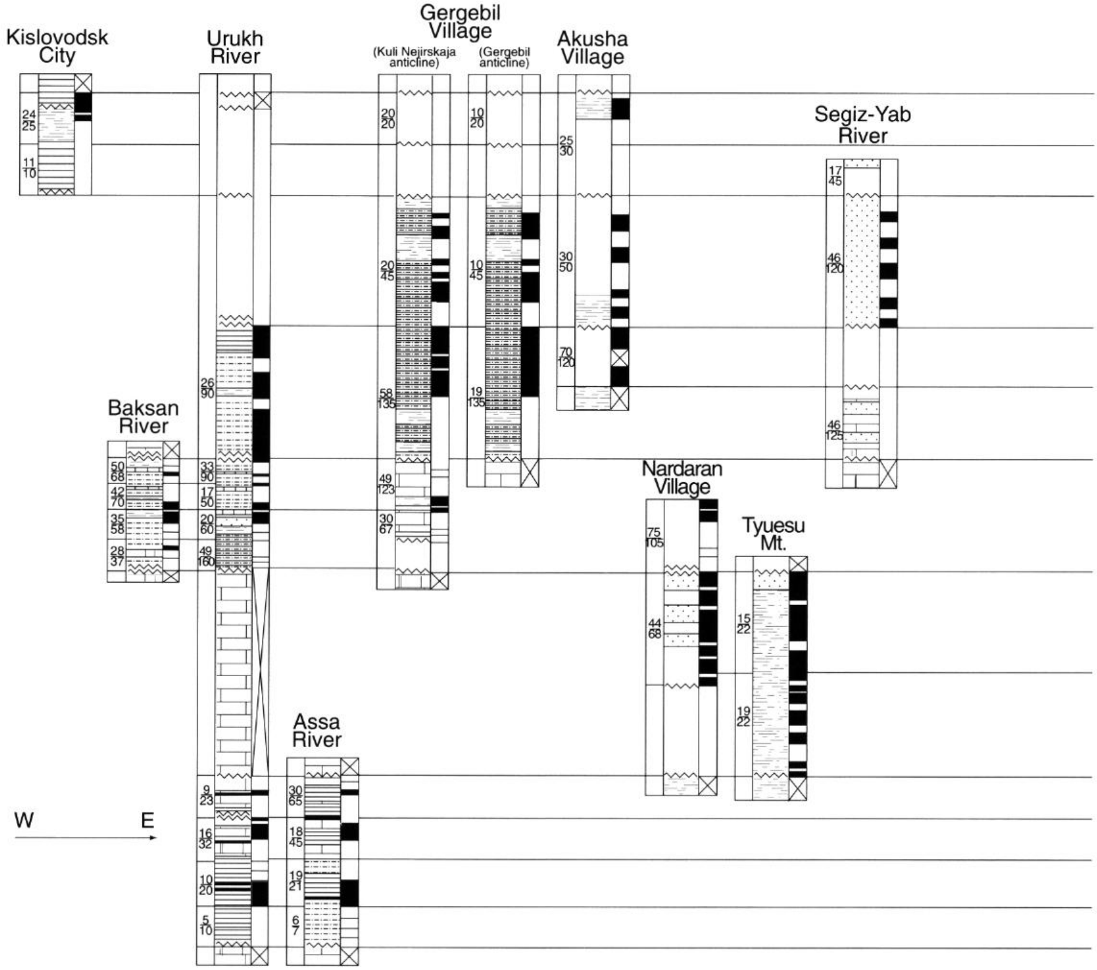
REGIONAL SCHEME OF THE NEOCOMIAN (BERRIASIAN-LOWER APTIAN) MAGNETIC ZONALITY IN THE NORTH CAUCASUS

The working magnetostratigraphic scheme of the Lower Cretaceous in the North Caucasus (Fig. 3) is based on palaeomagnetic study results from ten outcrops of the marine Lower Cretaceous; their geographic positions are presented in Figure 1. In all sections, the magnetozones recognised were reliably referenced to the ammonite zones in the general stratigraphic scale (Fig. 4), compiled from the data provided by numerous researchers (Prozorovsky 1989). On the total, the magnetostratigraphic scheme is characterised by ~7500 oriented samples from more than 1600 stratigraphic levels.

Composite palaeomagnetic columns for each of the Lower Cretaceous stages are described below. In conclusion, generalised characteristic of the regional Neocomian magnetic scheme is presented for the North Caucasus.

THE BERRIASIAN STAGE

The Berriasian beds, represented by alternating carbonate (limestones, marls) and terrigenous (clays, aleurolites) rocks, were studied in the North Caucasus on the Assa and Urukh rivers (Eremin 1991) (Fig. 4). In the first section, Sakharov (1976) has established all the ammonite zones of the Berriasian: each of them, except *Pseudosubplanites ponticus* zone, is further subdivided into two subzones. On the Urukh River, according to the finds of the corresponding index species, *Tirnovella occitanica*, *Euthymiceras euthy-*



mi and *Riasanites rjasanensis* zones were recognised (the *P. ponticus* lower zone, was not found there).

The composite Berriasian magnetostratigraphic section from the North Caucasian Region consists of five alternating subzones: three ones of reverse polarity (R_1b, R_2b, R_3b) and two of normal polarity (N_1b, N_2b) (Eremin 1991) (Figs 3, 4).

The Valanginian Stage

Palaeomagnetic study of the Valanginian beds was performed in the Trans-Caucasia (northern Azerbaijan, near the village of Nardaran) (Eremin & Guzhikov 1991) and in Mangyshlak (in Tyuyesu Mountains) (Fig. 3, Appendix 3).

In the first section, the uppermost of the Babadagskaya suite was exposed, represented by terrigenous-carbonate flysch (marls, clays, aleurolites, sandstones). The Valanginian age of the rocks was determined on the basis of microfaunal data (Aliev 1965).

The Valanginian Stage in Tuyesu Mountains is represented mostly by fine-grained sandstones. The two substages are recognised according to

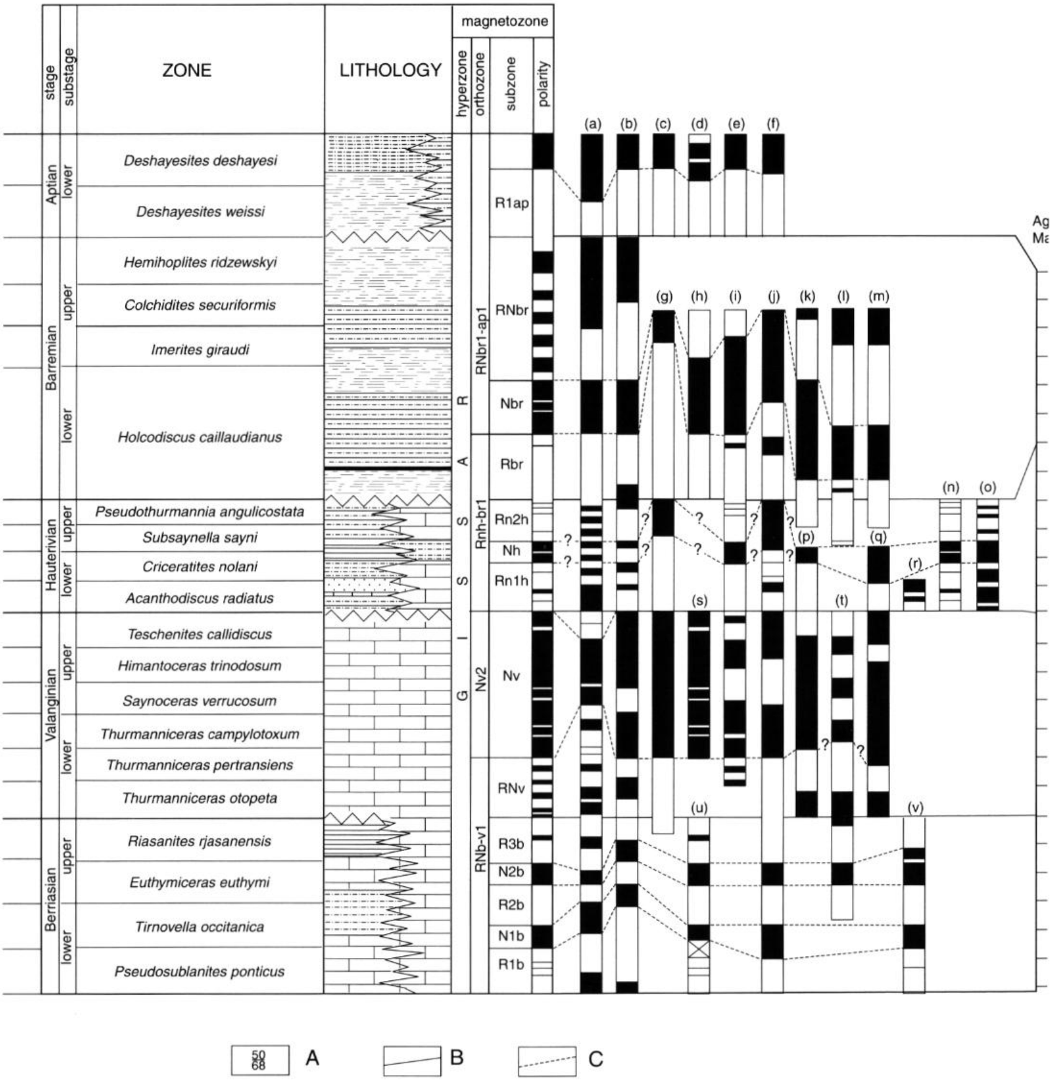


FIG. 3. — Regional magnetic zonality scheme for the Berriasian-lower Aptian from the North Caucasus. **A**, quantity of studied stratigraphic levels/Thickness (metres); **B**, correlative lines of biostratigraphic stages, substages and zones; **C**, correlative lines of palaeomagnetic subzones. Absolute age from Harland *et al.* (1982). **a**, Harland *et al.* (1982); **b**, Molostovsky & Khramov (1984) and Khramov (1982); **c**, Tarduno *et. al.* (1992); **d**, **j**, Pospelova (1976); **e**, **l**, Lowrie, Alvarez *et al.* (1980) and Lowrie, Channell & Alvarez (1980); **f**, Grishanov (1984); **g**, Pechersky (1970); **h**, Tretyak *et al.* (1976); **i**, Bralower (1987); **k**, Guseynov (1988); **m**, Channell *et al.* (1979); **n**, Ramazanov & Dedova (1990); **o**, Channell (1987); **p**, Ramazanov (1987); **q**, Rzhevsky (1968); **r**, Pospelova & Larionova (1971); **s**, Besse *et al.* (1986); **t**, Lowrie & Channell (1983); **u**, Galbrun (1985); **v**, Eremin (1991). For lithology, see legend on Appendix 4.

the macrofaunal complex, including ammonites (Bogdanova 1983).

The palaeomagnetic column of the Mangyshlak Section consists of two subzones: alternating (RNv) and normal (Nv) polarities. (Fig. 3, Appendix 3).

The Babadagskaya suite is encompassed by a major normal polarity magnetozone, complicated by five thin r-intervals (Eremin & Guzhikov 1991) (Fig. 3).

The Hauterivian Stage

The Hauterivian beds were studied on the Baksan and Urukh rivers, near the village of Gergebil (North Caucasus) and in the vicinity of Nardaran Village (northern Azerbaijan) (Eremin & Guzhikov 1991).

The first two sections are composed of clays, aleurolites and sandstones with subordinate marl and limestone interlayers. The Gergebil Section is represented by alternating terrigenous (clays, sandstones) and carbonate (limestones) members. The section near Nardaran consists of calcareous clays exclusively.

In the Central Cis-Caucasia (sections on the Baksan and Urukh rivers), deposits of all the Hauterivian biozones occur, which is confirmed by ammonite index species (Egoyan & Tkachuk 1965). In Gergebil, only the upper Hauterivian substage is recognised from ammonite fauna (Mordvilko 1960-1962). The underlying limestone sequence according to macrofauna is referred to the Hauterivian without further subdivision, and the lowermost section, devoid of organic remains, is referred to the Hauterivian Stage conventionally.

The Hauterivian age of the deposits near Nardaran is based on microfaunal data (Aliev 1965).

In each of the sections studied, three subzones were recognised: two of chiefly reverse (Rn) and one of normal (N) polarities (Eremin & Guzhikov 1991) (Fig. 3).

In the palaeomagnetic columns of all the four sections through the Hauterivian, despite its complexity, clear predominance of reverse polarity NRM is recorded (Fig. 4).

The Barremian Stage

The Barremian beds were studied on the Urukh River, in the vicinity of Gergebil and Akusha (North Caucasus) and on the Segiz-Yab River (Central Kopetdag) (Fig. 3, Appendixes 4-7).

The Barremian from the North Caucasus is represented by sandstones, aleurolites and, to a lesser extent, by clays. The Kopetdag Section consists mainly of limestones and marls.

In all the sections, both Barremian substages are recognised from the macrofaunal complex, ammonites included (Druzchiz & Michailova 1960; Mordvilko 1960-1962; Anonymous 1985). In the section of the Urukh, the upper Barremian deposits are condensed in a limestone layer 0.5 m thick.

The composite magnetostratigraphic section of the Barremian from the North Caucasus consists of three major subzones: those of reverse (R), normal (N) and alternating (RN) polarities (Fig. 3).

The palaeomagnetic column of the Kopetdag Section consists of two major subzones: those of reverse (R) and alternating (RN) polarities (Fig. 3, Appendix 7). The lower R-subzone corresponds to the lower half of the lower Barremian substage. The RNbr subzone encompasses the uppermost of the lower Barremian and the upper substage. The analogues of the North Caucasian normal polarity subzone are missing from the Segiz-Yab Section due to the early Barremian wash-out, that has not been previously recognised in this region, but is clearly pronounced in the adjacent Paroundag Range (Ammaniyazov *et al.* 1987).

The lower Aptian substage

The lower Aptian deposits were studied in four sections: near the town of Kislovodsk, in the vicinity of Gergebil and Akusha (all in the North Caucasus) (Eremin & Guzhikov 1991) and on the Segiz-Yab River (Kopetdag).

The lower Aptian in the North Caucasus is represented by terrigenous rocks exclusively: sandstones, aleurolites and clays. In the Segiz-Yab Section, the lower Aptian consists mainly of aleurolites with subordinate interlayers of limestones, marls and sandstones. In the Volga Region, the lower Aptian structures are composed chiefly of clays and clayey sands.

The lower Aptian beds are saturated with ammonite fauna remains (Druzchiz & Michailova 1960; Mordvilko 1960-1962; Anonymous 1985; Moskvin 1986).

Only the lower Aptian *Deshayesites weissi* and *D. deshayesi* zones are palaeomagnetically sampled in the Caucasus.

On the Segiz-Yab, the ages of all the lower Aptian beds, accurate within substages, were substantiated by macrofauna (Ammaniyazov *et al.* 1987).

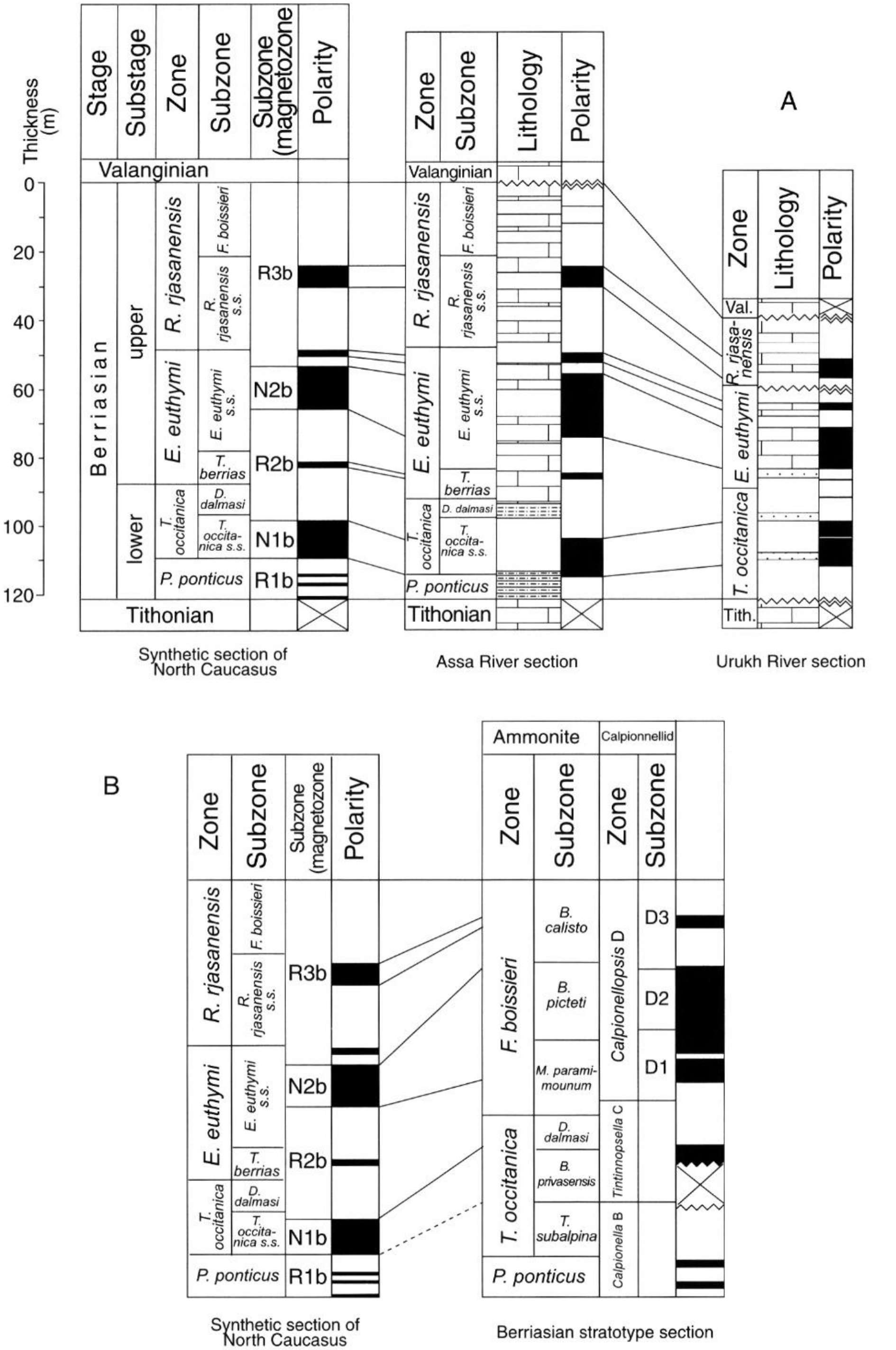


FIG. 4. — Magnetostratigraphical correlations of Berriasian deposits of North Caucasus (**A**) and between North Caucasus Region and the Berriasian stratotype section (**B**). For lithology, see legend on Appendix 4.

TABLE 1. — Correlations of the Berriasian ammonite scales from stratotype regions and North Caucasus.

<table>
<tr><th colspan="2">North Caucasus
after Druzchiz & Michailova 1960</th><th colspan="3">Stratotype</th><th colspan="2">North Caucasus
after palaeomagnetic data</th></tr>
<tr><th>Zone</th><th>Subzone</th><th>Zone</th><th>Subzone</th><th>Zone (calpionellides)</th><th>Zone</th><th>Subzone</th></tr>
<tr><td rowspan="2">Riasanites rjasanensis</td><td>Fauriella boissieri</td><td rowspan="4">Fauriella boissieri</td><td rowspan="2">Berriasella callisto</td><td rowspan="3">Calpionelliopsis (zone D)</td><td rowspan="2">Riasanites rjasanensis</td><td>Fauriella boissieri</td></tr>
<tr><td>R. rjasanensis s.str.</td><td>R. rjasanensis s.str.</td></tr>
<tr><td rowspan="2">Euthymiceras euthymi</td><td>E. euthymi s.str.</td><td>Berriasella picteti</td><td rowspan="2">Euthymiceras euthymi</td><td>E. euthymi s.str.</td></tr>
<tr><td>Tirnovella berriassensis</td><td>Malbosiceras paramimounum</td><td rowspan="3">Tintinnopsella (zone C)</td><td>Tirnovella berriassensis</td></tr>
<tr><td rowspan="3">Tirnovella occitanica</td><td>Dalmasiceras dalmasi</td><td rowspan="3">Tirnovella occitanica</td><td>Dalmasiceras dalmasi</td><td rowspan="2">Tirnovella occitanica</td><td>Dalmasiceras dalmasi</td></tr>
<tr><td rowspan="2">T. occitanica s.str.</td><td>Berriasella privasensis</td><td>T. occitanica s.str.</td></tr>
<tr><td>Tirnovella occitanica</td><td rowspan="2">Calpionella (zone B)</td><td colspan="2" rowspan="2">Pseudosubplamites ponticus</td></tr>
<tr><td colspan="2">Pseudosubplamites ponticus</td><td colspan="2">Pseudosubplamites grandis</td></tr>
</table>

In all the examined sections from the Caucasus and the Kopetdag, the lowermost Aptian is distinguished for a reverse polarity magnetozone (R_1ap) (Fig. 3, Appendixes 4-8). This magnetozone is stratigraphically equivalent to the *D. weissi* biozone, and the lower part of the *Deshayesites deshayesi*.

It may be seen from the correlation of the materials available (Fig. 3), that four relatively large zones of alternating, normal and chiefly reverse polarities correspond to the Lower Cretaceous portion in the composite palaeomagnetic section from the North Caucasus. The gap within the Valanginian part of magnetostratigraphic scale (no Valanginian beds were sampled in the North Caucasus) was eliminated owing to palaeomagnetic studies of the sections from Mangyshlak and Azerbaijan) (Fig. 3). Their stratigraphic ranges (stage, substage) correspond to the orthozones from the general palaeomagnetic scale (Anonymous 1992). Each orthozone is characterised by a rather complicated structure owing to subordinate sub- and microzones of opposite polarities.
The Lower Cretaceous palaeomagnetic scale opens with the alternating polarity orthozone $RNb\text{-}v_1$, embracing the Berriasian Stage and the lowermost lower Valanginian substage.
The normal polarity orthozone Nv_2 characterises the uppermost of the lower Valanginian and the upper Valanginian substage.
The chiefly reverse polarity orthozone, $Rnh\text{-}br_1$, comprises the Hauterivian stage and the base of the Barremian. The studies of the Hauterivian reference sections from the North Caucasus, have, for the first time, revealed the correspondence between the determined magnetozones and the ammonite zones of general stratigraphic scale.
The alternating polarity orthozone $RNbr_1\text{-}ap_1$ is stratigraphically equivalent to the uppermost of the lower Barremian, upper Barremian and lower Aptian.

COMPARISON OF THE REGIONAL AND GLOBAL DATA ON THE LOWER CRETACEOUS

The current ideas of the Lower Cretaceous magnetic zonality are based upon the data on linear magnetic anomalies, as well as upon fairly numerous, but unequally informative data on the Lower Cretaceous palaeomagnetism from various regions of Eurasia.
In the known models of the Phanerozoic general magnetostratigraphic scale (Khramov 1982;

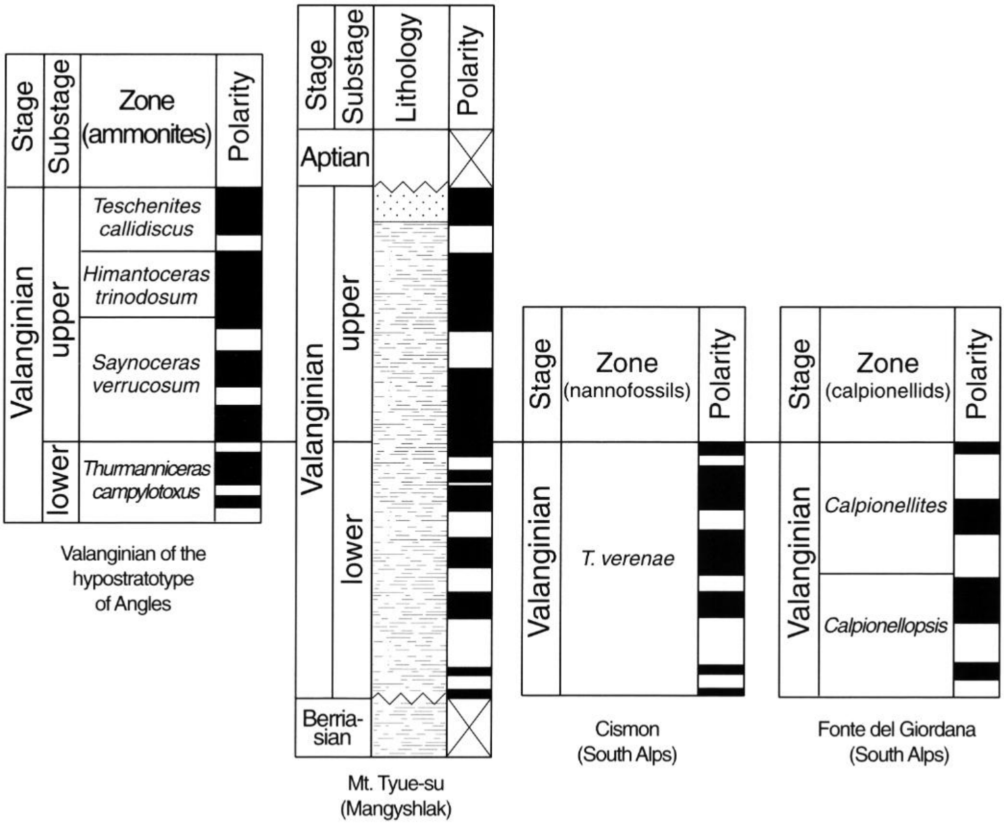


FIG. 5. — Magnetostratigraphical correlations between the Valanginian hypostratotype section of Angles (Besse *et al.* 1986), Mangyshlak Region and South Alps Region (Bralower 1987; Cirilli *et al.* 1984). For lithology, see legend on Appendix 4.

Molostovsky & Khramov 1984), as well as in the scale by Harland *et al.* (1982), the Lower Cretaceous is sharply differentiated into two parts. The Neocomian belongs to the alternating polarity interval, while the Aptian and the Albian stages correlate with the epoch of stable normal polarity field. Thus, the boundary between two major magnetostratones is established within the base of the Aptian: between the NR-Gissar and N-Djalal hyperzones (Khramov 1982; Molostovsky & Khramov 1984).

THE BERRIASIAN STAGE

The commonly accepted views upon the Berriasian magnetic zonality as an alternating polarity interval, are based on research results from various continents [the stratotype section from southern France included (Galbrun 1985)] and on the data from oceanic magnetometric surveys (Fig. 3).

The results of the present study are in complete accord with the ideas of sign-changing magnetic zonality of the Berriasian, with slight R-polarity prevalence.

Analogues of the palaeomagnetic zones distinguished by Galbrun (1985) in the Berriasian stratotype section (Fig. 4), are recognised the sequences from the Caucasus, which has made it possible to reveal the correlations among ammonite scales from the two regions, and, moreover, to record the approximate positions of calpionellid zones the Assa and Urukh sections.

The right side of Table 1 shows parallelization results for the Berriasian palaeontologic units from the stratotype and the North Caucasian regions (the left side of the Table, correlations among ammonite biozones and subzones, previously accepted by palaeontologists, are given for comparison (Prozorovsky 1989).

THE VALANGINIAN STAGE

The Valanginian magnetic zonality shows some problem. Alternating polarity is recorded in the scale of oceanic anomalies and in the North Mediterranean sections. At the same time, the data on the stage Angles hypostratotype (Besse *et al.* 1986) testify to the normal polarity dominance in the late Valanginian.

Comparisons of the Valanginian magnetostratigraphic sections from Mangyshlak, North Mediterranean (Cirilli *et al.* 1984; Bralower 1987) and the Angles stratotype, have made it possible, in the first place, to present an explanation for the reason of discord among magnetostratigraphic data on the Valanginian, and then to consider the interrelations among the ammonite and calpionellid scales of the stage.

In the South Alpine sections, provided with microfaunal grounding, the Valanginian is characterised by alternating polarity (Fig. 5). In the parastratotype and Mangyshlak sections, divided according to ammonites, an abnormal polarity orthozone corresponds to the upper substage (Fig. 5). An alternating polarity subzone (Fig. 5) corresponds to the lower Valanginian sequence in the Tyuyesu Mountains Section. Regretfully, the lower Valanginian deposits from England were not described in terms of magnetic polarity.

The above data considered, we may suppose the deposits from the *Calpionellites* zone and from the uppermost of the *Calpionelliopsis* in Umbria, to be analogous to the lower Valanginian substage. This inference is in agreement with Kent & Gradstein (1985) data on correlations between the Valanginian calpionellid and ammonite zones.

In the scale of linear magnetic anomalies, the largest normal polarity chron (M10N) is probably analogous to the Nv orthozone.

THE HAUTERIVIAN STAGE

The Hauterivian is characterised by sign-changing magnetic polarity.

The data on the Hauterivian palaeomagnetic structure in the Caucasus, is in accordance with Harland *et al.* materials on linear magnetic anomalies /90/, with those by Pospelova & Larionova (1971) from West Siberia, Ramazanov (1987) and Ramazov & Dedova (1980) from Turkmenia, Pechersky (1970) from north-east Russia, Bralower (1987) from South Alps. In all the listed regions, the Hauterivian palaeomagnetic columns show reverse over normal polarity dominance, and record at least eight magnetic field reversals (Fig. 3).

In the oceanic scale (Harland *et al.* 1982), the only major normal polarity chron (M4) is registered in the middle of the Hauterivian interval of the scale (Fig. 3). In the composite magnetostratigraphic section from the Caucasus, this may be analogous to the Nh subzone, associated with the substage boundary.

Polarity distributions within the North Italian Capriolo and Xausa sections, are a little bit different from the above sketch, according to Channell *et al.* (1979), normally magnetised rocks obviously prevail there (Fig. 3). This fact has not yet been unequivocally explained.

THE BARREMIAN STAGE

According to the current views, the Barremian Stage is characterised by complex magnetic zonality (Fig. 3).

Our results on alternating magnetic polarity of the Barremian from the North Caucasus and Kopetdag, are, on the whole, in good accord with the data by Lowrie *et al.* (1980) and Bralower (1987) on the South Alpine sections of Umbria, Cismon, Gubbio, etc., with the lowermost of the stage corresponding to a probable analogue of the Rbr subzone (Fig. 3).

At the same time, according to Channell *et al.* (1987) definitions for the North Italian sections of Capriolo and Xausa major normal polarity magnetozones correspond to the lowermost of the Barremian Stage (Fig. 3).

The comparisons of the composite magnetostratigraphic section from the North Caucasus and Kopetdag with Harland *et al.* (1982) scale, do not deny correlation of the Rbr subzone with the M2 anomaly, or that of the RNbr subzone with M1 and M1n chrons (Fig. 3).

THE APTIAN STAGE

In all the examined sections from the Caucasus, Kopetdag and Volga Region, the lowermost of the Aptian are distinguished for a reverse polarity magnetozone, most probably analogous to the MO chron of the anomaly scale (Harland *et al.* 1982) (Fig. 3).

CONCLUSION

Comparisons of the regional and global data on the Berriasian-lower Aptian have shown the results obtained to accord in principle with the magnetostratigraphic materials known. The results allow to have more precise ideas of the Neocomian part of the palaeomagnetic scale.

In the stratigraphic aspect, the magnetozones recognised are reliable stratigraphic bench marks for synchronous correlations of the deposits, both on the regional and global scales.

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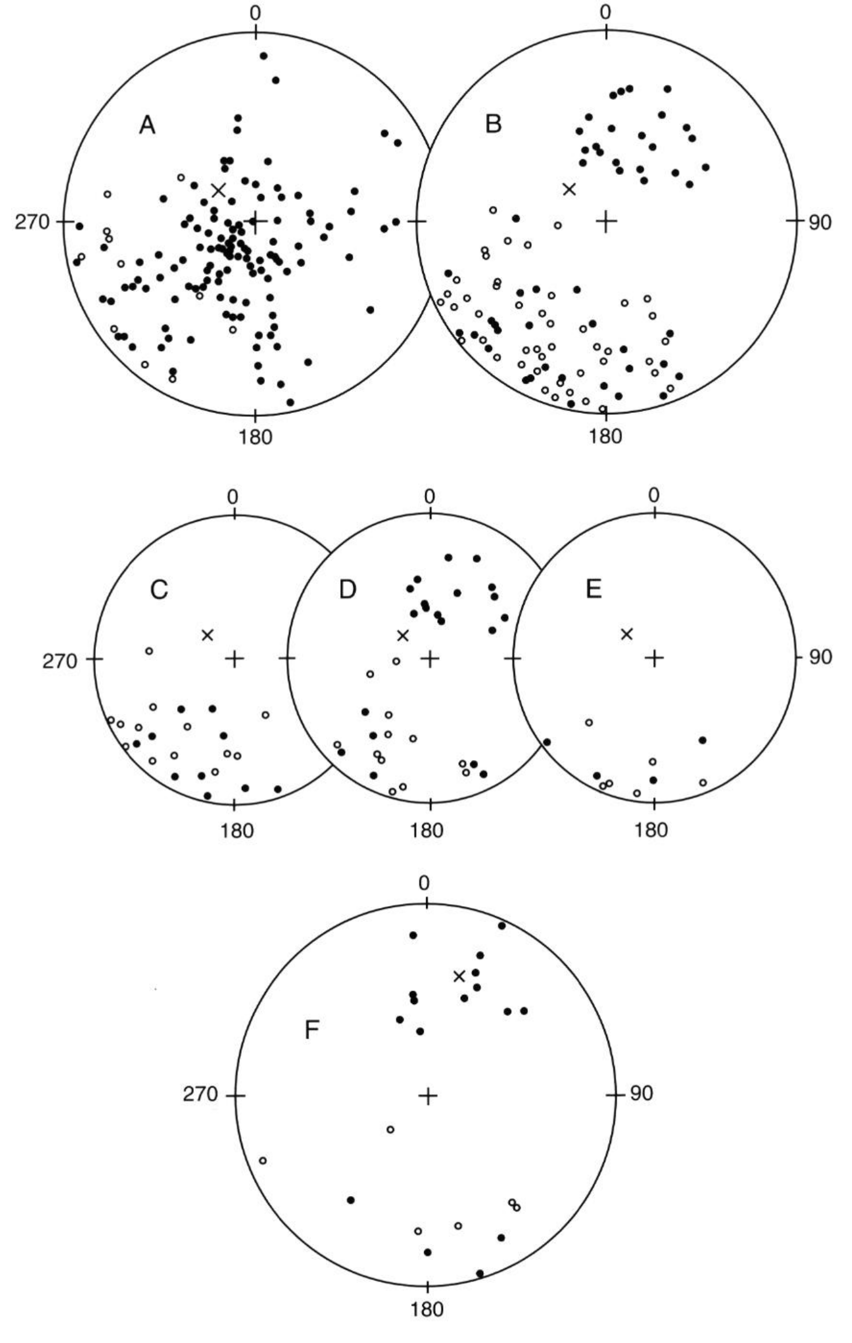
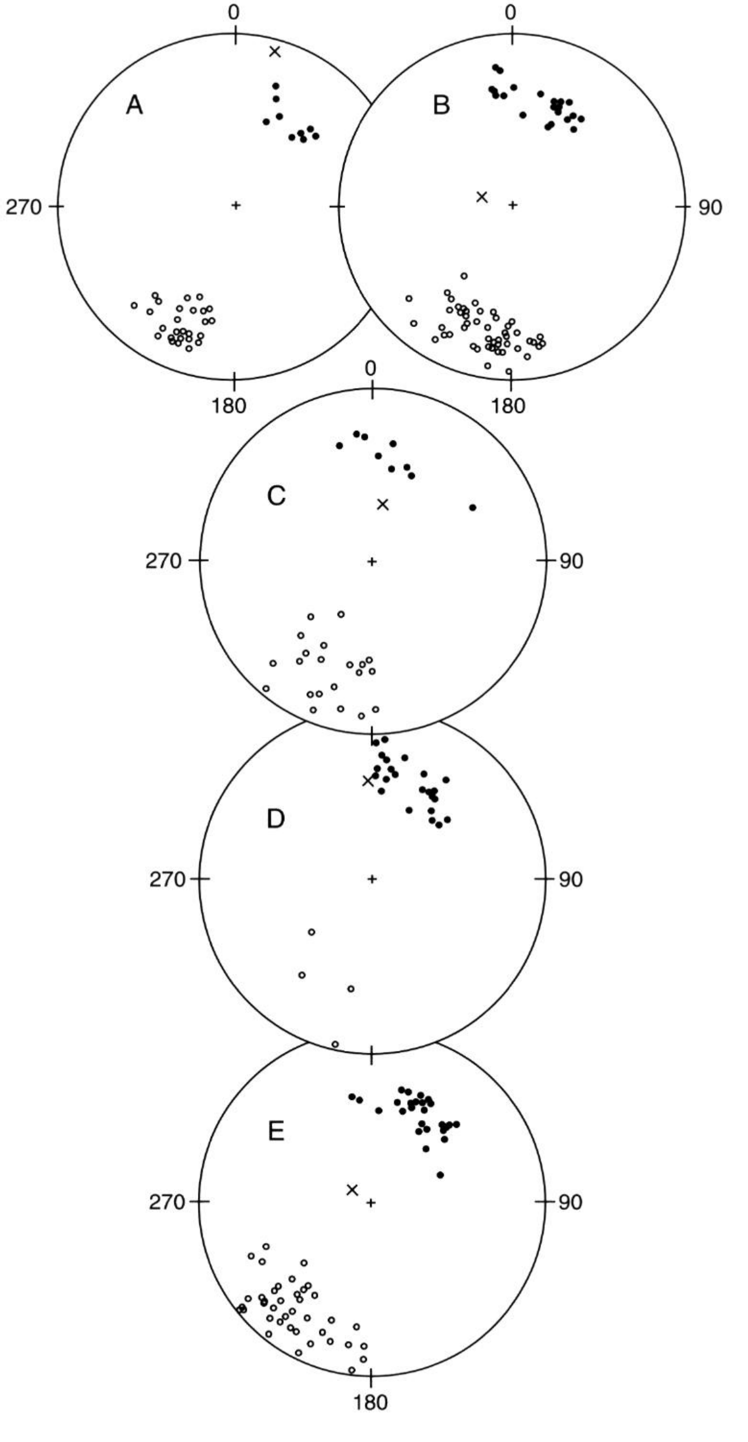
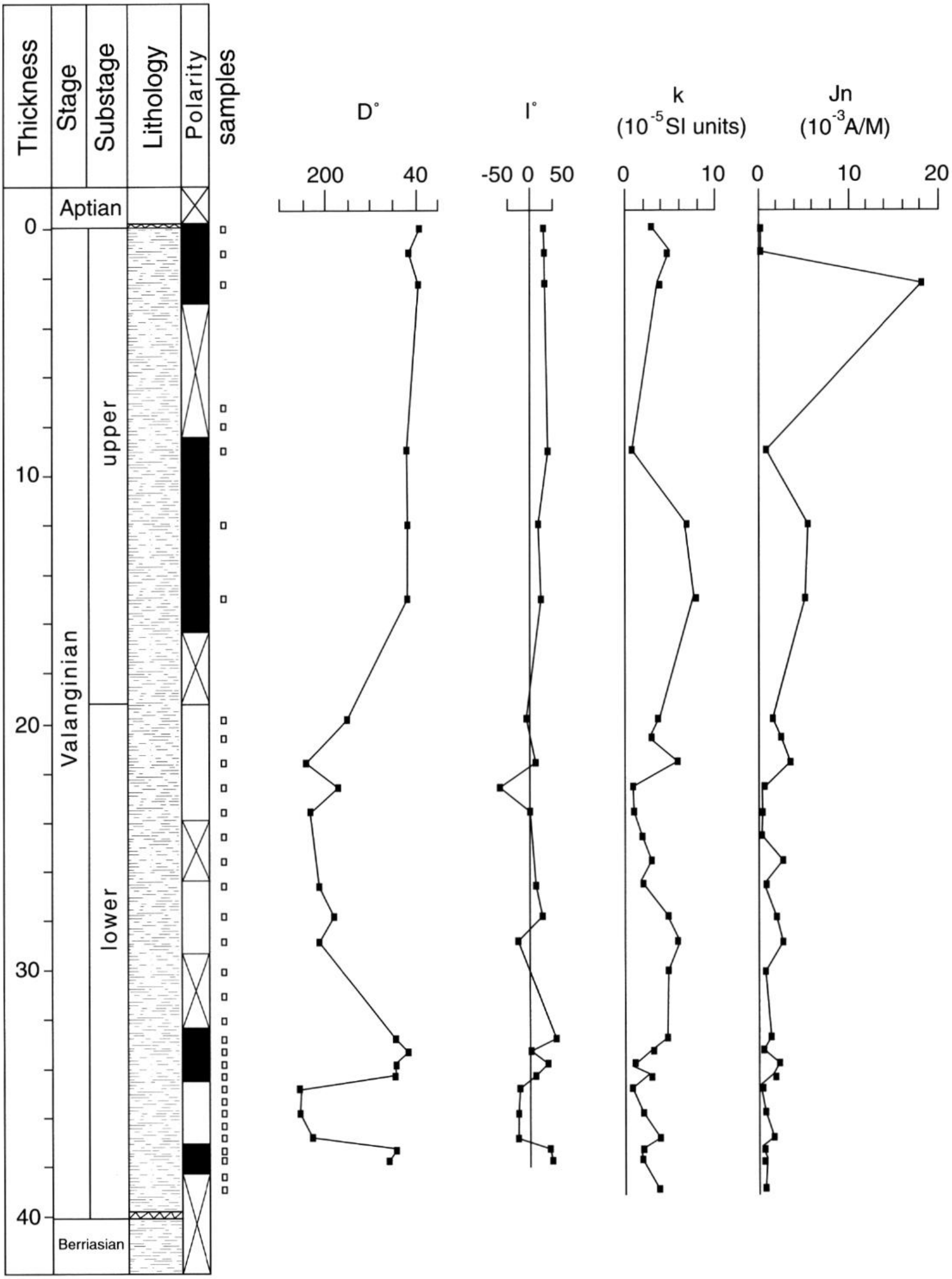
APPENDIX



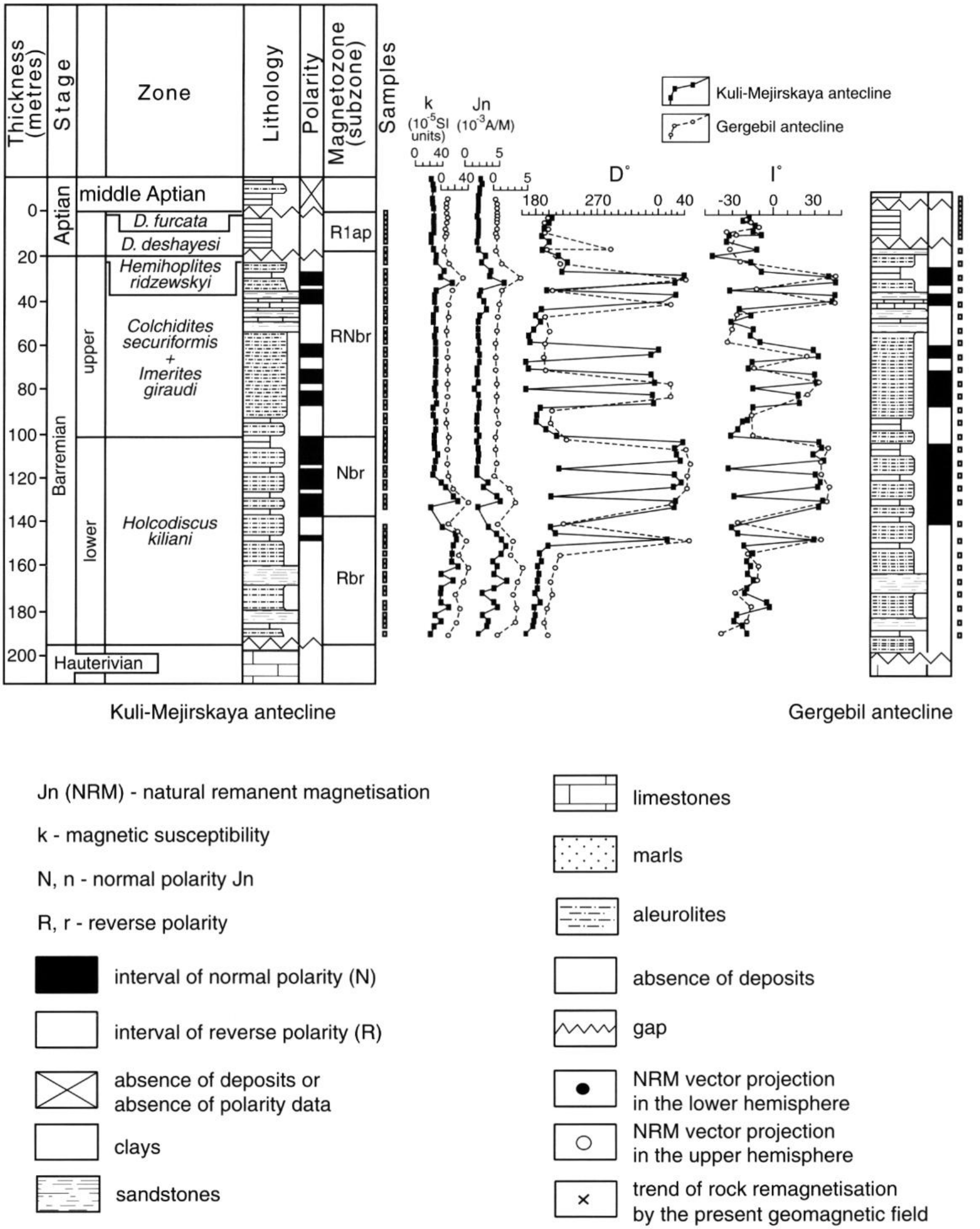
Appendix 1. — Stereographic projections of NRM vector. **A**-**E**, the Segiz-Yab River Section: **A**, **B**, the Barremian-lower Aptian deposits (A, after *in situ* measurements); **C**-**E**, magnetozones: **C**, Rbr; **D**, NRbr; **E**, R1ap; **F**, the Valanginian deposits from Tyuyesu Mountains.



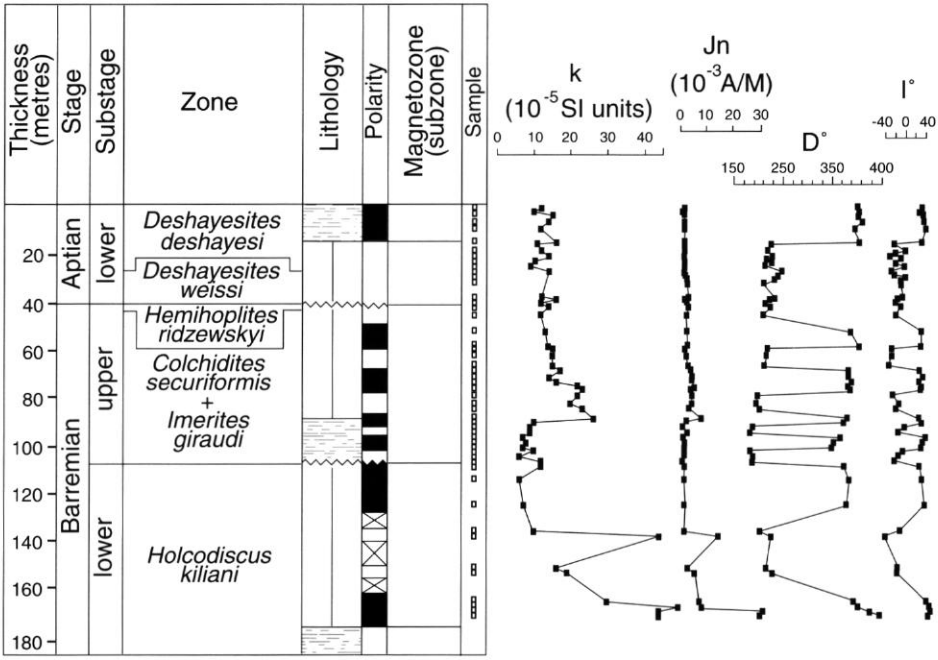
APPENDIX 2. — Stereographic projections of NRM vector. The Barremian-lower Aptian deposits: **A**, Gergebil Section (Gergebil anticline); **B**, Gergebil Section (Kuli-Mejirskaja anticline); **C**, Kislovodsk Section; **D**, the Urukh River Section; **E**, Akusha Section.



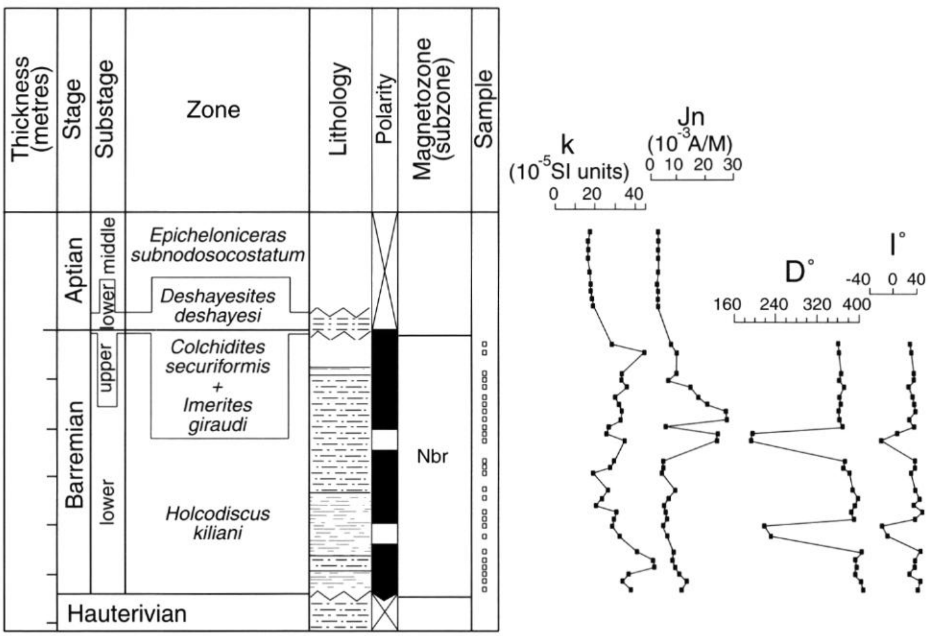
APPENDIX 3. — Palaeo- and petromagnetic characteristics of the Valanginian deposits from Tyuyesu Mountains. Same legend as Appendix 4.



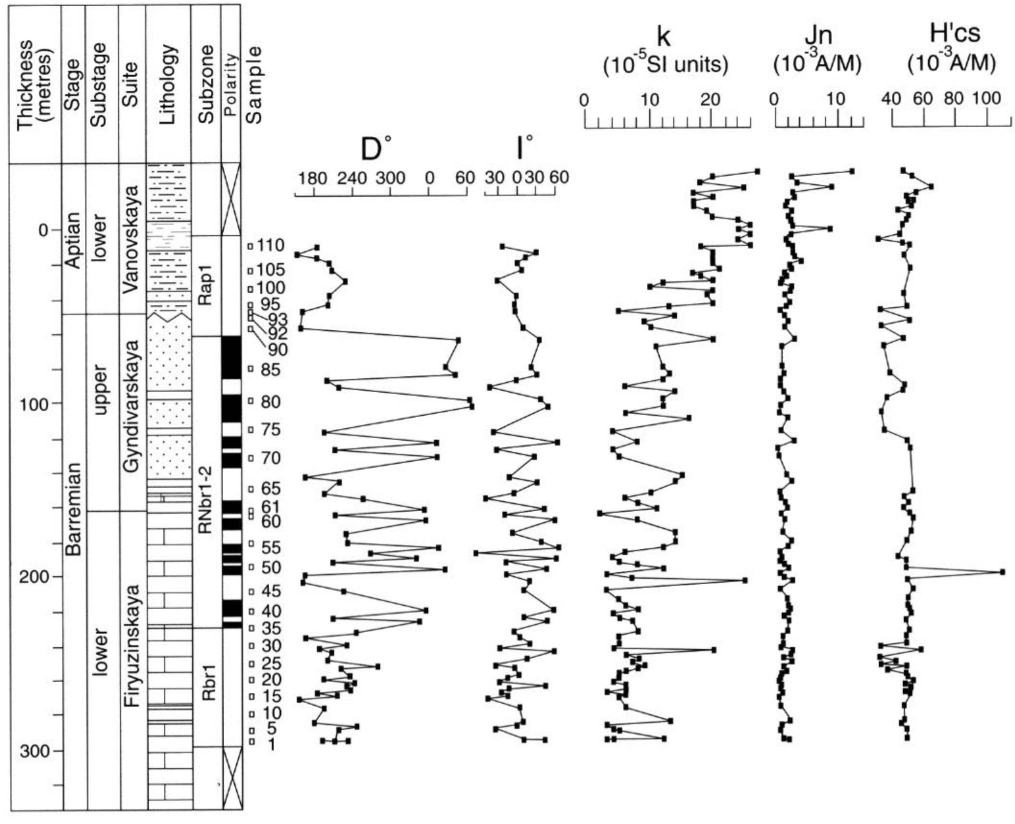
APPENDIX 4. — Palaeo- and petromagnetic characteristics of the Barremian-lower Aptian deposits from Gergebil Village.



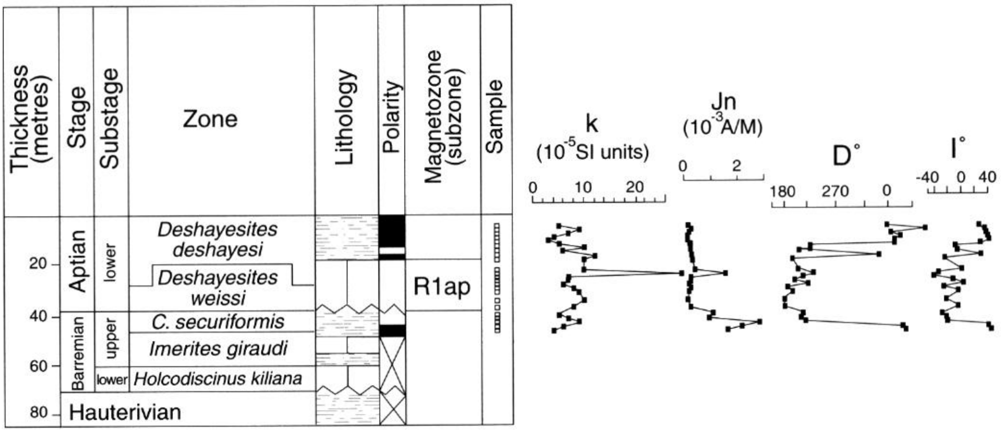
Appendix 5. — Palaeo- and petromagnetic characteristics of the Barremian-lower Aptian deposits from Akusha Village. Same legend as Appendix 4.



Appendix 6. — Palaeo- and petromagnetic characteristics of the Barremian deposits from the Urukh River. Same legend as Appendix 4.



APPENDIX 7. — Palaeo- and petromagnetic characteristics of the Barremian-lower Aptian deposits from the Segiz-Yab River. Same legend as Appendix 4.



APPENDIX 8. — Palaeo- and petromagnetic characteristics of the lower Aptian deposits from the Kislovodsk city. Same legend as Appendix 4.