Available online at www.sciencedirect.com

SciVerse ScienceDirect

Russian Geology and Geophysics 53 (2012) 895–905

RUSSIAN GEOLOGY AND GEOPHYSICS

www.elsevier.com/locate/rgg

Paleomagnetism of the Cretaceous sediments of the southern West Siberian Plate (from well 8 core studies)

Z.N. Gnibidenko *, N.K. Lebedeva, B.N. Shurygin

A.A. Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences, pr. Akademika Koptyuga 3, Novosibirsk, 630090, Russia

Received 15 April 2011; accepted 15 September 2011

Abstract

The paper presents magnetobiostratigraphical data on the Cretaceous sediments stripped by well 8 in the southern side of the Om' basin within the Om'–Lar'yak facies zone (southern West Siberia). The biostratigraphical data show that the sediments under study formed in the Albian–Maastrichtian. The componential analysis of natural remanent magnetization, based on thermal demagnetization and demagnetization with an alternating magnetic field, revealed the characteristic magnetization component. This confirms the paleomagnetic data used to compile the Cretaceous paleomagnetic section of the well. A paleomagnetic description was obtained, and a magnetobiostratigraphic key section of the Cretaceous sediments of the well was compiled on the basis of comprehensive data. It comprises five Upper Cretaceous regional horizons and same-named formations (Pokur, Kuznetsovo, Ipatovo, Slavgorod, Gan'kino), which have not been studied paleomagnetically at all in West Siberia. The magnetobiostratigraphic section comprises Albian–Maastrichtian stratigraphic units (43.5 Myr) and consists of three magnetozones. For example, the Pokur, Kuznetsovo, and Ipatovo Formations (total thickness 210 m), which show normal polarity with small reversed-magnetization horizons, form one long normal-polarity zone, *N*(al-st). The Slavgorod and Gan'kino Formations (total thickness 75 m), separated by a sedimentation gap, form two reversed-polarity magnetozones, R_1(km) and R_2(mt).

Reference datums (paleontologically well-constrained magnetozones) were used to correlate the magnetobiostratigraphic section with the common magnetostratigraphic and magnetochronologic scales. The long normal-polarity magnetozone *N*(al-st), spanning the Albian, Cenomanian, Turonian, Coniacian, and Santonian, matches the Dzhalal hyperzone and chron C34 (~112–83.6 Ma). The reversed-polarity zones, spanning most of the Campanian (R_1(km) (Slavgorod Formation)) and Maastrichtian (R_2(mt) (Gan'kino Formation)), match chrons C33(r) and C31(r) in the absolute chronology (~83.6–80 and 71–68.5 Ma, respectively) with a gap two chrons long (C33(n), C32).

Keywords: paleomagnetism; magnetobiostratigraphic section; magnetozone; polarity; dinocysts; spore–pollen assemblages; ammonites; Cretaceous sediments; Om' basin; southern West Siberia

Introduction

Regional paleomagnetic sections of key geologic provinces such as the West Siberian Plate are important for creating the world magnetic-polarity scale, understanding the development of the Earth's magnetic field, and solving a wide spectrum of applied geological and geophysical problems. World scientific literature contains ample data on Mesozoic paleomagnetism and magnetostratigraphy, both global and that in individual geologic provinces or regions. Progress in the development of the world Cretaceous magnetic-polarity scale greatly depends on the results of the future paleomagnetic studies on the continents in the key geologic provinces. In connection with this, note that the Upper Cretaceous sediments of the West Siberian Plate, which is one of the world's largest petroleum provinces, have not been subjected to any paleomagnetic studies. This paper opens a series devoted to the development of the Cretaceous magnetobiostratigraphic scale for the West Siberian Plate.

The present study is aimed at compiling a Cretaceous magnetobiostratigraphic section,based on comprehensive studies of core from well 8, drilled in the Russko-Polyanskii District, on the southern flank of the Om' basin, within the Om'–Lar'yak facies zone, southern West Siberia (φ = 53°31′ N; λ = 73°34′ E) (Fig. 1). The well crossed a Meso-Cenozoic rock unit almost 600 m thick and stopped at a depth of 593 m, in the Lower Cretaceous sediments of the Pokur Horizon. The geologic section of this area consists of marine and continental Meso-Cenozoic rocks, which form a

* Corresponding author.
E-mail address: gnibidenkozn@ipgg.nsc.ru (Z.N. Gnibidenko)

1068-7971/$ - see front matter © 2012, V.S. Sobolev IGM, Siberian Branch of the RAS. Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.rgg.2012.07.005

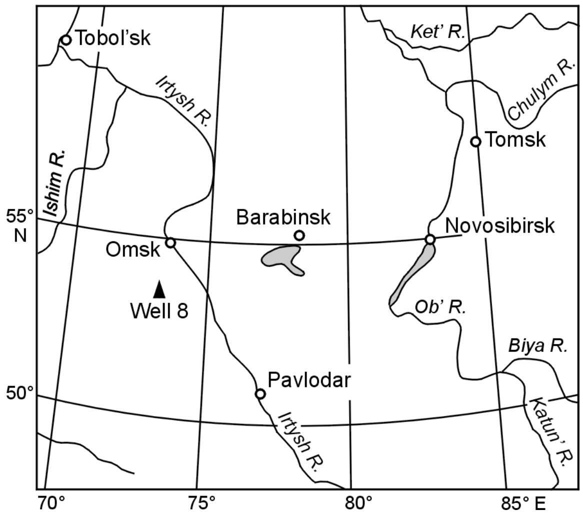

Fig. 1. Sketch map of the southern West Siberian Plate, with well 8.

platform cover overlying the eroded surface of pre-Jurassic sediments.

All of our studies were comprehensive and based on paleomagnetic, paleontological, geological, and stratigraphical data. Paleontological data (Gnibidenko et al., 2008; Lebedeva et al., 2012) were used to divide the section into the Pokur, Kuznetsovo, Ipatovo, Slavgorod, and Gan'kino Formations and to substantiate the age of the sediments under study.

Materials and methods of the paleomagnetic studies

In general, a standard technique was used to take oriented samples for the paleomagnetic studies and process the results (Khramov, 1982; Khramov and Sholpo, 1967; Molostovskii and Khramov, 1997; and others). Note that the oriented monolithic hand specimens were taken from the well in situ (as it was drilled). Cubic samples were handpicked or taken from the monolithic hand specimen with a Bishaev-type corer. In the wells, the cubic samples were cut out from the core center, so that the Z-axis was directed downward and the X- and Y-axes had arbitrary directions; that is, the samples were oriented vertically. Each stratigraphic unit was represented by two, three, or, sometimes, more cubic samples. During the laboratory treatment of these samples, the averages of magnetic parameters were calculated for the stratigraphic unit and the entire formation. The samples were taken at intervals of 0.8–1.0–1.5 m. To ensure accurate comprehensive studies, the oriented samples were taken simultaneously with samples and specimens for paleontological and lithostratigraphical studies. Log diagrams were used in the integrated studies of the well log. Componential analysis of natural remanent magnetization vectors (EOH, J_n) was performed by analyzing Zijderveld diagrams (1967), demagnetization plots, and magnetization directions during demagnetization with the software developed by R. Enkin (1994). The magnetization components were calculated by Kirschvink's least squares method (1980).

Natural remanent magnetization was measured with JR-4 and JR-6 devices, and magnetic resistivity was measured with KT-5 and KLY-2 meters. Demagnetization was carried out on TD48 and LDA-3A setups. A 5-P dc-field electromagnet with a maximum magnetizing field of 1088 kA/m was used to plot normal magnetization curves for the rock samples.

Geologic section and biostratigraphy

The Cretaceous sediments in the section are the clays, silts, siltstones, mudstones, sandstones, and sands of the Pokur, Kuznetsovo, Ipatovo, Slavgorod, and Gan'kino Formations (total thickness 320 m).

Lower Cretaceous. The Pokur Formation (K_{1-2}**pk**) (185 m thick, 593–408 m deep) is a thick unit of predominantly continental sediments, which overlie the Kiyalin Formation conformably and the pre-Jurassic rocks with a washout and an angular unconformity. It consists of alternating light gray to dark gray and greenish gray sands, sandstones, siltstones, clays, and mudstones. The lower part of the section is dominated by sandstones and siltstones with minor clay and mudstone interbeds. The clay content of the sediments increases upsection. The presence of pyrite and siderite indicates sedimentation in the reduction regime, in an alkalescent (pH = 8.4) water environment. This formation was dated by N.K. Lebedeva at the Late Cretaceous–Albian and Cenomanian–Turonian from the PA-I and PA-II spore–pollen assemblages and, in the upper part, from the DA-I dinocyst assemblage. From the Pokur sediments, we took 127 cubic samples, representing 48 stratigraphic units, for the paleomagnetic studies.

Upper Cretaceous. The Kuznetsovo Formation (K_2**kz**) (28 m thick, 408–380 m deep), overlying the Pokur Formation with a washout, marks the beginning of the Upper Cretaceous sea transgression. It consists of gray, dark gray, and greenish gray silty to sandy clays, which are compact and thinly laminated, and its upper part consists of sands. The clays are montmorillonitic, with hydromica; quartz pebbles; glauconite, pyrite, and siderite inclusions; and plant remnants. The sands are gray, fine, and micaceous. Beds with dinocysts typical of the Middle and Upper Turonian were identified within the Kuznetsovo Formation (407.1–380 m) by Lebedeva.

The sedimentation took place in a shallow sea, in a transitional redox environment, and under changeable climatic conditions in an alkalescent (pH = 8.4) water environment. We took 36 cubic samples, representing 16 stratigraphic units, from this formation for the paleomagnetic studies.

The Ipatovo Formation (K_2**ip**) (37 m thick, 380–343 m deep), overlying the clays of the Kuznetsovo Formation with a washout, consists of nonuniformly interbedded sands and minor sandstone, silt, and clay interbeds. The rocks are gray, dark gray, and greenish gray, with plant detritus and pyrite and glauconite inclusions. The sands and sandstones are ultrafine-, fine-, or coarse-grained, quartz-glauconitic and feldspar-quartz, low-mica, with rounded quartz and cherty pebbles and rare gravelstone interbeds. The silts are compact, clayey, sandy, and calcareous. The clays are silty and sandy, montmorillonitic (sometimes, gaizelike), with rare quartz pebbles. At depths of 372.1–343 m, Lebedeva identified the PA-III spore–pollen assemblage, which constrains the formation at the Coniacian–Santonian along with the DA-II dinocyst assemblage. Marine conditions persisted during the accumulation of the Ipatovo Formation, as evidenced by the presence of gaize, glauconite, and foraminifers (Podobina and Kseneva, 2007). The sedimentation took place in frequently changing environments, with the formation of glauconite (when the water level fell almost to the sediment roof) or pyrite (when the water level rose dramatically). Cooling took place, judging by the presence of opal and the absence of calcium carbonates from the rocks. From the Ipatovo sediments, we took 75 cubic samples, representing 25 stratigraphic units, for the paleomagnetic studies.

The Slavgorod Formation (**K_2sl**) (21 m thick, 343–319 m deep), overlying the Ipatovo Formation with a local washout, consists of locally gaizelike clays interbedded with silts, siltstones, sands, and sandstones. The silts and siltstones are clayey, sandy, glauconitic and quartz-glauconitic, and micaceous. The rocks are fractured and contain plant remnants, bivalve fragments, and pyrite inclusions. At depths of 339.9–311.2 m, Lebedeva identified the DA-III dinocyst assemblage, which constrains this stratigraphic unit at the Campanian. Also, this interval contains the PA-IV spore–pollen assemblage, which is Campanian, according to regional stratigraphic charts. The sedimentation took place in a sea basin, under transitional redox (glauconite–pyrite) conditions in an alkalescent low-temperature water environment.

Form the Slavgorod Formation, we took 73 cubic samples, representing 22 stratigraphic units, for the paleomagnetic studies.

The Gan'kino Formation (**K_2gn**) (46 m thick, 319–273 m deep), overlying the Slavgorod Formation with a local washout, consists of gray, greenish gray, and dark gray clays and siltstones, which are compact and locally gaizelike. Sands and sandstones are of minor importance; they are glauconitic, gray, dark gray, and dark green. The entire formation contains pyrite accumulations and rare plant detritus. Calcareous interbeds with abundant fauna are observed at its base. This formation is rich in fossils, including the DA-IV and DA-V dinocyst assemblages and the PA-V spore–pollen assemblage (identified by Lebedeva) as well as bivalves, ammonites, and gastropods (identified by B.N. Shurygin). The DA-IV dinocyst assemblage (depth 309.9–288.4 m) constrains this stratigraphic interval at the Early Maastrichtian, and *Hoploscaphites* cf. *constrictus constrictus* ammonites from the interval 288–288.5 m constrain it at the late Early Maastrichtian, Acanthoscaphites tridens Zone, Belemnella sumensis Subzone. The DA-V dinocyst assemblage higher upsection (288.3–274.2 m) constrains the host interval at the Early–Late Maastrichtian boundary. The appearance of *Cerodinium speciosum* marks the Lower–Middle Maastrichtian boundary. The PA-V spore–pollen assemblage, identified within the Gan'kino Formation, is Maastrichtian, according to the 2003 stratigraphic charts. The uppermost part of the formation (depth 273.5–268.6 m) contains *Operculodinium centrocarpum*, *Chatangiella* spp., *Cerodinium diebelii*, and other Maastrichtian dinocyst index species. The Gan'kino Formation is overlain by the Talitsa Formation with a washout.

The sedimentation took place in an open sea basin, during relative warming in an alkaline reducing medium.

From the Gan'kino Formation, we took ~140 oriented cubic samples, representing 46 stratigraphic units, for the paleomagnetic studies.

Results

Magnetic properties of the rocks. We took ~500 oriented cubic samples, representing 159 stratigraphic units, from the Cretaceous sediments in the well (total thickness 320 m). In general, these sediments are weak-magnetic and have very inhomogeneous magnetic properties. Their magnetic susceptibility varies from 4.7 to 135.7×10^{-5} SI units, and their natural remanent magnetization (NRM) varies from fractions of unity to 33.5 mA/m. The Koenigsberger ratio (Q), which is the ratio of NRM to induced magnetization ($Q = J_n/\chi H_i$), varies from 0.01 to 4.12. The viscous magnetization J_{nv} of the studied rocks is 5–40% of the NRM. The Slavgorod clays and gaize showed the minimum magnetic susceptibility ($\chi = 9.6$–23.4×10^{-5} SI units, the average being 11.7×10^{-5} SI units). The Pokur red-colored clays, siltstones, and mudstones showed the maximum magnetic susceptibility and NRM (χ = 7.1–135.7 $\times 10^{-5}$ SI units; J_n = 0.7–33.5 mA/m). The magnetic characteristics of the Cretaceous marine and continental sediments by formations are given in more detail in Table 1.

Analysis of the distribution of χ and J_n values over the section shows that the fluctuations in J_n are due to changes of the sedimentation conditions and provenance areas of terrigenous matter. The variations in magnetic susceptibility and NRM observed in the Cretaceous continental and marine rocks from the bottom upward indicate that these parameters are geologically informative enough and can be used for well log correlation.

Magnetization carriers, composition, and origin of natural remanent magnetization. Analysis of the magnetic-mineral distribution in the Cretaceous sediments showed that the magnetic-mineral compositions of the Cretaceous marine and continental rocks were somewhat different. When the magnetic minerals (magnetization carriers) were identified, emphasis was placed on magnetic-mineralogy methods, because these minerals are finely dispersed (grain size <0.01 mm). The magnetization carriers were identified using analysis of the normal-magnetization parameters (I_r, H_s) and the interpretation of thermal-demagnetization curves. These methods permitted accurate enough identification of magnetite, maghemite, hematite, and iron hydroxides. The saturation remanent magnetization $J_r(H)$ from the normal-magnetization curves is 650–825 mA/m for the Pokur Formation, the saturation field H being 280–360 kA/m (Fig. 2, *a*, *b*). For the Ipatovo Formation, J_r varies from 65 to 225 mA/m at a saturation field equal to 360–440 kA/m (Fig. 2, *c*). The

Table 1. Magnetic characteristics of the Cretaceous sediments stripped by well 8 (Russko-Polyanskii District, southern side of the Om' basin)

Formation, rock	$N(n)$	χ, 10^{-5} SI unit	J_n, mA/m	Q
Pokur (clays, siltstones, mudstones, sandstones)	48 (127)	$\frac{7.1–135.7}{18.1}$	$\frac{0.7–33.5}{5.47}$	$\frac{0.10–4.12}{0.70}$
Kuznetsovo (clays, silty clays)	16 (36)	$\frac{8.4–46.6}{14.9}$	$\frac{0.14–1.18}{0.58}$	$\frac{0.01–0.19}{0.10}$
Ipatovo (sands, sandstones, silts, clays)	26 (75)	$\frac{8.4–49.8}{22.4}$	$\frac{0.15–1.13}{0.78}$	$\frac{0.01–0.23}{0.16}$
Slavgorod (clays, gaize, silts, siltstones, sandstones)	36 (111)	$\frac{9.6–23.4}{11.7}$	$\frac{0.36–3.43}{1.24}$	$\frac{0.04–0.71}{0.22}$
Gan'kino (clays with sandstone and sand interbeds)	34 (98)	$\frac{4.7–48.2}{16.7}$	$\frac{0.2–1.02}{0.48}$	$\frac{0.01–0.34}{0.07}$

Note. *N*, Number of stratigraphic units; *n*, number of cubic samples. Numerator shows the minimum and maximum values of the magnetic parameters, whereas the denominator shows the averages (stratigraphic-unit statistics).

saturation remanent magnetization $J_r(H)$ of the Slavgorod and Gan'kino Formations is 375–600 mA/m at a saturation field equal to 520 kA/m (Fig. 2, *d*, *e*). The great saturation-field values for the Gan'kino and Slavgorod Formations at small magnetization values as compared with those for the Pokur Formation indicate that hard-magnetic minerals of the hematite group are present among the magnetization carriers. The small saturation-field values for the Pokur Formation suggest that the magnetization carriers are minerals of the magnetite–titanomagnetite group.

Demagnetization and componential analysis were carried out to detect the characteristic remanent magnetization (ChRM) in the total EOH. Thermal demagnetization revealed two magnetization components (low-temperature, high-temperature) in most of the Cretaceous rocks of the well. The former is usually detected at up to 100–200–300 °C, and the latter persists at up to 550–600 °C (Fig. 3, *A*). Some Zijderveld diagrams indicate that the magnetization vectors are stable throughout the temperature range (Fig. 3, *B*).

Demagnetization with an alternating magnetic field also revealed the presence of one or two magnetization components: an unstable one, detected within small alternating fields (up to 12–20 mT) and a highly stable one (fields of 20–80 mT). Some rock samples are very stable in relation to the alternating magnetic field, when only 10% of the NRM is removed from fields of 100–110 mT and the magnetization vector remains unchanged. The most efficient demagnetization method for the Cretaceous rocks in the well is thermal demagnetization.

All the rocks under study except the Pokur siltstones are clays, silts, siltstones, sandstones, and sands belonging to sedimentary rocks with depositional magnetization, which is produced during the deposition of magnetic-mineral particles owing to the statistical equalization of their magnetic moments in the direction of the Earth's current magnetic field. Small values of the Koenigsberger ratio (hundredths and tenths) also confirm the depositional origin of the magnetization of these rocks. The Pokur siltstones at depths of 495–482 m have depositional-chemical magnetization, as evidenced by Q varying from 1.5 to 4.12.

Componential analysis of NRM, based on the results of thermal demagnetization and demagnetization with an alternating magnetic field, revealed the characteristic (primary) magnetization component. The studied rocks of the Pokur, Kuznetsovo, Ipatovo, Slavgorod, and Gan'kino Formations showed predominant normal and subordinate reversed magnetization. The distribution of differently directed characteristic magnetization over the well log (paleomagnetic section) is shown in Fig. 4.

Magnetobiostratigraphic section. The paleomagnetic column, based on the characteristic magnetization component and correlated with the paleontological data, is clearly divisible into three magnetozones (from the bottom upward), one with normal polarity and two with reversed polarity, and has the following structure. In general, the Pokur Formation (185 m thick), constrained by the PA-I and PA-II spore–pollen assemblages and by the DA-I dinocyst assemblage (Albian–Turonian) in its uppermost part shows normal polarity. Also, it contains two thin horizons with reversed magnetization in its lower (545–543 m) and middle (468–466 m) parts (Fig. 5). According to the spore–pollen dating, the former is Albian, and the latter is Cenomanian. The Kuznetsovo, Ipatovo, and the lowermost Slavgorod Formation, constrained by the PA-II and PA-III spore–pollen assemblages and the DA-I and DA-II dinocyst assemblages at the Turonian and the Coniacian–Santonian, also show normal polarity. It is accompanied by three reversed-magnetization horizons in the lower, middle, and upper parts of this interval (Fig. 5). The lower horizon with reversed magnetization (14 m thick, interval 406–392 m) is localized in the middle Kuznetsovo Formation. Two other reversed-magnetization horizons are localized in the lower (372–368 m) and upper (347–345 m) parts of the Ipatovo Formation. According to the dinocyst and spore–pollen data, the *R*-horizon in the Kuznetsovo Formation is Middle–Upper Turonian, and two overlying *R*-horizons are Coniacian–Santonian. The Slavgorod and Gan'kino Formations, constrained

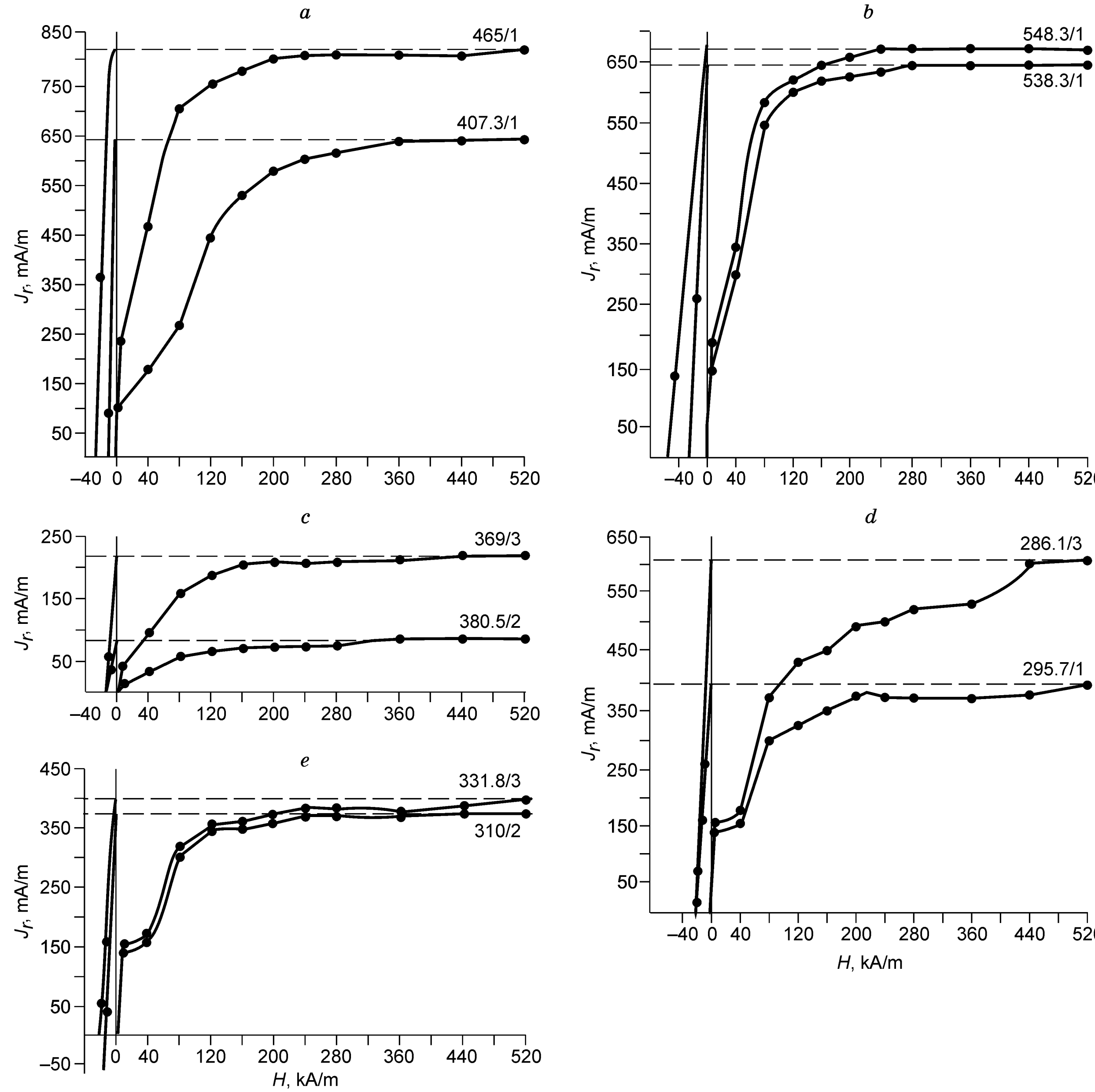

Fig. 2. Normal-magnetization plots for rock samples from the Pokur (*a*, *b*), Ipatovo (*c*), Gan'kino, and Slavgorod (*d*, *e*) Formations. Figures show the numbers of the samples.

by the PA-IV and PA-V spore–pollen assemblages and DA-III, DA-IV, and DA-V dinocyst assemblages at the Campanian and Maastrichtian, show reversed polarity up to the Paleogene boundary. The only exception is the 3-m-thick normal-magnetization horizon at the base of the Slavgorod Formation, which belongs to the upper part of the underlying normal-polarity magnetozone. The lower Gan'kino Formation (312–310.5 m) shows reversed polarity with an *N*-horizon. The reversed polarity of the Slavgorod Formation, dated on the basis of the paleontological data (dinocysts, spore–pollen asemblages) at the Campanian, and that of the Lower Maastrichtian Gan'kino Formation (bivalves, ammonites, gastropods, dinocysts, spore–pollen assemblages) suggest that the Upper Campanian, with corresponding flora, fauna, and normal polarity, is missing from the section (sedimentation gap). This permits identifying two reversed-polarity magnetozones, separated by a gap as big as the normal-polarity interval in the Campanian Stage (Gradstein et al., 2008): one in the Slavgorod Formation (Campanian) and the other in the Gan'kino Formation (Maastrichtian). Thus, the Pokur, Kuznetsovo, and Ipatovo Formations (total thickness 210 m), which show normal polarity with five reversed-magnetization horizons, form one thick normal-polarity zone, *N*(al-st). The Slavgorod and Gan'kino Formations (75 m thick) form two reversed-polarity magnetozones, R_1(km) and R_2(mt). As regards the paleomagnetic record as a whole, the gaps (up to 10 m thick) in the paleomagnetic column do not preclude the existence of r-intervals. However, such intervals hardly affect

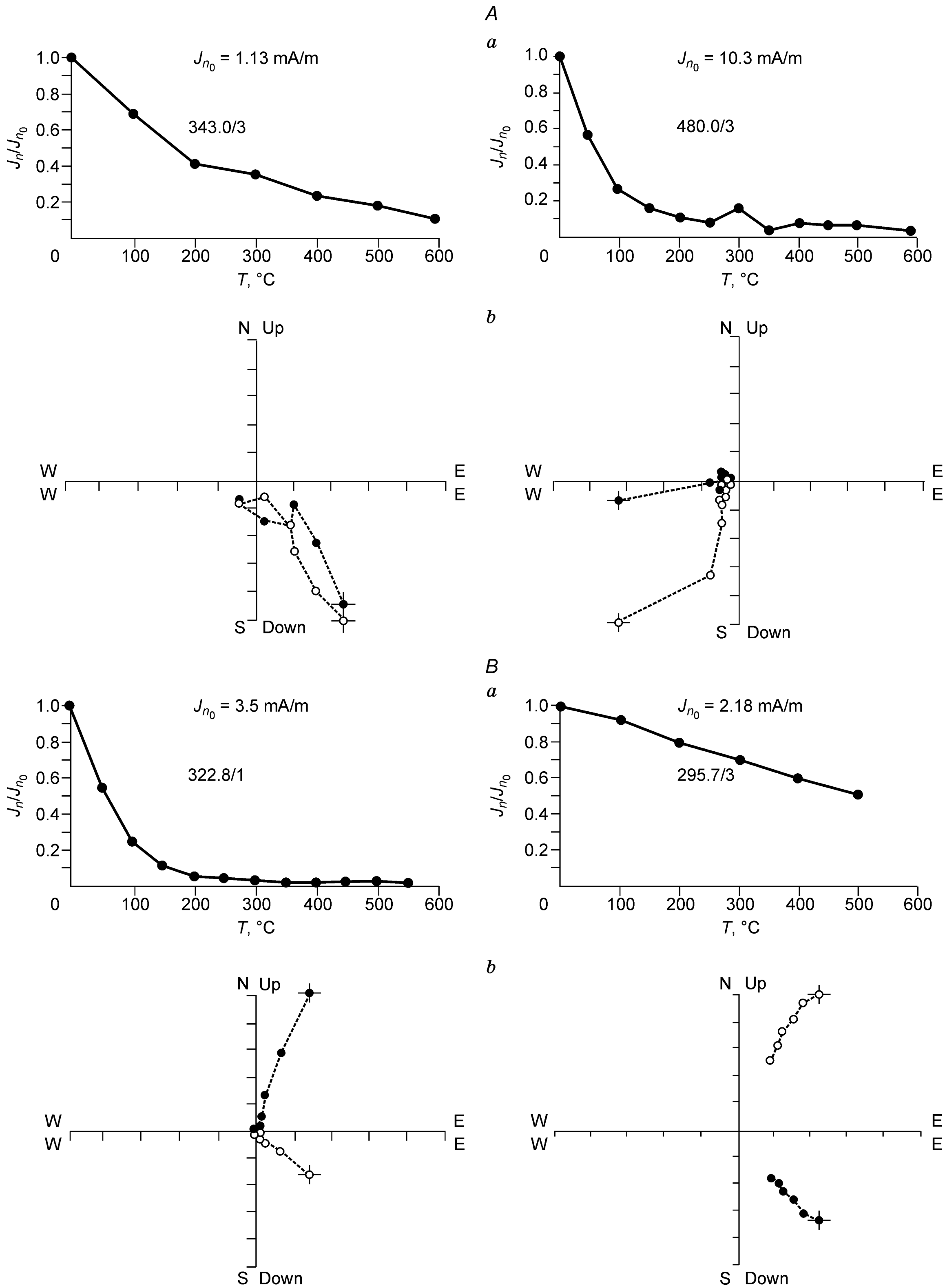

Fig. 3. Characteristic thermal-demagnetization plots for J_n and Zijderveld diagrams for the Cretaceous rocks stripped by the well: *a*, normalized thermal-demagnetization curve for J_n; *b*, Zijderveld diagram, J_n projections onto horizontal (dark symbols) and vertical (light symbols) planes. See text for *A* and *B*.

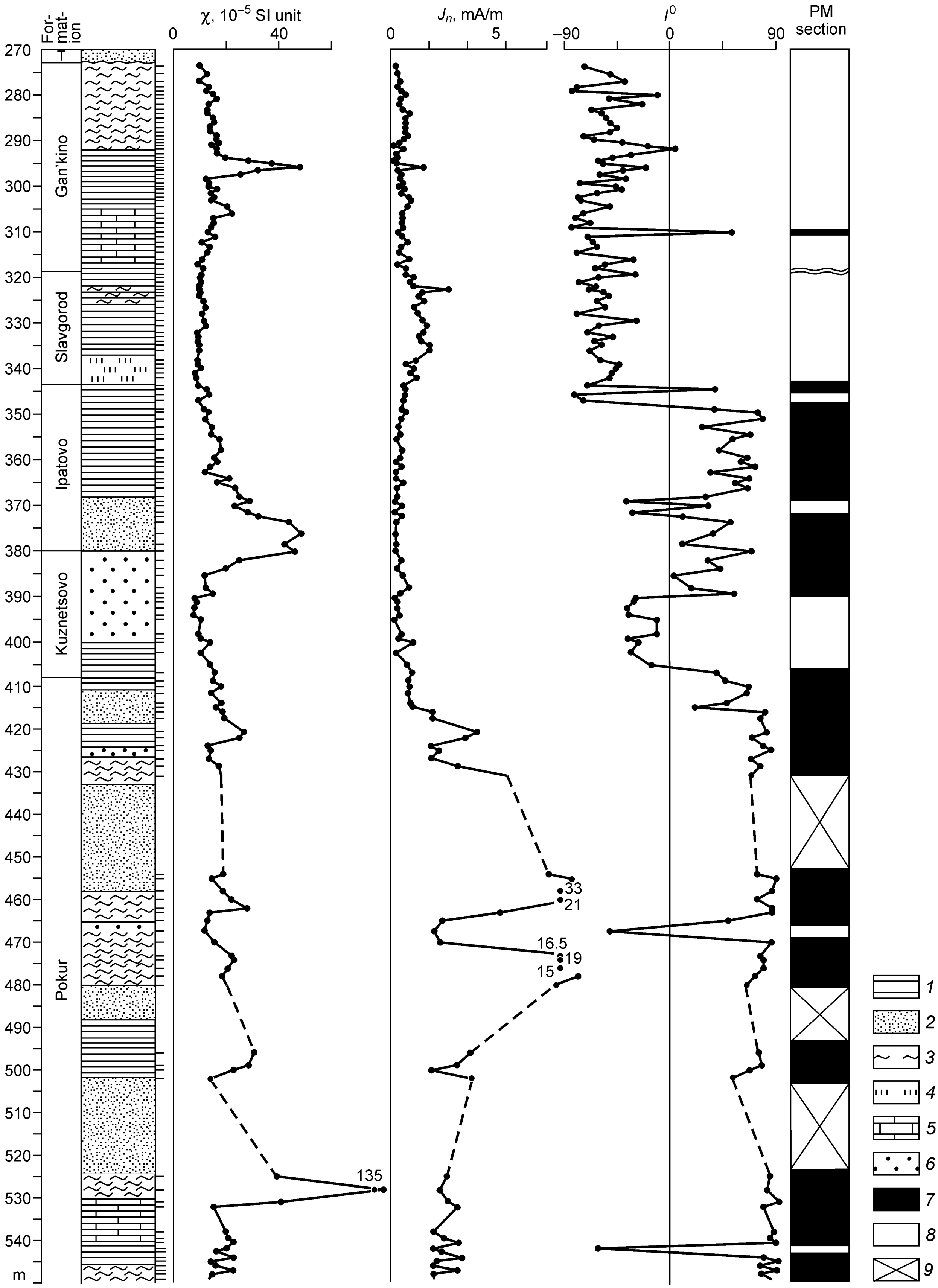

Fig. 4. Cretaceous paleomagnetic section, stripped by well 8. *1*, clays; *2*, sand; *3*, silt, siltstone; *4*, gaize; *5*, sandstone; *6*, gravelstone; geomagnetic polarities: *7*, normal; *8*, reversed; *9*, no data available.

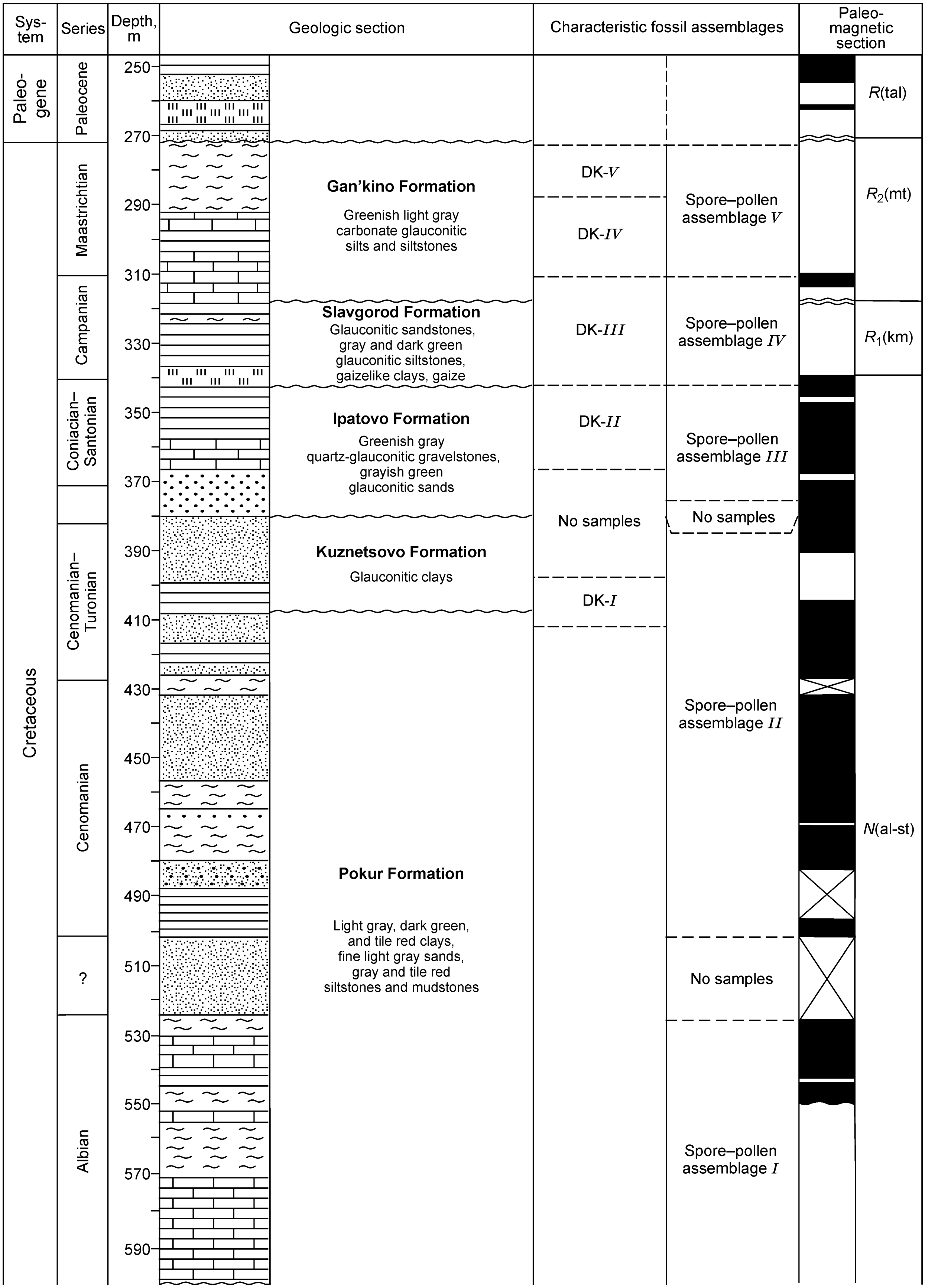

Fig. 5. Cretaceous magnetobiostratigraphic section of well 8. See legend in Fig. 4.

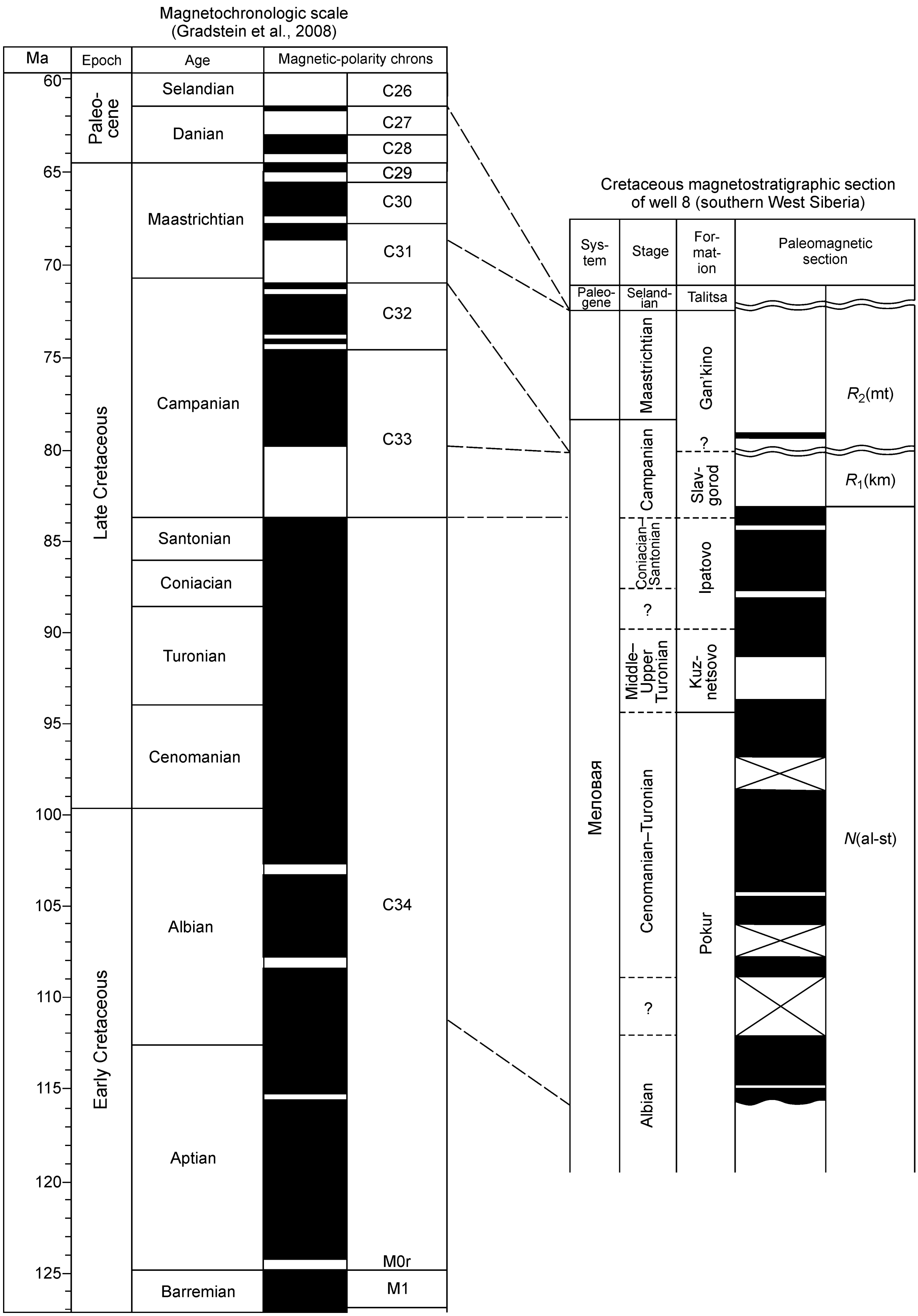

Fig. 6. Correlation between the Cretaceous magnetobiostratigraphic section of well 8 and the magnetochronologic scale (Gradstein et al., 2008).

the paleomagnetic structure of the zone and its correlation with the world scale. Thus, the paleomagnetic column, based on the paleontological and lithostratigraphical data, was correlated with the regional stratigraphic scale.

The resulting magnetobiostratigraphic section can be correlated with world scales on the basis of the reference datums (magnetozones well-constrained by the paleontological data). Nowadays, there are several magnetostratigraphic (Guzhikov et al., 2007; Molostovskii, 2002; Zhamoida, 2000; and others) and magnetochronologic (Cande and Kent, 1992; Gradstein et al., 1995, 2004, 2008; Harland et al., 1982; and others) scales. Both are permanently improved and revised on the basis of new data derived from paleomagnetic studies on the continents in the key geologic provinces. The long normal-polarity magnetozone *N*(al-st), spanning the Albian, Cenomanian, Turonian, Coniacian, and Santonian, matches the Dzhalal hyperzone on the common magnetostratigraphic scale (Molostovskii, 2002; Zhamoida, 2000; and others) and is correlated with chron C34 on the World Magnetochronologic Scale (~112.5–83.6 Ma) (Gradstein et al., 2004, 2008). Two reversed-polarity magnetozones, spanning most of the Campanian (R_1(km), Slavgorod Formation) and the Maastrichtian (R_2(mt), Gan'kino Formation), match chrons C33(r) and C31(r) in the absolute chronology (83.6–80 and 71–68.5 Ma, respectively) (Fig. 6). In Fig. 6, the Cretaceous magnetstratigraphic section of the well is shown in the chronologic version.

Comparing the Cretaceous magnetobiostratigraphic section of well 8 with the World Magnetochronologic Scale (Gradstein et al., 2008) makes it possible to estimate the gap between the Slavgorod (R_1(km)) and Gan'kino (R_2(mt)) Formations: It lasts for ~9 Myr, spanning part of the Upper Campanian. Thus, normal-polarity chrons C33(n) and C32 (Upper Campanian, 80–71 Ma) are missing from the section. The duration of the gap between the Gan'kino (R_2(mt)) and Talitsa (*R*(tal)) Formations will depend on that of chrons C31(n), C30, C29, C28, and C27 (~68.5–61.5 Ma).

One of the important results of this work is the detection of a 14-m-thick *R*-horizon (Turonian) in the long normal monopolar magnetozone *N*(al-st), corresponding to the Albian, Cenomanian, Turonian, Coniacian, and Santonian. This is further evidence for the more intricate structure of the Cretaceous normal monopolar superchron, in which new reversals and episodes are being detected (Guzhikov et al., 2007).

Conclusions

Detailed paleomagnetic studies and paleontological data made it possible to compile a Cretaceous magnetobiostratigraphic section of well 8, drilled into the southern edge of the Om' basin (southern West Siberia). The resulting biostratigraphical data show that the sediments under study formed in the Albian–Maastrichtian. We detected a long normal-polarity magnetozone, *N*(al-st), spanning the Albian, Cenomanian, Turonian, Coniacian, and Santonian (Pokur, Kuznetsovo, Ipatovo Formations), with five reversed-magnetization horizons (chron C34). The upper part of the studied sediments contains two reversed-polarity magnetozones, which span the lower Campanian (R_1(km), Slavgorod Formation) and the lower Maastrichtian (R_2(mt), Gan'kino Formation) (chrons C33(r), C31(r)), with a gap in between (chrons C33(n), C32). The accuracy of the paleomagnetic data which served as the basis for the Cretaceous paleomagnetic section of this well was determined by the composition of the rock NRM, the possibility of identifying the primary component, and structural similarity between the Cretaceous paleomagnetic section of the well and the magnetostratigraphic and magnetochronologic scales as well as magnetostratigraphic sections of coeval sediments in other regions such as the Tuarkyr area, Caucasus, Kopet Dag, and Volga region (Guzhikov et al., 2007).

The study was supported by the Russian Foundation for Basic Research (grants no. 09-05-00210, 10-05-00021) and the Presidium of the Russian Academy of Sciences (grants "Fundamental Problems of Oceanology: Physics, Geology, Biology, and Ecology," "Origin of the Biosphere and Evolution of Geobiologic Systems").

References

Cande, S.C., Kent, D.V., 1992. A new geomagnetic polarity time scale for the Late Cretaceous and Cenozoic. J. Geophys. Res. 97 (B10), 13,917–13,951.

Enkin, R.J., 1994. A computer program package for analysis and presentation of palaeomagnetic data. Pacific Geosci. Centre, Geol. Surv. Canada, Sidney, Canada.

Gnibidenko, Z.N., Lebedeva, N.K., Dolya, Zh.A., 2008. Magnetostratigraphical and spore–pollen analysis of Cretaceous sediments in well 8, Russko-Polyanskii District (southeastern West Siberia), in: Dzyuba, O.S., Zakharov, V.A., Shurygin, B.N. (Eds.), Proc. IV All-Russ. Conf. on the Cretaceous System of Russia and FSU Countries: Problems of Stratigr. and Paleogeogr. (Novosibirsk, 19–23 September 2008) [in Russian]. Izd. SO RAN, Novosibirsk, pp. 58–61.

Gradstein, F.M., Agterberg, F.P., Ogg, J.G., Hardenbol, J., van Veen, P., Thierry, J., Huang, Z., 1995. A Triassic, Jurassic and Cretaceous time scale, in: Berggren, W.A., Kent, D.V., Aubry, M.-P., Hardenbol, J. (Eds.), Geochronology, Time Scales, and Global Stratigraphic Correlation, SEPM Spec. Publ., Vol. 54, pp. 95–126.

Gradstein, F.M., Ogg, J.G., Smith, A.G., 2004. A Geologic Time Scale. Cambridge Univ. Press, Cambridge, United Kingdom.

Gradstein, F.M., Ogg, J.G., van Kranendonk, M., 2008. On the geologic time scale 2008. Newsl. Stratigr. 43 (1), 5–13.

Guzhikov, A.Yu., Baraboshkin, E.Yu., Fomin, V.A., 2007. The Cretaceous magnetostratigraphic scale: state of the art, problems, and outlook, in: Pervushov, E.M. (Ed.), The Cretaceous System of Russia and FSU Countries: Problems of Stratigraphy and Paleogeography [in Russian]. Izd. Saratovsk. Gos. Univ., Saratov, pp. 69–87.

Harland, W.B., Cox, A.V., Llewellyn, P.G., Pickton, C.A.G., Smith, A.G., Walters, R.W., 1982. A Geologic Time Scale. Cambridge Univ. Press, Cambridge, United Kingdom.

Khramov, A.N. (Ed.), 1982. Paleomagnetology [in Russian]. Nedra, Leningrad.

Khramov, A.N., Sholpo, L.E., 1967. Paleomagnetism; Principles, Methods, and Geological Applications of Paleomagnetology [in Russian]. Nedra, Leningrad.

Kirschvink, J.L., 1980. The least-squares line and plane and the analysis of palaeomagnetic data. Geophys. J. R. Astron. Soc. 62 (3), 699–718.

Lebedeva, N.K., Aleksandrova, G.N., Shurygin, B.N., Ovechkina, M.N., Gnibidenko, Z.N., 2012. Paleontological and magnetostratigraphic description of Upper Cretaceous sediments in well 8, Russko-Polyanskii District (southern West Siberia). Stratigrafiya. Geologicheskaya Korrelyatsiya, No. 5, 65–78.

Molostovskii, E.A., 2002. Phanerozoic magnetic-polarity scale, its structure and significance for stratigraphy and geodynamics, in: Geology, Geochemistry, and Geophysics between the 20th and 21st Centuries [in Russian], Vol. 3: Geophysics. Regional'naya Obshchestvennaya Organizatsiya Uchenykh po Problemam Prikladnoi Geofiziki, Moscow, pp. 63–64.

Molostovskii, E.A., Khramov, A.N., 1997. Magnetostratigraphy and Its Geological Implications [in Russian]. Izd. Saratovsk Gos. Univ., Saratov.

Podobina, V.M., Kseneva, T.G., 2007. Upper Cretaceous stratigraphy and microfauna of southern West Siberia. Izv. Biisk. Otdeleniya RGO, Issue 28, 26–30.

Zhamoida, A.I. (Ed.), 2000. Supplement to the Russian Stratigraphical Code [in Russian]. Izd. VSEGEI, St. Petersburg.

Zijderveld, J.D.A., 1967. A.C. demagnetization of rocks: Analysis of results, in: Collinson, D.W., Creer, K.M., Runcorn, S.K. (Eds.), Methods in Palaeomagnetism, Proc. of the NATO Advanced Study Inst. on Palaeomagnetic Methods (Newcastle upon Tyne, 1–10 April 1964), Developments in Solid Earth Geophys. (Vol. 3). Elsevier, Amsterdam, pp. 254–286.

Editorial responsibility: A.D. Duchkov