Lithology and Mineral Resources, Vol. 39, No. 3, 2004, pp. 203–212. Translated from Litologiya i Poleznye Iskopaemye, No. 3, 2004, pp. 241–251.

Lithofacies Features and Formation Conditions of Aptian–Albian Rocks in the Western Ciscaucasus

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Received December 19, 2001

Abstract—The composition of Aptian–Albian rocks in the western Ciscaucasus is considered. Their lithofacies features and formation conditions are established. The data obtained can be used to determine the mineralogical potential of terrigenous complexes of the western Ciscaucasus.

Numerous works are devoted to investigation of Aptian–Albian rocks of the western Ciscaucasus (Zhabreva, 1965a, 1965b; Zhabreva *et al.,* 1965; Drushchits and Mikhailova, 1960, 1979; Egoyan, 1964; Luppov, 1952; Mordvilko, 1960; *Nizhnii*…, 1985). However, the investigation of lithofacies features and formation conditions and the construction of separate lithological-paleogeographic maps for the Lower Aptian, Middle–Upper Aptian, and Albian rocks have not been carried out. However, lithofacies studies and paleogeographic reconstructions allow us to estimate the mineralogical potential of the rocks under investigation.

MATERIALS

The study area embraces the western part of the epi-Paleozoic Scythian Platform where the Irklievskaya Depression, Kanevskaya–Berezanskaya Swell, Timashevsk Step, western centricline of the West Kuban Foredeep, East Kuban Foredeep, West Stavropol Depression, and Adygeya Uplift of the North Caucasian Marginal Massif are located (Letavin and Prerva, 1987; Letavin *et al*., 1987). The Azov Uplift located in the northwest belongs to the pre-Cambrian Russian Platform. The West Caucasus Meganticlinorium (Alpine fold–block structure) situated in the south includes the Abin–Gunaika and Novorossiisk synclinoria and the Goitkha Anticlinorium. A fragment of the Transcaucasian Median Massif occupies the marginal southeastern part of the study area (Lunev and Serezhenko, 1972), but the major part of this massif is situated beyond the studied territory.

This work is based on the lithological study of 55 sections of Aptian and Albian rocks and the overview of data on 102 exploration boreholes. Figure 1 shows the typical logs. Description of the key section was accompanied by sampling. The samples were studied under microscope and analyzed by the mineralogical, X-ray, and thermal methods.

LITHOLOGICAL FEATURES OF APTIAN AND ALBIAN ROCKS

Analysis of the composition and structure of Aptian and Albian rocks in the western Ciscaucasus showed that the lower Aptian, Middle–Upper Aptian, and Albian rocks significantly differ from each other.

The **Lower Aptian rocks** are exposed as a narrow continuous band in the Novorossiisk and Abin–Gunaika synclinoria. In the Goitkha Anticlinorium, they are locally found in the interfluve of the Abin and Ubin rivers and upper reaches of the Papai and Shebsh rivers. Additionally, these rocks crop out at the southeastern termination of the West Kuban Foredeep (Pshekha River) and on the Adygeya Uplift (Kurdzhips River). Exploration boreholes recovered Lower Aptian rocks in the southeastern part of the West Kuban Foredeep and western centricline of the East Kuban Foredeep. The presence of alternating units of sandstones, siltstones, clays and, more rarely, conglomerates, with the predominance of sandstones and siltstones at the base of all sequences of the West Caucasus Meganticlinorium is a characteristic feature (Fig. 1). The thickness of these rock units is 7–100 m in the Abin–Gunaika Synclinorium and 80–180 m in the Novorossiisk Synclinorium. The upper part of the sequence includes clays with siderite concretion horizons. The western and eastern parts of the meganticlinorium are dominated by silty and sandy clays, respectively. Interlayers of limestones and carbonaceous clays are present in the southern sequences (Fig 1, Section I). The content of terrigenous material in the clays is increased in some places (Pshada, Afips, Bezeps, Shebsh, and Psish rivers). The thickness of the Lower Aptian sequence is 200–750 m.

In the West Kuban Foredeep (Fig. 1, Section III) and on the Adygeya Uplift (Kurdzhips River), the Lower Aptian section (50–100 m) is composed by an alternation of clays, siltstones, sands, sandstones, and gritstones. On the Adygeya Uplift, clays are present as a subordinate component including frequent thin inter-

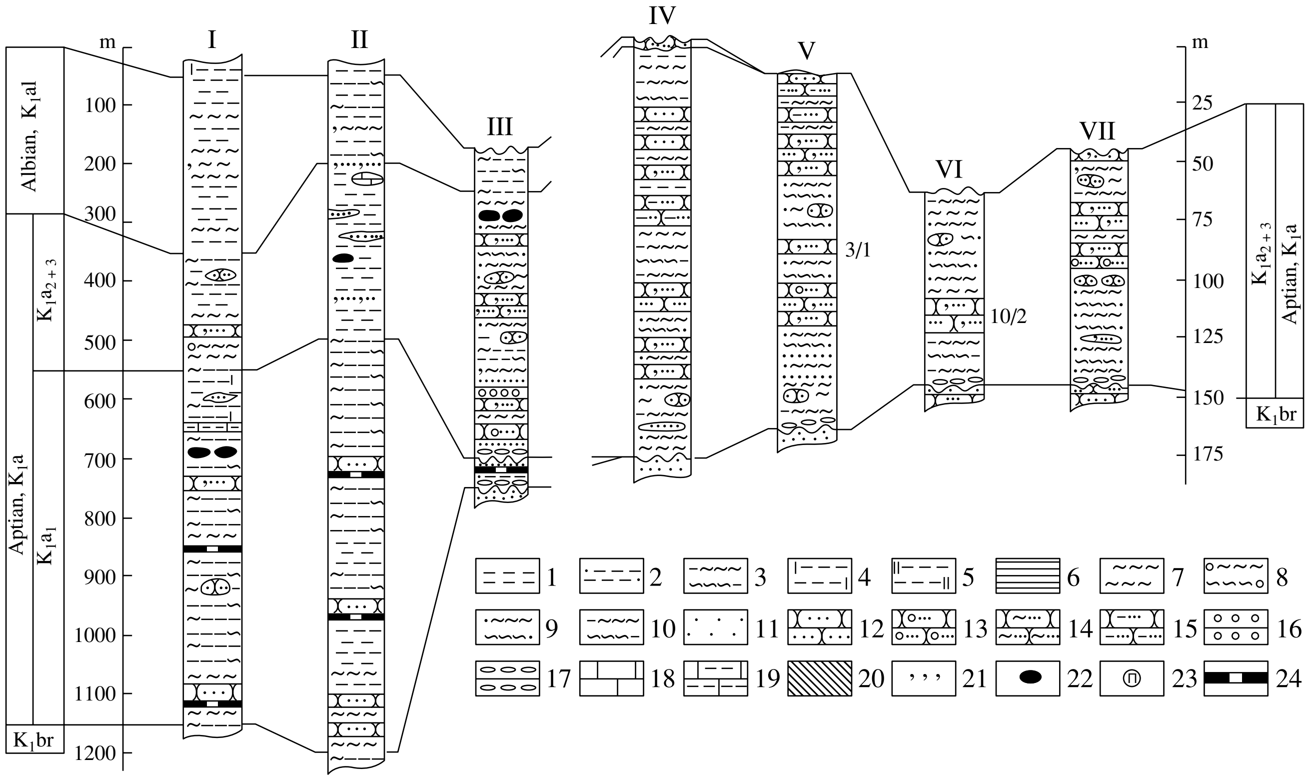

Fig. 1. Correlation scheme of Aptian–Albian sections of the Western Ciscaucasus. Sections: (I) Pshada River, (II) Il River, (III) Pshekha River, (IV) Khokodz-Polkovnichii interfluve zone, (V) Borehole 2 (Semiyablonevyi Spring), (VI) Belaya River, (VII) Fars River. Numbers near stratigraphic columns designate numbers of samples studied. Lithological composition: (1) clays, (2) sandy clays, (3) silty clays, (4) calcareous clays, (5) calcareous clays, (6) mudstones, (7) siltstones, (8) gravelly siltstones, (9) sandy siltstones, (10) clayey siltstones, (11) sands, (12) sandstones, (13) gravelly sandstones, (14) silty sandstones, (15) clayey sandstones, (16) gritstones, (17) conglomerates, (18) limestones, (19) pelitic limestones, (20) intercalation of clays, siltstones, sandstones, and coquinas, (21) glauconite, (22) siderite concretions, (23) pyrite concretions, (24) siderite interlayers.

layers of ferruginated fine-grained sand and small siderite pebbles.

The **Middle–Upper Aptian rocks** are exposed in the West Caucasus Meganticlinorium. They are also found in a large area of the Scythian Platform. They gradually pinchout toward the north and northeast. These rocks are absent or appreciably reduced in several areas of the Kanevskaya–Berezanskaya Swell, southern Timashevsk Step, and the Akhtyrsk and Tsytsa fault zones. In the West Caucasus Meganticlinorium, the Middle–Upper Aptian rocks are represented by clays with interlayers of siltstones, sandstones, and siderites (Fig. 1, sections I and II). The dark gray with greenish tint (sometimes black), sandy and micaceous clays include thin interlayers (<0.01 mm) of glauconite sand. In the Vulan–Shakhe interfluve zone and the Pshish River basin, the basal section contains dense carbonaceous sandstones and conglomerates with rare glauconite dissemination and abundant brachiopod remnants. In the Shebsh, Vulan, and Shapsukho river basins, the clayey rocks contain abundant sandy-silty less common gravel–pebble materials, as well as irregularly distributed siderite concretion piles. Moreover, sections along the Shapsukho, Afips, and Bezeps rivers include numerous fragments of Late Jurassic limestones. At the southeastern termination of the West Caucasus Meganticlinorium (Tuapse–Pshekha interfluve), the sequence is dominated by dense glauconite-rich calcareous sandstones with coquina horizons. The presence of spheroidal sandy–calcareous concretions (up to 0.3 m in size) is a specific feature of the Middle–Upper Aptian rocks. The thickness of the Middle–Upper Aptian rocks varies from 150 to 700 m.

In the southeastern part of the West Kuban Foredeep, the basal section includes alternating layers of obliquely laminated sandstones, siltstones, and gritstones (total thickness 120 m). They contain abundant fossilized remnants of ammonites and brachiopods (Fig. 1, Section III). Siltstones intercalating with clays are found upward the sequence. The sequence contains interlayers of dark gray (with greenish tint) glauconite-rich siltstones and sandstones. Horizons with sandy-calcareous concretions and siderite concretion dissemination are typical of the whole sequence. The thickness of the Middle–Upper Aptian sequence in this area is 485 m. The gradual change in its lithology in the northern direction is manifested as the prevalence of silty and sandy clays with sandstone interlayers and reduction of thickness decreases to 150–200 m in the same direction. On the Adygeya Uplift, the Middle–Upper Aptian section includes a basal horizon with redeposited phosphatized fauna of the Barremian and Lower Aptian (Fig. 1, sections V–VII). Upward the sequence, conglomerates are replaced by dark gray siltstones containing up to 15–30% (sometimes more than 50%) glauconite. These rocks include horizons of sandy–calcareous concretions (up to 2.5 m in diameter) with well-preserved ammonite shells. In the Belaya and Fars interfluve area, interlayers (0.4 m) of phosphorite nodules are found in upper parts of the sequence. The thickness of the section varies from 175 m (Fig. 1, Section IV) to 20 m (Gubs River). In the East Kuban Foredeep, the Middle–Upper Aptian rocks have similar characteristics, but their thickness increases to 300 m.

Lithology of the rocks changes in the northern direction. Sandstones with abundant plant detritus and lignite interlayers predominate within the Azov Uplift and Irklievskaya Depression. The thickness of the section here is 15–160 m.

The **Albian rocks** are exposed in the West Caucasus Meganticlinorium. They are almost everywhere recovered by numerous exploration boreholes on the Scythian Platform. On the northern slope of the western Caucasus (Abin–Gunaika Synclinorium and Goitkha Anticlinorium), the Albian rocks are represented by dark gray to black, dense, noncalcareous and calcareous clays with thin interlayers (3–5 cm) of glauconite sandstones and siltstones (Fig. 1, Section II). Lenslike interlayers and concretions of siderite are noted. The thickness of the section varies from 30 to 200 m (locally, 344 m).

In the northwestern Novorossiisk Synclinorium, the Albian section includes alternation of siltstones, sandstones, and clays (Fig. 1, Section I). Clays account for 72% of the sequence, while sandstones and siltstones make up 28%. Some sections (e.g., Pshada River) contain up to 0.5-m-thick interlayers of coarse-pebble conglomerate. In the southeastern Novorossiisk Synclinorium, one can see mudstones (95–170 m) with rare siltstone and sandstone interlayers. Their number diminishes to the east. In the Transcaucasian Median Massif, the lower part of the Albian section is composed of alternating limestones and sandstones (40–50 m), whereas the upper part consists of clayey and pelitic limestones (55–65 m).

Albian sequences are very variable on the Scythian Platform. The western part of the West Kuban Foredeep is mainly composed of dark gray to black clays. They include interlayers (up to 0.2 m) of polymictic sandstones and siltstones. The upper part of this sequence contains interlayers of greenish gray and dark gray pelitic limestones (up to 1.5 m). In the eastern part of the West Kuban Foredeep and on the Timashevsk Step, the sequence is composed of two units. The lower unit (10–100 m) includes alternating glauconite sandstones and siltstones, whereas the upper unit (250 m) is mainly composed of clays. Rare interlayers (0.53 m) of glauconite sandstones and siltstones are encountered in the upper unit. Within a large territory of the Timashevsk Step (the Kanevskaya–Berezanskaya system of uplifts and Irklievskaya Depression), the Albian rocks are represented by dark gray to black, obscure-bedded, dense clays with pyrite concretions and a variable amount of silty and micaceous materials. Interlayers (up to 1–8 m) of gray and dark gray, bedded, hard, clayey, glauconite siltstones and sandstones are occasionally encountered. In the northern area of the Adygeya Uplift, East Kuban Foredeep, and West Stavropol Depression, the Albian section includes two units. The lower unit is composed by clayey sandstones, whereas the upper unit contains dark gray to black clays with pyrite concretion and rare sand interlayers. In the East Kuban Foredeep, phosphorite nodule horizons are traced at the base of the sequence. The total thickness of this sequence is 50–155 m.

On the Azov Uplift and in the northern Irklievskaya Depression, the Albian section (25–60 m) is chiefly represented by quartz sandstones and siltstones with characteristic oblique bedding, frequent horizons of reworked rocks and conglomerates at the base. These sediments were eroded during the Late Cretaceous transgression in the Belaya and Gubs interfluve zone. In the area adjacent to the Azov Uplift, the Albian basal section (40–80 m) includes quartz and glauconite–quartz sandstones and less common siltstones grading upward into clays with glauconite–quartz sandstone and siltstone interlayers (0.6–4 m). The content of siltstones and sandstones in the clay unit increases to the northwest.

Terrigenous and clayey rocks prevail in the Aptian and Albian sections. Siltstones and sandstones are most widespread among the terrigenous rocks. Limestones, gritstones, and gravel–pebble conglomerates are subordinate.

The clastic component has an oligomictic (glauconite–quartz, quartz–glauconite) composition. The polymictic composition is less common. Accessory minerals are mainly represented by zircon, apatite, titanite, and garnet. Rock fragments are present in the psephites. Terrigenous rocks are observed as cemented and uncemented varieties. One can see both monomineral (calcite, hydromica, and very rare phosphate) and polymineral (calcite–hydromica and siderite–hydromica) cements.

Clayey rocks are also widespread among Aptian–Albian rocks of the western Ciscaucasus. They include clays, mudstone-type clays, and mudstones with an admixture of silty and sandy material. The clays can be divided into sandy–silty varieties with different proportions of the sandy and silty components. The clayey material (52.19–79.8%) consists of cryptocrystalline hydromica matrix and equant (less often, irregular) glauconite aggregates (0.03–0.2 mm). The terrigenous admixture is mainly com-

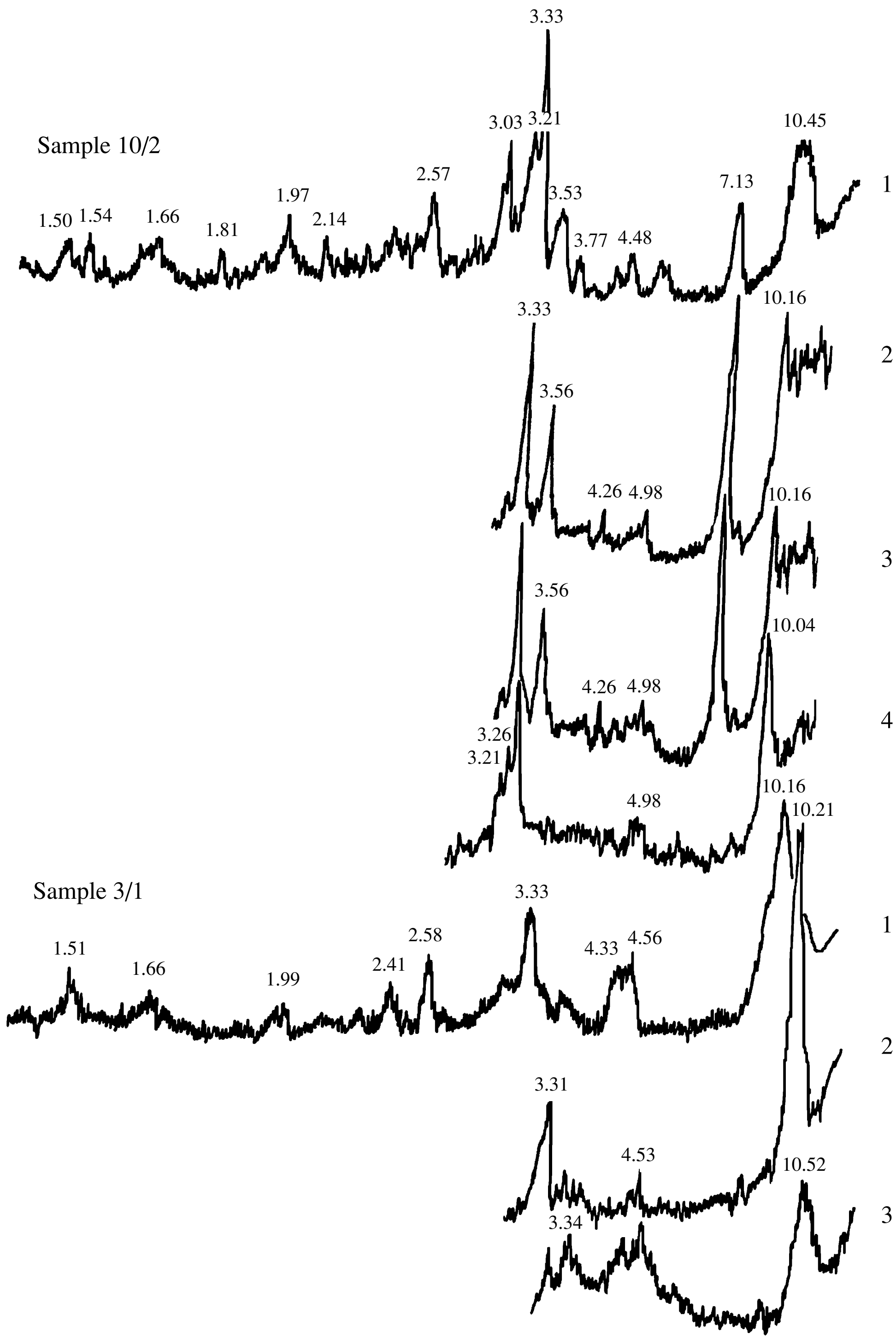

Fig. 2. X-ray diffraction patterns of oriented and nonoriented specimens of clayey rocks (Sample 10/2) and glauconite grains (Sample 3/1). (1) Powdered air-dry; (2) oriented air-dry; (3) oriented glycerin-saturated; (4) oriented (calcined at 650°C).

posed of quartz, feldspar, and muscovite. The X-ray study of the clayey fraction from sandstones, siltstones, clays, and mudstones showed their similar mineral composition. Thus, hydromica is the common predominant phase in the samples. In the oriented X-ray diffraction patterns, the hydromica is marked by an almost regular series of basal reflections with $d(001) \sim 10.16$ Å. Kaolinite ($d(001) \sim 7.14$, 3.56 Å) occurs as admixture (sometimes, abundant). Figure 2 shows an example of oriented X-ray diffraction patterns of Sample 10/2. It is obvious that quartz and feldspars are present as admixture in this sample.

In the powder diffractogram of this sample, the $d(060)$ region shows a reflection with $d = 1.50$ Å corresponding to the dioctahedral Al-mica ($b = 9.00$ Å).

The DTA curves of this sample demonstrate two distinct endothermic effects at 107–139°C and 535–555°C and a weak extremum at 810–875°C. All of them are typical of the hydromica-group minerals.

Analysis of the Aptian and Albian rocks showed that all of their principal types contain glauconite (Kholodnaya and Khardikov, 2000). The majority of glauconite grains are represented by green and dark green microconcretions of silt (0.03–0.095 mm) and sand (0.125–0.6 mm) size. Study of the X-ray diffraction patterns of their oriented samples demonstrated that they consist of hydromicaceous minerals with the content of expanding layers ranging from 10 to 20%. Figure 2 shows diffraction patterns of glauconite grains from Sample 3/1. This mineral is characterized by $b = 9.06$ Å ($d(060) = 1.51$ Å), which corresponds to glauconite.

FORMATION CONDITIONS OF APTIAN AND ALBIAN ROCKS

Regular lateral changes of different rock types in the Aptian section allow us to distinguish the coastal–shallow-water and shallow-water shelf lithofacies (Fig. 3). The coastal–shallow-water lithofacies is locally developed and can be divided into two subcomplexes. The first (sand) subcomplex is found in the southern Adygeya Uplift and along the shoreline of the western Ciscaucasus. The second (siltstone, sandstone, coquina, and clay) subcomplex is located in the southeastern part of the Novorossiisk Synclinorium. The shallow-water shelf lithofacies occupies the entire area of the West Caucasus Meganticlinorium, southeastern part of the West Kuban Foredeep, western centricline of the East Kuban Foredeep, and Adygeya Uplift. The shallow-water shelf lithofacies is also divided into two subcomplexes. The first (sand and siltstone) subcomplex occupies the East Kuban Foredeep and the most part of the Adygeya Uplift. The second (sandstone and clay) subcomplex is observed on the southeastern slope of the West Kuban Foredeep and in the West Caucasus Meganticlinorium (Fig. 1, sections I and II).

The Middle–Upper Aptian rocks are characterized by different domains and lithological features. They are divided into coastal–shallow-water, shallow-water shelf, and deep-water shelf lithofacies (Fig. 4). The coastal–shallow-water lithofacies discovered in the southern Adygeya Uplift is represented by sandstones, gritstones, and conglomerates. The shallow-water shelf lithofacies is developed in the platformal part of the studied territory. Interrelations of the principal rock types make it possible to recognize the following subcomplexes: (a) sandstones and clays; (b) sandstones and siltstones; (c) siltstones and sandstones; and (d) mudstones and sandstones. The sandstone–clay subcomplex occupies the West Kuban Foredeep (Fig. 1, Section II) and Timashevsk Step. The sandstone–siltstone subcomplex is found on the Adygeya Uplift and in the western centricline of the East Kuban Foredeep (Fig. 1, sections IV–VII). The siltstone–sandstone subcomplex occupies the southern slope of the Eisk monocline on the Azov Uplift, Kanevskaya–Berezanskaya Swell, and Irklievskaya Depression. The mudstone–sandstone subcomplex is localized in the southeastern part of the Novorossiisk Synclinorium.

The Albian rocks are developed over the entire territory of the Western Ciscaucasus. Based on the facies pattern, thickness, and section type, the Albian rocks can be divided into the coastal–shallow-water, shallow-water shelf, deep-water shelf, and continental slope lithofacies (Fig. 5). The coastal–shallow-water lithofacies found on the Adygeya Uplift is composed of conglomerates and sandstones (Fig. 1, Section IV). The shallow-water shelf lithofacies is divided into two subcomplexes. The first (clay, siltstone, and sandstone) subcomplex is developed on the Azov Uplift, as well as in the northern parts of the Irklievskaya Depression and Kanevskaya–Berezanskaya Swell. The second (sandstone and clay) subcomplex is found in the West Stavropol Depression, East Kuban Foredeep, and northern Adygeya Uplift. The deep-water shelf lithofacies can be divided into the following subcomplexes: (a) sandstones and clays; (b) sandstones, siltstones, and clays (Fig. 1, Section III); (c) clays; and (d) sandstones and limestones. The first subcomplex encompasses the western part of the West Kuban Foredeep. The second subcomplex is observed in the eastern part of the West Kuban Foredeep and the western part of the East Kuban Foredeep. The third subcomplex is developed in the Timashevsk Step, Kanevskaya–Berezanskaya Swell, and western slope of the West Stavropol Depression. The fourth subcomplex is found in the southeastern part of the Novorossiisk Synclinorium. Sediments of the continental slope lithofacies can be subdivided into the following subcomplexes: (a) clays distributed in the Abin–Gunaika Synclinorium (Fig. 1, Section II); (b) siltstones and clays in the northwestern Novorossiisk Synclinorium (Fig. 1, Section I); and (c) sandstones and mudstones on the southern limb of the Novorossiisk Synclinorium.

The lithofacies analysis indicated the existence of a shallow sea in the Early Aptian time in the territory of the western Caucasus, adjoining southeastern slope of the West Kuban Foredeep, western centricline of the East Kuban Foredeep, and northern Adygeya Uplift. The basin represented an E–W-oriented gulf with two principally different (coastal–shallow-water and shallow-water shelf) sedimentation conditions. Compensated depressions are noted in the shallow sea (10 to 70–90 m). The first depression corresponded to the Abin–Gunaika Synclinorium of the recent structural pattern. The second depression was situated northwest of the Adygeya Uplift. The third depression was located in the central part of the Novorossiisk Synclinorium.

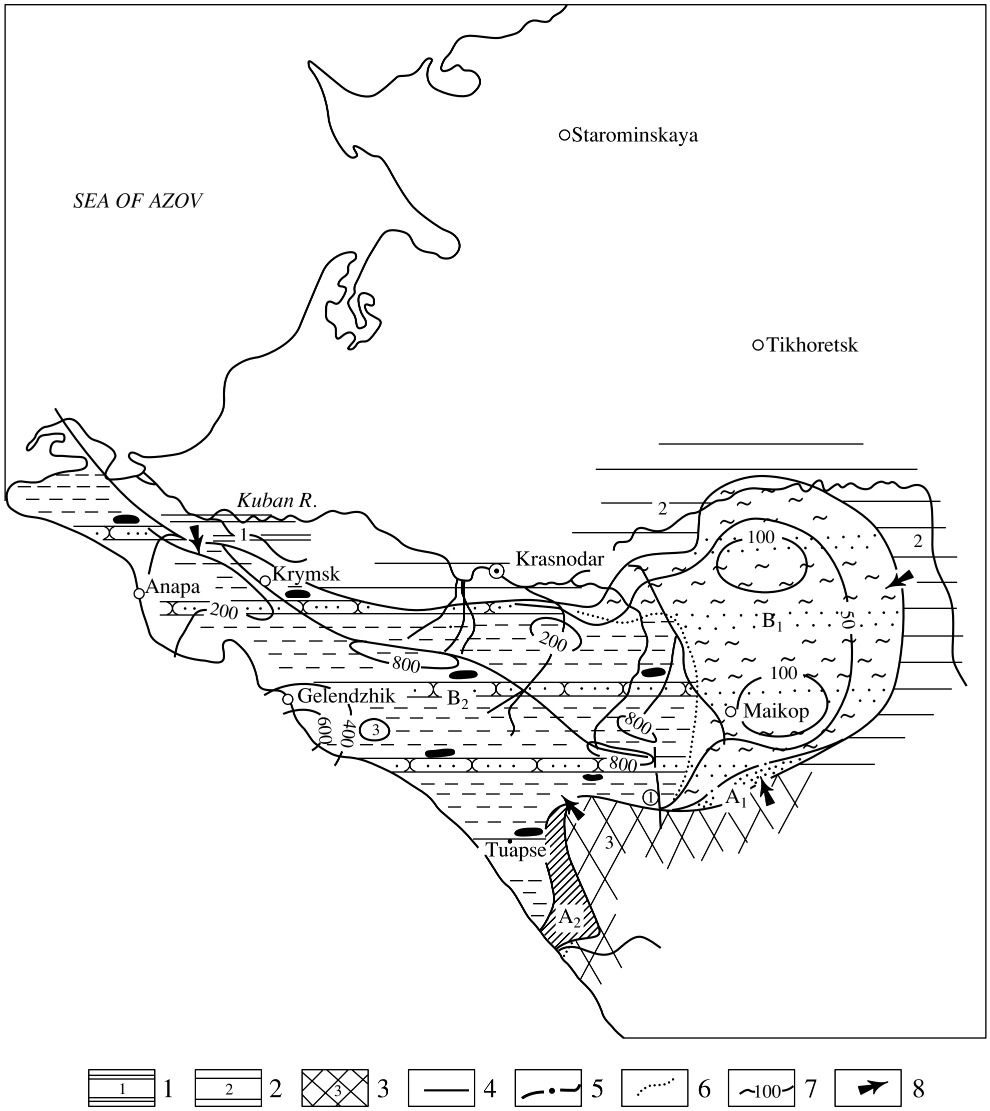

Fig. 3. Lithological–paleogeographic scheme of the Early Aptian. Lithofacies complexes: (A) coastal–shallow water sediments, (B) shallow-water shelf; subcomplexes: (A_1) sands, (A_2) clays, siltstones, sandstones, and coquinas, (B_1) sands and siltstones, (B_2) sandstones and clays. Rock types in erosion areas of ancient land: (1) Carbonate, (2) terrigenous, (3) magmatic, metamorphic, and sedimentary, (4) deep faults, (5) boundaries of lithofacies complexes, (6) boundaries of lithofacies subcomplexes, (7) isopach lines, (8) direction of clastic material supply.

These depressions accumulated thick clays with siderite concretion horizons.

The land occupied vast areas of the Western Ciscaucasus. They extended southward to the axial West Caucasus Meganticlinorium and formed a chain of islands. Uplifted blocks situated on the Stavropol Arch and Adygeya Uplift included Paleozoic–Mesozoic magmatic, metamorphic, and sedimentary rocks. They served as the principal provenances of clastic material. The northern land represented a periodically flooded lacustrine-deltaic coastal plain (Yasamanov, 1978) and relicts of Upper Jurassic organogenic buildups were located near the coastline (Boiko and Sedletskii, 1986; Khain *et al.*, 1960). This is evidenced by numerous findings of reefal limestone blocks in western sequences of the Lower Aptian rocks.

The marine basin expanded in the Middle–Late Aptian as a result of the northward expanding transgression. The northern shoreline is drawn on the basis of zero values of the thickness of Middle–Upper Aptian rocks recovered by exploration drilling. The shoreline is traced along the southern flank of the Azov Uplift, northeastern limb of the Irklievskaya Depression, passes across the West Stavropol Depression, and extends beyond the territory under study. In the south, the basin boundary is traced along the Adygeya Uplift and axial West Caucasus Anticlinorium. Shallow-water conditions gave way to a deeper-water environment. On

Fig. 4. Lithological–paleogeographic scheme of the Middle–Late Aptian. Lithofacies complexes: (A) coastal–shallow-water sediments, (B) shallow-water shelf, (C) deep-water shelf; subcomplexes: (B_1) sandstones and clays, (B_2) sandstones and siltstones, (B_3) siltstones and sandstones, (B_4) mudstones and sandstones.

the basis of sedimentary conditions, the region is divided into the coastal–shallow-water, shallow-water shelf, and deep-water shelf zones.

The coastal–shallow-water sedimentation zone was located near the shoreline in the southern area of the Adygeya Uplift. Since the magmatic, metamorphic, and sedimentary rocks were eroded, the basin was mainly filled with sandy sediments of the psephitic and psammitic dimensions.

The shallow-water shelf zone stretched over the entire area of the Scythian Platform and southeastern West Caucasus Meganticlinorium. The significantly expanded shallow-water shelf zone and low rates of terrigenous material sedimentation promoted the formation of glauconite. Sedimentary material was redeposited in the East Kuban Foredeep under conditions of intense and variable currents. They favored the deposition of obliquely bedded, predominantly fine-grained sandstones and siltstones with a high glauconite content (25–80%), numerous lenses of middle- to coarse-grained rock varieties, and fragments of belemnites and small ammonites. The thickness of the glauconite-rich sandstone layers is 2–14 m. The influence of currents is indicated by the development of oblique- and wavy-bedded structures and the presence of reworked horizons.

In the northern part of the basin adjacent to the Azov Uplift, the Middle–Upper Aptian sediments are characterized by poor sorting, abundance of charred plant material, absence of fauna, and kaolinitization of rocks. The Kanevskaya–Berezanskaya Swell hampered the free water exchange between this part of the shallow-water shelf and open marine basin. Sedimentary conditions here were close to the shallow-water and lagoon environments. Relatively subsided areas existed within the shallow-water shelf in the Timashevsk Step and

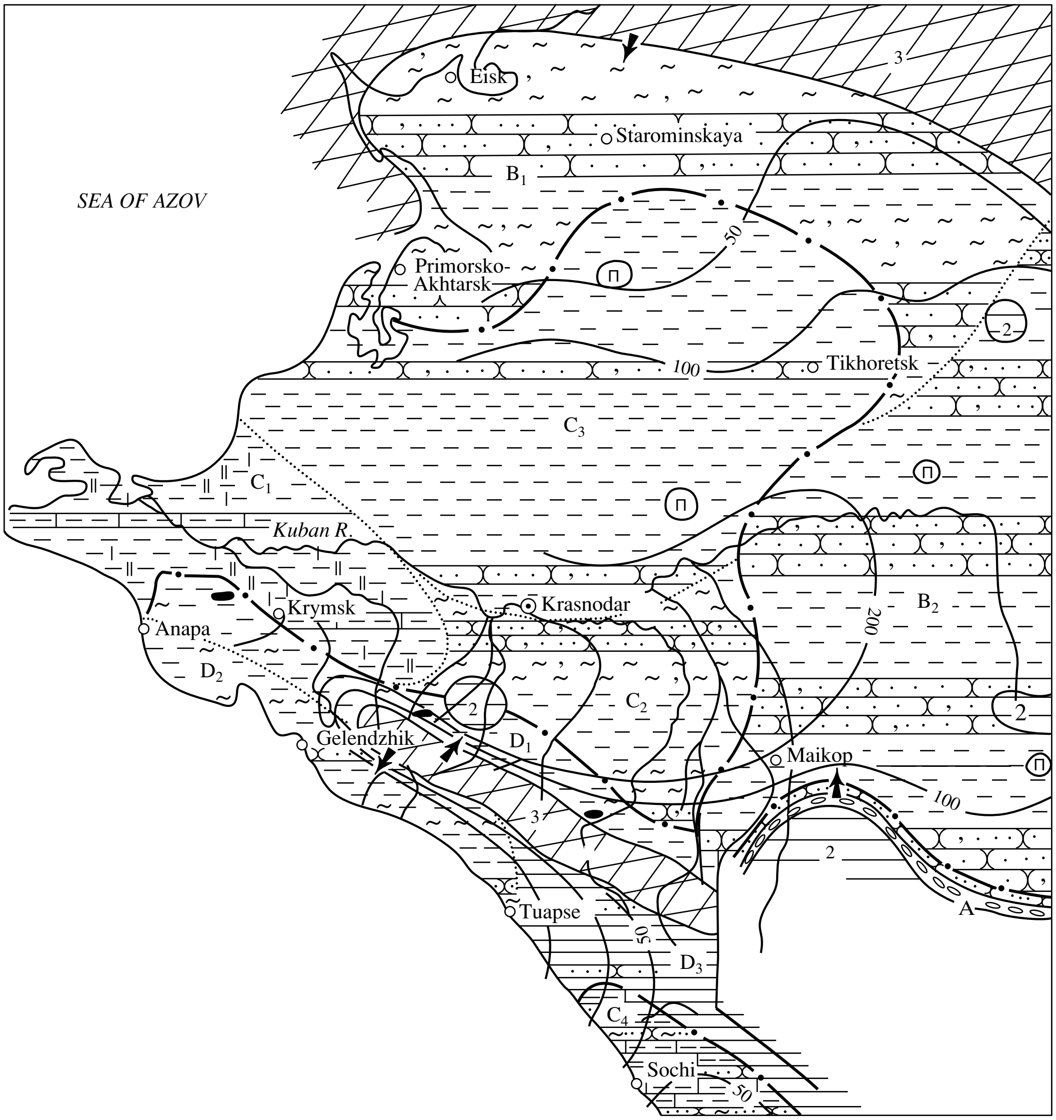

Fig. 5. Lithological–paleogeographic scheme of the Albian. Lithofacies complexes: (A) coastal–shallow-water sediments, (B) shallow-water shelf, (C) deep-water shelf, (D) continental slope; subcomplexes: (B_1) clays, siltstones, and sandstones, (B_2) sandstones and clays, (C_1) sandstones and clays, (C_2) sandstones, siltstones, and clays, (C_3) clays, (C_4) sandstones and limestones, (D_1) clays, (D_2) siltstones and clays, (D_3) sandstones and mudstones.

West Kuban Foredeep. This zone was characterized by the accumulation of mainly clayey sediments with low glauconite concentration as a result of calm sedimentation environment. The supply of coarse-grained material was restricted and mainly related to the washout of islands situated on large synsedimentary uplifts.

The deep-water shelf environment was developed in the Western Caucasus and on the adjoining southern slope of the West Kuban Foredeep. The depth of the basin was as much as 200–250 m. The zone was bounded in the north and east by a chain of reef islands and buried uplifts inherited from Jurassic time. Subsidence areas within the deep-water shelf were located in the Abin–Gunaika Synclinorium and northwestern segment of the Novorossiisk Synclinorium marked by the accumulation of thick clays with rare thin interlayers of glauconite silt. The subsidence areas were separated by the western Caucasian land, which abundantly supplied the basin with clastic material of the sand, silt, and pelite dimensions. This land was a high island or archipelago composed of acid volcanic, metamorphic, and clastic rocks.

The northern land was strongly reduced as a result of sea transgression. The land preserved in the northern (Azov Uplift) area represented a weakly denudated plain. The provenance included mature weathering crusts. This is indicated by the quartz-rich composition of the clastic material. The eastern part was occupied by a large island situated in the Stavropol Arch area. The denudation area was composed of Mesozoic sedimentary rocks.

The Early Cretaceous transgression was maximal in the Albian. The sea covered the whole western Ciscaucasus. The Albian basin was open toward the southwest where the Tethys was located. The northern shoreline extended along the Azov Uplift and Manych depression. The Albian sequence is composed of two discrete units, indicating the intensification of transgression. The lower unit is mainly composed of sand and silt, whereas the upper unit is dominated by clays. In the Albian, the study region included the following four types of sedimentation areas: coastal–shallow-water area, shallow-water shelf, deep-water shelf, and continental slope.

The coastal–shallow-water sedimentation environment existed in the northern Adygeya Uplift, the most part of which represented a land composed of Mesozoic sedimentary rocks. The shelf zone occupied the entire Scythian Platform and Transcaucasian Median Massif. The shallow-water shelf included the northern and northeastern periphery of the Albian basin, which accumulated a large amount of clastic material delivered from the Azov Uplift that represented a large denudation area of crystalline rocks (Shardanov, 1966, 1968). Sedimentation conditions in the central western Ciscaucasus and Transcaucasian Median Massif corresponded to a deep shelf that accumulated thick clayey sediments. In general, the Albian rocks are characterized by a significantly lower content of glauconite relative to the Middle-Upper Aptian rocks. This is caused by the deceleration of glauconitization on the shelf of the western Ciscaucasus due to the general deepening of the marine basin. Carbonate materials accumulated on the outer deep-water shelf (West Kuban Foredeep). Sedimentation conditions corresponding to continental slope were created in the western Caucasus as result of the northward sea transgression. The Novorossiisk and Abin–Gunaika Synclinoria areas were characterized by the further development of deep troughs, which accumulated thick silty–clayey sediments. The northern trough was preserved as an elongate narrow depression that turned out to be uplifted relative to the trough of the southern slope of the Caucasus Megaanticlinorium. The axial part of the meganticlinorium continued to rise. The land situated in the Stavropol Arch area was separated into small islands by the end of the Albian.

The Aptian and Albian stages were noted by a stable humidization trend as a result of the significant expansion of marine areas and other processes. The water temperature in the basin reached 19–20°C in the Early Aptian, decreased to 13–16°C in the Middle Aptian, and again increased to 20°C in the Late Aptian–Albian (Yasamanov, 1980). The presence of radiolarian remnants suggests that the basin was characterized by a normal salinity (Vishnevskaya, 1996; Vishnevskaya and Sedaeva, 1988). The land area of the western Ciscaucasus was covered by coniferous forests of the tropical and subtropical types (Yasamanov, 1978).

CONCLUSIONS

We have established specific features of the development and formation of Aptian and Albian rocks in the western Ciscaucasus. Regular changes of lithofacies complexes reflect the evolution of the Aptian–Albian sedimentary basin in the western Ciscaucasus. The sedimentation took place on the shelf of the epicontinental marine basin with normal salinity. The basin expanded to the north and northeast. This was accompanied by the gradual subsidence of the basin and the development of deeper-water environments. The clastic material was delivered from a land situated in the Azov Uplift, Stavropol Arch, and West Caucasus Meganticlinorium regions, as well as the World Ocean. The influence of volcanism on the process of sedimentation was insignificant.

REFERENCES

Boiko, N.I. and Sedletskii, V.I., Role of Organisms in the Origin of Mesozoic Carbonate Deposits in the Northern Caucasus, in *Rol' biogeokhimicheskikh issledovanii v rasshirenii mineral'no–syr'evoi bazy SSSR. Sb. nauchnykh trudov* (Role of Biochemical Studies in the Expansion of the Mineral Resource Base of the Soviet Union: Collection of Scientific Works), Leningrad: Min. Geol. SSSR, Vses. Geol. Inst., 1986, pp. 36–43.

Drushchits, V.V. and Mikhailova, I.A., Lower Cretaceous Rocks of the Central and Western Caucasus, *Materialy po geologii i metallogenii Tsentral'nogo i Zapadnogo Kavkaza* (Proc. on Geology and Metallogeny of Central and Western Caucasus), Moscow: Gosgeoltekhizdat, 1960, pp. 78–87.

Drushchits, V.V. and Mikhailova, I.A., The Aptian Stage and Its Zoning, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1979, no. 4, pp. 47–62.

Egoyan, V.L., Essays on the Lower Cretaceous Stratigraphy of the Nothwestern Caucasus, in *Voprosy stratigrafii i litologii mezozoiskikh i kainozoiskikh otlozhenii Krasnodarskogo kraya* (Problems of the Stratigraphy and Lithology of Mesozoic and Cenozoic Rocks in the Krasnodar Territory), Leningrad: Nedra, 1964, pp. 113–153.

Khain, V.E., Afanas'ev, S.L., Burlin, Yu.K., *et al.*, *Novye dannye po geologii Severo–Zapadnogo Kavkaza. Materialy po geologii i metallogenii Tsentral'nogo i Zapadnogo Kavkaza* (New Data on the Geology of Northwestern Caucasus: Proc. on the Geology and Metallogeny of the Central and Western Caucasus), Moscow: Mosk. Gos. Univ., 1960, vol. 2.

Kholodnaya, I.A. and Khardikov, A.E., Lithology of Aptian Glauconite–Bearing Rocks in the Western Caucasus, *Izv. Vyssh.Uchebn.Zaved., Geol. Razv.*, 2000, no. 3, pp. 52–58.

Letavin, A.I. and Prerva, V.M., *Razryvnaya tektonika i perspektivy neftegazonosnosti kraevoi zony Severo–Zapadnogo Kavkaza* (Fault Tectonics and Petroleum Potential of the Marginal Zone of the Northwestern Caucasus), Moscow: Nauka, 1987.

Letavin, A.I., Orel, V.E., Chernyshev, S.M., *et al.*, *Tektonika i neftegazonosnost' Severnogo Kavkaza* (Tectonics and Petroleum Potential of the Northern Caucasus), Moscow: Nauka, 1987.

Lunev, A.L. and Serezhenko, V.A., Tectonic Zonation of the Northern Caucasus, in *Tr. po geologii i poleznym iskopaemym Severnogo Kavkaza* (Proc. on Geology and Mineral Resources of the Northern Caucasus), Moscow: Nauka, 1972, vol. 13, pp. 3–12.

Luppov, N.P., *Nizhnemelovye otlozheniya Severo–Zapadnogo Kavkaza i ikh fauna* (Lower Cretaceous Rocks and Fauna of the Northwestern Caucasus), Leningrad: Gostoptekhizdat, 1952.

Mordvilko, T.A., *Nizhnemelovye otlozheniya Severnogo Kavkaza i Predkavkaz'ya* (Lower Cretaceous Rocks of the Northern Caucasus and Ciscaucasus), Moscow, Leningrad: Gostoptekhizdat, 1960, vol. 1, 1960.

Nizhnii mel yuga SSSR (The Lower Cretaceous of the Southern USSR), Alieva, M.M., Drushchits, V.V., Krylova, N.A., *et al.*, Eds., Moscow: Nauka, 1985.

Shardanov, A.N., Tectonics of the Western and Northwestern Caucasus, *Voprosy geologii i neftegazonosnosti Krasnodarskogo kraya* (Problems of the Geology and Petroleum Potential of the Krasnodar Territory), Leningrad: Nedra, 1966, pp. 15–33.

Shardanov, A.N., Tectonics Of the Western Caucasus, *Geologiya SSSR. Severnyi Kavkaz* (Geology of the Soviet Union: The Northern Caucasus), Moscow: Nedra, 1968, vol. 9, part 1, pp. 584–590.

Vishnevskaya, V.S., Peri-Tethyan Radiolarians and Their Implication, *Dokl. Akad. Nauk*, 1996, vol. 346, no. 5, pp. 638–641 [*Doklady Earth Sci.*, 1996, vol. 347, no. 2, pp. 179–183].

Vishnevskaya, V.S. and Sedaeva, K.M., Siliceous Sequences in Mesozoic Carbonate and Terrigenous–Carbonate Rocks of the Greater Caucasus, *Litol. Polezn. Iskop.*, 1988, no. 5, pp. 38–50.

Yasamanov, N.A., *Landshaftno–klimaticheskie usloviya yury, mela i paleogena Yuga SSSR* (Jurassic, Cretaceous and Paleogene Landscapes and Climate in the Southern Soviet Union), Moscow: Nedra, 1978.

Yasamanov, N.A., Jurassic, Cretaceous and Paleogene Paleothermometry in Some Regions of the Soviet Union, *Byull. Mosk. O–va Ispyt. Prir., Otd. Geol.*, 1980, vol. 55, no. 3, pp. 117–125.

Zhabreva, P.S., On the Mineral–Geochemical Facies of Lower Cretaceous Rocks in the North Caucasus, *Fauna, stratigrafiya i litologiya mezozoiskikh i kainozoiskikh otlozhenii Krasnodarskogo kraya* (Fauna, Stratigraphy, and Lithology of Mesozoic Rocks in the Krasnodar Territory), Leningrad: Nedra, 1965a, pp. 432–442.

Zhabreva, P.S., Textural Features of Rocks from the Cretaceous Terrigenous Sequence of the Western Caucasus, *Fauna, stratigrafiya i litologiya mezozoiskikh i kainozoiskikh otlozhenii Krasnodarskogo kraya* (Fauna, Stratigraphy, and Lithology of Mesozoic Rocks in the Krasnodar Territory), Leningrad: Nedra, 1965, pp. 443–457.

Zhabreva, P.S., Voronina, S.I., and Sarkisova, K.S., Lithological Features and Petrographic Relationships of Neocomian Rocks in the Northwestern Caucasus, in *Fauna, stratigrafiya i litologiya mezozoiskikh i kainozoiskikh otlozhenii Krasnodarskogo kraya* (Fauna, Stratigraphy, and Lithology of the Mesozoic Rocks in the Krasnodar Territory), Leningrad: Nedra, 1965, pp. 411–431.