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Research Article

LITHOLOGICAL AND STRATIGRAPHIC FEATURES OF OIL AND GAS-PROMISING PALEOZOIC DEPOSITS OF THE KUANYSH-KOSKALA SHAFT

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ABSTRACT
The Kuanysh-Koskala shaft is one of the highly promising oil and gas fields in the Ustyurt region, where commercial gas flows have been obtained from Paleozoic formations. The gas deposits are confined to Lower Carboniferous carbonate deposits, which are represented by limestones. Studying the formation stages of the Paleozoic rock complex, their lithological and stratigraphic characteristics, and distribution patterns is a pressing issue for the search for new oil and gas-bearing structures.

Keywords: *Kuanysh-Koskala Shaft, Paleozoic Formations, Lithology, Limestone, Reservoir, Gas, Oil*

INTRODUCTION

Targeted work on the study and exploration of Paleozoic carbonate deposits was initiated in the Ustyurt region in connection with the discovery of oil and gas shows from cavernous organogenic-clastic limestones of Lower Carboniferous age in the areas of the Kuanysh-Koskalinsky swell, which were uncovered by deep drilling in the Karakuduk, Western Barsakelmes, Central Kushkair, Kokchalak, Urtatepe, Kubla Chink structures and others. To study, map and prospect Paleozoic formations, it is necessary to study their structure, sedimentation conditions, the formation of the oil and gas bearing system, including the reservoir, seal and the presence of source rocks, for further exploration of hydrocarbon deposits and fields.

MATERIALS AND METHODS

Reinterpretation of existing geological and geophysical data using lithological, stratigraphic and paleogeomorphological effective methods related to various factors of formation of ancient relief elements and sedimentation.

RESULTS AND DISCUSSION

In the geological history of the Northern Ustyurt Basin, the Permian period saw a transition from marine to continental sedimentation, resulting in the area becoming a land mass with a sharply dissected relief, subject to intense denudation processes (Akramkhodjaev et al., 1979, Yuldasheva M.G et al., 2022, Fozilov R.A. et al., 2024). As a result of these processes, deposits ranging from the Carboniferous in the central part of the Kuanysh-Koskala shaft (Karakuduk, Western Barsakelmes, Central Kushkair, Karachalak, and Chibiny), to Devonian (southwestern edge of the Kuanysh-Koskala shaft and the Central Ustyurt dislocation system) and Precambrian (Koskalinsky Uplift) ages were brought to the surface. They were subsequently overlain by late Paleozoic argillite or effusive strata, and in zones where these are absent, by Upper Permian-Lower Triassic red-colored rocks or younger sediments, including Lower Jurassic (Table 3.1, Fig. 3.1).

In the northern part of the Kuanysh-Koskala shaft, Lower Jurassic sediments are overlain by volcanic cover formations, which are intruded by granite intrusions in the Southern Kuanysh and Bashchuak. The volcanic-sedimentary complex is represented by interbedded tuffites, tuffaceous sandstones, and diabase porphyrites, i.e., Lower Permian-Upper Carboniferous cover lava deposits. The intrusive formations are represented by granites and granitoids intruded into the host strata during the Upper Carboniferous. In the area of the Karakuduk and Kushkair fields, the Lower Jurassic deposits lie on a

terrigenous-carbonate complex, represented by organogenic-clastic limestones, dolomites, shales and argillites of the Lower-Middle Carboniferous age.

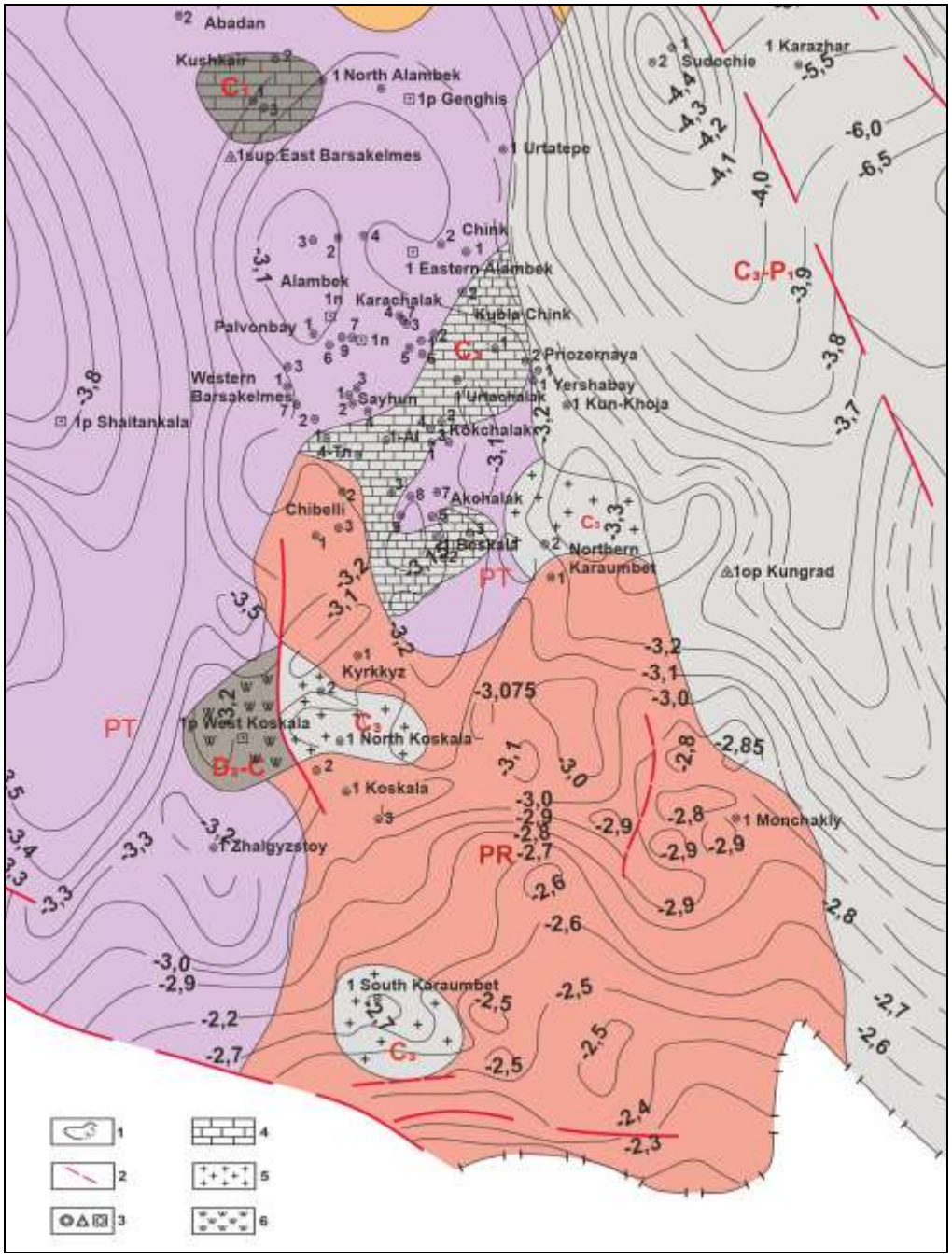

Figure 1: A fragment of the scheme of the lithological composition of the Paleozoic formations of the central and southern parts of the Kuanysh-Koskala shaft
(1-isohypses of the roof of pre-Jurassic deposits, m; 2-tectonic faults; 3-deep wells; 4-limestones; 5-granites and granodiorites; 6-volcanic-sedimentary deposits)

In the central part of the Kuanysh-Koskala shaft, beneath the Lower Jurassic deposits from the Tillali deposit to the Kubla Chink area, a band composed of Lower Carboniferous organogenic-clastic limestones and dolomites is also observed. In the area of the Northern Karaumbet and Northern

Koskala areas, sections of intrusive formations represented by granites and syenites are exposed beneath the Lower Jurassic deposits.

In the southwestern part of the Kuanysh-Koskala shaft, in an area encompassing the Western Koskala and Kyrkkyz areas, Lower Jurassic deposits underlie pre-Jurassic formations represented by an Upper Devonian-Lower Carboniferous terrigenous-carbonate sequence, represented by black limestones and mudstones, which belong to the gas-generating suite in the Paleozoic rock complex. The vast territory of the southern part of the Kuanysh-Koskala shaft, in the area where Lower Jurassic deposits pinch out, is composed of ancient Proterozoic formations, represented by metamorphosed schists and gneisses.

Table 1: Depths, age, and lithology of pre-Jurassic deposits in the central and southern parts of the Kuanysh-Koskala shaft

No. in order	Area	well number	Depth of Permian-Triassic sediments, m	Depth of Paleozoic sediments, PZ, m	Age and lithological description of Paleozoic rocks
1	2	3	5	6	7
1.	Cibelli	1	are absent	3340	PR schists, gneisses
2.	Cibelli	2	are absent	3322	PR schists, gneisses
3.	Cibelli	3	are absent	3356	PR schists, gneisses
4.	Beskala	2	are absent	3250	PR schists, gneisses
5.	Beskala	3	3234	3368	PR schists, gneisses
6.	Hakim-Ata	1	are absent	3262	C1-2 limestones
7.	Sherkala	1	3266	3276	C1-2 limestones
8.	Kyrkkyz	1	are absent	3222	C1-2 limestones
9.	Kyrkkyz	2	are absent	3238	C1-2 limestones
10.	Koskala	1	are absent	3177	PR schists
11.	Northern Koskala	1	are absent	3158	D brecciated tracheandesites
12.	Monchakly	1	are absent	2844	PR schists, gneisses
13.	Southern Karaumbet	1	are absent	2880	γσC3 granodiorites
14.	Alambek	1p	4170	not opened	
15.	Alambek	2	3192	not opened	
16.	Alambek	3	3150	not opened	
17.	Alambek	4	3285	not opened	
18.	Alambek	7	3244	not opened	
19.	Alambek	10	3269	not opened	
20.	Palvanboy	1	3335	not opened	
21.	Western Barsakelmes	1p	3288	3387	C1 limestones
22.	Western Barsakelmes	2	3313	not opened	
23.	Western Barsakelmes	6	3312	not opened	
24.	Western Barsakelmes	7	3280	not opened	
25.	Western Barsakelmes	8	3330	not opened	
26.	Western Barsakelmes	9	3247	not opened	
27.	Western Barsakelmes	10	are absent	3329	C1 gray dolomites
28.	Sayhun	1	3293	3455	C1 limestones
29.	Sayhun	2	3312	3650	C1 limestones
30.	Sayhun	3	3298	3736	C1 limestones
31.	Sayhun	4	3284	3480	C1 limestones
32.	Tillali	4	are absent	3293	C1 limestones
33.	Eastern Alambek	1p	3380	4170	P1 volcanic rocks

34.	Kubla Chink	1	are absent	3324	C1 limestones
35.	Karachalak	1	3300	3525	C1 limestones
36.	Karachalak	2	3362	3848	C1 limestones
37.	Karachalak	3	3290	3520	C1 limestones
38.	Karachalak	4	3296	not opened	
39.	Karachalak	5	3298	3683	C1 limestones
40.	Karachalak	6	3298	3575	C1 limestones
41.	Karachalak	7	3202	3664	C1 limestones
42.	Urtachalak	1	are absent	3328	C1 dolomites
43.	Kokchalak	1p	3282	3490	νσC2 syenite porphyrites
44.	Kokchalak	2	3290	not opened	
1	2	3	5	6	7
45.	Kokchalak	3	are absent	3375	C1 dark-gray shales
46.	Kokchalak	4	3264	not opened	
47.	Akchalak	18	are absent	3276	C1 dolomites
48.	Priozernaya	2	are absent	3320	C3-P1 siltstones and mudstones
49.	Ershabai	1	3276	3296	C3-P1 siltstones and mudstones
50.	Southern Karaumbet	1	are absent	2880	C3 granodiorites

Metamorphosed Precambrian deposits in the area were encountered in five boreholes at the Monchakly, Koskala, and Cibelli sites, representing Archean and Proterozoic metamorphic rocks. Lithologically, the rocks are represented by greenschists with tourmaline, amphibole, garnet, and graphite of Riphean age (V.S. Knyazev et al., 1976, Akramkhodjaev et al., 1979, 1981, Uzakov H., 2022), formed during the metamorphism of felsic and mafic igneous and sedimentary rocks. In the western part of the shaft, at the Cibelli site, they are represented by orthogneisses, in some cases completely replaced by calcite.

Terrigenous-carbonate deposits of the Upper Devonian and Lower Carboniferous were encountered in parametric borehole No. 1p, Western Koskala, where they are represented by interbedded siltstones, mudstones, and sandstones. Sandstones and siltstones are gray to dark gray, quartz-feldspar, dense, and hard. Argillites are dark gray to black, dense, with coal interlayers.

Lower Carboniferous rocks have been exposed at various depths up to 700 m in the Kubla-Chink, Urtatepe, V. Barsakelmes, Karachalak, Kokchalak, Akchalak, Western Barsakelmes, Beskala, Sherkala, and other areas. These rocks are represented by light-gray, dense, organogenic-clastic, thin-platy, cavernous and fractured, organogenic-clastic and organogenic limestones and light-gray dolomites.

At the Kubla Chink area, well 1, a metasomatically altered porphyry rock was encountered in the upper part of the exposed carbonate section. The bulk of this rock is composed of tiny grains and plates of plagioclase and dark-colored minerals replaced by sericite, carbonate, and hydromica. The groundmass contains phenocrysts of decomposed plagioclase, hornblende, and mica (Kh. Uzakov, 1996).

At the Urtatepe area, well 1 in the Lower Carboniferous section, frequent interbeds of sericite-chlorite-hydromica carbonaceous mudstones are observed among organogenic limestones from a depth of 3,442 m.

In the Kokchalak 21 well, four structural types of secondary dolomites (developed after limestones) have been identified in the carbonate section: clumpy, microgranular, lumpy, and organogenic-detrital (Fig. 2). Microgranular dolomites (limestones) are light gray with a beige tint. The texture of the rocks is massive, fissured, less commonly layered, of medium strength, easily split with a hammer, forming a comminuted fracture. The cracks are thin, hair-like, widespread, unevenly distributed throughout the rock groundmass, oriented in various directions, intersecting, and forming a web-like network. Some cracks are branching. Many cracks are healed by microgranular calcite. Rare recrystallized

organogenic detritus is noted. Numerous stylolite sutures are encountered: thin, in places relatively thick (up to 1.0 cm), finely toothed, layered, healed by a black carbonate-clay-bituminous substance. Terrigenous admixture is rare, locally averaging 2-3%. Porosity is below average, predominantly fissured, with no caverns and small, poorly developed pores.

Figure 2: A sample of Lower Carboniferous cavernous limestone exposed at the Kokchalak deposit

Clumped dolomites (limestones) are gray or beige-gray, with a dark brown tint in areas saturated with oil. In some areas, the lumpy structure often transitions to a lumpy structure, with inclusions of organogenic fragments, most often detritus. The texture is massive, sometimes layered, with the bedding inclined at an angle of up to 20°, rectilinear, and parallel. Unevenly distributed cavernousness is also observed throughout the layer. Cavities vary in shape and size, with denser caverns in some areas, and in others, virtually no caverns, with small pores present. The rock has low strength, is relatively easily split with a hammer, and forms an uneven, cavernous, and porous fracture. The organogenic detritus is recrystallized and consists of indeterminate small fragments of corals, bryozoans, brachiopods, and others. Stylolite sutures are thin, hair-like, and serrated, vertically oriented in the core. Terrigenous admixture is virtually absent. The rock is porous and cavernous. Inter- and intragranular porosity is secondary and associated with the accumulation of organic debris, related to leaching.

Lumpy dolomites (limestones) are found in all layered carbonates as transitional structural varieties. Both clumpy and organogenic-detrital varieties transition into lumpy carbonates.

Organogenic-detrital dolomites (limestones) are light gray, whitish, and, less commonly, beige with a brownish tint, to dark brown. The texture is often massive, cavernous, and less commonly fissured. The rock is of low strength; it can often be broken by hand, forming a porous fracture. The organogenic fragments are recrystallized and represented primarily by fragments of cephalopods, bivalves, brachiopods, and, most commonly, detritus. Stylolite sutures are thin, capillary, and finely serrated, healed by a black carbonate-clay-bituminous substance. The absence of terrigenous admixture indicates the burial site is located far from the shore. The rock is cavernous and porous. Secondary caverns, up to 2.0-3.0 cm in size, vary in shape from oval to bizarre, hollow, and interconnected. Large caverns are encrusted with cubic, translucent crystalline dolomite with a glassy luster. The internal cavities of the caverns are often coated with a dark brown, sometimes black, oil-like mass. The distribution of caverns is uneven, dense in places, and diminishing in number and size in other areas. Cracks are widely and unevenly distributed throughout the rock matrix, oriented in

various directions and intersecting; the caverns often communicate through microcracks. Many cracks are healed by microgranular calcite.

Upper Carboniferous-Lower Permian deposits are exposed in the Ershabay, Northern Koskala, and Southern Karaumbet areas. In the Ershabay area, they are represented by black, calcareous, thin-bedded mudstones with sulfide mineralization, sponge spicules, and radiolarians. The rocks contain microfaunal fragments and charred plant remains, interbeds of siltstones, fine-grained sandstones, and dolomites.

In the Akchalak area, they are represented by felsic vitroclastic tuffs with a layered texture, recrystallized into siliceous-chlorite aggregates with ash particles; mudstones, sandstones, siltstones, thin interbeds of dolomites, crystalline and organogenic-clastic, dolomitized limestones; Intensively altered basaltic porphyrites, and in the Southern Karaumbet area, effusive rocks are brownish-brown, greenish, chloritized, fractured, dense, and strong.

The East Alambek well contains black horizontally layered mudstones, marls, and pelitomorphic limestones.

At the Northern Koskala, Paleozoic rocks are represented by gray and greenish-gray granodiorites with inclusions of white and black minerals, micas, quartz, and pyrite. They are chloritized, dense, non-porous, brittle, and heavily fractured, with fractures running vertically. In the Beskala-2 well, light-gray limestones with a yellowish tint and black oil stains were collected from the Carboniferous section. They are massive in texture, biomorphic-detrital, crystalline, and contain faunal inclusions. They are dense, strong, unevenly porous, unevenly impregnated with oil, and contain black bitumen stains with a hydrocarbon odor.

Undifferentiated, red-colored strata of the Upper Permian-Lower Triassic were lithologically exposed in wells at the Beskala, Khakim-Ata, Alambek, Western Barsakelmes, and other sites, where the sediments are represented by red-colored conglomerates, gravel, sandstones, siltstones, and mudstones. Thus, it can be concluded that the shaft's territory at the end of Paleozoic sedimentation consisted of uplifted areas in the southeastern part, encompassing the eastern slope of the Kuanysh-Koskala shaft. The remaining territory was covered by continental, red-bedded formations of Upper Permian-Lower Triassic age, the thickness of which varies depending on the dissection of the Paleozoic relief.

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