

GEOLOGY

The Perovsk–Kornilovka Swell: A Previously Unknown Large Structural Unit of the Orenburg Cisural Region

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Analysis and reinterpretation of several regional seismic profiles carried out by the Orenburg Geophysical Expedition in the Orenburg Cisural region (Fig. 1) allowed us to suggest the existence of an uplift (swell) in the central part of the present-day Ural Foredeep. This suggestion is consistent with an idea stated by Korolyuk et al. [1]. We mapped the Riphean–Vendian uplift, which is traced by the Riphean–Vendian deep reflectors and called the Perovsk–Kornilovka Swell, along three near-latitudinal profiles. The northern profile, profile 28 of the seismic group (s/g) 10/03, extends east of the Orenburg Swell across Well 108 and wells 70, 71, and 73 at the eastern wall of the foredeep to the frontal folds of the Urals (Fig. 2). The second (Mednogorsk) profile (Novouspenovka s/g 10/79-80) extends 20 km south and parallel to profile 28 and reaches the town of Mednogorsk (Fig. 3). The third profile, profile 26 (s/g 10/04), extends 20 km south of the Mednogorsk profile (Fig. 4). The fourth near-longitudinal profile, profile 27, crosses the near-latitudinal profiles and extends to wells at the eastern wall of the foredeep.

Seismic profiles show reflectors related to the wells located at the Sol-Ilets and Orenburg swells. Many wells are situated at the western wall of the Ural Foredeep (Fig. 1). Along all near-latitudinal profiles, the reflectors plunge nonuniformly eastward from the western wall and make up the Artinskian sedimentation escarpment at the first subsalt horizon. At deep horizons, the plunging is gradual. The reflection from the Ordovician sequence, which extends to the east from

wells at the Sol-Ilets Swell, plunges slightly at first and then rises. As a result, the time interval between horizon O and the overlying horizon D reduces from 1.0 to 0.2 s toward the foredeep axis, while the reflection from the Ordovician (or presumably Vendian) sediments within the sequence wedges out toward the paleouplift (Fig. 3). Paleozoic rocks in the axial zone make

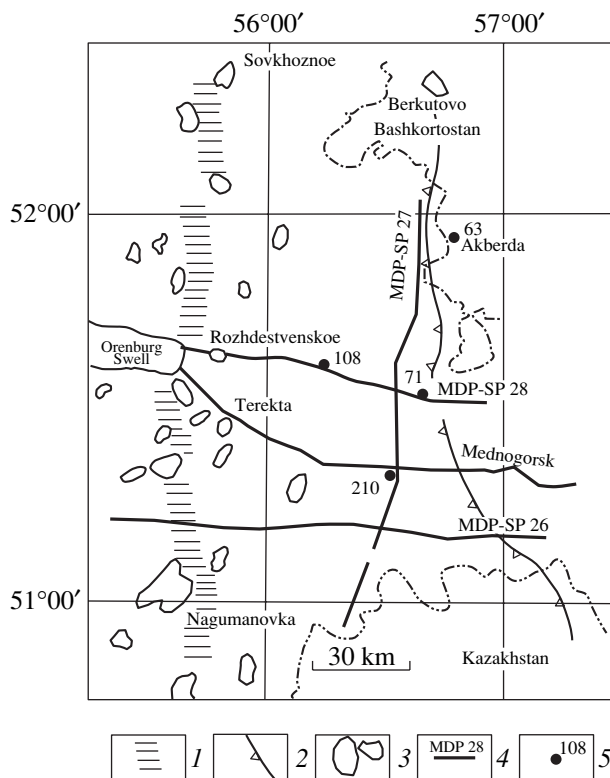


Fig. 1. Index map of regional seismic profiles. (1) Gravity steps that control the western boundary escarpment of the Ural Foredeep; (2) western boundary of the foredeep–frontal folds transitional zone of the Urals; (3) hydrocarbon fields; (4) regional seismic profiles; (5) wells.

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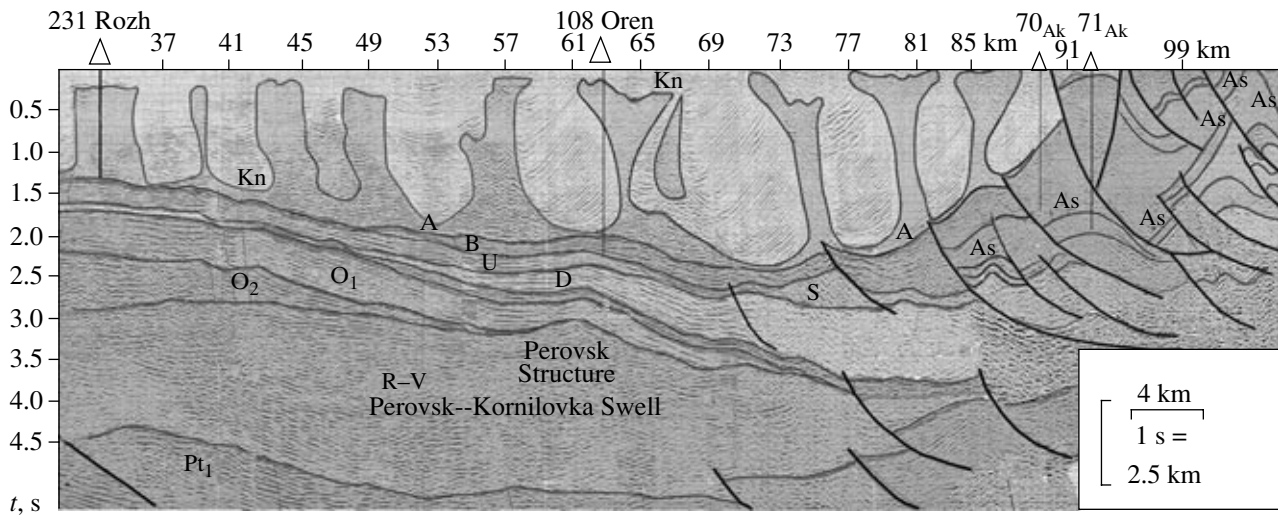


Fig. 2. Seismogeological profile 28. (Kn, A, As, B, U, S, D, and O) reflectors (see text for explanation). Stratigraphic units: (P₂) Upper Permian molasse, (P₁ art) Artinskian Stage, (P₁ art-ass) Artinskian and Asselian stages, (O₁, O₂) Ordovician sequences; (V–R) Riphean and Vendian rocks; (PT₁) Paleoproterozoic rocks. Vertical scale: 1 s = 2.5 km.

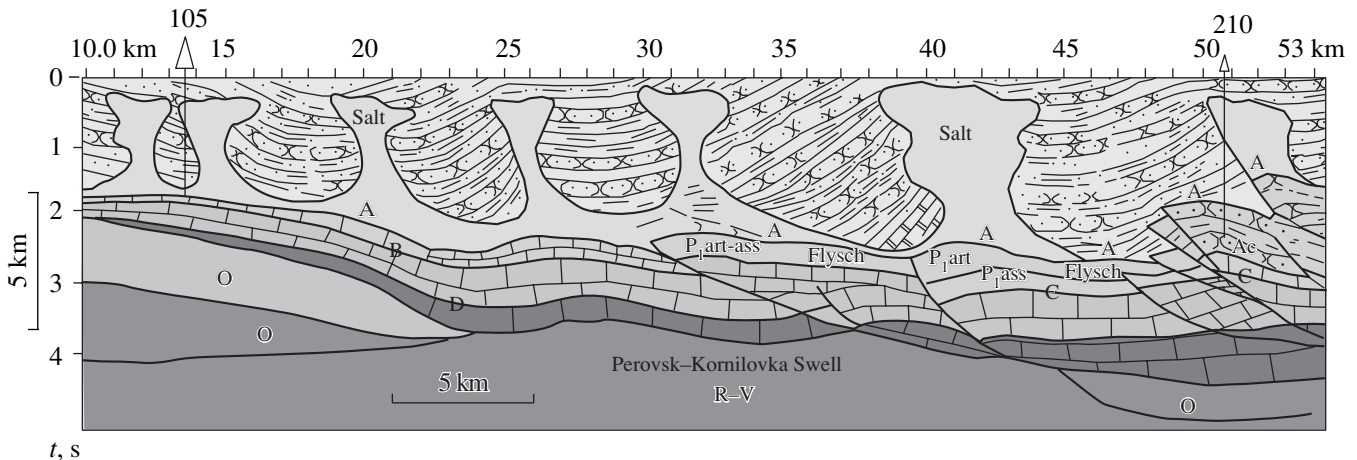


Fig. 3. Seismogeological and lithostratigraphic section along the Mednogorsk profile. See Fig. 2 for legend.

the uplift conformable to the structure of the Riphean–Vendian rocks. In 1968, Timasheva [2] revealed the eastern uplifted part of this structure based on examination of the first and second subsalt reflectors and called it the Perovsk Structure. Thus, the paleouplift is traceable based on reflectors in both pre-Paleozoic and Paleozoic rocks. The first subsalt horizon A at the roof of the Artinskian sequence is located at a depth of 4236 m bsl, while the second subsalt horizon B (roof of the Carboniferous rocks) is located at a depth of 4450 m bsl. The time interval between A and B reduces from west to east toward the foredeep axis, indicating the reduction of Artinskian carbonate rocks and their replacement by the basinal facies. At the deep (presumably, Riphean) reflectors, the Perovsk–Kornilovka Swell strikes in the near-longitudinal direction slightly inclined to the southwest. The crest of the swell in the Mednogorsk

profile is traced by reflector O at 3 s (approximately 7.5 km). The swell is ~10–15 km wide (Fig. 2). The northern pericline, presumably situated north of wells 102 and 108, is not recorded in the seismic data. The southern portion of the swell is outlined in profile 26 between the Kzyloba and Orlovka salt domes. The crest of the swell is contoured by reflector O at a depth of 8–9 km. Since the swell is rather wide (15 km), the pericline is probably located farther to the south.

To the east of the Riphean–Vendian swell, reflectors Ac1 and Ac2 are correlated in Well 71 with the roof and base of the Asselian Stage. These reflectors serve as reference horizons observed in all (three near-latitudinal and one near-longitudinal) seismic profiles. They are traced almost continuously over 120 km along near-longitudinal profile 27, which extends from the Bashkir Cisural region to the border of Kazakhstan. The Riph-

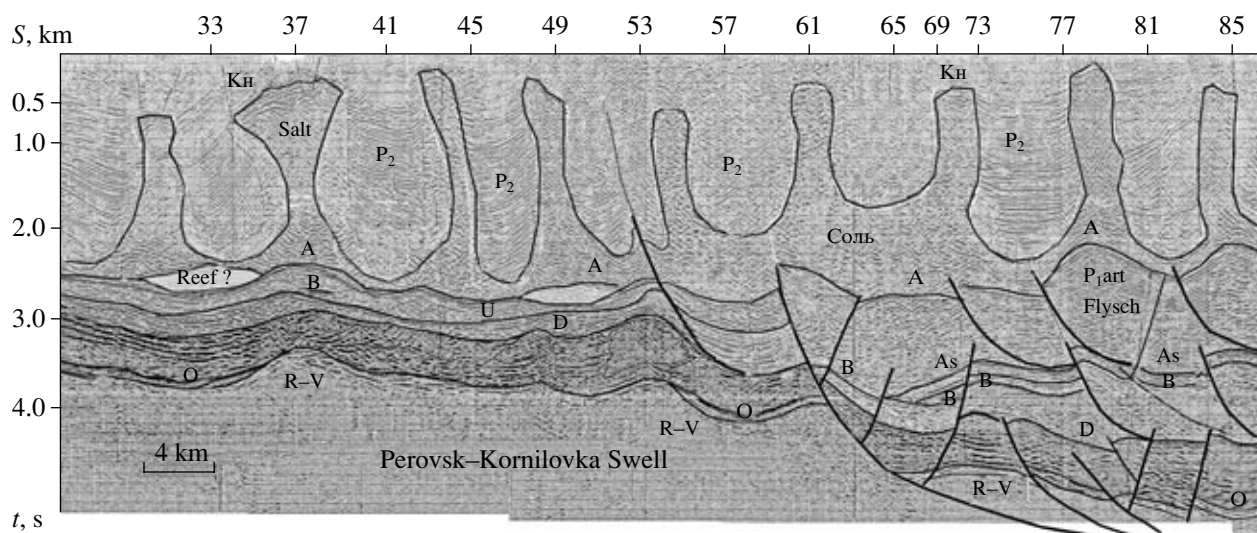


Fig. 4. Seismogeological profile 26. See Fig. 2 for legend.

ean–Vendian paleoswell is localized west of profile 27. The reflectors are not traced further to the west, because the Lower Permian sequences here consist of thin and uniform basinal facies. To the east of the Riphean swell, the Asselian rocks are distinctly identified in seismic records, indicating that the physical properties of these rocks differ from those of the common flysch. In the central segment of profile 26, east of the swell, one can see clearly the contact of the Asselian reference unit with the inferred roof of the Carboniferous carbonate sequence. In terms of seismic stratigraphy, this contact corresponds to the baselap.

The petroleum resource potential of the eastern Ural Foredeep depends on the lithology and mode of occurrence of the Asselian carbonate sequence. The Asselian reflectors are best traced along seismic profile 26 (Fig. 4), because the foredeep here is much wider than in profile 28. This sequence is traced here from its exposure in the east (clastic and aphanitic limestones recorded by authors of the present communication) to the Riphean–Vendian swell in the axial zone of the foredeep. In this regard, the facies composition of Asselian rocks is important. According to Khvorova [3], the foredeep can be divided into two (Aktyubinsk and Ural–Ilek) zones distinguished by the compositions of rocks and their combinations. The Aktyubinsk zone is characterized by an abrupt change of rock complexes in both the latitudinal and longitudinal directions. The coarse-clastic material juts out far to the west as latitudinal tongues typical of Permian sedimentation. Along the seismic profiles studied, the Ural–Ilek zone is characterized by a different assemblage of rock complexes. The thickness of conglomerate, sandstone, and sandshale sequences decreases, whereas the clayey limestone and pure limestone units become abundant. The abundance of carbonate rocks increases to the west. The lateral zoning is expressed in the westward replacement of terrigenous flysch with fine-grained carbonate flyschoid

sediments intercalated with aphanitic limestone beds, which are favorable for the formation of fracture-type reservoirs.

As follows from the seismic and geological data, the thickness of the Lower Permian rocks abruptly increases east of the paleoswell due to the transition of sediments into the flysch formation. For example, the thickness of only Artinskian and Sakmarian flyschoid rocks in Well 71 reaches 2000 m. They overlie the 400-m-thick Asselian limestone sequence marked by reflectors Ac1 and Ac2 at its roof and base, respectively. Well Dongolyuk 210, which penetrated 1500 m of the Lower Permian flyschoid rocks [4], was stopped at a depth of 300–400 m above the Asselian rocks. Seismic profile 26 (Fig. 4) demonstrates the overlapping of the eastern part of the paleoswell by Carboniferous and Permian flysch complexes along westward thrusts. The thrust wedge abuts the paleoswell margin as a thick lens. The tectonic contact is known as the Orlovka Normal Fault. The seismic data indicate that this fault displaces both the Riphean–Vendian and the overlying Lower–Middle Paleozoic rocks, but damps off in the Permian sequence. Thus, downfaulting probably took place in the Late Carboniferous. In the Permian, the fault could be reactivated as thrusting owing to collision.

The timing of the Perovsk–Kornilovka Swell remains a matter of debate. On the one hand, this swell could have originated in the Devonian, because the Ordovician beds (reference reflector O) extending from the Sol-Iletsk area wedge out at the western wall of the swell, suggesting their erosion due to dislocations in the Devonian (by analogy with formation of the Sol-Iletsk Swell). This interpretation implies that the margins of the Perovsk–Kornilovka Swell were reactivated (renewed) in the Late Paleozoic owing to the collision of the Urals with the platform. On the other hand, the swell could have been formed in the Late Paleozoic in

response to collision with the Urals and the consequent involvement of the Riphean–Vendian sedimentary rocks of the aulacogen at the platform margin. This interpretation is supported by the nearly conformable bedding of Riphean–Vendian rocks and the overlying Paleozoic sequences, suggesting the presence of anticlines in the western and eastern framing of the swell. Moreover, the swell is characterized by the near-longitudinal orientation of the swell, whereas the Devonian uplifts lack the Uralian trend. This fact is additional evidence in favor of the above interpretation

The Perovsk–Kornilovka Swell in the Orenburg Cisural region, particularly its eastern part, represents a western boundary escarpment similar to the boundary escarpment in the Bashkir Cisural region, where many reef-related oil fields are known. Seismic profile 26 displays a wedge-shaped structure of the Lower Permian, Carboniferous, and older rocks that resembles the structure of the boundary escarpment in the Bashkir Cisural region. The seismic anomalies established in the Paleozoic (probably, Carboniferous) sequence on the western slope of the paleoswell are promising for hydrocarbon accumulations.

CONCLUSIONS

Data on the geology of the Bashkir segment of the Ural Foredeep and interpretation of the seismic profiles considered above suggest the existence of platformal carbonate rocks beneath the flysch and molasse sequences in the southern segment of the foredeep as well. In the Bashkir Cisural region, oil fields are local-

ized in carbonate reefs at the western wall of the Ural Foredeep and in the anticlines at its eastern wall. The depth of productive units reaches 2.5–3.0 km. Moreover, the oil pools give way to the gas and gas condensate reservoirs in the southern direction. All petroliferous units known in Bashkortostan are subject not only to the overall regional southward plunging toward the Orenburg region, but also to stepwise subsidence in the same direction with an amplitude reaching 500–1000 m. This fact is supported by recent seismic survey data. These circumstances hamper prospecting for hydrocarbons in the Orenburg region. Nevertheless, the occurrence of high-quality caprocks (Kungurian evaporites), the presence of good reservoir rocks (inference based on analogy with Bashkortostan), and the development of a large anticlinal structure suggest that gas or gas condensate fields can be discovered in this area.

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