G. N. DOLENKO

PRINCIPAL PROBLEMS OF OIL-AND-GAS ACCUMULATION IN THE EARTH CRUST

(Figs. 1—12)

Abstract: The author is based on the latest information about development of the earth's crust, which he also tried to apply to formation of oil-and-gas-bearing provinces, mainly to the regularities of their spatial distribution. He supports his opinions with examples of the most important oil-and-gas-bearing provinces of Ukraine.

Резюме: В статье на основании взаимосвязи развития земной коры и верхней мантии автор обосновывает теорию об образовании нефтяных и газовых провинций и их пространственного размещения. Свои доводы иллюстрирует примерами развития нефтяных провинций Украины: Предкарпатского прогиба, Днепровско-Донецкой впадины и Крыма.

During the last decades the geological science was enriched by a number of scientifical achievements in the knowledge of the development of the earth and in the determination of the accumulation regularities of mineral resources. Special attention should be payed to the notions about polymorhic, phase and chemical transformations of the earth mantle substance. Basing on the above mentioned notions, the new schemes of principal geostructural elements of the earth crust were worked out and a series of geochemical and thermodynamic conceptions about the forming of magmatic chambres and useful minerals connected with them was substantiated. The new opinions about the earth crust thickness and the structure dependence on the transformation processes of the earth mantle substances were expressed at that time. During this period, the ideas of causal connection of geotectonic and geochemical phenomena taking place in the earth crust were expressed. It was settled that the upper mantle is not only a supplier of the earth shell substance, hydrosphere and atmosphere but also is a powerful generator of all the earth crust movements.

The notions of mechanical properties of rocks and the nature of their deformations have undergone changes. During almost a century the opinion prevailed in the geological science that a plicative bending of the strata was a main form of the earth crust deformation. But at present time certain views have formly established that the major part of the earth crust displays block structure has but not the faulted one, and that the disjunctive dislocations are the main forms of rock deformations.

Extremely great progress was achieved in the investigation of the ocean bottom geology. At that time "an ocean revolution" took place which was expressed by the discovery of submarine mountain ridges and plateaus, large master faults, submarine volcanism, heat and gas flows, etc.

All the latest achievements of geological science should be taken into consideration for the solution of the theoretical problems of oil geology, in particular, the regularities of oil and gas accumulation.

The analysis of geology and the oil-and-gas content of the individual oil-and-gas-

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bearing provinces offer the possibility to state the existence of a genetic relationship between the processes of the geotectonic development of the oil-and-gas-bearing provinces, between the processes of anorganic synthesis of oil hydrocarbons in the mantle conditions, between the migration of oil fluids from magmatic chambers to the earth surface along the deep faults, and the processes of oil and gas accumulation in the earth crust.

This relationship, to our opinion, begins immediately with the genesis and subsequent geotectonic development of the earth crust sections which became later an oil-and-gas accumulation region. These sections, as a rule, are represented by the submountain depressions, intermontane areas, platformal slopes adjoined to the submountain depressions, intermontane troughs, platformal slopes adjoined to the geosynclinal regions and interplatformal depressions. The development of these geostructural elements of the earth crust may have occured in accordance with the present-day views of S. I. Subbotin (1966), V. A. Magnický (1965), V. V. Belousov (1966) etc., due to the mantle substance, volume contraction and expansion during polymorphic, phase and chemical tranformations in an increasing pressure and temperature conditions acting constantly in the great depths of the earth.

The tectonic movements of the initial stages of the geotectonic elements development are stimulated by the processes being realised in the surficial zones of the mantle. The vertical movemeats of final stages of the development are caused by the processes occuring in the greater depths of the mantle. It is characteristic of the geostructural elements of the earth crust submountain depressions, intermontane areas, platformal slopes and interplatformal sags which the oil-and-gas-bearing provinces are connecting with, that they arose and developed mainly at the final stages of the development of the geosyncline and platformal regions, when the tectonic forces reached their maximum strain. Along with the previously mentioned, the processes known as compensating ones, attained a significant importance — an inflow of a suberustal substance from under the flanks towards the central part of the depression; that fact facilitated the formation of the flange slopes adjoined to the depression.

At the border of the suberustal masses contraction and the expansion zones, according to S. I. Subbotin's views, deep faults were formed causing the earth crushing and stoping in the earth surface. During the earth crust subsidence the longitudinal deformations have arisen in the central and lateral parts of the depressions and uplifts but they have no more so deep initial stages of the subsidence.

The subsequent processes of the earth crust rock destruction have taken place in the zones of its uplift, and the accumulation of a sedimentary strata in the depression zones has accelerated the contraction and the expansion of the suberustal masses. The whole process of the suberustal masses contraction within the depression limits continued during long geological time up to an appearance of the maximum critical thermodynamic and thermodynamic—thermoelastic strains of the mantle substance. At this period the replacement of contraction into expansion took place along with the inversion of the regional territory geotectonic development.

The fractures restricting the geostructural elements have undergone the maximum stress during this period, since a subsidence of the earth crust took place, on the one hand, and an uplifting — on the other hand, along these fractures. Drawing a conclusion, we may say that these fractures occuring at the earth surface have the maximum apparent slip (shift) of rocks. They have been comparatively easier recorded by the geological and geophysical methods of exploration, and the scientists called them the longitudinal regional fractures.

The detailed exploration of the oil-and-gas-bearing provinces shows that the cross deep faults have a widespread occurrence along with the longitudinal deep ones. They developed, mainly, in the consolidated rocks of the basement and also in the lower stages of the sedimentary complex of the formations. The peculiarities of them are the facts that they split at the same time several geostructural elements of the earth crust which are contiguous to each other but they are obviously marked within the limits of the geostructural elements which have undergone the maximum subsidence; in other words, within the limits of the submountain depressions, intermontane troughs, platformal slopes and interplatformal sags. This peculiarity points out to the fact that they have, in many cases, an inherited nature from the former regional fractures. The beginning, or rather, "the regeneration" and the development of these are connected with the change of the contraction and expansion regime of the mantle substance because of unequal thickness of the accumulated sediments along the strike of the constituting geostructural elements. These fractures have formed or regenerated at the place of the old, "healed" disturbances at a final inversional stage of the regional development when the tectonic forces caused by a prominent expansion of the suberustal masses volume at great depths reached their maximum strain. In this connection, an increase of amplitude at the depths, and decrease or damping to the surface is characteristic of these fractures. This peculiarity complicates their dectection. In many cases these fractures have the nature of strike-slip fractures.

The combination of the longitudinal and the transverse regional faults caused the block structure of the basement of the sedimentary rock complex of the oil-and-gas-bearing provinces and also the nature of their tectonic pattern. As a rule, the availability of the cross uplifts and depressions which embrace simultaneously the oil-and-gas-bearing province regions an the adjacent territories, attracts special attention. There is a reason to believe that such cross uplifts and depressions just as the cross deep faults have an inherited nature from the former dry land, and during the whole geological history of the oil-and-gas-bearing provinces development had not undergone the inversion of the geotectonic regime and along with that, they had constantly affected the distribution of folding.

The transverse uplifts and depressions together with the cross fractures, usually developed at the border between them have formed a cross tectonic zoning within the limits of the oil-and-gas-bearing provinces. The latter affected essentially the regularities of the oil-and-gas fields distribution.

The exploration data of oil-and-gas presence of the best examined provinces, show us that the regularities in the dimensional displacements of the oil-and-gas accumulations in the provinces are first of all controlled by the general structure; along with this the cross uplifts and depressions and also the regional deep fractures of longitudinal and transverse directions have a dominating importance.

Within the limits of the submountain sags (depressions) and the intermountain areas there are large cross tectonic elevations limited by the regional deep faults. On the territory of the platformal oil-and-gas-bearing provinces such elements are represented by the valuting (arch) upheavals and conjugated depressions.

The oil-and-gas-accumulation zones locate, mainly at the uplift slopes sides or at the intermediate sections enclosed between the uplifts and the depressions. It is responsible for the fact that just here was revealed a favourable combination of the factors promoting the forming of an oil-and-gas accumulation — the forming of oil-and-gas containers of granular and fracture types conduced to the oil-and-gas accumulation, deformational traps catching oil hydrocarbons in the processes of their

migration, dislocations with a break in the continuity — the main ways of the oil-bearing fluids displacement from the deep plutonic centres of the formation towards the earth surface and that just here a favourable situation was formed for an oil-and-gas field conservation from destruction.

The development of the oil-and-gas containers was stimulated, on the one hand, by the fact that in these sections during the transition from the uplifts to the depressions a sea-current velocity change and one the other hand, a settling of coarse-clastic sediments took place. In the rocks the fractures have formed which may be considered as additional capacity for the oil-and-gas accumulation. It should be noted that these fractures have been formed under the influence of the tectonic stress during the faulting process.

The faulting concentration in these sections is caused by an abvious changing of rock thickness gradient during the transition from a depression towards an uplift, and by the fact that here the maximum vertical displacements took place. The depressional sections have undergone the maximum displacements at the initial stage of the development and the minimum — at the final stage but the uplifts at the beginning have plunged up to the minimum and have undergone the maximum uplifts at the end. We cannot say the same about the intermediate sections enclosed between the depressions and uplifts. At the beginning they have undergone relatively smaller submersion than the depressions and at the end — the relatively small bulging up rise than the uplifts, but it should be mentioned, that the general amplitude of their vertical displacements is greater than the amplitude of depression-uplift sections.

At these sections an intensive development of different kinds of local disjunctive dislocations complicating the fold structure is stimulated by the same reasons. The combination of these local disjunctive dislocations with the regional deep fractures promoted the migration and oil-and-gas accumulation within the limits of the structures. The most favourable conditions for the migration of oil hydrocarbons from the depth to the surface existed in crossing sections of the longitudinal and transverse deep fractures and in zones of their sharp bending where a maximal rock deformation took place.

At last, the presence of the rocks known as "cap rocks" and the favourable hydrological situation represented by an impeded water-exchange promoted the forming and conservation of oil-and-gas accumulations and also the oil pools on the territory discussed.

The forming of the oil-and-gas accumulations was in progress at the final stages of the geostructural element development which the oil-and-gas-bearing provinces are connected to, that is, in the periods of the realization of the main inversions of the Hercynian, Kimmeridgian and Alpine geotectonic cycles (G. N. D o l e n k o 1966, 1967). During the Caledonian orogenesis, the forming of oil-and-gas accumulations did not probably occur since the development of sharply marked submountain depressions, intermontane and platformal troughs did not take place in this period.

We may suppose that also the forming of oil hydrocarbons in the earth mantle conditions was in progress during the inversional stages of oil-and-gas territory development. It should be noted that the most favourable conditions for polymorphic and phase transformations and also for chemical reconstructions of the substance existed in these periods. They had a possibility to develop owing to the sudden change of the mantle substance volume contraction into the increase of that volume.

The rise of deep faults at this time was responsible for an obvious pressure decrease, a temperature change and the mantle substance mobility and, apparently, of oil hydro-

carbons having formed just in this stage but not in another one of geochemical processes development in the mantle conditions.

According to E. B. Chekaluks (1966) and I. B. Grinberg (1966) researches, the synthesis of oil hydrocarbons could at first take place with carbon dioxide-hydrogene and water interaction in the presence of ferrous oxide with later forming of methane and then a complex composition of primary oil (mineral oil) formed by means of polymorphic conversions of methane. The need of the great number of heat required for an oil hydrocarbons synthesis have been provided by the thermal energy of the mantle substance.

Having been formed in the mantle abyssal (plutonic) zones conditions rather in the sphere of Gutenberg "wave guide" as E. B. Chekaluks thermodynamic calculations pointed out (1967), the oil hydrocarbons were in a position to shift (to displace) along the deep faults — developed intensively at that time — to the surficial zones of the earth crust where they have formed the oil-and-gas accumulations in favourable conditions of the rock sedimentary complex.

We believe that the whole process — the forming of a modern structural and tectonic plan of the oil-and-gas-bearing provinces with longitudinal and transverse zoning which is characteristic of the former, the oil hydrocarbon synthesis in the mantle conditions, the oil fluids migration (of oil, gas and oil waters) from the depth towards the surface along the transverse deep faults developed in this period and a forming of the commercial oil-and-gas fields occurring in the conditions of the sedimentary earth crust shell — is a genetically homogeneous whole.

The distribution of the oil-and-gas-fields (deposits) within the limits of oil-and-gas-bearing provinces have been cotrolled, as it was pointed out, by the general plan of the territory tectonic structure and and by the distribution nature of the lithologic-facial rock complexes.

The concentration of the oil-and-gas deposits in the fields took place, mainly, along the vertical section of sedimentary rocks. The more favourable zones for the forming of gas and especially oil are connected with the tectonic and stratigrafic interruptions in the process of sedimentation, representing the beginning of the sea transgression and the regression epoch.

The zones of the main oil-and-gas accumulation with commercial (industrial) oil-and-gas fields were disposed at the intermediate sections between the ancient uplifts and depressions of the basement. The latter are characterized by the development of brachy-anticlinal folds in the sedimentary cover (mantle). These zones were disposed also an the sections adjoined directly to the regional deep faults of longitudinal direction which were accompanied by the forming of the adjacent fault forms.

The migration of oil hydrocarbons from the deep mantle hearths to the suprazones of the earth crust had developed, mainly, on the sections where the deep fractures had undergone the change of their basic direction, then in the zones of ruptures crossing which have the longitudinal and transverse directions, on the sections of the main ruptures amplitude development, in the other words, at that place where the maximum rock deformation took place with the forming of gaping fissures.

The displacement of oil fluids and the forming of oil-and-gas fields (deposits) occurred in the inversional periods of oil-and-gas bearing territories development when the tectonits strains attained great importance. We have a good reason to suppose the periods of post-Hercynian, post-Kimmeridgian and post-Alpine oil-and-gas accumulation in the earth crust. In the oil-and-gas-bearing provinces where a superposition of several tectonic cycles movements took place, the oil-and-gas accumulation took place in

several stages. However the redistribution of deposits an the forming of modern oil-and-gas fields were in progress at a tectonic cycle final stage of the territory development.

Taking into consideration three main periods of the oil-and-gas accumulation in the earth crust there is a possibility to distinguish, according to age-relation and physical-chemical properties the Paleozoic, Mesozoic and Cenozoic oils. All of them are subdivided into submontane trough oil, intermontane oil, platformal slope oil and intraplatformal depression oil, according to the thermodynamic conditions of their formation in the deep mantle chambers and to the conservation conditions in the sedimentary rock complex. The main principles of forming conditions and of displacement regularities of oil-and-gas fields in the earth crust had been tested in many oil-and-gas-bearing provinces of the USSR and abroad.

Here, because of the limited paper volume, we shall give only some examples of oil-and-gas-bearing provinces of the Ukraine directly investigated by the author: the provinces of Subcarpathian sag, Dnieper-Donets depression and the Crimea.

The Subcarpathian oil-and-gas-bearing province coincides with a typical submountain sag consisting of two zones differing sharply from each other: the internal zone bordering upon the mountain structure of the Carpathians and the external one which is contiguous to Volyn-Podolian platform of the East-European continental plateau. The sag evolution was in progress at the final stages of the Alpine tectonic cycle of the Carpathian geosyncline development and was connected with the elevation of the Carpathian zones which were composed by a thick series of the flysch formations, and also with the present-day (modern) territory downwarping of the Subcarpathian sag which represented the area of the molasse formations accumulation. The uplift (elevation) in the Carpathians and the subsidence of the sag territory was accompanied by the border deep fractures forming, on the one hand, situated between the Trans-Carpathian Neogene depression and the Carpathians, on the other hand, and then between the Carpathians and a modern internal zone of the Subcarpathian depression, between the internal and the external zones of the depression and between the latter and the Volyn-Podolian platform (fig. 1). These fractures intersect the whole earth crust and penetrate into the earth mantle with their roots. Their origin and development were connected with the contraction and expansion of the upper earth mantle substance which were responsible for the tectonic movements giving rise to the uplift in the Carpathians and the subsidence in the submountain depression.

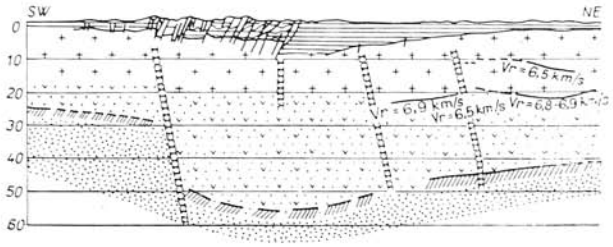

Fig. 1. Scheme of the earth crust structure within Eastern Carpathians (the Ukraine), according to V. B. Sollogub.

The forming of the individual tectonic zones of the Subcarpathian depression proceeded in a different way. Their internal zone have formed on the Carpathian geosyncline flysch Cretaceous-Paleogene basement, the external one — on the Mesozoic platformal substratum (fig. 2). The forming of the internal zone took place in the Lower

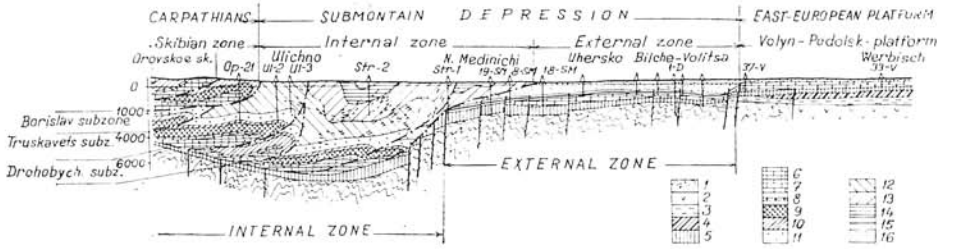

Fig. 2. Submountain depression of Eastern Carpathians (the Ukraine). Transverse geological profile. 1 — Paleozoic. 2 — Cambrian. 3 — Silurian. 4 — Devonian. 5 — Jurassic. 6 — Cenozois flysch formation. 7 — Cenozoic platformal formation. 8 — Paleocene Yamnensk suite. 9 — Eocene Manjavsk, Pasechnjansk, Vygodsk, Bystritsk, Popel suites and horizon od Borislav sandstone. 10 — Oligocene Menilite suite. 11 — Aquitanian Poljanitsk suite. 12 — Aquitanian-Burdigalian Vorotischensk suite. 13 — Helvetian Stebnick suite. 14 — Helvetian Balich suite. 15 — Tortonian with gypsum-anhydrite horizon. 16 — Lower Sarmatian.

Miocene period, thanks to that, it was made by the molasse formations of the Aquitanian, Helvetian and Burdigalian systems and only in the individual sections — it was made of the sediments of the Tortonian and the Sarmatian. The external zone development began only at the Lower Tortonian; due to that fact the Lower Miocene molasse complex was absent in th's zone and on the contrary, the Tortonian and Lower Sarmatian sediments have a wide distribution. In its structural relation the internal zone of the Subcarpathian depression is differed by the development of the brachyanticline folds occurring in the sedimentary rock complex and the grouping into an individual persistent regionally anticlinaly lines which the scientists subdivide into the following subzones: the Borislav, Truskavets and Drogobych ones. The external zone in a d'fference from the internal one is characterized by the development for the most part of the dome-shaped folds occurred irregularly. Within the limits of that zone there are two subzones in the general tectonic plan, they are the following: the Krukenich and the Ugersko-Kosov ones. The first is differed by the presence of the Jurassic rocks occuring at the basement of the Neogene formations and the second one — is differed by the presence of the Cretaceous rocks.

There are distinguished the transverse uplifts and depressions of the longitudinal direction in the Subcarpathian depression. They have usually the regional distribution and comprise not only the territories of the submountain depression but they are distributed also up the adjacent regions of the platform and the folding Carpathians. The following uplifts are distinguished there: Starosolsko-Chodnovichian, Orov-Rosdol-Van, Majdan-Ivan-Frankovian, Mikulichin-Kolomyjan and Pokutsko-Bucovinian. There the following subzones are related to the depressions: in the internal zone — Podluzhian, Dolinian, Nadvornyanian, and Verchovinian; in the external zone — Krukenich, Bolochovian, Otynsk and Kosov ones. The transverse deep fractures have developed between the uplifts and the depressions. They were formed, particularly, in the rocks of the basement and in the lower structural series of the Miocene rock complex, and like the uplifts and the depressions they comprised simultaneously a series of the geostructural elements — the Subcarpathian depression, the Carpathian themselves and the adjacent Volyn-Podolian platform.

However, their principal development, as regarts the modern tectonic plan, is ob-

serving at the territory of the submountain depression. There are reasons to ascribe younger age to them than the longitudinal fractures and to connect their origin and development just with the final (after the Lower Sarmatian phase), rather the post-Pliocene phase of the Alpine tectonic cycle.

The main oil-and-gas accumulation zones are disposed at the intermediate sections between the depressions and the uplifts (fig. 3).

Fig. 3. Scheme od relationship of regional tectonics and oil- and gas fields dislocations of Submountain depression of Eastern Carpathians (the Ukraine). 1 — Ukrainian crystalline shield slope. 2 — Lvov Paleozoic depression trough. 3 — Buried Caledonian mountain structure. Forecarpathian submountain depression: 4 — Krukenich subzone of external zone. 5 — Ugersko-Kosov subzone of external zone. 6 — Part of Kru-

In the North-Western region known as the Borislav oil-producting region we may select the Blazhevian and the Borislavian zones of the oil-and-gas accumulation. The first zone is between the Starosolsko-Khodnovichian uplift and the Podbuzhian depression, the second one — between the latter and the Orov-Rosdolian uplift. The oil-and-gas content in both zones is related to the deposits of the Yamnenskaya suite (Paleocene), the Manyavsk and the Popelsk series (Eocene the Lower — Menilite series of the Menilite series Oligocene), the Polyanitsk and lower Vorotischensk series (Aquitanian).

In the central Dolinsk oil-producing region we may distinguish the Dolinsk and the Ripnyansk oil-and-gas accumulation zones. The first zone is between the Orov-Rosdolian transverse elevation and the Dolinsk depression which has a maximal downwarping in the basin of the Chechva-river, the second one — is between the latter and the Majdan-Ivan-Frankovsk uplift. The presence of oil-and-gas in this region is timed to the deposits of the Manjavian and Bystritsk series (Eocene) and to the Menilite series.

In the South-Eastern Nadvornjansk oil-producing region connected with the Nadvornjansk depression we may distinguish the Bitkovsk and the Delyatinsk zones of the oil-and-gas accumulation. The Bitkovsk zone is situated between the Majdan-Ivan-Frankovsk elevation and the Nadvornyansk and Mikulichin-Kolomyjsk transverse elevations. The oil-and-gas presence of the region under consideration is connected with the Menilite series deposits (Eocene) and the Lower-and-Middle Menilite series of the Menilite formation (Oligocene). The concentration of the oil-and-gas deposits along the vertical section of the depositions is characteristic of all oil-and-gas accumulation zones. The example of this are the Borislav and Dolina oil deposits. The Borislav oil field (fig. 4) includes the oil pools in the Popel-series deposits (Eocene) and in the Lower Menilite series (Oligocene) of the deep (underthrust) fold, in the Yamnensk series (Paleocene), in the Manyavsk and the Popelsk series (Eocene), in the Lower Menilite series (Oligocene), in the Poljanitsk and the Lower vorotyschensk series (Aquitanian) of the Borislav fold and in the deposits of the Stryjsk series of the Upper Cretaceous system and Yamnensk series (Paleocene) overthrusted on the Borislav fold of the Coast Skiba.

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kenich subzone overlapped by external zone rocks. 7 — Part of Ugersko-Kosov subzone overlapped by internal zone rocks. 8 — Part of Ugersko-Kosov subzone overlapped by internal zone rocks of depression and Skibian Carpathians. 9 — North-Eastern boundary of Stebnick overthrust. 10 — Internal zone of depression. 11 — Part of internal zone overlapped by Skibian zone rocks of the Carpathians. 12 — North-Eastern boundary of Coastal Overlap. 13 — The Carpathians. Ancient transverse to the Carpathian uplifts: 14 — PK-BUK- Pokutsko-Bukovian. 15 — MK-KL — Mikulichin-Kolomyjskoe. 16 — M-IV- Fr. — Majdan-Ivan-Frankovsk. 17 — OR-ROZD — Orov-Rozdolian. 18 — St-SOL — Khodnov — Staro-Solsk-Khodnovchian. Internal zone depressions: 19 — POD — Podbugsian. 20 — DOL — Dolinian. 21 — NADV — Nadvornjansk. 22 — VRCh — Verchovinian. External zone depressions: 23 — KR — Krukenich. 24 — BOL — Bolochovian. 25 — OT — Otynian. 26 — KS — Kosov. Fractures: 27 — longitudinal. 28 — transversal. 29 — Gas fields: 1 — Svidnitsa. 2 — Rudki. 3 — Khodnovichi. 4 — Northern Medinichi. 5 — Girsek. 6 — Malogorozhanka. 7 — Oparv. 8 — Bilche-Volitsa. 9 — Ugersko. 10 — Kavsko. 11 — Dashava. 12 — Kadobno. 13 — Kalush. 14 — Grinovka. 15 — Kosov. 30 — Oil fields: 16 — Stara Sol. 17 — Nagvevichi. 18 — Borislav. 19 — Skhodnitsa. 20 — Urich. 21 — Orov-Ulichno. 22 — Dolina. 23 — Northern Dolina. 24 — Spass. 25 — Strutin. 26 — Olkhovka. 27 — Ripne. 28 — Nebilov. 29 — Sloboda-Nebilovsk. 30 — Majdan. 31 — Bitkov. 32 — Starunja-Gvizd. 33 — Pnev. 34 — Sloboda-Rungurska. 35 — Kokhanovka.

The Dolinsk oil field (fig. 5) contents oil deposits located in the Manjavsk, Vygodsk and Bystritsk series deposits (Eocene), and in the Lower and Middle Menilite series (Oligocene). At this stage the oil presence of the Menilite deposits reached over 1000 m. Interesting is the fact, that the oil-deposits properties do not change in dependence on the age of the enclosing rocks but of the occurrence depth — the deeper is the oil deposit the lighter and less viscous is the oil, and according to the group composition, it is characterized by the increase of the paraffinic hydrocarbons and the decrease of the naphthenic and aromatic hydrocarbons. The increase of the oil saturation in the sections of the intensive development of the disjunctive dislocations is of great interest. Everything points to the fact that the oil supply originated from the depth along the different dislocations.

The Dnieper-Donetsk oil-and-gas-bearing province in accordance with the geostructural relation represents an intraplatformal trough (depression).

The origin and the development of the former have taken place in the body of the Sarmatian crystalline shield of the pre-Cambrian East-European platform due to the drawing of the territory under consideration into the subsidence along the regional deep fractures system of the North-Western strike (the azimuth of 305—310°). As for the longitudinal geophysical section, the depression structure is characterized by the presence of the flange slopes and the central graben limited by the deep fractures which reached the Mohorovicic discontinuity. There were recorded the warping zones adjoining the marginal faults, within the graben, in the nearflange parts. In the central part of the graben the horst-like occurrence of the rocks is observed. Such a phenomenon has been caused by the displacement along the deep fractures reaching the Konrad surface. In the middle part of the central horst graben-like subsidence is carried along the fractures reaching the basalt layer surface.

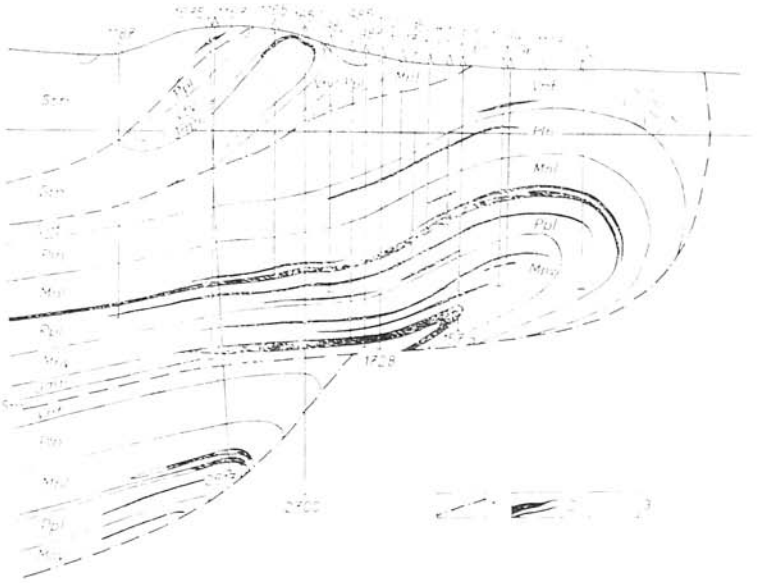

Fig. 4. Borislav oil field. Transverse section. 1 — Overlaps. 2 — Oil and gas deposits. 3 — Ozokerite mineral or fossil wax indexes similar to Dolina oil-field.

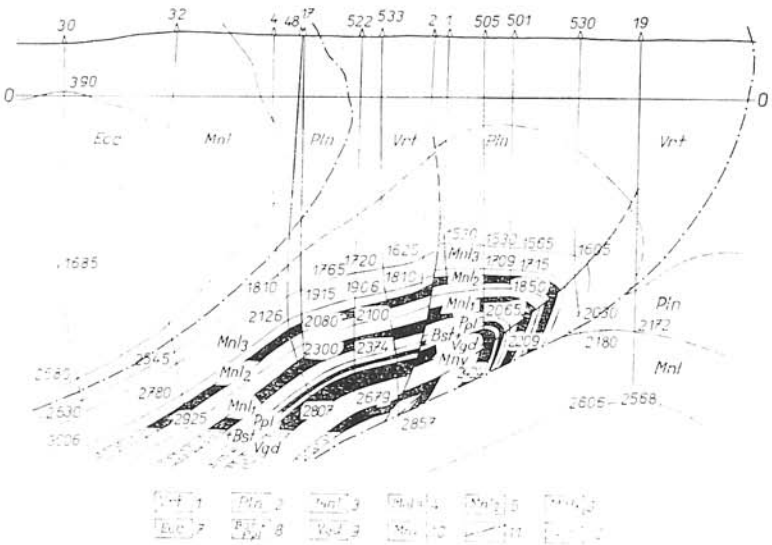

Fig. 5. Dolina oil-field. Transverse section. 1 — Vorotischensk series. 2 — Poljanitsk series. 3 — Menilite series non-dissected one. 4 — Upper Menilite series. 5 — Medial Menilite series (Lopjanetsk series). 6 — Lower Menilite series. 7 — Eocene. 8 — Bystritsk-and-Popelian layers. 9 — Vygodsk series. 10 — Manjavian series. 11 — Overthrusts. 12 — Fractures.

The Mohorovicic discontinuity characterized the general nature of the earth crust behaviour within the limits of the Dnieper-Donetsk depression and makes up an inversional stage condition of the depression development when a continuous contraction and the decrease of the subcrustal substance volume changed into reversed process — a sharp widening. Konrade surface reflects the nature of a deep structure of the depression itself. It is uplifted in the flange parts but in the central graben it is relatively subsided. Along the depression strike this surface is more downwarped in that place where the maximum thickness of the sedimentary rock complex is observed. In the structure of Dnieper-Donetsk depression the Paleozoic, Mesozoic and Cenozoic formations take part (fig. 6, 7). The thickness of the deposits is increasing from the flanges up to the central part of the depression and also along the depression strike from the North-West to the South-East. The maximum thickness of the sedimentary complex (10—12 km) may be observed in the transition zone between the Dnieper-Donetsk depression and the Donetsk fold basin.

The sedimentation conditions were controlled by the tectonic peculiarities of the washout territories development. These territories are the Ukrainian shield, confining the Dnieper-Donetsk depression on the South-West, and the Voronezh crystalline rock massif confining this depression on the North-East. The sedimentation conditions were controlled also by the peculiarities of a substratum structure of the depression itself. The geophysical studies of the basement indicate the positive forms of the relief which are expressed by the uplifts (elevations) and the negative ones which are expressed by the depression or the trough (basin). Among the elevations we may single out the following ones: Chernigov, Gmirjansk, Ljutensk, Kharkov. To the depression are related: Nezhinsk, Romensk, Poltavian and Shebelinsk.

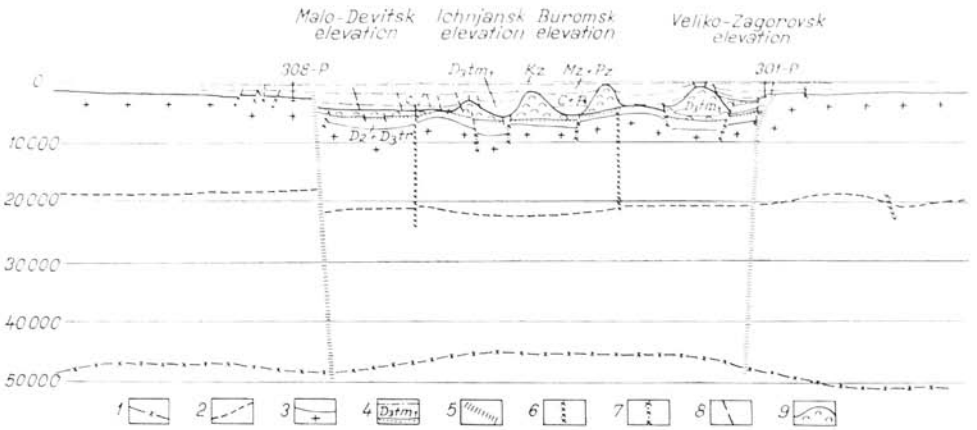

Fig. 6. Scheme of the earth crust structure in limits of Dnieper-Donetsk depression profile of GSZ along line of Zvenigorodka-Novgorod-Seversky, according to Y. B. Demidenko, M. G. Manjuta (1963). 1 — Mantle and earth crust boundary border line the Mohorovicic discontinuity. 2 — Border line of basalt and granite layers of the earth crust Konrad surface. 3 — Granite layer surface. 4 — Boundaries of structural-and-tectonic stories of sedimentary cover: $D_2+D_3f_2$ — Devonian subsalt story. D_3fm+C_1V — PreUpper Visean. C_1V_2 — P_1 — PreUpper Permian. M_z — Mesozoic. K_z — Cenozoic. 5 — Fractures of deep depression subsidence reaching mantle. 6 — Fracture of deep depresion subsidence reaching basaltic layer. 7 — Factures reaching granite layer. 8 — Factures of sedimentary cover. 9 — Outlines of saline masses.

In the time of the geological development the depressions, the elevations and the deep fractures affected the regularities of the facial deposits distribution and structural and tectonic peculiarities of the territory structure.

The actual geological data concerning the occurrences of the Carboniferous and Devonian deposits indicate the manifestation of the transverse uplifts and the basins at the early stages of the depression development. The accumulation of the effusive rocks and their tuffs in the Devonian was confined, mainly, to the sections of the uplifted blocks (the Anisov and Pavlov structures of the Chernigov elevation and etc). The depressional basins represented the areas of the saltbearing Devonian deposits accumulation.

The Ljutensk uplift in the Lower Carboniferous period drew a line between the carbonate facies developed to the South-East from the former and the subcontinental sandy-clayey facies having a distribution in the North-Western direction. In the Upper Visean time a significant increase of deposit thickness is observed on the territories situated in the Eastern direction from the Ljutensk elevation and then a decreasing, and instead of that an increase of an arenacity along the section in the areas near the elevations.

The regional deep fractures of longitudinal and transverse directions had strongly affected the forming of the geological structure of the Dnieper-Donetsk depression.

The longitudinal fractures have usually a continuous history of their development and a significant widening of the dislocation zone. Their amplitude is increased from the depth to the earth surface. They are accompanied usually by the development

of the nearflange (nearfaulting) compensating syncline troughs which are characterized by a comparatively increased thickness of the sedimentary formations.

The transverse deep fractures are situated, mainly, on the border lines of the uplifts and the depersions of the foundation. Their origin or "regeneration" is connected with an inversional period of the territory geotectonic development. These fractures are well defined in the basement rocks and in certain degree in the lower structural stages of the sedimentary cover (mantle). The longitudinal and the transverse deep fractures were responsible for the block structure of the basement and along with the development of uplifted and depressional sections in a sedimentary complex of the basement.

The studies have shown that the most part of the local structures is arranged on influenced the conditions of the folding development.

The peculiarities of the basement and the sedimentary mantle structure have the sections enclosed between the elevation and the depressions, and also in the nearflange (near fault) zones of the longitudinal regional fractures, that is, there where the sharp change of the gradient of the sedimentary formation thickness is observed. The structures, according to their nature, are polygenic ones. They consedimentally developed in the pre-Upper Permian period, after the Upper Permian period their forming taken place under the influence of the folding movements. It is determined that the lower structural plans of the sedimentary rock complex are in an agreement with the basement in their building but the upper ones are controlled mainly by the regional plan of fracture tectonics. On account of this the local structures of the upper stages have an orientation along the basic depression strike parallel to the longitudinal fractures but in the lower stages the axial lines of them (the local structures) deviate from this direction and orientate to the meridional course. More often than not it is observed in the intersection zones of the regional transverse and longitudinal fractures.

The analysis of the oil-and-gas content shows that the oil-and-gas accumulation zones are on the intermediate sections between the transverse uplifts and depressions, and also on the sections adjoining the regional fractures (fig. 8). It is stimulated by the fact that the container-rocks, the trap structures and rupture ways of oil-and-gas migration have developed just in these zones, and along with this a favourable situation existed for a deposit preserved from demolition. For example, there are located Prilukian, Gnedintsian, Leljakovian, Chernukhin and Bubnovsk oil deposits around the Gmirjansk elevation limited by Nezhinsk depression (basin) from the North-West and by Romensk depression from the South-East.

There are the following oil-deposits (oil-pools): Kachanovsk, Ribalsk, Sahajdak,

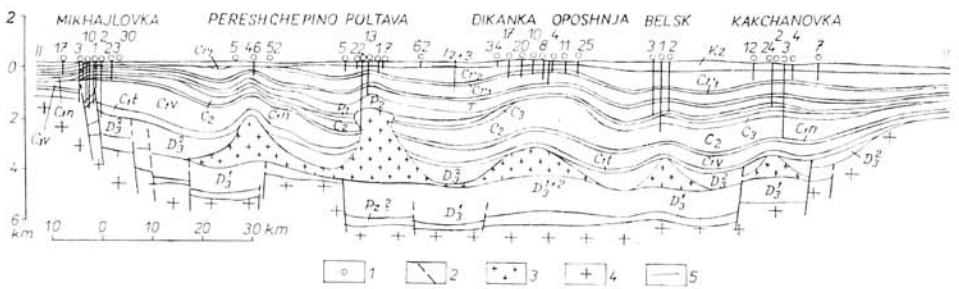

Fig. 7. Dnieper-Donetsk depresion. Transverse geological profile. 1 — Wells. 2. Stratigraphic border lines. 3 — Saline masses. 4 — Granite basement of depression. 5 — Fractures.

Solokhov, Belsk, Radchenkovsk, Glynsko-Rozbyshevsk and etc., they are situated on the intermediate sections between Romensk depression and Ljutensk transverse elevation (uplift) and also between the latter and the Poltavian depression. The Shebelinsk, Kegichevsk, Ephremovsk, Melichov, Golubovsk-Ilychevsk and Leventsovsk gas-deposits are confined to Kharkov transverse elevation.

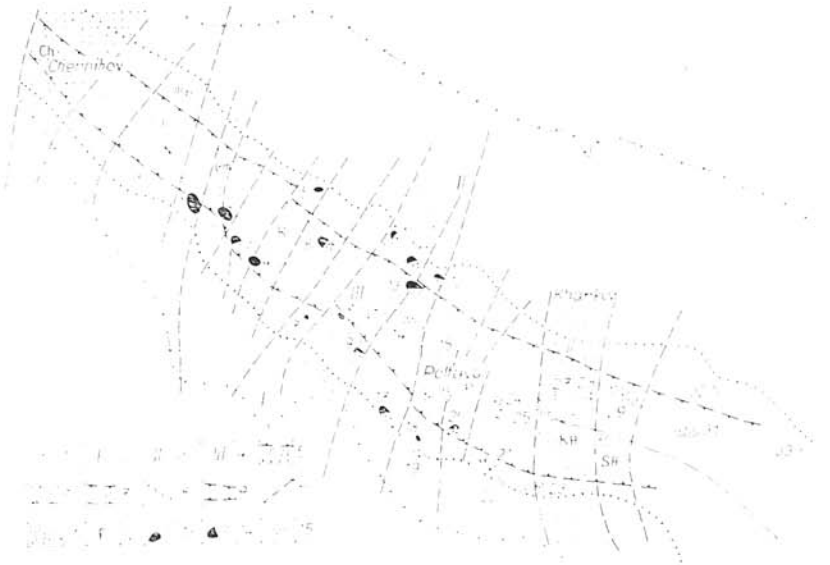

Fig. 8. Scheme of tectonic plan relation and oil-and-gas field location of Dnieper-Donetsk depression. 1 — Border lines of Dnieper-Donetsk oil-and-gas-bearing province. 2 — Southern flange of depression Northern-Eastern slope of the Ukrainian crystalline shield. 3. — Northern flange of depression South-Western slope of Voronezh crystalline massif. 4 — Dnieper-Donetsk graben. 5 — Southern nearflange zone. 6 — Northern nearflange zone. 7 — Central zone. 8 — Marginal fractures. 9 — Longitudinal dislocations breaks. 10 — Transverse breaks. 11 — Ancient transverse uplifts. Ch — Chernihov. Gm — Gmirjansk. LT — Ljutensk. Kr — Kharkov. 12 — Ancient transverse depressions basins. N — Nezhinsk. R — Romensk. P — Poltavian. SH — Shebelinsk. 13 — Oil fields. 14 — Gas fields. 15 — Oil-and-gas fields: 1 — Priluki. 2 — Leljaki. 3 — Gnedintsy. 4 — Chernukhi. 5 — Romny. 6 — Glinsk-Rozbyshev. 7 — Kibintsy. 8 — Radchenky. 9 — Sahajdak. 10 — Novo-Troitsk. 11 — Kachanovka. 11 — Rybalsk. 13 — Belsk. 14 — Solokha. 15 — Runovschina. 16 — Mashewka. 17 — Zachepilovka. 18 — Novo-Nicolaevka. 19 — Michajlovka. 20 — Novo-Grigorjevka. 21 — Pereschepino. 22 — Gobulovka-Iljichewka. 23 — Leventsovka. 24 — Verchne-Lanovka. 25 — Sosnovka. 26 — Kegichevka. 27 — Melikhovka 28 — Yefremovka. 29 — Shebelinka. 30 — Miroljubovka. 31 — Spivakovka. 32 — Severo-Golubovka. 33 — Krasno-Popovka.

All these deposits are characterized by an increased arenacity of the terrigenous formations of the Upper Visean, the Middle Carboniferous and the Lower Permian periods. Most of them are of the multiseamed formations. For example, Kachanovsk oil-field (fig. 9) has more than 20 productive horizons, the Shebelinsk one (fig. 10—14), the Rybalsk one — 12, the Radchenkovsk — 11, Gnedintsevsk one — 6. The other oil deposits have also several producing horizons. The forming of oil-and-gas deposits in these horizons took place in the Pre-Paleogene period when an inversion of a geo-

tectonic regime of the Dnieper-Donetsk depression development was under the way. The brachyanticlinal folds are the main types of the oil-and-gas-bearing structures. These folds are often complicated by the diapir folds of the Devonian and the Lower Permian salt. The prevailing forms of the oil-and-gas deposits are the bedded arched ones, the bedded arched massive ones and the bedded tectonically and stratigraphically shielded ones.

The oil-and-gas-bearing province of the Crimea is connected according to the geostructural relation with a young epihercynian Scythian platform enclosed between the Pre-Cambrian East European platform and the Alpine structure of the Mountain Crimea. The part in the delimination of the geostructural elements — southern slope of the Ukrainian crystalline shield, the Scythian platform, the Mountain Crimea and the Black sea depression play deep sublatitudinal fractures (fig. 11). Proceeding the data of the geophysical researches (G. N. Sobacar 1966; V. B. Sollogub 1966 et al.) these fractures penetrate into the katazones of the earth and in their development they are connected with the processes occurring in the mantle. In this connection they

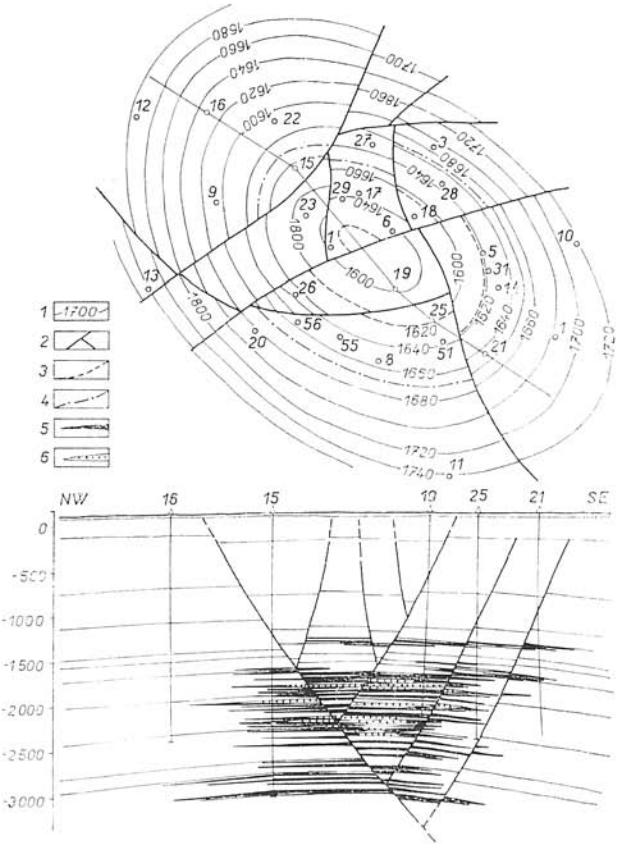

Fig. 9. Kachanov oil-and-gas field. a — in plan, b — in section. 1 — Contour lines along the Lower Permian bottom, 2 — Fractures, 3 — Gas pool outlines, 4 — Oil pool outline, 5 — Oil deposits, 6 — Gas deposits.

have prolonged geological development and they are characterized by significant with of the dislocation zone.

The transverse submeridional deep fractures display wide distribution along with the longitudinal and sublatitudinal ones. They intersect simultaneously an epihercynian platform and the contiguous Mountain Crimea and the southern slope of the Ukrainian shield. A step-like subsidence of the epihercynian platform in the direction to the Black sea and the sea of Azov took place along these fractures. Important is the fact, that the active seismic zones, the epicentres of the earthquakes and the Neogene-Quaternary volcanism are connected with them.

As a result of the interaction of a transverse and a longitudinal zonings, the basement of the epihercanian platform is divided into a series of blocks which, to a certain degree, are uplifted and subsided in relation to each other (N. Y. Uspenskaya 1966). The tectonic blocks of the basement are presented in the sedimentary cover as the depressions and elevations. The basic depressions and elevations are the following: Northern-Crimean sag dividing into Karkinitsk and Sivasch depressions by Perekopian Transverse elevation: Evpatorian-Novoselovsk rampart (arch): Simpheropolian transverse uplift: Novotsaritsinsk elevation: Almine depression and Indolian trough (fig. 12).

The Northen-Crimean depression adjoins the southern slope of the Ukrainian shield. The thickness of its sedimentary series is 4—6 thousand metres. Among the deposits there are determined the Neogene, the Paleogene and the Cretaceous formations: it is possible that there also present the Jurassic rocks. Along the longitudinal fractures, and more seldom along the transverse ones there are located the rampart-like zones of the local structures. At the Northern flange we may distinguish the following elevations: Genichensk, Novoaleksejevsk, Novotroitsk; on the southern flange there are theree lines of folds: Oktjabrsk-Mjelovaya, Kirovsko-Karlovsk and Bokalsk-Mezshvodnensk ones.

The Evpatorien-Novoselovsk rampart (arch) is characterized by the uplifted position of the Paleozoic folded substratum. It is divided by faults into several tectonic blocks: Evpatorian ,Western-Novoselovsk and Saksian ones. The Novoselovsk block has more elevated position where the Paleozoic rocks have been discovered in the depth of

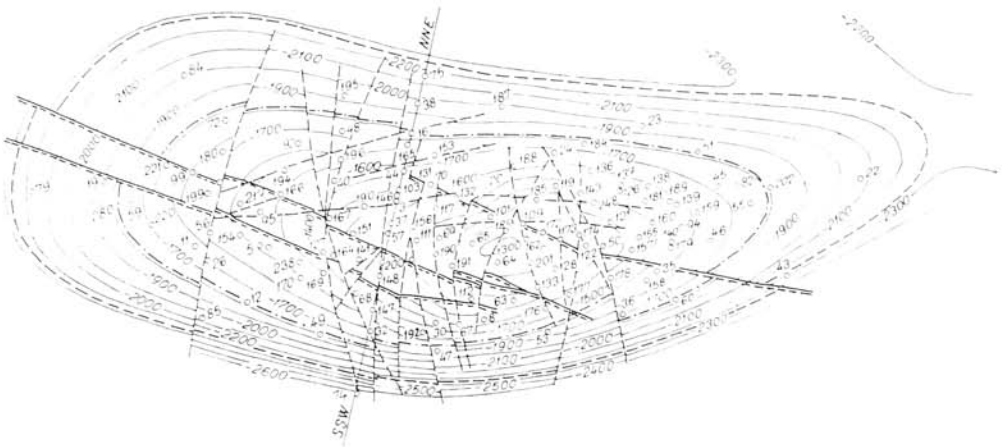

Fig. 10. Shebelinsk oil-and-gas fields in plan.

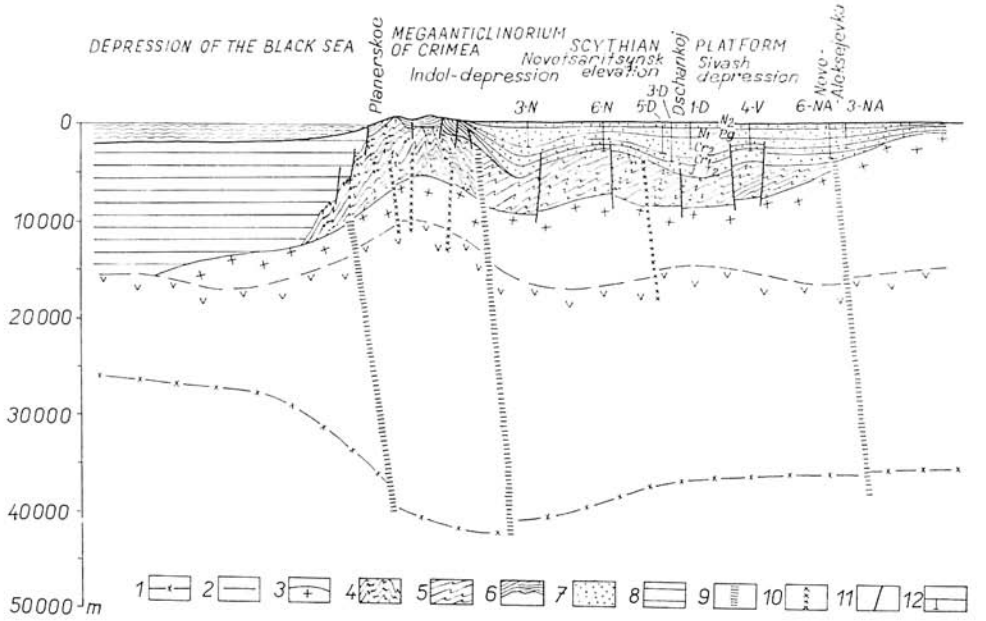

Fig. 11. Scheme of the earth crust structure in limits of the Crimea. 1 — The Mohorovicic discontinuity. 2 — Konrad surface (discontinuity). 3 — Granite layer surface. 4 — Tavria series and Paleozoic of Mountain Crimea. 5 — Paleozoic formations of Scythian platform. 6 — Jurassic geosyncline formations of Mountain Crimea. 7 — Sedimentary platformal cover. 8 — Sedimentary deposits of the Black Sea. 9 — Fractures of deep-seated locations reaching mantle. 10 — Fractures of deep-seated location reaching basalt layer surface. 11 — Dislocations in sedimentary series. 12 — Wells.

900—1200 m. The local structures on this arch (rampart) are, mostly, consedimentational ones according to their nature and they are situted without special regularities.

The Simpheropolian transverse uplift (elevation) stretches as a meridional arch (rampart) up to the Perikopian isthmus and further to the North up to the border of the Pre-Cambrian platform. This elevation separates the Almine depression and the Indolian trough (sag) into the transversal direction. The Novotsarithnsk elevation is similar to the Simpheropolian one. It separates the Sivasch depression (basin) and the Indolian trough (sag) into the longitudinal direction. Within its limits the deposits of the metamorphosed Paleozoic have been discovered at the depth of 2745 m: it should be noted that the section of the Cretaceous, Paleocene, Eocene and Neogene formations increased sharply.

The Almine depression is characterized by the presence of the two comparatively subsided sections divided by the Bakhchysaraj uplift (elevation). In the depression structure the Pre-Cretaceous, Cretaceous, Paleogene and Neogene deposits took an active part. The depth of the foundation is 2.5—3 km. The sedimentary cover (mantle) is complicated by the small local structures, namely: the Teplovsk, Nicolaevsk, Kolchuhinsk and etc.

The Indolian trough (sag) is the Western part of the whole Indolian- and Cubanian depression. The Paleogene and the Neogene (of a significant thickness) and the antropo-

genic formations took part in its building. The whole thickness of the sedimentary strata, according to geophysical data, is of 6—8 km. The southern slope of the depression is complicated by the structures of mud volcanism prolonged mostly in the sublatitudinal direction.

The regional tectonic plan of the substratum structure of an epihercynian platform with its uplifts and depressions has considerably influenced the distribution of rock thicknesses of the sedimentary cover and their structural formations.

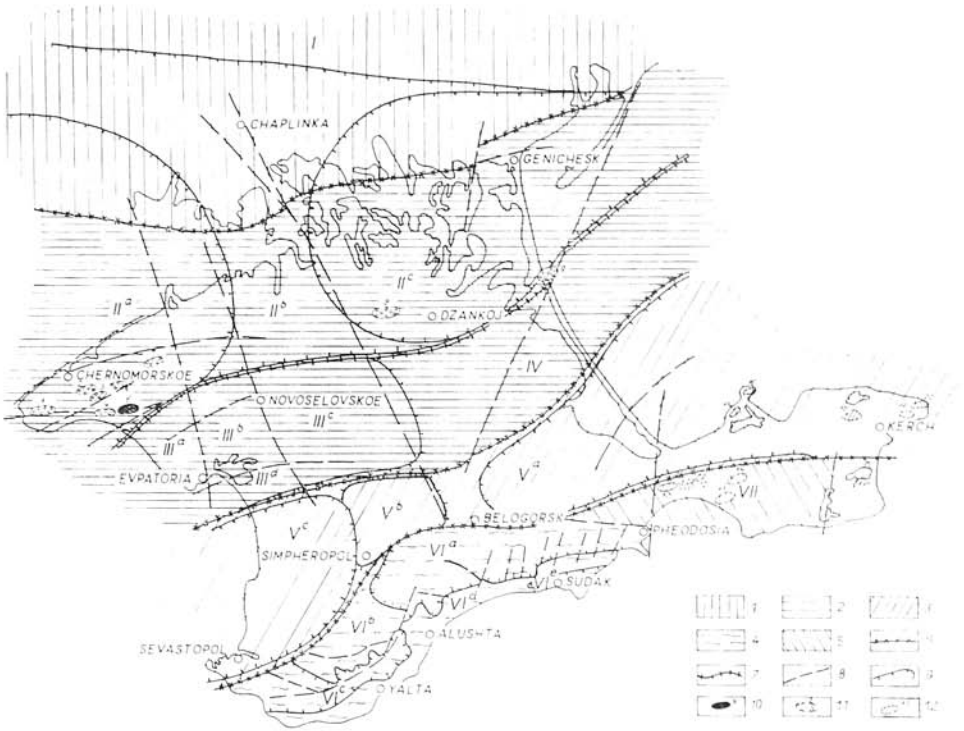

Fig. 12. Sketch map of tectonic zonation and oil-and-gas accumulation distribution of Crimean oil-and-gas-bearing province. 1 — Southern slope of PreCambrian East European platform. 2 — Epihercynian Scythian platform. 3 — Submountain foredeep of Crimean mountain structure. 4 — Crimean mountain structure. 5 — North-Eeastern continuity of Crimean mountain structure. 6 — Deep-seated fractures at geotectonic elements border line. 7 — Deep-seated inside of geotectonic elements. 8 — Deep-seated trasverse fractures submeridional ones. 9 — Outlines of separate structural and tectonic elements, fields. 10 — Oil fields. 11 — Gas fields. 12 — Old low separate structural and tectonic elements, fields. 10 — Oil fields. 11 — gas fields. Structural-and-tectonic elements: I — Southern slope of Ukrainian shield. II — North-Crimean depression. IIa — Karkinitsk depression. IIb — Perekopian uplift. IIc — Sivashian basin. III — Expatorien-Novoselovsk uplift. IIIa — Expatorien block. IIIb — Western-Novoselovsk block. IIIc — Novoselovsk block. IIId — Sacksk block. IV — Novotsaritsin uplift. V — Submountain foredeep depression of Crimean mountain structure. Va — Indolian depression. Vb — Simpheropolian uplift. Vc — Almine basin. VI — Crimean mountain structure. VIa — East-Crimean synclinorium. VIb — Kachinsk uplift. VIc — West-Crimean synclinorium. VId — Southern coast uplift. VIf — Sudaksk synclinorium. UP — North-Eastern subsidence of Crimean mountain structure.

The oil-and-gas content of the Crimean territory is connected with the Lower Cretaceous and Paleogene formations and also with the Neogene formations. Within the limits of the North-Crimean depression which is the main zone of the oil-and-gas accumulation, there are discovered the gas-condensate fields in the depositions of Albian stage (Oktjabr and Western Oktjabr structures) in the Cenoman (area), and also gas-deposits in the Paleogene (the following gas-fields: Glebovskovian, Zadornynsk, Karlovsk, Krasnopoljansk, Western-Kirovsk and Olenevsk) and in the Oligocene-Neogene (Majkopian) formations (the Dzankoj and Strelkov structures). In the Indolian depression (trough) there are discovered small oil deposits in the Neogene formations on the structures of mud volcanism. In the other regions of the Crimea the gas or oil deposits have been discovered yet. One of the peculiarities of the oil-and-gas fields distribution of the Crimea indicated by their confining to the southern pflange of the Karkinite and Sivasch basins where a sublatitudinal fracture have developed at a border line of the Northern-Crimean depression and the Evpatorian-Novoselovsk Paleozoic rampart (arch).

Summing up the discussion of the oil-and-gas presence of the concrete oil-and-gas bearing provinces of the Ukraine it should be noted that the regularities of the oil-and-gas fields distribution have been restricted, mainly, by the tectonic plan of the structure and by the lithologic-and-facial changes of the rocks which are in close genetic relation to each other and which reflect simultenecously the nature of the substratum. The development of the oil-and-gas-bearing provinces is in a genetic relation (connection) with the processes of the earth upper mantle.

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