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1. The Kertch-Taman Oil Region. By V. Obruchev.
2. The Berekei Oil Region. By A. Pritula.
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4. The Oil Regions of the Eastern Coast of the Caspian Sea. By D. Sokolov.
5. The Fergana Oil Region. By A. Pritula. 1926.
6. The Cukhta Oil-Bearing Region. By S. Obruchev.

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THE COUNCIL OF PETROLEUM INDUSTRY

V. OBRUCHEV

PROF. OF MINING ACADEMY OF MOSCOW

**THE KERTCH - TAMAN
OIL REGION**

With 20 figures and 2 maps

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GENERAL DESCRIPTION

Geography.—The Kertch-Taman oil region comprises two Peninsulas,—one, the Kertch Peninsula, that forms the eastern part of the Crimean Peninsula, and the other—the Taman Peninsula, that forms a part of the Caucasian Isthmus, projecting westward. The two Peninsulas projecting from opposite sides towards each other separate the Sea of Azov from the Black Sea, being themselves separated by the narrow Strait of Kertch (fig. 1). Owing to its position between two seas, this region is very accessible, especially since the shores of the Peninsulas offer several bays that are deep enough and afford all facilities for the construction of harbours; the town of Kertch possesses a well equipped harbour. The Strait of Kertch is navigable for ships of a draught up to 5 m. The town of Theodosia, situated at the western base of the Kertch Peninsula and connected with Kertch by a railroad, has an excellent harbour that is accessible for ships of any draught. On the northern shore of the Taman Peninsula there is also a sea-port town Temriuk in a large bay, accessible for ships navigating the Black Sea. Both Peninsulas lie at 45° of northern latitude.

1. *The Kertch Peninsula* is nearly 100 kilometers long and from 20 to 45 kilometers wide; it presents an arid plain, where long, wide and flat valleys alternate with more or less narrow, in places rocky, hills and flat ridges rising to a height of from 100 to 150 meters. In the northern and north-eastern part of the Peninsula these ridges stretch in a latitudinal direction, while in the south-eastern part of the Peninsula they extend in a north-eastern direction; mud volcanoes are to be found in places on the ridges and in the valleys. The south-western part of the Peninsula presents a large plain cut at the sea-side by gullies and ravines; in the north and east it is bordered by the steep slope of the Parpach ridge. There is no running water on the Peninsula; water appears in the ravines only during the period of rains and the thaw-

ing of snow. Lakes of different sizes are situated at the mouths of large valleys near the sea shore; these lakes,—as the Aktash, Chokrak, Churubash, Tobechnik, Elkin, Uzunlar and Kachik,—contain more or less salt water and are partly worked for the production of salt. People use water from wells and scarce springs and collect rain and snow water into basins and pools, as the ground water is more or less salt.

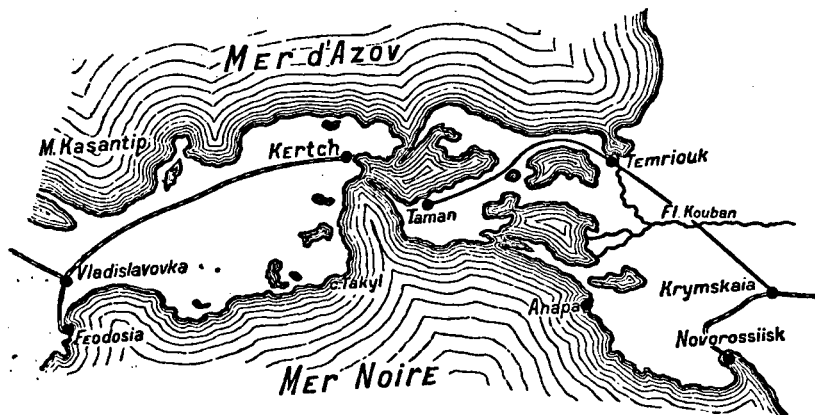


Fig. 1. Map of the Kertch and Taman Peninsulas.

THE POPULATION of the Kertch Peninsula consists of Russians, Tartars and German colonists. They live in small villages and farms scattered over all the area at a distance of from 3 to 10 kilometers from each other; they breed cattle, fewer cultivate land, and in the sea-side villages their occupations are salt production and fishing. Theodosia being situated outside the Peninsula, there is but one town of Kertch on it, on the shore of the Strait of Kertch, with nearly 30,000 inhabitants; in the town there are numerous small factories and works (a tobacco factory, soap factories, a cement works, a candlemaking works, a saw mill, a brandy-distillery, a flour mill, fish smoking plants) and a big foundry and iron-works, which is not yet completed, but has already partly utilized the vast local deposits of iron ore, that is principally exported to the south-russian metallurgical works. Owing to the proximity of inhabited localities to the districts where mineral deposits are found, the future industry is fully provided with workmen.

WAYS OF COMMUNICATION. The standard gauge railway cuts the Kertch Peninsula across from west to east, from the Vladi-

slavovka station to Kertch; in the north of the Crimean Peninsula this railway joins, at the station Djankoy, the main line Moscow—Sebastopol. Throughout the rest of the country there are cart roads connecting all the villages and farms; on account of the hardness of the soil and the flatness of the land these roads are passable in all weather and are suitable for motor-car traffic.

BUILDING MATERIALS there are in abundance,—such as limestone, sandstone, marls and clays; they compose the Tertiary deposits of the Peninsula and in many places are exposed on the surface. Particularly well known is the «Kertch stone» from the Meotie strata, large quarries of which are found near Kertch and the village of Eni-Kalé on the shore of the Strait of Kertch. This stone is mined and shipped in large quantities in coasters to all the towns in the Crimea and along the shores of the Sea of Azov. The «Kertch stone» is a white soft shell-limestone which is easily sawed into pieces of regular shape. There is also a hard limestone mined in the vicinity of Kertch and the villages of Bulganak and Tarkhan, sandstone in various places, asphalt near Eni-Kalé; a stone of higher strength can be easily supplied from quarries on the southern shore of the Crimea. The mountain Karadag near Koktebel in the vicinity of Theodosia contains vast deposits of trass which is an excellent hydraulic cement.

THE CLIMATE of the Kertch Peninsula, the latter not being protected from north-east winds, is not so mild as that of the southern shore of the Crimea; the former approaches the climate of the Ukraine steppes; the average annual temperature in Kertch is +8.7°C with a maximum of +29°C and a minimum of -26°C; the rainfall is 330 mm. The summer is hot, while the winter is cold, windy and scanty of snow; the Strait of Kertch freezes for a period of several weeks; the pleasantest seasons are spring and autumn with their steady and warm weather. The largest amount of rainfall the country receives in the summer time, when rare but heavy rains fall.

2. *The Taman Peninsula* is about 60 klm. long, taking as its base the meridian passing Temriouk, and 35—40 klm. wide; owing however, to numerous large bays and estuaries (limans), the area of this Peninsula is considerably smaller than that of the Kertch Peninsula. From the Kertch Strait the Taman bay cuts far into the Taman Peninsula; likewise the Akhtaniz and Temriouk limans extend from the sea of Azov, and the Kiziltash liman from the Black Sea; there are also some smaller bays and lakes separated

from the sea and limans by spits and bars. Between these bays and limans the land partly forms swampy lowlands, but chiefly the country consists of flat plains and valleys gently rising towards separate hills shaped as flat cones and towards short ridges rising 140—160 m. above sea-level. Swamps are especially numerous at the base of the peninsula along the branches of the Kuban river; to the west of them the locality is much drier and its character approaches that of the Kertch Peninsula with its wide shallow valleys between ranges of hills. In addition to that of the Kuban river, running water is found here and there in small streams that dry up in summer time; the inhabitants of the country provide themselves with water from wells and basins where rain and snow-water is collected.

THE POPULATION of the Taman Peninsula is concentrated in Temriouk on the Kuban river (about 20,000 inhabitants) and in a few large «stanitsas» («stanitsa»—a cossack village) in the western part of the Peninsula; the population consists chiefly of Russians; fewer in number are Armenians, Germans and mountaineers; cattle-breeding and fishing are their principal occupation, while less common are cultivation of land, horticulture (tobacco, grapes, melons and watermelons, fruit) and bee-keeping. Beside the «stanitsas» many farms are scattered in different localities along the sea shore as well as around the bays.

WAYS OF COMMUNICATION. Temriouk is a sea-port which lies at a liman of the same name and at the mouth of the Kuban river; however, Temriouk is connected with the Krasnodar-Novorossisk railroad only by a highway nearly 80 klm. long which joins the railway station Krymskaia; all villages and farms are also connected by highways that are in most cases fairly good, only in some places swampy; a highway and a telegraph line lead westward to the stanitsa of Taman.

BUILDING MATERIALS are plentiful; to them belong limestone, sandstone, marl and clays of the Tertiary sediments, of which hilly ridges are composed. Along the shores of the Sea of Azov and the shores of the Black Sea there are widespread dune-sands containing shells.

THE CLIMATE of the Taman Peninsula differs from that of the Kertch Peninsula only by a greater humidity, due to the abundance of bays and limans; the climate is unhealthy in swampy localities, especially in the delta of the Kuban River.

GENERAL CONDITIONS OF WORK. The proximity of inhabited localities to the places where oil seeps and springs are found warrants the supply of labour for the industry to be developed here; the irregular shore-line of the Taman Peninsula due to intersection of the coast by bays and limans facilitates the delivery of stores and materials by means of small boats and lighters, while a final delivery to future oil fields can be made by highways over short distances of 3—5 km. On the Kertch Peninsula the railroad and numerous highways connecting the villages fully guarantee transportation facilities in supplying enterprises of the Peninsula; here these enterprises are more distant from the sea shore, which is not much intersected and is rocky in many places. On account of the scarcity of snow in winter the automotive traffic may be kept up throughout the year, while new highways can be constructed at a low cost, owing to the qualities of the soil. The ports of Temriouk, Kertch and Theodosia can be properly equipped for the exportation of local products abroad. The land relief should present no difficulties in case of the construction of a pipe line. The drawback of this region is the entire absence of forests which might supply timber and firewood; these have to be brought from ports on the Sea of Azov or from the western shore of the Caucasus; however, the abundance of local building stone to a great extent diminishes the need of timber.

GEOLOGY

Both Peninsulas are composed of nearly identical sedimentary rocks belonging to Tertiary and Post-Tertiary deposits; igneous rocks are absent; the geological structure is comparatively simple. Without entering into details, the following table of formations may be given:

THE KERTCH PENINSULA.

THE TAMAN PENINSULA.

I. Recent.

Deluvium and Eluvium on the slopes of hills.

Valley and sea shore alluvium. Sea-board dune sands. Silts and sands of the Kuban delta.

Mud volcanoes ejections and mud flows.

II. Post-Tertiary.

1. Loess-like clays with land shells.

1. Loess-like clays below intercalated with sand layers containing fresh-water shells (occasionally). Up to 20 m. thick.

2. Marine and salt water sands and fossil shells; sometimes underlain by estuary shells (the Chokrak Lake). 2. Micaceous sands and pebblestones with fresh water shells and elephant and Elasmotherium teeth; in places with sea shells.

III. Neogene.

1—Upper Pliocene.

1. Limestones and sand of the Cape of Chauda. 1. Quartz yellow, white and gray sands.
2. Sands of Adjibay and Akhtara—Kodjalka. 2. Grayish clays interbedded with layers of ferruginous sand and soft ferruginous sandstone.
Super-ore sands and clays of Kamysh-Burun.

2—Middle Pliocene.

- Ore beds of Kamysh-Burun and other ore-bearing synclines (1+2=up to 50 m. thick). Hard clays interbedded with layers of brown clayey hematite and shell limestone.

3—Lower Pliocene (Pontian stage).

- Sub-ore beds of Kamysh-Burun (clays, marls, sands, phalenes). Sands of Kiten. Cavernous limestones of Kertch, Ossovin and others (up to 60 m. thick). Gray sandy clays interbedded with layers of ochre and fossil shells (in the north-western part of the peninsula absent). (From 80 to 90 m. thick).

4—Meotic stage.

- Building limestone of Kertch (up to 80 m. thick). Gray shaly clays with fish remains and fossil shells, in places shell limestones.

5—Upper Miocene (Sarmat).

1. Bryozoa limestone. 1. Bryozoa limestone, in places gray shaly clays interbedded with limestone.
2. Light shales with gypsum. Cement marls. Oolitic limestone of Kez. Opuka sands with *Mactra Caspia*. 2. Gray, «worm» shaly clays with *Mactra Vitaliana* and others.
3. Marls, sands and limestones with *Vincularia*, *Nubecularia*, or detrital with *Mactra podolica*, *Cardium obsoletum*. 3. Dark hard clays with interbedded layers of silicious dark marls and cobbles of porous limestone.
(1+2+3=120—160 meters thick). 4. Dark slightly laminated clays with interbedded strata of silicious marls and layers of conglomerate; *Mactra podolica*, *Cardium protractum*.
4. Upper dark shaly clays with concretions of sphaerosiderite and with *Cardium protractum* (300 m. thick).

6—Middle Miocene (second Mediterranean Sea stage).

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|---|--|
| 1. Spaniodon beds (limestones, sands, sandstones and clays with <i>Spaniodon-Barbotii</i>). (70 m. thick.) | 1. Dark shaly clays with fish remains, <i>Spaniodontella</i> and intercalations of marly or porous limestone. |
| 2. Chokrak limestone, Bryozoa limestones with <i>Pecten</i> , detrital limestones and sands with <i>Cardium multicosatum</i> ; green clays with <i>Spirialis</i> . (4—30 m. thick.) | 2. Bituminous dark clays with remains of fossil fishes, <i>Foraminifera</i> and <i>Spirialis</i> ; fine layers of sand and marl, at the base—marl strata with <i>Spirialis</i> and <i>Pecten denudatus</i> . |

7—Lower Miocene (and upper Oligocene).

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| Lower dark shales with gypsum, intercalations of sands and marls and with fish remains (scales of <i>Melletta</i>), <i>Pecten denudatus</i> , <i>Spirialis</i> , ophiures, needles of siliceous sponges, diatoms (300—400 m.) | Maikop series of dark shaly clays with large concretions of sphaerosiderite, fish remains, gypsum and ochre streaks. |
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IV. Paleogene.

8—Upper Eocene.

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| White and gray marls of the Barton stage in the Durmen mud volcano and near the village of Karangyt; granular hard limestones near Theodosia (up to 200 m.). | Not exposed. |
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Comparing the formations which are most widespread over both Peninsulas, it is easy to note a greater variety of rocks building up the Kertch Peninsula, while on the Taman Peninsula clays predominate. The sea which covered both peninsulas during the Upper-Tertiary period, was originally deep and has deposited a thick (300—400 m.) body of dark clays of Maikop series. Later it grew shallow in its western part, on the site of the Kertch Peninsula, depositing sands and calcareous silt interbedded with clays. This process of shoaling but slightly touched the region of the Taman Peninsula, where clays predominate as formerly with embedded but thin layers of marl, limestone and sandstone. During the early period of the Upper Miocene (Sarmatian) epoch the sea deepened again and deposited a second thick (300 m.) series of dark clays; then it grew shallow—quicker in the Kertch region and slower in the Taman region. Only at the end of this epoch the conditions in both regions became nearly similar. Still

even later, to the very end of the submersion, the sea remained deeper in its eastern part covering Taman, compared with its western part. Even in the strata of the Kertch Peninsula one may trace, by a study of their character in an east to west direction, that the sea grew shallow from west to east; there is seen, however, a difference in the character of strata in various places of the area of the Taman Peninsula; for instance, in the north-western part the Lower Pliocene is wanting, while in other localities Pontian sediments unconformably overlie the beds of the Middle and even Lower Miocene. This is due to movements of the crust that spread over this region, forming folds on the sea bottom, some of the latter even pushed above the surface. At the beginning of the Pliocene period, during the Pontian epoch, there existed on the site of the Kertch Peninsula almost fresh-water limans beneath which subsequently iron ore strata were formed; during this epoch on the site of the Taman Peninsula there still existed a shallow sea with a few islands.

As is shown by the geological map, the above described sedimentary formations are distributed over both Peninsulas in an irregular manner, which is principally due to irregular upheavals and to processes of erosion.

The Kertch Peninsula is sharply divided into two parts by the Parpach ridge, which in the west stretches almost in an east to west direction, afterwards turning abruptly to the south. Within the arc of this ridge, i. e., in the southwestern part, are exposed almost exclusively the oldest formations—the lower dark clays of the Maikop strata covered in places with remnants of later formations—Chokrak, Sarmatian and Pontian; on the Durmen hill, as well as near the village of Karangyt, below these formations there appear marl beds of the Upper Eocene. The Chokrak limestone crops out everywhere throughout the Parpach ridge, and in the remaining northern and eastern parts of the peninsula are spread formations of all the stages of the Upper-Tertiary system, the older formations predominating in the ridges and hills, the later—in the adjacent valleys.

There is no such sharp subdivision of rocks on the Taman Peninsula; here are developed, more or less completely, all the stages of the Upper-Tertiary system with the above cited exceptions; the older formations—the Sarmatian and partly the Second Mediterranean—occur chiefly on ridges and single hills, while on their slopes and in valleys prevails the Pliocene; the oldest Maikop

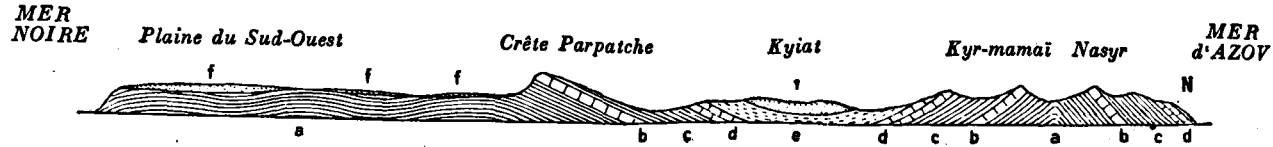


Fig. 2. Section through the southwestern plain, the Parpatch ridge, the Kyat syncline and the Mamai anticline; a—the Maikop beds; b—the Chokrak limestone and Spaniodon beds; c—the upper dark-coloured clays; d—the upper Sarmatian stage; e—the Meotie stage; f—the upper Pliocene sands and loess (after Andrusov).

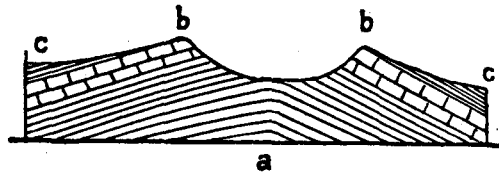


Fig. 3. Section across the Tagan antichinal valley: a—the Maikop beds; b—the Chokrak limestone and Spaniodon beds; c—the upper dark-coloured clays (after Andrusov).

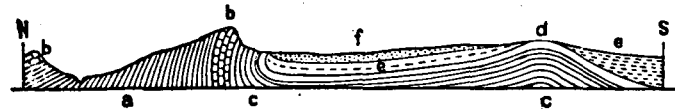


Fig. 4. Section of the Burash depression: a—the upper dark-coloured clays; b—marls, limestones; c—the light-coloured clays; d—the Pontian (after Andrusov).

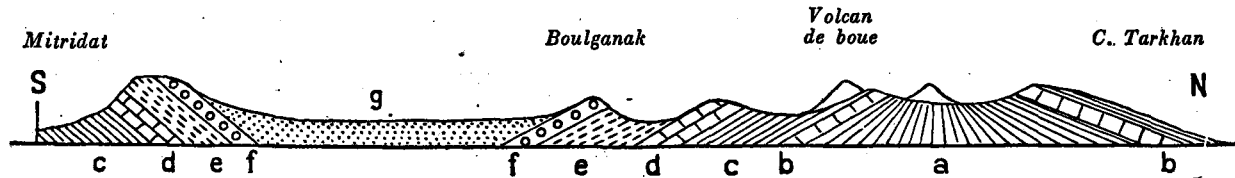


Fig. 5. Section of the Tarkhan anticline and Kerch syncline: a—the Maikop beds; b—the Chokrak limestone and Spaniodon beds; c—the upper dark-coloured clays; d—marls, sands and limestones; e—the light-coloured clays; f—the Bryozoa limestone; g—the Meotie stage and Pliocene (after Andrusov).

formation is exposed only in some places—on the tops of some dome shaped hills and on the shore of the Sea of Azov to the west of the Cape Kamenny.

It should be mentioned that throughout both Peninsulas the Recent and Post-Tertiary sediments often cover extensive areas, thus burying Tertiary rocks especially in valleys and on the lower parts of slopes. On the tops and on the upper parts of

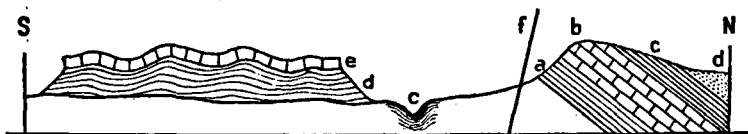


Fig. 6. Section of the Sartovskaia depression: a—the Maikop beds; b—the Chokrak limestone; c—the upper dark-coloured clays; d—marls, sands, limestones; e—the Bryozoa limestone; f—fault (after Andrusov).



Fig. 8. Section of the south-eastern flank of the anticline of the Zelenetsky mountain: S₃—light-coloured shales; S₂—marls of the Middle Sarmatian stage; S₁—dark-coloured of the Lower Sarmatian stage (after Andrusov).

hills the part of such a covering is often played by ancient and recent mud flows thrown out by mud volcanoes (fig. 2).

The geological structure of both Peninsulas is as follows: on the Kertch Peninsula the Parpach ridge (fig. 2) forms a flexure (monoclinal fold) with gentle north and east (after the southward turn) slopes and steep south and west slopes; on the latter all strata of the Chokrak limestone are eroded. On the southwestern plain lying within this ridge four flat anticlines are conjectured to have existed, stretching from east-northeast or northeast to west-southwest or southwest.

The northern part of the Peninsula is composed of anticlinal folds which follow the east to west direction, corresponding to the general trend of the ridges, and are separated by synclinal valleys; the number of these folds increases from west to east, in the west there is only one fold, in the middle part there are two folds, and four folds in the east. In the southeastern part of the Peninsula,

to the east of the turn of the Parpach ridge, there are found two large folds running NE—SW, and near the turn—two small folds running NW—SE. The anticlinal folds are from 1 to 20 km. long and from 0.5 to 3 km. wide, and belong in general to the type of elongated domes; a characteristic feature of most of them is the eroded arch forming a valley surrounded by a rocky ridge (fig. 3) which is broken in one or several places. In some of these anticlines there are depressions on the crest giving rise to minor anticlines and synclines. The synclinal folds separating the anticlines are in general longer and wider, compared with the latter (fig. 4 and 5). According to the latest investigations in the northeastern extremity of the Peninsula, it may be inferred that the geological structure of the country is still more complicated than it is assumed by Andrusov (on whose data the characteristic given above is based), as a part of these folds should be defined as «diapir structures», that is having a perforated core. Likewise faults and thrusts, which have been traced by Andrusov only in a few anticlines and synclines, are much more common. The faults connected with folding belong to the type of reverse faults along a longitudinal fissure which dips gently in the same direction as the strata and crosses the latter at a very oblique angle; these faults have been encountered in a number of anticlines (fig. 6 and 7). The thrusts along the steeply dipping fissures which strike at a right angle to the strike of the strata have been discovered in two places. Normal faults apparently constitute a structural feature of the

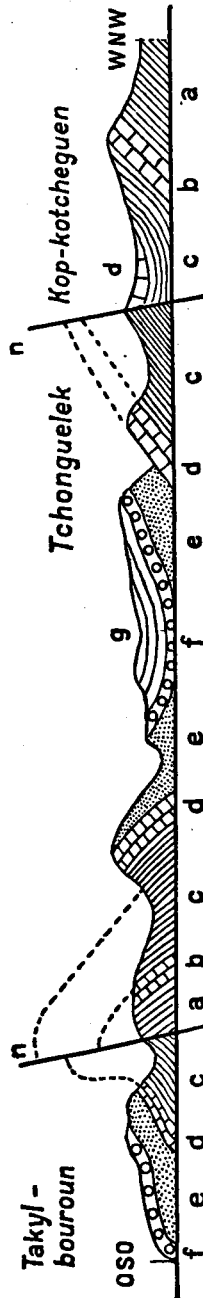


Fig. 7. Section of the Yanysh-Takyl and Chonguelek anticlines: a—the Maikop beds; b—the Chokrak limestone and the Spaniodon beds; c—the upper dark-coloured clays; d—marls, sands, limestones; e—the light-coloured clays; f—the Bryozoa limestone; g—the Meotie and Pontian stages; n—revers faults (after Andrusov).

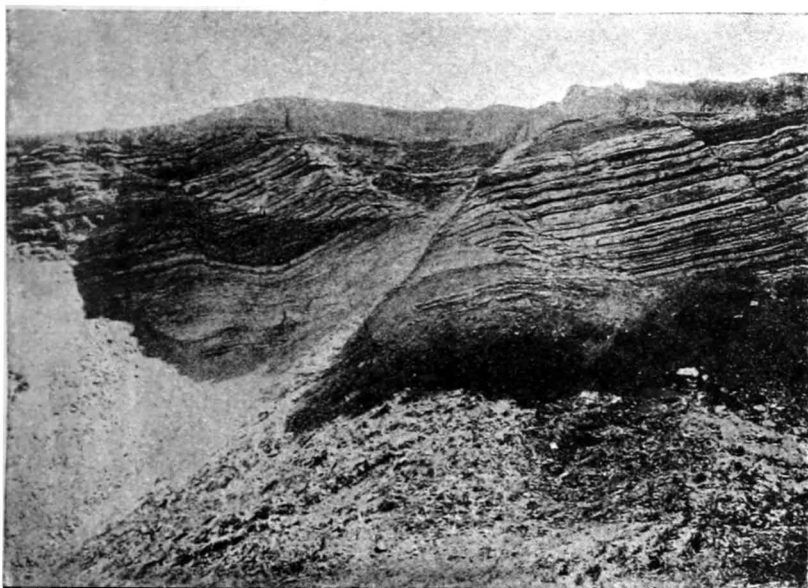
land relief of the peninsula and gave rise to the formation of the Strait of Kertch, as it was inferred by Abich in the middle of the past century.

On the Taman Peninsula there are flat conical hills and short ridges, which also form elongated domes (fig. 8), but are of shorter extension than those on the Kertch Peninsula, reaching from 1 to 3—4, and seldom to 5—7 klm. in length; their arches are not eroded. Between these ridges there are wide synclinal valleys. The strike of the axes of these folds is not uniform everywhere; in the larger part the strike is east-northeast—west-southwest; however, on the ridges of the Capes Kamenny and Pekla on the northern extremity of the peninsula folds strike west-northwest—east-southeast, and near Temriouk two ridges have a trend north-west—southeast. As to the long ridges, into which single elongated domes are aggregated and which number 6 or 7 on the whole peninsula, they trend nearly east to west (except the ridge Kamenny—Pekla, which strikes west-northwest—east-southeast), forming an angle of 15°—20° to the direction of the anticlinal axes. Faults and thrusts are also to be found (fig. 9). The identity of the sedimentary formations and a uniform character of the dislocation of strata on both the Peninsulas has long ago suggested the idea that the latter constitute a single structural body, their folds having been closely related to each other prior to the formation of the Strait of Kertch (fig. 10). By the time of their orogeny and by their position both Peninsulas belong to the Caucasian mountain range. Movements of the earth crust began in the end of the Miocene on the passage from the Middle Sarmatian to the upper one, giving rise to primary folding and to the alteration of sea depth; the most intensive deforming movements occurred during the Meotie epoch, after which their intensity considerably decreased, judging by the fact that in places the Pliocene overlies the Miocene unconformably and is much less disturbed itself, having even often retained its horizontal position. The Kertch-Taman folds are the extreme northwestern waves of the vast upheaval of the Caucasus: joining the folds of both Peninsulas we find resulting flat bows bulging out to north (fig. 10). The Parpach ridge, which breaks the regular picture of the folding on the Kertch Peninsula, is apparently to be connected with the fact that beneath the southwestern plain there lie the more strongly disturbed strata of Eocene and the Cretaceous age which belong to the system of the Crimean range, of a somewhat older formation; these strata formed

an underground abutment which stopped the development of the Kertch-Taman folding; around this abutment formed the flexure of the Parpach ridge, while normal folds extend north and east of it.

OCCURRENCE OF OIL

The presence of oil springs on the Kertch Peninsula was already known to the natives at the time of the Tartar Rule, when



Photograph by N. Andrusov.
Fig. 9. Faults in the Middle Sarmatian beds on the cape Kamenny (the northern shore of the Taman Peninsula).

the natives even had a knowledge of certain ways of producing oil by shallow pits; they used oil for dressing harness, and skins, for wheel axles, as well as for illuminating and medicinal purposes. Evidences of oil deposits are mentioned by the first Russian travellers in the Crimea, beginning from Pallas, who has described some mud volcanoes and cited ten mineraloil springs. At the end of the eighteenth century Captain Klobukov brought to the seaport town Nikolaev samples of petroleum derived from Kertch, Taman and Kuban deposits, together with a list of localities where oil had been produced, giving also the amounts of their annual

production (from 245 to 1230 liters of oil). Gradually the number of these localities increased in connection with further investigations and prospecting; at present there are several dozen of them, which we shall briefly describe, below giving characteristics of the oil indications and seeps.

On the Kertch Peninsula, moving from east to west and from north to south, we find the following petroleum deposits (shown on the map attached, correspondingly numbered).

1) **THE ENIKALÈ CAPE.** On the southern slope of a ridge ending in the Kertch Strait by the Enikalè Cape there was a cliff composed of marl of Middle Sarmatian age, fully soaked with asphalt; this cliff was worked out at the end of the XIX century, the asphalt yielded having been used for the construction of pavements in the town of Kertch. Asphalt remains yet in strata of Sarmatian limestone saturated with oil and containing native sulphur in the pores and interstices of the rock. According to Lidov, the «asphalt ore» contains 14.67% of bitumen. Potylitsyn has seen seeps of thick black petroleum on the sea-shore cliffs near the Enikalè light-house. In the middle of the XIX century there existed an asphalt making plant in the vicinity of Kertch, which produced about 32 tons (2000 poods) of asphaltic substance from thick oil and petroliferous limestone and gravel.

2) **THE ANTICLINAL VALLEY OF ENIKALÈ** opens into the Kertch Strait south of the above described ridge with its cape and light-house; the floor of the valley is composed of upper dark clays (Lower Sarmatian), the slopes are of Meotic and Bryozoan limestone. In its lowland are situated three mud volcanoes issuing gas in abundant quantities (methane with from 2 to 4.6 per cent of carbon dioxide), which have been described many times, beginning by Pallas; in a small side-valley on the left slope there is an oil spring running from clays near outcrops of limestone on the arch of a minor fold; there is an escape of gas and sometimes films of oil appear on the salt water surface. The mud of one of the mud volcanoes contains boracic acid, (0.1552 gr. to 100 gr. of mud).

3) **THE TARKHAN OIL DEPOSIT** (fig. 5) lies in the eastern part of the Chokrak-Tarkhan anticlinal valley, on the floor of which lower (Maikop) dark shales are exposed, while on the slopes—Chokrak and Spaniodon beds. In the vicinity of the Maly Tarkhan Farm a group of large and small mud volcanoes (fig. 11) is situated on a flat plain; two of these are active, with violent intermittent issues of gas. In a gorge north of the Farm oil seeps are met

with in a marl limestone, as well as sulphurous springs issuing from underlying dark clays. In the beginning of the XIX century oil was got by pits between the villages Bolshoy and Maly Tarkhan. There were also bore holes.

4) THE BULGANAK MUD VOLCANOES. The plain where the Tarkhan mud volcanoes are situated drops sharply down to a flat basin in the upper part of the Bulganak valley (fig. 5); a group of mud volcanoes is situated in the basin; they issue liquid silt and bub-

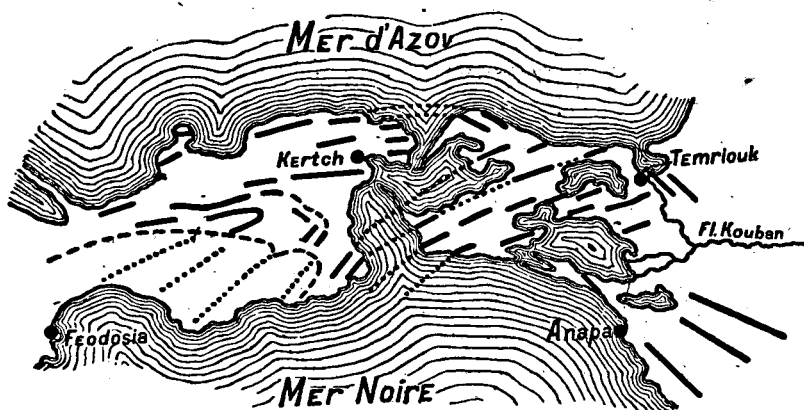


Fig. 10. Structural map of the Kertch and Taman Peninsulas. Full lines—the axes of anticlines; dashed lines—the Parpach ridge; dotted lines—anticlines of the south-western plain and supposed connection of the folds of both Peninsulas (after Andrusov).

bles of gas having an odour of oil (fig. 12); a number of analyses of the mud has proven the presence of boracic acid. Some of the volcanoes present small pools issuing gas and oil (fig. 13 and 14). The gas consists of methane (97.5 per cent) and carbon dioxide (2.5 per cent). In 1864 Helmersen saw a thin layer of oil on the surface of one of the fresh mud flows. These volcanoes have been repeatedly investigated and described.

5) THE MISYR OIL DEPOSIT lies on the western shore of Lake Chokrak (on the eastern shore of which there are numerous sulphurous springs close to the mud-cure hospital); in ancient times petroleum was obtained from hand-dug pits in the vicinity of the village of Misyra; the latter lies at the southern foot of the Misyra plateau, which is composed of Upper Sarmatian strata. Wells have been drilled in this district.

6) THE KARALAR OIL DEPOSIT is situated in an anticlinal valley bearing the same name. Shales of the Maikop strata crop out on the valley floor, and Chokrak limestone on the valley slopes; there are sulphurous springs in the gorges which drain the valley west and east. In the western part of the valley near the village of Karalar there is a pit exuding petroleum; there have been some drill holes in the vicinity.

7) THE BURASH OIL DEPOSIT is situated in a small basin of the same name southeast of Lake Chokrak (fig. 4); at the foot of a ridge springs issue from the Lower-Sarmatian beds; gas seeps through the water in these springs and there are traces of oil on the water surface, while in one spring a fluid mud oozes out. These springs seem to be embryo mud volcanoes.

8) THE DJERJAVA OIL DEPOSIT lies in an anticlinal valley of the same name, which opens into the sea south of Kertch; on the valley floor the upper shaly clays are exposed, viz. the Lower Sarmatian. A hill composed of these clays and of Sarmatian limestone rises at a distance of 4 klm. from the coast; on its northern slope are situated three mud volcanoes, two of them being active and issuing gas and fluid mud which contains boracic acid and petroleum. Wells have been drilled in this locality.

9) THE KAZAN OIL DEPOSIT in the Taganash anticlinal valley (fig. 3) on the western extension of the Djerjava valley; the floor of the former is composed of lower shaly clays, viz. the Maikop strata. On the extremities of the valley there have been drill holes which still yield petroleum.

10) THE KARAMYSH-KELECHY OIL DEPOSIT is located in the middle part of a long anticlinal valley of Shokul-Kachain the floor of which is composed of clays of the Maikop strata; in the estate Kar-mysh-Kelechy in the middle of the valley there were about 30 hand-dug pits from which oil was obtained for the illumination of Kertch. Some wells have been drilled in this locality.

11) THE KASHYK OIL DEPOSIT is in the western part of the same valley west of the village Djermy-Kashyk; some traces of ancient pits which yielded oil are found at an isolated rocky hill. Wells have been drilled.

12) THE TCHUBURTMA-SART OIL DEPOSIT is within the anticlinal valley of Sart, in the middle of which rise several isolated hills formed of Sarmatian limestone (fig. 6); the floor of the valley is composed of the upper shaly clays (the Lower Sarmatian). Formerly Tartars of the village of Tchuburtma-Sart obtained oil from

hand-dug pits south of the village at the foot of one of these hills. In the south the valley joins the Parpach ridge, while its northern boundary is defined by a fault. Wells have been drilled in this district.

13) THE KENEGHES KODJALAR OIL DEPOSIT lies in the anticlinal valley of Kodjalar; at its western extremity near the village of Kuchuk - Kojalar there are a few oil pits dug by Tartars, and in the Keneges estate on the southern border of the valley oil was obtained in 1864.

14) THE NASYR OIL DEPOSIT on the southern edge of the anticlinal valley of Kuchuk - Mamaï (fig. 2); on the southern shore of the central one of three lakes a mud volcano is situated on the top of which there are seeps of water and oil; south of this place there are many vents issuing fluid mud and petroleum with small quantities of gas; the soil of the



Photograph by N. Izgarychev.

Fig. 11. Gas-ejecting pool, 3 m. x 6 m., on the summit of the Trubetskoi mud volcano belonging to the Tarkhan group.

area around the vents is highly impregnated with dried out oil (kir) for a distance of 3—4 m.; there are traces of borax in the mud.

15) THE SOULTANOVKA OIL DEPOSIT is in a small anticline joining in the south the eastern extremity of the Shokul-Kacha valley. On the floor of the latter there are water springs with shows of oil from the lower clays of the Maikop strata.

16) THE AIMAN-KUIU OIL DEPOSIT is situated within the Saraimin depression within a horse-shoe shaped ridge west of the Saraimin ruins; this deposit is related to strata of the Chokrak

clays which embrace the outcrops of the Pontian. There has been prospecting by hand-dug shafts, which yielded much gas and from which oil was recovered.

17) THE KOP-KOCHEGHEN OIL DEPOSIT (fig. 7) lies in a hilly locality due southwest of the Tobechik salt lake; the area is made up of the upper shaly clays (the Lower Sarmatian). The surroundings of the village of Kop-Kocheghen abound in ancient oil pits. Wells have been drilled.

18) THE CHONGHELEK OIL DEPOSIT (fig. 7) lies on the southern shore of Lake Tobechik in a valley of the same name; the floor of the latter is composed of the upper shaly clays (the Lower Sarmatian). On the land of the village of Chonghelek on the south-western shore of the lake there were pits dug by Tartars, which yielded oil. The area has been prospected repeatedly and oil had been recovered from wells.

19) THE CHORELEK OIL DEPOSIT lies in a valley southwest of the Chonghelek valley, which is a prolongation of the latter. Wells have been drilled. The valley floor consists of the upper shaly clays (the Lower Sarmatian).

20) THE YANYSH-TAKYL OIL DEPOSIT on the Takyl anticline (fig. 7) southwest of the Chonghelek valley; on the sea-shore there is an oil seep on an anticline eroded by sea-waves and composed of the Chokrak beds; oil seeps from the shaly clays and marls with embedded thin layers of oil sands 1—9 cm. thick. The district has been prospected by shallow shafts and drill holes.

In addition to the above cited definite evidences of petroleum deposits on the Kertch Peninsula there are numerous references in different publications to surface indications of petroleum,—these references not always being sufficiently definite.

21) At Cape M. ESKIZ (Ziuk?) on the coast of the Sea of Azov there was in 1819 a volcanic eruption, partly submarine.

22) Near the village of KULTEPE on the same coast lands have been leased to be prospected for oil.

23) In the village of POUSTAIA ERIAL which is 5 klm distant from Kertch there is an abandoned pit, which produced oil.

24) Near the village of SEIT-ALI (Chokur-seit-ali) there are signs of oil and lands have been leased to be prospected for oil.

25) At the village TASHLYIAR to the south from the large Kazantip Bay of the Sea of Azov there are asphalt deposits, according to the new topographical map (scale—one verst to an inch).

26) At the station SEM KOLODTSEV of the Kertch rail road there are indications of oil.

27) On the ARABAT ROAD in a locality 33 klm. distant from Kertch nine pits were situated in a shallow valley, which yielded small quantities of oil.

28) In the village KARYK at a distance of 40 klm. from



Photograph by N. Klepinin.

Fig. 12. Small mud volcano of the Bulganak group, 2.5 m. high, spouting gas and mud every 1—2 minutes.

Kertch (Karyk on the south-western plain) was an oil pit dug by Tartars.

29) At the village of KARASE-DJERT (Kara-Sidjeut?) lands have been leased for oil prospecting.

30) Near the village of MAMAT, south of the village mentioned there were oil pits in the estate of Funduklei on the above, Samar-chik river.

31) Near the village of KOP-SAIRAMIN south of Aiman-Kuiu (see the deposit numbered 16) there are signs of oil, according to Andrusov's map.

32) In the vicinity of the mud volcano DJOU-TEPE (fig. 15, 16, 17) on the south-western plain there are found, according to

Pallas, a few wells yielding mineral oil; they are not cited in later descriptions of that district.

33) The mud volcano AKHTARKA-KODJALKA on the southern shore west of lake Uzunlar; long extinct.

34) The mountain of DURMEN on the same shore at lake Kachyk also appears to be an extinct mud volcano.

35) The mud volcano SHIBAN, south of the Parpach ridge, on the western border of the Peninsula, issues inflammable gas and liquid mud with a slight petroleum odour.

36) On the south-western plain between the villages of KIRLEUT and DJANAR-BERDY there are numerous swellings of the soil, which appear to be due to gas seeps.

On the Taman Peninsula indications of oil deposits are numerous, having been known at the times of Pallas. Beginning from the north and pursuing from west to east, there are the following indications of petroleum, cited below:

1) On the CHUSHKA Spit in the Kertch Strait there is a mud volcano which proves the existence of oil bearing strata on the floor of the strait which are similar to those on both Peninsulas.

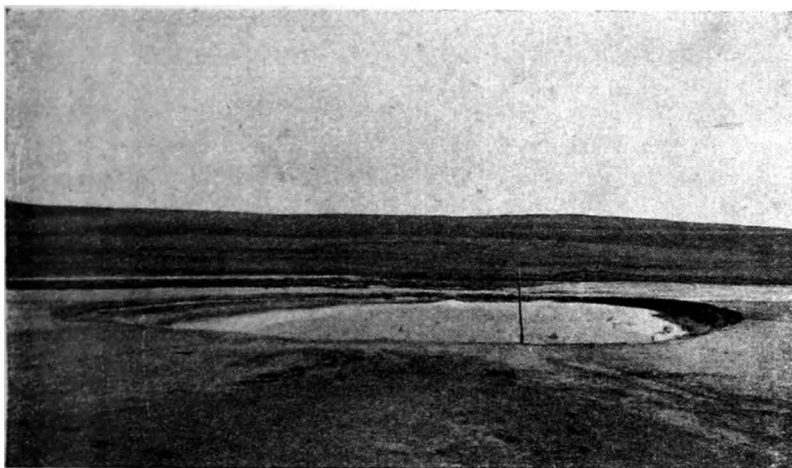
2) The ridge of Cape KAMENNY on the coast of the Sea of Azov is composed of the Lower Sarmatian clays and «worm» limestone dissected by faults 1 (fig. 9). West of that ridge near the farm of Nazarov an oil saturated layer crops out in the Spirialis strata of the Middle Miocene.

3) On the same coast near the farm of Garkushy is situated the mud volcano PEKLA, which is a cirque shaped depression sloping in two benches towards the sea; on the edge of the lower bench two cones emit a wide mud flow, while on the lower bench itself small mud volcanoes spout mud; side by side there are seeps of salt water with films of oil on it; in the sides of the lower bench steeply dipping beds of oil sand of Post-Tertiary age are seen; however, the base of the mud volcano is made up of clays and marls of the Lower Sarmatian.

4) The next line of mud volcanoes to the south is begun at its western extremity by the mount GORELAIA (Kuku-oba), which was already known in ancient times; it is a perfect cone, 75 m. high, the slopes of which are covered with thick mud flows produced at the eruption of 1794; on its top is a crater 15 m. in diameter; a small cone on the southern rim of the crater issues sticky mud and gas.

5) In the FONTANOVSKAIA ridge there are dome-shaped hills with numerous seeps of oil which are seemingly associated with the Spaniodon beds composing the arches of folds. In this ridge, 5 klm. east of the station Fontanovskaia there are to be seen in eluvium oil seeps and a number of salt water springs issuing gas and bearing films of oil on their surface.

6) On a cliff on the shore of the Sea of Azov, north of the stantsiya AKHTANIZOVSKAIA, there are outcrops of petroliferous



Photograph by N. Klepinin.

Fig. 13. Mud pool about 12 m. in diameter within the area of the Bulgnak group of mud volcanoes.

sands, seemingly of Post-Tertiary age, which take part in a structure having the shape of an elongated dome the long axis of which stretches southwest to northeast. To the southwest of these sands a large mud volcano is situated (fig. 18).

7) The ridge of the mount TSYMBALY (Shumunkay) forms the beginning of the next line of mud volcanoes, on the isthmus between the Taman Bay and the Akhtanizovsky liman. The mount has three peaks, which are extinct mud volcanoes (fig 19); the base of the eastern peak is built up of the Maikop clays with an interbedded layer of sand impregnated with dried petroleum (kir); this layer is 20—30 cm. thick; close to it oil seeps from clays; beneath the middle peak appears to lie the Meotic, while the Pontian lies beneath the western peak. Oil seeps also from the eluvium

of volcanic sediments on the southwestern slope. In the middle of the XIX century there were still craters which spouted gas and mud, and on the slope of the western peak a brine spring which issued gas and oil. To the east in the same volcano line lies the large mud volcano Kussu-oba, which erupted in 1842, and still further east, on the neckland between the Sea of Azov and the Akhtanizovsky liman, there is a small mud volcano Bekul-oba exuding insignificant quantities of gas and oil.

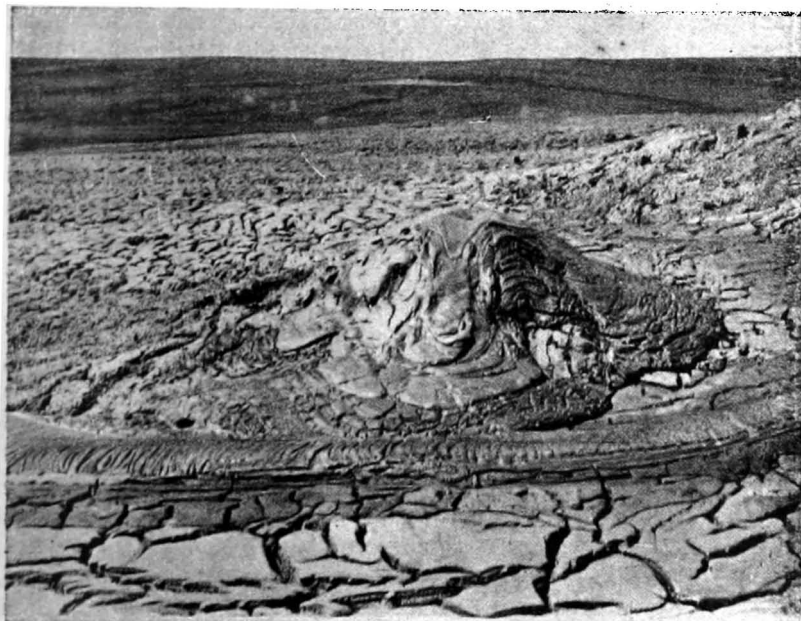
8) THE FANAGORIYSKAIA RIDGE stretches along the southern part of this neckland; its western extremity is a cone-shaped mud volcano with a flattened crater, on the slopes of which there were in the middle of the XIX century swampy places issuing gas. In a part of this ridge, north of the Lake Yanovski, a few hand-dug shafts are scattered at the foot of the western slope of a dome-shaped hill; in these shafts gas seeps through water and a thin layer of black oil floats on the water. The surroundings have been prospected on a small scale.

9) THE MOUNT BORIS AND GLEB in the eastern end of this ridge at an liman, constitutes the remnants of a mud volcano covered with erupted material. In a precipice of the mount looking down upon the liman there are seen outcrops of sandy and clayey formation of Post-Tertiary and Pliocene (super-ore beds); it is 15 m. thick, being impregnated with oil, especially at the water surface; at the foot of the precipice there is a series of gas seeps (fig. 20). The locality has been prospected.

10) THE MOUNT ZELENAIA (ZELENETSKY) lies on the coast of the Black Sea at the extremity of the next line of mud volcanoes; this line, which is the longest, extends between the Taman Bay and the Akhtanizov liman in the north and the Tsokur and Kisiltash limans in the south. A sea cliff on the shore 52 m. high shows formations of which the mount is built up (fig. 8); there appears a flat lying fold which is overturned to southeast and enables one to follow up all the strata beginning from the super-ore strata of the Upper Pliocene to the dark shaly clays of the Lower Sarmatian composing the core. A bit is considered the core to be an irregular body of porous dolomite, impregnated with a bituminous matter having odour of carbon bisulphide; clays lying by the sides of this body are impregnated with asphalt and petroleum.

11) THE MOUNT KARABETOVA, southeast of the stanitsa Taman, constitutes the western extremity of a long ridge of mud volcanoes stretching to Lake Yanovsky; almost on every dome-

shaped hill of this ridge there are found indications of petroleum, located in most cases on tops of the hills. The mount Karabetova itself is a mud volcano that produced in 1835 a violent eruption; next to the east is the mud volcano KIRPINNAIA or Azovdag, which is a massive swelling of mud with fragments of bedrocks. On a hill east of the mount VASIURINSKAIA or Kirkol petroleum seeps down its south-western slope and flows down



Photograph by N. Klepinin.

Fig. 14. Cone eruption, 0.7 m. high on a mud volcano of the Bulganak group.

with water into a small valley; on the north-eastern slope of the mount a layer of black oil floats on the surface of a pool formed by a seep of salt water; in the lower part of the slope at the eastern base there is found a spring issuing sulphuretted hydrogen, as well as outcrops of dark shaly clays with fish remains; higher on the slope and on the top—outcrops of marl of the Middle Sarmatian.

12) On the top of a low ridge including the hill BLIZNETSY north of the Vyshestiblievskaiia' stanitsa, oil and salt water seep from the clays.

13) On the dome-shaped hill GHIRKA located in the same line and composed of the Middle Sarmatian, as well as in the core which consists of the steep Spirialis strata, there are seeps of oil associated with salt springs; at the base of the eastern slope there is a water spring emitting sulphuretted hydrogen.

14) In the locality KOPANTSY, 4 klm. east of the hill Ghirka, there are seeps of oil.

15) THE MOUNT NEFTIANAIA, north of the Starotitarovskaia stanitsa, is composed in its inner part of clays of the Maikop strata, folded; on the top of the mount there is a series of oil seeps as well as evidences of oil pits from which oil has been obtained. On the northern slope the clays are covered with thick sand strata, in places saturated with oil.

16) THE MOUNT DUBOVY RYNOK constitutes the eastern end of this line of mud volcanoes; on the slopes of its crater, which is flattened and filled up, there are traces of old pits, from which oil has been obtained; oil seeps from the clays of the Maikop beds carrying concretions of sphaerosiderite.

17) The next line of volcanoes lying to the south begins at its western extremity with the mount PECLA situated on the shore of the Black Sea east of Cape Zhelezny Rog; a sea cliff exposes the structural features of the mount, which is an anticline composed of the Pliocen (ore and sub-ore beds) and Meotic, while its inner part consists of the Spirialis beds of the Middle Miocene. Vast rockslides along the axis of the anticline form an amphitheater, on the floor of which at an elevation of nearly 60 m. there are seen distinct seepages of oil associated with salt springs.

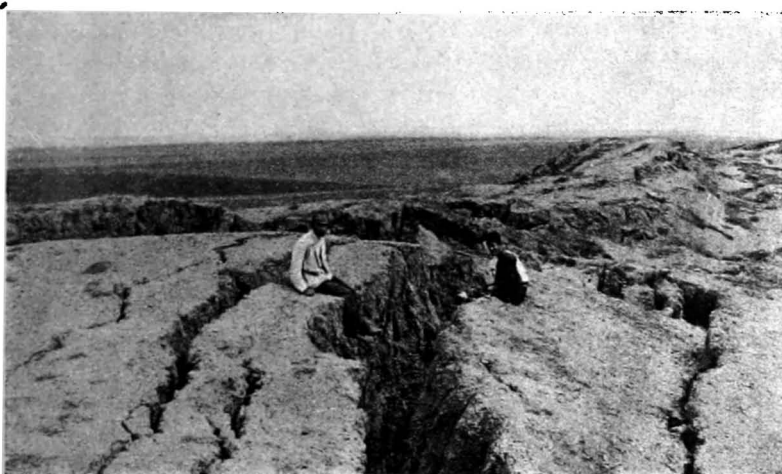
18) THE MOUNT BOGAZ on the northern shore of the Bugaz liman, at its head, is a mud volcano with gas seepages.

19) THE KAPUSTINA RAVINE, on the northern shore of the Kisiltash liman, cuts through a flat elongated dome composed of the ore and Pontian beds of the Pliocene; there were seeps of oil and ancient oil pits on the right slope of the ravine. The district was explored by drilling in 1860—1870 and in 1912—1914, when a light petroleum was found.

20) THE MOUNT NEFTIANAIA, to the south of the Starotitarovskaia stanitsa, is also an elongated dome, which is, however, more complicated and composed of the Maikop and Spirialis beds as well as of clays interbedded with hard marl of the Lower and Middle Sarmatian. Oil seeps are found chiefly on the apex of the dome which is composed of the Maikop beds; some oil seeps occur

also on slopes in the Middle and Lower Sarmatian, where brine springs are found emitting gas and heavy oxidized oil; while on the top of the dome there occurs light oil similar to that in the Kapustina ravine. The mount was prospected by drilling in 1860—1870 and in 1911—1912. On the top of the dome there were numerous oil pits that yielded much gas and oil.

21) Eastward of the mount OCHERETINA or Kamyshevataia, which is also a mud volcano, lies the mount Strelka



Photograph by N. Klepinin.

Fig. 15. Summit of the Djow-tepe mud volcano after the eruption of 1909; deep cracks in the mud.

at the end of a line of volcanoes near the edge of the Kuban delta; its structural feature is a compressed anticlinal fold overturned northward and complicated by a syncline along its axis. The clays of the Maikop beds outcrop along the axis, while on the slopes there are exposed the clays of the Pontian and further the ore and super-ore beds. At the foot of the mountain, within a belt of the Maikop clays, there is a hand-dug shaft in which oil seeps through water; at the approach to Strelka near Kompaneitsev's farm the sands of the super-ore horizon are exposed in a coastal precipice sloping down to the lowland of the Kuban; these sands are impregnated with oil, especially to a high degree at the base of the outcrop. Prospecting by drilling was conducted in 1860—1870 and in 1912 when light oil was discovered.

22) On the northern slope of the mount at the foot of which TEMRIOUK is situated there are seeps of oil on the right shore of the Kuban river, viz. outside of the Taman peninsula. The top of the mount is a large crater of a mud volcano with a pool inside it; here is the beginning of the ravine of the northern slope which exposes the clays of the Maikop beds; in the channel of the ravine green oil seeps in several places from the eluvium of these clays, while surrounding rocks have a strong odour of kerosene.

23) A little further to the southeast lies the mount GNL. LAIA on the south-western slope of a range that trends in a south-eastern direction from Temriouk past the Kourchanskaia stanitsa; this mount is also a mud volcano with a crater and a pool on the top of a dome-shaped hill the core of which is composed of the clays of the Maikop beds. Oil seeps on the top and at the foot of the hill being associated with salt water springs issuing gas; oil accumulates in small pits. In 1844 the mount produced a violent eruption.

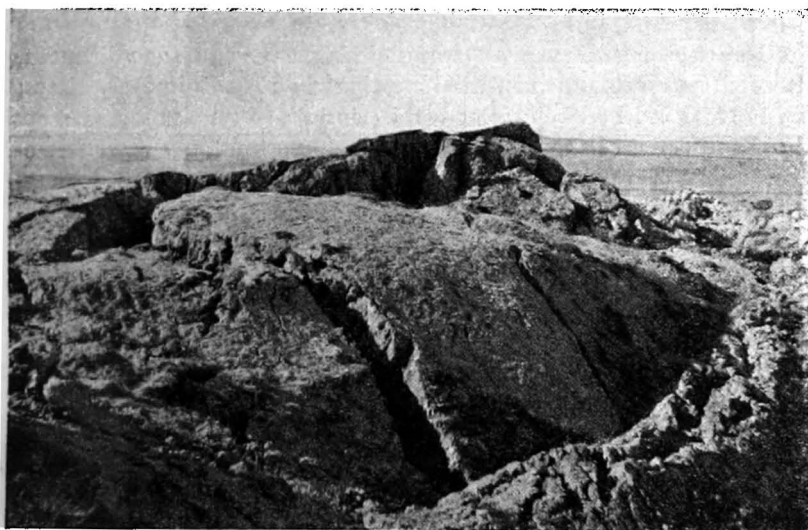
It remains to be mentioned that immediately south of the Kuban river, between its delta and the Black Sea shore at the Vitiazevsky liman lies the Suvorovsko-Cherkessky oil region of the Kuban province.

Considering in general the indications of oil deposits on the Kertch and Taman Peninsulas, it may be stated that they are distributed rather uniformly throughout the whole area; these indications are less numerous in the northern part of the Taman Peninsula between the Sea of Azov and the Taman Bay, while the poorest in oil evidences is the south-western plain of the Kertch Peninsula within the Parpach ridge. On the remaining area of these Peninsulas indications of petroleum are very numerous.

Another striking feature is that the oil indications are associated with the mud volcanoes; this is particularly pronounced on the Taman Peninsula, where almost every mud volcano issues oil together with gas and salt water. On the Kertch Peninsula, where mud volcanoes are less numerous, the indications of petroleum are associated also with the eroded crests of the anticlinal folds converted into anticlinal valleys.

Regarding the geological structure of the Peninsulas there appears a definite and close relation of oil indications to the anticlinal folds which are for the most part elongated domes of various length and breadth. A number of these folds, especially on the Kertch Peninsula, belong to a normal type, while the rest of

them are to be classified as «diapir» folds, i. e. with a perforating core composed of older strata that have broken the overlying younger ones. Those mud volcanoes which are not concealed entirely by mud flows everywhere appear located on the crests of the anticlines. This coincidence is not accidental but is due to the fact that the crests of the folds are the most favourable parts of the structure in respect of accumulations of gas, water and oil. While being projecting parts of the relief, the crests are in the highest degree liable to the erosion, which enables escaping of gas, water and oil.



Photograph by N. Klepinin.

Fig. 16. Summit of the Djou-tepe mud volcano after the eruption of 1909; the subsidence of the northern portion.

In connection with the geological features it may be noted that on the Kertch Peninsula oil derives from strata of various ages,—most frequently from the clays of the Maikop beds,—that is from the Lower Miocene and Oligocene; besides that oil is yielded by the Chokrak limestone and Spaniodon beds (the Middle Miocene) as well as by the marls, clays and bryozoan limestone of the Sarmatian (the Upper Miocene) and in one case by the Meotie beds. On the Taman Peninsula oil comes from beds that are of still more various ages, beginning from the Maikop beds and ending by the Post-Tertiary sands. Consequently, in the Kertch-

Taman oil region there is a whole series of oil-bearing horizons. But the question is whether all of them are sufficiently prolific and contain oil of primary origin.

Prior to answering this question and outlining the prospective economical importance of the region, it is necessary to learn the results of explorations and prospecting that have already been conducted in the region and to show to what an extent it is investigated geologically.

THE HISTORY OF EXPLORATION

Both the Peninsulas being abundant with mud volcanoes, attracted attention of scientific investigators already in early times; in 1794 Pallas described the ring-shaped mountains, seeps of oil and some of the mud volcanoes. Klobukov and Kozin referred to oil pits dug by Tartars. In the reports of the investigators Verneuille, Demidov and Dubois-de-Monperé of their travels to South Russia, the Caucasus and the Crimea, are outlined geological features of the two Peninsulas and are described some oil seeps and eruptions of mud volcanoes. Voskoboinikov and Guriev have described the geology of the Taman Peninsula, outcrops of ore, springs of mineral oil and a series of mud volcanoes. The latter as well as the geological structure of the Peninsulas were studied in a particularly detailed manner by Abich in the middle of the last century, while Helmersen and Romanovsky described the first prospecting work they happened to visit during their geological investigations of the country. Later some mud volcanoes were investigated by Alexeev, chemical analyses of mud and oil from them are given in works of Dubinevich, Potylitsyn, Lidov and Kramarevsky. Some information concerning the Kertch Peninsula is collected by Golovkinsky. However, the most careful and detailed study of its structural features was performed during a number of years by Andrusov, who made the first geological map of the Peninsula on the scale of 3 versts to one inch. In the very end of the XIX th century he investigated a part of the Taman Peninsula. The following investigations were completed in the XX th century: Beketov, Vernadsky, Isgaryshev and Sludsky—concerning the water and mud of the mud volcanoes; Klepinin and Borisiak gave a new description of mud volcanoes of

the Kertch Peninsula; Gubkin completed the first detailed geological survey of the Taman Peninsula, the results of which are published only as a preliminary report accompanied by a structural map on the scale of 5 klm. to one inch; the same investigator has summarized all the information concerning the occurrence of petroleum on this Peninsula, while identical information on the Kertch Peninsula are given by Obruchev. Dvoichenko



Photograph by N. Klepinin.

Fig. 17. Djow-tepe mud volcano after the eruption of 1914; the middle portion has subsided.

gives data concerning deposits of petroleum in his article describing the minerals of the Crimea.

Besides such information to be found in the reports of various investigators cited above, information concerning other minerals of the region are given in articles written by Baiar, Bogdanovich, Keppen, Zeigler (iron ores of the Kertch) Mokrinsky (sulphur of Chokur-Koiasch) and Dvoichenko (various minerals). Although in general the Kertch Peninsula is more fully described, compared with the Taman, the geological map made by Andrusov not on a basis of systema-

tical detailed investigations is not sufficiently accurate. In 1924 Arkhangel'sky began a detailed study of the Peninsula, which is confined so far to its north-eastern angle; the results of his work have not yet been published, but according to a verbal communication of the named geologist, Andrusov's map requires to be corrected in the essential, as the structural features of the country are considerably more complicated; in that part of the Peninsula which is geologically investigated there are short elongated domes of the «diapir» type and numerous faults and thrusts. The Taman Peninsula is explored in an exhaustive manner by Gubin, but the detailed description and the geological map of the Peninsula have not yet been issued.

PROSPECTING AND EXPLOITATION

Prospecting for oil began on the territory of the region already in the sixties, and continued with interruptions until the beginning of the European war, that is for a period of nearly half a century. The greater part of the prospecting and exploration has taken place on the Kertch Peninsula; in places exploitation was conducted together with the exploration. All the prospecting work and exploitation done in the region are briefly described below, following the order in which the indications of petroleum have been described.

1. The Kertch Peninsula.

1) CAPE ENIKALE. The asphalt-making plant of Bruno built in 1838 in the vicinity of Kertch produced petroleum for a number of years from four pits at a distance of 10.6 klm. north-east of the town; the asphaltic product manufactured of petroleum was used for covering floors, footpaths and roofs, for caulking ships and for the manufacturing of a special tile. In 1880 an asphaltbearing cliff of the cape was exploited, yielding 14.67 per cent of bitumen; a mastic was manufactured of the latter at the plant of Grutzmacher in Kertch.

2) In the ENIKALE ANTIKLINAL VALLEY oil was exploited in the sixties by the Enikalé Town Board, from two pits 6 m. deep each.

3) The TARKHAN deposit of petroleum was exploited by pits as far back as the times of the Tartars. In 1907 the Firm of Voeykov (later that of List) sunk a drill hole on a syncline of beds

of the Middle Miocene, having in view to tap the petroliferous sands of the Chokrak; the first well (14 in. diameter) was abandoned at the depth of 185 m. on account of its deflection. Another well (18 in. diameter) located close to the first was sunk to a depth of 645 m. (final diameter 4 in.); however, in 1908 the well was abandoned, owing to enormous rock pressure; there is no information of occurrence of oil; from both wells gas still issued in 1920.

5) MISYR. In 1908 the List Company moved its prospecting to Misyr after their unsuccessful drilling operations in the Tarkhan district. A well 18 in. in diameter was sunk on the axis of the anticline formed by the upper shaly clays; in November 1909 the depth of 534 m. was reached, with 4.5 in. diameter. Beginning from the depth of 400 m., the drilling progressed very slowly, owing to high rock pressure and the collapsing of casing, as well as to rock-caving; at a depth of 482 m. strong gases were encountered. There are no data of indications of oil in the report of the district engineer who furnished the information stated above.

6) THE KARALAR VALLEY. In its western part near the village of Beshevli the Société Anonyme, a French company, has developed drilling operations beginning from 1880; some wells have been drilled to a depth of 183 m., penetrating the lower clays (the Maikop beds). Prior to that one well had been sunk in 1865 by Gowen near the village of Karalar; this well reached the depth 135 m., penetrating the gray clay from the surface to the depth of 129.6 m., when a layer of hard rock was struck; beginning from a depth of 130.8, a slight petroliferous odour was encountered, which became stronger at a depth of 135 m. There is an oil pit dug by Tartars at a distance of 3.5 m. from this well.

8) The DJERJAVSKAIA VALLEY. In 1907 — 1909 the Raky Company drilled a well southeast of the Djerjava Farm on a small hill composed of the Upper Sarmatian limestones; the well reached a depth of 292 m., when it was stopped on account of the collapsing of 5 in. casing; gas was encountered at a depth of 230 m., while indications of oil were found a little deeper; in the beginning of 1909 the drilling was stopped and the well abandoned. Prior to that time Gowen drilled apparently near the mud volcano situated a little farther east in this valley; according to Helmersen, a well 19 m. deep which penetrated the gray clay down to the bituminous sandstone yielded oil in 1864. The gray clay was impregnated with oil and carried large fragments of hard rock; no gas was issued. In 1884 a French Company sunk a hole on the

western bench of the Djerjava hill almost in the village itself; at a depth of 45 m. a stratum was encountered 0.6—0.9 m. thick, consisting of soft sandstone carrying liquid green petroleum of 46° Bé gravity (0.800); the flow was, however, meager; drilling was continued with a 14 in. diameter of casing; above the said stratum and below it extended blue clay with embedded concretions and partings of pyrite 25 to 50 mm. thick, that caused difficulties in drilling and deflection of the hole. This clay compressed the lower part of the casing sometimes so strongly as to cause its collapse and cavings plug the drill-hole. In June 1884 the well reached a depth of 51 m., no further information concerning it is available.

9) KAZAN. In 1895 a French Company drilled a hole under supervision of Dufleau, an engineer, in the Kazan valley near the ruined village of Taganash; the hole reached a depth of 420 m. penetrating clays with hard concretions; there occurred periodical spouts of water and gas. Another drill-hole located at the eastern extremity of the village reached a depth of 323 m. having pierced a layer of gray sand at a 200 m. level. The head of the casing is still projecting on the surface; gas is escaping from this well and a light oil that burns like kerosene is collected sometimes.

10) KARMYSH-KELECHI. In the forties the Tartars of the village Seit-Ali in the center of the Shokul-Kachin anticline extracted oil from 30 hand-dug pits 8—10 m. deep. In 1864 Kibler produced oil from 7 pits 4—6 m. deep at a distance of 2 klm. from the village Karmysh-Kelechi; this oil obtained at a rate of 125 to 250 liters weekly was used for illuminating purposes in Kertch. In the eighties a French Company drilled a hole 754.7 m. deep above a junction of two ravines on the floor of the valley; the hole penetrated dark clays carrying in places hard concretions and an intervening layer of sandstone impregnated with oil. The land owner has lately cleaned this well to a depth of 60 m. and extracted oil from it (up to 0.03 tons daily), gas escaping in large quantities. In 1913 a Circassian Khun sunk another hole beside the former, using hand drilling tools; the hole was drilled to a depth of 63 m. and oil was obtained from a depth of 14 m.

11) KASHIK is in the western part of the valley Kashik. At the foot of an isolated hill west of the village of Kashik a drill-hole was sunk in 1864 by Gowen; the hole, 8 in. in diameter, penetrated sticky blackish clay from which oil seeped in heavy streams; it is known definitely that the hole reached a depth of 25.5 m., but was abandoned on account of an exceedingly strong escape of gas.

In the eighties, the French company having been wound up, its successor sunk in the district of the village of Kashyk about 50 drill-holes 10 m. deep each from which oil was extracted; this oil was distilled in a refinery erected in Kertch. Earlier there existed Tartar pits near the village.

12) CHUBURTMA-SART in the synclinal valley of Sart. Hand-dug oil pits existed in the vicinity of the village of Chuburtma-Sart, near an isolated hill located in the center of the valley. In 1864 Gowen drilled a well that struck meager oil at a depth of 8.4 m.; the gray clay became, however, so hard that the sinking of casing met great difficulties; at the depth of 54.6 m. the well was abandoned on account of the very hard rock. The well is filled with inflammable gas.



Photograph by N. Izgarychev.

Fig. 18. Siniia Balka mud volcano near Stanitsa Akhtanizovskaia; view of the crater.

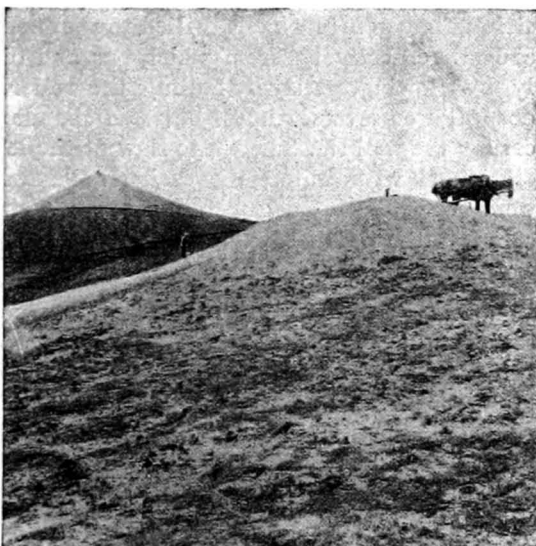
13) KENEGHES-KODJALAR In 1864 Levandovsky produced oil in the Keneghes estate of Lampsy and in the vicinity of the village of Maly Kodjalar; there are oil pits dug by Tartars 3 to 4 m. deep. In the end of the XVIII century one pit near the village of Kop-Keneghes yielded up to 250 liters of oil daily.

16) AIMAN-KUIU. In 1913 a Cirkassian Khun sunk two wells, 25 to 30 m., on the land of Kuznetsov and produced oil; these wells were, however, abandoned owing to the small diameter ($3\frac{1}{2}$ in.) of the holes and the lack of casing. In 1920 the Military Department undertook exploration work, sinking ten shallow shafts 17 to 19 m. deep; three of them yielded oil (5 to 6 kg. daily) and emitted large quantities of gas.

17) KOP-KOCHEGHEN. The surroundings of the village of Kop-Kocheghen abound in old so called Venetian pits from which oil was extracted at early times. In the seventies a French Company sunk in this district nearly 150 drill-holes, 149 to 170 m. deep; oil was encountered at two horizons—17 m. and 85—96 m. below the surface. According to Potylitsyn, oil is found in a sand layer at a depth of 2—3 m. (this information refers apparently to hand-dug pits); the oil is heavy, 0.903—0.904 sp. gr. One hundred active wells yield about 1300 kg of oil monthly. In 1884 Andrusov investigated three wells of this company; the first located on the floor of a ravine was sunk to a depth of 97.8 m.; a water gusher struck from this depth throwing out large quantities of glauconite sand which probably forms an intercalation within the clays; the second well located up the slope of the valley reached a depth of 108 m.; the third one that is located still higher up the slope and produced oil, reached a depth of 76.8 m. penetrating the Spaniodon clays with interbedded thin but hard layers of sandstone; the rocks are highly saturated with sulphurous water and carry grains of pyrite. According to Mokrinsky, a drill hole on the hill yielded up to 80 tons of oil daily from a depth of 313.5 m.; Potylitsyn states that there were attempts to drill this site to a depth of 50 m. but only gas was encountered instead of oil. According to all the data which are available, it may be inferred that the upper shaly clays (the Lower Sarmatian) underlain by the Spaniodon beds outcrop throughout this area.

18) CHONGHELEK has been explored in the most extensive manner. In early times there existed old pits 4 to 6 m. deep. In 1864 Gowen drilled a hole 116 m. deep that pierced sticky clays impregnated with oil and water; there were intercalated hard hematite and sandstone, while the clay strata with interbedded sand up to 0.60 m. thick were fully impregnated with oil; the well emitted large quantities of gas and 72 to 102 liters of oil daily. As oil seeped very strongly from the lumps of clay extracted from the well, a shallow shaft was sunk close to the latter to be deepened to 23 m. with a view to produce up to 500 liters daily; in the eighties a French company drilled a few deep holes that penetrated shaly clays carrying concretions in places impregnated with oil; there were «shells» of hard rock. In one of these holes the «shell» was pierced at a depth of 252 m., what gave rise to a strong flow of salty water followed by oil in small quantities; however, on further deepening oil ceased to flow, while the clays pe-

netrated were highly saturated with water. According to Potylitsyn there were flowing wells in Chonghelek which yielded oil with salty water, but the wells became plugged in a short time. One well 350 m. deep flowed in 1890 with oil of a specific gravity 0.854, while another well 403 m. deep flowed in 1891 with oil of a specific gravity 0.887. The oil was always accompanied with gas, what gave rise to a gusher as soon as the oil bearing stratum was tapped. The latter well with a depth of 403 m. flowed in 1891 beginning from May 4 during more than a month; at first the well gushed every half hour for 4—5 minutes, then the gushes became rarer, occurring in the beginning of June only once or twice a day. In the middle of June the well still flowed, later it was bailed; the specific gravity of the oil increased meanwhile from 0.882 to 0.889. This oil was of a brown colour and fluorescent; it was shipped to a refinery in Odessa. The gas pressure was so high in the gas bearing strata penetrated by these wells that the casing completely collapsed when piercing these strata. The gas burned brightly and was used for illuminating purposes. According to Dvoitchenko, up to ten thousand tons of oil with a high content of light hydrocarbons was extracted from these wells.



Photograph by N. Izgarychev.

Fig. 19. Mud volcano of the Tsybaly ridde and an active parasitic cone (in front of the picture) east-north-east of the volcano.

In 1902 a new oil company drilled a number of wells on an adjacent area one of which is said to have been sunk to a depth of 575 m.; at a level of 108.5 m. a little gas and indications of oil were encountered, while a constant issue of gas and oil began at

a depth of 151 m., the oil gathering on the water surface. No further information concerning prospecting for oil in this district is available. Bogdanovich states that in 1901 a well was drilled which reached a depth of 320 m.; a gusher struck at the depth of 240 m., causing collapse of casing; on being repaired and deepened the well flowed again from the level of 320 m., at which seemingly oil sands were encountered.

In 1907—1913 the Raky Company was operating in this district; there were four wells drilled to the depths of 405, 537, 350 and 556 m. respectively from which gas and oil were recovered, partly by flowing, partly by bailing; the well No. 3, which is 350 m. deep, flowed several times, but was abandoned owing to damaged casing; the well No. 2 began to flow at the level of 537 m., yielding oil mixed with water; the casing collapsed; the Spaniodon beds were penetrated at a depth of 285 m.; a strong flow of water occurred at the depth of 525 m. that has not been shut off. In the well No. 4 a green oil (specific gravity 0.875 to 0.890) of a high quality appeared at the depth of 556 m. In 1912 this well flowed periodically producing up to 491 tons of oil daily; in 1914 it continued to flow twice a day yielding each time 24.6 tons; later, owing to intentional sanding up, the production decreased to 9.8 tons. In 1919 the German troops, before the evacuation of the Crimea, dropped into this well a wire rope with a bailer, in consequence of which the flow decreased to 0.5 tons. In 1920, during Vrangél's occupation of the Crimea, a British company started to clean the well and its monthly production increased to 18 tons; but when leaving the Crimea the British drillers dropped another bailer into the well, where still remained the bailer dropped before. In 1921, under Soviet rule, the Crimean Economic Council undertook repairing this well; one bailer with a length of rope was extracted from the well. In April the production reached 0.65 tons daily. Since then (1921—1925) oil has been extracted by bailing the well every other day, the monthly production being 7.3 to 8.5 tons; one bailer still remains in the well. The oil production for the last few months is as follows: May—7.5 tons, June—8.47 tons, July—8.07 tons, August—7.18 tons. The well No. 2 which is also sanded up produces only 0.4 tons monthly.

In 1920 prospecting was conducted in this district also by test pits (up to 17 m. deep) and by drill holes (up to 74 m.); the results proved occurrence of oil in sediments the total thickness of which reaches 1500 m., their age ranging from the Oligocene

to the Lower Sarmatian; there are embedded sand strata (9 to 12 m. thick) and fissured hard rocks, accumulating oil.

19. CHORELEK. In 1907—1913 the Raky Company sunk two drill-holes in this locality that penetrated the Lower Sarmatian and Spaniodon beds; one hole reached a depth of 190 m., gas and oil being encountered at the level of 148 m.; another hole struck oil sand at the depth of 83 m., but further drilling was dropped.

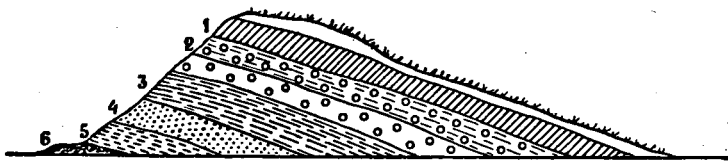


Fig. 20. Section of the mountain of Boris and Gleb (after Abich): 1—dark-brown arenaceous clays; 2—gray clays with concretions; 3—arenaceous and clayey beds with concretions; 4—gray quartz sand impregnated with oil; 5—argillaceous sand with gypsum, alum and copperas; 6—clayey breccia cemented by gypsum and slightly impregnated with oil.

20. YANYSH-TAKYL. In this district exploration work was conducted in 1908 by Forkatch, an Austrian engineer, who discovered at a shallow depth large quantities of oil in the outcrops of three beds of *Spirialis* sand. The Ilinskaia Company sunk a shallow shaft to a depth of 15 m. and obtained up to 0.35 tons of heavy oil daily; little gas was encountered and no water altogether.

It should be mentioned that the majority of data concerning exploration and prospecting on the Kertch Peninsula were gathered by geologists and chemists that visited prospects, rather incidentally; the data are therefore not complete, constitute casual characteristics and features and do not always tally. The exploring companies and single investigators refrained from publishing the results of their operations. No doubt that most test holes were located without any adequate knowledge of structural features existing in the prospected locality; in locating test holes only such indications were taken into consideration as seeps of oil and the presence of oil pits dug by Tartars. Drilling operations were conducted carelessly, without exclusion of encountered water sands, and were stopped prematurely, owing to the collapse of casing and other causes. The logs of the formations through which wells were drilled are meager and not exact, while data concerning quality and quantity of oil encountered in wells are still more incom-

plete. Owing to such practice in exploration and prospecting operations, oil-bearing horizons of the Kertch Peninsula are not yet investigated in any adequate measure in spite of 60 years prospecting, and the question of the commercial importance of this oil region remains unanswered.

2. *The Taman Peninsula.* On this Peninsula the number of localities which have been explored or prospected is much smaller and information concerning them still more scanty.

8. In the FANAGORIYSKAIA ridge, on the left slope of the valley that opens into the Yanovsky Lake, two old drill holes are to be seen, with 8 in. casing and a shallow shaft surrounded with heaps of dark shaly clays and Spirialis clays which are found also in drillings from the holes; the latter are apparently shallow and filled with water.

9. On the mount of BORIS AND GLEB the Taman Peninsula Syndicate sunk in 1913 a drill hole 322.5 m. deep, which reached only the ore horizon (the Middle Pliocene); this hole penetrated the strata of sands and clays with outcropping oil sands; a strong flow of water was encountered and very insignificant shows of oil, such as emulsions and films.

19. The KAPUSTINA ravine on the northern shore of the Kisiltash liman was explored most particularly; Novosiltsev drilled in this locality in 1860; then the Raky Company operated here early in the XX century; they sunk, however, only shallow drill holes 30 and 60 m. deep, which produced small quantities of light oil (sp. gr. 0.817, 0.878 and 0.894),—only 100 to 250 liters daily; oil derives from the Pontian clays in the central part of the fold. Later, in 1912—1914 the Taman Peninsula Syndicate sunk a deep hole on a property adjoining from the north directly to the property of the Raky Company; according to Bogdanovich, the log of the formations is as follows:

0—237.3 m. The Upper Pliocene strata and the Pontian, chiefly clays.

273.3—445.5 m. Meotic; clays, often sandy or micaceous, with *Ostracoda*, fish remains and inclusions of tripolite.

445.5—480 m. Upper Sarmatian. Greenish plastic clays, chiefly not calcareous, and sometimes sandy laminated clays with fish scales and *Mastra caspia*; intercalation of hard marl.

480—498 m. Calcareous clays carrying rare fish scales.

498—513 m. The same as above with inclusions of brown sandy clay and fragments of limestone,—interbedded with marls.

513—528 m. Dirty-greenish clays not calcareous with inclusions of fragments of limestone and white clays.

528—541.5 m. Light-gray clays with carbon streaks and fish scales; in places clays banded owing to thin porous and dolomitic sediment, reminding «worm» sediments, and constantly alternating with calcareous-sandy layers.

At a depth of 298.2 m. a small flow of oil (sp. gr. 0.819) was encountered; at the level of 362 m.—thin layers of oil sand carrying gas; at the level of 490 m.—small showings of oil, and finally at a depth of 540 m. a considerable flow (up to 1.1 tons daily) of oil (sp. gr. 0.914) was encountered. Thus indications of oil were found in the Meotic and Upper Sarmatian, while a stronger flow derives from rocks similar to «worm» rocks, that is to the Middle Sarmatian, according to Gubkin. Bogdanovich gives the following description of the geological features of this locality: owing to the likeness of these rocks to those underlying the Spaniodon strata, that is to the Middle Miocene of the Chonghelek and Suvorovo-Cherkessky regions, it may be inferred that between the Upper Sarmatian and the underlying rocks there is a structural unconformity, caused by the «diapir» folding, what is evidenced by the crushed rocks. Both investigators came to the conclusion that further deepening of the well was not promising. The well was abandoned, but later it flowed several times, e. g. in the middle of November 1915, when the well threw out up to 82 tons of oil during a few minutes.

20. THE MOUNT NEFTIANAIA (the southern one). The prospecting on this mountain was done in the sixties also by Novosiltsev; and then in 1911—1912 the Chernomorsko-Kuban Company sunk a hand-drilled hole on the northern slope of this mountain; the well reached a depth of 149—153 m., where showings of heavy oil were found such as coatings and small accumulations in the dark shaly clays (the Lower Sarmatian?); among the clays there was a flow of highly iodized water. The well was abandoned without having given any definite results.

21. STRELKA was also investigated and prospected by Novosiltsev in the sixties. In 1912 the Maikop-Enem Company sunk a number of hand-drilled holes, which yielded small quantities of oil from a shallow horizon.

Thus, of the 23 above cited localities of the Taman Peninsula carrying indications of oil, only five have been explored and deeper drilling has taken place only in the Kapustina ravine. As to the production of oil, there are no exact data with respect either to the Taman or the Kertch Peninsula.

THE COMPOSITION AND COMMERCIAL VALUE OF THE OIL

The characteristics of the oil obtained at different places of the region are not sufficiently ascertained, owing to the causes stated above, that is the lack or irregularity of information concerning former explorations. A well near the village of Djerjava produced a liquid green oil, specific gravity 0.800. The oil recovered from pits and shallow drill holes in Kop-Kocheghen was heavy, sp. gr. 0.903—0.904. According to Potylitsyn, the oil obtained in Chonghelek in 1884 had a specific gravity 0.800 or 0.790, the heavier occurring nearer to the surface; in 1895 the oil from the well 350 m. deep had a specific gravity 0.854, while the well 403 m. deep produced oil of sp. gr. 0.887, that is the heavier oil lying deeper; the oil was of a brown colour and fluorescent, like the Baku oil. According to Bogdanovich in 1915 green oil was extracted with sp. gr. 0.875—0.890. On the Taman Peninsula oil in seeps is thick and heavy; similar oil was found in shallow drill-holes at 149—153 m. on the southern Neftianaia mountain. However, in the Kapustina ravine the oil recovered from a deep hole at 298 m. horizon had sp. gr. 0.819, while that from the 540 m. horizon had sp. gr. 0.914.

Thus, according to this scanty information, the oil on the Kertch Peninsula is in general a light one, and somewhat heavier on the Taman Peninsula; but on both the Peninsulas oil is distributed through the strata in conformity with its specific gravity, i. e. the heavier oil lies at deeper horizons. Thick and heavy oil, seeping on outcrops in pits and in shallow holes, constitutes an oil thickened and oxidised by the oxygen of the air. This oxidizing process gives rise also to the partings of streaks of hardened oil, which is found in places in clays, and to the formation of asphalt on the Enikale cape (and on Tashlyiar). A commercial analysis of the petroleum of this region was performed only once (so far as is known) by Potylitsyn and Bernstein, viz. the analysis of the dark-brown oil with a green tint, obtained in Chonghelek, probably from the well 403 m. deep; this oil is fluorescent, its sp. gr. 0.888.

Fractional distillation gave the following results:

Fractions.	Yield per cent.	Spec. gravity.
100° to 150°	3.2	0.7506
150° " 200°	6.4	0.7730
200° " 250°	10.7	0.8220
250° " 300°	26.7	0.8860
300° " 320°	8.7	0.9290

At a temperature over 320° the distillation was accompanied by decomposition of the oil, thus only 55.7 per cent of the sample was distilled. 78.6 per cent of all the distillates (150°—300) are illuminating oils beginning from the colourless one (150°—200°) to the yellowish one (300°). This cut corresponded to kerosene and had a flash point 37.3°. The residuum was distilled in a stream of steam, by which process was produced a heavy yellow-brown oil carrying no paraffin. The oil of the Kapustina ravine, of a specific gravity 0.816, subjected to a distillation up to 125° yields 26.87 per cent of cuts,—from 125°—300° yields 53.5 per. cent of cuts and contains traces of paraffin.

Helmersen has seen the kerosene manufactured in Kertch from oil obtained by Gowen; this colourless and transparent kerosene with a feeble odour could not be fired by a burning match.

The water extracted from the Chonghelek hole is of yellowish colour, highly salty and alkaline; it has a feeble petroleum-like odour and contains iodine (0.1645 gr. of NaI per one liter); this water is almost identical to the water of the Kuban oil field by its contents of iodine and its alkaline characteristic.

SUMMARY

According to their geological age, the deposits of petroleum occurring throughout both the Peninsulas are distributed as follows:

THE KERTCH PENINSULA	THE TAMAN PENINSULA.
1.—Post-Tertiary sediments	
None	Azovskaia Pekla. A precipice north of the Akhtanizovskaia stanitsa. The mount Boris and Gleb? The northern mount Neftianaia.
2.—Upper Pliocen.	
None.	The mount Boris and Gleb. Strelka.

3.—Middle Pliocene.

None.

None.

4.—Lower Pliocene.

None.

Tsymbaly. The Kapustina ravine.

5. Meotic.

The Burash basin.

The Kapustina ravine.

6. Upper Sarmatian.

Cape Enikalé. The Enikalé anti- The Kapustina ravine.
cline. Misyr?

7. Middle Sarmatian.

None.

The Southern mount Neftianaia.
The Kapustina ravine?

8. Lower Sarmatian (the upper clays).

Djerjava. Djerjay-Kashik.
Kop-Kocheghen. Chonghelek.
Chorelek. Yanysh-Takyl.
Tashlyar. Chuburtma-Sart.
Kop-Sairamin. Nasyr.

The mount Zelenaia.
The southern mount Neftianaia
Bliznetsy. The Karabetova mountain.

9. Middle Miocene (Spaniodon and Spirialis).

Bulganak. Kuchuk-Kodjalar. Ai- Cape Kamenny. Fanagoriskaia.
man-Kuiu. The lower horizons of Girka. Pekla Chernomorskaia. Fonta-
Kop-Kocheghen, Yanysh-Takyl and in novskaia. The Kapustina ravine?
part the Chonghelek and Chorelek
horizons.

10. Lower Miocene and Upper Oligocene (the lower clays, the Maikop beds).

Maly Tarkhan. Cape Tarkhansky. Ka- Tsymbaly. The southern mount Nef-
ralar. Kazan. Karmysh-kelechy. Sul- tianaia. The northern mount Neftianaia.
tanovka. Indications at Kopkeneghes. Dubovy Rynok. Strelka. Temriuks-
Kara. Mamat. Mud volcanoes of Tar- kaia. Gnilaia.
khan. Shiban. Akhtarka, Djou-Tepe.
The gas seeps of Kerleut.

The above table shows that in this region all the horizons of sedimentary rocks seem to be petroliferous, especially on the Taman Peninsula, while oil is absent in the Pliocene, Post-Tertiary and Middle Sarmatian rocks on the Kertch Peninsula. No doubt, however, that in a part of deposits the oil is of secondary origin, having migrated into the younger strata from the older ones along

the fault and thrust fissures, and owing to a contact of younger and older strata in the «diapir» folds. Among such secondary deposits, which are not promising, are to be included all the Post-Tertiary and Pliocene of the Taman peninsula, consisting of sands or clays with intercalations of fossil shells which are impregnated with oil that has migrated from the older sediments. It is doubtful also that a primary oil is to be found in the Meotic of the Burash basin and in the Upper Sarmatian of Cape Enikalé and the Enikalé valley,—as the cited deposits are related to faults and thrusts, along which oil could rise from deeper horizons. The results of drilling in the Kapustina ravine have proven that both the above named stages do not carry commercial oil. The oil which is found in the Middle Sarmatian of the southern mount Naftianaia could hardly be classified as a primary one, as the main outcrops are related here to the Maikop beds, of which the core of the dome is composed; the oil could migrate from these beds and penetrate into the Sarmatian on the slopes of the mountain. A strong flow of oil from the Middle Sarmatian was encountered in the Kapustina ravine; however, Bogdanovich assumes with great probability the presence of «diapir» folding and the migration of oil from the Spaniodon beds. Thus, the oldest stages in the region constitute prospective receptacles of the primary oil-bearing horizons of commercial importance, that is,—the Lower Sarmatian, Spaniodon and Spirialis beds of the Middle Miocene and the Maikop beds of the Lower Miocene—Oligocene. Most of the oil deposits are related to these stages, as it is seen in the above table. Therefore, they should be examined with respect to their lithological character to ascertain the prospective commercial value of different horizons.

The comparative table given in the geological part of this monograph shows that within the Kertch Peninsula the strata of greater thickness are found only in the Middle Miocene; owing to their perviousness these strata are apt to accumulate considerable amounts of oil, thus forming natural receptacles; such are the limestones, sands and sandstone of the Spaniodon beds and the different limestones and sands of the Spirialis beds; in the Lower Miocene, that is in the Maikop beds, the interbedded layers of sand and marl that might serve as oil receptacles are scaried and thin. On the Taman Peninsula even the Middle Miocene, like the Lower Sarmatian and Maikop beds, is composed in its essential by clays; the only difference is the presence of intercalations of marl and porous limestone in the Spaniodon beds, while in the Spirialis

beds there are interbedded layers of sand and marl; these rocks may serve as oil reservoirs, but they are stratified into layers of small thickness. The shaly clays which predominate in the Lower Sarmatian and Maikop beds throughout the whole region, and in the Middle Miocene of the Taman Peninsula, are also more or less impregnated with oil. Helmersen has already stated that oil was seeped in streams by the clay extracted from Gowen's well in Chonghelek and Kashik; these clays impregnated with oil burn with a long flame when fired. The same clays are saturated, besides oil, with gases, the escape of which often causes difficulties in drilling operations, the collapse of casing and formation of clay plugs. However, these clays exude their oil very slowly.

The said characteristics of the petroliferous rocks of the region explain all the features brought forward during drilling operations and the exploitation of wells and pits. These are some of the features: rare and brief gushers, occurring only when the holes reached an oil receptacle—a layer of sand or limestone, which is in most cases too thin and consequently gives up its oil very rapidly; the small production of the wells and pits, which is due to the slow drainage of oil from clays; the gradual exhaustion of old pits, which are consequently abandoned; violent escapes of gas from wells, which are usually not accompanied by oil gushers; the failure of many drill-holes, which did not tap even thin beds—receptacles for oil.

Thus, the primary oil-bearing horizons, that have been discovered at outcrops and by prospecting and exploring, would appear not to be promising by their characteristics, as they do not promise easy exploitation of oil deposits possessing commercial importance. That would lead to the conclusion, that the region which at first sight seems to be very favourable, owing to the abundance of oil indications which long ago attracted investigators and oil producers, is actually of no considerable commercial importance.

Happily this unfavourable conclusion has no sufficient basis, as is shown by the following consideration:

- 1) Prospecting and exploration work has been carried on up to the present time without any consideration of the structural features of the country; the drill-holes were located without any geological guidance except surface indications of oil; such evidences, however, are liable to deceive expectations for the following reasons: first, at the localities where oil has seeped on the surface during a long period of time, oil horizons may be drained off; se-

condly, the oil indications are found along the fault and thrust-fault lines, near which drilling is generally not reliable. Then it should be mentioned that no well was sunk sufficiently deep, that is, to a depth at which the whole series of oil-bearing strata down to its bottom would be penetrated by the hole; thus the lithological features of the series through its whole thickness are not ascertained. In the lower part of the series there may exist large receptacles of a greater thickness, carrying considerable reserves of oil. Besides, there are no accurate drilling logs, giving characteristics of formations penetrated by the drill-holes or showing the number and features of the petroliferous and water-bearing horizons, as well as other information, such as quantity and quality of the oil that was recovered, and reason of discontinuing the drilling operations. It is to be generally assumed and positively asserted with respect to prospecting in the XIX century that all exploration work was conducted without any adequate guidance and records of all the features which are of particular importance when drilling in a new region; the holes were abandoned without sufficient reasons, only on account of accidental failures, or the disappointment of prospectors who hoped for prompt success, such as a big gusher, etc. Considering all these facts we must infer that the exploration work which has hitherto been performed in the region, absolutely can not be accepted as an adequate basis for an unfavourable conclusion as to the commercial importance of the region.

2) On the Kertch Peninsula the strata of the Middle Miocene (Spaniodon and Spirialis beds) carry fairly large oil and gas receptacles or reservoirs. These very strata remained, however, unexplored in most of the localities which were mentioned above; this is due to errors in drilling operations,—the holes were located at sites where the strata of the Middle Miocene were eroded, having exposed the underlying Maikop clays, which are almost deprived of oil reservoirs. Only in the south-eastern corner of the Peninsula,—on Chonghelek, Chorelek, Yanysh-Takyl and Kop-Kocheghen,—the Middle Miocene is not exposed, being buried under the clays of the Lower Sarmatian and partly also by the next overlying strata. It was just in this locality that old prospecting was most favourable,—producing gushers and large quantities of oil. On the Sart anticline the Middle Miocene is stratified probably on a deeper horizon and was not tapped by the drilling in the sixties, which was prematurely stopped. On the eastern extremity of the valley of Djerjava the Middle Miocene is also to a great degree buried, excepting one

hill; in this locality exploration work was likewise stopped prematurely. This leads to the conclusion that further prospecting and exploration should be conducted in the localities cited, as well as in other synclinal valleys, where the Middle Miocene lies more or less deep and may not have lost its oil by outflowing on the surface.

On the Taman Peninsula this stage contains fewer oil reservoirs; however, it also deserves further exploration,—for in the Kapustina ravine it was from the strata of this stage that oil was obtained, provided the information given by Bogdanovich is accurate.

3) In the adjacent eastern regions of the Kuban province, that is Anapsky, Eisky, Kalouzhsky and Maikop regions, petroliferous horizons, except those belonging to the Lower Sarmatian, Spaniodon, Spirialis and Maikop beds, are also associated with the so called Foraminifera strata (Middle and Lower Oligocene) underlying the Maikop beds. These strata were not tapped by test holes on the Taman and Kertch Peninsulas, although the occurrence of Foraminifera strata in this region is quite possible. Besides, an arm-shaped bed of sands highly saturated with light oil was discovered at the contact plane between the Foraminifera and Maikop beds; this bed has already yielded the main part of the production of the Neftiano-Shirvansky area, viz. 760,000 tons during the period of 1909—1922. On the Khadyzhinsky area the horizon of light oil was encountered in 1915, lying in the clays of the footwall of the Maikop beds; one well produced from this horizon 2200 tons of oil. The Maikop beds have not been completely penetrated by drill-holes either on the Taman or on the Kertch Peninsula. The presence of oil in the lower part of the beds is yet to be investigated; the presence of oil sands is inferred by comparison with the Maikop region. Both the Peninsulas are abundant with mud volcanoes, the eruptions of which are undoubtedly caused by hydrocarbon gases; this feature, as well as the distribution of mud volcanoes most frequently on the outcrops of the Maikop beds in the anticline cores, leads to the conclusion that the lower horizons of the Maikop beds or the underlying strata having no outcrops on the surface may be more prolific than all the exposed strata, that is, may form the rich oil and gas reservoirs, which are the primary sources that gave rise to the mud volcanoes and their eruptions.

4) Even should further exploration prove the absence of these deep and prolific oil-bearing horizons in this region, there remains,

however a question of practical importance,—the possible utilization of the upper (the Lower Sarmation) and lower (Maikop) clays, which are impregnated with oil; the latter might be recovered by distillation, the clays themselves serving as fuel; the clay production might be developed on a large scale by the use of excavators for open mining. Abundant gases escaping from mud volcanoes and drill-holes may also find a practical application in connection with a new cracking process; these gases are said to contain 93—97 per cent of methane. In spite of abundant indications of oil, as well as prospecting and exploration at different times during a period of sixty years, this region has not been developed,—this being attributable to the failures experienced in prospecting and exploration work, that was conducted without any system; drill holes were abandoned uncompleted, thus giving no proof of the occurrence of oil in a deposit and of its commercial importance. The oil producers were attracted by the prolific Baku and Grozny fields, which diverted their attention from Kertch and Taman, where exploration work is more complicated. Only just before the outbreak of the European war a British company undertook a thorough exploration of deeper horizons (the Kapustina ravine); however, the war and succeeding events have prevented completing the prospecting.

FUTURE POSSIBILITIES OF THE DISTRICT

The Taman and Kertch Peninsulas form the western extremity of the rich oil-bearing belt of the Tertiary sediments which stretches along the northern foothills of the Caucasus; within this belt there are producing oil fields, such as Old-Grozny, New-Grozny and a number of oil fields in the Kuban province; all these fields have been worked for many years. West of the Kertch Peninsula in the steppes of the Crimea oil-bearing formations seem to vanish; the Tertiary strata form in general a broad syncline in partly sunk below sea level; in this region, as well as in the belt of the South-Russian steppes on low-lands of the rivers Dneper, Bug and Dneșter, only the Pliocene is exposed on the surface, being stratified almost horizontally and without folding. There is no information proving the presence of petroliferous beds at deeper levels in this locality. However, on the other side of the Dnester river, approaching the Karpatian bow in Roumania, the Miocene and Paleogen again come to the surface, owing to the displacements of the Alpine phase (to which belongs also the last upheaval of the Caucasus); here again

we find the numerous and prolific oil fields of Roumania and Galicia. Thus, the Kertch-Taman region lies on an intermediate area between the Karpathian region on one side and the North-Caucasian region on other side,—this position allowing us to consider the Kertch-Taman oil region as a promising one with respect to the occurrence of oil of commercial value.

On the other hand, the advantageous position of this region on the two Peninsulas, between two seas,—with the equipped harbours of Theodosia, Kertch and Temriouk, with numerous bays, which facilitate the construction of new harbours, with the railroad on the Kertch Peninsula, with a flat relief of the country and a hard soil, which allows an easy automotive traffic in every direction, and finally with numerous inhabited localities, scattered over the whole area of the region and warranting a supply of labour,—all these features combined together make the region easily accessible, as if adapted by nature itself for the exploitation of the mineral deposits and their easy transportation, both northward, to the seaports of the Sea of Azov and by the Don river into the inland, and southward and westward, to the seaports of the Black Sea and the Mediterranean. This accessibility of the region may compensate for the lesser wealth of the different oil fields, as well as for the greater cost of prospecting and exploration. ¹⁾

In addition to oil and natural gas the region carries also in appreciable amounts other minerals, the exploitation of which may be developed partly by the oil and gas producers, partly as independent enterprises. A number of investigations have shown that the mud and waters of the mud volcanoes contain certain quantities of boracic acid and iodine, the extraction of which may be a profitable operation (see the reports of Izgaryshev and Sludsky); the reserves of mud are enormous. Then the iron ores are of considerable importance; there are deposits lying in several synclinals of the Kertch Peninsula and in the western part of the Taman Peninsula that are related to the ore horizon of the Pliocene; the ore lies near the surface and the sea shore; mining operation may be developed on a large scale by using excavators. The ore reserves on the Kertch Peninsula alone are estimated to be 900,000,000 tons; prior to the war these ores were mined for supplying the Taganrog and Kertch works. Further, in the south of the Kertch Peninsula, by the mount

¹⁾ The cost of pipeline pumping of oil from Baku to Batum is 4 kopecs per pood,—consequently by so much cheaper will be the export of the Kertch-Taman oil.

Opuk there is a deposit of native sulphur, which deserves to be explored; indications of sulphur are also known near the Chokrak lake. Numerous sulphurous springs and the mud of the mud volcanoes and lakes should acquire importance for medicinal purposes, while several large salt lakes are already being exploited for salt production. Finally the strata of gypsum, cement marls and Kertch building stone also present a certain value and are partly (marl, Kertch stone) exploited. Owing to the accessibility of the region the exploitation of all these minerals may be developed on a very large scale.

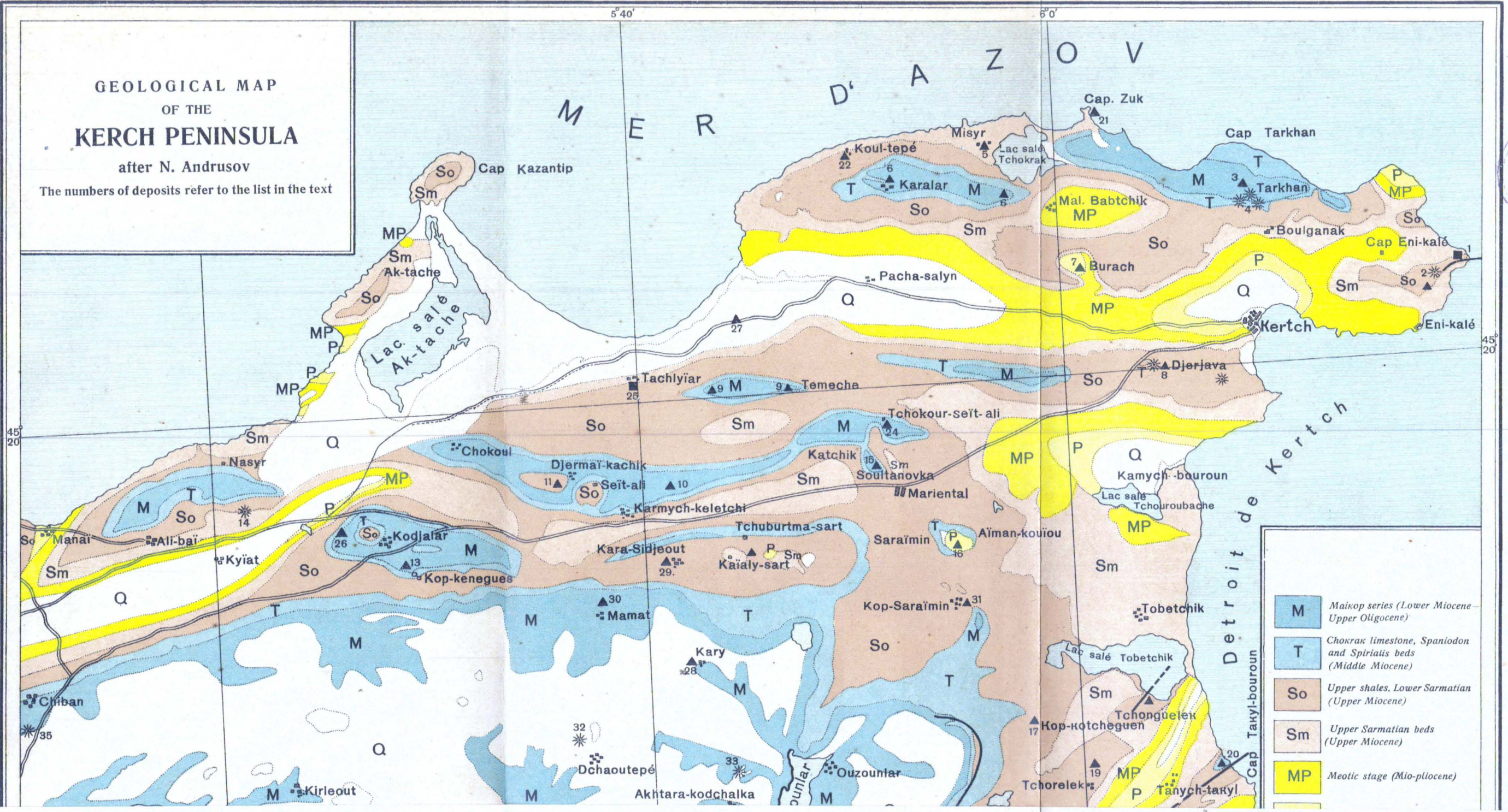
SELECTED BIBLIOGRAPHY

1. A b i c h. Einleitende Grundzüge der Geologie der Halbinseln Kertsch und Taman.—*Mem. de L'Acad. Imp. d. Sc. de S. Pet.* (7), IX, 1865, No. 4.
2. N. A n d r u s o v. The geological structure of the Kertsch Peninsula.—*Materials for the geology of Russia*, XVI, 1893, pp. 63—336. With a geological map.
3. N. A n d r u s o v. Geological investigations on the Taman Peninsula. *Materials for the geology of Russia*, XXI, part 2, 1904, pp. 255—382, with a geological map and 7 tables.
4. K. B o g d a n o v i c h. The report on a trip to the Kuban oil fields in the summer of 1914.—*Gorny Journal*, 1915, III, Book 7—9, pp. 1—59, with 6 tables.
5. G. H e i m e r s e n. Die Schlammvulkane und die Naphta bei Kertsch and Taman.—*Bull. Acad. Imp. d. Sc. de S. Pet.* XI, 1867, pp. 172—190 (or *Melanges Phys. et Chem.* VII, 2, pp. 210—244).
6. J. G u b k i n. The description of the geological formations of the Taman Peninsula. (A preliminary report).—*Bull. Geol. Com.* 1913, No. 8, pp. 803—857, with a structural map.
7. J. G u b k i n. The oil deposits of the Taman Peninsula.—*Natural Resources of Russia*. Petrograd 1918. Vol IV, iss. 22, pp. 48—56.
8. P. D v o i c h e n k o. The minerals of the Crimea. A brief description with a bibliography.—*Bull. of the Krymsk. Obsch. Est. i Liub. Prirody* IV, 1914, 208 p.
9. I s g a r y s h e v a n d S l u d s k y. The mud volcanoes of the Kertsch Peninsula and the Temriouk-Taman region.—*Rudny Vestnik*, 11, 1917. No. 3—4, pp. 97—112.
10. V. O b r u c h e v. The oil and gas deposits of the Kertsch Peninsula.—*The Petroleum and Oil Shale Industry* 1921, No. 5—8, pp. 181—221, with a map (A full summary of all data, with a bibliography).
11. A. P o t y l i t s y n. On oil deposits of Crimea.—*Journ. of Russ. Phys.—Chem. Soc.* 1895, XXVII, issue 4, pp. 276—279.
12. A. S t o p n e v i c h. Natural gases.—*The natural resources of Russia*, Vol. IV, iss. 39. Petrograd, 1917, pp. 31—33.

**GEOLOGICAL MAP
OF THE
KERCH PENINSULA**

after N. Andrusov

The numbers of deposits refer to the list in the text



- M** Maikop series (Lower Miocene - Upper Oligocene)
- T** Chokrak limestone, Spaniodon and Spiralis beds (Middle Miocene)
- So** Upper shales, Lower Sarmatian (Upper Miocene)
- Sm** Upper Sarmatian beds (Upper Miocene)
- MP** Meotic stage (Mio-pliocene)

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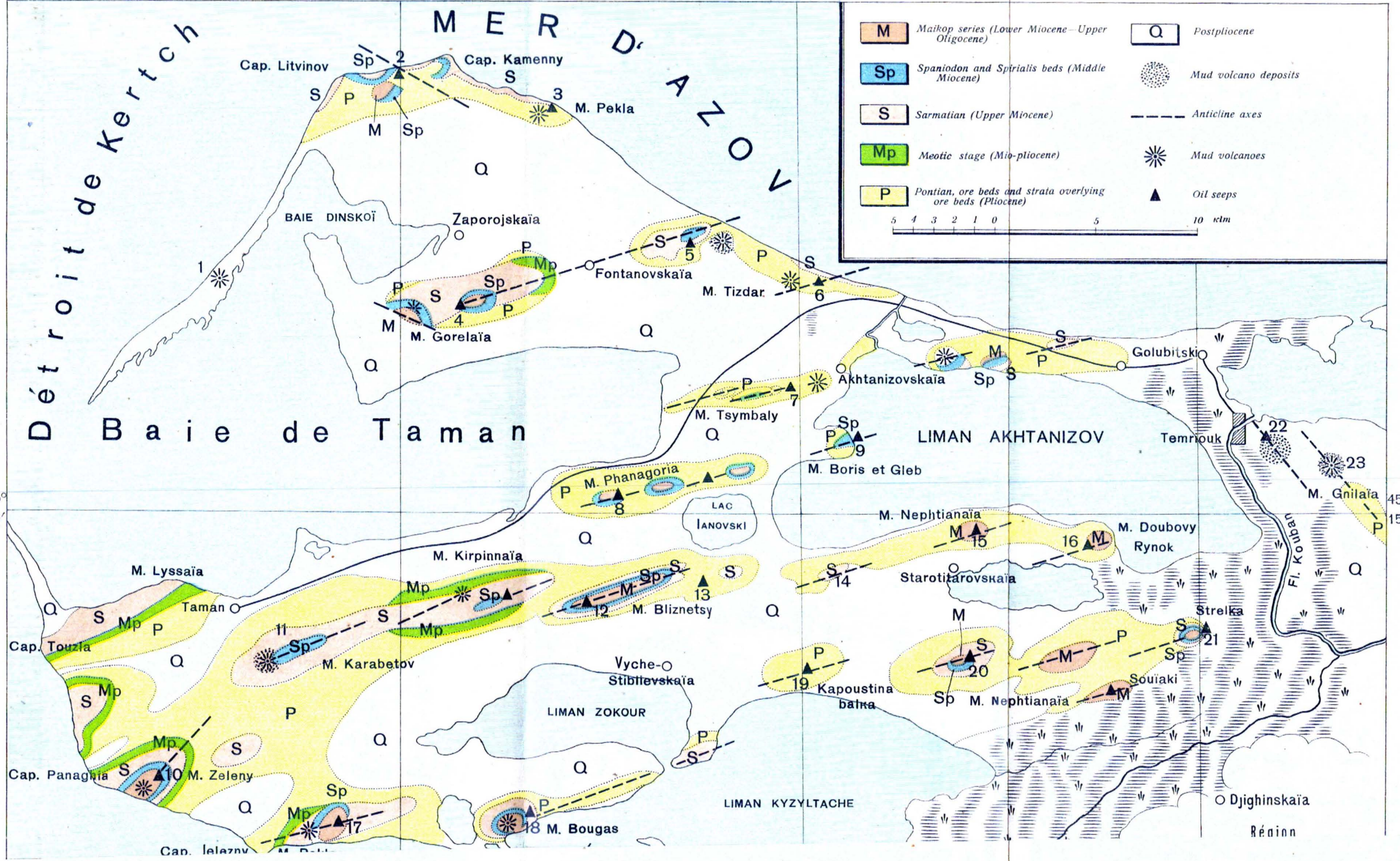
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Détroit de Kertch
Baie de Taman

MER D'ANOV

M	Maikop series (Lower Miocene–Upper Oligocene)	Q	Postpliocene
Sp	Spaniodon and Spiralis beds (Middle Miocene)		Mud volcano deposits
S	Sarmatian (Upper Miocene)		Anticline axes
Mp	Meotian stage (Mio-pliocene)		Mud volcanoes
P	Pontian, ore beds and strata overlying ore beds (Pliocene)		Oil seeps

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THE COUNCIL OF PETROLEUM INDUSTRY.

A. PRITULA

MINING ENGINEER

THE BEREKEI OIL REGION

With 4 figures

**PUBLISHED BY THE COUNCIL OF PETROLEUM INDUSTRY
MOSCOW—1926**

Москва. Главлит 63.889.

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GENERAL DESCRIPTION

Geography. The Berekei oil field is situated in the Caucasus on the very coast of the Caspian Sea, within the Daghestan Soviet Socialist Autonomous Republic, about halfway between Grozny und Baku. The nearest railway station is at a distance of 5 km. from the field (the Berekei station of the North - Caucasus Railway).

The territory on which the oil field is situated is a low coastal plain: the nearest mountains begin 13 km. to the west. Oil has been produced here before, the exploitation being confined within the State property Berekeiskaya Datcha. This property is shown in the accompanying map (fig. 1 and 2); it is bordered on the north by the Bugan-Chai river, on the west and south by lands of the neighbouring villages, and by the Caspian sea on the east. Adjacent lands owned by private individuals were leased for oil production by the Nobel Brothers Co. and A. Mac Garvey (subsequently the founder of the most important North Caucasus Oil Company).

Ways of communication. The distances of the Berekei Station from various points by rail are as follows:

From Petrovsk	101 km.
» Grozny	260 »
» Baku	244 »
» Batum	1144 »
» Tuapse	925 »
» Derbent	29 »
» Rostov	996 »

Since the stream of goods, both for the domestic market and for exportation, is directed northward, Berekei oil is in this respect in a more favourable position than Baku oil, and less favourable than Grozny oil. As to water transportation (the Caspian sea and the Volga river), Berekei is more favourably situated than Baku and Grozny. If the oil products are shipped from Berekei via Pe-

trovsk, Berekei will have the advantage over Grozny in the distance, the distances Grozny—Petrovsk and Berekei—Petrovsk being respectively 165 and 101 km. As compared with Baku, Berekei has the advantage, the distance from Petrovsk to Astrakhan being shorter than from Baku to the latter port.

Although the sea off Berekei is shallow and ships can not approach the shore, nevertheless, when the oil field is developed, it would be possible to construct a wharf to load oil into tank-steampers. This would materially reduce the cost of transportation of the oil to Volga and would place Berekei, so far as transportation is concerned, in an exceptionally advantageous position in comparison with Baku and Grozny.

When comparing the distances from Grozny, Baku and Berekei to Astrakhan, it is to be taken into account that the cost of pipe line transportation is as much again as the cost of water transportation; therefore, the distance Grozny—Petrovsk, which is 165 km., is equivalent, as to cost of transportation, to 330 km. of sea-way. This granted, the distances from the following points to Astrakhan would be:

From Petrovsk	779 km.
» Berekei	512 »
» Baku	768 »

As to the export ways for the Berekei oil, it should be noted that after the construction of the Grozny—Tuapse pipe line the difference between the cost of transportation from Berekei and Grozny will be materially reduced, because, when large quantities of the Berekei oil have to be exported, the latter may be pumped through the Berekei—Grozny pipe line, which will have been constructed, and further through the Grozny—Tuapse pipe line, which is now already under construction.

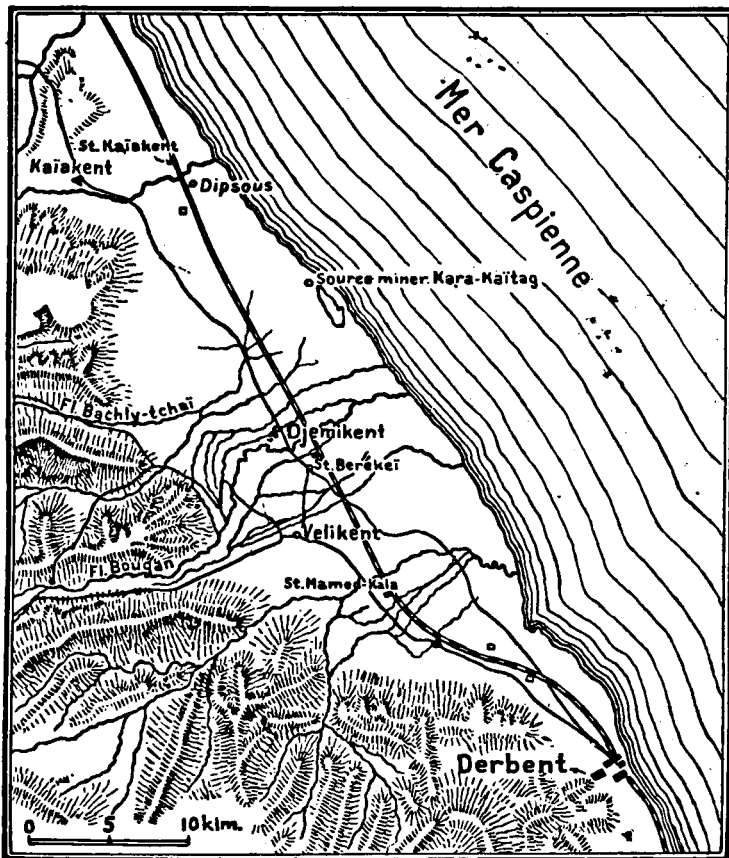
It is therefore to be believed that the Berekei oil, as well as its products, will find ready markets both at home and abroad.

Population. The majority of the population of Daghestan are Lezghins, who have long since been supplying labour to the Grozny oil fields. The inhabitants of Daghestan are well known as skilful armorers, and they are capable of the most highly qualified work. Consequently, there is no doubt that the Berekei fields will be fully supplied with labour.

The close proximity to the railway favourably solves the problem of transportation and communication facilities. In the pre-war times there was a branch railway from the oil field to the Be-

rekei station. Now it would be more economical to construct a macadam-highway, about 5 km. long.

Building materials: sand, clay, stone exist in abundance; this circumstance greatly reduces the operating costs.



— Fig. 1. Map of the Berekei region.

General conditions of work. An unfavourable factor is the malaria much spread in the region, which reduces the efficiency of labour. But prophylactic measures and a gradual draining of the locality, clearing the latter of bushes and thickets, will considerably reduce the infection.

GEOLOGY AND OCCURENCE OF OIL

More or less detailed data concerning the geology of the Berekei oil-bearing area may be found in the works of D. V. Golubyatnikov and in more recent works of D. V. Golubyatnikov cited at the end of the present paper.

Below is given a schematic section of the formations (following in descending order) involved in the stratigraphy of the Berekei oil-bearing area.

1. Post-Tertiary formations, reaching a thickness of 10—12 meters, at the base of which lies quicksand with a considerable flow of water.

Generally the sinking of shafts is greatly handicapped by this quicksand, preventing the shafts reaching the bed rock.

2. Dark-brown, almost black clays with *Spirialis*, containing thin layers of sandstones and marls. At various depths moderate seeps of oil and gas have been encountered. This formation is referred to the lower part of the Chokrak and *Spirialis* beds (the second Mediterranean stage, Middle Miocene); its thickness is 150—200 m.

3. Strata of gray and dark clays and clay shales containing scales of fishes *Meletta* cf. *sardinites*, relating to the Maikop beds and belonging to the Lower Miocene and Upper Oligocene. The strata underlying the Maikop bed have seemingly not been reached by drilling, therefore their thickness is not defined exactly for the area in question; nevertheless, the thickness of the Maikop beds may be considerable, since according to prof. J. M. Gubkin, in some places, as e. g. in the section along the Sulan river and in other points of Daghestan and the Black Mountains, as well as in the Naftalan region (Transcaucasia), the thickness of the Maikop beds reaches 1000 m. In the upper 200 m. of the formation here discussed there are feeble seeps of oil and gas.

As to an interbedded layer of grayish globigerina marl which has produced several big gushers yielding nearly 65,000 tons of oil, this layer seemingly lies within the Maikop beds and is younger than typical foraminifera beds of the Middle Oligocene, developed throughout the North Caucasus. Judging by the geological section of neighbouring localities, at the base of the globigerina horizon there lie the strata of shales which belong to the type of the Maikop clays, containing ferruginous concretions and intercalations. The horizons of the Middle and Lower Oligocene, as well

as of Eocene underlying the shales, likewise have not been tapped by drillholes.

There is reason to believe that a deeper drilling through the above mentioned formations in the Berekei oil field may disclose loose sediments (sands and sandstones) which may serve as a reservoir for more or less considerable accumulations of oil.

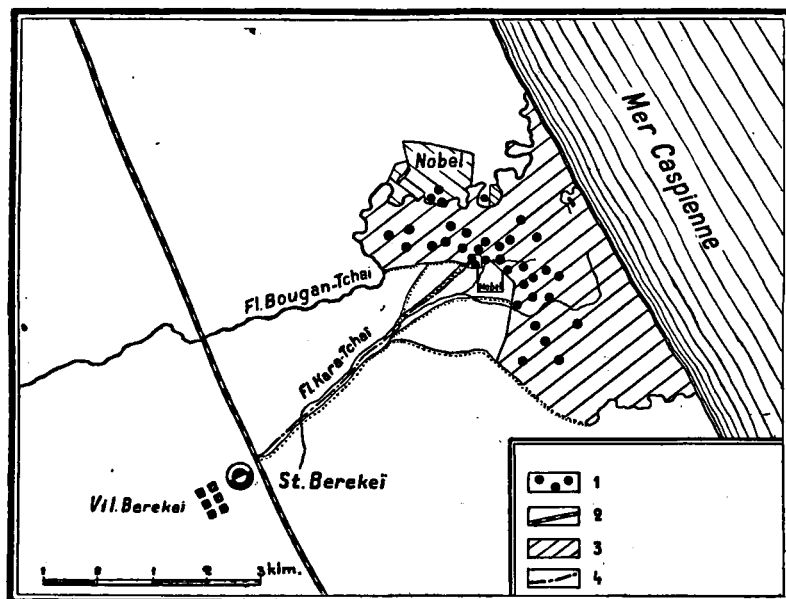


Fig. 2. Map of the Berekei oil field: 1—wells; 2—railroad; 3—area of the Berekei oil property; 4—pipe line.

GEOLOGICAL STRUCTURE. As far as has been cleared up by the geological work done in this region, the main structural feature of Berekei is an anticline trending in a northwestern direction, the axis of which passes through the plot of the group XXIX.

The north eastern flank of the anticline dips at an angle of 28° — 30° ; the south-western flank has not been sufficiently explored so far.

Occurrence of oil. By drilling operations four horizons have been proved to be petroliferous; however, they are not uniformly saturated with oil. In the *Spirialis* beds and gray shales underlying them a thick oil was encountered at various depths, the oil being

thicker in the horizons nearer the surface. There were small seeps of no commercial importance.

Considerable quantities of oil were obtained from the globigerina horizon encountered at the depth of 393—457 m. In some wells this horizon produced a number of gushers; other wells yielded only «showings» of oil but no flowing oil. This as well as the absence of oil in a number of wells may be attributable to the fact that water has not been shut off. In the central part of the plot XXIX, in a well sunk by O. A. Benkendorf, a periodical gusher has been brought up from the globigerina horizon at a depth of 393 m. This gusher yielded about 163 tons of oil per day. In the well No. 2 of the Nobel Bros. Co. the same horizon at a depth of 412 m. produced a gusher yielding 49 t. per day. Up to January 1st 1907 this gusher yielded 8,200 tons of oil. The well No. 1 of Nobel Bros Co. likewise a gusher, yielded a daily average of about 49 t.; during the period from May 1903 to January 1st 1905 the well produced 32,760 tons of oil, etc. The results obtained in exploiting this new area should be regarded as exceedingly proving, inasmuch as 15—20 years ago efficient methods of development were unknown (for instance, a well 925 m. deep was regarded as a record) and the importance of water exclusion was not sufficiently understood, the methods of shutting off being unsatisfactory.

Besides the horizons mentioned, which have been tapped by drill-holes, oil may be present at the base of the ferruginous clays, among the strata underlying the globigerina horizon; still more promising are the beds of yellow sand overlain by the ferruginous clays. Along the Yangichai river inflammable hydrocarbon gases issue from this sand.

Water-bearing strata are one of the chief impediments to development of the Berekei oil field; the difficulty of shutting off strong flows of hot water was one of the main reasons owing to which the oil companies lost interest in this area and abandoned it many (15—20) years prior to the nationalization of the oil industry. Moreover, there was no stimulus to overcome the difficulties, on account of the low prices of oil and the competition of Baku and Grozny, which presented no such difficulties as those encountered at Berekei.

These are the water-bearing strata in the Berekei oil fields:

1. Upper fresh water at the depth of 6—11 m. The flow is considerable; the water is used for boilers.

2. First water-bearing horizon with salt water at the depth of 96 to 149 m. The water overflowed in many of the wells.
3. Second water-bearing horizon at a depth of 213 to 299 m.
4. Third water-bearing horizon at the depth of 427—448 m.

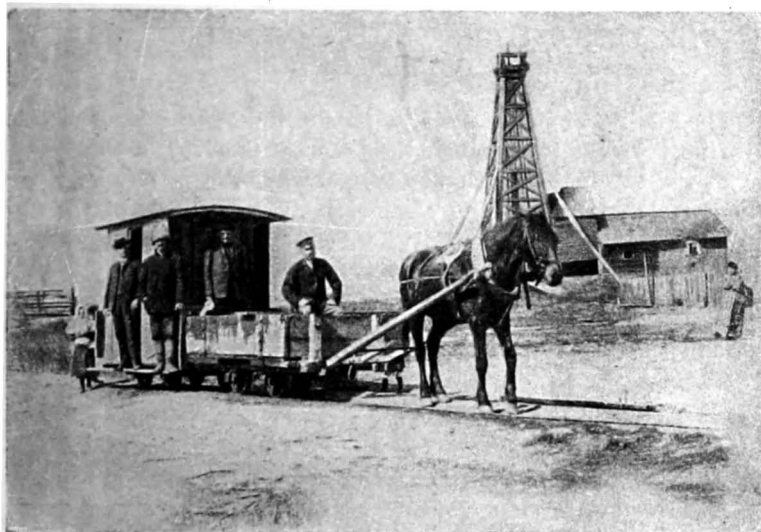


Fig. 3. Derrick and horse-tramway in Berekei.

The latter is the most considerable water horizon, so much the more detrimental, as it lies immediately below the globigerina stratum yielding gushers.

Seeps of gas. Hydrocarbon gases issue not only from wells, but directly from the soil, especially near the station «Ogni» of the North Caucasus railway. The gas is utilized by the glassworks «Daghestanskie Ogni» constructed in this locality. The geological survey made by V. D. Golubyatnikov has positively confirmed that these gas seeps are associated with an anticlinal upheaval of strata. Thus, along the Darvag-chai river, west of the station Mamed-kala, there are outcrops of formations of the Second Mediterranean stage with *Spaniodontella pulchella*, dipping to SW 238° at an angle of 29°. At a distance of 1.5 km. northeast of the gas seeps, of the «Daghestanskie Ogni», in a railway cutting, there are outcrops of dark clays of the same stage, dipping to NE 54° at an angle of 35°. The «Daghestanskie

Ogni» are situated on a line trending strikewise between the two above said outcrops. The construction department of the «Daghestanskies Ogni» proposes to sink a deep well within the area where gas seeps are found.

THE COMPOSITION AND COMMERCIAL VALUE OF THE OIL

The quality of the oils of the Berekei field varies in connection with the horizons from which they are obtained. The characteristics of the oil of the upper horizons are as follows (K. V. Kharichkov. On composition and commercial value of oils of the Russian oil fields. 1902); sp. gravity—0.9056 (at 15° C); colour—black, without a greenish shade; flash point (after Marteno-Pensky)—42° C, fire point 95° C. The results of fractional distillation are as follows:

Fractions	Yield (per cent).	Sp. gravity.	Flash point.
Below 150°C	0.45	0.741	Below zero.
150 to 200° C.	12.40	0.791	17° C
200 to 220° C.	6.20	0.811	31.5° C
220 to 250° C.	7.20	0.831	44.0° C
250 to 270° C.	6.00	0.848	—
270 to 300° C.	5.10	0.867	75° C
300 to 310° C.	2.40	—	—

Fractions 150—270° have sp. gravity 0.820 and flash point 27°. To raise the flash point to 30°, a kerosene of spec. gravity 0.822 is prepared, its yield being 31.8%. On raising the spec. gravity to 0.8246, the yield of kerosene increases to 34%. So high a yield of kerosene with high specific gravity is due to the fact that the residuum amounting to 60 per cent has a very high sp. gravity (0.9486), its flash point being 128°. A fractional distillation was carried out with a view to ascertain the fitness of the residuum for the manufacturing of lubricating oils; the results were satisfactory. The first «cuts», about 23 per cent, were of the nature of solar oil; the next «cuts», after being treated by sulfuric acid, yield a yellow oil having sp. gravity 0.9275 and Engler viscosity of about 5 minutes. According to the distillation results, the following «cuts» are obtained from the heavy Berekei oil:

	Sp. gravity	Yield (per cent).
Kerosene	0.8247	34.00
Solar oils	0.860	17.00
Spindle oil	0.903—0.910	4.60
Engine oil	0.920—0.927	6.10
Cylinder oil	0.939—0.950	16.00
Tar (hard goudron)	1.012	18.00
Losses		4.30

The fractionation of the oil obtained from the globigerina horizon (sp. gravity 0.8648—0.8741) yields the following results:

Benzine	1.57 per cent
Ligroin	5.85—10.50 per cent
Kerosene	29.42—34.50 » »
Lubricants	56.85—60.70 » »

PROSPECTING AND EXPLORATION

In the pre-war times the development of the Berekei oil fields was carried on pretty intensely. At beginning oil was extracted by natives from hand-dug wells and used for local domestic purposes, and it was not until 1896 that commercial exploitation was begun. The main factor controlling the industry was naturally the demand, which entirely depended on the prices.

The prices of the Baku crude oil were as follows (in kopeks per pood):

1896	7.8
1897	7.7
1898	9.7
1899	13.7
1900	15.7
1901	8.2
1902	6.7
1903	9.1
1904	14.7
1905	19.9
1906	25.6
1907	27.7
1908	21.6
1909	21.0
1910	15.0

The rather low prices of oil and primitive methods of work (adopted from Baku, where the richness of the oil-fields compensated for all the deficiencies of equipment and production methods),

as well as some specific local conditions, not only tended to hamper the development of the Berekei area but stopped the work altogether. These particular conditions were:

1) The lack of outcrops of older bed rocks and the impossibility of obtaining artificial exposures on this swampy area, what impeded the study of the geology of the country and accounted for a high percentage of unsuccessful wells.

2) Ignorance of methods of shutting off water, owing to which many wells that might be producers were classed as failures. Malaria was an unfavourable factor, but with the development of the work it would have gradually decreased, as the improvement of the living conditions would have gradually reduced the cases to a minimum.

Drilling was first begun here by V. I. Kozlyakovsky who obtained at a depth of 115 m. ejections of water, mud and oil. After that I. I. Lubimov has sunk two hand-drilled wells to a depth of about 100 m.; gas and small quantities of a thick oil were obtained. Balabanov obtained a small flow of a thick oil at a depth of 128 m. In a well of O. A. Benkendorf two flows of heavy oil were encountered at a depth of 128—160, yielding up to 1.1 t. daily. At length, well No. 1 of the Nobel Bros. Co. began to flow on November 29th 1902 from a depth of 408 m., yielding nearly 49 tons of pure oil per day; its total production was about 47,500 tons. The coming in of this gusher attracted the attention of several large oil companies to Berekei; the Nobel Bros. Co. has developed active operations, being followed by the Caspian and Black Sea Oil Company, Shibaiev Society, A. Mac Garvey, etc.

In the summer of 1904 the well No. 3 sunk by Balabanov, onplot No. 48, began to spout hot salt water from a depth of 472 m., no exploitable oil being obtained and the water gusher preventing further drilling. The water had a temperature of 47° C and deposited a sediment of salt on casing near its mouth the salt rapidly forming a thick crust. Another gusher having similar characteristics struck in the well No. 1, belonging to A. Mac Garvey, which flowed from a depth of 480 m.; the drilling being deepened, the gusher became stronger.

Water troubles and lack of experience in shutting off water, as well as general economical conditions, brought the Berekei field to a standstill. The concerns which were operating there gradually began to curtail up their operations, and before the nationalization the district was already abandoned.

During the whole of this period about 78 wells were drilled, ranging in depth from 85 to 582 m. The following table taken from the Reports of the Caucasus Mining Direction for the years 1907—1911, gives data pertaining to the exploitation of the Berekei oil fields:

	1906	1907	1908	1909	1910	1911
Number of producing wells. . .	—	28	46	33	42	28
Wells in process of drilling. . .	—	12	32	—	1	—
Production (tons);						
By flowing.	—	3,007.4	1,338.8	1,052.3	847.7	—
By bailing	—	81.9	44.2	37.8	70.8	—
<hr/>						
Total production	9,061.8	3,089.3	1,383.0	1,090.1	918.5	603
The average depth of wells (meters)		318	222	166	183	228

THE KAYAKENT OIL FIELD

The Kayakent oil field is located so close to the Berekei oil field that some authors (A. A. Ivanov. The geology of the Berekei—Kayakent oil bearing district. 1906) do not admit any pronounced difference between the two areas in respect of their geological features and prefer to consider them as one Berekei-Kayakent oil district.

The Kayakent oil field is situated near the railway station of the same name, which is at a distance of but 19 km. from the station Berekei.

The Kayakent oil field includes four groupes of oil pits which are located on a line extending 300° NW—120° SE for a distance of 6 km.

The Kayakent group comprises several pits with cold sulphurous water with floating films of thick oil.

At a distance of 107 m. from these wells there is a small lake of hot slightly sulphurous water.

The Bashlin group is situated 0.5 km. southeast of the Kayakent group; its numerous pits (about 100); about 1 m. deep, have seeps of heavy oil together with water.

The Neut-Kutan or Nap-Kutan group is situated 200 m. southeast of the Bashlin group. There were about 12 pits the depth of which varies from 6 to 11 m. Sp. gravity of oil—0.900; colour—dark-green. The line connecting the Bashlin and Neut-Kutan groups, being extended in a southeastern direction, passes through

the outlets of the Kara-Kaitag hot mineral waters, thus indicating a geotectonic connection between the two.

In 1899—1901 the Anglo-Russian Company, a British concern, was operating on the Neut-Kutan areas. The company drilled 7 wells. The well No. 1 penetrated five beds impregnated with oil. Seeps of gas were observed at the depth of 415 m.; bailing gave the following daily productions:

February	5 th	1900	6.2	tons
»	6 th	»	1.9	»
»	7 th	»	0.98	»
»	16 th	»	5.2	»
»	17 th	»	1.3	»
»	18 th	»	2.6	»

The well was commenced with a diameter of 10'' and finished with that of 4''

Well No. 2 located close to No. 1 encountered the first oil horizon at the depth of 25.9—29.8 m.; the second oil horizon was encountered at the depth 42—44 m., in sands. The third oil horizon was reached at the depth of 131 m. in arenaceous shales overlying sandstone impregnated with oil. The fourth oil horizon—at a depth of 168 to 169 m., in bluish shale, with a strong escape of gas. The fifth oil horizon—at the depth of 225 m., lying in the same rock. From this horizon took place an ejection of oil and gas. The sixth oil horizon—at the depth of 332—360 m., in dark argillaceous shales. The total depth of the well is 419 m., with an initial diameter of 16'' and a final one of 5''.

Well No. 5 is located near the Nos. 1 and 2, east of them and seemingly nearer the axis of the anticline than the Nos. 1 and 2. The first and second oil horizons were encountered, but further drilling was stopped on account of technical difficulties met with in attempting to bore deeper. The initial diameter of the well was 26'', the final one—14''.

Well No. 3 was drilled in a locality called Dipsus-Kutan, in which the fourth group of pits is situated, 0.5 km. SW of the group Neut-Kutan and at a distance of 0.5 km. from the Dipsus medicinal mineralized mud. No petroliferous beds were encountered by this well. At the depth of 54 m. water appeared from sands; at the depth of 183 m. gas was struck, at the depth of 393 m.—gas and oil. From 393 to 416 m.—sand; water and sand were spouted to a height of 6 m.

Well No. 8, the drilling of which was stopped at a depth of 64 m. in dark-brown shales, produced oil during several years, yielding over 16. 3 tons of oil per month.

The deepest well No. 4 was drilled by the Anglo-Russian Company in a locality called Ullu-Isti-Su, within the area of the 3rd



Fig. 4. Office at Berekei.

group of pits, 1.5 km. from the Kara-Kaitag mineral waters. This well was started Jan. 13th 1900 with a diameter of casing of 14'' and stopped March 14th 1901 with a diameter 6'', at the depth of 666 m. Altogether there were discovered 5 arenaceous and argillaceous layers impregnated with oil, all belonging to the Mediterranean stage. The well was stopped in the Spirialis beds; here oil spouted from the well, but no records as to the output are now available.

In the remaining wells Nos. 6 and 7 flows of oil were likewise encountered.

The analysis of the data pertaining to the sections of wells has led D. V. Golubyatnikov (Bull. Geol. Com., vol. XXI, 1902, No. 4) to the conclusion that «there are no adequate data for the final solution of the question relating the reliability of the oil-bearing tracts near the station Kayakent: besides a thorough study of the neighbouring country shallow shafts should be sunk for the determination of the structure of strata; the mantle rock is not thick and such shafts would not involve considerable expenses. Test holes should be sunk down the dip and along the strike of the strata; the number of holes to be drilled depends on the geological structure of the latter. Little information as to the attitude of the beds was obtained from the test wells of the British Company, because the wells were sunk near the oil seeps which were observed in the old hand-dug pits, which were located almost in one line. The petrological character of the rocks does not exclude the possibility of encountering arenaceous beds saturated with oil».

Thus, the Kayakent area, like that of Berekei, has given positive evidences of the presence of oil in paying quantities. The lack of experienced geological guidance in making trial borings was the reason why the latter did not yield adequate data for ascertaining the geology of the region. Further progress of exploration and development was stopped, first, on account of the general economical situation, which offered no incentive for the development of a new region, and, secondly, by those difficulties of a technical nature which the development of new fields had to encounter and which the technology of that time was not equal to cope with. But the results of previous drilling operations both in Berekei and Kayakent fields are in no way discouraging and they are only waiting for an opportunity which may facilitate their development.

FUTURE POSSIBILITIES OF THE DISTRICT

As has been stated above, the Berekei oil contains a pretty considerable quantity of benzine, up to 6 per cent; in reality the benzine content of the crude oil will be even higher, when the improved hermetical apparatus prevents evaporation losses, which were unavoidable in the past. The kerosene content reaches 30 per cent and even more; lubricating, engine and cylinder oils—22 per cent.

The kerosene of the Berekei region will find a rather ready market in the interior of the country, but the consideration of

the trade prospects for the next years to come makes it necessary to provide for the exportation of benzine and lubricating oils. In order to secure a market for the oil products, it is essential that the latter should be cheaper in the districts of their consumption than the competing products. The low prices of oil products depend on the cost of production and the amount of additional expenses such as transportation expenses, storage, trade expenses, etc.

So far as has been ascertained by the prospecting operations, which are far from being completed, the Berekei and Kayakent oil fields have wells of moderate depth, the average depth not exceeding 320 m. and the daily yield reaching 49 t. per well. At the present time it is quite possible to adopt the most modern methods of drilling and of oil production, which will secure at least as cheap a production of oil as in the neighbouring regions of Baku and Grozny.

As to additional expenses, the Berekei and Kayakent oil fields are more favourably situated than Baku and Grozny in respect of the domestic market and somewhat less favourably in respect of the foreign market.

Baku, Grozny, Emba and Berekei oil products are sent to the centers of domestic market by various routes, via Astrakhan; the further transportation via the Volga River and its tributaries is alike for the oil products of all the four districts. It is therefore only in the distance from the oil fields to Astrakhan, that the geographical advantage lies. The estimate of this advantage (in kopeks per pood) is as follows:

	Grozny.	Baku.	Berekei.	Emba.
Pipe-line transportation Grozny—Petrowsk and Dossor—Rakushi	1.50	—	—	2.00
Storage in the port	0.80	—	—	0.80
Loading on steamers	0.35	—	—	0.35
Transportation from place of loading to Astrakhan	3.00	6.00	5.00	8.00
Total	5.65	6.00	5.00	11.15

The data pertaining to transportation cost are taken from J. Piotrovsky's article «Transportation of oil products to the Volga River during the next season of navigation» (Petroleum Bulletin, 1925 № 7).

Consequently, the advantage which the Berekei oil fields have over any other producing regions, as regards the home market, amounts to 0.65—6.15 kop. per pood.

As to the foreign market, the Berekei oil fields are in a less favourable situation. Admitting that in a short time the pipe lines Grozny—Tuapse and Baku—Batum will be laid down and that the crude oil will be conveyed from Berekei to Grozny or Baku by rail and thence piped to the seaports, the cost of the Berekei oils at the latter ports will be composed of the following constituents:

	Grozny	Baku	Berekei.
Transportation by rail from Berekei to Grozny	—	—	7.97
Same to Baku	—	—	7.73
Piping Baku—Batum	—	4.00	4.00
Piping Grozny—Tuapse	3.00	—	—

It may be seen from the above table that the transportation cost of crude oil from Berekei to Tuapse will amount to 10.97 kopecks, as compared with 3.00 kop. for the Grozny oil, and from Berekei to Batum—to 11.73 kop., as compared with 4.00 kop. for the Baku oil. Although Baku and Grozny have undeniable advantages over Berekei as to export, this does not clear the destiny of the Berekei oil field, since the output of all the oil producing regions of the USSR is easily marketable abroad; the question will be therefore not of the possibility of competition with Baku and Grozny, but of the possibility of exportation when the freight to the exporting sea-ports amounts to 10.97 kop. per pood.

The Grozny crude oil is easily marketed abroad, the freight to Novorossisk being as high as 11.40 kop., at prices exceeding the cost of oil; it is therefore clear that, the freight for the Berekei oil amounting to 11 kop., the latter, on being refined at a sea terminal, will find a profitable sale. Moreover, the railway rate for goods to be exported may possibly be reduced; lastly, if the district is developed on a large scale, it will not be impossible to lay down a pipe line about 250 km. long, joining Berekei with Grozny. This would involve an expenditure of about 7,000,000 roubles, but the cost of transporting oil products from Berekei to Novorossisk would then not exceed 4.5 kop. per pood.

SELECTED BIBLIOGRAPHY.

1. K. V. Charichkov. On the composition and technical properties of oils derived from the Russian oil fields. Published by the Council of the Congress of the Baku Oil Producers, 1902.

2. Reports of the Caucasus Mining Direction for 1906—1911.
 3. N. Lebedev. Prospecting for oil within the Baku Government (exclusive of the Apsheron Peninsula) and Daghestan Region.—Materials for the geology of the Caucasus, series III, book 3, pp. 278—295 (esp. p. 281—Berekei oil fields).
 4. D. B. Golubya tnikov. Geological explorations of the oil-bearing areas of the Kaitag-Tabarasan District of the Daghestan Region and the vicinity of the town Derbent.—Bulletins of the Geological Committee, v. XXI. pp. 742—745 (Wells on the Berekei State property).
 5. Test drilling by Nobel Bros. Co.—Neftyanoe Delo 1902. No. 8, p. 462.
 6. A new oil-bearing area.—Ibidem 1903, No. 3, p. 167.
 7. Of the new oil region of Berekei.—Ibidem 1903, No. 5, p. 283, 287.
 8. J. Glushkov. Some notes on the Berekei oil fields.—Ibidem, 1903, No. 13, p. 769—770.
 9. J. Glushkov. A letter to the editor.—Ibidem, 1903, No. 17, p. 111.
 10. J. Strijov. A new oil area (Berekei).—The Grosny Bulletin of Trade and Industry 1903, No. 25.
 11. B. A. Bulgakov. The Berekei oil fields.—Works of the Tersk Section of the Engineering Society. 1903, p. 17—21.
 12. A. P. Ivanov. New data relating to the geology of the Caucasus oil fields.—Neftyanoe Delo 1904. No. 3, p. 218. (Berekei oil fields).
 13. D. V. Golubya tnikov. The Berekei oil-bearing area.—Ibidem 1905. No. 6, p. 508.
 14. A. P. Ivanov. Of the Berekei anticline.—Ibidem 1905. No. 18—19.
 15. Idem. The Geology of the Berekei-Kayakent oil-bearing area.—Works of Baku Engineering Society. April-December 1905, p. 1—90.
 16. D. B. Golubya tnikov. The Berekei oil bearing area.—Bull. Geol. Com. vol. XXV. p. 361—412.
 17. J. N. Strijov. Of the Berekei oil field.—Memoirs of the Caucasus Section of the Geographical Society, book XXVI, No. 6, p. 1—14.
 18. K. Kalitsky. Berekei.—Bul. Geol. Gom. vol. XXX, 1911.
 19. J. M. Cubkin. The Naftalan oil field. The Petroleum and Oil-Shale Industry. 1923 No. 6.
 20. V. D. Golubya tnikov. «Daghestanskije Ogni» near Derbent. Ibidem. 1924. No. 4.
 21. V. Golubya tnikov. Prospecting in the gas-bearing area of «Daghestanskije Ogni».—Ibidem. No. 2.
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N. KHALIAEV

THE TRANSCAUCASIAN
OIL REGIONS

(TIFLIS — GANDJA)

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GENERAL DESCRIPTION

The oil fields of the Tiflis region are situated within the extent of the Kakhétia ridge, mostly in the valleys of the Alazan and Iorà rivers (left-hand tributaries of the Kura river). The Kakhétia ridge is a watershed between the said rivers and extends for 160—170 km. from SE to NW, joining in the northwest the main Caucasus range and ending in the south east near the Lagbe river.

The Alazan valley is one of the most prosperous and densely populated localities of Georgia; but towards ESE the valley passes into arid steppes: the Great Shiraki steppe in the north and the Small Shiraki and Eldar steppes in the south. In these steppes there are present a few indications of oil which are more or less of importance.

Some distance away from the latter indications of oil there is a locality called Chatma, situated west of the Shiraki steppe on the right bank of the Iora river. The central portion of this locality is occupied by the bed of a dried lake Kodjeris. There are also some oil seeps to be found.

Othershowings of oil are encountered in the neighbourhood of Tiflis, notably within the boundaries of the former districts of Dushet, Gori and Akhalkalaki.

Within the former province of Elizabethpol (now Gandja) there lies the Naftalan oil field situated at a distance of 20 km. from the station Ghefan of the Transcaucasian railway and at a distance of 45 km. from Gandja.

THE KAKHETIAN OR ALAZAN VALLEY

The Alazan valley, or the Interior Kakhétia, begins near the confluence of the Ilto and Alazan rivers, from the village Akhmety. The portions of the valley adjacent to the foot of the

Kakhetian ridge are covered with orchards, while the strips of land in close proximity to the hillsides are covered with vineyards. Along the river there extend maize plantations and wheat fields, sloping towards the river banks. The exceeding abundance of vegetation and its variety make this valley perhaps the richest locality in Transcaucasia. The middle part of the valley is covered at many places with leafed woods. South of the Gurdjani village the valley somewhat widens and reaches 16 km. in width at its southern border near the village of Tsarskie Kolodtsy.

The Kakhetian (Gambory-Tsivi) ridge bordering the valley from the west is likewise known for its copious vegetation. The northern extremity of the ridge is narrow and cut by gorges; the middle part of the ridge widens considerably, its summits (up to 2000 m. high) are devoid of forests; beginning from the mountain Saimterio, the ridge grows markedly lower, ramifies and winds southeastwards.

The Kakhetian ridge is crossed by two macadam highways: one leads via Udjarmi-Gambory to Telav, and the other from Kachreti to Bakurtsikhe via Chalaubani. Besides there is a number of cattle paths such as, for example, from Sagaredjo to Telav, etc.

As to the ways of communication in the valley itself, there passes a macadam highway along it, linking Tiflis with Signakh, as well as a way connecting Sagaredjo and Tiflis.

Of the most important inhabited localities of this rather densely populated territory, the following towns are to be mentioned: Tionety, Telav and Signakh.

In accordance with the natural resources of the Kakhetian valley, the principal occupations of the people are agriculture, horticulture (especially the growing of grapes) and cattle-breeding.

While describing the natural resources of the Kakhetian region from the point of view of its future possibilities in the oil industry it is necessary to mention the presence of a few other minerals. The lignite deposit in the neighbourhood of Gambory, embedded in sandstones of the upper part of the Turdo river, has evidently no commercial value for the time being.

But there are numerous and large deposits of building materials: stones which may be used for making rubble and for the construction of street pavements and macadam highways; different kinds of clays, sand, gravel, limestone, tuffs, gypsus, millstone grit, etc.

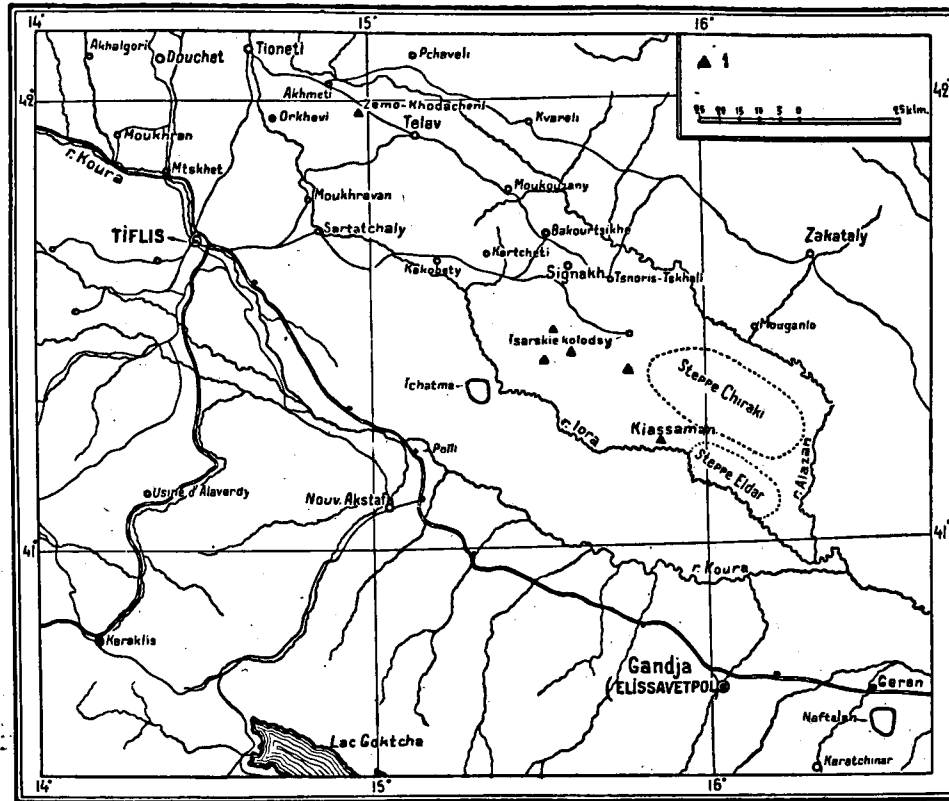


Fig. 1. Map of the Tiflis-Gandja (formerly Elisabethpol) region. 1—Oil deposits.

Geology.—The Post-Tertiary, Tertiary and Cretaceous rocks are involved in the geology of the Kakhetian region, Tertiary rocks being developed most of all.

The following is a generalized section of the formations of the region, according to A. N. Riabinin, geologist.

I. Post-Tertiary.

II. Tertiary.

a) Upper Miocene. Middle Sarmatian.

1. Oolitic shell limestone, clays and flaggy sandstones containing a fauna typical to the Middle Sarmatian.
2. Beds with *Cryptomactra pesanensis*.

b) Lower Miocene and Oligocene:

1. Laminated highly ferruginous mineralized clays.
2. Bluish-gray and dark-gray marls and sandstones.
3. Volcanic tuffs.
4. Black and bluish-gray marls interbedded with calcareous and flinty sandstones.
5. Gray and yellow coarse-grained sandstones in thick strata.
6. Red and yellow marls, yellow and laminated sandstones with interstratified layers of coal.
7. Greenish-gray marls and glauconitic sandstones.
8. Blue marls and sandstones.

c) Eocene.

1. Black clays.
2. Banded formation with orbitoides and bryozoa.
3. A series of white and whitish-yellow marls interbedded with red and green marls, carrying petroleum; glauconitic yellow calcareous sandstones with orbitoides, nullipora and bryozoa.

III. Cretaceous.

Senonian.

White, yellow, pink, violet and red clayey limestones interbedded with chloritic clays, carrying dendrites of manganese and veins of calcite.

Showings of oil are associated almost exclusively with the Tertiary sediments, being encountered in rocks which range in age from the Akchagyl, or Upper Miocene, to the Eocene. The most pronounced indications of petroleum are observed in the Eocene, notably in compact calcareous sandstones and micaceous clays of the Upper Eocene and marls and limestones of the Middle Eocene.



Photograph by A. Riabinin.

Fig. 2. Tsiva range in the region of the upper course of the Turgu river (the northern slopes).

THE GEOLOGICAL STRUCTURE is exceedingly complicated and consists of a number of anticlines seemingly of the «diapir» type, which are complicated by secondary folding and faulting.

Along the axial line of the Kakhnetian ridge outcrops of igneous rocks are observed.

Occurrence of oil. As has been stated above, along the Kakhnetian ridge there are scattered numerous oil seeps. Those of them are of greater importance which are associated with eroded and fractured rocks of the Paleogene and are accompanied by inflammable gas and salt water.

Of the numerous surface indications of oil the following are to be mentioned:

1. In the neighbourhood of the village Ildokani (Ildokani anticline), along the right-hand tributaries of the Ilto river, viz.—

along the banks of the Anis-Khevi river,—oil seeps from a series of blue sandstones, as well as along the Naftis-Khevi river—from dark-gray calcareous sandstones (on the southern flank of the anticline named above). There is found also an oil seepage on the bank of the Ghighian-Khevi river (a tributary to the river Ilto), from sandy shales alternating with layers of sand and sandstone. Wells were once sunk in this locality.

2. In the neighbourhood of the village of Zemo-Khodasheni, along the Rike river and its small tributaries and in the basin of Bochorma and Kochebani rivers (the right bank of the Iora river) oil seepages are found in two localities: a) in the upper part of a right-hand tributary of the Alazan river called Yolais-Khevi,—apparently from a formation of steeply-dipping bluish-white and red marls and gray limestones, and b) in the upper part of the left-hand tributaries of the Rike river: Krintskhlivianis-Khevi, Naftis-Khevi, Tsikadis-Khevi and others,—from sandstones interbedded with marls,—as well as on a right-hand tributary of the Rike called Vatauris-Tskhali—from blue calcareous sandstones and marls.

3. South of the monastery Shua-Mta, near the river Turdo,—from a conglomeratic series.

4. Along the Kizis-Khevi river (a right-hand tributary of Alazan).

5. On the Dampal-Tskhali river (a left-hand tributary of the Iora river).

6. At the junction of the Dampal-Tskhali river with the Iora river, on the right-hand bank, near the Udjarmo deposit of Glauber's salt (the Mukhravan village).

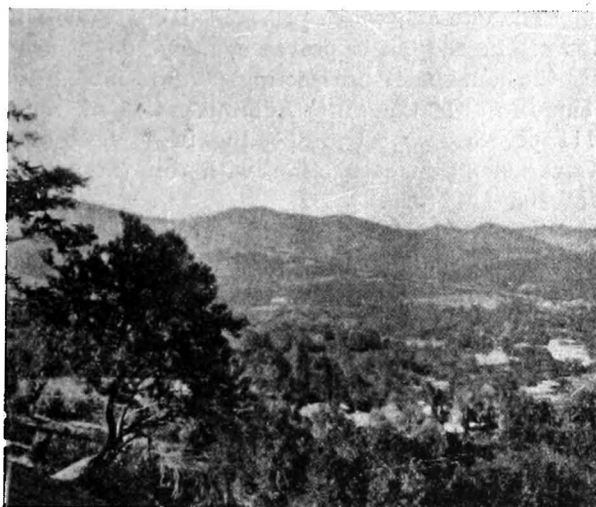
7. On the Cheremis-Khevi river and its tributaries: Naftis-Khevi, Vedzis-Khevi and Tkhili-Khevi, along the strike of the same series of blue sandstones and clays.

8. Near the Gurdjoany village from Post-Tertiary conglomerates, oil being derived seemingly from the underlying Tertiary strata.

9. In various localities near the village of Pkhoveli.

Prospection and exploitation. The surface indications of oil in the Tiflis and f. Elisabethpol Provinces, especially in the localities adjacent to the Kakhetian ridge have long since attracted the attention of the local population and have likewise interested, to some extent, industrial circles. In places even oil production was established but in the majority of cases the extracted oil was

used only within the boundaries of the region being utilized, instead of its usual commercial application, for purposes in connection with the customs of the people, and sometimes even for medicinal purposes; the reason for the latter being the curative properties inherent or ascribed to petroleum («Naftalan», in the f. Elizabethpol Province). Oil pits were leased by the government for exploitation long before the seventies. The production of oil in the Signakh district alone reached 25 tons per annum. On the abolition, in 1872, of the exclusive lease system, which was common in all the oil fields of the Caucasus, there came a marked revival of the prospecting and development of the said fields; the Tiflis and Elizabethpol oil fields were also affected; for example, in the



Photograph by A. Riabinin.

Fig. 3. Tsiva range near the village of Sagaredjo (the southern slopes).

Little Shiraki valley there were sunk (by Siemens) between 1869 and 1877 not less than 180 small drill holes, varying in depth from 6 m. to 100 m.; the aggregate output of 62 of these wells amounted in 1876 to 2,100,000 liters, which averages a daily yield of 100 liters per well.

The Baku region was invariably the center of the oil industry in Transcaucasia, to which the attention of oil men as well as of the government was always attracted; nevertheless, the Mining Department realized the importance of investigations in other parts of Transcaucasia, including the petroliferous deposits of the Tiflis province. The investigations were conducted, beginning from the nineties of the last century, first by the geological

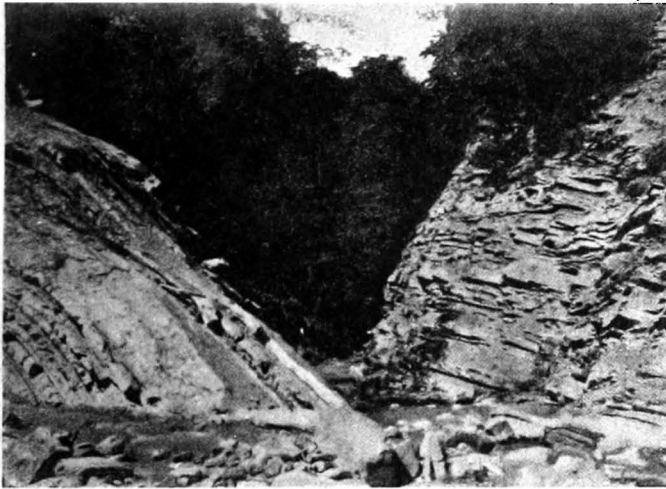
parties of the Caucasus Mining Board, and then, from 1901, by the Geological Committee. At the same time many investigations were made on behalf of private persons and companies. Such was the work done in the Tiflis province by G. Abich, the academician, by I. Muck, a geologist from Galicia, by G. I. Litevsky, mining engineer, by K. P. Kalitsky, E. Hoffmann, A. Stahl and many other geologists: some of them did not publish the reports on their investigations.

The interest, which private initiative took in the prospecting for oil in the Tiflis province, may be gauged to some extent by the number of prospecting permits issued by the Government. Thus, in 1914 the Tiflis Administration of State Properties issued 111 permits for oil prospecting in various districts of the Tiflis Government; in connection with this the amount of extracted oil reached 591 tons.

The Kakhetian oil fields were developed on a small scale long before the geological investigations and prospecting for oil were undertaken. Oil was extracted from pits and shallow hand-dug wells in the Gambory ridge near Bochorma, and conveyed in raw leather sacks to a small refinery. The quality of the extracted oil was so high that, according to Litevsky, a mining engineer, the yield of kerosene reached 47 per cent, notwithstanding the primitive plan of the Bochorma refinery. Pits from which oil was extracted (on the road from the village Zemokhodasheni to Bochorma and Gambory) were shallow and yielded from 240 to 1600 kg. per well daily. This production almost ceased upon the construction of the railway from Baku to Tiflis, owing to a rapid decline in the market prices of kerosene. It was not until 1896 that this oil field attracted the attention of business people, in connection with investigations performed by Townsend, an English geologist, and A. F. Stahl¹⁾. The presence of two parallel anticlines crossing the rivers Rike and Krintskhlivianis-Khevi rivers was disclosed, while a well drilled here in 1899 to a depth of 24 m. discovered a light oil of a very high grade. In spite of very favourable reports of the above named experts, the foreign capitalists who backed the said exploitation work abstained from further operations in this area, for reasons of economical nature, and chiefly on account of the insufficient capacity of the Transcaucasian railroad. Later, in 1901 the Bochorma oil fields were examined

¹⁾ The author of the first geological map of Persia.

by I. Muck, a mining engineer from Galicia, who ascertained the presence of four anticlines, carrying petroleum. Three of them were investigated by I. Muck. In connection with his favourable report, a well was sunk, which struck a shallow oil-horizon; the well flowed at a high gas pressure. Owing to its small diameter, the well was drilled only to a depth of 143 m., which was insufficient,



Photograph by A. Riabinin.

Fig. 4. Series of gray marls and calcareous sandstones in the region of the upper course of the Orvili river.

for, according to the estimation of Muck, oil could not have been encountered at a depth of less than 320—430 meters. In the autumn of 1903 another well was sunk on the southern flank of the southern anticline, with an initial diameter of 16 in.; this well was driven to a depth of 254 m. A flow of oil with strong escapes of gas was encountered at 218 m. in a gray sandstone 2 m. thick. Oil was likewise met with in overlying and underlying horizons.

Apart from these tests a shallow hand-dug well was sunk near the village Ildokani, which began to flow from a depth of about 107 m.

Muck classifies the investigated area equalling nearly 3277 hectares as undeniably oil-bearing, it being but a small portion of a vast territory in which oil seeps have been found in many points.

Should any oil production on a commercial scale be started in the Kakhetia oil fields, the situation of the latter in the center of Transcaucasia, nearer the Black Sea ports, would present material advantages over the Baku district, so far as transportation is concerned.

Summarizing the general results of explorations and prospecting, I. Muck expressed the opinion that «in the investigated area there are present all the conditions which in other localities, under similar circumstances, have given excellent results» and further that «the district ¹⁾ embracing an oil-bearing area 9—10 km. long by more than 1½ km. wide, where extend three or four or probably even more parallel anticlines, which may likewise be regarded as oil-bearing, has a promising future and is capable of a prosperous industrial development».

Despite explorations accomplished by prominent geologists, the oil deposits of the f. Tiflis government still remain insufficiently explored, and their commercial value so far cannot be estimated. To that aim systematical deep drilling operations should be conducted. All information concerning oil occurrence in this region that has so far been published shows that the areas deserving to be particularly investigated are situated in the vicinity of Zemo-Khodasheni, Ildokani, Pkhoveli, further in Shiraki, Eldar and Tsnoris-Tskhali. The development of these oil fields was suspended owing only to the lack of proper technical guidance in drilling operations, as well as to the want of capital necessary to proceed with the further development of the operations.

The rest of the oil fields referred to above are not described here, no data pertaining to the drilling operations conducted on them being available. Some analyses of the oil obtained in the Zemo-Khodasheni area are given below:

The composition and commercial value of the oil. Chemical analyses of the samples of oil taken from the Zemo Khodasheni oilfield, made in the laboratory of the Nobel Bros Co.:

	1st sample from a depth of 197 m.	2nd sample from a depth of 250 m.
Specific gravity at 15° C. .	0.8843	0.8864
Flash point after Brenken.	40°	32°
B. S. (water, sand, etc.) .	5.8%	4.3%

¹⁾ In the neighbourhood of Zemo-Khodasheni.

Distillation in a flask up to 285° C.

Below 125° C	5.87%; sp. gr. 0.7373	6.60%; sp. gr. 0.7315
125° C to 285° C	32.45%; sp. gr. 0.8183	32.62%; sp. gr. 0.8196
Flash point	28.5° C.	29.0° C.
Residue	61.68%; sp. gr. 0.9405	60.30%; sp. gr. 0.9415

Properties of the residue.

Flash point, after Br. 170°, after P. 138° C.	after Br. 170° C.,	after P. 144° C.
Cold test.	10° C.	10° C.

Distillation in a flask up to 200° C.

Below 120° C	3.38%; sp. gr. 0.7275	4.10%; sp. gr. 0.7231
120°—200° C	16.16%; sp. gr. 0.7797	15.02%; sp. gr. 0.7767
Residue	80.35%; sp. gr. 0.9161	80.81%; sp. gr. 0.9148

Properties of the residue.

Flash point	{ after Br. 106° C.	after Br. 108° C.
	{ after P. 90° C.	after P. 88° C.
Viscosity after Engler 50°	3.00	2.84
Sulphur content	0.244%	0.31%
Paraffin content	0.340%	0.40%

The determination of sulphur content was made after Lidov, that of paraffin content after Zalozetsky.

The above analyses show that samples of oil yield about 32 per cent of kerosene.

THE GREAT AND LITTLE SHIRAKI STEPPES

The Shiraki steppe is an eastern prolongation of the Kakhetian valley and represents an elevated flat plain (averaging about 700 m. above sea-level) with raised northern and southern borders. It is bordered by the locality called Tsarskie Kolodtsy in the west, the Alazan river in the east; in the south-west it joins the Eldar steppe. The climate of the Shiraki steppe is hot and arid; that of the Eldar steppe is more humid. Being devoid of woods, the Shiraki steppe produces nevertheless good crops of wheat and excellent hay, whereas the Eldar steppe is less favourable for cultivating grain.

Geology. After A. N. Riabinin, a geologist, the following formations are developed in the Shiraki steppe:

I. Post-Tertiary.

II. Tertiary:

a) Upper and Middle Pliocene.

The Apsheronian and Akchagyl series, containing the following rocks:

1. Thick conglomerates, yellow clay and sands with *Helix* sp.
2. Loose yellow and green sands interstratified with conglomerates, sandstones and clays.
3. Sandstones and clays of bluish-gray to bluish-yellow colour, partly ferruginous, with gypsum; conglomerates; these beds contain a typical Akchagyl fauna: *Cardium dombra*, *Mactra Karabugasica*, *Potamides caspius*, etc.

b) Upper Miocene.

A fresh-water series, which is referred by the above named geologist to this stage, is divided into two horizons:

1. The horizon of conglomerates and clays, or beds with *Unio flabellatus*.
2. The horizon of arenaceous and argillaceous sediments with fresh-water and land fauna; this horizon carries oil; sandstones of this formation contain the so called Shiraki oil-bearing horizon (or the first horizon).

Upper Sarmatian.

1. Red clays with *Hipparion*,
2. Beds with *Mactra caspia*. With these beds the second, or Eldar, oil-bearing horizon is associated.

III. Cretaceous. Hard crystalline or semicrystalline, white and pink limestones, red and whitish-green clayey limestones.

THE GEOLOGICAL STRUCTURE of the Shiraki area is not sufficiently investigated. A. Riabinin gives only the following information in this connection: the Cretaceous limestones are thrown into anticlines trending northwestward, their flanks dipping NE 15° and SW 245° at an angle of 40°—45°. The Upper Miocene beds which rest unconformably on the Cretaceous limestones overlap the latter on all sides, and are also strongly disturbed. The forma-

tions referred to are folded to form an anticline of diapir type; its axis trends northwestward. Only the northern flank of the anticline extends within this area.

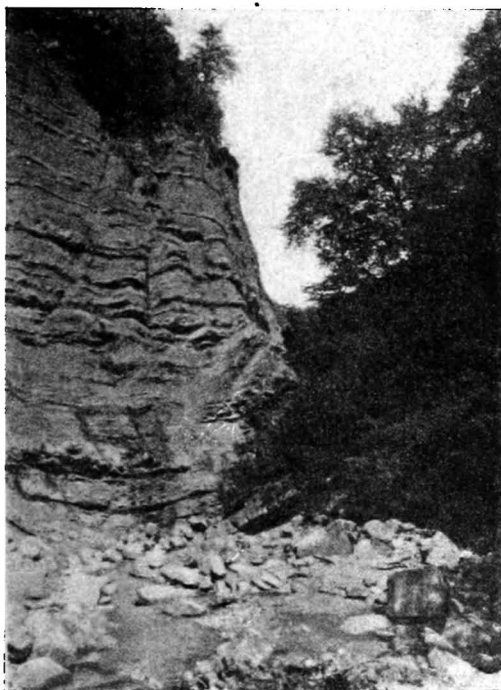
Occurrence of oil. There are numerous oil indications in the Chiraki steppe. The most important oil seeps are found in the following localities:

Mlashis-Khevi—oil seeps from sandstones and clays of the Upper Sarmatian; Mirzaany (at the foot of the northern slope of the mountain Kvabebis-Mta)—from clays and blue sandstones of the same stage; Nabambrebi (all the above groups are situated west of the village of Tsarskie Kolodtsy); near the stream Tsnoris-Tskhali (south of the village Tsarskie Kolodtsy), in the vicinity of Gkushebis-Tavi, etc.

Within the Little Shiraki steppe oil seeps are found in the locality Kala-Dara.

Within the Eldar steppe oil seeps are known in the locality Kiasaman, 32 km. south of the village of Tsarskie Kolodtsy.

Near the stream Tsnoris-Tskhali, in Great Shiraki, at the foot of the mountain Gkushebis-Tavi, composed of conglomerates interbedded with sandstones, there are oil seeps and kir¹⁾ deposits in different places.



Photograph by A. Riabinin.

Fig. 5. Rock formation with orbitoides on the Shavkabe river.

¹⁾ Kir—Russian name given to petroleum solidified on exposure.

The whole area of the Little Shiraki steppe is to be classified as a proven oil bearing area on the surface of which there are numerous kir outcrops. Oil was extracted here from hand-dug pits as far back as the sixties of the last century: In 1869 the oil-bearing area was leased by Simens Bros., whereupon the oil production by wells was started. As has been already stated, 180 shallow wells were sunk on this area, ranging from 6 to 100 m. in depth, the total production of 62 wells amounted in 1876 to 2,100,000 liters, the average daily yield being about 100 liters per well. A small oil refining plant was erected. The oil production and refinery operations were discontinued here in consequence of the development of the petroleum industry in the Baku region.

As to the locality Kiasaman, in the Eldar steppe, which is connected with the village of Tsarskie Kolodtsy by a road passing by the spring Nazarlebi, the most important seeps are found there in two points; 1) on the left hand bank of the Iora river, and particularly, 2) two kilometers northeast of the latter place. Oil pits dug in clays were located in places where fractured Sarmatian sandstones are spread. They were 15 in number, each about 4 meters deep, and yielded daily about 80 kg. of oil.

The oil-bearing strata, cited above, are concentrated in two main horizons:

I. The first, upper-horizon is the Shiraki oil-bearing horizon, embedded in the fresh-water sediments of the Upper Miocene, is composed of gypseous coarse-grained sandstones, alternating with conglomerates and clays; it is observed in the vicinity of the mountain Gkushebis-Tavi, on the stream Tsnoris-Tskhali and in the Little Shiraki steppe.

II. The second, or lower-horizon is the Eldar horizon, consisting of clays and shell sandstones of the Upper Sarmatian, was discovered in the Eldar steppe near the locality Kiasaman, on the left bank of the river Iora and in the neighbourhood of the village Mirzaany. The oil deposits along the Mlashis-Khevi river on the localities Nabambrebi and Mlashis-Khevi are related to the Eldar horizon.

Commercial value of the oil. The oil extracted in the Shiraki steppes has the following characteristics: specific gravity 0.875—0.910; distillation gives 6 per cent of benzine, 24 per cent of kerosene and 65 per cent of residuum.

THE CHATMA OIL FIELD

The locality Chatma, of the Signakh district is situated to the right of the Jora river, close to the boundary of the f. Elizabethpol province, at a distance of about 15 km. from the station Poili of the Transcaucasian railway by a good highway. It is situated 80 km. southeast of Tiflis. The Chatma steppe



Photograph by A. Riabinin.

Fig. 6. Islets of the Akchaghyl sandstones in a semi-desert south of the mountains Nazarlebi

serves as a winter pasturage; it is a plain covered with a thick argillaceous alluvium and surrounded on all sides by mountains: Aladjighi and Katar ridges on the north, Kodjeris and Tiulki-Tapa mountains on the east and the Cheban-Dag ridge on the eastwest.

In the center of the district there is a dried reed-grown lake Kodjeris; forests are almost entirely absent and grasses are very scarce. Obtaining drinking water in sufficient quantities is not an easy task.

Geology. The geologist K. P. Kalitsk'y gives the following section of the formations involved in the geology of the Chatma district:

A. Recent.

B. Tertiary.

a) Akchagyl:

1. Conglomerates, sands and clays. . .
2. Clays and sands with layers of fossils: *Gardium dombra*, *Cardium cumuchicum*, *Cardium trinacria*.
3. Sandstones and sands, clays, conglomerates (Break— Akchagyl beds rest unconformably on the Upper Sarmatian strata).

b) Upper Sarmatian. .

4. Clays: green, red, gray and yellow with rare layers of sands and loose sandstones.
5. Green and gray clays with fragments of *Pianorbis* sp. Sandstones occur more frequently.
6. Sandstones predominate over green clays. Sandstones are in part petroliferous (the first oil-bearing horizon). Intercalations of lignite.

c) Middle Sarmatian.

7. Brownish-gray clays and sandstones.
8. Same clays with intercalations of limestone and calcite. Clays are included between thick strata of sandstones (the second oil-bearing horizon).
9. Brownish-gray clays without intercalations of limestones and calcite.
10. Oolitic limestone with *Macra ponderosa*, *Cardium Fittoni*, *Cardium obsoletum*, etc.

d) Deposits of unknown age.

11. Very hard limestone filled with mactras.
12. Green and red clays interbedded with sands and sandstones. Intercalations of lignite.

(Break, unconformity).

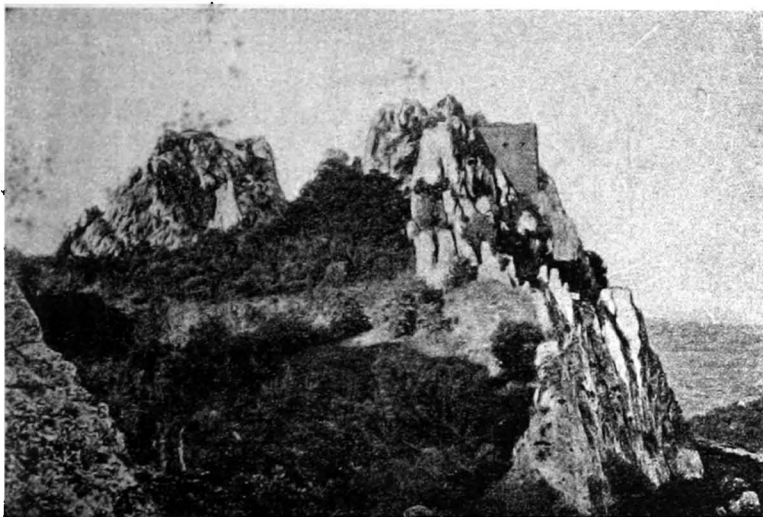
13. Sandstones and clays, unfossiliferous (break).

e) The lower portion of the Mediterranean stage.

14. Light-gray shaly clays, laminated. Big calcareous concretions with *Cryptodon sinuosus* and *Spirialis* sp. This formation devoid of sands and sandstones, forms the crest of the Chatma anticline.

It should be noted that the geological structure of the Chatma area is exceedingly complicated.

The Chatma field is cut by a fault which divides the oil-bearing area into two parts: an anticline lies in the northwestern part, while a monocline is confined in the southeastern part. According to the section referred to above, the oil-bearing horizons are related to the Upper and Middle Sarmatian.



Photograph by A. Riabinin.

Fig. 7 Cliffs of the Cretaceous sandstones and the castle of Tamara in the Karagach mountains, near Tsarskie Kolodtsy.

Occurrence of oil. THE FIRST HORISON. In the locality Kirdurma there are several oil pits, sunk in the base of a northward dipping sandstone impregnated with oil. Liquid oil accompanied by gas accumulates in the pits. Formerly kir was mined here.

Paatov's oil property is located at the foot of the Katar ridge. Beside pits there were 27 wells, ranging in depth from 9 to 30 m., from the majority of which thick oil was extracted in fairly considerable quantities. Layers of kir are also found here.

In Kapichi there are 5 beds of petroliferous sandstones, some of which were exploited by means of hand-dug pits. On the east

the oil-bearing strata of Kapichi are concealed under clayey alluvium and there are no positive indications as to their further continuation.

When the Chatma Oil Field Co., Ltd, an English Company, operated in the district Polpoitebi, a well No. 2 was drilled which aimed to encounter oil-bearing beds of Kapichi. However, this attempt did not meet with success: neither oil nor beds were encountered, because at the locating of the well the turn of beds in the mountain Kodjeris was not taken into consideration, as well as the change of strike of the Upper Sarmatian beds of the Katar ridge, which are overlain by the Akchagyl of Kodjeris. In reality, the sandstones of Kapichi lie some distance away and, under such circumstances, could evidently not have been encountered, even had the well in question been sunk considerably deeper.

The oil-bearing sandstones of Tiulki-Tapa are identified with those of Kidpurma, of Paatov's property and of Kapichi. Oil-seepages are observed in depressions at a distance of 215—325 m. south west of the summit of Tiulki-Tapa.

THE SECOHD HORIZON. Oil seeps on the Aladjighi ridge and on Polpoitebi refer to the second horizon which is composed of grayish-yellow clays with a good many thin layers of limestone and calcite; this horizon is overlain and underlain by thick layers of sandstone.

Oil seeps are numerous; oil oozes from beneath the limestones, most important showings of oil being observed in Polpoitebi. In that locality a well No. 1 was sunk by the above named English company; the well discovered an oil-bearing horizon which, however, was but slightly saturated.

Prospecting. Primitive methods were used for extracting oil from pits and shallow wells. Pits and two wells, 12 and 21.5 meters deep, on Paatov's property gave a total yield of 2,410—3,200 kg. of petroleum per month. The well No. 2, drilled in Polpoitebi for testing the first horizon, and sunk to a depth of 215 m., gave, as already stated, no satisfactory results, owing to the entirely wrong location of the well.

The composition and commercial value of the oil. The distillation of the Chatma oil gives the following products: gasoline, benzine, kerosene and lubricating oils; the two latter considerably predominating. Seven samples of oil taken from Paatov's property and the locality Kapichi were sent to Mr. William Ramsay, in England. Analises made by the latter gave the following results:

water 2 to 16 per cent; specific gravity of crude oil at 15° C from 0.9278 to 0.9883; flash point 15.5° to 17.2° C.

Fractions.	%%	Sp. gravity.
Below 150° C.	4.8—7.2	0.7229—0.7452
150—275° C.	18—19.8	0.8118—0.8223
275—300° C.	4.5—5.4	0.8756—0.8869

The analyses of the Chatma oil made by the laboratory of Tiflis gave the following results:

Fractions.	%%	Sp. gravity.
Below 150° C.	3.9	0.7532
150—275° C.	25.4	0.8445
275—300° C.	17.5	0.9075
Residue	52.2	

THE NAFTALAN OIL FIELD

The Naftalan (or Gheran) oil field is situated 20 km. south of the Gheran station of the Transcaucasian railway, and 48 km. southeast of the town of Gandja (Elizabethpol), between the right hand tributaries of the Kura river, Kara - Chai and Incha - Chai. The locality represents a shallow depression surrounded on the east, south and west by elevations of a moderate height and cut by a small creek Naftalanka.

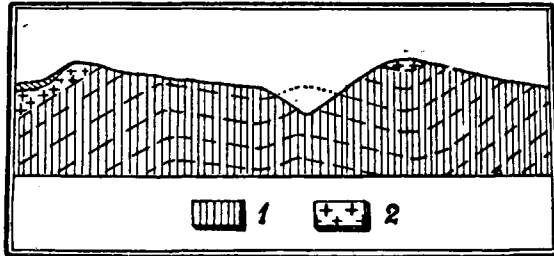


Fig. 8. Generalized section of the Naftalan oil field (in a latitudinal direction): 1—the Akchaghyl strata; 2—the beds overlying Akchaghyl.

The presence of petroleum in this locality was known in ancient times: petroleum was obtained here in small quantities from shallow pits and was utilized not as fuel, illuminant or lubricant, but for medicinal purposes.

Geology. The sediments involved in the geology of the Naftalan oil field belong, according to Prof. J. Gubkin to the Akchaghyl unconformably overlying the Maikop beds; the latter belong in part to the Lower Miocene and in part to the Upper

Oligocene. The Akchagyl is represented by coarse-grained sands, conglomerates and white and gray clays. The Maikop underlying the Akchagyl may be divided into the following four horizons:

1. Dark-gray bituminous clays interbedded with sandstones, of a total thickness of about 200 m.

2. Argillaceous beds, with layers of hard flinty marl, about 150 m. thick.

3. A horizon with numerous layers of sands and sandstones, each one exceeding 10 m. in thickness; the total aggregate thickness of the horizon is approximately 200 m.

4. A thick series of clays without any porous beds (such as sands and sandstones). The total thickness of the series reaches 400 m.

The geological structure of the Naftalan oil field may be described as follows: the Akchagyl beds are folded into a dome-shaped anticline trending almost longitudinally (SW 190°—NE 10°). The said anticline consists of two parallel minor anticlines. The eastern flanks of the latter dip SE 100°—110° at an angle of 10°—15°, the western flanks dip steeper at an angle of 20°—30°.

The Maikop beds which underlie the Akchagyl are thrown into folds which trend almost latitudinally (SW 250°—NE 70°).

Both these folded systems cross each other at an angle of 60°. According to Prof. J. G u b k i n, the Naftalan dome-like fold was formed in the course of the Akchagyl and Maikop disturbances which have influenced one another.

It may be of interest to test by deep drilling the third horizon (mentioned above) of the Maikop series, which contains numerous beds of sands and sandstones. This horizon is of interest because it lies between two thick strata of bituminous clays and is overlain by thick clays which protect it from exhaustion.

Prospecting. Oil production in the Naftalan oil field was undertaken by Mr. Yegeer, an engineer; up to ten shallow wells of a small diameter were drilled by hand. Later (1890 and thereafter) several deeper wells were sunk and plants were erected for the manufacture of lubricating oils, as well as of the so called «naftalan» to which curative properties were ascribed.

According to Prof. J. G u b k i n, the Naftalan depression is a locality worthy of being tested by deep holes. A properly located well sunk to a depth of at least 650 m. will ascertain the presence of oil and in a favourable case an area of more than 3000 hectares may be developed.

The composition and commercial value of the oil. The oil obtained by Mr. Yeger from shallow horizons has the following characteristics:

Sp. gravity	0.960
Flash point	140°C.
Cold test	20°C.

The crude oil was of a dark-green colour, free of acids and paraffin. Combustion is perfect, no cinder, ashes. A continuous distillation yielded:

Light oils	35 per cent.
Cylinder oils	45 per cent.
Petroleum tar	20 per cent.

Specific gravity of light oils: 0.895—0.940.

In past years Mr. Yeger recovered at least 24.6 tons of petroleum per month; light oils, about 8 tons, were used as fuel.

FUTURE POSSIBILITIES OF THE DISTRICT

As to the conclusions which may be drawn with reference to the commercial importance of the Tiflis—Gandja (Elisabethpol) oil region on the basis of the available data, it should be stated, that although the region is to be regarded as being positively petroliferous, nevertheless the question concerning its commercial importance may only be solved after the area is tested by deep drilling, conducted under proper geological and technical guidance.

The results of the exploration work accomplished so far, as well as, to a still higher degree, general economical conditions undeniably certify that, far from deserving inattentive or even unfavourable treatment at the hands of oil men and of the Government, this region is of much interest from the point of view of both the oil industry and the economic development of Transcaucasia.

As already stated, this inattentive and somewhat unfriendly treatment was dictated by general economical considerations, and first of all, by the anticipation of insufficient transportation facilities and the competition of the Baku district. Moreover, the consideration of the detriment which might arise to the Baku interests in the event of the development of the new oil areas, was a restraining factor, inasmuch as there was the question of attracting capital owned by those directly interested in Baku. Consequently, capitals went either to Baku or not unfrequently to even more remote regions, notwithstanding the hazardous outlays for geological researches and prospecting, to say nothing of the

less favourable conditions of starting operations and of their further development.

As far as the district here discussed is concerned, besides the favourable conditions of a technical nature (but few water-bearing horizons, or even the absence of them) and the high quality of the oil, with considerable yields of benzine (up to 25 per cent) and kerosene (up to 32 per cent and more),—the proximity to the Black Sea should be considered. The distance from this district to Batum is on an average 480 km. shorter than the distance from Baku to the latter port. The advantages of such a situation, compared with that of Baku, in the event of the development of the oil industry, are readily seen, both, as to keeping down the transportation expenses in general and, particularly, as to the sale of oil products on foreign markets and even home markets bordering the Black Sea.

In this connection there arises the question of the transportation of the oil or its products to the main of the Transcaucasian railway.

As has been already stated, the region, as a whole, has relatively good transportation and communication facilities (macadam highways and other earthen roads), the distance of different oil fields from the railway line varying from 20 to 120 km. It should be added that before the outbreak of the European war, projects were prepared of constructing two new railway lines; one of the latter should have connected, among others, Zemo-Khodasheni and Tiflis, and the other should have crossed the Shiraki steppe, which at that time was being rapidly peopled with colonists. It is to be believed that under the present circumstances these projects, being correlated with the general development of the country, are more likely to be realized.

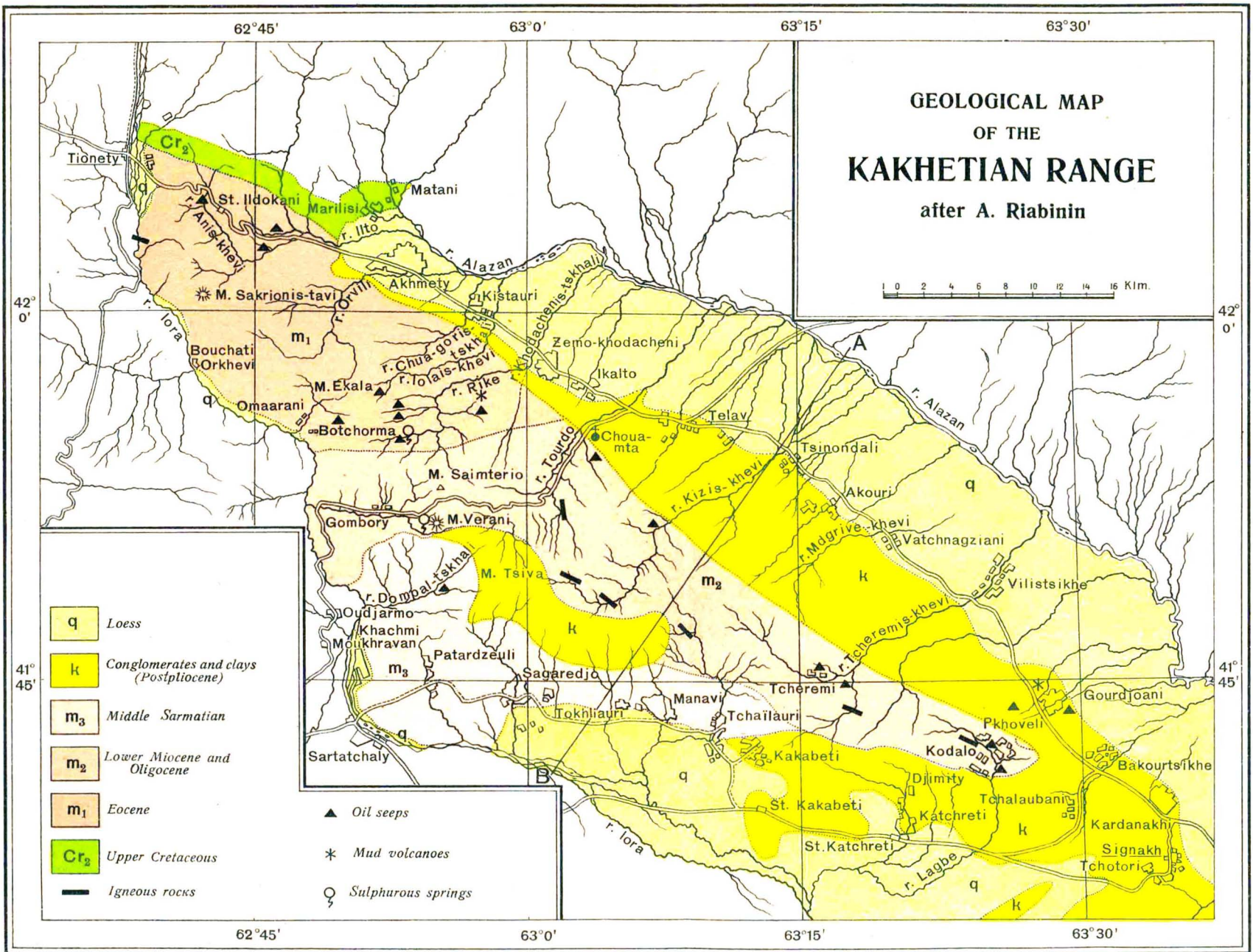
For the oil industry as such, should it arise in the district, the transportation problem may be easily solved by laying down pipe-lines, to link up the oil fields either with the railway line, or with the kerosene pipe-line, or with the projected Baku—Batum crude oil pipe-line.

The possibility of connecting Zemo-Khodasheni with the railway line by means of an oil pipe-line was foreseen in the beginning of this century, when wells were being drilled near Zemo-Khodasheni. It was then decided that the pipe-line would not exceed 60 km. in length, whereas the natural slope of the country surface might be utilized on two thirds of the line, with the installation of but small power plants.

As to the various oil fields of the wide area under discussion, it should be noted that the conditions of oil occurrence and the properties of the oil in them are different. Whereas the oil reserves of some fields, for example of those in the Shiraki steppes, are seemingly larger than in Kakhetia, the oil of the latter is of a higher quality. There are no adequate data for making any accurate estimations of the oil reserves of each of the fields discussed above; to estimate their relative importance is therefore a matter of great difficulty; it may only be said without any hesitation that each of them deserves a detailed investigation with a view of ascertaining its commercial importance.

SELECTED BIBLIOGRAPHY

1. G. J. L i t e v s k y. On ore and mineral deposits of the Transcaucasia.—Mining Journal, v. IV, 1873.
 2. L. B a t s e v i t c h. The geological description of the Signakh district, Tiflis province.—Materials for the Geology of the Caucasus. 1878.
 3. F. G a v r i l o v and S. S i m o n o v i c h. Geological observations in the region of the valleys of the Iora and Alazan rivers.—Materials for the Geology of the Caucasus, 2nd series, book IX, 1895.
 4. S. S i m o n o v i c h. Geological observations in the watershed plateau of the Iora and Kura rivers within the district from Tiflis to Samukhe (confluence of the rivers Alazan, Iora and Kura).—Materials for the geology of the Caucasus, 3rd series, V. 1, 1896.
 5. A. R i a b i n i n. Notes on the geology of the Kakhetia ridge.—Memoirs of the Geological Committee, No. 69, 1911.
 6. A. R i a b i n i n. Geological investigations in the Shiraki steppe and its vicinities. Ibidem, No. 93. 1913.
 7. K. K a l i t s k y. The Chatma petroliferous area.—Bulletins of the Geological Committee, v. XXVI. 1907.
 8. A b i c h. (1872) A letter «On the technical and geological significance of the presence of oil in Kakhetia near the village Zemo-Khodasheni».—Journal of Mining Industry and Irrigation of the Caucasus. 1902.
 9. Results of the geological researches made by I. M u c k, geologist, during the summer 1901 in the neighbourhood of the village Zemo-Khodasheni (In a pamphlet «Kakhetia Oil Field», St Petersburg. The year is not indicated).
 10. A. S t a h l. Kakhetia as an oil-bearing region (ibidem, translated from Chemiker Zeitung No. 1, 1902).
 11. A. S t a h l. Les gisements de petrole de la région du Caucase.—Revue de Petrole, No. 11, 1908.
 12. I. M u c k. Ueber ein neues Petroleumterrain im Kaukasus.—Naphta, H. 21. 1901.
 13. E. H o f f m a n n. Die Oelfelder von Tschatma, Takla und Eldar. Petroleum, VI Jahrg., No. 1.
 14. J. M. G u b k i n. The Naftalan Oil Field.—Petroleum and Oil-Shale Industry, No. 6, 1923.
-

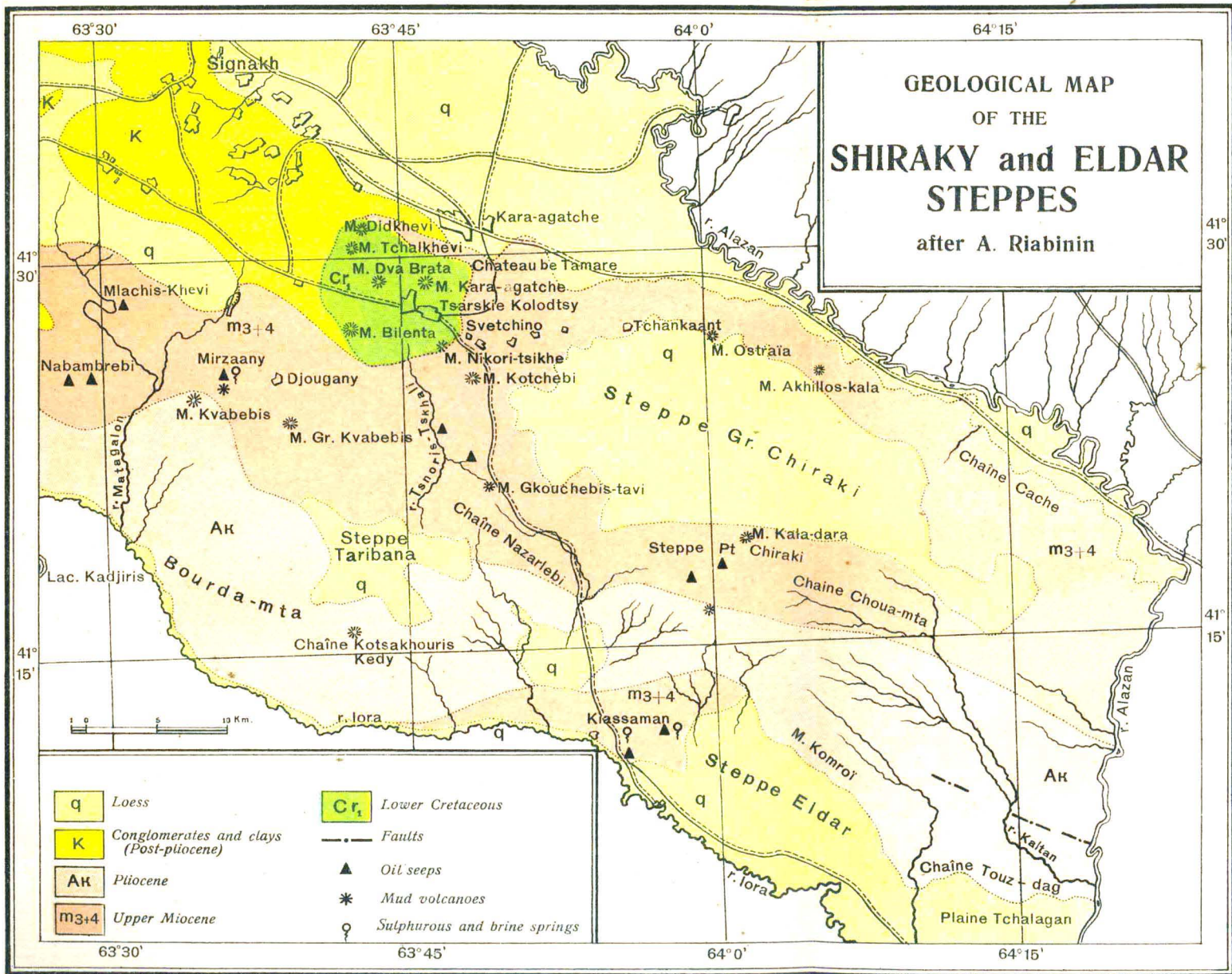


ГЛАВЛНТ. №51186 ТИРАЖ 2000

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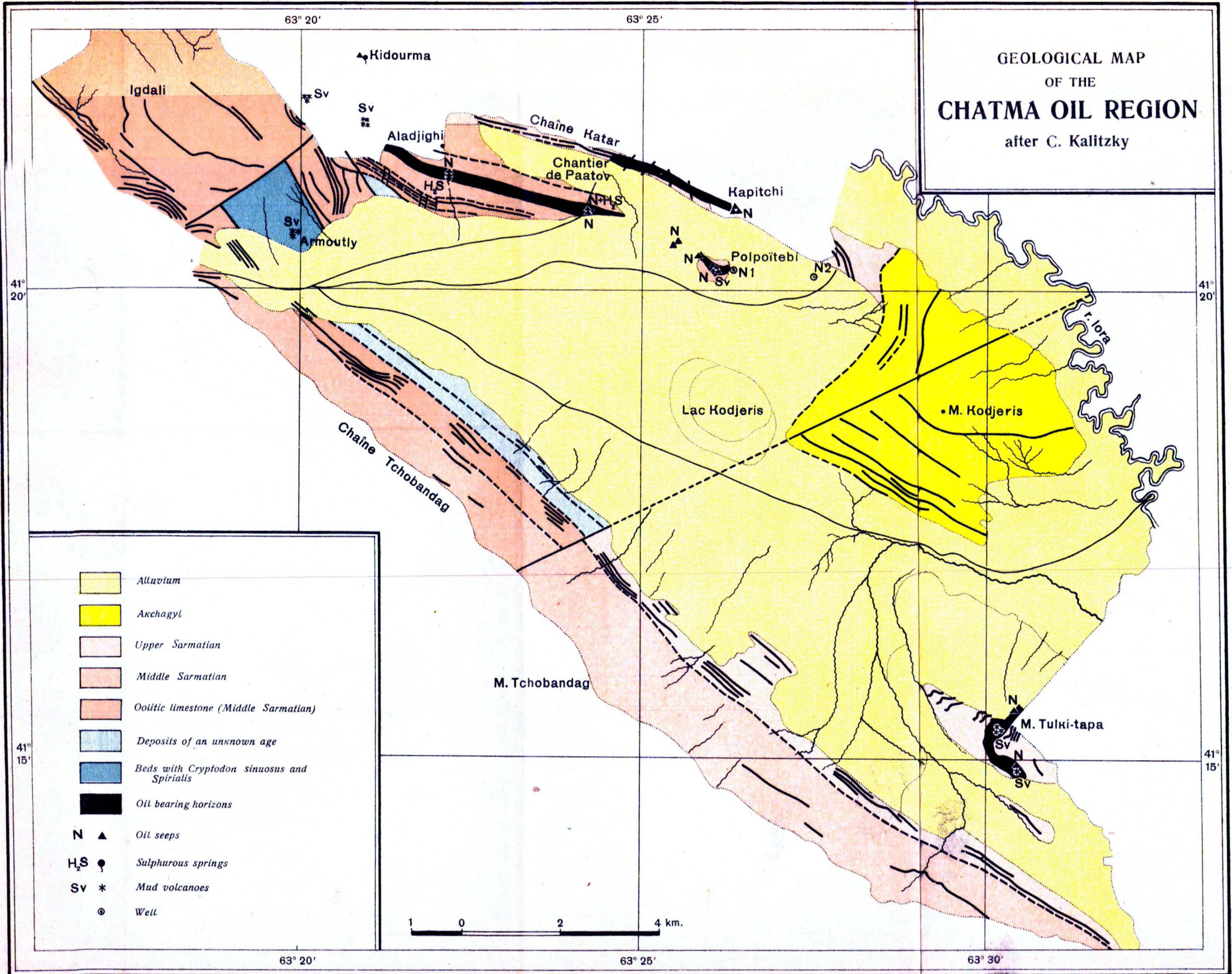




GEOLOGICAL MAP
OF THE
**SHIRAKY and ELDAR
STEPPES**
after A. Riabinin

- | | |
|--|---|
| <p>q Loess</p> <p>K Conglomerates and clays (Post-pliocene)</p> <p>AK Pliocene</p> <p>m3+4 Upper Miocene</p> | <p>Cr₁ Lower Cretaceous</p> <p>--- Faults</p> <p>▲ Oil seeps</p> <p>* Mud volcanoes</p> <p>♀ Sulphurous and brine springs</p> |
|--|---|

GEOLOGICAL MAP
OF THE
CHATMA OIL REGION
after C. Kalitzky



- Alluvium*
- Akchagyl*
- Upper Sarmatian*
- Middle Sarmatian*
- Oolitic limestone (Middle Sarmatian)*
- Deposits of an unknown age*
- Beds with *Cryptodon sinuosus* and *Spiralis**
- Oil bearing horizons*
- N ▲** *Oil seeps*
- H₂S ●** *Sulphurous springs*
- Sv *** *Mud volcanoes*
- o** *Well*



THE COUNCIL OF PETROLEUM INDUSTRY

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THE OIL REGIONS
OF THE EASTERN COAST
OF THE CASPIAN SEA

With 17 figures and a map

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INTRODUCTION

Oil deposits and indications of oil are known to exist in the following districts on the eastern coast of the Caspian Sea: 1) the Manghyshlak Peninsula; 2) the Island of Cheleken; 3) the district of the Nefte-dag and Boia-dag mountains, on the mainland shore, east of the Cheleken Island; 4) the district of the village Chikishlar, near the frontier between U. S. S. R. and Persia.

The Manghyshlak district is the northernmost one, and that of Chikishlar is the southernmost district. All the districts named are described in the following pages in their sequence from north to south.

1. THE MANGHYSHLAK PENINSULA

General description

The first reliable information relating to the Manghyshlak oil appeared in the special press not long before the outbreak of the Great War, and this was seemingly the principal reason why the Manghyshlak oil district failed to attract the attention of exploring and industrial interests. Geological conditions controlling oil deposits in this district and their commercial importance are, so far, wholly unknown; consequently, in outlining the industrial prospects of the region it is essentially important that all the natural resources and general economic conditions of the region should be taken into account.

GEOGRAPHY. The Manghyshlak Peninsula was formerly a part of the Mangyshlak district of the Transcaspian region; now it is within the boundaries of the Adaievsky district of the Autonomous Socialist Soviet Republic of Kossaks (Kirghise). This part of the eastern coast of the Caspian Sea is most projected westward and very sharply outlined, bordering the Sea on the north, west

and south. The central part of the Peninsula lies at the intersection of 44° northern latitude and 22° eastern longitude (from Pulkovo).

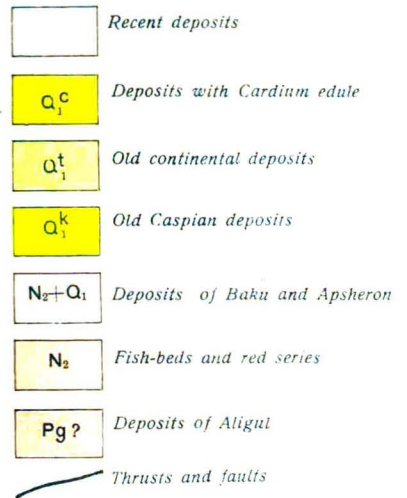
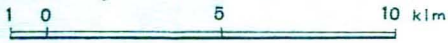
OROGRAPHY. The Peninsula is a flattened and fairly elevated country, raised up to 200 m. above sea-level; its monotonous landscape is varied by two parallel ridges,—Kara-tau and Ak-tau, which extend from northwest to southeast along the Peninsula, for a distance of about 120 km., and attain at places 750 m. of absolute altitude. Their slopes are dissected by numerous steeply sloping gorges and ravines, through which rapid torrents of water rush down in springtime; when the snow is melting; these torrents, however, disaffear at the foot of the mountains dwindling in the sands that cover the plains of the Peninsula. The latter are dissected by long, wide, branched valleys, which open into the sea or undrained salt lakes, the level of the latter usually being below the level of the Caspian. No permanent streams of water exist in these valleys; only in springtime, when the snow is melted, there are to be found in places accumulations of water, which disappear in summer, leaving salt lands. Rare springs are the only fresh-water sources in the region of the Kara-tau and Ak-tau mountains; in plains fresh water can be obtained only by sinking deep wells. The latter are very numerous, but most of them contain either salt alkaline water or water carrying sulphuretted hydrogen or, at the best, saltish water; only few wells, which are very deep, yield fresh water.

NAVIGATION. The Caspian sea off the Mangyshlak shore is far from being equally navigable along the whole extent of the latter; the Cape of Tub-Karagan, on the northwestern extremity of the Peninsula, is a point north of which the sea is exceedingly shallow and inaccessible for sea-ships, whereas south of that point the sea is deeper, so that the bays existing here,—viz., the Alexandrovsky and Kendyrli (Alexander-bay and Kinderli) Bays provide anchorage for sea ships, although not quite convenient and open to sea winds. Moreover, the part of the sea lying north of the above named cape has a lower salinity of the water; this together with a more severe climate in this part of the sea leads to the freezing of the bays to a more or less considerable extent off their shores,—for a period of time from the middle of December to the middle of March. South of the Tub-Karagan Cape the bays freeze only sometimes when the winter is exceptionally cold.

THE CLIMATE of the Peninsula may be termed a distinctly continental and severe one. According to the data of the Meteor-

70°45'

71°0'



M E R C A S P I E N N E

Baie Balkhansky

Baie Kert-iakha

M. Tchokrak

Baie Kara-gueul

Presqu'île Deriche

Kourtly

i. Aulak

i. Arykh

GEOLOGICAL MAP
OF THE
CHELEKEN ISLAND
after V. Veber and C. Kalitzky

39° 30'

39° 30'

39° 15'

39° 15'

70°45'

71°0'

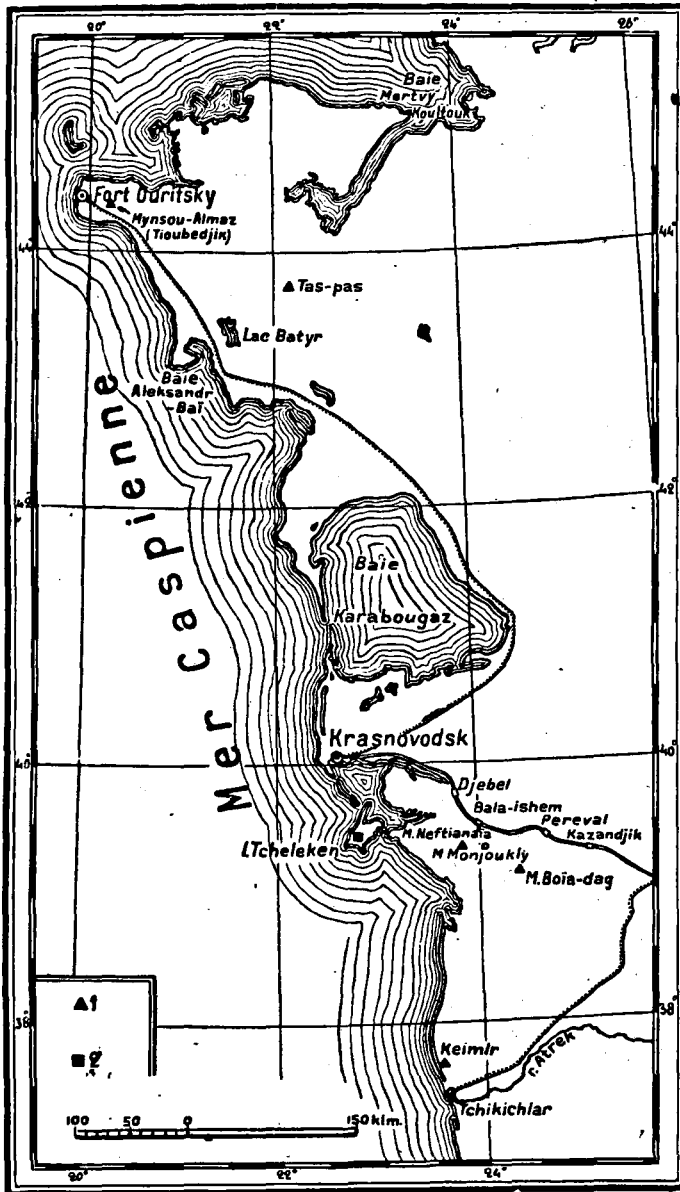


Fig. 1. Map of the eastern coast of the Caspian Sea. 1—oil fields which are not exploited; 2—producing oil fields.

logical station at the Fort Uritsky (formerly Alexandrovsky), which is situated on the northwestern extremity of the Peninsula, the average yearly temperature is $+10.9^{\circ}\text{C}$, the absolute maximum and minimum being respectively $+41^{\circ}\text{C}$ and -24.5°C (the annual range equals 65.5°). The average annual amount of rainfall at this station is estimated at only 173 mm., the months having the maximum and minimum rainfall being respectively December (22 mm.) and July (only 8 mm.). The prevailing winds are easterly, and they are exceedingly dry. The snow falls in December and lies until the end of February or the beginning of March.

Such climatic conditions render the Manghyshlak Peninsula a very severe country, which affords no facilities for civilized life. Only in small and more humid valleys on the Kara-tau and Ak-tau mountains may be found in summer time, in addition to grass, single trees; all the rest of the Peninsula is absolutely devoid of trees and covered with grass only early in spring, prior to the summer heat. The glowing sunrays rapidly burn the grass and there remain only a few species of *Artemisia* as the only representatives of plants, covering the arid sun-cracked clayey ground of the Peninsula for thousands of kilometers.

THE NATIVE POPULATION of the Peninsula consists of Kirghises (Cossacks), nomads, engaged in cattle-raising. Russians live only in the Uritsky fortress (formerly Alexandrovsky) and the Nikolaevsky village, located near the latter; the total number of Russians at the outbreak of the Great War did not exceed 3,000; now, however, this number has probably decreased, inasmuch as in 1923 the Russian population of the Uritsky Fortress was estimated at 1,235, instead of 1,700. The total population of the former Manghyshlak district the, area of which is over 220,000 square km., was at that time estimated at about 77,000, the density being about 0.3 per square kilometer. There is no manufacturing industry within the territory of the peninsula. Cereals are imported from the European part of Russia by sea via Astrakhan, or from Krasnovodsk, likewise by sea or even from Khiva (Khoresm) by caravans of camels. On the sea-shore there are considerable fisheries, in which Russians and partly Kirghises are engaged. Fish is not only consumed locally, but shipped also to Astrakhan, fish and livestock products being the sole exports. Almost all commodities of life, exclusive of fishery products, have to be imported.

WAYS OF COMMUNICATION. Overland traffic between the Manghyshlak district and Khiva is conducted (on the backs of camels)

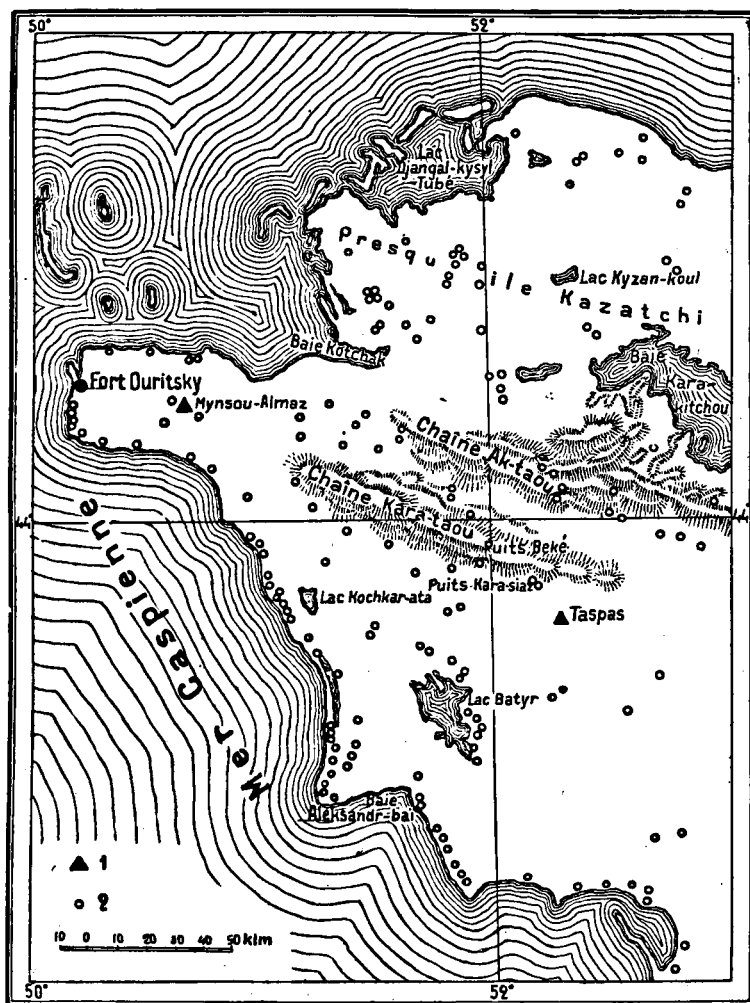


Fig. 2. Map of the Mangyshlak Peninsula. 1—oil fields; 2—main wells.

over the ancient caravan route leading southeastward; the length of the latter from the Uritsky Fortress to Kunia-Ourgench, an important commercial center of Khiva, is about 820 km. The whole of the sea trade is run through the Uritsky fortress, which has a convenient natural harbour, 8.5 m. deep in its middle part, and is situated at a distance of nearly 270 km. from Astrakhan, 320 km.

from Petrovsk (Makhach-Kala), a sea port on the western shore of the Caspian, at the point where the North-Caucasian railway approaches the sea, 630 km. from Krasnovodsk, the main port on the eastern shore of the Caspian and a terminus of the Mid-Asiatic railway. In the pre-war time steamers made, regular trips once a week from Astrakhan, via the Uritsky fortress, to Krasnovodsk and backwards. Trips of the Caspian steamers, owned by the State are at present run by another route; notably from Petrovsk via the Uritsky Fortress to Astrakhan and back, but only three times a month, so that there is no regular communication between the Uritsky Fortress and Krasnovodsk.

Geology and occurrence of oil

Manghyshlak may by no means be considered to be a thoroughly investigated territory, as regards its geology. Owing to its vast area and the difficulties encountered in making surveys, the investigations of the Peninsula are of an essentially itinerary character; every new expedition therefore furnishes additional information, which is materially new, as compared with that gained by previous expeditions. Anyhow, it may be deemed a proven fact that sediments greatly varying in age are involved in the geology of the Peninsula, namely, those referred to the Triassic (possible even Permian), Jurassic (Lower, Middle and Upper Jurassic), Cretaceous (Lower and Upper Cretaceous), Tertiary (Paleogene and Neogene) and Post-Tertiary (distinctly developed sediments of the Aralo-Caspian transgression). The following is a generalized geological section of the Manghyshlak Peninsula (comprising its mountainous portion).

1. The schists, which are the oldest sediments in the region, are mostly argillaceous; in places strongly metamorphosed and replaced by chloritic shales.

To all probability they belong to the Triassic period, possibly even to the Permian period.

2. Overlying the foregoing formation are strongly altered clayey sandstones, and in places quartzite-like sandstones and black carbonaceous limestones. The fauna which was found in the latter proves that they belong to the Werfenian stage of the Lower Triassic.

3. Jurassic and Cretaceous sediments unconformably overlying the above mentioned strata may be divided as follows:

a) Variegated mostly argillaceous series with coal layers and vegetal remains.

b) The main coal-bearing series, consisting of gray clays and yellowish and gray sandstones, with coal layers; in the upper part of the series there are layers which contain marine fossils and belong seemingly to the Bathonian stage.

c) Arenaceous and argillaceous beds with a typical marine fauna of the Lower, Middle and Upper Callovian and Lower Oxford.

d) Sandstones with a marine fauna of the Upper Oxford and Lower Kimmeridgian.

e) Coarse limestone, which is to be referred, according to the fauna which it contains, to different horizons ranging from Portland (Upper Jurassic) to Lower Valanginian (Lower Cretaceous).

f) Sandstones and sands some of which are unfossiliferous and some contain fossils; their age cannot be accurately stated as yet, but at any rate they belong to the Neocomian (the Lower Cretaceous), which is suggested also by a very persistent horizon, with *Trigonia* (*Trigonia* limestone); the latter horizon, as well as the underlying sandstones and sands, are to be especially marked on account of oil indications being associated with them in one of the Manghyshlak oil fields (Taspas), as will be shown later.

g) Coarse-grained sandstones with some ammonites typical for the Aptian.

h) The series of shales with marly concretions (septaria clays), containing ammonites and other fossils of the intermediate horizons between Aptian and Gault (the Lower Cretaceous).

i) The series of sandstones which are characterized by the presence of concretions and are interbedded with arenaceous clays; it contains a fauna of the Gault; the latter fauna should be seemingly referred to different zones; oil indications in the second Manghyshlak oil field (Mynsu-Almaz) are associated with these horizons.

k) Glauconitic sandstones and marls which are rich in phosphorites represent only the lower horizon of the Upper Cretaceous (Cenomanian).

l) Farther upward follows a compact white chalk which passes into greenish marls and is referred to the Turonian.

m) Pure writing chalk, very rich in fossils belonging to the Senonian.

n) The section of the Upper Cretaceous beds is crowned by limestones containing bryozoa, with flint intercalations carrying fossils of the Danian stage.

4. The Tertiary sediments apparently lie unconformably on the Cretaceous beds; moreover, two or even three unconformities may be discerned in the Tertiary beds; the latter are divided as follows:

a) The Paleocene yellow sands bearing pebbles of the Cenomanian phosphorite (secondary deposits) and a peculiar fauna of oysters, sea-urchins, etc.

b) Glauconitic and chalk-like marls and nummulitic limestone of the Eocene, which seem to overlie unconformably the above mentioned sands.

c) Dark shales, sandy marls, sandstones, manganiferous sands (with few intercalations of manganese ore) and shales with scales of *Meletta*, belonging to the Oligocene.

d) Unconformably overlying the latter are *Spaniodontella* sands, marls, clays and sands with *Pholas* and the Sarmatian clays and limestones (the Middle and Upper Miocene).

e) The uppermost formation of the Tertiary consists of the limestones of the Pontian stage (the Pliocene).

5. The sediments of the Aralo-Caspian sea transgression are mostly arenaceous rocks.

Thus, the general stratigraphy of the Peninsula is exceedingly complicated and very variable with regard to the fauna and lithological characteristics of the rocks. It should be noted that the core of the ridges Kara-tau and Ak-tau consists of the oldest rocks (the Mesozoic), whereas the peneplain of the Peninsula is composed chiefly of the younger strata of the Neogene and the Aralo-Caspian. However, important corrections have been made in this scheme on the basis of the latest detailed investigations, which have discovered the exposures of the Mesozoic rocks (the Jurassic and Cretaceous) also outside of the mountainous part of the region. The geological structure of Manghyshlak is likewise more intricate than it was formerly believed, and is at present to be regarded as a complicated anticlinal system accompanied by flexures and even faults, the strata having been subjected to the most intense deformation in the mountainous part of the Peninsula.

The first vague information concerning the showings of oil in Manghyshlak appeared in periodicals in the early nineties, and was based on the report of Colonel N a s s i b i a n t s, who had made a topographical survey on the Peninsula. The said information refers to the locality near the Karasiaz wells, in the interior portion of the Peninsula. In 1910 that locality was visited by Mr.

M. B. Baiarunas, geologist, whose description is hitherto the sole source from which the data pertaining to the geology of that field may be derived; the following description is based on these data.

The most convenient road leading to the Karasiaz water wells (if it were generally possible to speak of conveniences of camel-back transportation and ride through a dry country) is the above mentioned caravan route from the Uritsky Fortress to Kunia-Urghench; the distance between the said wells and the Fortress by this route being approximately 180 km. Besides, the navigable Alexander-Bay already referred to lies at a shore line point which is the nearest to the Karasiaz wells; the distance between the latter and the shore is only 85 km. But the Alexander-Bay so far is not connected by a regular steamship line with any sea port, and the surrounding country is deprived of cultured population; thus, the said Bay cannot be chosen as a starting point for an expedition to be sent inland. According to «The Caspian pilot guide» (1908) the greatest depth of the bay, in the middle of it, does not exceed 10.5 m.

The Karasiaz water wells are located in a broad anticlinal valley which is formed by the Cretaceous beds and extends from west-northwest to east-southeast; but east of the wells the valley trends southeastward.

The oil indications were discovered, however, 20 km. southeast of the Karasiaz wells, near the so called Tebpai grave, in the locality of *Taspas*. This locality is situated in the anticlinal valley already referred to, but owing to an extensive development of the arenaceous and clayey soil, the bed rocks are here almost entirely concealed; the sands were formed probably by the desintegration of the Cretaceous sandy rocks. The locality *Taspas* is a sandy plain covered with small hills; numerous wells yield fairly tolerable water at comparatively shallow depths. Near the Tebpai grave in small ravines and in the ridge rising above the plain, there are outcrops of the limestone bed with trigonias of the Neocomian age, underlying which are sands and sandstones belonging likewise to the Lower Cretaceous; the latter strata, as well as those with trigonias, are impregnated with a bitumen called by the Kirghise «karamai», which means «black tallow». The thickness of the rocks impregnated with this solidified bitumen (kir) attains in outcrops 4 m., the strata dipping northeastward at a very low angle (4°—5°).

In summer, when it is extremely hot, the sandstones are heated and the bitumen melts and flows down the outcrops; but no fluid petroleum proper is known to occur here; furthermore, despite the most thorough search, the above named explorer failed to trace any other indications of oil in the neighbourhood of the Tebpai grave. On the other hand, M. V. Baiarunas does not consider it impossible that some shows of oil may be found under circumstances more favourable than those which existed when he visited this locality. While referring to the possibility of discovering petroleum by test drilling along the dip of the strata at some distance from the outcrop, he emphasizes the necessity of a preliminary detailed geological survey.

A similar outcrop of rocks impregnated with «kir» was discovered by the same geologist at a point lying considerably nearer to the Uritsky Fortress, viz., about 37 km. southeast of the latter. At a distance of 26 km. from the Fortress there is a wide depression Khanga-Baba bordered on the north and east by a rather high acclivity. A broad valley of Tubedjik—Mynsu-Almaz joins the depression from the northeast; at about 5 km. from the mouth of the valley the latter is divided into two main systems: that of Tubedjik, which runs from the north in an almost straight direction, and that of Mynsu-Almaz, running from the northeast. In the slope on the right-hand bank of the *Mynsu-Almaz* valley, near the mouth of the latter, there are exposed sands containing *Spaniodontella* (the Miocene), which are underlain by sandstones impregnated with bitumen (the same «karamai») and containing spherical concretions. In M. B. Baiarunas's opinion the bituminous matter could not have penetrated those sandstones, unless it had been raised along fissures from deeper horizons. Numerous ammonites (different species of *Hoplites*), excellently preserved, have been found in the spherical concretions, demonstrating that the strata should be referred to the Gault (the Lower Cretaceous).

The geological structure of this locality cannot be considered to be sufficiently ascertained. There is no doubt that the Tertiary *Spaniodontella* beds rest unconformably on the eroded surface of the Cretaceous strata; the latter are more strongly disturbed than the former and even fractured by faults; the faulting, however, involves at places the *Spaniodontella* beds as well, which means sequent disturbance along the old fissures. The main structural feature of the Khanga-Baba depression is a northwestward-tren-

ding anticlinal uplift of strata, on the crest of which there are outcropping Gault beds with Hoplites. The faults dissecting the Cretaceous beds are approximately parallel with the strike of the latter, the displacement of faults attaining 20 m. These data, however, apply to the Khanga-Baba region as a whole, no detailed information being available concerning the structure of the locality where the oil indications are encountered.

Future possibilities of the district

The foregoing gives full information concerning all the available data pertaining to the oil indications in Manghyshlak. No prospecting for oil has been done in that area thus far, and the commercial importance of it is wholly unknown. It may be inferred from the above discussion that the Manghyshlak oil is associated with geological horizons different from those bearing oil in the Caucasian oil fields as well as in other Transcaspian fields, which will be described later. The sands and sandstones impregnated with the solidified bitumen «karamai» are overlain in Taspas by a layer of limestone with trigonias of the Neocomian age; furthermore, the comparison of this section with those of other localities of Manghyshlak shows with certainty that the arenaceous horizons under question belong also to the Lower Cretaceous. On the other hand, rocks of the Mynsu-Almaz fold are referred to considerably younger horizons of the Gault, although they apparently resemble the rocks outcropping at Taspas, as far as the presence of the bitumen is concerned. It is noteworthy that, in spite of the fact that both the latter and former horizons are fairly widespread in Manghyshlak, no more indications have been so far encountered in any of them. It may be therefore presumed that in both fields here discussed the oil is found not *in situ*. The question as to whence the oil which penetrated those beds had been derived, and in what strata it lies *in situ*, cannot be definitely answered; but, since to the best of our knowledge there is no oil in the Tertiary strata of Manghyshlak, it may be rather presumed that it originated in older strata, namely in the Lower Cretaceous or possibly even in the Jurassic; should that be the case, a certain analogy may be observed between the Manghyshlak oil fields and those of the Ural and Emba regions. The peculiarities of the anticlinal structure which have been noted in both fields are of course favourable circumstances. At any rate, the Manghyshlak area is

worthy of being further searched for oil; both fields described above, which have not hitherto attracted the attention of oil producers, deserve to be thoroughly investigated. As to other mineral resources of the Manghyshlak, there have been reported deposits of lignite, copper, iron and manganese ores and phosphorites, chiefly in the Kara-Tau mountains, but none of these deposits have been exploited thus far. It is highly probable that the beginning of the production of oil, should it really take place, will be an incentive for the development of the exploitation of the rest of the mineral resources, which under the present circumstances can hardly attract the attention of industrial interests. Moreover, the salt lakes in the coastal strip of Manghyshlak are saturated with salt, the latter being even exploited on a small scale. There is no timber wood in the Peninsula, but stone, sand and lime, necessary for building purposes, can be easily obtained. Labour may be drawn from local Kirghise as well as from the Russian inhabitants of the Urtsky fortress; some of the Kirghise are quite fit for regular work, as they are used to be employed in fisheries not only on the shore of Manghyshlak, but also in the region of the Lower Volga.

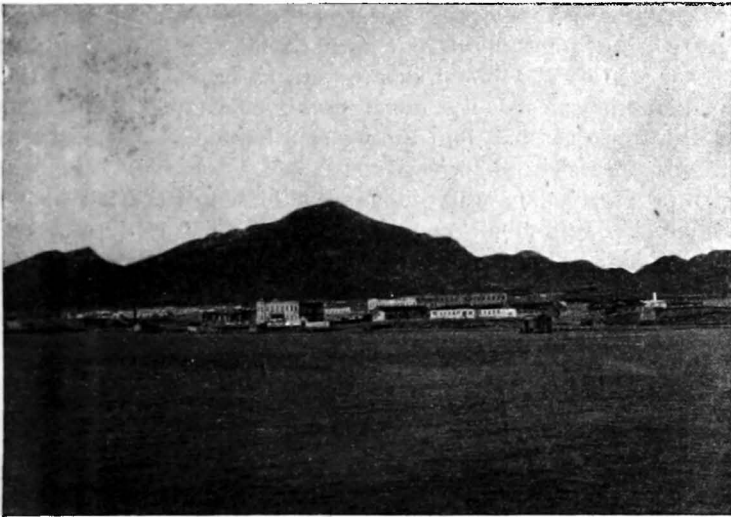
SELECTED BIBLIOGRAPHY

1. N. I. Lomakin. On the Manghyshlak Peninsula and the routes leading from it to the various points of the Transcaspian Region.—Transactions of the Caucasus Section of the Russian Geographical Society. VIII. 1873.
2. N. I. Andrusov. Geological investigations in the Transcaspian Region during 1887.—Proceedings of the Aralo-Caspian Expedition. VI. 1889.
3. N. P. Barbot-de-Marni. Through Manghyshlak and Ust-Yurt to Turkestan.—Ibidem. 1889.
4. M. M. Vasilyevsky. Contributions to the geology of the Manghyshlak Peninsula.—Materials for the Geology of Russia. XXIV. 1908.
5. N. I. Andrusov. Report on a Geological Investigation of Manghyshlak carried on in summer 1907.—Transactions of the Society of Naturalists of St-Petersburg. Section of Geology and Mineralogy. XXXV. 1910.
6. N. I. Andrusov. Brief report of the geology of the Tub-Karagan Peninsula and the mountainous region of Manghyshlak.—Transactions of the Commission for the Investigation of Phosphorites. III. 1911.
7. M. V. Baiarunas. Geology of the phosphorite-bearing deposits of the Western portion of the Manghyshlak Peninsula.—Ibidem. 1911.
This paper contains data relating to indications of oil on Mynsu-Almaz.
8. M. V. Baiarunas. Preliminary report on the geological investigations in the region of steppes of the Manghyshlak district, performed in 1910.—Bulletins of the Russian Geographical Society. XVII. 1911.
This paper contains data pertaining to indications of oil on Taspas.
9. Prince V. I. Massalsky.—The Turkestan region. «Russia», edited by V. P. Semenov-Tian-Shansky. XIX. 1913.

2. THE ISLAND OF CHELEKEN

General description

The oil-bearing district of the Island of Cheleken is of an undoubted commercial importance. Oil had been extracted by the native inhabitants in a very primitive manner many years before the Island was annexed by Russia; but it was not until the



Photograph by V. Sokolov.

Fig. 3. General view of the town of Krasnovodsk from the sea shore.

seventies of the last century that the commercial production of oil may be said to have begun. The bibliography on the geology of the Island and on its oil production contains numerous works; in the first decade of the present century the Island was thoroughly investigated on behalf of the Geological Committee, with the participation of prominent geologists such as V. Veber and K. Kalitsky. The result is that the geology and petroleum resources of the Island have been investigated better than in any oil field of the eastern coast of the Caspian, and indeed better than in many other oil fields of the U. S. S. R., including those which are of the highest commercial importance.

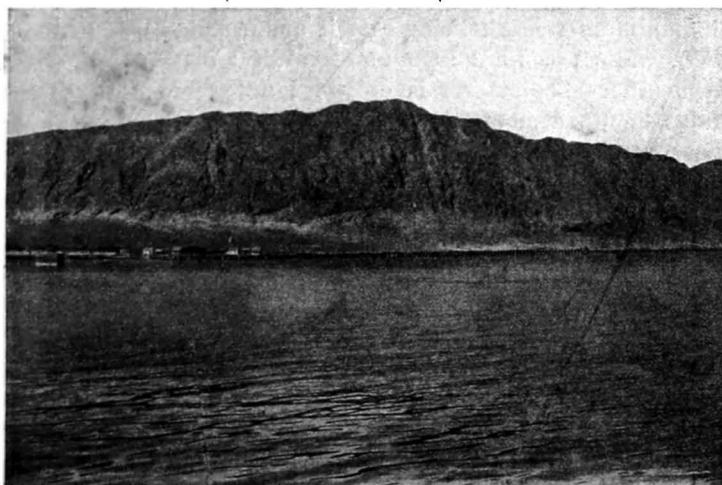
GEOGRAPHY. Cheleken belonged formerly to the Krasnovodsk district of the Transcaspian region; now it is a part of the S. S. R. of Turkmenistan. It is the largest island in the Caspian sea and is situated at the intersection of coordinates $39^{\circ}30'$ northern latitude and 23° eastern longitude (from Pulkovo); it lies off the Asiatic coast, close to the latter, blocking from the south the passage to the large Krasnovodsk Bay. The town of Krasnovodsk is situated on the northern shore of the Bay at a distance of about 50 km. from Cheleken. Krasnovodsk is a terminal of the Mid-Asiatic railway, the most important town on the eastern coast of the Caspian and the administrative center of the district. The Island, with an area of about 500 square km., has a curious oval shape, extending from west-southwest to east-northeast; two sandy spits projecting into the sea join the western border of the Island, thus continuing its shore line.

OROGRAPHY. The western, or seaward, side of the Island is elevated, and a belt of hills made up of the exposed country rocks attains 5 km. in width and extends thence along the longitudinal axis of the Island to the east-northeast, where it gradually grows lower and finally dwindles in the sands without reaching the sea-shore, from which it is at a considerable distance. The highest summits are in the Chokhrak ridge, in the middle portion of the Island. The vast areas of the northwestern, eastern and southeastern portions of the Island are occupied by sands, both wind-driven (of the type of barchanes) and more or less stationary sands,—and by salt lands. Wind-driven sands lie, as a rule, on the periphery of the Island, near the sea-shore, while stationary sands and sandy hillocks are spread nearer to the central part of the Island; salt lands encircle the central part occupied by the outcropping country rocks.

There is almost no vegetation on the Island. In springtime only small bushes and grass appear on sands near the shores, but both bushes and grass are scorched in summer.

Although Cheleken does not differ essentially, as to climate, from the eastern coast of the Caspian, the latter region having the appearance of an arid desert, the Island is nevertheless rich in underground waters, the presence of which is evidenced by numerous springs, whose water soaks not only salt lowlands, but even clayey slopes of the elevation Chokhrak. However, the water of most springs is highly mineralized with chlorine salts predominating in it, being unsuitable for drinking. Furthermore, there is

a number of hot springs with a temperature reaching 62°C (in the locality Kharaz). Only one group of springs, distinguished by the exudation of gaseous hydrocarbons, yields water which is comparatively poor in salts (the amount of salts being 1.77 per cent) and may be drunk by animals. These latter springs are visited by wild «djeirans» (antelopes) and are therefore called «djeiran springs». Almost all the Cheleken springs are brought to existence by faulting (fissure springs), and only the «djeiran springs» are of the ordin-



Photograph by V. Sokolov.

Fig. 4. The sea-shore of the town of Krasnovodsk.

ary hillside type. The only large lake on the Island is the so called «Rosovy Porsu-Ghel», the water of which is also distinguished by a comparatively low salinity (3.91 per cent); gaseous hydrocarbons likewise issue from this lake. It is quite natural under such conditions that hand-dug wells usually yield a saltish water which often has the odour of petroleum. The best water wells existed on the southern shore of the western portion of the Island, where the main storage tanks of petroleum were also located. Nevertheless, sea-water had to be artificially evaporated, to satisfy the needs of the petroleum industry.

CLIMATE. The situation of the Island in a close neighbourhood to the vast desert areas of the Transcaspian region accounts for its

markedly continental climate, while the influence of the sea is scarcely perceptible. The average annual temperature for Cheleken may be referred as $+15.6^{\circ}\text{C}$ (according to the data of the Meteorologic Station in the Mikhailovsky Bay—Uzun-Ada, as on the Cheleken there have been no continuous observations for a number of years), the absolute maximum and minimum being respectively $+43.6^{\circ}\text{C}$ and -11.8°C , which corresponds to an annual range of 55.4°C . The average yearly rainfall is equal, in the above mentioned Uzun-Ada, to a quite insignificant amount of 105 mm., the months with maximum rainfall being March and April (21 mm. in each month), while the total amount of rainfall for the four summer months (June—September) is only 4 mm.; there are practically no rains on Cheleken in summer, but stormy showers may occur in very rare cases. The snow cover is absolutely insignificant. During the summer, when the amount of rainfall is the smallest, there prevail easterly winds, which blow from the vast Trans-caspian deserts and are, therefore, extremely hot and dry.

NAVIGATION. The spits extending from the western shore northward and southward form two bays, which are well protected from the side of the open sea; the northern bay, which is a part of the large Balkhan Bay, is called Kertyke, while the southern one is named Karakul-Daria ¹⁾.

The entrance into the Kertyke Bay, located north of the latter, is 3.5—4 m. deep, while the deepest places in the Bay itself are found in the middle of it, nearer the spit and amount to about 6.5 m. The Karakul-Daria Bay is deeper, its greatest depth being almost 13 m., and it is more accessible for sea-ships.

Although there are sandbanks east and west of the northern shore of this Bay, still on the meridian of the Chokhrak mountain there is a depth of 3.5 m. at a distance of about 1 km. from the shore, and it is just in that place, where the depth reaches 3.5—4.5 m., that the ships usually anchor. Several wharves have been constructed here by Nobel Bros. and other companies for loading oil into the ships. Eastward of the northern and southern shores of the Island the sea becomes extremely shallow, and the straits which separate Tcheleken from the mainland and connect the two

¹⁾ These bays are named so in Russian maps and in the «Caspian pilot guide»; both names are apparently corrupted Turkomanic, words: Kert-Yakha and Kara-Ghel, both words being the names of the Turkomanic villages situated on the shores of the bays.

Bays are inaccessible not only for ships, but even for boats with a deep draught.

POPULATION. The native population of Cheleken was scarce and consisted of Turkomans, who dwelled in three villages. Their chief occupation was, long since, the extraction of oil from hand-dug wells; the bulk of the production was exported to Russia. They were engaged also in fisheries and in the salt industry.

During the last decades, while the oil industry was being developed, a population of newcomers grew on the Island, who were engaged in the oil industry. The living conditions on Cheleken are far from being convenient for a European, inasmuch as most of life commodities have to be brought into the country, chiefly from Baku.

WAYS OF COMMUNICATION. The nearest town to the Island and the administrative center is Krasnovodsk. The communication with the latter was maintained by Turkomanic sailing boats and steamers owned by Nobel Bros., through the Northern Cheleken Bay (Kertyke).

The Island has never been connected by regular steamship lines with other ports of the Caspian; in the pre-war time the communication with the Island was carried on, by ships belonging to the companies which were operating on Cheleken Island, and among them first of all by ships of Nobel Bros.

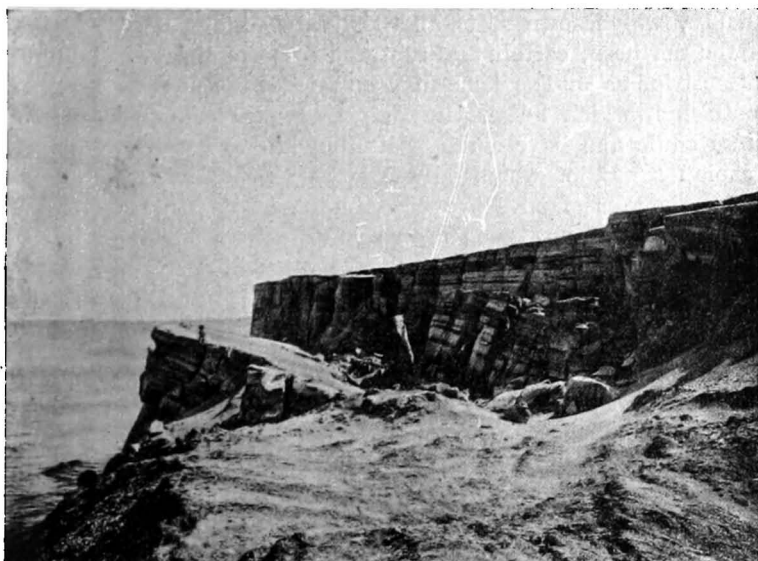
Geology and occurrence of oil

Exceedingly numerous oil indications and the existence of a primitive oil production, which dated from ancient times, were the reasons why this Island became, long ago, a center of attention of Russian geologists. We may quote a long list of articles describing its geology, which have been published during a number of decades, beginning from the thirties of the last century up to the present time. In 1907 a detailed geologic survey of the Island was undertaken by the Geological Committee, on the basis of the map on a $\frac{1}{21000}$ scale (1 inch to 250 sazhen), with the participation of V. V e b e r and K. K a l i t s k y. As a result of the work of those eminent geologists, several papers were published, thoroughly elucidating the geology of the Island as well as the occurrence of oil. The following description is based on the data contained in the works just referred to, which are the most complete and accurate.

GENERALIZED GEOLOGICAL SECTION OF THE ISLAND OF CHELEKEN.

Sy- stem.	Geological age of strata.		Lithological Character.	Thickness, meters.	Occurrence of oil.			
	Division.	Stage.						
Quaternary.	Transition rocks below the recent (Q ₂)		Sediments with Cardium edule.	Grayish-yellow sands, gray in deeper horizons.	Unknown.	Not containing oil.		
			Ancient terrestrial deposits.	Yellowish gray sands, often with reddish shade, with layers of pinkish marls.	11 max.	Not containing oil.		
	Postpliocene (Q ₁)		Ancient Caspian sediments.	Sands; a thin layer of gravel at the base.	Not less than 8.	In the western part of the Island contains accumulations of oil.		
			Beds with Cordicula fluminails.	Sands pure and clayey; pinkish marls, mud-volcano breccias.	Unknown.	Oil-bearing, but of no commercial value.		
			Upper division of the Baku stage.	Gray and reddish marls and gray micaceous sands; with a characteristic layer of gravel at the base.	147.	Oil-bearing, but of no commercial value.		
			Lower division of the Baku stage.	Reddish marls alternating with sands; characteristic horizons are: black shaly clay; marl filled with shells Didaena catillus; beds with Neritina liturata; a very variable Bryozoa horizon at the base.	164.	Oil-bearing, but of no commercial value.		
			Upper Apsheronian.	Reddish marl; at the base a horizon filled with dreissencias.	16.	Not containing oil.		
			Middle Apsheronian.	A thick formation of black shaly clay; sand, reddish marl; shell horizon exceedingly variable in lateral extent.	175.	Oil-bearing, but of no commercial value.		
	Tertiary.	Neogene.	Pliocene.	N ₁ sp	Lower Apsheronian.	Dense, gray to reddish marl, with a thin intercalation of sand (ashes?); black shaly clay, sands with Streptocrella Sokolovi; black shaly clay; thin layers of sandstone and more compact dark-coloured marl lying almost at the base of the Apsheron.	207.	Oil-bearing and can have some moderate commercial value.
					Fish beds.	Light-gray shaly marls, with a bed of black shaly clay and three layers of pumice ashes at the base.	107.	Pumice intercalations are oil-bearing, but of no commercial value.
			N ₁ st	Red-coloured series.	Brick-red marls interbedded with gray and green sands.	Not less than 320.	Oil-bearing and of positive commercial value.	
				Paleogene (Pg?).	Rocks of the Allgul range.	Green limestones, very hard calcareous sandstones, olive-coloured shaly clays.	Unknown.	Not containing oil.

The outcrops of country rocks are found on the Island almost exclusively in its central elevated part, which borders the sea only on the west and is separated from the latter on all other sides by a strip of sands and salt lands. Thus, the country rocks crop out only in a few places of the eastern shore, while along the western shore the bed rocks are exposed in steeps of moderate height,



Photograph by V. Veber and K. Kalitsky.

Fig. 5. The western shore of the Cheleken Island.

beneath the mantle of sands. All the country rocks of Tcheleken belong to the Pliocene, i. e., to the uppermost horizon of the Tertiary, and to the still younger Quarternary system (Postpliocene), with the exception of only one place, situated between the western extremity of the Chokhrak mountains and the locality Aligul, on the sea-shore, in which place there are developed olive-coloured shaly clays, hard calcareous sandstones and bright green limestones; the age of all these rocks is not established, but they may be referred, with a fair degree of certainty, to the lower series of the Tertiary system, the Paleogene. In compiling the following generalized geological section of Tcheleken we have availed ourselves of the works of V. Veber and K. Kalitsky, with such alterations

as are necessary, for the ideas concerning the stratigraphical attitude of some beds have been changed since the works referred to were published for the first time (1909—1911).

We will discuss in some detail the formations cited in the accompanying section, especially those of them that are of importance in regard to the occurrence of oil on the Island. From this viewpoint the youngest arenaceous deposits containing *Cardium edule*, which form spits and low sandy shores on the periphery of the northern, eastern and southern parts of the Island, are of no interest for us ¹⁾. The same may be said of the ancient continental sediments, which lie stratigraphically higher than beds with *Cardium edule* and have a rather limited lateral extent. The ancient Caspian sands, of which only isolated patches remain in various places on the Island, have been impregnated with oil originated in other strata, and thus converted into «kir» sandstones, but these rocks are likewise of no commercial value altogether. These beds are unconformably overlying older sediments. Beds with *Corbicula fluminalis* have been preserved on Cheleken only in three places of its western portion and exhibit some deformation, dipping in one place at an angle of about 5°. This formation contains several layers of «kir» sandstones, but is of no commercial importance. The *Corbicula* beds are likewise separated from older strata by an unconformity.

The Baku beds are divided into two divisions—the Lower and Upper divisions,—have a rather wide extent on Cheleken; they border the central elevated portion mainly on the south and east. The Upper Baku beds are bituminous, but yet of no commercial importance; although the Lower Baku beds contain oil in situ, its commercial value is negligible, because the sands are everywhere outcropping and losing the oil. The Upper Baku beds unconformably lie on the Lower Baku beds; both are disturbed. They are separated from older strata by an unconformity.

The sediments of the Apsheronian stage, with which the Tertiary system of rocks commences, here are divided into three divisions: the Upper, Middle and Lower Apsheronian; they have still wider lateral extent than the Baku beds and lie more or less parallel with the latter, between them and the central elevated part of

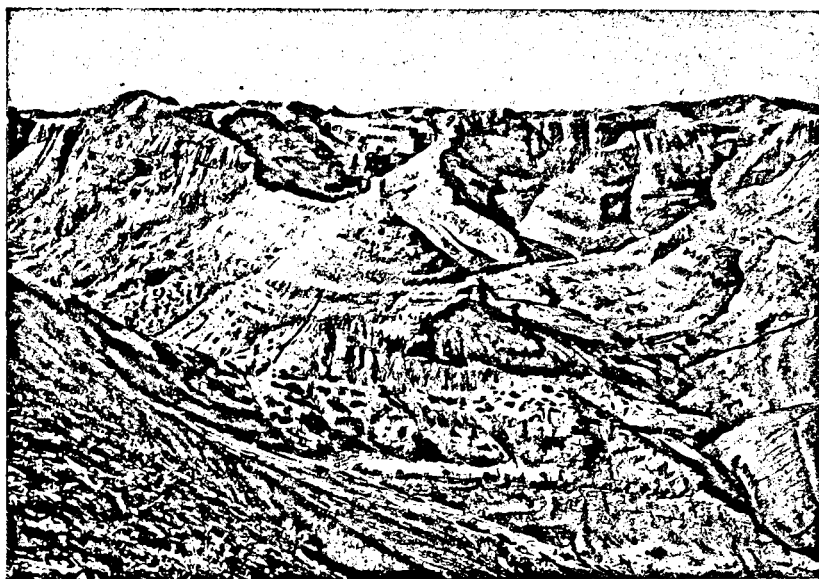
¹⁾ These sediments may contain slightly bituminous sands, if the material of which the latter are composed has been derived from some older bituminous rocks washed out by sea water; but it is quite evident that no such bituminous sediments can be of any commercial value.

the Island. All the three divisions are disturbed, the disturbance being in places very considerable. Unconformities are observed within the Apsheronian stage, notably between the upper and middle divisions and the middle and lower ones, as well as between the Lower Apsheronian and the Fish beds underlying it. Three beds of black shaly clays and reddish and gray marls separating them are characteristic for the Apsheronian and serve as good key rocks at drilling operations. With regard to oil, the upper division is not petroliferous; the middle division contains two oil-bearing sandy beds, which, however, are always exposed and are therefore of no commercial value at the present time; but formerly the upper bed was exploited in many places by Turkomans; the Lower Apsheronian is also petroliferous, and in some places the oil-bearing beds are not exposed on the surface and may have a moderate commercial value: Nobel Bros. have extracted oil from these beds by bailing.

Further downward there are the Fish beds with an abundance of vertebrae of fishes,—identified, as to the age, with the Akchaghyl stage; the Fish beds lie in many places still nearer the central range, than the Apsheronian; in the northeastern part of the elevations they alternate laterally with the red-coloured rocks, but upon the whole they do not occupy extensive areas. The deformation of these rocks is very considerable, while no unconformity could be found separating them from the underlying red-coloured rocks, although such unconformity would be quite natural between rocks belonging to markedly different facies. Three layers of fine pumice ashes and a black shaly clay are characteristic horizons and key rocks. The layers of ashes are bituminous, but of no commercial importance.

The rocks of the red-coloured formation occupy the largest area, as compared with other country rocks, and form the whole of the central elevated portion of the Island; moreover, they likewise extend along the borders of the latter and occupy at least half of the whole area of exposed rocks. This formation is a very characteristic, as to its aspect, persistent, banded formation of brick-red marls, alternating with gray or greenish-gray sands and loosely consolidated sandstones. Marly and sandy beds are variable in lateral extent and their mutual relations unceasingly alternate; thus, although the formation is very characteristic as a whole, no separate horizons within it can be chosen to serve as key rocks in drilling or geological field work. The formation is greatly deformed

and broken by faulting. As it is unfossiliferous, the determination of its age is difficult, but in view of the stratigraphical correlations it shall be regarded as identical with the productive series of the Apsheron Peninsula. Oil is found in sands of the uppermost part of the formation, and this is the only horizon of a commercial importance within the Island, which has even yielded gushers.

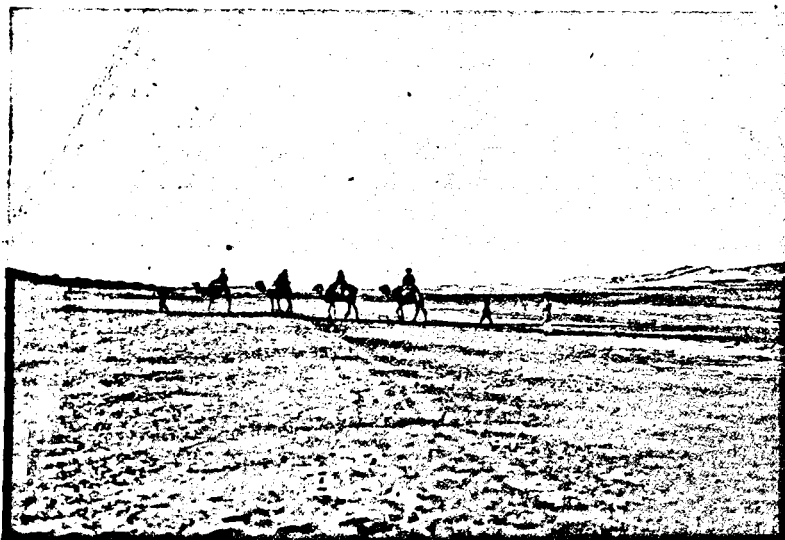


Photograph by V. Veber and K. Kalitsky.

Fig. 6. The northern slope of the elevation Chokhrak on the Cheleken Island.

The average thickness of the horizon is 1.8 m. The rocks of the red-coloured formation are widely outcropping and broken by intense faulting, owing to which they are far from being uniformly petroliferous throughout their extent; besides, the said formation contain only a few oil-bearing horizons, as it has just been stated. The most favourable conditions in regard to oil occurrence are in the western part of the interior tract of the island, approximately delimited by the line connecting Kur-Tepe and Gheok-Chulba hills, because the superficial beds of this tract are composed, chiefly, of the Baku and Apsheronian sediments, while the Fish and Red-coloured beds lie at deeper horizons. Most of the drilling for oil was done within this tract.

Finally, the sediments of the Aligul locality are delimited on all sides by faults and are themselves strongly disformed; they consist of curious green argillaceous and calcareous rocks and sandstones and do not contain any fossils enabling one to determine their age. However, a comparison of these rocks with the corresponding members of the geological section on the Apsheron



Photograph by V. Veber and K. Kalitsky.

Fig. 7. Salt land on the Island of Cheleken.

Peninsula shows that the sediments in question should be referred to the Lower Tertiary (Paleogene) beds, namely to the Oligocene, which is characterized on the Apsheron Peninsula by teeth of Lamna. The Aligul beds carrying no oil lie at the base of the whole series of sedimentary rocks of Cheleken.

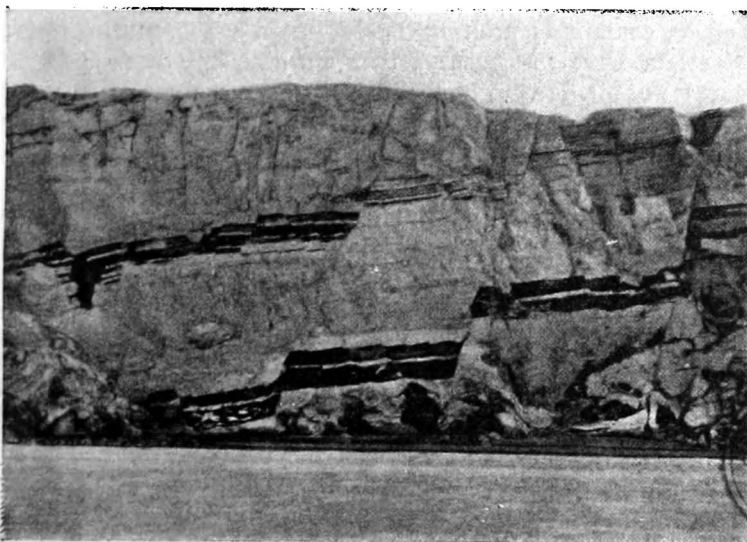
GEOLOGICAL STRUCTURE. While describing the stratigraphy of Cheleken, we have noted numerous unconformities, which serve to evidence the reiterated activities of orogenic forces. In fact, the geological structure of Cheleken is very complicated, representing a combination of such different forms, that it cannot be characterized by one salient feature predominating throughout the Island. Despite a small geological period of time, during which the rocks of the Island were deposited, the strata have been undergone at

least seven times a more or less considerable deformation. The strongest deformations took place after the sedimentation of the Baku beds, thus determining the complicated structure of Cheleken; the last displacements occurred after the beds with *Corbicula fluminalis* had been deposited in the region of the still existing mud volcano of Aligul. Upon the whole, taking into consideration the attitude of the Apsheronian and Baku beds, bordering the exposed rocks of the interior portion of the Island, the main structural feature of the latter may be defined, with a considerable degree of certainty, as an anticlinal dome-like uplift which is stretched from SW to NE. But the strata are so intensely broken by faulting within a relatively limited area of this dome, that it may be said that nothing has been left of this dome; it cannot be definitely stated after all whether an independent elongated dome has ever existed on Cheleken or the dome-shape structure of the Baku strata on the periphery of the Island is due to the uplift of the central part produced by step-faulting. With regard to the structural deformations in the central part of the Island, the words of V. N. Veber may be cited, who says that «there is no undisturbed spot: all is broken and separate pieces have sunk differently in respect to each other»; N. Andrusov compared Cheleken with a broken plate. It is impossible to plot all faults even on a detailed map; only the principal faults are shown on the accompanying map.

There are, in general, two predominating directions of faulting on Cheleken: a northeasterly direction (parallel to the longer axis of the Island) and a northwesterly one, which runs transversely, or rather diagonally; the latter direction is common mainly to the western part of the area with exposed rocks. The above described structural features of Cheleken cannot be considered to have been produced by plicative, contractive forces acting in the earth's shell; the structure may be rather associated with a deeply buried intrusion of magma, which failed to reach the land surface, having cooled and solidified within the crust; this intrusion has given rise to an uplift of overlying sedimentary rocks.

Such an explanation of the geological structure of Cheleken has been first held by K. Kalitsky, who backs his opinion by a number of convincing considerations. Anyhow, the intensive faulting which has broken the Red-coloured formation, appears as a very unfavourable factor with regard to the occurrence of oil, inasmuch as the only petroliferous horizon of commercial importance is asso-

ciated with the said formation. In fact, owing to faulting, the oil-bearing strata have been cut into isolated oil pools, each of which had to be affected necessarily in a very different manner. For example, some pools may have been enclosed between two fault planes without any connection with the land surface; consequently, their oil reserve could be preserved; but it may happen that an



Photograph by K. Kalitsky.

Fig. 8. Oil-bearing beds of the Baku stage broken by faulting, on the western shore of the Island of Cheleken.

oil pool is leaned upon a fault plane only by one edge, its other one being exposed; in such a case the water rising along the fault fissure might have driven the oil out of the bed. Leaving aside any other possible cases, it is only necessary to note that, as a result of a strikingly complicated structure, oil is very unequally distributed on Cheleken. As stated above, the most favourable conditions are confined to the western portion of the Island between the sea-shore in the west and a line connecting the Kur-Tepe and Gheok-Chulba hills in the east. However, particular details of the geological structure control the occurrence of oil in different plots of this tract. Moreover, there are considerable surface indications of oil in the so called Zachokhrachie, along the eastern and north-

eastern slopes of the Chokhrak elevation; but the oil-bearing rocks of the Red-coloured series are largely exposed, so that commercial oil may hardly be expected to exist there.

All that has been said above concerning occurrence of oil has been based on the following general statement put forth by the geologists who have investigated Cheleken in detail, viz., V. V e b e r and K. K a l i t s k y: on Cheleken commercial oil is found in strata containing primary deposits of oil; deformations of the said strata have influenced rather unfavourably with respect of occurrence of oil. It is to be mentioned that a contradictory opinion has been expressed in literature by A. I v a n o v, concerning the origin of Cheleken oil, which has led to an animated controversy. The said geologist holds that the Cheleken oil has migrated along the structural faults and fissures from great depths, over 1600—1700 m., and saturated sandy beds which were adjacent to those fissures, thus forming secondary deposits of oil. It is clear that, should this view be proven, the practical results would be greatly different from what has been stated above. But at the present time it is justifiable to regard such an explanation as an expression of very old schemes, in the destruction of which the attainments of V. V e b e r and K. K a l i t s k y have played such an important rôle.

OZOKERITE. A high paraffin content of the Cheleken oil accounts for the presence of numerous deposits of ozokerite (mineral wax), which was exploited long since. Ozokerite is a derivative of paraffin oils, which is formed in nature after the oil has lost its lighter components. It is therefore quite natural that the Cheleken deposits of ozokerite have a distinct character of veins, inasmuch as fissures are greatly developed in the Island and a paraffin base oil has migrated along these fissures. According to K. K a l i t s k y, veins of ozokerite form an intermediate link between oil reservoirs of the deep horizons and «kir» covers on the surface. The best deposits of ozokerite are found therefore in the western portion of the Island, where the oil-bearing rocks (the uppermost portion of the Red-coloured formation) lie at a depth of many tens of meters, so that ozokerite veins extend throughout the whole thickness of the overlying rocks, sealing, along with wall rock breccia, fissures which were once unfilled. Ozokerite was exploited just in this portion of the Island, the number of developed deposits being about twenty. The ozokerite deposits of Miut, Koshlar, Meshed, etc., within the boundaries of properties formerly held by Nobel Bros.,

are of the greatest interest. Many wells drilled for oil in the western part of the Island have encountered ozokerite. On the contrary, the prospecting for ozokerite in the eastern part of the Island, Zachokhrachie, was unfavourable, because the oil-bearing strata are there too much exposed and the ozokerite veins are not extensive. Moreover, the ozokerite of Zachokhrachie contains such fine-

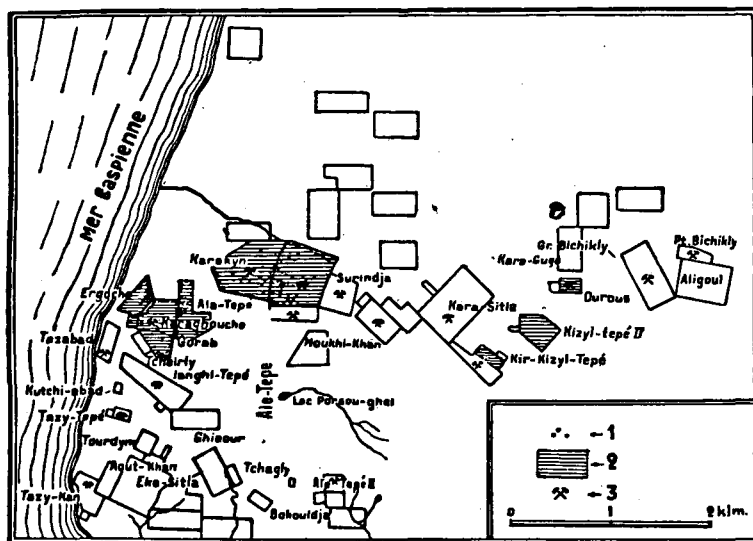


Fig. 9. Map of the producing oil field of the western portion of the Island Cheleken; 1—wells; 2—tracts on which oil has been extracted on a commercial scale; 3—extraction of ozokerite.

grained sand that the latter would not settle at the melting of ozokerite, whereas the ozokerite of the western region has much higher qualities ¹⁾.

There are two water-bearing horizons in the producing oil field. The upper one is embedded in the rocks of the Baku and Apsheronian stages and yields a salt water with a temperature up to 25°C. This horizon has to be penetrated when drilling for oil. The lower water horizon lies some meters below the productive horizon of the Red-coloured formation and has a wide lateral extent within the latter. It contains a water which has a high tem-

¹⁾ However, it should be noted that during the European War there was started an exploitation of ozokerite beds, forming the uppermost part of the exposed rocks carrying a paraffin oil, in the eastern portion of the Island (the locality Da gadjik).

perature and carries sulphuretted hydrogen together with small quantities of hydrocarbon gases; this horizon is so copious in water, that the latter flows out of wells.

Prospecting and exploitation.

The Turkomans who inhabit Cheleken were long since engaged in the extraction of oil from shallow hand-dug wells. As reported by E. Eichwald, I. Blaramburg and Felkner, there were in the thirties of the last century over 3000 oil pits on Cheleken, reaching 40 to 60 m. in depth; oil floated on the surface of warm salt or sulphurous water. The output of the wells was not considerable; only the most prolific among them yielded 150 to 300 kg. of oil per day, while not more than 20 kg. a month could be extracted from many small pits. The oil so extracted was of a different quality and belonged to two main varieties: dark-coloured and light-coloured oil. The principal oil market was Persia, to which country over 1,500 tons of oil were exported yearly. Beside the oil, black and white ozokerite was produced for illuminating purposes, being used for the manufacture of candles; various authors applied different names to this ozokerite, such as nefte-deghil, nefte-dakhil, nefte-ghil, etc. It may be mentioned that Cheleken was referred to in the Russian literature of those times, as «Neftianoi ostrov» (Oil Island), the idea of its richness in petroleum being very popular in Russia.

Under such circumstances it is quite natural that, at an increased interest in petroleum in the early seventies in Russia, the general excitement could not have failed to influence Cheleken as an oil producing region. One of the chief pioneers of the Cheleken oil industry was S. P a l a s h k o v s k y, an engineer, who found of interest a considerable paraffin content of the Cheleken oil. He carried on drilling during the period from 1877 to 1883, but unfortunately the wells were sunk largely in the places where surface indications of oil were located; no geological investigations had been conducted; drilling results were not, nor could be successful, inspite of heavy expenditures. Moreover, the wells sunk by S. P a l a s h k o v s k y were shallow (about 70—80 m. deep), the deepest one was only about 170 m. deep. Nearly at the same period of time Nobel Bros., a well known concern, started operations on Cheleken, which proved to be much more successful. They began by drilling in the western, most reliable, portion of the Island, and

on the property Kara-kyn No. 1 brought in a gusher from a depth of only 38—40 m. Wells were not equally productive, and while some of them yielded by overflow a daily output of 3 to 6.5 tons, others outburst periodically, ejecting to 160 tons per twenty four hours. The above named concern started the extraction of oil in 1876, and for about 20 years they were the sole oil producers on

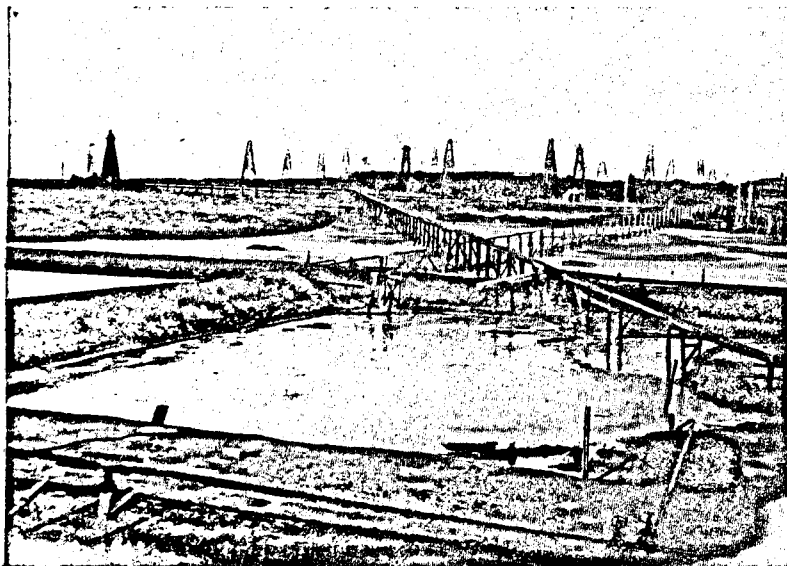


Fig. 10. A producing oil field on Cheleken.

Cheleken. During this period they did much toward the improvement of the methods of oil production. The oil was exported principally to Baku for manufacturing kerosene, paraffin, etc. From the middle of the nineties new oil producers came in and prospecting operations greatly revived. But drilling of wild-cat wells located without reference to structural features of the country failed to give successful results, and by the middle of the nineties the public interest in Cheleken slackened again, although Nobel Bros. continued to produce a fairly stable but moderate output, ranging to several thousand tons per annum. Besides that concern, two or three companies operated on the Island; wells were rather shallow and did not exceed 215 meters in depth, the average daily output being about 8 tons per well.

The end of 1907 was marked by the coming in of a gusher No. 40 on the Kara-kyn property of Nobel Bros. The gusher spouted daily about 278 tons of oil, and about 90 tons of water and mud. In 1908 a stronger gusher was brought in on Gadjinsky's property in the locality Kara-gush, within the area of the unsuccessful operations carried on by Palashkovsky. This well spouted from a depth of 170 m. to a height of about 80 m. and yielded over 8,000 tons of oil per day. This gusher was followed by others, and Cheleken once more attracted the attention of oil producers. As a result, the production curve began to rise rapidly from 1909, and in 1911 the development of the Cheleken oil industry reached its maximum. In 1911, 17 oil companies were operating, which possessed 66 wells; but only five companies were actually oil producers, exploiting 30 producing wells, the total daily output being approximately 820 tons. However, during the subsequent years the production began to decline steadily and many companies stopped their operations. Only three oil producers remained: Nobel Bros., Gadjinsky and Wischau, who controlled the whole production. In January 1917, that is to say a little before the February Revolution, there were 37 producing wells on the Island, with an average total production of only 110.5 tons. During the Civil War in Russia the equipment of the productive fields was greatly damaged and by 1923 there were on the Island only 12 producing wells (flowing and bailed), which yielded 600—620 tons of oil per month.

No data relating to Cheleken are to be found in the published oil statistics for the latter years.

The following table contains figures relating to the production of petroleum on Cheleken for the period 1891—1924 (in thousands of tons).

1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
2.9	3.2	3.9	1.3	1.4	1.5	1.4	5.6	6.5	8.2
1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
8.2	6.5	3.2	9.8	14.7	9.8	13.1	19.6	49.1	157.2
1911	1912	1913	1914	1915	1916	1917	1923	1924	
217.8	212.9	127.7	81.9	65.5	49.4	22.9	5.7	5.2	

The composition and commercial value of oil

A characteristic feature of the Cheleken oil is a high paraffin content. The analysis made in 1895 by our eminent expert K. K h a r i c h k o v was one of the first analyses of the Cheleken oil and possibly even

the very first; according to it, this oil contains 5 per cent of paraffin (an average of a number of analyses). Therefore, this oil, which is a black fluid with a comparatively high viscosity and a specific gravity of 0.8686 (at +15°C), becomes thicker at +9°C, being like to an ointment; the oil entirely solidifies at + 2°C. The result of a fractionation is as follows:

Fractions.	Yield (per cent).	Specific gravity.
1) Below 200°C	2.8	0.7724
2) 200°to 250°C	11.9	0.7961
3) 250°to 270°C	7.6	0.8100
4) 270°to 310°C	6.6	0.8228
	Total 28.9 per cent.	

It is worth mentioning that corresponding fractions of the Baku oil have somewhat higher specific gravities.

Residuum after the distillation up to 310°C (71.1 per cent) reminds by its consistency a thick ointment; its specific gravity is 0.9033; this residuum corresponds to the product which is known in America as petrolatum. This leads K. K h a r i c h k o v to believe that the Cheleken oil must be utilized chiefly for the manufacture of vaseline and paraffin wax. The samples examined by the above named chemist had been obtained from the test well of the Transcaspian railway.

In 1897 F. M a i e v s k y published an analysis of oil obtained at a shallow depth from the well No. 4 sunk by Nobel Bros. on the Kara-kyn property. The results closely resemble those cited above; on being agitated with sulphuric acid the oil yielded 5 per cent of black crude wax, wherefrom 2.67 per cent. of refined paraffin were extracted, with a melting point of 50°C. A few years later (1901 and 1902) K. K h a r i c h k o v, already mentioned, published data pertaining to the examination of an oil of a somewhat different type (derived from the property held by Mr. Kozmin): the latter oil belongs to the group of oils which are lighter and have a higher content of volatile constituents, viz.:

Fractions.	Yield (per cent).
1) Below 100°C	0.25 (benzine)
2) 100° to 150°C	1.75 (ligroin)
3) 150° to 270°C	27.90 (kerosene)
4) 270° to 300°C	8.00
5) Residue	60.00, with a specific gravity 0.9078.

The latter do not resemble vaseline and have a liquid consistency. This oil contained only 1 per cent of paraffin.

A very high paraffin content (9.89 per cent) has been reported by I. Strijov (1903) for the oil extracted from the well of the Cheleken-Daghestan Co. at a depth of 85—87 m.; the oil solidified at +10°C, its residuum being a crude vaseline. It is noteworthy that shallower horizons in the same well contained semi-fluid ozokerite. On the other hand, analyses of lighter oils are available, for example, the analysis of the oil made by W. Gery (1908); the oil was derived from a gusher of Gadjinsky's, from a depth of about 170 m. The oil had a specific gravity of 0.8493 (at 15°C) and yielded at fractional distillation the following distillates:

Fractions.	Yield (per cent).
1) Below 100°C	10.1 (benzine)
2) 100° to 125°C	4.9 (ligroin)
3) 125° to 275°C	27.0 (kerosene)
4) Residue	56.5 per cent

The specific gravity of the residuum was 0.9063; it solidified at +17.5°C, resembling then vaseline; the paraffin content was 10.11 per cent.

It may be seen from what has been stated above that there are apparently two different types of oil on Cheleken; to one type belongs a heavy oil which is characterized by a higher paraffin content compared with the lighter oil belonging to the other type. The lighter oil is found at a greater depth than the heavier one, and this fact corresponds with the general principle, according to which an oil lying near the surface of the earth easily loses its lighter components, thus becoming heavier.

Future possibilities of the district.

At the periods when Cheleken attracted considerable attention some exaggerated estimates of its possibilities were published in the press; some even held that Cheleken could claim to be of an importance equal to that of Baku. On the other hand, the failure of a hasty and irregular prospect drilling led to quite contradictory and likewise extreme conclusions. However, the results of impartial geological investigations of the island, made by V. Veber and K. P. K l i t s k y on behalf of the Geological Committee, show that neither of these extreme opinions is correct, the truth lying

somewhere in the middle. There may be no question of comparing the Cheleken oil region with that of Baku for the following reasons: firstly, the aggregate thickness of the productive beds represents a very small portion of the general geological column of the Island; secondly, an extremely complicated structure of the country is rather unfavourable for the preservation of large subterranean reserves of oil; thirdly, the most valuable field has but a moderate area. Nevertheless, the presence of oil in paying quantities cannot be doubted, the oil being, moreover, of a rather high grade, which enables the extraction of such valuable constituents as paraffin and vaseline. Considering, therefore, that such valuable products may be manufactured from the Cheleken oil, besides the usual volatile and inflammable constituents, it should be admitted that the oil under discussion is worthy of occupying a definite place in the oil industry of this country.

The desolate character of the Island, want of water, lack of labour, absence of victuals and timber are adverse circumstances for the development of industry on Cheleken. Nevertheless, owing to the conveniences of transportation by water and the presence of protected bays, the said difficulties can be overcome, inasmuch as it has been possible, for a number of decades, to cope with them. The development of the oil industry on the Island largely depends on the further study of the geology of the latter, together with a study of the former drilling results; such investigations should be conducted with an aim to expand productive areas within the central portion of the Island, which is made up of country rocks, as well as in the periphery of the Island, where the productive strata are concealed under different covering rocks. The development of the oil industry will, no doubt, facilitate the mining of ozokerite, which can seemingly be conducted on a commercial scale.

SELECTED BIBLIOGRAPHY

A complete, almost exhaustive list of the literature referring to Cheleken, together with digests of papers, is found in the work of V. V e b e r and K. K a l i t s k y «Cheleken» (1911). While recommending that list to those who may wish to possess an adequate notion of the richness of the literature on Cheleken, we cite below only the most important sources, which are necessary for a study of the geology of the oil fields.

1. A. P. I v a n o v. The Cheleken oil fields.—*Neftianoe Dyelo* Nos. 6, 7 and 9. 1903.

2. K. Kalitsky. On occurrence of oil on Cheleken Island.—Transactions of the Geological Committee, No. 59. 1910.

3. V. Veber and K. Kalitsky. Cheleken.—Ibidem, No. 63. 1911.

4. K. Kalitsky. Cheleken.—Natural Resources of Russia, vol. IV, No. 22. Petroleum and ozokerite. 1918.

This brief account contains a list of references, which firstly supplements the list included in the book published in 1911 and secondly enumerates papers issued after the publication of the latter work.

5. K. Kalitsky. The Transcaspian oil region.—The Petroleum and Oil-Shale Industry. Nos. 7—8. 1922.

3. NEFTE-DAG AND BOIA-DAG

General description

GEOGRAPHY. East of the Cheleken Island, on the Asiatic coast of the Caspian Sea, amid a low coastal plain there are two isolated mountains,—Nefte-Dag (the oil mountain) and Boia-Dag, the former lying northwest of the latter. The country around them is a desert which abounds in salt lands and is devoid of fresh water and vegetation. The shortest distance from Nefte-Dag to the sea shore is about 37 km., while Boia-Dag is about 55 km. distant from the sea-shore. But the beach belt is exceedingly shallow, abounding in sandy islands and sand-banks; the shore is almost desolate and inaccessible for sea-ships. Salt lands or «shors» are spread over the coastal plain, alternating with areas of sands, and reach very considerable dimensions. These salt lands, as well as the whole tract adjacent to Nefte-Dag, have been a part of the bottom of the Caspian Sea at a relatively recent time, which may be inferred from the presence of shells of marine mollusk *Cardium edule*.

WAYS OF COMMUNICATION. The shortest way to Nefte-Dag is via Balla-Ishem, a small station of the Mid-Asiatic railway, with no population but the station personnel. Balla-Ishem is connected with Nefte-Dag by a highway 34 km. long, leading to the southwest from the station; the latter is situated at a distance of 166 km. from Krasnovodsk, a terminus of the above named railway on the Caspian sea-shore. A horse-tramway existed once between the said station and Nefte-Dag, but more than fifteen years ago it was partly taken away and remained only for a distance of 23 km., from the station to the rock salt mines. From these mines up to Nefte-Dag the traffic was conducted either on carts having extra wide wheel rims to prevent them from sinking into the loose salt soil, or else by caravan on camel backs. During the years of the Civil War

the tramroad was completely ruined, but, owing to the interest which the Mid-Asiatic Railway took in Nefte-Dag in quite recent years, the road has again become more or less fit for traffic. The section of the road under discussion, which is nearest to the Balla-Ishem station, passes through a gently undulated desert plain covered with gravel and small bushes. This desert gradually passes into a sandy desert with low sandy hillocks covered with a scarce vegetation; still farther there are flat salt lands covered with salt



Photograph by V. Sokolov.

Fig. 11. General view of Nefte-Dag from north-west.

eflorescence, which extend to Nefte-Dag. The other way to Nefte-Dag leads from the station Djebel, of the same railway, and is somewhat longer than the first. But Djebel holds some advantages over Balla-Ishem, because it is nearer than the latter to Krasnovodsk (134 km.), has a village with a post and telegraph office; there may be found men, camels and horses, and provisions may be made; there is good drinking water. This route, however, is devoid of any modern means of transportation and is passable only by caravans, as it traverses a clayey and desolate salt plain.

The most convenient way to Boia-Dag leads from the same station Balla-Ishem and is 40 km. long. The track, which is practicable

also only for pack transportation by caravan, has a general south-southeasterly direction, and first traverses sands with a scanty vegetation and then enters an immense desolate salina. Nearer the Boia-Dag the track once more enters sandy and clayey spaces, which are richer in phenomena of plant and animal life, but the mountain is surrounded by a belt of the same salt lands which continuously concentrate salt brought in by the streams of salt or, generally, mineralized water, which run from Boia-Dag and end by dwindling in salt lands. The shortest distance between Boia-Dag and Nefté-Dag is relatively moderate and does not exceed 50 km., but no permanent tracks suitable for transportation exist in that desolate salt land.

OROGRAPHY. Although the absolute altitude of Nefté-Dag is very moderate (only 71 m.), its situation on a plain accounts for its silhouette being distinctly visible from a great distance, even from the station Balla-Ishem, when the air is clear. The mountain extends about 4 km. in a southwest to northeast direction and has a flattened gentle relief with a scarcely discernible summit. However, its slopes, particularly the northern one, are precipitous and cut by deep ravines having steep walls. The northwestern part of the mountain presents the most dissected relief, but on the whole Nefté-Dag cannot be classified as being intensively eroded. A very high salinity of the soil and an arid climate account for the exceedingly poor vegetation, which is found, mainly, on the sands of both alluvial mantle and country rocks, which are easily leached out.

In general, Boia-Dag is not much different from Nefté-Dag by its nature. The mountain is an elevation which extends in a latitudinal direction for about 6 km. and is about 3 km. wide; it is made up of argillaceous rocks. Streams of salt water run down the elevation and end by dwindling in flat salt lands which border it. Boia-Dag is intensely dissected; its relief is rather complicated, especially in its central part. In the western portion there projects an isolated summit—Kara-Burun, which is a huge stone column, representing a neck of an ancient mud and gas volcano. On Boya-Dag there are deposits of a ferruginous substance distinguished by its variegated colours. The substance is utilized for the preparation of paints and is called by Turkomans «Kara-boia», and the name of the mountain itself is due to the fact that its highest point is a sandy hillock impregnated with «Kara-boia».

CLIMATE. With regard to the climate of the area surrounding the mountains under consideration, only all that has been previously

said relating to the climate of Cheleken may be repeated, inasmuch as the discussion of the climate in the former district could not be based on any data other than those of the previously mentioned meteorological station in the Mikhailovsky Bay. Authors who wrote about the mountains here discussed recorded the unusually strong winds driving clouds of dust and producing striking dust-



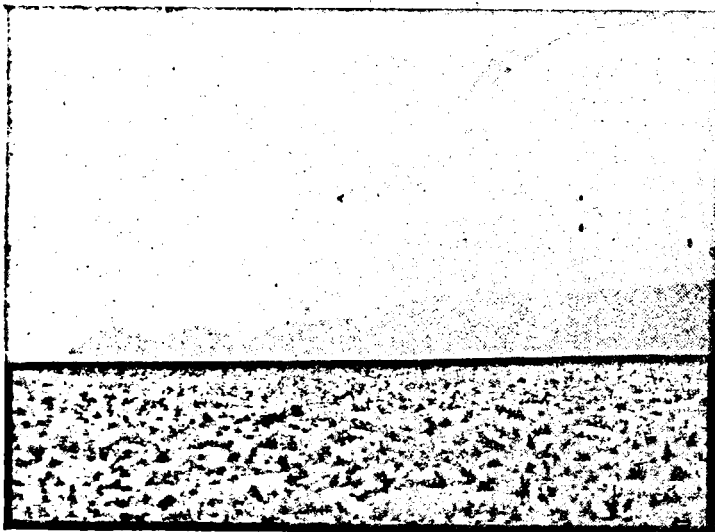
Photograph by V. Sokolov.

Fig. 12. Environs of Nefte-Dag and Boia-Dag; rubble desert near the station Balla-Ishem; on the horizon—mountain Bolshoi Balkhan.

storms. There prevail, apparently, dry easterly winds, which affect some phenomena of the physical geology, for example, the superficial distribution of sands. Westerly winds blowing from the sea contain by far more moisture, but they blow infrequently and cannot markedly mitigate the arid continental climate of the country.

POPULATION. There is no permanent native population in close vicinity to the two mountains, the native inhabitants, the Turkomans, living nearer the railway-line and the mountains Bolshoi Balkhan and Maly Balkhan. The country is desolate on account of lack of water and the absence of pasturage for cattle. There was a temporary working population at Nefte-Dag at the end of the last century, when prospecting operations were going on. But after the latter were suspended, the population disappeared, so that ten years

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later barkhanes of sand were formed within the rapidly ruined buildings, filling them up to the ceiling. It is hardly necessary to mention that the materials necessary for those buildings had to be brought from outside the country, and, generally speaking, it was very difficult to get timber in the district, so much so, indeed, that the buildings at the salt mines in the locality Bala-Khodja had to be erected of slabs of rock salt.

Nefte-Dag

GEOLOGY. Owing to a multitude of surface oil indications in close vicinity to the railway line, Nefte-Dag has more than once attracted the attention of investigators and oil producers, and the number of literary references to that mountain is estimated at more than fifteen articles. In 1908 and 1912 the mountain was thoroughly investigated by K. K a l i t s k y, who prepared a geological map of it on a scale of 1:10,500. The results of the work of this eminent oil geologist were published in the Transactions of the Geological Committee, 1914, from which the following description has been drawn, the work mentioned being the most recent and accurate and at the same time most authoritative.

We are not going to describe here recent sediments, which include barkhane sands, salt lands («shors»), «kir» covers and those different products of desintegration of country rocks, which lie in situ; we only have to note that the country rocks have the following sequence (beginning with the youngest ones).

1. Ancient Caspian sediments (the Quarternary system, Post-pliocene).

2. Rocks of the Baku stage (the Quarternary system, Post-pliocene), consisting of two divisions: the upper division and the lower one.

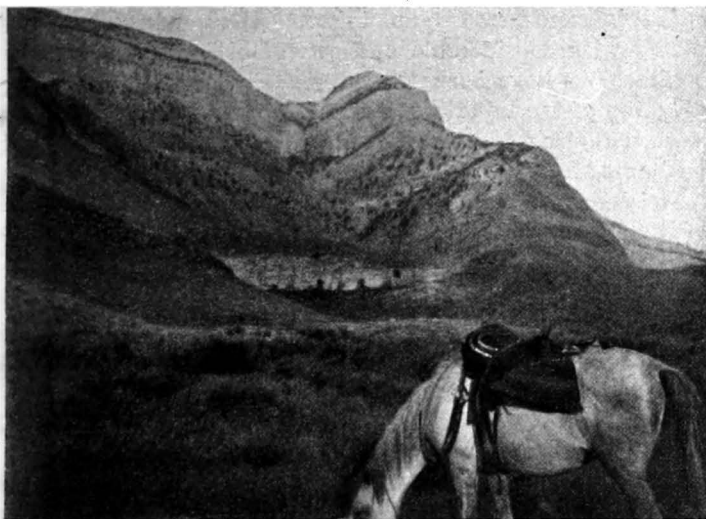
3. Rocks of the Apsheronian stage (the Tertiary system, Pliocene), consisting of two divisions: the middle division and the lower one; the latter is, in its turn, divided into three groups.

Below are described in a more detailed manner the characteristic features of each of the above said subdivisions and their rôle in regard to occurrence of oil.

The Ancient Caspian deposits represented, chiefly, by fossiliferous sandy rocks have not been preserved but as a few patches of remnants, on the elevation of Nefte-Dag. They lie almost horizontally, and are in places impregnated with oil and converted

into extensive «kir» covers. In regard to occurrence of oil the ancient Caspian deposits are of no commercial importance.

The upper division of the Baku stage is represented by a gravel, in which some fossils are found that enable the determination of its age. The gravel belongs to the top of the Upper Baku beds, but occurs only on the periphery of the Nefte-Dag elevation and



Photograph by V. Sokolov.

Fig. 13. Environs of Nefte-Dag and Boia-Dag: mountain Bolshoi Balkhan.

has nothing to do with occurrence of oil. The lower division of this stage underlies the Upper Baku gravel and begins, in its complete form, with clayey sands and pure sands which are underlain by thick plastic clays of a brownish-gray colour, overlying a bed of sand. Further down there are alternating clays and sands, the former predominating, and within them a thick reddish clay is distinguishable which contains *Didacna Baeri* and resembles a similar stratum on the Cheleken Island. At the base of the Lower Baku beds there lies a layer of gravel, which is traceable around the whole Nefte-Dag and, being very resistant to destructive agencies, encircles that mountain by an elliptical ring of diminutive ridges and hillocks. But such a complete section is observed only in the northwestern portion of the mountain, while in the remaining

portions the Lower Baku strata, encircling the mountain, are concealed to a considerable extent by salt soil and sands. These strata are deformed and in places broken by faulting; they are separated from the Upper Baku beds by an unconformity. They are petroliferous in only one place, in the western portion of the mountain, where a big fault trending in a latitudinal direction brought them into contact with the Apsheronian beds. However, the accumulation of oil in these strata is, no doubt, of a secondary character and is related with considerable outflows of oil on the surface, where wide kir covers have been formed.

The top of the middle division of the Apsheronian is represented by alternating clays and sands of grayish shales. Underlying the latter are green and reddish clays with intercalations of sands, the clays resting on strongly argillaceous fossiliferous sands interbedded with pure sands. Still farther down there lies a yellow shell rock with embedded layers of gravel, and clays alternating with clayey sands, underlying which is a compact marl with an abundant fauna; owing to its hardness, it is readily distinguished in the relief of the locality. The Middle Apsheronian is thrown into a multitude of faults, which divide it into separate portions, which are either in contact with each other or are separated by other sediments. However, the distribution of these portions clearly exhibits the general annular aspect. These separate portions, or fields, lie within the belt of the Baku rocks, between the latter and the central portion of the mountain; they underlie unconformably the Baku beds and have a general dip from the center toward the periphery of the Nefte-Dag elevation. Sands and marls of the Middle Apsheronian are in places impregnated with oil; the saturation was a secondary process and took place at different periods of time; thus the rocks in question form indurated, as well as soft and still not compacted «kir» covers.

The rocks of the Lower Apsheronian may be divided into three groups. The upper one is made up of a series of alternating sands, clays and marls, containing layers of gravel and rounded fragments of shells, Apsheronian fossils and even ammonites, crinoids, etc., originating at a place at least as distant as Maly Balkhan. The beds of this series overlie the likewise Apsheronian strata, in many places without any reference to the strike of the latter; they are distinguished by their inconstant lateral extent, rapidly thinning out along their strike as well as down their dip; they have winding edge lines which do not conform to the strike. It may



Fig. 14. Geological map of Nefte-Dag (after K. Kalitsky): 1—Ancient Caspian sediments; 2—the Baku stage; 3—the middle division of the Apsheronian stage; 4—alluvium; 5—clay with ferruginous laminae; 6—gray marl with *Adelina voluta* (4—6 belong to the lower division of the Apsheronian stage); 7)—covers of kir; 8 — outcrops of the oil-bearing strata; 9—faults; 10—hand-dug wells; 11—drill holes. I—IV—oil regions.

be inferred from the foregoing description of this series that it was deposited by an Apsheronian river or, in general, by a permanent or periodical stream. This series extends around the central elevation, being exposed on wide but irregularly shaped tracts, and is extensively broken by faulting; in general, its strata are dipping from the centre toward the periphery. Sands of this series are petroliferous in many places, in the northern and northeastern portions of the mountain and are frequently converted into soft kir covers of relatively recent origin: K. Kalitsky believes this to be a secondary saturation with oil.

The middle, or second, group of the Lower Apsheronian is represented by a bedded dark coloured clay with a reddish shade, abounding with thin ferruginous partings. The clay overlies a black compact marl, which is quite similar to that of the Lower Apsheronian of Cheleken and is the uppermost horizon of the lower group. It is underlain by a compact light-coloured marl (greenish to light-gray) with small ferruginous concretions and fossils (*Adelina voluta*). At last on the south-eastern and north-western slopes of the central elevation there are observed thin bituminous sands embedded in the marls of the Lower group. Sediments of both these groups are widely spread over Nefte-Dag. The lower marls occupying chiefly the central elevation, whereas the middle clay encircles them on their periphery and reaches on the South-West and North-East the very edges of the mountain, where it outcrops beneath the alluvium. Both groups are greatly disturbed. Having been subjected to extensive faulting these beds, are cut into strikingly shaped plots, but as a rule there prevails the previously indicated dip, viz.,— the strata dip from the central elevation toward the periphery. The clay of the middle group is naturally of no value as an oil reservoir, while the lower marls are impregnated with bitumen to a certain depth on the northeastern extremity of the central elevation, in those places where they underlie the wide cover of the Ancient Caspian sands, impregnated with kir.

The marls of the lower group of the Lower Apsheronian lie at the base of the section of the country rocks composing Nefte-Dag. Under them the so-called «blue clays» were encountered at the bottom of only one well (Simonov's well No. 1), which was the deepest (296 m.). These «blue clays» are believed by K. Kalitsky to be nothing else but the equivalent of the Cheleken Fish beds. The section of Cheleken and Nefte-Dag thus closely resemble each other, except that the strata with *Corbicula fluminalis* and the

Upper Apsheronian are lacking in the section of Nefte-Dag. K. Kalitsky holds, therefore, as being quite possible that the Fish beds of the latter mountain may overlie the beds of the red-coloured formation, which contains commercial quantities of oil on Cheleken and is identical to the productive formation of the Apsheron Peninsula.

GEOLOGICAL STRUCTURE. A quite definite idea of the geological structure of Nefte-Dag may be derived from the remarks previously

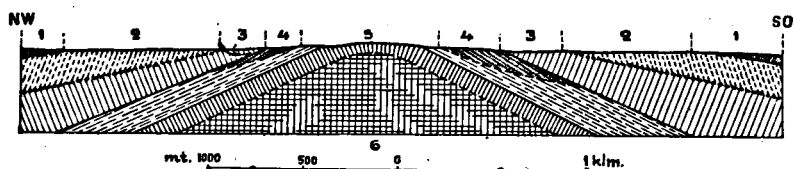


Fig. 15. Generalized section of Nefte-Dag from north-west to south-east (after K. Kalitsky): 1—the Baku stage (upper division); 2—the Baku stage (lower division); 3—middle division of the Apsheronian stage; 4—lower division of the Apsheronian stage (alluvium); 5—the lower division of the Apsheronian stage (clay and marl); 6—red-coloured formation. Faults are not shown on the map, owing to the lack of adequate data.

made concerning the attitude of the separate stratigraphical groups of beds. In fact, the oldest strata lie in the central part of Nefte-Dag and are surrounded on their margins by younger beds,—the general dip of the strata being from the center toward the margins, which corresponds to a structural form representing a short domelike anticline, somewhat elongated in a southwest-northeast direction. But this essentially simple structure is strongly complicated by a multitude of faults striking in various directions, which, however, approach the latitudinal or northwesterly one. The strata composing the mountain have been most thoroughly broken into pieces by this faulting. The chief field of activity of forces causing faulting was the central, elevated portion of the mountain; but the faulting likewise involves the periphery of the latter and even the adjacent plain, where, however, it soon dies out, so that the Lower Baku beds encircle the mountain like a continuous ring. It cannot be doubted that the faults were produced at different periods of time and that the subsequent faulting occurred along the old fault planes, having, however, a diminished slip.

OCCURRENCE OF OIL. The oil indications relating to each of the geological groups have already been described above. K. Kalits-

ky distinguishes on Nefte-Dag four separate fields in which showings of oil are concentrated, such as oil seeps, «kir» coverings, bituminous rocks, etc. Three of these fields are located on the northern part of the annular valley encircling the main elevation, and are outlined on the periphery by an elliptical belt of the Lower Baku gravels. The fourth field lies on the northeastern extremity of the central elevation, over which extends a continuous cover of «kir». This latter field is remarkable for the springs, which issue within the field and in the vicinity of it. Oil and inflammable gases issue from the springs together with the water; they are, in part, hot. Moreover, mud volcanoes, ejecting oil and gases, exist in this field. A feature peculiar to all the fields consists in that the oil is of secondary origin. According to K. K a l i t s k y, the outflows of oil from the depths to the surface took place at the time of the intense deformation which Nefte-Dag underwent. Extensive outflows of oil on flat areas have formed kir covers and facilitated the downward penetration of oil into heading portions of the underlying rocks, provided the latter were sufficiently dry to receive the oil. It is noteworthy that the southern portion of Nefte-Dag is much poorer compared with the northern one in regard to indications of oil.

PROSPECTING AND EXPLOITATION. The following is a brief account of all prospecting and development work carried on in the oil fields of Nefte-Dag. In the western, or first, field there were many years ago numerous wells, which were dug by the Turkomans and ranged in depth from 10 to 15 m., yielding from 80 to 100 kg. of oil per day. One of the wells, 30 m. deep, is reported to have yielded about 500 kg. of oil per day. The oil extracted was exported to Merv and Khiva, where it was used for illuminating purposes and even for curing domestic animals.

During the period 1882—1887 test drilling was conducted on behalf of the Transcaspian Railway, by Konshin and Simonov, engineers, within the 2nd and 3rd fields, at the places of the most copious surface indications of oil, north and northeast of the main elevation. Five wells were sunk in all, one in the 2nd field (Simonov's well No. 3) and four in the 3rd. The former was 113 m. deep and penetrated alluvial deposits of the Lower Apsheonian. It yielded at trial bailing about 50 tons of oil during 45 days, which makes a little over one ton per twenty four hours. Seemingly this well continued flowing later, and a cover of kir was observed around it by K. K a l i t s k y, as well as a pool of liquid oil with-

in the cover. Two wells sunk by Mr. Konshin were 130 m. and 160 m. deep and likewise penetrated alluvial deposits of the Lower Apsheronian, the well No. 1 having been stopped, probably, in the middle division of the Lower Apsheronian. This well was drilled through three oil-bearing horizons and yielded in 1882 from the third one a daily output of 9.8 tons, in 1883—about 6.5 t. and in 1884—about 3 t. This was the most successful well on Nefte-Dag. The well No. 2 yielded in 1884 about 4.9 tons per day. Of the two wells of Simonov, one (No. 2), about 155 m. deep, resembled Konshin's well and was located near it; in 1886 the trial bailing from this well resulted in the extraction of 69 tons of oil with mud and water. The second well (No. 1) reached the greatest depth, viz., 296.5 m., but no oil was extracted from it. Unfortunately, the section of the well has not been preserved, although it is known that at the end of drilling it entered some strata which are probably related to the Fish Beds of Cheleken. The results of test drilling could not have favoured the development of Nefte-Dag oil industry, and although the mountain attracted the attention of producers in subsequent years, nevertheless no further test drilling has been done. In 1923 it attracted the attention of the Mid-Asiatic Railway, and it was intended to drill two deep wells, which, however, to the best of our knowledge, have so far not been sunk.

According to K. Kalitsky, who has investigated Nefte-Dag, the unsuccessfulness of prospecting for oil on that mountain was due to the fact that all test holes have been drilled through the strata in which the accumulations of oil are of a secondary origin. According to K. Kalitsky, these oil pools are connected with outflowing of oil from the depth. He emphasizes the similarity of the geological section of the Nefte-Dag mountain to the section of Cheleken and expresses the opinion that the Fish beds encountered in Simonov's well No. 1 must overlie the strata of the Red-coloured formation, with which, just as on Cheleken, the productive horizons should be associated. The latter served as an original source for such outflows of oil on the surface, as were due to diastrophic disturbances. Thus, the problem regarding the commercial accumulation of oil may be solved by testing those primary petroliferous deposits which are supposed by the said geologist to underlie the strata of the Lower Apsheronian. According to K. Kalitsky, the most favourable place for drilling to test this territory is a large field covered by kir, northeast of the main summit, on the crest of the Nefte-Dag elongated dome; con-

sidering that Nefte-Dag resembles as to oil-bearing horizons, the western, commercially important, portion of Cheleken, he believes that Nefte-Dag will give results at least as satisfactory as those attained on the latter.

THE COMPOSITION AND COMMERCIAL VALUE OF THE OIL. So far as the qualities of the Nefte-Dag oil are concerned, K o n s h i n reported in 1888 that oil derived from the deepest horizon of his well (130 m.) had a specific gravity of 0.875, contained 30 per cent of light distillates, the residuum being a thick dark-brown liquid. In 1898 a more complete analysis was made by K; K h a r i c h k o v; the results were as follows: specific gravity—0.8736 at 15°C. A fractional distillation yielded:

Fractions.	Yield (per cent).	Sp. gravity.
1. Below 100°C	0.3 (benzine)	
2. 100 to 150°C	4.8 (ligroin)	0.754
3. 150 to 270°C	17.9 (kerosene)	0.8171
4. 270 to 310°C	7.8 (solar oil)	0.840

The residuum had a specific gravity 0.9144 and contained 40 per cent of paraffin.¹⁾

In K. K h a r i c h k o v's opinion this oil yields little kerosene (15 per cent of the first grade or 22 per cent of the second grade), which is, however, of a good quality, and is not fit for the preparation of lubricating oils. An excellent vaseline may be obtained from this oil (the quantity of the former amounting to 36.15 per cent of residuum or 27.2 per cent of petroleum) as well as paraffin oils. Moreover, the oil which overflowed from Simonov's well No. 3 in August 1911 had a specific gravity of 0.8807. It is to be mentioned that an experimental refinery was constructed in 1882 at the Balla-Ishem station, where 58.3 tons of petroleum were distilled and 12 tons of kerosene were obtained, having specific gravity 0.818, the yield of kerosene being, thus, about 20 per cent.

¹⁾ In K. Kharichkov's book: «On the composition and commercial properties of Russian oils» (1902) there seems to be a discrepancy as to paraffin content, viz., in one place he speaks of 2 per cent of paraffin, meaning, apparently, the paraffin content of petroleum as such; in another place, speaking of residuum, he gives the figure 4 per cent (p. 125), while at the end (p. 127) he says that the residuum solidifies at +12°C «owing to the presence of 40 per cent of paraffin»; it is possible that the latter amount is not an erratum, but is made tenfold in accordance with the results of the steam distillation at temperatures over 270°C.

OZOKERITE. Describing Nefte-Dag, we cannot avoid mentioning that besides petroleum, deposits of ozokerite have been long since known to exist on the mountain. Ozokerite (mineral wax) occurs chiefly in veins and intercalations on the mentioned large kir cover of the central elevation; small ozokerite balls are carried out by spring water. Such deposits are genetically connected, just as on Cheleken, with the deposits of oil of paraffin base. Its properties proved quite satisfactory, vis., according to Konshin and Letny the natural ozokerite has specific gravity 0.95, melting point 62°C, contains 11 to 12 per cent of sand, and yields 62 to 63 per cent of ceresine and 23 to 25 per cent of liquid oils. Small quantities of ozokerite have long since been extracted by the Turkomans for their domestic uses, but the deposits have not been exploited on a commercial scale. A cursory search was carried on in 1881 by Konshin, but it was not sufficient; thus, the deposits of ozokerite are practically untested thus far. The most favorable area for testing is, according to K. Kalitsky, the «kir» cover mentioned above; the uppermost points of the latter are believed by him to correspond to the places of former effusions of oil, because the cover has not been disturbed.

Boia-Dag

GEOLOGY. Contrary to Nefte-Dag, the literature concerning Boia-Dag is exceedingly scanty; there are only two articles concerning it, which have been written by H. Sjögren (1887) and K. Kalitsky (1914). The work of the latter author is more complete and contains more accurate data. According to it, the mountain consists of two portions,—the eastern and western one, which are separated by an oblique fault trending southeastward. The central part of the western portion is made up of clays and sands, referred by K. Kalitsky to the Apsheronian stage and overlain by thick gray and brown clays and marls. The latter are unconformably overlain, on their marginal part, by a series of brown clays interstratified with sands, filled with concretions; the age of the latter cannot be accurately stated: possibly it is the freshwater facies of the Baku stage or it may be even younger, being equivalent to the beds with *Corbicula fluminalis* of Cheleken; it may likewise belong to the Apsheronian. Amid the Apsheronian clays and sands there are projecting thick sands, which are outlined by faults and forming horsts; their age is also undetermined, but they are the oldest rocks on Boia-Dag. The eastern

portion of the mountain is made up of the same alternating beds of brown clays and sands, as border the Apsheronian formation of the western portion. A salient feature of the southern slope of the eastern portion is a triangular area composed of a dense gray marl with ferruginous concretions and layers of black sandstone belonging to the Apsheronian stage. Sandy and argillaceous rocks of unknown age join the eastern part of the mountain from the north; they begin with a ferruginous sandstone containing gravel; these rocks unconformably overlie the series of brown clays alternating with sands. Both in the western and eastern portions the strata are involved in a short anticline trending almost east to west; the beds are dipping distinctly from the middle part of the mountain toward its periphery. This fold is cut by a set of dip faults, which have formed several horsts and grabens; but the anticlinal structure of each horst and graben is readily observable, because the faults strike at a right angle to the axis of the fold. The main fault crosses the mountain, as previously stated, in an oblique direction, and the eastern portion is, in relation to the western one, a sunk wall of the fault.

The above mentioned western columnar elevation Kara-Burun represents an agglomeration of fragments and boulders composed chiefly of calcareous sandstones; this elevation is surrounded by rocks of the Apsheronian stage. Both investigators mentioned above agree in that it is a neck of an ancient mud and gas volcano, the neck being open due to destructive agencies, which cut away the Apsheronian rocks, in which the neck had once been enclosed. Around the neck a group of salt and ferruginous springs are situated, which eject also inflammable gas; the water is of a high temperature which reaches 60.5°C. The water of some springs is not mixed with oil, but in others oil issues together with water and forms films on the surface of the latter. Gases of some springs do not smell like those associated with petroleum such as, for example, gases issuing from oil wells, but in other cases they have an odour of petroleum. Some springs yield considerable quantities of water which flows down the slope as rivulets; salt and ferruginous sediments are deposited on the beds of the latter. At least a part of springs are evidently associated with faults. Beside Kara-Burun, there is still other group of springs, which are situated on the southern slope of the main elevation of Boia-Dag, in thick sands which crop out in horsts and grabens of the central part of the mountain. This latter district is remarkable for the presence of hot and cold sul-

phurous springs, which are lacking in the vicinity of Kara-Burun and which do not carry up films of oil, although they exude inflammable gas.

OCCURENCE OF OIL. With respect to occurrence of oil K. Kalitsky distinguishes three fields on Boia-Dag. The first field is situated in the vicinity of the easternmost elevation, which has

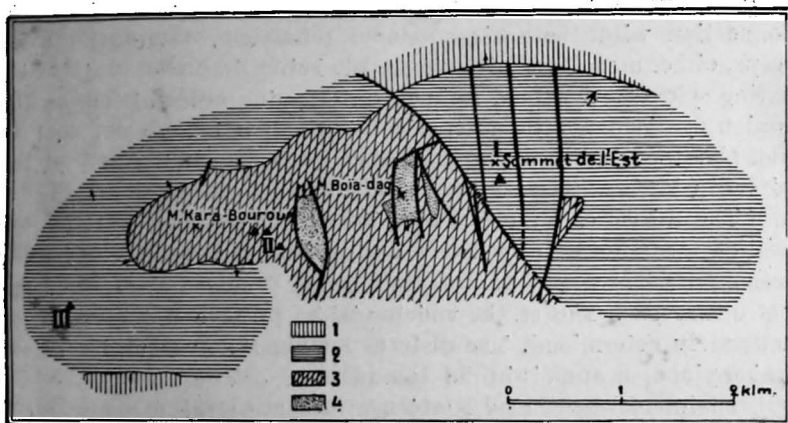


Fig. 16. Geological map of Boia-Dag (after K. Kalitsky); 1—arenaceous and argillaceous rocks of unknown age; 2—formation of brown clays and sands of unknown age; 3—clays, sands and marls of the Apsheronian stage; 4—sands of unknown age; ▲—oil and gas seeps; I—III—oil regions. Black lines indicate faults.

a flattened relief and represents an exposure of thick sand impregnated with oil. This field includes both slopes of the mountain and is delimited—however, not quite exactly—by two faults trending longitudinally. Beds of sands crop out there, which are interbedded with clays and vary in thickness from 1 m. to 6.4 m.; the sands are more or less oil-stained and represent oil reservoirs of two kinds: either they are oil-bearing strata *sensu stricto*, which have the thickness just indicated, or else pockets and lenses of oil-bearing sand are included in the rocks devoid of oil. It is curious to note that such oil-bearing lenses are projected in some places, and have an aspect of rather odd columns, the rock which once surrounded them having been eroded. Some thin veins of ozokerite were found there, demonstrating the high paraffin content of the Boia-Dag oil. The oil-bearing strata of the first field are primary reservoirs of oil, which is evidenced by the presence of the oil-bearing lenses, and belong to a series of brown clays, the age of which

is unknown: but they are probably younger than the Apsheronian.

The second field is situated between the main elevation (Boia-Dag) and the western one (Kara-Burun), at a distance of approximately 1 km. west of the former. In this field there are several pits containing salt water; oil and inflammable gas, having odour of oil, issue from the latter, as has been already mentioned in connection with the springs near Kara-Burun. Some strong gas seeps, either associated with oil or not, being fired are burning with a fine splendid flame. A strip of outcropping sands of the Apsheronian age is likewise situated in this field; it is over 100 m. long and about 40 m. wide, and abounds with seeps of oil and gas from pits filled with water.

The third field, the last one, lies on the extreme southwestern end of the mountain, where many small mud volcanoes issuing inflammable gas may be observed, as well as large seeps of dry petroleum gas. The strata which yield gas have not been so far accurately determined. These strata may be the Apsheronian sands, which yield gas and oil in the second field, or else sands embedded with series of brown clays, which are of the same age as the oil-bearing strata of the first field. Either solution of the question will involve essentially different practical consequences, inasmuch as in the first case test wells will have to be driven to a depth of about 420 m., while in the second case gas-bearing strata may be encountered at a small depth.

No test drilling has been done on Boia-Dag, and the possibility of obtaining oil in commercial quantities has not been verified thus far. K. Kalitsky devotes, in his article, much attention to the question whether the oil accumulations on Boia-Dag are primary or secondary ones, and comes to the decision that those accumulations are of primary origin. His arguments must be acknowledged to be conclusive, but the practical consequences of such a solution of the question are, unfortunately, rather unfavourable. In fact, at an assumption that the oil of the above discussed pools is of primary origin, its reservoir rocks should belong to the Apsheronian or even to younger strata, with which no prolific oil horizons are associated either on Nefte-Dag or on Cheleken. We know that the horizons which are the most important ones from a commercial viewpoint belong to the uppermost portion of the Red-coloured formation and may be disclosed on Boia-Dag only by drilling deep wells. It is possible, however, that a de-

tailed prospecting, of which this mountain is, no doubt, worth, may reveal some more productive horizons, inasmuch as, e. g., on Cheleken the Apsheronian oil has some commercial value. Furthermore, it is not improbable that a thorough investigation may discover on Boia-Dag some commercial deposits of ozokerite, because indications of the latter have already been found, and the area of oil seeps east of the Kara-Burun elevation seems to be sufficiently favourable for this.

Future possibilities of the district

At the first impression Boia-Dag, Nefté-Dag and Cheleken (Chokhrak), rising amidst the plains, may be taken for remnants of a great mountain system which has been cut down by eroding agencies and possibly was once connected with the mountains Bolshoi Balkhan and Maly Balkhan, lying to the east of the above named elevations. Such a view has been held by some authors with regard to the origin of these elevations. K. Kalitsky was the first to express a quite different idea; notably, he holds that these isolated elevations arose as a result of subterranean volcanic intrusions, which, even though they did not succeed in reaching the surface, have uparched the overlying rocks; the latter have formed dome-like uplifts, which were broken by faulting, when being raised. The following facts present positive evidence in favour of such an idea: an absolute structural isolation of each of these elevations, which are characterized by the utmost intricacy of their structural features in their interior portions and the dying out of such features toward the periphery of the elevations; the existence, within each of the latter, of springs of mineral water, which are in general associated with faulting, the existence of springs with hot water, which must be considered to be juvenile, etc. It is quite natural that the oil-bearing horizons proved to be among the strata which were uplifted by the said intrusions; the most important of these oil-bearing horizons are found in the Red-coloured formation, which is, to all probability, equivalent to the productive beds of the Apsheronian Peninsula. Furthermore, the faulting of petroliferous strata and beds overlying them brought about outpourings of oil upon the surface and the formation of kir covers over the latter, as well as the sealing of fissures by ozokerite deriving from the paraffin bearing oil. Nefté-Dag and Boia-Dag belong, consequently, to those places, where, in virtue of natural

conditions, the productive strata proved to be nearer the earth's surface, compared with the same strata in the surrounding plains. This condition has to be regarded as a highly favourable one from a commercial standpoint, because owing to it we can reasonably expect to encounter commercial accumulations of oil at quite accessible depths in both localities referred to. According to the data of the Cheleken geological section, the aggregate thickness of the Baku and Apsheronian rocks overlying the productive horizons of the Red-coloured formation amounts to 800—850 m., but these figures represent the maximum thickness; and, so far as Nefte-Dag and Boia-Dag are concerned, where many of the beds of those formations are lacking, this figure will probably prove to be more moderate ¹⁾.

SELECTED BIBLIOGRAPHY

A list of references for Nefte-Dag and literary digests is found in the book of K. Kalitsky referred to below, which is a fundamental work on Nefte-Dag; we need not, therefore, enumerate these references in this place.

1. K. K a l i t s k y. Neftianaia gora (The Oil Mountain) in the Transcaspian Region.—Transactions of the Geological Committee, No. 95. 1914.

As to the latest literature, the most valuable data are contained in a work by the same author:

2. K. K a l i t s k y. The Transcaspian Region. The Petroleum and Oil-Shale Industry, No. 7—8, 1922.

There are only two articles concerning Boia-Dag:

1. H. S j ö g r e n Ueber das Transkaspische Naphtaterrain.—Jahrbuch d. K. K. Geolog. Reichsanst. XXXVII. 1887.

2. K. K a l i t s k y. Boia-Dag. Bulletin of the Geological Committee. XXXIII. 1914.

¹⁾ The mountain Monjukly is sometimes cited in lists of oil fields of the eastern shore of the Caspian Sea. The mountain lies amidst a plain, 18 km. southwest of the station Balla-Ishem. In the main, it resembles Nefte-Dag or Boia-Dag and is made up of the Baku and Apsheronian beds, which form a dome cut across by large faults. Toward the end of the first decade of this century reports were circulating concerning the discovery of oil on that mountain, and the mountain was covered by prospect oil claims. This induced the Geological Committee to undertake an investigation in 1913, which was carried on by K. K a l i t s k y (see Bulletin of the Geological Committee, XXXIII, 1914, p. p. 1221—1231: «Kum-Dag and Monjukly») and showed that there are no showings of oil on that mountain, nor are there any data indicating the existence of subterranean reserves of petroleum. Although the uprise of Monjukly must also be attributed to a magmatic intrusion, but in this case the latter apparently took place under a place where no oil was present; consequently, so far there is no reason for including Monjukly in a list of oil fields.

4. THE CHIKISHLAR OIL REGION

General description

Chikishlar is a small fortress with a wharf, located on a low shore of the Caspian Sea, about 320 km. south of Krasnovodsk, a short distance to the north of the Persian frontier of the Union S. S. R. It is at present within the Krasnovodsk district of the S. S. R. of Turkmenistan. Close to the fortress there is a poorly organized settlement serving as headquarters for the local administration, with a Russian population estimated at a few hundred. The sea-shore here has a straight outline and is so shallow that steamers have to anchor at a considerable distance from Chikishlar. The monotony of the shore-line is interrupted only by a long and narrow bay, Hassan-Kuli, the inlet to which is located about 20 km. south of Chikishlar. The Atrek river, which is a part of the boundary between this country and Persia, discharges its waters into this bay, which is important for fish-trade, but is inaccessible for sea-ships on account of its extreme shallowness both at its entrance as well as in its interior (0.6—1.2 m.).

In the neighbourhood of Chikishlar there lies a low desolate plain, which has emerged from the Caspian Sea at a comparatively recent time; this is evidenced by vast agglomerations of hitherto living marine shells far inland from the present shore line. This plain has a sandy soil and is covered by a scanty and monotonous vegetation of bushes. The valley of the Atrek river has a quite different aspect, and, owing to the abundance of fresh water, there are grown cereals and cultivated orchards, gardens and cotton plants. The native population consisting of Turkomans is concentrated in this valley, whereas it becomes very scarce north of Chikishlar. The climatic conditions in the Chikishlar region, situated between 37°30' and 38° north latitude, are more favourable, as compared with those of the previously described oilbearing regions of the Caspian coast, lying north of the Chikishlar region. The latter receives a greater amount of rainfall. The sea does not freeze at all.

WAYS OF COMMUNICATION. In prerevolutionary times Chikishlar was connected with Krasnovodsk by regular weekly steamship voyages, but at present the regular steamship navigation is not yet reestablished here. The passenger and cargo traffic through Chikishlar is greatly impeded by the lack of a protected haven and by the shallowness of the sea off Chikishlar. When the sea is very

rough, the steamers do not touch at Chikishlar at all, but even in fine weather they drop anchor in the roadstead a few kilometers from the shore, and the transportation of passengers and cargo is conducted on sailing boats owned by Turkomans. A highway leads inland, connecting Chikishlar with the Bami station of the Mid-Asiatic railway, which is situated at a distance of 390 km.

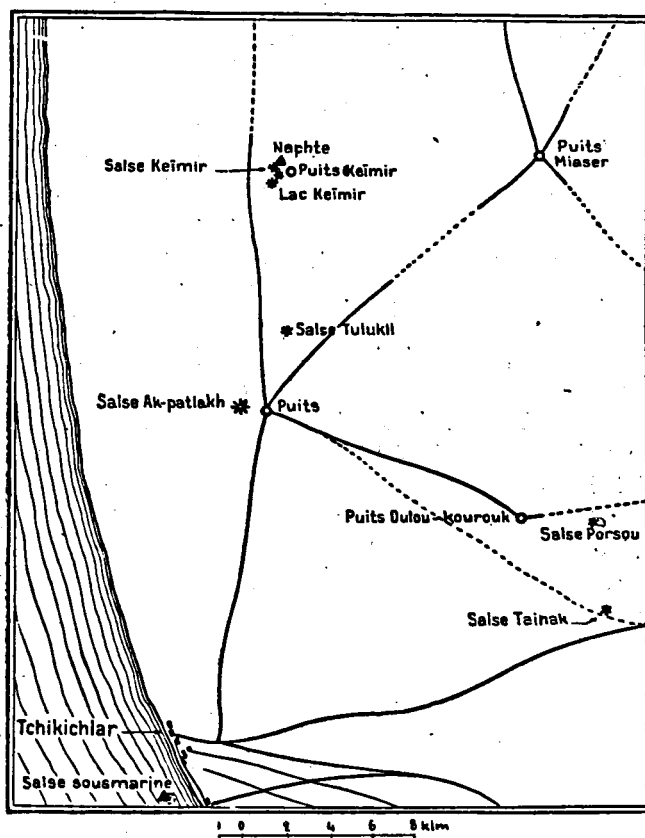


Fig. 17. Map of the Chikishlar region:
▲—Oil and gas seeps.

from Krasnovodsk. This road is 360 km. long, but it is not now in a satisfactory condition; the transportation on it is not organized, so that it is nothing else but a caravan route. This road may be likewise taken to reach the town Kizil-Arvat, on the same railway line (336 km. from Krasnovodsk), which is connected with Chikishlar by a telegraph line.

Geology and occurrence of oil

On the coastal plain north of Chikishlar there are many hillocks of more or less regular conical shape, which are nothing else but active or extinct mud volcanoes. The latter were investigated in 1913 by K. Kalitsky, on behalf of the Geological Committee, and the following description is based on the report of this geologist. Among the mud volcanoes, those of Keimir are especially of importance; the said volcanoes are known for their positive indications of oil; they lie near the Keimir water wells, 29 km. northeast of Chikishlar and 10.5 km. from the sea-shore. They may be reached from Chikishlar by caravan route on horseback or on camel-back. These volcanoes do not project above the surrounding plain, but are located in a shallow depression, amidst sands covered with scanty vegetation, so that they are not easily reached without the assistance of guides acquainted with the neighbourhood. The volcanoes represent, in fact, a flattened gray cone covered with salt efflorescences; there are four craters on the cone. The northernmost crater (its diameter was 10.6 m. in Mai 1913) issues gases, but no oil is observable there. The second crater (its diameter was 7.4 m. in Mai 1913) lies close by, south of the first, and does not yield either gas or oil, water flowing from it northeastward. Farther southward there is a crater which presents a combination of two intersecting circles of different diameters and is filled with water which runs down westward into the crater lake close by. It exhales gas energetically; a muddy froth with oil flows on the surface of the water, while around the latter, on the border of the volcano, a fringe of thick oil is deposited. The fourth crater, or crater lake, is situated west of the three craters which have been just mentioned, and is about 80 m. in diameter. Gas likewise issues from this crater and petroleum froth flows on the water, but the latter may have been derived, like the water, from the third crater. Northwest of the described group of craters there is a fifth one, which is the largest and forms a combination of a number of craters which have successively subsided. The active crater is situated in the center and is filled with water having no outlet, its level being 7.5 m. below the edge of the old crater, which is the largest. Gas issues from the water, and a muddy froth with oil flows on the surface of the latter; around the present crater there are a few minor mud volcanoes, which eject mud, inflammable gas and sometimes small quantities of oil. The edges of the old crater

are composed of sand impregnated with kir. North of it, close by, there is a filled crater, the sixth; it is made up of a finegrained bituminous sand, which is easily driven by wind. Some fossils (*Didacna trigonoides*, *Dreissensia polymorpha*, etc.) occur in this sand, which resemble the fossils from the beds with *Corbicula fluminalis* of the Cheleken Island; the latter beds are referred to the Post-Pliocene and are older than the deposits of the Ancient Caspian transgression and younger than the beds of the Baku stage. Near the sixth crater there is a funnel-shaped hole, which is almost as large as the latter, but is of no importance.

There are, thus, on Keimir seven craters, which may be subdivided into two groups; oil issues from three craters, and four issue inflammable gas.

Besides the Keimir mud volcanoes, there are many others in the neighbourhood of Chikishlar; the largest of the latter mud volcanoes is Bely Bugor (White Hillock) or Ak-Patlak, 17 km. north of Chikishlar, 60 m. high. This is the most conspicuous elevation in the district of Chikishlar, well observed from the sea and marked on sea-charts as a guide point. Ak-Patlak does not eject either oil or gas, but is of interest, because some pieces of rock with fossils have been found in the material thrown out by it; the fossils being of the same age as those previously indicated for Keimir. We shall not describe the mud volcanoes Tulukly (4 km. northeast of Ak-Patlak), Porsu (5 hours ride on camel-back east of Chikishlar) and others, as they have no indications of oil, although on Porsu gas issues from water and the previously named fossils occur in massés ejected by the volcano. We shall mention the so called Kipiashchy Bugor (the Boiling Hillock) situated at a distance of 10.5 km. from Chikishlar, towards the Hassan-Kuli Bay. This hillock lies on the sea-shore and appears as a group of active mud volcanoes ejecting mud and gas; but the latter is not petroleum gas; it is apparently marsh gas mixed with sulphuretted hydrogen and other gases and is derived from youngest beds lying at a small depth, because the only shells carried by the ejected products are the shells of now living forms.

Furthermore, there is a submarine mud volcano about 6 km. south of Chikishlar, near the shore; the volcano forms a hole 6.5 m. to 8.5 m. deep in the sea bottom, where the depth of water is only about 1.5 m. This mud volcano manifests itself by issuing bubbles of gas and, sometimes, petroleum, according to Turkomans' tales. During the periods of eruption gas is ejected very strongly. Accor-

ding to fishermen's statements, there is still another large submarine mud volcano, about 65 km. from the shore, discharging oil, which affects the sea waves in a calming manner, when the sea is rough.

The foregoing is all that is known about indications of oil in the Chikishlar district. The territory has never been tested by drilling and the strata from which this oil is derived are not identified. A geologist who attempts to study the geology of the territory will find himself seriously handicapped, because the coastal plain over which the mud volcanoes are spread is composed of only recent deposits with *Cardium edule* and, consequently, has emerged from the sea at a recent period. We do not know what are the strata that lie deeper in the earth's crust; only the ejected material enables to conclude that those strata should contain beds with *Corbicula fluminalis*, which are referred to the Postpliocene. The geological structure of the strata which lie concealed at greater depths is likewise unknown; for, whereas the recent sediments rest quite untilted, a variety of diastrophic phenomena may have deformed the older strata; and the topographical features produced by such deformation may have been obliterated by the sea abrasion in a later period, when the sea was spread over a wider area than at the present time. We have, thus, to draw a final conclusion from what has been stated above that the geology of the Chikishlar district can be disclosed only by drilling prospect holes; otherwise all considerations concerning the composition and sequence of the rocks involved in the geology of the district, their attitudes and oil bearing horizons will remain absolutely groundless. The fact that the strata of the region are so little exposed is to some extent a favourable factor, allowing the conservation of oil in reservoir rocks, whereas in those territories where the beds are well exposed oil is liable to be wasted by loss of gases and outflow. As may be inferred from the data indicated above, the surface indications of oil are rather feeble in this district, but this does not mean that the reserves of oil are poor, because no correlation is known to exist between the subterranean reserves of petroleum and the surface indications of the latter; consequently, the character of the petroliferous deposits of the Chikishlar district cannot be ascertained otherwise than by test drilling.

Furthermore, if considerable quantities of inflammable gas are discovered in the district under discussion, this gas may be utilized for further field operations as well as for heating and illu-

minating purposes in this province, where the region of the Atrak river and Hassan-Kuli Bay has, owing to natural conditions, a chance of successful development und progress.

Future possibilities of the district

So far, the commercial value of the Chikishlar oil is entirely unknown. In this respect of all the previously described regions only Manghyshlak may be compared to Chikishlar, while there is a sufficient quantity of fundamental data to form a positive idea of the possibilities of the Cheleken, Nefte-Dag and Boia-Dag oil regions. But the Chikishlar region differs from Mangyshlak in that the oil horizons of the latter are seemingly associated with the Mesozoic strata and have quite a different character, resembling the region of the Ural and Emba on the northern shore of the Caspian Sea. Anyhow, it can hardly be doubted that Chikishlar lies within the region of the development of productive petroliferous strata belonging to the Tertiary and Post-Tertiary and embracing the whole of the southern half of the Caspian Sea. It is possible that the paying quantities of oil lie on the eastern sea shore in the horizons which are stratified not above the Red-coloured series, which is equivalent to the productive series of the Apsheron Peninsula; but, according to the section of Cheleken (see p. 20), the thickness of the strata overlying the latter formation is estimated at 800 to 850 m.; these figures should be taken into account in starting to search for oil in the neighbourhood of Chikishlar. On the other hand, it is not, of course, impossible that the Red-coloured series will prove to be nearer the land surface, owing to the absence of some part of the overlying beds, the decrease of the thickness of the latter or some structural features. Such a hypothesis is corroborated by the fact that no mud volcanoes are so far known to exist on the territory between the Chikishlar district and Boia-Dag, while on Boia-Dag, Nefte-Dag and Cheleken such mud volcanoes are associated with certain upheavals of the earth's crust. The subsequent development of the recent sediments may have levelled the present surface. At any rate, it may be inferred from the foregoing description that the Chikishlar region is unquestionably worthy of being prospected for oil.

SELECTED BIBLIOGRAPHY

There are but few references for Chikishlar, the following being their complete list:

1. F. Maievsky. The Mineral Resources of the Transcaspian Region. 1897. (page 34).
 2. Prince V. I. Massalsky. The Country of Turkestan. «Russia», edited by V. P. Semionov-Tian-Shansky, XIX. 1913.
 3. K. Kalitsky. Mud volcanoes in the neighbourhood of Chikishlar.—Bulletin of the Geological Committee. XXXIII. Pp. 473—493. 1914.
 4. K. Kalitsky. On Chikishlar gas-bearing district.—Ibidem. Pp 1129—1148. 1914.
 5. K. Kalitsky. Oil fields of the Transcaspian Region.—Natural Resources of Russia. Vol. IV, 22. p. 92. 1918.
 6. K. Kalitsky. The Transcaspian Region.—The Petroleum and Oil-Shale Industry. Nos. 7—8 1922.
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THE COUNCIL OF PETROLEUM INDUSTRY

A. PRITULA

MINING ENGINEER

THE FERGANA OIL REGION

With 15 figures and a map

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GENERAL DESCRIPTION

Geography. The Fergana oil fields are located in the Fergana region, which is now within the Uzbek Soviet Socialist Republic; the fields may be divided into three groups, each comprising several fields.

The first, southern, group includes six most important oil fields: Tash - Ravat, Sel - Rokho, Shur - Su, Kamysh - Bashi, Rishtan and Chimion; two of these fields, viz. Sel-Rokho and Chimion, were producing oil for many years and have given positive evidences of commercial reserves of oil.

The northern group consists also of six fields: Maili-Sai, Piteu-Sai, Encunim-Sai, Shing-Sai, Maili-Sai, Kulmen. None of these fields have yet been developed.

The eastern group comprises two fields: Changyr-Tash and Tekebel.

As shown on the accompanying map, the oil fields are confined to relatively small areas, especially those of the northern and eastern groups. All the fields lie near the Mid-Asiatic railway line. Thus, the Sel-Rokho field (the Santo property) is situated 14 km. south of the Melnikovo station, and the Chimion oil field—19 km. south of the Vannovskaia station. The oil fields of the northern, remotest, group, is at a distance of 21 km. from the Uch-Kurgan station. The Changyr-Tash field of the eastern group lies at a distance of 6—7 km. from the railroad.

Ways of communication. On a general map may be seen the situation of Fergana oil fields in relation to the sea-ports for export trade (Batum and Poti) and the wharfs of the Volga river (Samara), as well as to the main water way of the U. S. S. R.,—the Volga river and its mouth.

The shortest way for shipping petroleum products from the Fergana region to the foreign market is as follows: by the Mid-Asiatic railway to Krasnovodsk, next by sea to Baku and finally—

transportation by the railroad tank-cars or pipe line to Batum. The distances are: from the stations Vannovskaia or Melnikovo to Krasnovodsk 1,955 or 1,850 km., and from the same stations to Samara—2,622 or 2,517 km.

Although the Fergana region is bordered by China (Kashgar) on one side and by Afganistan on the other, and is in the immediate proximity to India, the boundaries separating the region from these countries extend along the almost impassable mountain

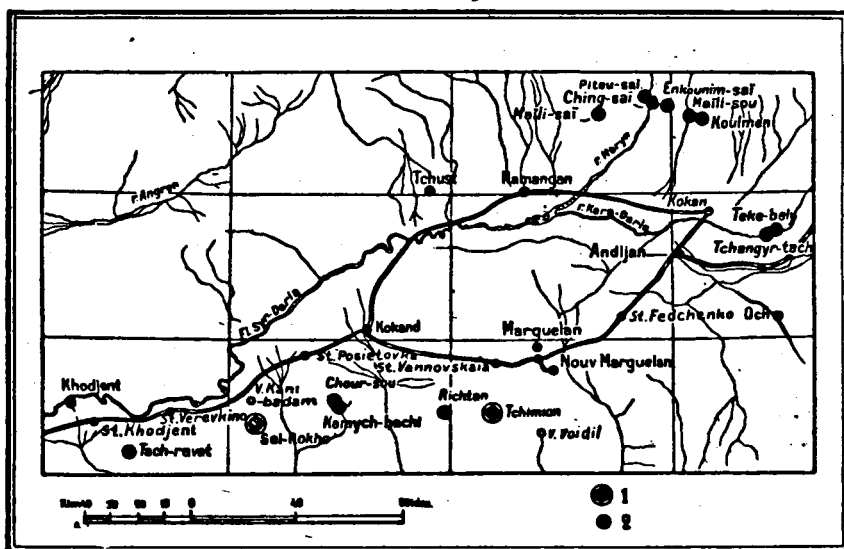


Fig. 1. Map of the oil fields of Fergana: 1—producing areas; 2—oil fields.

ranges of Pamir and its spurs, which border the Fergana depression on the south.

Thus, the remoteness of the Fergana oil fields from ports of exportation to Europe (Batum), the inaccessibility of the boundaries of the neighbouring countries, which hampers extensive trading operations, and finally the small consumption of oil products in those countries,—all these circumstances lead to consider the fields under discussion as being only of domestic importance, inasmuch as their products are marketable only on the territory east of the Caspian Sea. Nevertheless, this circumstance in no way restricts the development of the oil industry in the Fergana region, because the consuming capacity of the local market is so large, as to easily absorb all the production of the local oil fields during

the first period of their development; and the natural resources of the Fergana region are so large, that the future growth of its industry warrants the consumption of the whole production of the local oil fields. It should be added that formerly only 10 per cent of the Turkestan demand of oil products was covered by local production; the rest had to be imported from Baku.

Orography. The Fergana region is a depression measuring 250 by 100 km. and surrounded by high mountain ranges. On the north and east it is bordered by the Chatkal and Fergana ridges, which are offshoots of Tian-Shan; on the south it is confined by the Altai mountain range; beyond the latter lies the mountainous region of Pamir extending almost to India. On the southwest the region is separated from Eastern Bukhara and the Samarkand region by the Turkestan range. Only on the west the narrow valley of the Syr-Darya river serves to join the Fergana region with the Syr-Darya and Samarkand regions.

The oil fields are located on the edges of the Fergana depression: on the foothills of the Alai range (the southern group), as well as of the Fergana range (the eastern and northern groups).

As has been already stated, all the above said fields are situated in an immediate proximity to the Mid-Asiatic railway, with which they are connected by macadamized and common cartroads; goods are transported in motor-cars or teamed wagons; these roads are now kept in full order.

Population. The Fergana region has a thick population which consists of various nationalities, and has a density ranging from 30 to 36 persons per square kilometer, excluding the almost desolate Pamir. The most densely populated are the Kokand and Margelan districts. The various nationalities of the region are numbered as follows (statistics for 1912):

Russian and Ukrainian	10,000	0.64%
Uzbeks	943,000	60.60%
Tadjiks	114,000	7.33%
Kashgars and Karakalpaks	26,000	1.67%
Kara-kirghises.	202,000	13.00%
Turko-tartars	261,000	16.76%
	<hr/>	
	1,556,000	100.00%

The oil fields lie in the most densely populated districts (36 persons per square kilometer). In the villages surrounding the oil deposits live Uzbeks, Tadjiks and Kara - Kirghises. Natives gene-

rally are employed as common labourers. However, they furnish also such qualified labourers, as pumpers, drilling workmen, tool-dressers, masons and carpenters. The percentage of native labourers employed in the oil fields reaches approximately 50 per cent of the total number of oil field workmen.

Skilled labour for deep drilling is supplied by Persians; workers of various nationalities usually coming from Baku are engaged as locksmiths, turners, engine fitters, machinists, blacksmiths, founders and carpenters. The close vicinity of populated localities solves the question of supplying the oil fields with common labour and considerably simplifies the housing problem, inasmuch as most workmen reside their villages.

Water is found in sufficient quantities in all inhabited localities; there is no difficulty in providing the oil fields with victuals.

Building materials are found in the Fergana region in abundance. Limestone used for the preparation of unslaked lime, as well as sand and clay, are to be found in the vicinity of the oil fields. Raw bricks made of Turkestan clay and dried in the open air constitute a good building material. For plastering purposes gypsum is used, deposits of which are found in every part of Fergana.

All the foregoing leads to the conclusion that in the Fergana region there are present all the conditions favourable for its industrial development.

Among the oil fields mentioned above only two are producing oil on a commercial scale, viz. the Sel-Rokho and Chimion oil fields.

GEOLOGY

The oil-bearing formations of Fergana consist mainly of Tertiary strata, viz. Oligocene and Eocene.

The upper part of these strata is characterized by its red colour due to the ferric oxide compounds, while the lower part is green coloured by ferrous oxide compounds. This green formation is known as the Fergana stage and contains oil-bearing horizons.

A geological column of sediments involved in the geology of the oil fields is here given (fig. 2) which has been drawn by K. P. Kalitsky for the Tertiary formations of Rishtan. In this section the letters l, m, n, o, p, q, r indicate the key horizons traceable throughout the oil-bearing areas of Fergana.

I. Post-Tertiary sediments.

1. Gray gravels and conglomerates.

II. Tertiary sediments.

A) OLIGOCENE

2. Brick-red clay interbedded with thin layers of gypsum. The clays are homogenous, only in the lowest part of these strata there are sandstones of the same brick-red colour. The thickness of clay strata is in places very great and attains 300 m., e. g. in the Chimion field.

3. The sand «r» is up to 40 m. thick. This horizon is in places waterbearing or stained with oil; in other places it contains neither water nor oil.

4. Crimson clays «q»—a homogenous and thick horizon in which are interstratified layers of hard sandstone and oyster limestone, consisting of *Exogyra ferganensis* and *Exogyra galeata*; fragments of *Pecten* Sp. and teeth of sharks are also found. Locally gypsum veins are observed. The thickness of the clays «q» reaches 40 m.

5. Pale-green marl, approximately 4 m. thick.

6. The horizon «p»,—a constant horizon throughout Fergana—is a layer of greenish-yellow colour, with ochrous spots and thin intercalations of yellowish gypsum. *Gryphaea Severzovi*, *Pecten* sp. and other fossils have been found. Thickness—0.12 m.

7. Green marl, 50 meters thick. For the uppermost part of this horizon *Gryphaea Severzovi* is characteristic, while *Ostrea tianschanensis* is found in lower parts of the horizon.

8. Gray shaly clays interbedded with gray limestone, thickness up to 50 m.

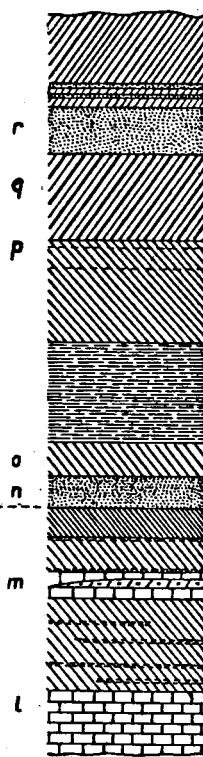


Fig. 2. Typical section of formations composing the petroliferous deposits of Fergana (outcrops of Rishitan). The meaning of the letters is given in the text.

9. The brownish-green or tobacco-coloured clay «o» interbedded with layers made up of *Platygena asiatica*; this horizon is traceable in all oil fields of Fergana and is also known under the name of «plate horizon». Thickness amounts to 18 meters.

10. Light-yellow fine-grained sands interbedded with conglomerate consisting of small pebbles and limestone. There are found *Ostrea kokanensis*, as well as sands and sometimes calcareous layers unequally stained with oil.

The calcareous layers of Rishtan are identical with the limestone «n» of the Kamysh-Bashi and Sel-Rokho geological sections.

B) EOCEN

11. Bright green clays with oil-bearing sands.

12. Grayish-green clay or marl, with intercalations of oil-bearing marl. At the bottom of these strata *Gryphaea Estershazyi* is occurring.

13. Limestone «m». The upper part of this formation is composed of yellow sandy limestone which is very persistent along the strike of the strata involved. It is underlain by a gypsum layer of varying thickness. The lower part of the limestone «m» consists of white granular limestone which near the top of the bed becomes cellular. Oil has been encountered in places in the cellular part of this formation.

14. Grayish-green clay or marl with numerous layers of oyster with *Gryphaea Romanovskyi*.

15. Limestone «l»; its thickness exceeds 30 m. This limestone is the lowest member of the Fergana stage which rests on the gypseous formation of the Cretaceous age.

Below follows the description of the different oil fields of the Fergana region.

THE CHIMION OIL FIELD

As has been mentioned above, the Chimion oil-field belongs to the southern group and lies 19 kilometers south of the Vannovskaya station of the Mid-Asiatic railway. This field has been exploited for many years and thoroughly explored, giving positive evidences of commercial oil.

The hilly territory on which the property is situated is on an average about 41 meters above the Vannovskaya railway station.

The oil field is in places connected with the station by a macadam road. The latter passes through the large village of Alt-Aryk, which is 4 kilometers distant from the station; farther no villages are encountered on the way to the property.

This field embraces two low ridges (adys) lying at the foothills of the Alai mountain range. It comprises two oil pools: the Chimion oil pool properly and the Yarkutan oil pool.

The Chimion pool is situated on the Kashkar-kyr hills, between the villages Langar and Chukur - Kishlak; the Yarkutan is located on the hills southwest of the Chukur - Kishlack village.

North of the ridge on which the oil field is situated extends a broad valley which is an absolutely barren gravel desert. South of the ridge lies another broad-valley which separates the ridge from the foothills of the Alai range, composed of the Paleozoic and

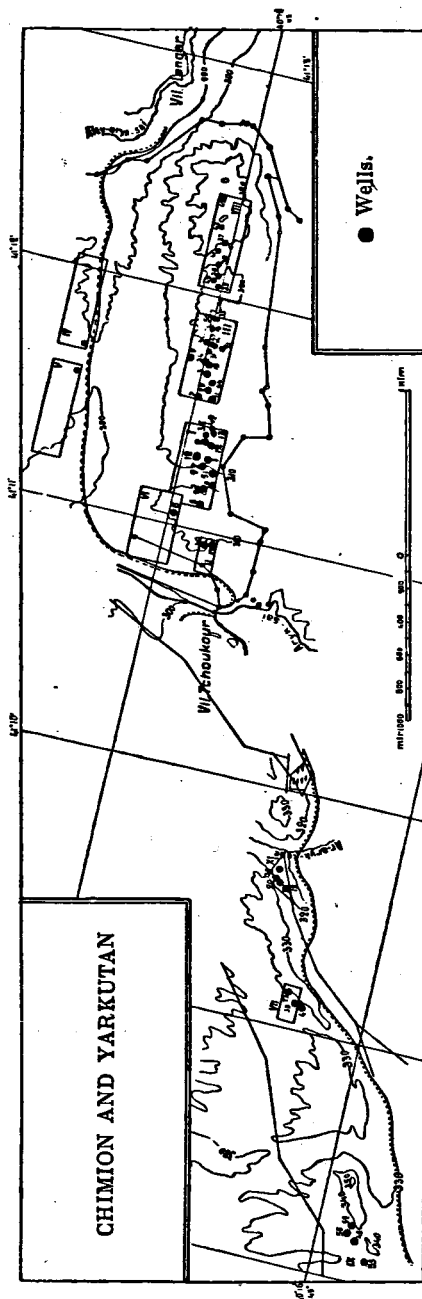


Fig. 3. Map of producing areas of Chimion and Yarkutan.

Mesozoic rocks. That part of the valley which is in close vicinity to the foot of the southern slope of the Chimion ridge is filled with loess-like deposits and is known for its fertility; it is exceedingly rich in underground water, what is evidenced by the presence of numerous springs situated at the foot of the southern slope of Chimion adyr and in deep excavations from which water was drawn for boilers in those times when all the work in Chimion was done with steam-engines. There is seemingly a fair degree of certainty that fresh water may be obtained in any point at the foot of the southern slope of the Chimion adyr.

The wells which were sunk here at different times are located on an interrupted line about 6 kilometers long, in conformity with the geological structure (fig. 3).

Geology. Compared with other oil fields of Fergana, the productive series of the Chimion field are very little exposed; thus, the Eocene formation, which includes all productive horizons, does not crop out at all. The thickness of the Oligocene formation on the Chimion area is about 350 meters.

Within the Yarkutan area the beds of the Fergana stage form an anticline which is so compressed from both sides that its flanks are nearly vertical. This circumstance accounts for a peculiar appearance of the geological map of the Yarkutan area—a narrow band of green clays curiously winding amid the spacious areas occupied by red clays. The map of the Yarkutan area would assume such an appearance, if the cap consisting of thick gravels, lying north of Yarkutan ridge, as well as loess sediments on the southern slope of the latter are removed from the land surface (fig. 5). Strongly compressed folds are usually overturned; such is the case with the Yarkutan fold, which is overturned alternatively toward either side.

The geological structure of the eastern area, or the Chimion area proper, is on the whole similar to that of the Yarkutan area; between the Chukur and Langar kyshlaks there is an anticline with a narrow arch and steeply dipping beds on both flanks. Due to the lack of outcrops, it is impossible to draw such a detailed map of the Chimion area as are the maps of other Fergana oil fields. The structure of this area has been therefore investigated by deep drilling. But as the wells are located along the axis of the anticline, they serve only to explore the crest of the anticline (fig. 4).

The Chimion fold extends from ENE to WSW; its axis is plunging in either direction. The fold is complicated by a strike fault,

cutting it approximately along the axial plane, owing to which the southern flank of the fold is somewhat pushed over the northern one (fig. 6). This thrust dies out eastward, whereas its displacement increases westward, towards the wells Nos. 22 and 40. The fault plain dips south at an angle of approximately 80° .

Occurrence of oil. The oil bearing strata of the Chimion oil field belong exclusively to the Eocene formation.

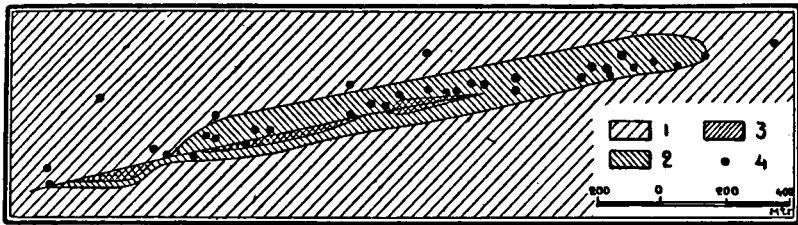


Fig. 4. Geological map of Chimion 1—red clays of the Oligocene; 2—the green formation (Oligocene and Eocene); 3—gray clays overlying the horizon «o»; 4—wells.

The green clays overlying limestone «m» are interbedded with petroliferous sands which are being exploited within the Yarkutan area. In the Chimion field oil is extracted mainly from the sands overlain by limestone «m». The green clays underlying the petroliferous sand do not carry oil within the area under consideration.

The oil-bearing formation is overlain by the Oligocene green clays, by the horizon «n», and by the strata underlying the latter; it is underlain by the gypseous formation of the Cretaceous age, in conformity with what has been observed in the rest of Fergana oil fields south of the Mid-Asiatic railway. The strata underlying the Chimion oil-bearing formation have been explored by several deep test holes.

These deep tests have brought out the fact that the gypseous formation does not contain even the slightest indications of oil.

The petroliferous formation does not crop out within the producing area. In places of its nearest approach to the land surface there were seeps of oil, and the Oligocene rocks are coloured with oil. The oil seeped a comparatively long time ago, inasmuch as the rocks stained with oil are absolutely dry and easily crushed into powder. Such places are encountered in the Yarkutan area, where

there are outcrops of the horizon «n» immediately resting on the Eocene.

The most interesting of these outcrops are those of the section along the right bank of the Arap-Tepe channel. Rocks impregnated with oil are here underlying and overlying the horizon «n»; liquid oil still seeps here. In the Chimion field the oil-staining has been

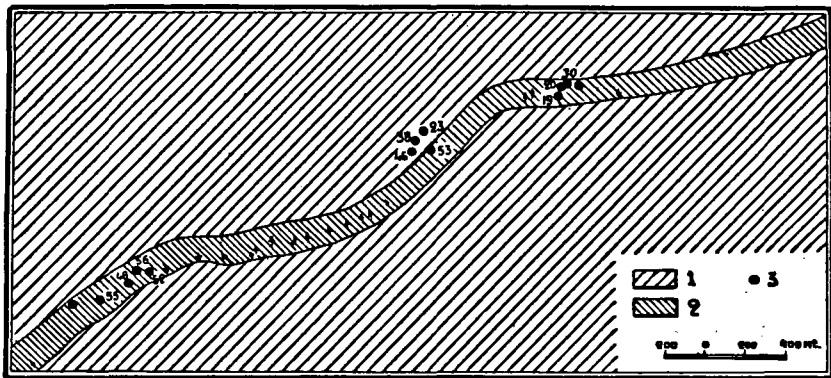


Fig. 5. Geological map of Yarkutan: 1—red clays of the Oligocene; 2—the green formation (Oligocene and Eocene); 3—wells.

observed in gray clays on the crest of the fold in a large excavation.

Prospecting and exploitation. Oil seeps in the Chimion field had attracted attention long before the methods of oil refining have been learned. In the times of the Khans, before Fergana had been joined to Russia, oil was extracted here from shallow pits. But the geological investigations and prospecting were first started in the region after it was annexed to Russia.

Interest to mineral fuel, both coal and oil, was always roused by want of fuel in Turkestan. The explorations were conducted mainly by the administrative establishments of the region, but sometimes by private persons. Below in the list of leading bibliography referring to the Fergana region all such explorations are cited in their chronological sequence.

Among the oil fields of Fergana the Chimion and Santo fields are those which have been best explored and most exploited. On the Chimion area 72 deep holes have been drilled,—their average depth being 282 meters. Regular development began in 1904 when the spouter from well No. 1 struck, which yielded during 6 years

of its life 34,900 tons of oil. Considering the relatively shallow wells (267—482 meters), such an output from a single well may be taken as very satisfactory.

The productive life of wells averages 8 years. The average spacing of wells was about 53 meters. There are top waters; during drilling operations these waters have to be excluded from the oil bearing horizons. Moreover, there exist bottom waters the character and origin of which are not yet established.

By 1915 the plots of the Chimion area proved to be exhausted to a considerable extent and flooded with water; the Chimion Company that exploited this area has moved its operations to Yarkutan. The yield of the Yarkutan wells is lower than that of the Chimion area proper.

The production of oil in the Chimion area is shown in the following table:

Years	1904/5	1905/6	1906/7	1907/8	1908/9	1909/10	1910/11	1912	1913	1914
Number of producing wells . . .	3	7	12	14	15	17	15	20	25	32
Production in 1,000 tons .	17.4	61	56	46	19	20	33	29	13.2	16
Years	1915	1916	1917	1918	1919	1920	1921/22	1922/23	1923/24	
Number of producing wells . . .	30	34	35	35	37	36	30	28	25	
Production in 1,000 tons .	11	10	11	10	7	6	5	4	5	

The decrease of the production during the last years before the war and during the war time is due only to the lack of initiative

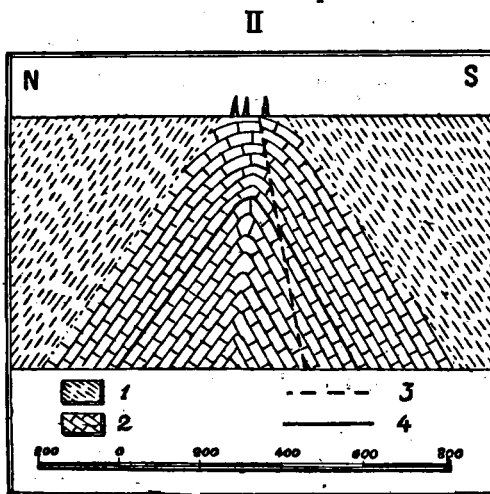


Fig. 6. Section of Chimion across the strike of the strata: 1—red clays of the Oligocene; 2—the green formation (Oligocene and Eocene); 3—the reverse fault plane; 4—limestone «m».

and insufficient prospecting in the adjacent areas. Had American prospecting methods been adopted and test holes been drilled wherever there was the slightest hope of obtaining oil, regardless of the expenses, the production of the Chimion area would have surpassed by far its present limited extent.

K. P. Kalitsky considers the southern slope of the middle dome of the Chimion fold, as well as the anticline situated 1 kilometer north of the latter, as a reserve of oil-bearing lands in this region (besides the intermediate tracts). Further to the north of the Chimion fold, half-way between the Chimion field and the Vanovskaya station, a low ridge named Kapchagai extends in a latitudinal direction. The conglomerate strata form in this place an anticline with gently sloping flanks and a rather wide arch. The favourable structure and the proximity to the Chimion field make this area worth prospecting. In 1917 a well was sunk in Kapchagai by the Nobel Brothers Company.

The lack of initiative was not the only impediment to the development of the Chimion field; there were also reasons of a purely technical nature. All drilling was conducted by the rod system, which is the most expensive and slow of all the systems now in use. The wells were of a large diameter, which required great quantities of casing. The oil was extracted by bailing, which is also the most expensive method of oil production. While the rich deposits of the Baku and Grozny oil regions permitted the use of old production methods, the Chimion oil field, being less prolific, could not be operated profitably by such wasteful methods.

It is quite evident that the introduction of the rotary or cable drilling systems, the replacement of bailing by pumping, etc., will contribute to the development of the Chimion field in conformity with the oil reserves of the latter, which apparently are very large.

The composition and commercial value of the oil. The qualities of Chimion oil deserve a thorough consideration. The specific gravities of Chimion oil and Yarkutan oil are respectively—0.866 and 0.888.

Fractional distillation has given the following results:

Fractions.	Yield (per cent).	Specific gravity.
70— 90°C	0.8	—
90—110 ♦	2.1	—
110—130 ♦	3.2	0.709
130—150 ♦	3.6	0.737

Fractions.	Yield (per cent).	Specific gravity.
150—170°C	4.6	0.760
170—190 »	3.0	0.776
190—210 »	3.2	0.788
210—230 »	3.7	0.803
230—250 »	2.2	—
250—270 »	3.2	0.817
270—290 »	3.2	0.826
290—310 »	5.3	0.836
Residue	61.8	0.913

The paraffin content is 3 to 4 per cent. The distillation of the oil in the refinery of the Chimion Company at the Vannovskaya station yielded the following oil products:

Benzine	4.92—9.05%
Kerosene.	22.75—29.95%
Mazout (fuel oil).	71 —61 %

Further distillation showed the presence of lubricants. Mazout taken for distillation had the following properties: specific gravity 0.921; viscosity—9.05; flash point 142 M. P. Fractions were separated by specific gravity. The results were as follows:

Nos. of fractions.	Yield (per cent).	Name of product	Sp. gravity (45°C).	Flash-point M. P.	Flash-point Frenken.	Viscosity. E.	Cold test.
1	11.36	Pyronaphta	0.849	108°	131°	1.4	—
2	11.55	»	0.865	111	131	1.6	—
3	10.10	Vaseline oil	0.875	120	140	2.16	—
4	11.40	Heavy solar oil	0.888	130	150	2.16	—
5	7.25	Spindle oil.	0.896	155	175	2.65	—
6	9.02	Compressor oil	0.904	167	187	3.92	—
7	2.80	Engine oil	0.910	182	202	5.05	+10°
8							
9	2.34	Heavy engine oil	0.917	203	223	7.45	+17°
10							
Residue 31.00		Oily goudron and cylinder oils.					

The qualities of benzine obtained from the Chimion oil are defined by the results of the fractional distillation done by the Chimion Co., which owned the property and refinery prior to their nationalization. The dephlegmator of Glinsky was used for the distillation.

Specific gravity 0.6855 at 15°C, boiling point 33°C.

Fractions.	Yield (per cent).	Specific gravity.
To 50°C	20.1	0.6468
50 to 60°»	18.3	0.6625
60 to 70°»	20.0	0.6860
70 to 80°»	16.5	0.7030
80 to 90°»	10.7	0.7210
90 to 100°»	9.3	0.7310
Residue over 100°C	3.7	0.7310

Benzine of 2nd quality, sp. gr. 0.729; the distillation of the latter with the use of a dephlegmator of Glinsky yielded the following results (initial boiling point 42°):

Fractions.	Yield (per cent).	Specific gravity.
To 70°C	3.3	0.6900
70— 80°C	11.3	0.7175
80— 90°C	19.5	0.7300
90—100°C	26.5	0.7380
100—110°C	16.6	0.7450
110—120°C	11.3	0.7600
Over 120°C	12.5	0.7600

Equipment of the oil fields. The Chimion oil fields are equipped both for drilling and oil production, and have all the necessary auxiliary plants: mechanical shops, water pipe system, etc. Electricity is used as power. A central power station of 736 kw. supplies current to all the plants both for exploitation of well and lighting.

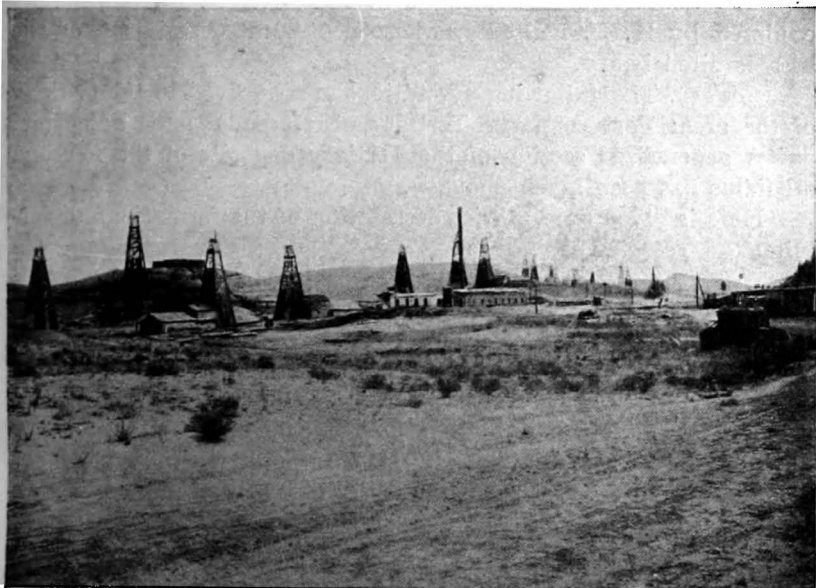
The Chimion oil was and is distilled in the refinery which was erected in 1906 at the Vannovskaia station; oil is pumped through a 4 in. pipe line 19 km. long.

The daily capacity of the refinery is about 410 tons. As the refinery capacity greatly exceeds the production of the field, the refinery is operated intermittently, twice or three times a year. Kerosene has specific gravity 0.815, the grade of refining being 2.4. Fuel oil (mazout) has sp. gravity 0.910; cold test +10°, paraffin content 4—6 per cent.

The aggregate capacity of the storage reservoirs is about 16,300 tons.

THE SEL-ROKHO OIL FIELD

The Sel-Rokho oil field lies in the Kokand district of the Fergana region, which is now within the boundaries of the Uzbek SSR; the nearest railway point is the Melnikovo Station of the Mid-Asiatic railroad. South of that station is situated the large



Photograph by N. Geishtor.

Fig. 7. Eastern part of the Chimion oil field.

village of Kanibadam. The distance from the station to the property is only 14 km.; one third of the road passes through the Kanibadam village; further the road crosses a gravel desert; after passing the latter and ascending the Barras pass the road descends into the Sel-Rokho valley. Here are situated the oil and ozokerite fields, which were owned prior to nationalization by the Santo Co., V. Alexeiev Co. and the Neft Co. In the middle of the area lies the ozokerite property of the V. Alexeiev Co. mentioned above. The latter undertook in 1915 an intensive exploitation of the ozokerite deposits and constructed for this purpose a small plant as well as dwelling houses.

The Sel-Rokho valley is arid; springs with a small flow are found only in the western part of the valley at the foot of the Kara-Tau range. The property is supplied with water conveyed by pipe line from a spring in the mountains.

The Sel-Rokho field lies so close to the Chimion field that all said above about its situation with reference to the foreign and interior markets is equally applicable to the Sel-Rokho field.

The Sel-Rokho oil-bearing area has been most thoroughly explored by K. P. Kalitsky, whose geological description of the area is cited below.

Geology. The following formations are involved in the geology of the area: Post-Tertiary, Tertiary, Cretaceous and Paleozoic.

A generalized section of the Tertiary deposits of the Fergana oil fields has been given above ¹⁾.

Here is given only a brief description of the formations underlying the Tertiary sediments.

CRETACEOUS SEDIMENTS

1. Gypsiferous formation. This formation is distinguished from the overlying Fergana stage by the difference of colours; the clays of the Fergana stage are of yellowish-green colour, whereas the clays of the gypseous formation are of a more bright green colour.

2. The red sand series.

3. Dark red clays interbedded with conglomerates, sandstones and limestones.

At the base of this series lie conglomerates overlying unconformably the Paleozoic rocks.

THE PALEOZOIC

4. Strata of dark shales. These strata are of a dark-violet, brown, gray, and green colours.

¹⁾ On the accompanying map of the Sel-Rokho petroliferous area, which is plotted after K. Kalitsky, all the green Eocene and Oligocene beds are shown in the same colour. The reason is that at the time of the preparation of his work Kalitsky considered the boundary between the Oligocene and Eocene to be below the clay «q». Now the fauna of the strata has been defined, and the author draws the boundary line lower, below the horizon «n».

The outcrops of the limestone «m», occurring in the upper part of the Eocene, are marked on the map with a full red line; the limit between the Oligocene and Eocene being thus approximately marked.

GEOLOGICAL STRUCTURE. The main structural feature of the field is an anticline trending in almost latitudinal direction and made up of Tertiary and Cretaceous rocks. In the crest of the anticline strata of the Cretaceous gypsiferous formation are exposed. The northern flank of the anticline dips northward at an angle of 25°. The northern flank passes westward into a monocline.



Photograph by V. Sokolov.

Fig. 8. Valley of the Isfara river near Sel-Rokho.

To this main Sel-Rokho anticline a wide and flattened syncline composed of rocks of the Fergana stage joins from the south. The syncline is adjoined on the south by another short anticline resembling an eroded dome. In the crest of the latter there are exposed not only Cretaceous sediments, but also dark Paleozoic shales. The axis of the said anticline trends SW—NE and plunges northeastward.

Occurrence of oil. The development of the field began on the northern slopes of the anticline and its monoclinical continuation on the west. The results obtained by the Santo Co. proved the commercial importance of four horizons belonging to Eocene.

The first (upper) oil horizon is composed of limestone «m» and the rocks immediately overlying and underlying the same (sands and sandstone). This horizon proved to be productive in the western and central parts of the property and unproductive in its eastern part. Two pools belong to this horizon; the contour of the western pool is not yet determined on the east and west, while the central one is contoured on the south and east.

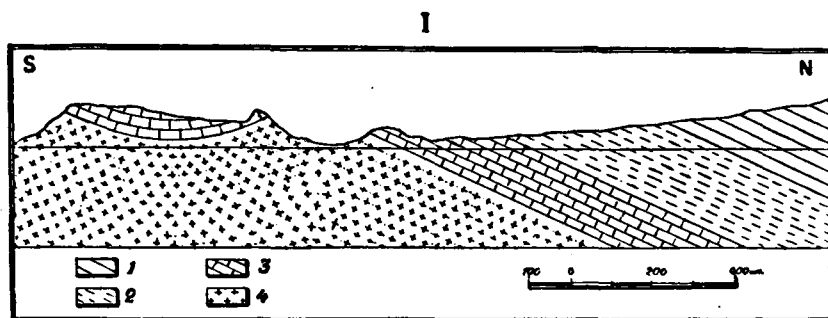


Fig. 9. Section of Sel-Rokho: 1—light-brown formation (the Oligocene); 2—brick-red clays and the clay «q» (the Oligocene); 3—the green formation (the Oligocene and Eocene); 4—the cretaceous rocks.

The second horizon is made up by sand included in the formation of the green clays, interbedded with layers of Gryphaea shells, below the limestone «m»; it is productive only in the eastern part of the area. Two oil pools are located here. The boundaries of the western pool are definitely outlined on the west and east and remain so far undetermined on the north and south. The second pool is wider; its boundaries are well defined on the southwest, but are not defined as yet on the north, east and south.

The third horizon lies between the limestones «b» and «m», and is represented by a layer made up of oyster shells underlaid by marl. This horizon is productive only in the central part of the area where there are two pools. The large western pool has definite boundaries on the north and south, but on the western and eastern extremities it still admits being countoured. The small eastern pool is not outlined on the north.

The fourth horizon (the middle part of the limestone «b») comprises three separate pools: the western, eastern and central ones. The limits of oil sands are outlined only on the north side of the western pool. No limits of the pool are defined on the north side of the central pool. The eastern pool has been outlined only on

the north and east sides, but possibly continues southward and passes into the southern flank of the anticline.



Photograph by V. Sokolov.

Fig. 10. The valley of the Isfara river near Sel-Rokho.

The distances of this petroliferous horizons from the bottom of the red clays in wells are as follows:

		On average
The top of the 1st horizon	79—94 m.	85 m.
» » » » 2nd »	96—107 »	100 »
» » » » 3rd »	109—124 »	115 »
» » » » 4th »	128—141 »	135 »

The composition of the oil. The oil yielded by the 1st horizon has a specific gravity of 0.845—0.850; it is accompanied with strong flows of gas, the benzine content is 30 per cent, paraffin content is 6 per cent.

The 2nd horizon yields oil of a specific gravity of 0.868—0.875. Benzine content is to 15 per cent. The oil contains paraffin and solidifies being exposed in winter in the open air. By its

properties this oil occupies an intermediate position between the oils of the 1st and 3rd horizons.

The 3rd horizon yields oil of sp. gravity 0.890—0.900. It contains little gaseous compounds, no benzine and no paraffin.

The 4rd horizon yields the heaviest oil, spec. gravity being 0.920 and even 0.940.

Exploitation. The development of the Sel-Rokho oil field was started by the Santo Co. in 1908. In 1912—13 the Neft Co. began to operate. The yearly productions and the numbers of producing wells are given in the following table:

Y e a r s .	1909	1910	1911	1912	1913	1914	1915	1916
Producing wells .	1	4	8	11	17	20	24	24
Production in tons	819	4,231	6,158.3	9,516.38	9,862.8	16,577	19,330	20,535

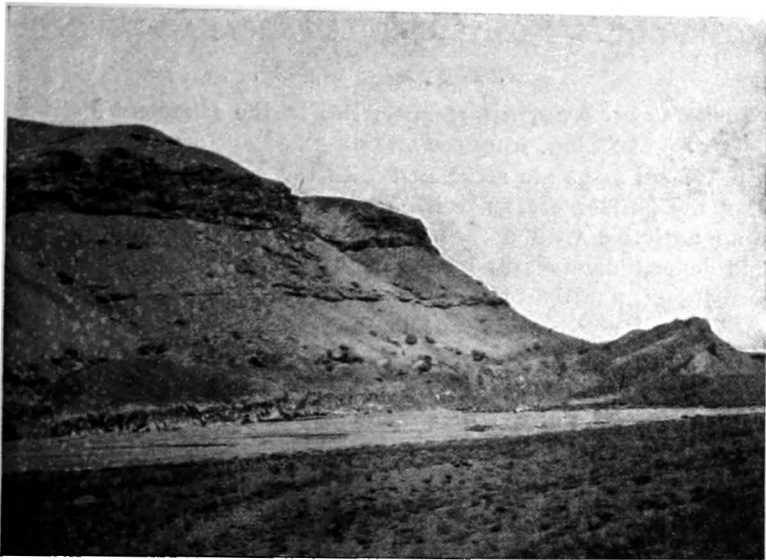
Y e a r s .	1917	1918	1919	1920	1921/22	1922/23	1923/24
Producing wells .	24	31	33	—	—	—	26
Production in tons	23,932	19,700	14,315.5	10,875.5	11,035.5	11,431	10,192.8

The total production up to the present time amounts to about 197,000 tons. During the first year of development the average yield per well was about 1300—1475 tons (80,000—90,000 poods). Absence of water flows facilitates the drilling operations and simplifies the casing methods. The productive life of a well exceeds 5 years. The average spacing of wells is about 85 m.

The area on which the wells are located in the eastern and central parts of the field is a stretch of land 5 km. long and 530—750 m. wide.

Equipment of the oil field. The Sel-Rokho oil field is provided with all equipment necessary for drilling operations and oil production. This field is supplied with three-phase electric current generated at a central station whose capacity is 500 kw. The oil is distilled at a refinery located within the oil field. The refinery was constructed in 1913—1914, being of a comparatively modern design. Its daily capacity is approximately 130 tons of crude oil.

The oil having been produced until now but in limited quantities not adequate to the capacity of the refinery, the latter is operated periodically, in connection with the accumulation of required quantities of crude oil. Owing to a proper design of the



Photograph by V. Sokolov.

Fig. 11. Sel-Rokho near the «santo» oil property. An anticlinal fold.

refinery, the consumption of fuel is insignificant, being only 1.5—2 per cent.

The average yield of oil products was as follows:

Benzine	5—6%
Kerosene	19%
Fuel oil (mazout)	75—76%.

Both benzine and kerosene yields could be increased by some measures, especially by eliminating the oil losses due to evaporation and other causes which take place when the oil is transferred from the well to the refinery; besides it should be born in mind that the topping distillation is far from being complete. As to kerosene, a portion of it is purposely left in fuel oil to reduce the temperature of its solidifying, otherwise it would be difficult to pipe it to the station Melnikovo.

The fuel oil (mazout) is piped through a 4 inch pipe line to the Melnikovo station; kerosene is piped through a 3 inch pipe line. Benzine is transported in cans.

The capacity of the refinery reservoirs is about 16,000 tons.

OTHER OIL DEPOSITS OF THE FERGANA REGION ¹⁾

I. The Southern group.

THE TASH-RAVAT OIL DEPOSIT lies in the Khodjent district at a distance of 23 km. from the station Khodjent of the Mid-Asiatic railway. Oil seeps are associated with the petroliferous sand overlying the horizon «o», as well as with the underlying beds. There is an anticline with a rather wide arch and flat dipping flanks. This deposit deserves to be thoroughly investigated.

THE SHUR-SU AND KAMYSH-BASHI OIL DEPOSITS. The first is located at a distance of 21 km. southwest of the station Posyetovka of the Mid-Asiatic railway; 3 km. south of it is situated the Kamysh-Bashi oil deposit. Both localities lie in the region of the northern foothills of the Alai range and comprise a row of ridges and valleys trending in the latitudinal direction.

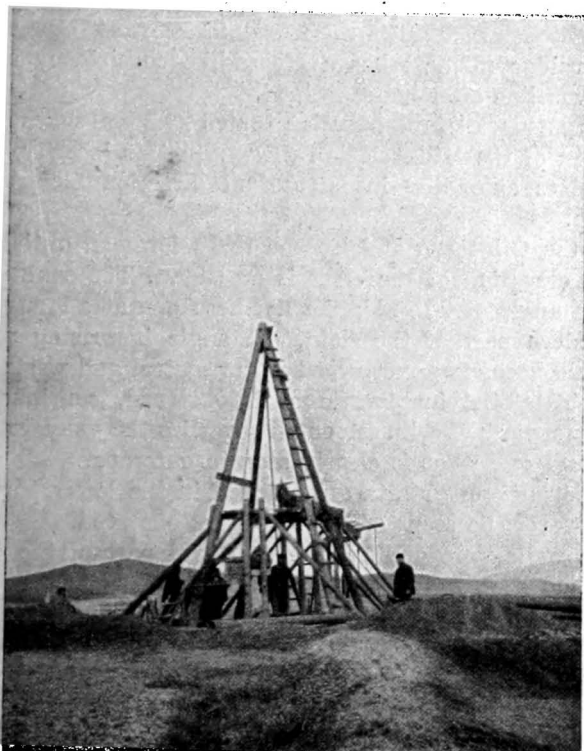
In Shur-Su there are two anticlines extending from east to west, separated from each other by a narrow syncline. On the crests of the folds there are outcrops of gypsiferous strata overlain by rocks of the Fergana stage. NNW of the Shur-Su anticline, on the opposite (western) bank of the Achik-Su river, there has been traced another isolated short anticline of small extent (Achik-Su anticline); on the crest of the latter there are outcropping rocks of the Fergana stage; the flanks of this fold are steep-dipping.

South of the two Shur-Su anticlines lies a wide syncline which extends southward and passes into the Kamysh-Bashi monocline, trending in latitudinal direction with strata dipping northward. On the meridian passing the Uch-Kara mountains the monocline turns to southeast and forms there the Lakan anticline trending north; the lowest Cretaceous beds are exposed on the crest of the latter. The Kamysh-Bashi monoclinal fold is cut by a strike fault.

Oil seeps on the western extremity of the Shur-Su anticline and on the Kamysh-Bashi monocline are associated with limestones «m» and «l».

¹⁾ The brief description of the oil deposits cited under this heading is obtained from the «Handbook of the Petroleum Industry» published by the Council of the Petroleum Industry in Moscow.

The Kamysh-Bashi oil deposit has been tested by several drill holes, the depth of each hole not exceeding 235 m. These holes were sunk through the Fergana stage, but were unsuccessful. In the Shur-Su field only two small wells were sunk: one of them, drilled



Photograph by V. Sokolov.

Fig. 12. Sel-Rokho. Drilling a well on the «Santo» property.

to the depth of 41 m., yielded in 1911 from the upper part of the limestone about 0.2 tons of heavy oil per day, which was hand-bailed.

In the Shur-Su anticline the limestones «m» and «l» are the oil-bearing strata to the extent of about 1 km. The latter (a stratum 32 meters thick) contains arenaceous layers. Test-drilling may be recommended on the northwest part of the Shur-Su anticline, as well as on the fold adjoining the latter on the west.

The properties of the Shur-Su oil are as follows: sp. gravity 0.8615; sulphur content—0.57 per cent; paraffin content—2.6 per cent; the following fractions are yielded at distillation:

100—150°	0,5%
150—270°	23,8%
270—300°	8,3%

The residue (62.8%) has a grease-like consistency and gives excellent vaseline after being refined.

THE RISHTAN OIL DEPOSIT is situated 23.5 km. south of the Serovo station of the Mid-Asiatic railway. In this locality there are several ridges extending in latitudinal direction along the Fergana plain.

Here the Oligocene and Eocene rocks form an anticline. The maximum elevation of the crest is at Bidau. The southern flank dips at an angle of 20—25°; the northern one at an angle of 85° in the eastern part of the field, the angle increasing westward, and the fold becoming overturned in its central and western parts. West of Tutak-Sai an overthrust is observed, continuously increasing westward; the limestone «b» overlies the younger horizons «m», «n» and «o», what is clearly seen in outcrops.

The petroliferous strata are exposed in the lower parts of the relief. However, no seeps of liquid oil are observed.

Three wells were drilled in the central part of the oil field; but they had been wrongly located, and the negative results obtained here cannot serve as a base for estimating the Rishtan field. K. P. Kalitsky recommends to sink test holes south of the Khudai-Nazar springs, on the eastern extremity of the fold, and points out the possibility of obtaining oil also on the southern flank of the western part of the fold.

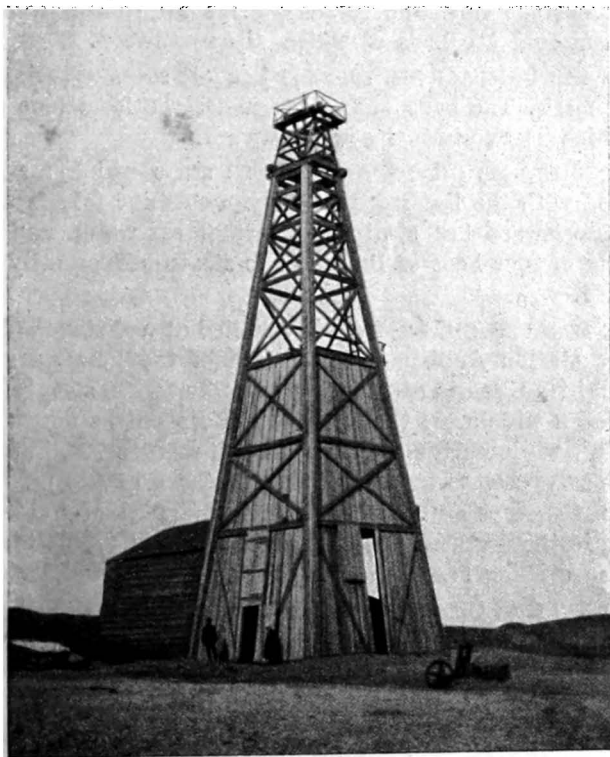
Sp. gravity of the oil is 0.9165—0.9375. Paraffin content—1.3—1.5 per cent.

II. The Northern group.

THE MAILI-SAI OIL DEPOSIT is situated 59 km. northeast of the town of Namangan and at a distance of 21 km. from Uch-Kurgan, the nearest railway station.

The rocks of Paleogene form a west-southwest trending anticline, the crest of which is composed of a gypsiferous formation. The axis of the anticline plunges westward; its southern flank dips at an angle of 40°, while the northern one dips at an angle of 33—40°. On the southern flank there are two small faults.

Three oil-bearing horizons are known in Maili-Sai: horizon I carries mere indications of oil on the northern flank of the fold; horizon II (limestone «m») proved to be a «gusher horizon» in a State well and gave but small quantities of oil in other wells; horizon III—is made up of limestone «l»; of the three wells which



Photograph by V. Sokolov.

Fig. 13. Sel-Rokho. A derrick on the «Santo» property.

have penetrated below this horizon only one yielded 5 tons of oil (well № 2, formerly owned by English Co.).

In Maili-Sai 7 wells have been drilled on the northern and southern flanks. The gusher mentioned above yielded more than 4,900 tons of oil; of the remaining wells only two yielded 5 tons each.

Sp. gravity of the oil of the horizon II is 0.8845, that of the horizon III is 0.8212. The distillation of the oil of the hor. III yields: benzine—17.66 per cent and kerosene—43.4 per cent; the residue contains up to 3.37 per cent of paraffin and solidifies at +10° C.

THE PITEU-SAI OIL DEPOSIT. Oil indications are observed only in the limestone «m». The Tertiary rocks are thrown into a steep monoclinical fold the beds of which dip southward.

THE ENKUNIM-SAI OIL DEPOSIT has oil seeps associated with limestone «l'». The beds of the Fergana stage form here a monocline which is overturned southwestward.

THE SHING-SAI OIL DEPOSIT has oil seeps which are likewise associated with the limestone «l'». The monocline fold is overturned southwestward but straightens farther eastward; and a series consisting of four beds of limestone is stratified normally dipping southward.

THE MAILI-SU OIL DEPOSIT is situated at a distance of 61 km. from the station Andizhan. The strata of the Fergana stage are involved in an eastward-trending anticline with steeply dipping flanks and a wide arch; the angle of the dip on the northern flank equals 55°, while on the southern flank it reaches 70°, but decreasing farther, becomes quite low at a distance of 420 m. from the oil seeps. Oil seeps are found in the limestones «m» and «l'»; in the arch and in the northern flank these limestones have no indications of oil. No drilling has been done in this area.

THE KULMEN OIL DEPOSIT has an oil seep in the southern flank of the anticline which is seemingly a continuation of the Maili-Sai anticline. The limestones of the Fergana stage are said to dip in direction SE 130°, the angle of the dip being 15—27°.

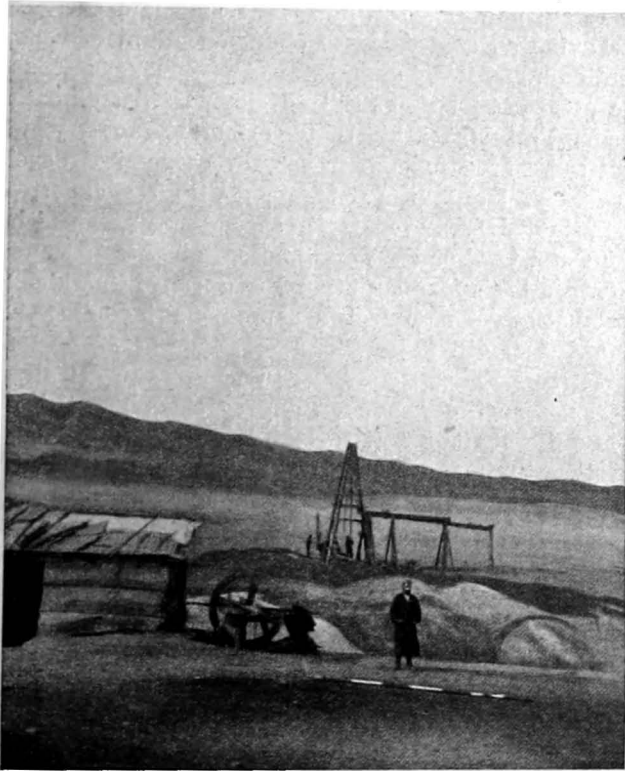
III. The Eastern group.

THE CHANGYR-TASH OIL DEPOSIT. An anticline is composed of the limestone beds of the Fergana stage. Oil seeps are found on the northern flank. K. P. K a l i t s k y. recommends to drill the area north of the seeps.

THE TEKE-DEL OIL DEPOSIT is seemingly related by its geological structure with the Changyr-Tash oil deposit.

FUTURE POSSIBILITIES OF THE DISTRICT

Above we have given a brief description of three oil-bearing areas from which considerable quantities of oil has been obtained. There is still a number of oil fields which have not yet been explo-



Photograph by V. Sokolov.

Fig. 14. Sel-Rokho. The «Santo» oil property.

red in detail, some of them having promising indications of petroleum. Within a country such as, for instance, the United States of America, this would have been quite sufficient to justify the development of the oil industry on a large scale, or at least extensive drilling operations. Unfavourable conditions for the development of the oil fields of Fergana in the past years and the lack

of money at the present time, such were and are still the difficulties preventing the proper development of the Fergana region. Fergana is so remote from the exporting ports, as well as from the centers of the home market, that only the most valuable products such as benzine can stand the cost of transportation. The remaining products are to be marketed within the region.

Turkestan, of which the Fergana region is a part, is a vast country having an area equal to about one third of Europe, and a population numbering approximately 8,000,000; this country has wide prospects for industrial development. Its climatic conditions render Turkestan a big center of cotton industry, which by itself can serve as a foundation for the economical development of the country. Horticulture, together with the export of high quality fresh and preserved fruit, sheep-breeding, which yields sheep-skins and wool of the best grades,—all these resources combine to form a basis for the national prosperity, on which depends the consumption of manufactured products including kerosene, benzine and fuel oil.

Furthermore, Turkestan being a country practically devoid of forests, has no fire wood, nor any considerable coal deposits; thus it is quite obvious that fuel of any other kind, and first of all fuel oil, will find a ready sale. The present consumption of fuel oil is already sufficiently considerable, as may be seen in the following table (in thousands of tons):

	1922—23	1923—24	1924—25
Railways	221.1	219.5	251.2
Industry	3.9	9.6	12.6
Water and light	2.6	2.9	2.9
Government establishments . .	1.1	1.1	1.4
Population	2.1	1.1	1.1
War office	2.4	2.7	2.9
Total	233.2	236.9	272.1

The yearly increase of fuel consumption is about 7.5 per cent.

As the production of petroleum products, especially of the less valuable ones (kerosene and fuel oil), should be adapted to the consumption of the local market, it is very essential that the capacity of the latter should be ascertained, if but approximately. In 1913 the average consumption of kerosene per one inhabitant in Russia was about 7 kgr.; bearing in mind that in Turkestan

a large consumption of kerosene is to be expected, not only as an illuminant but for heating and cooking purposes as well, 7 kg. per head of population should be considered as a minimum consumption. On this basis, the total consumption of kerosene in Turkestan is estimated at 50,000—65,000 tons even for the next years to come. As to benzine, this valuable product can not only be



Photograph by V. Sokolov.

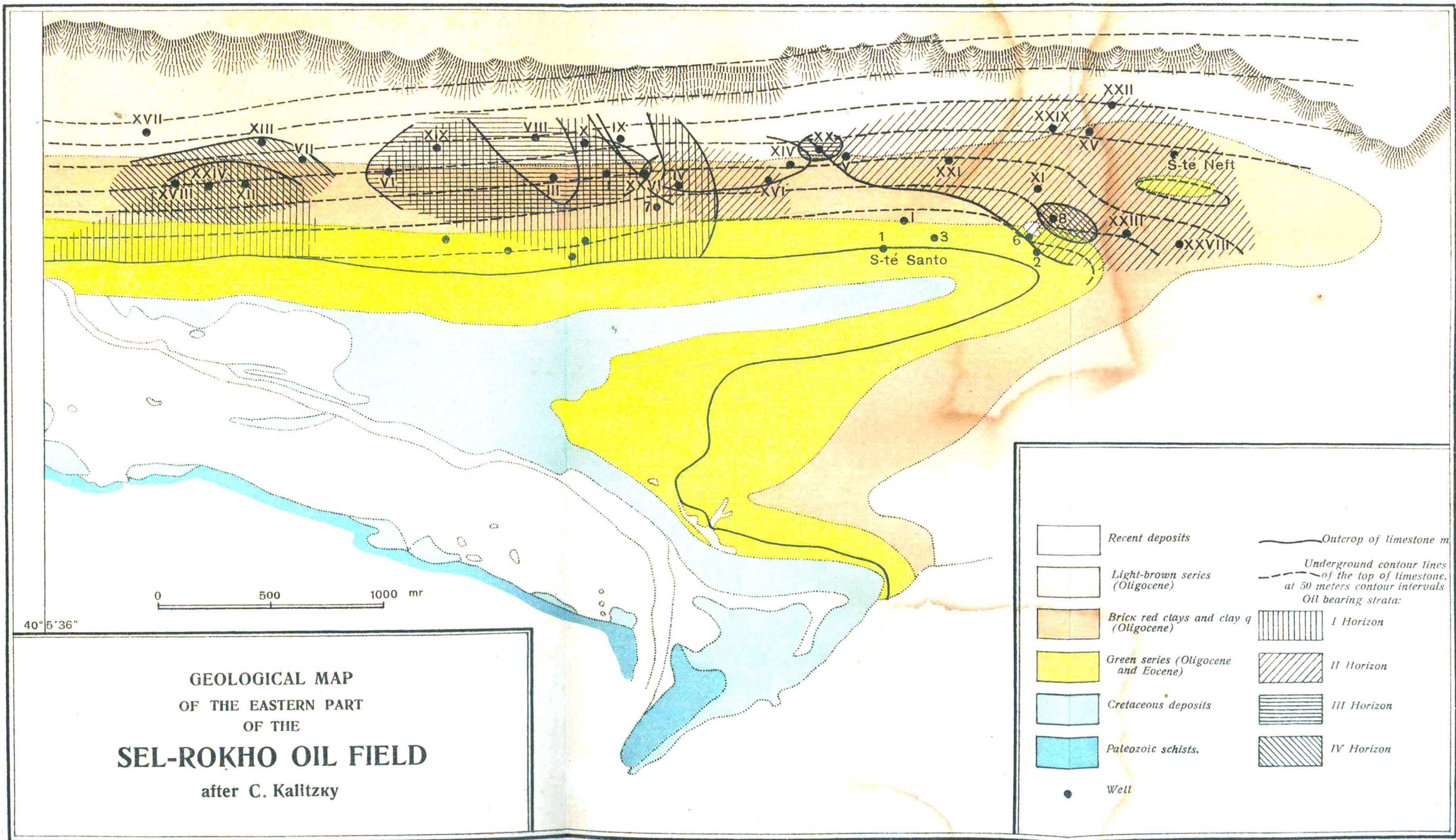
Fig. 15. Sel-Rokho. The «Santo» oil property.

marketed within the country, but will stand the cost of transportation to the interior parts of the U. S. S. R.

The coal industry of Turkestan cannot compete with oil, for although lignite possesses high caloric value, it cannot stand the transportation even within the country; moreover, it contains a considerable amount of sulphur. It is to be supposed that the development of the lignite industry will not weaken the oil industry, but will on the contrary assist the latter, because a rationally conducted lignite enterprise has to apply the briquetting process, for which the petroleum peck produced by the Fergana refineries is suitable as a binding material.

SELECTED BIBLIOGRAPHY

1. Weber, V. Mineral resources of Turkestan. Published by the Geological Committee. 1913.
2. Kalitsky, K. Maili-Sai. — Bulletin of Geol. Com., vol. XXXII, No. 3, 1918.
3. — .The Fergana oil fields. — Bul. of Geol. Com., v. XXXIII, No. 7, 1914 pp. 761—802.
4. — .The Shur-Su and Kamysh-Bashi oil fields (the Fergana region).—Memoirs of the Geol. Committee. New series. No. 133. 1914.
5. — .The Rishtan oil fields (the Fergana region).—Mem. Geol. Com. New series. No. 127. 1914.
6. — .The Sel-Rokho oil fields (the Fergana region).—Mem. Geol. Com. New series. No. 167. 1918.
7. — .The Fergana region.—Oil and Shale Industry Nos. 7—8, 1922.
8. — .Chimion oil fields (the Fergana region), idem. No. 6. 1923.
9. Oil fields of the Fergana and Samarkand regions. Natural Resources of Russia. vol IV. No. 22. 1918.
10. Kovalovsky, S. «Santo» (the Fergana region).—National Economy, No. 4—5. 1921, Baku.



GEOLOGICAL MAP
OF THE EASTERN PART
OF THE
SEL-ROKHO OIL FIELD
 after C. Kalitzky

THE COUNCIL OF PETROLEUM INDUSTRY

S. OBRUCHEV

GEOLOGIST OF THE GEOLOGICAL COMMITTEE

THE OUKHTA OIL-BEARING
REGION

With 26 figures and a map

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GENERAL DESCRIPTION

Geography. The Oukhta (Ukhta) oil field is situated within the Autonomous Region of Komi (inhabited by natives Komi or Zyrians), in the northeastern part of the latter, viz., in the former Pechora District of the Archangel province, partly in the Ust-Sysolsk district of the Vologda province. The tract of land which in 1909 was pronounced by the Ministry of Commerce and Industry as a proven oil-bearing area, comprises 13,700 square kilometers and extends from 62°45' to 64° north latitude and from 22° to 24° east longitude (Pulkovo). The area on which test holes for oil have been actually drilled and positive showings of oil have been discovered is much smaller—barely about 1,300 sq. km. and occupies the region of the middle courses of the rivers: Oukhta (with the tributaries of the latter: Yarega, Chut and Domanic) and Sed-Yu with its tributary Lya-Yol. Both these rivers are left-hand tributaries of the Izhma river, which in turn falls into the Pechora river.

Orography. The Oukhta region is situated on the southern extremity of the Timan mountain range. This part of the range is a low, slightly hilly territory, densely forested with coniferous trees, the monotony of the landscape being interrupted by river valleys cut into the ground to a depth of several dozen meters. The valley of Izhma at the point where the latter is joined by the Oukhta river is 70 m. above sea-level, the source of the Oukhta river being situated about 150—160 m. above sea-level. The river valleys, as well as frequently the flat watershed areas, are covered with swamps. Southwest of this territory, on the watershed between the basins of the Pechora and Severnaia Dvina rivers, there extends a flat elevated part of the range, with the hills reaching 325 m. in height (Pot-Churk).

Climate. As the district lies at a distance of only 300 km. from the polar circle, its climate is naturally severe. According to the

observations made by Mr. Stukachev during 3 years, the average yearly temperature does not fall below $+1^{\circ}$ C and is about equal to the average temperature prevailing on the White Sea shores. The average temperature of June and July is $+19^{\circ}$ C, that of January is -36° C. In January and February the frost frequently attains 47° C. Northerly, northeasterly and southwesterly winds predominate, which in summer carry rains continuing sometimes whole months. Snow falls at the end of October and holds till the end of May, the snow cover being of great thickness. The most favourable seasons for field operations are spring and autumn, when there are no rains, nor mosquitoes. The period from November till March is hardly suitable for drilling operations, owing to the intense cold. There is no permanently frozen ground within the district.

The population of the district is very scarce and consists chiefly of Zyrians and partly of Russians. The following inhabited localities are the nearest to the oil fields: a number of villages on the Izhma river, some 40 km. from the center of the petroliferous district, and a small village Volok, 80 km. from the latter point, at the head of the river Oukhta, near the «volok» to the Shonvukva river («Volok» is a place where boats are dragged across the watershed between two navigable rivers, a portage).

The Zyrians occupation is agriculture, cattle-breeding and hunting; they are characterized by their independence and intelligence. Formerly they showed great unwillingness to work in mining enterprises, and did so only for high wages. The oil fields have to be supplied with labour from more thickly populated places of the Vologda province, wages being naturally higher than in districts with developed industry, in the case of skilled workmen being about double.

Ways of communication. The communication with the Oukhta oil region is very difficult and slow. There are three routes leading to the region:

1. From Kotlas by steamer up the Vycheгда river to Ust-Vym, a distance of 320 km.; further by boats up the Vym river, then up the Vukva river and its tributary Shonvukva to the «volok», or portage, 6 km. long, near the village Volok; further by the Oukhta river,—a distance of 480 km., totalling 800 km. From Kotlas by railway to the northern trunk line (Viatka)—383 km., or by steamer to the same trunk line (Vologda)—601 km. A part of the journey up the lower course of the Vym river may be made either by small

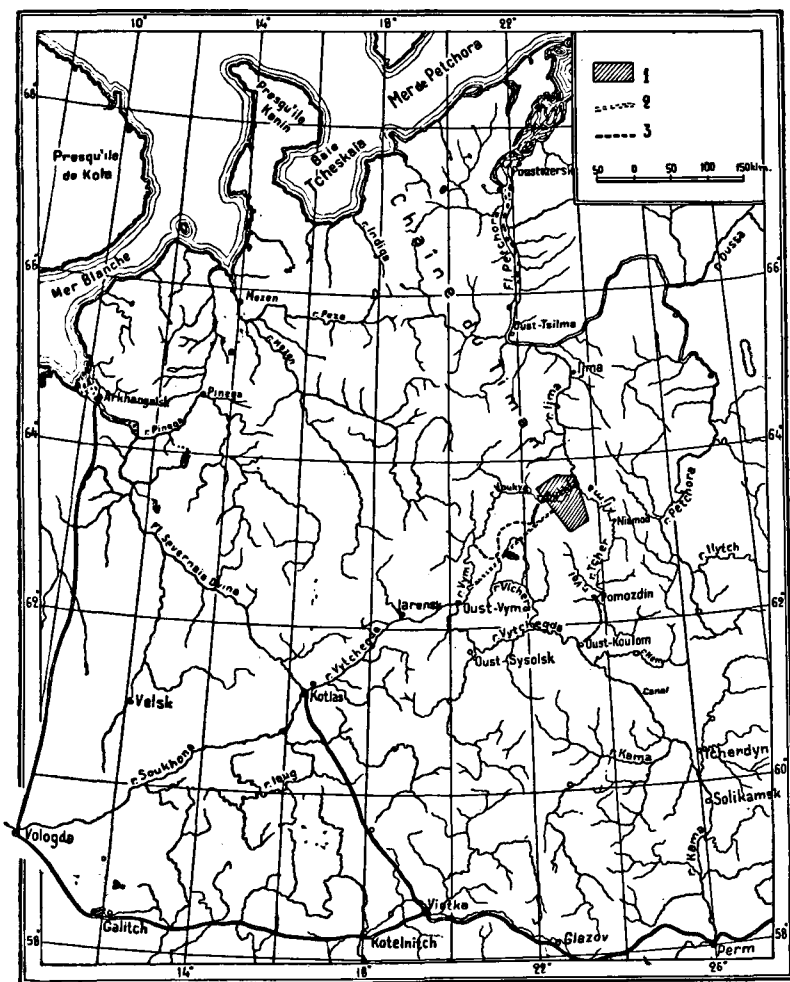


Fig. 1. Map of Northern Russia: 1—the Oukhta oil-bearing region; 2—winter road; 3—summer road.

draught steamer, such steamers running sometimes as far as the village Veslianskoe (127 km.), or by a highway to the village Turie (101 km.). The portage from Shonvukva to Oukhta is one of the best «voloks» on Timan, horses and vehicles being always obtainable there. This route takes from 8 to 16 days. As an alternative of the latter there is another way: from the village Veslianskoe by boats up the Veslianka and Ropcha rivers, across a portage to the Tobysh river and by the latter river as far as Oukhta. The «volok» here is 47 km. long, but the river channels, having been cleared in 1913, are by far deeper than the rivers of the preceding route, where at the times of shallow water the boats in places have to be carried. In winter the journey from Oukhta to Kotlas can be made in 6 days, owing to driving in sledges being quicker and the route being shorter by 160 km. (the sledge road leads along an opening in the forest cleared of trees from the village Polovniki, on the Vym river, as far as Sidorovskaya Kazarma on Oukhta).

2. The second route leads from Archangel by sea to the mouth of the Pechora river, thence by small draught steamer to the mouth of the Izhma river and further 149 km. by boats to Oukhta, the total distance aggregating about 2,180 km. Owing to the irregularity of the navigation on the Pechora river, the whole journey takes from 10 days to one month. This route is open from the 20th of July till the middle of September.

3. The third route, less used than the first two, is as follows: by steamer up the Vychehda river as far as Ust-Kulom, thence in carts to the village Pomozdin, further by boats up the Vychehda river and its right-hand tributary Cher Vychehodsky to the «volok» leading to Cher Izhensky (1.5 km.), and along the latter and Izhma in boats as far as Ust-Oukhta. Sometimes steamers go as far as the village Pomozdin. If the route were not shortened by the horse journey from Ust-Kulom to Pomozdin, it would be longer than the first route by 400 km. and its only advantage is that it passes through a more populated territory. Furthermore, this route is important because between Ust-Kulom and Pomozdin there begins the Severo-Ekaterinensky channel, which connects the Vychehda river with the Kama river (Severnaia Keltma, the channel, Djurich, Yuzhnaia Keltma). The channel is now abandoned, but in case of the development of the Oukhta district it may be restored, if it is necessary to connect the district with the Volga basin.

Rivers are the only means of communication within the oil region. The Oukhta river is quite navigable by boats from the «volok» to the mouth, for a distance of 120 km.; its width in its upper course near the «volok» is 40—50 m., near the oil fields—from 85 to 90 m., and below Domanik—up to 120 m. The grade of the river in this distance is 65 m., the maximum depths along the channel vary from 1 to 2 m. The navigation is obstructed by rapids; the largest of them, Idji-di-kos, has a grade of 2 m. within a distance of 850 m. The tributaries of the Oukhta and Sed-Yu rivers are navigable by small boats almost to their upper reaches or at least to the point where the river is divided into its northern and southern sources (Voi-vozh and Lun-vozh—into which every river is invariably divided by the Zyrians). Boats are propelled by oars or else with the aid of iron-strengthened poles (see the accompanying photographs). There are no bridle-ways of common roads; hunters' paths along the rivers and in the areas between the latter are very few; thus, river navigation is necessarily the only way of communication.

General condition of work. The Oukhta district is an entirely desolate territory situated at a distance of a thousand kilometers from centers of civilization. The nearest post and telegraph offices are in the village Izhma, on the Izhma river, and in the village Ust-Vym, on the Vychehda river, 250—480 km. from the region; the administrative center of the region, Ust-Syssolsk, is 600 km. from it. An industrial enterprise on Oukhta would have to rely exclusively on its own means; all supplies would have to be brought from Vychehda or from the village Izhma, materials and machines—from Archangel or Kotlas; as said before, the majority of workmen would likewise have to be engaged from remote places. The primitive means of transportation and communication, as well as the severe climate are likewise unfavourable for the development of the mining industry; but, of course, they do not make such development quite impossible, inasmuch as, for example, the operations in Alaska are carried on under conditions by far more difficult.

The abundance of timber (pine, fir, larch, cedar) is a great advantage of the district; building stone can also be had in sufficient quantities (limestones of the Devonian and Carboniferous systems).

GEOLOGY AND THE OCCURENCE OF OIL

Two quite opposite views exist concerning the geology of the Oukhta region, and finding of the true solution is not only a problem of high scientific interest, but is likewise of great commercial importance. The first explorer of Timan, Keyserling (1843), considered that the strata here are involved in a gentle anticline which is not complicated by faulting and trends in the direction of the Timan range, that is to say, northnorthwest. He referred the Domanik formation to the Lower Devonian or Silurian and believed it to be the most ancient formation of Oukhta.

Chernyshev, Academician and Director of the Geological Committee, who explored Timan in 1889—1890, subjected Keyserling's scheme to severe criticism. According to his opinion, the rocks with *Spirifer Anossofi*, lying in the flanks of the anticline, are to be placed in the Middle Devonian, while the Domanik occupying the axial portion, and the oil-bearing Under-Domanik formation contain a typical Upper Devonian fauna. Such a determination of the age of the mentioned formations necessarily involves the assumption that the central part of the fold has sunk along fault planes and a graben (trough) has thus been formed, having an elongated elliptical shape. In such a case the petroliferous area lies only within the trough. However, Chernyshev's assumption has not been proven by subsequent drilling. The wells, having penetrated the Sub-Domanik formation, did not encounter the expected Middle Devonian with *Spirifer Anossofi*, but, sunk below a thin layer of basal conglomerate, entered a thick series of old sericite schists. Nevertheless, Chernyshev's scientific authority (especially with reference to the stratigraphy of the Paleozoic beds) influenced the geological thought to follow the old course.

In 1918 K. P. Kalitsky put forth the following assumption, which was intended to reconcile the facts with theory: after the deposition of the Middle Devonian the latter was eroded in the central part of the region, and the Upper Devonian sediments were deposited immediately on the sericite schists in a bay which was thus formed.

At last, in 1923, D. V. Nalivkin, geologist, having reexamined and redefined the Devonian faunas of Central and North-Western Russia and Timan, arrived at a conclusion that the beds with *Spirifer Anossofi* which are spread in the said regions differ from the Middle Devonian strata with *Spirifer Anossofi* of the Urals,

being actually the Upper Devonian sediments overlying the Domanik. Therefore, nothing prevents our returning to Keyserling's idea, viz., the existence of an undisturbed anticlinal fold. Based on data resulting from his investigations, D. Nalivkin draws the following conclusions of considerable practical importance:

1. Oil-bearing beds may be encountered not only in the center of the dome, but on its flanks as well.



Photograph by Bessonov.

Fig. 2. View of the Oukhta river (from the mountains near the river).

2. The area of the oil-field and its oil reserves should be estimated at a higher figure compared with previous estimations.

Of course, only deep drilling can prove the correctness of either opinion,—in case of the discovery of the Domanik or some older rocks of the Middle Devonian below the beds with *Spirifer Anossofi*. I think it possible, however, to base the present description of the stratigraphy of the Oukhta region on the scheme brought forth by Keyserling and Nalivkin. The correctness of the latter scheme is in my opinion proven by the fact that I was able to show the erroneousness of Chernyshev's scheme in a similar case during investigations in Central Russia, near Voronezh. In the latter place

GEOLOGICAL STRUCTURE. As has been previously stated, the rocks of the Oukhta region are folded into an anticline with gently dipping flanks, trending north-northwest and gradually plunging northward and southward. The fold is, thus, a very flattened elliptical dome, in the middle of which, between the Oukhta and Lya-Yol rivers, the rocks of the petroliferous series crop out, while the other above cited formations are exposed in concentric belts,



Photograph by S. Obruchev.

Fig. 3. Timan, at the portage from Cher-Vychevodsky to Cher-Izhemsky.

closing with the Permian on the west and the Mesozoic on the east (see fig. 5). Strata dip at angles varying from 2° to 4° .

The second structural axis of the southern Timan lies in the western portion of the latter, in the region of the old sericite schists; the Devonian series slightly rises towards the latter but the schists are isolated from the Devonian by a fault striking in the same prevalent north-northwesterly direction. A. Zamiatin believes that within the Paleozoic there are, besides the one mentioned, still some other faults of the same direction.

OIL-BEARING HORIZONS. The characteristics of the oil-bearing series are interpreted chiefly according to the results of the drilling operations conducted in 1910—1913 on behalf of the Government,

the strata contemporaneous to the Domanik rocks also lie below the beds with *Spirifer Anossofi*, and Chernyshev considered them to have subsided, owing to rockslides. My investigations have shown that in reality the first series is older than the latter and lies quite normally.

The Oukhta region composed of the following rocks in the order of their age:

I. THE SERICITE SCHISTS of the Pre-Cambrian of Lower-Paleozoic age, over 450 m. thick.

II. THE UPPER DEVONIAN ROCKS.

1. Sub-Domanik oil-bearing formation. At the base of it lies basal conglomerate up to 7.5 m. thick, overlain by alternating blue, gray and red-brown marls and clays and, partly, sandstones. The formation includes 3 oil-bearing horizons (for particulars see below). The total thickness reaches 250 m.

2. Domanik,—calcareous and argillaceous bituminous shale with an abundant fauna of Cephalopoda. Thickness—75 m.

3. Over-Domanik formation,—blue marls with layers of micaceous sandstones and argillaceous limestones. Thickness—120 m.

4. Marls, sandstones, limestones, dolomites with *Spirifer Anossofi*, etc. (the Middle Devonian of Chernyshev); the lower strata of this formation are petrographically similar to the Over-Domanik formation, but are distinguished from the latter by their fauna. Thickness 210 m.

5. Gypsiferous formation (clays and dolomites). 40 m.

6. Limestones, marls and clays with *Rhynchonella livonica*. (90 m.)

The total thickness of the Devonian reaches 785 m.

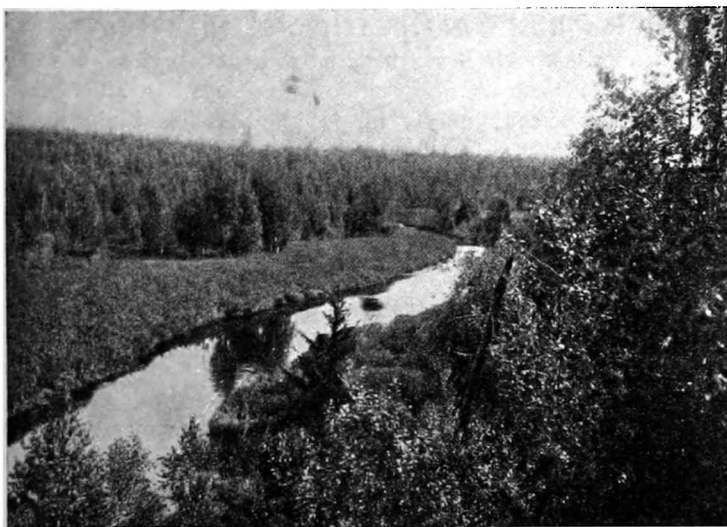
III. CARBONIFEROUS ROCKS rest on the west and in the Sed-Yu valley on the eroded surface of the Devonian, and are composed of limestones and marls.

IV. PERMIAN ROCKS occupying the upper course of Oukhta, are represented by varicoloured marls.

V. MESOZOIC CLAYS (Volga stage and Cretaceous) crop out only on the boundary of the district on the Izhma river.

VI. POST-TERTIARY DEPOSITS (ancient alluvium and boreal transgression) occupy the river valleys along the western and eastern borders of the district.

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OIL-BEARING HORIZONS. The characteristics of the oil-bearing series are interpreted chiefly according to the results of the drilling operations conducted in 1910—1913 on behalf of the Government,

under the supervision of V. Stukachev, and drilling operations performed in 1913 by the Russian company «Nefi». The data are somewhat contradictory. According to Stukachev, the oil-bearing series consists, as a rule, of the following horizons (beginning with the lowest):

1. On the sericite schists (defined by Stukachev as metamorphic sandstones) lie bituminous gray sandstones varying in thickness from 103 to 166 m. The uppermost part of these sandstones represents the 2nd more prolific oil-bearing horizon of Oukhta. Sandstones being tested by benzine yield a coloured extract.

2. Bluish viscous clays, marls and shales, their thickness varying from 4 to 90 m.

3. Brown-red marls, 6—43 m. thick.

4. Greenish-blue and gray marls, clays and shales, 17—124 m. thick. Within these strata lies the 1st oil-bearing horizon, which is poorer than the horizon mentioned above, and rests immediately on the brown-red marls.

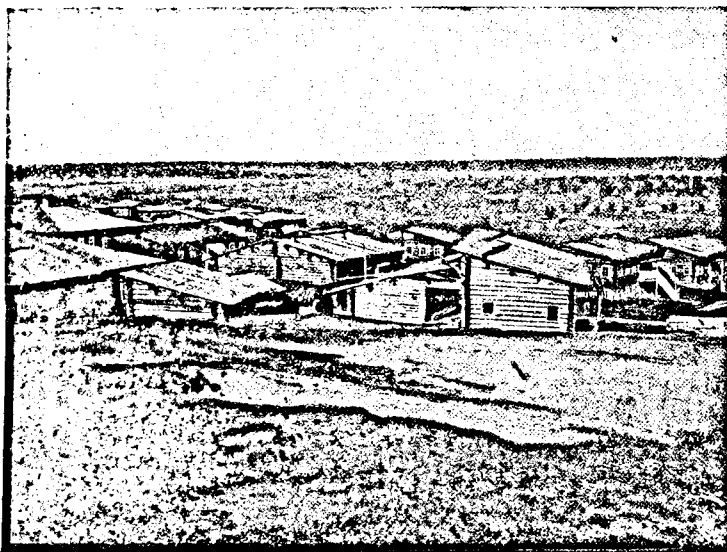
The data obtained by the company «Nefi» are not sufficient for the definition of similar horizons within the oil-bearing series. They rather tend to show that the whole formation consists of the alternating gray, blue and brown-red marls, clays and shales. The oil-bearing strata lie within this formation, and have been encountered chiefly in connection with the layers of sandstones. The western wells of the company exhibit approximately the same sequence of the oil-bearing horizons, as the wells drilled by the Government; the only well on the eastern border of the district encountered the lower horizon at a much greater depth, only 40 m. above the sericite schists. It is to be supposed that the second horizon is not developed in this portion of the district, and instead of it the 3rd horizon, lying deeper, is saturated with oil. We have thus, three horizons lying below the base of Domanik beds: the 1st—at a depth of 40—55 m., the 2nd—at 120—130 m., and the 3rd—at 205—207 m. ¹⁾

The accompanying three sections illustrate the foregoing. Section of fig. 6 is prepared by Stukachev according to the logs of drill holes sunk by the Government Mining Department; sections

¹⁾ The well No. 2, owned by the State and located on the bank of Lya-Yol, the only well within the southern part of the region, encountered the 2nd oil-bearing horizon at a vertical distance of 121 m. from the 1st (i. e., at 170 m. from the Domanik), consequently, deeper than it should have normally been.

of fig 7—AB (longitudinal) and CD (latitudinal) are prepared according to the data of all the wells drilled in the district. On section AB, besides the already indicated rocks, an intrusive sheet of diabase is marked, which was encountered in Voronov's well on the Yarega river.

The oil-bearing horizons of Oukhta are saturated very feebly: the 1st yields not more than 50 kg. a day, the 2nd yielded during 2 months 300 kg. daily (the well No. 3 on Chut, owned by Govern-



Photograph by S. Obruchev.

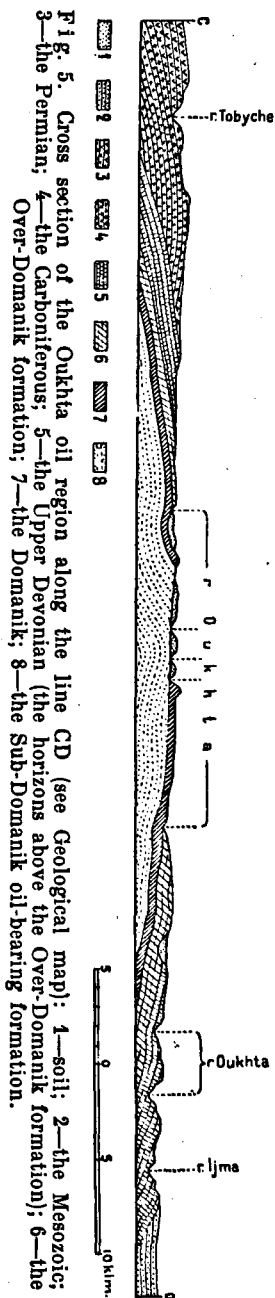
Fig. 4. A Zyrian village in Timan.

ment), the 3rd, on Chibiu, from 150 to 650 kg. (particulars see below).

The oil-bearing horizons are gas-bearing as well. There are strong escapes of gas from second horizon, as, for instance, in the well No. 3 of the Mining Department, on Chut, where gas ejected water and oil over the mast which was 20 m. high. The upper horizon, as well as the Domanik, yields only small quantities of gas.

Water-bearing horizons. There are the following water-bearing horizons:

- 1) Fresh-waters over the Devonian clays, below the alluvium.



2) Alkaline-salt waters,—a strong flow (sometimes overflowing) from the Domanik.

3) Alkaline-salt waters from the formation underlying the 2nd oil-bearing horizon (Stukachev's bituminous sandstones). A strong flow, the salinity about 3° Baumé, temperature about 7°C.

4) Alkaline-salt waters from the sericite schists; the flow is abundant.

Occurrence of oil. Seeps of oil were known in the Oukhta region as early as in the end of the 17th century (Witsen). According to the description of T o l u b e i e v, engineer, «the oil film on the Oukhta river and its tributaries produces an impression of a petroleum river. Oil issues on the river banks and forms pools, from which it flows in wide streams falling into the river».

During the geological investigations conducted by A. Z a m i a t i n, the following indications of oil were recorded on the area within which oil-bearing series, the Domanik and Over-Domanik formations, have been found:

1. Seeps of black liquid oil occur in many places; they are most numerous on the axis of the anticline, on the area of the lower course of Chut, a left-hand tributary of Oukhta, and along Yarega, a right-hand tributary of Oukhta. To the south, another group of seeps is known, situated likewise on the axis of the anticline, on the Lya-Yol river.

2) Inflammable gas issues near the mouth of the Tsibiu (Chibiu) river, in the bed of the Oukhta river.

3) The Domanik is bituminous in many places, viz., to a greater extent along the Oukhta and Chut rivers and to a lesser extent on the Lya-Yol river, while the

southernmost outcrops of the Domanik along the Vezh-Vozh river are only slightly bituminous or sometimes non bituminous.

4) Alkaline-salt water flows from the casing-heads of the shallow test holes, which are pretty numerous on the Oukhta river banks. The wells spout water with inflammable gas and oil films, to a height of 1 m.

5) Near Sidorovskaia Kazarma, on the bank of the Gas-Yol river, there is a well with a constant escape of gas; when lighted, it burns continuously, so that it has to be extinguished.

6) Dolomites, marls and limestones of the upper strata with *Spirifer Anossofi*, gypsiferous beds and others, when struck, yield a kerosene odour; this is particularly observed along the banks of the Siuz-Yu, B. Kyran and other rivers.

7) There are found in the Domanik shells of *Goniatites* and *Brachiopoda*, whose cavities are frequently filled with oil. Likewise shells which occur in the beds with *Spirifer Anossofi* contain bituminous substances.

8) Sulphurous springs are reported in the following places:
a) on the right-hand bank of the Krokhal river—alkaline-salt cold water containing sulphur dioxide spouts from a cast-iron pipe;
b) a less copious flow of the sulphurous water is observed on the left bank of Oukhta, near the Bolshoi Porog (Great Rapids).

The largest seeps of oil are shown on the accompanying map.

Zyrians tell of numerous swamps covered with a film of petroleum which are situated on the watershed areas. There are many reports of fabulous oil springs in the swamps. Oil seeps are often said to exist in the upper part of the course of the Vychegda river, on the southern prolongation of the Oukhta anticline. The latter seeps are of a great importance, but unfortunately they have not been yet located by geologists.

The present article was in print when I received information from Professor A. A. Chernov, stating that he has examined the bituminous limestones (Carboniferous) and dolomites (Permian), together with asphalt nests, all of which had been discovered by him earlier in the upper course of the Izhma river, between the villages of Kush-Kodz and Niamod. The said deposit lies east of the southern prolongation of the Oukhta anticline, at a distance of 60 km. southeast from the center of the oil region. The presence of faulting in the vicinity of this deposit enables one to suppose that oil was yielded by the Devonian series. These outcrops of bitumen are of great importance, as proving assumptions of a much

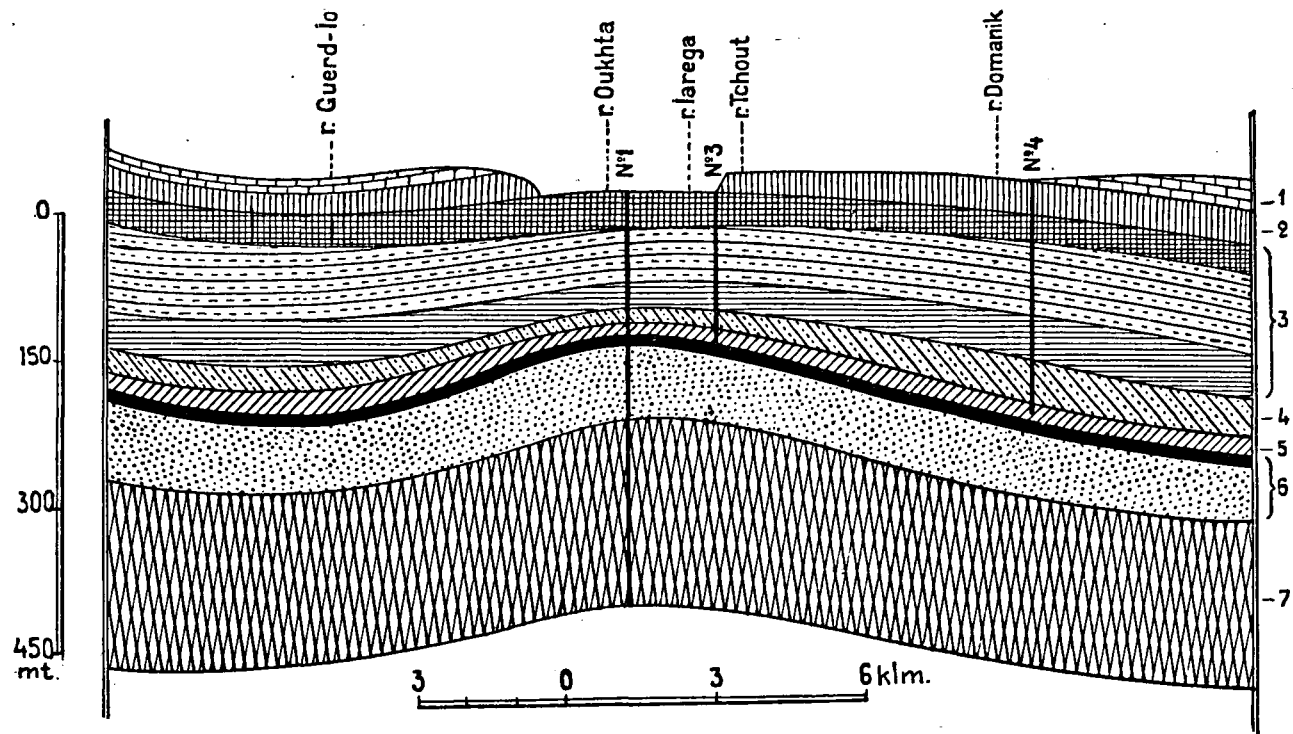


Fig. 6. Cross section of the central portion of the Oukhta oil region, after to V. Stukachev. Governments wells: No. 1—on Oukhta; No. 3—on Chut; No 4—on Domanik. Formations are marked as follows: 1—the Over-Domanik formation; 2—the Domanik; 3—blue clays, marls and argillaceous shales, which are petroliferous in their lower portion; 4—brownish-red marls 5—blue clays; 6—gray bituminous sandstones (the oil-bearing horizon in the Upper portion is marked with black; 7—the sericite shists (blue sandstones).

greater extension of the Devonian oil horizons. Chernov's article, describing the new deposit, will soon appear in print.

Origin of oil. According to D. Nalivkin, the oil-bearing series consists of lagoon, bay and, possibly, delta deposits. Such basins are most favourable places for the accumulation of organic matter and the formation of petroleum. The latter is, thus, of primary origin. The assumption of A. Chernov that the Oukhta oil is not associated with certain series, but migrates along fault planes so that it may be encountered in marked quantities in the Mesozoic rocks, is so far too little verified.

THE HISTORY OF EXPLORATION

The first scientific description of the Oukhta oil region was made by Keyserling (1843).

During the period 1860—1870 the Oukhta oil deposit was investigated and explored (details are given below) by M. Sidorov, the well known merchant and promoter of the industrial development of North Russia.

In 1889—90 an expedition operated on Timan, under the guidance of T. Chernyshev, Academician, who prepared the first map of the Oukhta region and described its stratigraphy and geologic structure. Prospecting work was also been done by the expedition; hand-drilled holes did not exceed 12 m. in depth.

In 1891 I. P. Boklevsky, mining engineer, examined the Oukhta oil field and sunk a few shallow drill holes.

In 1895 drilling operations were performed by Von-Wangel; over 20 shallow wells were drilled in various places of the Oukhta region; the deepest one reached the depth of 177 m. In the same year Oukhta was visited by V. Veber, geologist, on behalf of Von-Wangel.

In 1902 — 1904 A. P. Pavlov, Academician, and A. A. Chernov, geologist, investigated the Oukhta region. The latter has published a paper on the genesis of the Oukhta petroleum.

In 1906 V. J. Beloborodov, engineer, investigated the economic conditions and mineral resources of the region.

In 1905—1908 test drilling was carried on by Voronov, Abakovsky and the concern Hansberg, Kornilov and Co. Voronov drilled a well on the bank of the Yarega river (114 m. deep), Abakovsky—on the Chut river (79 m.) and the Hansberg Co.—on the left-hand bank of the Oukhta river (110 m.).

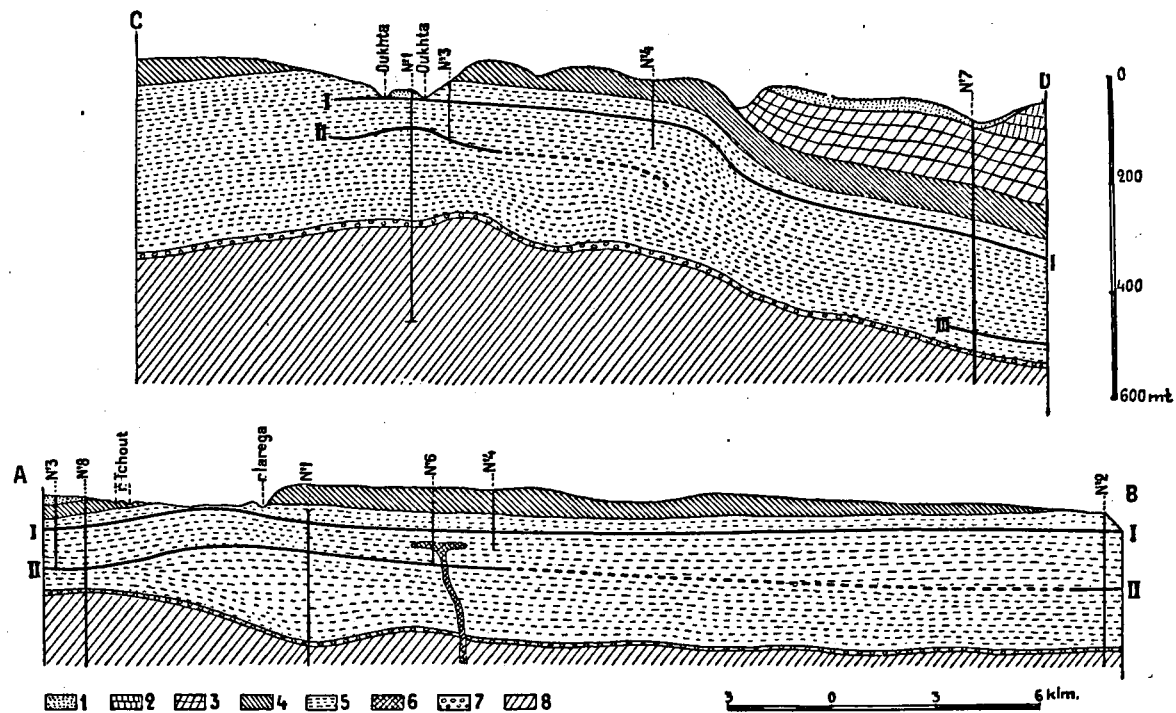


Fig. 7. Sections of the central part of the Oukhta region: AB—longitudinal section, CD—cross section (see the map). Governments wells Nos. 1—4: Nos. 1—on Oukhta; No. 2—on Lya-Yol; No. 3—on Chut; No. 4—on Domanik; No. 6—Voronov's on Yarega; No. 7—of the «Nefte» Company on Chibiu; No. 8—of the «Nefte» Company on Chut, the Karlovsky property. Rocks are marked as follows: 1—soil; 2—limestones with *Spirifer Anossofi*; 3—Over-Domanik formation; 4—Domanik; 5—Sub-Domanik oil-bearing formation; 6—diabase; 7—basal conglomerate; 8—sericite schists. I—III—oil-bearing horizons.

In 1907 explorations were conducted by P. I. Polevoi, on behalf of Voronov, and by Anderson, the geologist engaged by Nobel Company. The former has slightly modified the section prepared by Chernyshev.

In 1909 a group of French capitalists sent some experts to Oukhta.

In 1909—1910, on behalf of the Geological Committee, the Oukhta oil field was examined in detail by A. Zamiatin, geolo-



Photograph by S. Obruchev.

Fig. 8. Timan. Typical landscape, with forests of broad-leaved trees.

gist, while the adjacent district of the upper Oukhta and tributaries of Vym, northwest of the latter fields were investigated by N. Yakovlev. Reports and maps published by these geologists serve as guides for all subsequent investigations.

In 1910—1913 four test wells, ranging in depth from 149 to 427 m., were drilled under the supervision of V. Stukachev, engineer, on behalf of the Mining Department.

In 1913 the Russian Company «Neft» drilled four deep wells (from 200 to 657 m.) and sunk ten hand-drilled holes.

In 1918 K. P. Kalitsky and A. A. Stoianov, geologists, were sent to Oukhta by the Geological Committee.

In 1919 the Chief Petroleum Committee sent to Oukhta a large geological party, which, however, was unable to penetrate beyond the middle course of the Vym river, owing to the occupation of the Oukhta region by white troops.



Photograph by S. Obruchev.

Fig. 9. Timan. River encumbered by wood.

In 1920 the Archangel Economic Council cleaned the well located on Chibiu, formerly owned by the «Nef» Company.

PROSPECTING AND EXPLOITATION

The Oukhta oil region is the oldest in Russia. To Russians the Oukhta oil became known and was utilized long before the present oil producing regions were joined to Russia. There are reports that in 1697 Peter I sent to Holland some specimens of the Do-manik rock, to be analysed. The further history of the Oukhta oil industry is such:

In 1745 NABATOV erected in Ust-Oukhta a refinery; the kerosene produced was sent to Moscow apothecaries in quantities of about 16 tons per annum, up to the end of the XVIII century; the total oil production amounted to 60 tons per annum. Crude oil was sent

abroad. After Nabatov's death the refinery was burnt down and the oil production stopped.

In 1746 FEDOR PRIADUNOV built a refinery on Oukhta. «Above the very spring, spouting oil, a quadrangular log hut has been erected». In 1751 Priadunov was thrown into prison at the Berg-Collegium (Mining Committee) in Moscow, owing to the non-payment of the tithe money (royalties) amounting to 35.23 roubles for the oil produced in 1751, and died in confinement. After his death the plant passed to Nagavikov, a Vologda merchant, then to Mingalev, a peasant, and further to Bazhenov, a merchant of Yarensk.

In 1860, M. SIDOROV, who endeavoured to promote the development of all the mineral resources of North Russia, took interest in the Oukhta oil. In 1872, upon the investigation of the oil field and after lengthy solicitations to secure a prospecting permit (during 6 years the authorities obstructed in every way Sidorov's activity), Sidorov drilled a well on the bank of the Oukhta river, near the mouth of the Neft-Yol stream; the well was sunk to a depth of 52 m., with an initial diameter of 16 inches (?) and a final one of 5 inches. At this depth the drilling tool broke. According to the well log, there are in all eight oil-bearing beds, four of which were encountered within the last 4.5 m. from the bottom of the well, and two gas-bearing beds. The flow of oil steadily increased. All this oil seemingly rose from the 1st horizon. Sidorov ordered a set of tools for drilling to a depth of 200 m. with a diameter of 13½ inches, but such heavy tools could not be transported to Oukhta, the drillers brought from abroad fled away; Sidorov himself died soon afterwards, and all his numerous undertakings were abolished. The «Sidorov Property» (Sidorov's tract of land) and the «Sidorovskajia Kazarma» (a house) remained, to serve as memorials of this man (the house, however, was burned in the XX century).

In 1889—1890 a number of shallow wells were drilled by T. CHERNYSHEV, during his expedition to Timan; they were drilled with Voislav's hand drilling tools with bits 2 inches in diameter. The deepest well No. 3 on Chut reached a depth of only 12 m. When the well penetrated through the layer of limestone interbedded in the blue marls, oil appeared at a depth of 6 m.; the oil was first spouted continuously for 3 hours, whereupon it was ejected periodically, every 30 or 45 minutes, alternating with water. At a distance of ¾ km. from the well No. 3, up the river Chut, on

the left-hand bank of the latter, a well, No. 4, was drilled from which a stream of oil likewise issued at a depth of 3 m. from the blue marls. All these flows came from the first horizon.

In 1891 A. M. GALIN obtained an exclusive right for the term of 12 years of working the Oukhta oil field, as well as a license for manufacturing illuminating oils in quantities of 80,000 tons free of excise tax. Till 1895 nothing was done by him.



Photograph by S. Obruchev.

Fig. 10. Timan. Zyrian huntsman's hut.

In 1895 B. I. VON-WANGEL entered into partnership with Galin and started drilling operations; during that year he drilled 6 wells ranging from 3 to 6 inches in diameter, and from 50 to 177 m. in depth. In 1896 they had about 20 wells most of which were shallow. The deepest well, No. 2, 177 m. deep, was located on the right-hand bank of the Chut river, on the northern border of Sidorov's lease, $1\frac{1}{4}$ km. from the mouth of the river (No. 10 on our map). It seems that at a depth of approximately 100—105 m. the 1st oil-bearing horizon was passed through, from which large quantities of gas issued, while the flow of oil reached 50 kg. per day; oil and gas were struck at a depth of 9 m., and their flow was continuously increased to the 1st horizon. Below the latter salt

water appeared. The well was stopped in a hard calcareous sandstone. Further prospecting operations were suspended, owing to want of capital.

In 1900 count KANKRIN obtained an exclusive right of oil production within the Oukhta region for a term of 5 years, but up to the expiration of the latter, May 5, 1905, no prospecting operations were started.



Photograph by Bessonov.

Fig. 11. Oukhta at the mouth of the Nefte-Yol creek.

In 1907 I. A. VORONOV organized an expedition with the participation of P. I. Polevoi, a Russian geologist, and Andersen, a Swedish geologist, and in the autumn of the same year sunk a well on the beds of Under-Domanik formation in the valley of Yarega (No. 6 on our map). The drilling was supervised by N. E. Parshin, engineer; the well, 4 inches in diameter, reached a depth of 194 m. The first oil-bearing horizon was encountered at a depth of about 50 m.; the flow of gas was strong, that of oil being weaker. Below a sill of diabase, 12 m. thick, the well encountered at a depth of 65 m. a bed of petroliferous sandstone, in which drilling was stopped. Oil flowed in continuous small streams. Water was not shut of. The flow of oil markedly increased with the depth, the

thickness of the 2nd horizon in this well being considerable. Beginning with the sill of diabase, diamond drilling was applied.

In 1908 ABAKOVSKY sunk a 4-inch well on the left-hand bank of Chut, at a distance of 300 m. from the mouth of the latter. The drilling was performed first with the diamond drill, and further a rod drilling tool was used. The drilling operations were supervised by B a t s e v i c h, a mining engineer. In the first 25 m. of the hole the Domanik rocks were penetrated, then at a depth of 45 m. appeared large quantities of gas followed by oil. From a depth of 79 m. the well yielded 30 kg. of oil. There was no water at all.

Abakovsky had also conducted prospecting operations in 1904. Beginning from 1899 A. G. HANSBERG took part in the exploration and development of the natural resources of the Pechora region. In 1905 he founded an oil enterprise in the Oukhta district under the title of «The Northern Oil Partnership, founded by A. G. Hansberg, A. P. Kornilov and Co.». In June 15th 1905 the company drilled a well, 14 inches in diameter, on the Varvarinsky lease, on the left-hand bank of Oukhta, near Sidorovskaia Kazarma. By July 24th 1908 the well was sunk to a depth of 110 m., and stopped in sandstones. Drilling operations lasted about 600 working days; the reason for the suspension of the work was want of capital. In winter, till January 1908, only one shift was at work, in consequence of the strong exudation of gas, until the electric lighting was established. V. S o k o l o v estimated the number of oil and gas-bearing beds, penetrated by this well, to be 21, but the proven oilbearing horizons were seemingly encountered at 68 m. and 110 m. (possibly also at 93 m.).

Beside this well there was drilled on the Varvarinsky lease a 4-inch test well, 64 m. deep, which flowed intermittently; a column of water was thrown out of the well every 60—90 minutes, whereupon oil flowed during a few minutes. According to some reports, which, however, have not been checked, both the wells yielded in total about 2.5 tons per day.

In 1910—1913 test drilling was undertaken by the MINING DEPARTMENT with a view to ascertain the commercial value of the Oukhta oil region. By 1910 there were on the Oukhta about 1,000 oil claims; the banks of the Oukhta river as well as its tributaries were covered by locating posts, but any accurate data concerning the value of the oil-bearing territory were absent. The

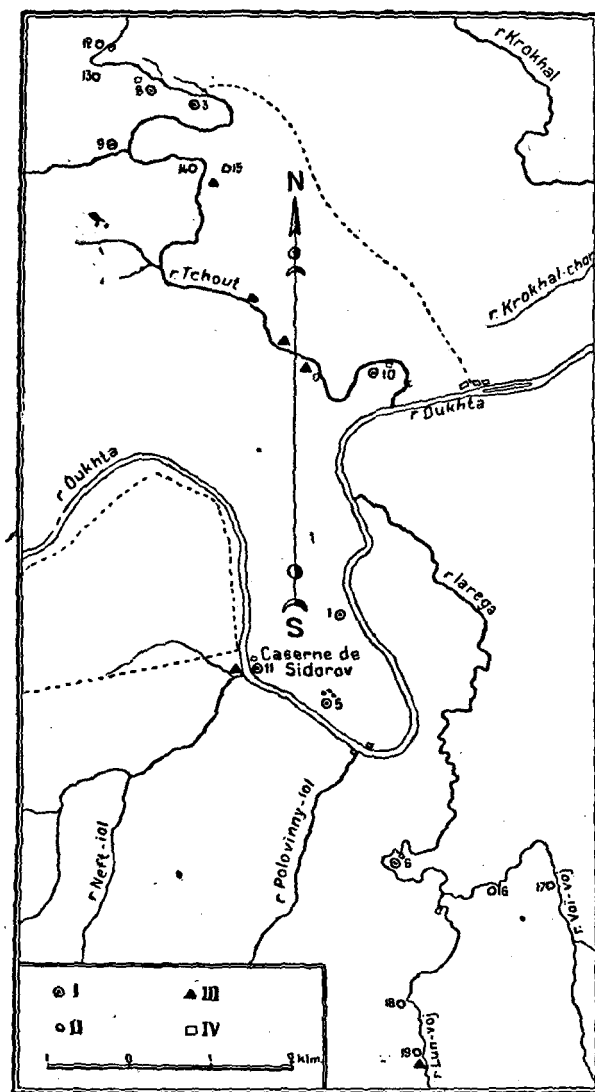


Fig. 12. Map showing distribution of wells of the central portion of the Oukhta district: I—deep wells; II—shallow wells of the «Neft» Company; III—oil seeps; IV—buildings.

Number of wells: 1—Government's well on Oukhta; 2—Government's well on Chut; 3—Hansberg's well on Oukhta; 4—Voronov's well on Yarega; 5—Well of the «Neft» Company on Chut, the Karlovsky property; 6—d-o, the Vladimirsky property; 7—B. Wangel's well on Chut; 8—Sidorov's well on Oukhta; 9—12—19—shallow wells of the «Neft» Company; 10—Sorokhtinsky well; 11—Samsousovsky well; 12—Valentinovsky well; 13—Petrovsky well; 14—Voi-vozh well; 15—Gorny well; 16—Nikolayevsky well; 17—Vladimirsky well.

The following wells are beyond the area covered by this map: 18—Government's well No. 2 on Lya-Yol; 19—Government's well No. 4 on Domanik; 20—a well of the «Neft» Company on Chibiu (see geological map on separate sheet).

drilling undertaken by the Mining Department was conducted under the guidance of V. S t u k a c h e v, an engineer; wells were drilled by standard cable tools with the use of Keystone's drill No. 25. As the rocks were solid, it was possible to drill without immediate lowering of casing; the speed of drilling varied from 12 to 18 feet (3.7—5.5 m.) in a twelve hours' shift. Wells were located in the following places:

1) No. 1—on the left-hand bank of the Oukhta river, above the Yarega mouth, on the southwestern flank of the anticline, at a distance of 400 m. from the crest of the latter (No. 1 on the map). The well, 427 m. deep, penetrated the 1st oil-bearing horizon embedded in the sandy marl at a depth of 55 m., the 2nd horizon embedded in a compact argillaceous sandstone at a depth of 82.3 m. The first horizon yielded daily about 130 kg. of oil of specific gravity 0.918, the second about 570 kg., sp. gravity 0.886. The second horizon represented a bed of sandstone, 7.6 m. thick, separated from the underlying bituminous sandstone, 166 m. thick, by a layer of marl, 1.5 m. thick. The extracted oil was heavy, with a sulphurous odour; alkaline-salt water was encountered not only in the underlying old «metamorphous sandstones» (the well penetrated the latter for 187 m.), but likewise in the formation of gray-blue marls and limestones overlying the 1st oil-bearing horizon. According to Stukachev, both the latter facts are due to the proximity of the earth's surface and to fractured rocks near the axis of the anticline. The bituminous sandstones yielded fluid oil only from its upper horizon, while gas issued also at a depth greater than 210 m. The marls yielded strong flows of gas at a depth of 40 m.

2) The well No. 2 was drilled on the bank of the Lya-Yol river, 30 km. south of the first, on the northeastern flank of the anticline, near the axis of the latter (No. 2 on the map). The drilling was stopped likewise in the Precambrian sandstones (which were penetrated by the hole for 50 m.) at a depth of 320 m. The oil-bearing horizon was encountered at a depth of 41 m., in gray marls (slightly impregnated); the upper portion of the bituminous sandstones, which was struck at a depth of 180 m., did not yield any fluid oil. There was a meager flow of gas from the 1st horizon. Oil seeps are found on the banks of the Lya-Yol river in places where the upper horizon crops out; the latter is, thus, drained and has here no practical value. There are 2 water-bearing horizons on the banks of Lya-Yol: 1) a feeble flow of fresh water at a depth of 23—30 m., 2) alka-

line-salt water issuing from the bituminous sandstones at a depth of 210—270 m. salinity—0.5° Baumé, temperature +7.3° C. The rocks are intensely fractured, owing probably to the proximity of the axis of the anticline).

3) The well No. 3, sunk on the right-hand bank of the Chut river, 8 km. NNE of the well No. 1 (No. 3 on the map). The drilling was stopped at a depth of 149 m. in oil-bearing sandstones. The 1st oil-bearing horizon was encountered at a depth of 75 m., the second—at 149 m. The first one yielded small quantities of gas and oil, the second—a strong flow of gas which ejected water, oil and even



Photograph by Bessonov.

Fig. 13. Seeps of oil in Oukhta.

wooden plugs to a height of 20 m. The gas was under a high pressure and had a pronounced odour of kerosene. The pumping of oil from this horizon was carried on during 5 months. The daily output was at first only 80 kg., but gradually increased and attained its maximum on the 46th day, when 700 kg. were bailed. The average daily output during the two first months was approximately 300 kg. Thereupon its production declined and by the end of the fifth month the output was equal to only 30 kg. per day. During 150 days a total of 30.7 tons was bailed. The exudation of gas continued for a long period of time, and the gas pressure attained 140 lbs. per square inch (9.84 kg. per square centimeter), with the well shut, and 10 lbs. per inch (0.70 kg. per square centimeter), when outflowing through a two inch tube. Further deepening of the well was refrained from, to prevent flooding by

alkaline-salt waters from the underlying sandstones. Sp. gravity of oil—0.779 ¹⁾).

4) The well No. 4 was located on the Domanik river (a right-hand tributary of the Oukhta), on the northeastern flank of the anticline, 6 km. away from the axis of the latter. The well penetrated the Domanik rocks, 53 m. thick, and the formation of blue-gray and red marls, to a depth of 225 m. The 1st horizon, slightly saturated with oil, was encountered at a depth of 94 m. (gas issued in small quantities, and insignificant quantities of oil not exceeding 10 kg. per day). Sp. gravity—0.886. The Domanik rocks yielded a strong flow water with a marked odour of sulphuretted hydrogen, to 738,000 liters per day.

A summary of Stukachev's data concerning the lithological character of the oil-bearing series and the section prepared by him according to well logs are given above in the description of oil-bearing horizons. Stukachev holds that the porosity of the sandstones of the lower horizon equals 0.08 of the volume; only the uppermost beds of the horizon, which lie immediately under the argillaceous cap, are believed by him to be oil-bearing, while the lower portions of the sandstones are saturated with alkaline-salt waters. The oil-bearing formation may be estimated 1.5—7.5 m. thick, which equals 1/70—1/15 of the whole thickness of sandstones. The oil always contains water which is mechanically mixed with it and amounts to 5 per cent of the volume of oil.

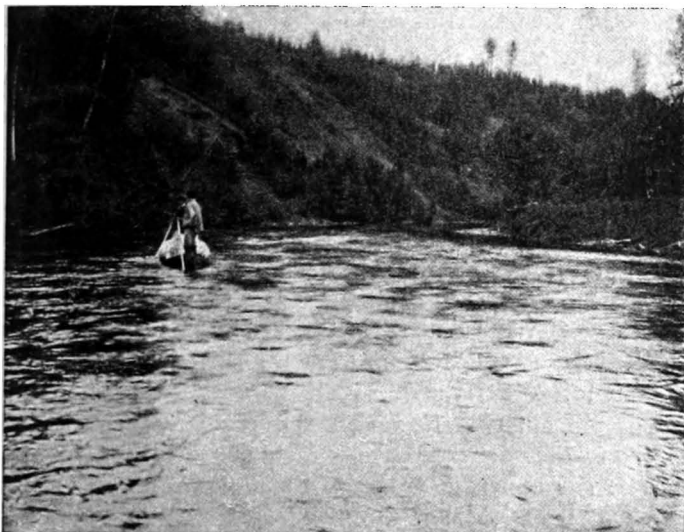
In 1913 THE RUSSIAN COMPANY «Neft» sunk four deep wells in the Oukhta region by means of the standard cable tools, using the drilling machine of Keystone and Star; the same Company sunk also ten hand-dug wells.

The report of A. Zamiatin and the saved well logs of some of the wells give the following particulars concerning the wells of the said Company.

1) Well No. 1 was drilled on the plot Karlovsky on the right-hand bank of the Chut river, 1 km. from the Mining Department's well No. 3 (No. 8 on the accompanying map); it reached a depth of 657 m., the 1st petroliferous horizon encountered at a depth of 84 m., the 2nd—at a depth of 143—147 m. The first horizon yielded drops of oil and some gas, the second showed the same results (according to Zamiatin; in the well log this horizon is not indicated at

¹⁾ Possibly, this is a misprint—the figure should have been apparently 0.879, because fractions distilled from this oil have sp. gravity of 0.73—0.84.

all). At a depth of 182 m. (according to the well log) drops of oil and salt water were encountered. At 193.5 m. the hole penetrated a bed of conglomerate, 7.5 m. thick, and entered the sericite schists. In order to ascertain the presence of oil in the strata underlying the oil-bearing series, the well was sunk further to 463.5 m. through the sericite schists, but no indications of oil were discovered, and



Photograph by S. Obruchev.

Fig. 14. Timan. Cher-Vychegodsky river in its mountainous banks.

the drilling of the well was stopped without reaching the rocks underlying the schists.

2) Two wells were sunk on the Vladimirsky property situated 1 km. south of the Karlovsky property. The first well, which was a deep one (No. 9 on the map), struck oil-bearing horizons at the depth of 64 m. and 160 m; the well ended in the sericite schists. Another one, located at point 20 m. distant from the first, was drilled by hand only to the first horizon (at a depth of 67 m.). The top water in the first well was carefully shut off; the absence of water flow between the oil-bearing horizons permitted the extraction of oil from both of them at the same time. Trial bailing yielded on the first day 220 kg. of oil, on the 10 th day—30 kg., and after the output decreased to 15 kg. per day; the well yielded

totally about 3 tons. The second well yielded from the upper horizon at first about 50 kg., and subsequently not more than 15 kg., like the first well.

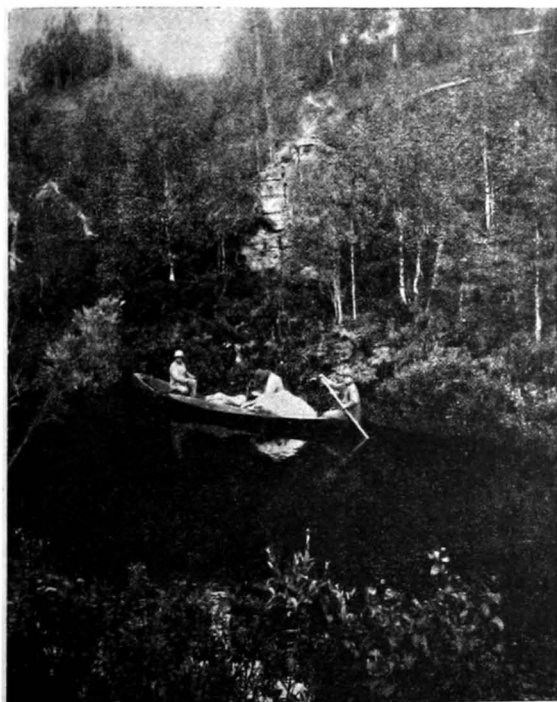
3) The wells located on the Gorny, Nikolaevsky and Vladimirsky properties on the Yarega river and drilled by hand gave oil and gas from the first horizon; the well sunk on the latter property struck a flow of oil amounting to 30 kg. per day.

The other five wells drilled by hand in the central part of the Oukhta region struck only gas and water.

4) With a view to ascertaining the conditions of the oil-bearing horizons on the flanks of the anticline, the company sunk three wells on a tract near the Chibiu river, a left-hand tributary of the Oukhta river, at a distance of 12—13 km. from the mouth of the former. Well No. 1 (drilled by the standard cable tools) was located at a short distance west of the line of the so called fault of Chernyshev and Zamiatin, or, according to the map prepared by the latter, even east of the fault, that is, the well possibly furnishes a positive evidence in favour of Nalivkin's scheme. The well drilled through alluvium, 7.6 m. thick, the Over-Domanik clays, 98.5 m. thick, the Domanik rocks 76 m. thick, in which it encountered a feeble flow of sulphureted hydrogen at a depth of 143 m., further down it encountered the 1st oil-bearing horizon, with feeble gas and rare drops of oil at 234 m., the second horizon, with a strong flow of gases and drops of light oil, at 387—389 m. The second horizon is represented by greenish-blue clay with sandstone; below some layers of coarse-grained sandstone issuing an odour of petroleum were met with. At a depth of 428 m. the sericite schists were encountered, within which the drilling was stopped at a depth of 478 m. Fresh water was encountered at the level of the Oukhta river, at 6.4 m. and at 16.5 m., a feeble flow of alkaline salt water at 117 m., a strong flow of the same water which overflowed the well—at 143 m.; both these flows were from the Domanik rocks. At a depth of 234 m. still another feeble flow of alkaline salt water was encountered, which possibly was also derived from the Domanik rock. Two strings of casing were lowered into the well; the last string was stopped at a depth of 412 m. The second oil bearing horizon yielded a gas fountain; a trial bailing of the well gave a daily output up to 500 kg., but at the end of the month only 115 kg. In order to open all the flows of oil in the well the string of casing was raised 36 m., whereupon the well yielded on the first day 650 kg., but a fortnight later

the output dropped to 160 kg. During 80 days 16.8 tons of oil were extracted. Water was carefully excluded.

Two other wells were sunk on the same property to the depth of 279 m. and 85 m. respectively. The first of them, located at a distance of 32 m. from well No. 1, penetrated, according to the well log, alluvium, 8 m. thick, the Over-Domanik series,



Photograph by S. Obruchev.

Fig. 15. Timan. A cliff of limestone in the narrow valley of Cher-Vychevodsky at the portage.

118.5 m. thick, the Domanik rocks, 72.5 m. thick; further downward the hole entered the sandy-argillaceous formation. At a depth of 244 m. the well struck gas (the 1st oil-bearing horizon); fresh water—at a depth of 14 m. Oil and salt water were not encountered.

In 1920 the ARKHANGELSK ECONOMIC COUNCIL cleaned the well on the Chibiu, formerly owned by the «Neft» Co., and recommenced

the exploitation of the old oil wells. During the winter 1920—21 about 33 tons of oil were extracted, but further production ceased, owing to large cavings in the well.

COMPOSITION AND COMMERCIAL VALUE OF THE OIL

There are about 20 analyses of the Oukhta oil. They were summarized in an article prepared by A. Vaipolin. Here we cite but some of the most important analyses taken from the said article. The most complete analysis of the oil derived from Wangel's well was made by Prof. A. Berkenheim. The results of the analysis are as follows:

The oil was thick and dark-brown; its specific gravity equalled 0.8832 at 17.5° C; the viscosity at 20°, as compared with water at the same temperature, was $E_{20}=9$; flash point 21° C (at barometric pressure of 747.9).

The results of the first distillation are shown in the following table; the 1st fraction comprises all products distilled at a temperature below 150°, including water contained in the petroleum.

Fractions.	Sp. grav.	Grammes.	Yield (per cent).
I. 28° to 150°C.	}	990	12.0
to 200°C.			9.2
II. 200° to 250°C.	0.820	342	7.3
III. 250° to 270°C.	0.832	630	13.4
IV. 270° to 300°C.	0.815	265	5.6
		2.227	47.5

Specific gravity of all the fractions was taken at 15.5—16° C. Percentage of residuum, sp. gravity 0.957, was 50 per cent.

The fractions obtained at the first distillation (2227 gr. in total) were subjected to the second fractional distillation. The latter was started with the first fraction, to which the other fractions were subsequently conveyed in the process of distillation.

Fractions.	Weight (grammes).	Yield. (per cent).	Total.	Volume (cubic cm).	Yield (per cent).	Total.
I. Benzines						
20°—100°C	76	1.62	} 7.88	106	2.00	} 9.00
100°—120°C	96	2.05		103	2.00	
120°—150°C	197	4.21		260	5.00	
II. Kerosines						
150°—200°C	404	8.63	} 26.57	501	9.55	} 30.76
200°—250°C	574	12.26		705	15.20	
250°—270°C	226	5.68		419	6.01	
III. Solar oils.						
270°—300°C	212	4.53	} 7.77	250	4.70	} 8.10
300°—320°C	153	3.24		180	3.40	
Total up to 320°C			42.22			47.86
IV. Cracked products of low boiling point (se- condary benzines).						
27°—100°C	36	0.77	} 1.56	51	0.96	} 2.14
100°—120°C	13	0.03		16	0.30	
120°—150°C	35	0.76		47	0.88	
V. Residuum, boiling point above 300°C.						
	126		2.67	143	2.70	
			46.45		52.70	

The specific gravity of «cuts» of the secondary distillation was determined with the aid of the Mor-Westfal balance at 17° C.

Fractions.	Sp. gravity.	Viscosity (Engler).
22°—100°C	0.7140	—
100°—120°C	0.7378	—
120°—150°C	0.7577	—
150°—200°C	0.7846	1.00
200°—250°C	0.8136	1.17
250°—270°C	0.8379	1.33
270°—300°C	0.8479	1.56
300°—320°C	0.8520	2.00
above 320°	0.8700	—

The flash point of the 150°—200° fraction was proved to be 15° C, i. e., below the standard (28°); the flash point of the other fractions was above the standard and above the limit of the apparatus of Abel-Pensky (40°). Viscosity was determined at 20° C in relation to water of the same temperature.

The residuum obtained upon the first distillation, amounting to about 50 per cent, represents a thick viscous fluid with specific gravity (at 17.5°) 0.957 (determined with the aid of an areometer). 300 gr. of residuum were subjected to further fire distillation for the determination of the yield of lubricating oils. During the distillation the temperature very soon exceeds 360° C, and of the whole quantity of residuum, the yield of distillate is 175 gr., i. e. 30 per cent. of the total amount of crude oil; a hard asphalt-like residuum is left in the distillation flask. 175 gr. of the lubricating oil obtained upon the distillation were frozen, to determine the paraffin content.

Being exposed to cold the whole sample solidifies and yields 2.25 gr. of crude paraffin; the content of the latter in the petroleum is therefore about 0.5 per cent.

The samples of oil brought from Oukhta in the autumn of 1918 at the initiative of the Putilov Works were examined in the laboratory of the Chief Petroleum Committee. The same samples have also been analyzed in the laboratory of the Putilov Works.

According to the analyses made by the Chief Petroleum Committee, Prof. M. M. Tikhvinsky refers these oils to the type of high tarry oils, deprived of paraffin. Benzine can be extracted only from Chibiu oil—these oils are not suitable for the manufacture of lubricants, while the Sidorov oil can be used only as fuel; but even for this purpose it cannot be used because of its high viscosity, unless it is diluted with a lighter oil.

But Tikhvinsky's conclusion is too pessimistic, being based on the analyses of oils which are evidently enriched with tarry substances; these oils were taken from abandoned wells, or even from pits near the wells,—and were exposed to the air for a long time. Therefore, only one analysis, viz., that of the Chibiu well, which is the newest, deserves attention. This analysis reads as follows:

Total quantity of oil	520 cubic cm.
Quantity of settled water	none
Specific gravity at 15°C	0.8944
Viscosity after Engler at 50°C	4.33
Flash point after Brenken	40°C.
Percentage of tar (the so-called excise method)	78%

Distillation after Engler:

Initial boiling point	99°C
Fraction below 150°C	7.9%
Fraction 150—270°C	26.0%
Specific gravity of the fraction at 15°C	0.8028
Fraction 270—285°C	7.1%
Residuum above 285°C	58.7%
Loss	0.3%
Cold test	under 3°.

A. Vaipolin gives the following comparative table of the fractions yielded from some samples of the Caucasian, Pennsylvanian and other oils:

	Specific gravity.	Fractions below 150°.	(Per cent) 150—300°.	Total.
Pennsylvanian I	0.817	14.6	31.1	45.7 per cent.
» II	0.801	21.5	29.2	50.7 »
Baku I	0.870	4.05	38.85	42.9 »
» II	0.880	0.63	37.28	38.9 »
Balakhany I	0.871	6.1	32.6	38.7 »
» II	0.882	1.0	40.9	41.9 »
» III	0.894	9.38	20.16	29.5 »
Oukhta I ¹⁾	0.883	7.88	31.1	39.0 »
» II ²⁾	0.878	10.46	40.26	50.7 »
» III ³⁾	0.879	11.61	21.84	75.0 »
		Cracked kerosene	41.54	
» IV ⁴⁾	0.894	7.9	33.1	41.1 »

From the examination of all the analyses of the Oukhta oil A. Vaipolin draws the following conclusions:

The percentages of respective fractions in different analyses are not equal: for instance, some samples contain practically no benzine (1 per cent), while other samples show from 4 to 11.6 per cent of it; the yield of kerosene varies from 21 per cent to 40 per cent; thus, the total percentage of distillates of some oils amounts to 25 per cent. of the crude petroleum, whereas for

¹⁾ Wangel's well, analyst Berkenheim (the lower horizon).

²⁾ Hansberg's well, horizon unknown.

³⁾ Mining Department's well No. 3 on the Chut river, analyst Alexeyev, from the depth of 151 m. (the lower horizon?). Specific gravity is shown by Stukachev to be 0.779, probably, erroneously.

⁴⁾ Well of the Co. «Nefte» on Chibiu, analysis of the Chief Petroleum Committee (the lower horizon?).

some other oils this percentage inclusive of the products of cracking reaches 75 per cent.

The same applies to the percentage of other fractions, likewise of paraffin.

The yield of lubricating oils is not considerable (in some particular cases it may be as high as 30 per cent), but the Oukhta oil is not sufficiently studied in this respect.

As to paraffin, its percentage in the oil, as is ascertained by different analyses, is variable; for example, B e r k e n h e i m's analysis (oil from Wangel's well) shows 0.5 per cent. of paraffin, the analysis of the Laboratory of the Mining Institute (I. A. A v a l o v analyst, oil from the Chut river, Wangel's well)—1.25 per cent.; K. T u m s k y points out a case where the oil yielded 2.4 per cent. of paraffin.

Yielding by distillation variable percentages of fractions, the oils derived from different wells differ from each other also in physical properties, such as viscosity, specific gravity, colour, etc. For instance, the oil of Sidorov's and Hansberg's (Varvarinsky) wells is thick and of a greenish colour, while the oil from the wells on the bank of the Chut river (those of Wangel, Mining Department No. 3, etc.) is less thick and has a comparatively low specific gravity. The oil from the deep wells of Chibiu is still more fluid. The oil from the Lya-Yol river is less thick than the oil from Sidorov's well.

When exposed to the air, the oil densifies (becomes more tarry), its specific gravity considerably increases; such oil will, of course, yield a lesser amount of light fractions than the fresh samples of oil just extracted from the well. These circumstances should be borne in mind, especially when the results of the analyses of the Oukhta oil are estimated: some investigators took the samples of oil direct from the wells by means of a bailer; other investigators (who visited the wells after the operations had been stopped) caught oil, that flowed with gases and water at a casing head, or simply gathered oil in pits near the wells.

It should be likewise taken into consideration that different conditions under which the distillation of even the same sample of oil was performed may be responsible for variations in results, which doubtlessly occurred in some cases.

As may be seen on the table cited above, the percentage of the illuminating oils yielded by the Oukhta oil is not below the respective percentage obtained from Caucasian petroleum, while

the lighter oil equals in this respect the Pennsylvanian oil, in spite of a by far higher specific gravity of the Oukhta oil.

It should be also mentioned that the figures in the above table are not quite comparable with each other, because the conditions of the distillation were not identical in all cases. The figures should necessarily vary within a small percentage, depending on whether the distillation was conducted with superheated steam or by means of open fire, with greater or smaller quantities of oil, or, possibly, was a distillation on a commercial scale.

The specific gravity of the distillates of the Oukhta oil (fractions of the second distillation by Berkenheim) is somewhat lower than that of the corresponding fractions of the Caucasian oil, but is higher than the specific gravity of the distillates of the Pennsylvanian oil:

	150°—200°	200°—250°	250°—300°
Pennsylvanian oil	0.757	0.788	0.806
Caucasian oil	0.786	0.824	0.861
Oukhta oil	0.784	0.813	0.843
		to 0.803	to 0.829 ¹⁾

W. K i n d holds that a relatively low specific gravity of the corresponding fractions of the Oukhta oil somewhat increases the value of the latter, as compared with the Caucasian oil, inasmuch as the fractions to be turned for manufacturing kerosene mixtures may have higher boiling points, than the fractions used for that purpose in the Caucasus oil regions; besides, the fractions of the Oukhta oil may be taken in that case in greater quantities, than the latter fractions; however, the Oukhta oil is in this respect inferior to the American oils. In the Pennsylvanian kerosene the fractions boiling above 290° C. amount to 26 per cent by volume, whereas the respective percentage for the Caucasian oil barely reaches 5.4 per cent.

The gas from the Mining Department's well No. 1 (Oukhta) has, according to N. I P o d k o p a i e v's analysis, the following composition:

Methane (CH ₄)	99.2 per cent.
Carbon dioxide (CO ₂)	0.6 » »
Oxygen (O)	0.2 » »

¹⁾ Analysis by I. D. Avalov of the oil from Wangel's well.

SUMMARY

The following conclusions may be drawn from the available data:

1. The structural feature of the Oukhta oil field represents a dome-like anticline with gently dipping flanks, unaffected by any considerable dislocations.

2. The oil-bearing area is not confined within the so-called graben (trough) of 1,300 square km., in which the rocks of the Over-Domanik, Domanik and Sub-Domanik formations are exposed. Test drilling may be conducted along the axis of the anticline northward and southward, as well as on the flanks, outside the mentioned area. It is evident, that to reach the oilbearing formation, the well must be drilled through the Domanik rocks, 75 m. thick, the Over-Domanik formation, 120 m. thick, as well as through the overlying strata of the Devonian, 300 m. thick (depending on the location of the well).

3. In the central part of the elongated dome the oil-bearing horizons lie at a depth of 40—55 m. and 120—130 m. below the bed of Domanik; in the southern part, on the Lya-Yol, the second horizon has been struck at a depth of 170 m., while in the eastern one it was encountered at a depth of 205 m., and may be here considered to be the third horizon; thus, in different parts of the region different horizons are saturated with oil. The discovery of oil in deeper strata, i. e., in the sericite schists cannot be expected. The oil is seemingly of primary origin.

4. The central part of the elongated dome is more or less thoroughly tested, while the southern and eastern parts are tapped only by one well each.

5. The daily output per well does not exceed 700 kg., the average being 300 kg. The maximum production of one well during 5 months is 33 tons. The best producer was a well located on the flank (Chibiu).

6. Specific gravity of the oil derived from the upper horizon is 0.923—0.928, from the lower—0.894—0.879. The oil from the central part of the dome often is thick, as well as the oil from the well located in the southern part (Lya-Yol). This is due to the fact that the crest of the anticline is eroded in those places, the oil-bearing series is exposed, and the oil-horizons are near the surface. The best, lightest oil is yielded by the well located on the flank (Chibiu).

7. The best samples of oil, warranted not tarry, yield 7.88 to 11.61 per cent of benzine and 31.1 to 63.38 per cent of kerosene, consequently, the Oukhta oil is not inferior to the Caucasian or even in some cases to the Pennsylvanian oil.

8. The average production of the Oukhta wells is not large indeed, but it should be taken into account that the best results were obtained by a well sunk on the anticline flank, whereas the flanks have almost not been tested, as the attention of investigators was directed towards the central part of the dome, owing to the attractiveness of the oil films on the Oukhta river, and in accordance with Chernychev's structural scheme.

9. In the Oukhta oil field only its central part should be considered as a tested area; the flanks with greater reserves of a more valuable oil, and the northward and southward plunging slopes of the axial part of the dome are yet to be tested, and their prospecting may yield interesting results.

10. Oil production in the Oukhta region with the present yield of the wells (should the above said prospecting give no better results) is not profitable. The development of this oil region is possible only after the construction of new roads and the establishment of new ways of communication, with the development of other natural resources of Timan, particularly of the forest industry.

It is to the question of a possible alteration of the economic possibilities of the Pechora region we shall now pass.

FUTURE POSSIBILITIES OF THE DISTRICT

During the last century more than 15 schemes were offered for linking the White Sea by means of a water-way with the Baltic and Caspian Seas and the basin of the Ob river. Some of these projects embrace also the Oukhta region. There are three schemes of water routes between the Severnaya Dvina and the Pechora rivers: first, by the Vym, Shonvukva, Vukva, Oukhta; secondly, by the Veslianka, Tobysh, Oukhta and finally, by the Vychegda, Vychegodsky Cher, Izhemsky Cher and Izhma. There are, further, several projects connecting the Pechora, Kama and Ob rivers. All these projects are of considerable importance for the development and prosperity of the Oukhta region, in which the water communication always played a predominant part, but so far as the transportation of oil is concerned, the route which

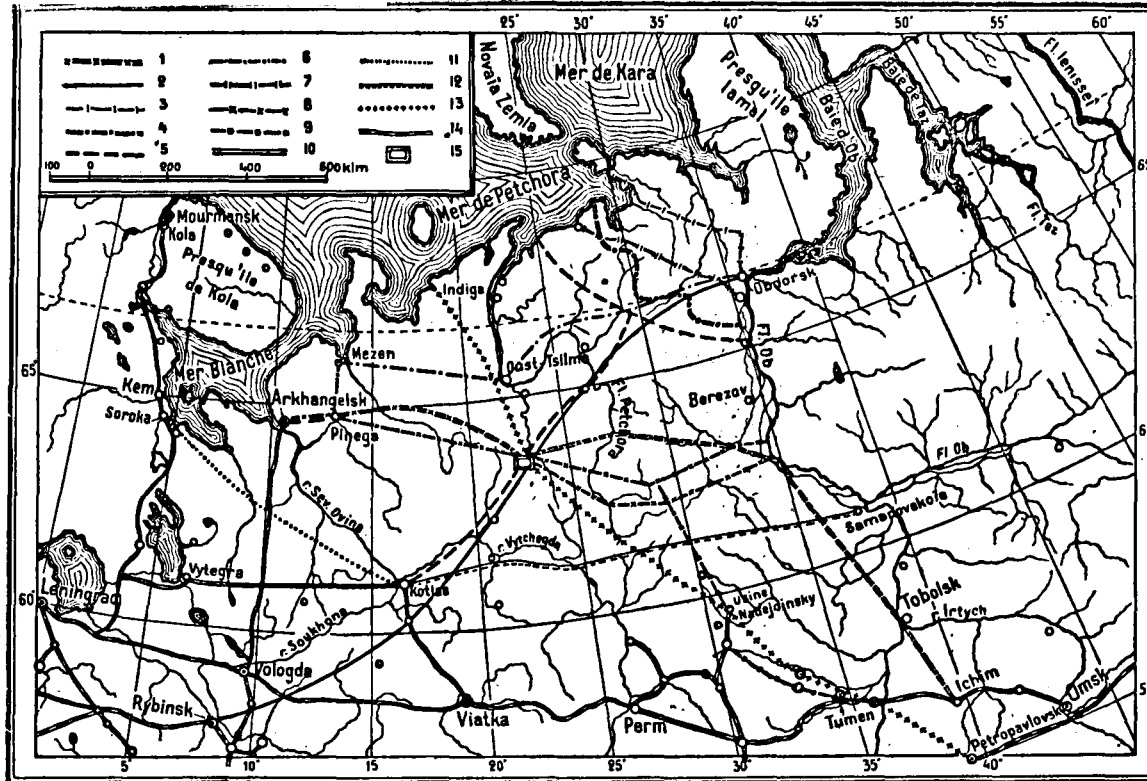


Fig. 16. Map of the projected railway of Northern Russia: 1—the Ob-Archangel'sk Rly (Pereshnov's project); 2—the Rybinsk-Obdorsk Rly (Vrioni's project); 3—the Ob Rly (Golokhvastov's project); 4—the Knorre's Rly; 5—the Beloborodov's Rly; 6—the Arkhangelsk-Obdorsk Rly (Zhuravsky's); 7—the Polar-Ural Rly (Gette's); 8—the fundamental project of the Eastern-Ural-White-Sea-Ob Rly (Vollmann); 9—a probable prolongation of the latter; 10—the Kotlas-Vytegra-Svir Rly; 11—Kotlas-Soroka; 12—the Samarovskoie-Kotlas Rly; 13—the Petropavlovsk-Indiga Rly; 14—the present railways; 15—Oukhta oil region.

is only open for a few months in the year will hardly answer the wants of the oil industry. Therefore, the projects of railways crossing the North Russia are by far more important from the view-point of the industrial development of the region. On the accompanying map the most important of the proposed lines are roughly marked; along some of these lines surveying has been already accomplished.

Those of the projects which link up the lower course of the Ob river with the ocean-shore between Pechora and Vaigach (the so-called polar roads) hardly deserve attention. Now that the Arctic Sea Route is about to be realized, such projects, as were prepared with a view to avoid the Kara Sea, are at present to be put aside, as being of secondary importance. Among the southern railways, the latitudinal road from Kotlas up to the Samarovsk village on the Ob river was recognized in 1916 (by a special Government commission) to be of primary importance, while the way connecting Ob with the White Sea (from Arkhangelsk through Oukhta to the Ob, Voltman's project) was defined as being of secondary importance. Both these routes, as well as a modification of the latter with a branch southward, to Nadezhdinsky Zavod (the terminus of the Bogoslovsk railway branch), are important not only for the development of the adjacent territories, but also for lowering the transportation cost for goods exported from Siberia. The realization of the projected line Ob-Arkhangelsk would reduce the freight for cereals from Novonikolaievsk to London (according to pre-war prices) to 30—34 kopecks per pood, instead of 67 kopecks via Leningrad, and 55 kop. via Kotlas. Such reduction is due not only to a shorter distance to the port, but also to the transportation of goods by water for a considerable portion of the route. It has been estimated that about 1,500,000 tons of goods might be transported from Siberia by such a railway, to say nothing of the cargo traffic connected with the eventual exploitation of forests along the projected line.

Both lines projected by Voltman do not embrace the basin of the Vychegda, where the floating of wood in rafts is carried on on a large scale, but pass through the basins of Pechora and Mezen, where the woods (which are, however, of a quality inferior to that of the Vychegda woods) are not utilized at all. It is difficult now to estimate the future export of timber, but, according to the most conservative estimates, the latter should yield

an amount at least as great as that of transit goods from Siberia¹⁾.

Of all the other projects of railways giving the Oukhta region an outlet to the sea, the line Petropavlovsk—Nadezhdinsky Zavod—Oukhta—Indiga attracted much attention in connection with the discovery of an unfreezing harbour in the bay of Indiga, within the Cheshskaia bay. In 1921 surveying was done along this line by N. I. Maslov, engineer, but it has been found out since that the Indiga harbour has important defects; therefore, the line leading to Arkhangelsk seems to be the most convenient one.

In 1919—1920 new surveying was accomplished of the projected railway line Moscow—Oukhta.

Upon the construction of the Ob-White Sea railway, the distances from the Oukhta oil region to Ob, Arkhangelsk and Sverdlovsk (Ekaterinburg) will be respectively 550 km., 670 km. and 1000 km., so that the freight per one pood of the Oukhta oil to the basin of the Ob river and to the Urals will be 3—4 kop. lower than the freight of the Baku oil. Central Siberia may be provided with the Oukhta oil from Arkhangelsk by the Arctic Sea Route.

The cost of transportation of the Oukhta oil to foreign markets will be likewise lower, because the distance Baku—Batum is 300 km. longer than the distance Oukhta—Arkhangelsk, while the distance from the latter to the ports of North and Central Europe is by one half less than from Batum. The pipe lines along the projected lines will materially facilitate the competition with other oil regions.

Under such conditions of the marketing, the oil production of the Oukhta region will become profitable. No wells with a production equal to that of the Baku wells, are, of course, to be expected at the present time; the yearly output per one well is likely to amount to about 150 tons, and the development should be planned in accordance with the said production.

The use of the standard cable system of drilling, central powers for pumping wells, the drilling of open holes without reaming, and a comparatively shallow depth of oil-bearing horizons will make profitable the exploitation of a well with the output of even less than a quarter of a ton per day, and will permit the extraction of oil in quantities sufficient for the development of a large enterprise.

¹⁾ For detailed estimates refer to the articles indicated below (Nos. 15—17. of the list).

Still greater profits may be derived from a development of other mineral resources and of forests in the region. But the discussion of the conditions for the development of such a combined industrial concern is beyond the scope of the present paper. It is to be stated, however, that the discovery of large coal deposits, made by A. Chernov in the region of the right-hand tributaries of the Pechora river, may entirely change the economical conditions and have a favourable influence on the development of the Oukhta oil region.

SELECTED BIBLIOGRAPHY

1. A. Vaipolin. The composition and commercial value of the Oukhta oil.—The Petroleum and Oil-Shale Industry. 1921. No. 9—12.
2. A. Zamiatin. The Oukhta oil region.—Bull. of the Geol. Committee, 1911, vol. XXX, No. 6. (with a map).
3. A. Zamiatin. Report on the Oukhta oil region (operations of the «Nefte» Company).—Bull. of the Geol. Com., 1918, No. 2, Records, 28—32.
4. A. Zamiatin. The Oukhta oil.—Natural Resources of Russia, v. IV, No. 22, 1919.
5. K. Kalitsky. The Oukhta oil region.—The Petroleum and Oil-Shale Industry, 1921, No. 9—12.
6. K. Kalitsky. The Oukhta region.—Ibidem, 1922, No. 7—8.
7. W. Kind. Oil in North Russia.—Bulletin of the Politechnical Institute, St. Petersburg. 1910, v. XIII.
8. D. Nalivkin. The geology of the Oukhta oil region.—Petroleum and Oil-Shale Industry, 1923, No. 2.
9. P. Polevoi. A preliminary note on the exploration of the Oukhta oil region. St. Petersburg. 1908.
10. V. Sokolov. The Timan oil. Moscow 1910.
11. V. Sokolov. The Oukhta oil concern under the name «The Northern Oil Partnership founded by A. Hansberg, A. Kornilov and Co.». Moscow, 1910.
12. V. Stukachev. The Oukhta oil region. Mining Department's test drilling 1911—1913.—Mining Journal, 1914, No. 9.
13. The Oukhta oil according to the operations of B. I. von-Wangel. Moscow, 1900.
14. T. Chernyshev. An orographical sketch of Timan.—Mem. of the Geological Committee, XII, No. 1, 1915.
15. V. Voltman. The East-Ural—White-Sea railway.—Bull. of the Arkhangelsk Association for the Study of North Russia. 1909, No. 7. (See also: 1909, Nos. 6 and 12).
16. A memorandum of the Arkhangelsk City-Council on the construction of the East-Ural—White-Sea railway.—Ibidem, 1911 No. 8—9.
17. W. Ewald. The colonisation of North Russia and the construction of new railways.—Transactions of the State Colonisation Scientific Institute, v. 1, 1924.

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