

Geological criteria and geophysical methods of natural bitumen deposits preparation to the development

B V Uspensky¹, M Ya Borovsky², R F Vafin¹, S E Valeeva¹, R A Mudarisova¹

¹ Institute of Geology and Petroleum Technologies, Kazan Federal University, Kazan, Russia

² LTD "Geofizservis", Kazan, Russia

Abstract. The article considers the provisions of the ontogenesis of the following factors in the formation of natural bitumen clusters in the Permian deposits of the Melekesskiy region: genetic, geodynamic, structural and hydrogeological.

It is shown that tectonically weakened zones and zones of Neogene incisions development are fixed by high-precision gravimetry in the form of intense local minima of gravity. A favorable factor contributing to the "strengthening" of anomalous geophysical effects is the coincidence of the locations of these geological section heterogeneities in the plan.

It is recommended at the stage of experimental-industrial operation a complex of geophysical methods for monitoring the processes of natural bitumen deposits development by means of secondary impact on the formation. High-precision magnetic, thermal and electrical prospecting in various modifications are used.

1. Introduction

Effective development of hydrocarbon deposits depends on taking into account the features of the geological structure, which are caused by the conditions of traps and the processes of minerals genesis.

There are essential factors of traps and natural bitumen formation. Clear boundaries between individual factors do not exist, i.e. their influence can affect both the formation of traps and deposits. The first is in different geodynamic manifestations of the oscillatory movement of the earth's crust, structureforming movements; palaeogeomorphology, sedimentation, litho-facies conditions, etc.; the second group includes factors of ontogenesis responsible for the generation, accumulation of hydrocarbons and the destruction of their clusters, i.e. geo(bio)chemical, hydrogeological, hypergenesis, etc.

2. Methodology

According to the ideas about the ontogenesis of oil are assumed [1-3], the following main factors of formation of natural bitumen clusters in the Permian deposits of the Melekesskiy region:

1. Genetic factor determines the generation of hydrocarbons. Formation of the Perm bitumen is associated with the presence of oil deposits in the Devonian and Carboniferous deposits (Fig. 1; 2). The main strata, with source potential in the Devonian system – clay-carbonate, domanic facies. In the above-lying lower Carboniferous rocks, the processes of oil and gas formation also took place in all negative structures.

Oil content of Permian deposits was provided by vertical migration of oil. The main source of hydrocarbons revenue are regional oil-bearing strata of Devonian and Carboniferous served, which is



confirmed by coincidence in terms of Permian bituminous areas with areas of concentration of oil deposits (Fig. 2)

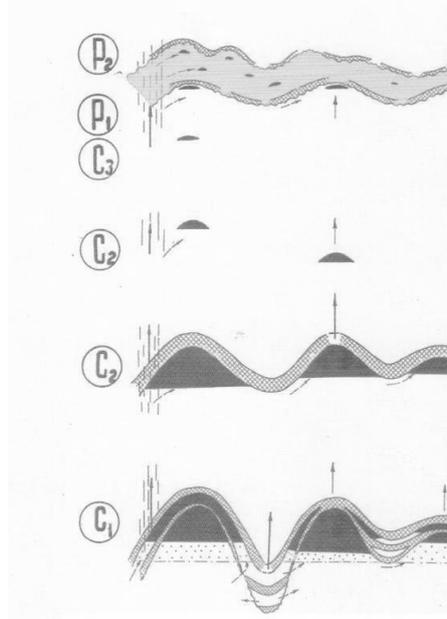


Figure 1. Scheme of oil deposits and natural bitumen accumulations formation in Carboniferous and Permian deposits (according to RS Khisamov, 2006)

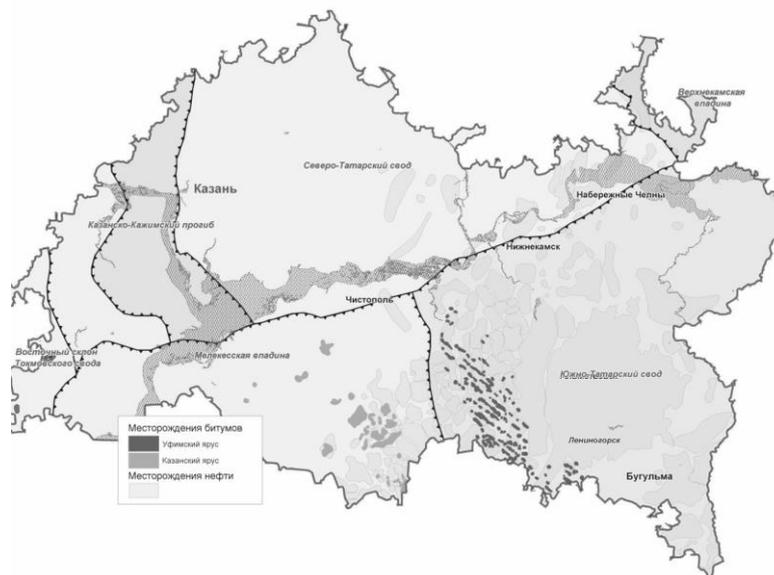


Figure 2. Map of natural bitumen deposits in Republic of Tatarstan (according to RKh, 1999)

2. Geodynamic factor characterizes modern and paleostructural plans, migration and accumulation of hydrocarbon deposits, phasing of formation.

Concentrations of natural bitumen of Permian deposits of Melekess depression formed by the lateral-vertical migration of hydrocarbons from more deeply buried Devonian and Carboniferous sediments. Ways of vertical flows are zones of tectonic disturbances, which provided, first of all, filling of the lower Permian reservoirs. The greatest development faults are at the junction of the South-Tatar arch, with its flanking valleys. On the Eastern side of the Melekess depression, this zone covers the entire complex of sedimentary formations. Migration of hydrocarbons in Sheshmian horizon went up the rise of the strata - eastward from the area of Melekess depression in the direction of the South-Tatar arch. Hydrocarbons enter Kazanian natural reservoirs as a result of gradual migration.

Modern and paleotectonic structural plans of the territory determine the conditions of hydrocarbon accumulation, the formation of their clusters.

Phasing of geotectonic development of the region. There were [3] several stages of generation, migration, accumulation of oil and destruction of its deposits, which determined the frequency of formation of oil deposits and its transformation into natural bitumen.

3. Hydrogeological factor manifests itself in two aspects:

1) in the formation of oil deposits - primary migration of hydrocarbon is carried out as part of the aqueous phase (aqueous molecular, mycelial, colloidal solutions, etc. [4]. The main reasons for the movement of oil in the reservoir rock are gravitational forces float lighter oil in the water, capillary forces and hydrodynamic water pressure. With the inclined position of the reservoir, the reservoir POPs up after the uprising of the reservoir until this pop-up is stopped (bending of the reservoir in the opposite direction, impenetrable screen, etc.). An important driving force in the process of secondary migration is the hydrodynamic pressure in the reservoir. This pressure helps the oil to float and helps to overcome the capillary forces in the narrowing of the pore channels;

2) when the deposits are destroyed. Under the influence of infiltration water, saturated with oxygen and microorganisms, processes hypergenesis. Plantar sulphate waters lead as a result of sulphate reduction to a change in the hydrocarbon composition of oil (bitumen) and, in general, to an increase in resinous-asphaltenic components. The formation of deep paleovalleys promotes the penetration of infiltration waters: the deeper erosion of the valley, and the greater the interval of the sedimentary cover affected by the processes of their impact. Long-term contact with oil deposits leads to oxidation of the latter and the formation of natural bitumen.

3. Results and Discussions

The results of the analysis of natural bitumen deposits formation conditions testify [1-3]:

1) Formation of Perm natural reservoirs occurred in different facies and paleogeographic conditions by successive changes in the conditions of sedimentation accumulation in the East of the Russian plate.

2) The initial stage of Permian sediments formation in some areas is associated with the covering of the nuclei of rhyme Carboniferous formations.

3) Many Perm structural forms are due to sedimentation processes mapped buried paleogeomorphological surfaces.

4) The structure of the pore space of the lower Permian oil sands reservoirs involved the pores diagenetic recrystallization and leaching, shallow cavities having predominantly isolated distribution; filtration capacity of the rocks determines the fracturing of carbonate rocks;

- 5) Traps of bitumen in Ufimian-Lower Kazanian are nontectonically. The coincidence of the structural plans of the roof of the sandstone pack and overlapping rocks is not associated with tectonic processes, and the consequence of uneven compaction processes lithologically heterogeneous rocks. The deposition of clastic material occurred in the mobile hydrodynamic setting with a cutout in the underlying rocks in deltaic and avandelta parts of paleorivers.
- 6) Deposits of sandstone pack form linear bodies, located in accordance with the flow of the river within the riverbed itself, delta and avandelta; allocated band (zone) elevations, separated from each other by depressions, within which the collector is characterized or sharply reduced (less than 10 m) capacity or completely absent.
- 7) The stretch of sandy bodies can be seen in the South-East direction outside Tatarstan in the Samara and Orenburg regions, where the transportation of terrigenous material (sandstone pack corresponds to the productive layers of the U-I and U -II in the roof of the Sheshmian horizon). In these areas the thickness of the formations increases, there are more coarse-grained differences of rocks. This suggests that the sandy sediments here are made of a paleorivers channel. Natural reservoirs of reservoir rocks are characterized by acies unevenness.
- 8) There is a certain sequence of formation and placement of lithographs.

On the basis of generalization of geological researches and pilot-industrial works results on extraction of heavy oils and natural bitumen it is revealed [1,2,5-8] a number of complicating factors which should be considered at the later stages of a geological exploration cycle:

- 1) Zones of increased tectonic fracturing of sedimentary thickness;
- 2) Valley of paleorivers (Neogene incisions);
- 3) Degree of destruction of bitumen deposit;
- 4) Hydrogeological features of the upper part of the cut.

4. Conclusions

Geophysical methods are used in the preparation of projects and technological schemes of industrial development of bitumen deposits at the exploration stage of mineral deposits. Lead is a highly mobile method of error-correcting gravity: traced the development zone and the Neogene incisions. It was found that the bitumen in the direction of the incision weighed down and in the zone are subjected to the most profound hypergenic effects. This phenomenon leads to a sharp deterioration in the commodity properties of hydrocarbons.

Gravity exploration acquires great importance as an effective method in the diagnosis of tectonic disintegration zones in the sedimentary thickness when solving a number of issues related to the processes of experimental and industrial exploitation of natural bitumen deposits by methods of secondary impact on the formation (intraplate moving center of combustion, steam injection, solvents, etc.). In case of extraction of hydrocarbons by in-situ technology in zones of increased tectonic fractures it can be observed premature breakthrough of heat carriers to the bottom of producing wells, or penetration of gaseous products of physic-chemical reactions into the covering deposit thickness up to the daily surface. Obviously, timely (at the stage of exploration) detection of zones of increased fracturing and permeability of layers can improve the efficiency of the development of hydrocarbon accumulations.

Tectonically weakened zones and zones of Neogene incisions development are fixed by high-precision gravimetry in the form of intense local minima of gravity. A favorable factor contributing to the "strengthening" of anomalous geophysical effects is the coincidence of the locations of these geological section heterogeneities in the plan.

At the stage of pilot operation, it is recommended to use a set of geophysical methods to control the processes of development of natural bitumen deposits by methods of secondary impact on the formation. It is applied [8,9] high-precision magnetic, thermal and electrical exploration in various modifications.

References

- [1] Muslimov R Kh *et al* 2012 *Complex development of heavy oil and natural bitumen Permian system of the Republic of Tatarstan* (Kazan: FEN Publishing House of the Academy of Sciences of the Republic of Tatarstan) p 396
- [2] Uspensky B V 2005 *Scientific and methodical bases of search, investigation and development of natural bitumen: the author. Diss. Doct. gay.- min. Sciences: 25.00.12* (Kazan: KSU) p 41
- [3] Uspensky B V *et al* 2008 *Geology of the deposits of natural bitumen of Tatarstan* (Kazan: Publishing house PF GARTH) p 347
- [4] Bazhenova O K *et al* 2000 *Geology and Geochemistry of oil and gas* (Moscow: Moscow state University Publishing house) p 384
- [5] Borovsky M Ya 2001 *Geophysical technology of prediction, prospecting and exploration of natural bitumen deposits: Avtoref. Diss. kand. gay.- min. Sciences: 25.00.10* (Kazan: KSU) p 23
- [6] Borovsky M Ya *et al* 2000 *Geophysical methods of preparation and control of processes of exploitation of natural bitumen deposits* (Moscow: GEOS) p 170
- [7] Mukhametshin R Z 2006 *Geological basis for the effective development and extraction of hard-to-recover oil reserves: Avtoref. Diss. Doct. gay.- min. Sciences: 25.00.12, 25.00.17* (Moscow: Irgi) p 51
- [8] Khisamov R S *et al* 2007 *Geophysical methods of prospecting and exploration of deposits of natural bitumens in the Republic of Tatarstan* (Kazan: FEN Publishing House of the Academy of Sciences of the Republic of Tatarstan) p 247
- [9] Shvydkin E K 1988 *Control of combustion front advance by means of ground magnetic survey in the development of shallow bitumen and viscous oil deposits: Diss. kand. technical Sciences: 04.00.12* (Moscow: Vniigeosystem) p 164
- [10] Muslimov R Kh 1999 *Unconventional sources of hydrocarbons – further development of old oil producing regions* (Georesources **1**) pp 21 – 27
- [11] Khisamov R S 2006 *Tectonic and petroleum geological zoning of the territory of Tatarstan* (Kazan: FEN Publishing House of the Academy of Sciences of the Republic of Tatarstan) p 328