D-21 **MAIKOP SERIES – MAIN CENOZOIC PETROLEUM SYSTEM OF CAUCASUS-SKYTHIAN REGION**

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The object of investigation is Maikop Series (Oligocene-Lower Miocene) widespread within the Caucasus-Skythian region. The predominantly clayey content of marine origin, mainly sapropellic type of OM, presence of oil and gas accumulations make these deposits the example of classic petroleum system. Maikop Series (MS) is main source oil-bearing in Cenozoic and, probably, upper Cretaceous strata. However, the oil reserves pooled in the Cenozoic reservoirs of the region are incomparably lower than that which could be expected in view of the above conditions.

Maikop series is also oil-gas bearing one (there are 43 oil deposits). Two types of deposits are established within it. The 1st type is associated with common porous collectors - sandy interlayers and lenses within clayey beds (Severo-Stavropolsk, Russky Khutor, Anastasievsko-Troickoe, Khadyzhenskoe and other). Deposits of the 2nd type occur in the clayey reservoir of the lower part of Maikopian Series - the Khadum horizon (Zhuravsk, Yuzhno-Spassk, Vorobyovsk and other fields). These particular deposits present special interest; their formation is associated with autigenous oil bearing.

The purpose of our investigation is to use organic geochemical data (pyrolysis Rock-Eval, extraction in Soxhlet instruments, chromatographic, GC-MS) for assessing the HC potential of the formation, correlating oils and source rocks, and explaining the striking contrast between the high potential of the formation and the modest oil reserves found in it.

The main large tectonic elements of the Caucasus-Skythian region are Skythian Epihercynian Plate, the North-Caucasus foredeep and the Great Caucasus Meganticly, limited by sublatitudinal faults. The Mineralovodsky projection of the Great Caucasus and Stavropol Arch divide the region into the West and East Pre-Caucasus. In the platformal part of the West Pre-Caucasus the Azov-Kuban hollow is located, with the East-Kuban trough as its eastern element, while within the limits of the foredeep - the Indolo-Kuban Depression. In the East Pre-Caucasus, in the north of the Skythian Plate the Karpinskiy Swell and Manych troughs are located; in the south - the Tchernolesskaya hollow and Prekumsk uplift zone. To the North-Caucasus foredeep the Tersko-Caspian Depression is confined.

The stratigraphic subdivision of the MS has been made difficult by the scarcity of fossils and the absence of reliable stratigraphic marker horizons. In this paper we use the stratigraphic scheme developed by Popov et al. (1993) is used. In the Western Pre-Caucasus and Azerbaijan the three-member division of the Maikop Series (MS) has been accepted. The Lower, Middle and Upper Maikop correspond to the early-middle Oligocene, the late Oligocene and the early Miocene, respectively. The Lower Maikop (or the Khadum sequence) includes the Pshekhsky, the Polbinsky (Ostrakodovy) and the Morozkina Balka horizons (units). In the Middle Maikop the Batalpashinskaya, the Septariyevaya and the Zelentchukskaya suites can be distinguished. Finally, the Upper Maikop is built up by the Karadzhalginskaya, the Olginskaya and the Ritzevskaya suites.

Maikop Series consists mainly of dark grey and brown claystones, with some siltstones and sandstones; the number and thickness of the sandy beds varies across the area. The thickness of the formation changes from hundreds of meters to more than 3.5 km in the deepest parts of the depressions.

The thick, predominantly clay-rich MS was deposited in the Eastern Para-Tethys, a huge sea, which covered the areas of the present-day Black, Azov, Caspian and Aral Seas and large regions between and around them. The Para-Tethys was formed at the final stages of the development of the Tethys in the middle of the Cenozoic and included vast shelf areas in the southern part of the European plate and more or less isolated deep-water areas in the Carpathians, the Caucasus and the Kopet-Dag. Sediments accumulated throughout the entire Oligocene-Early Miocene are mostly carbonate-free or carbonate-poor clays over large portions of the Para-Tethys (Sokolov et al., 1990).

OM accumulation occurred within different (by depth and solution) part of the marine basin, being greatly effected by continental environment. It is probable, that in some separate short periods of time anoxic accumulation took place. OM content along the succession and area varies rather dramatically (from 0.1 to 18%, average 0.9-1.4%). Horizons with high TOC concentration are confined mainly to Lower Maikop in Pre-Caucasus; the maximum concentrations (10%) are marked in mud volcano of the Black Sea and some succession in the Azerbaidzan (15-18%).

Data obtained from Rock-Eval, petrographical and elemental analyses of the OM composition have shown that in the MS deposits all types of kerogen are developed – from I to III (Fig.1). The predominate OM in the Maikop deposits of the Pre-Caucasus and Azerbaijan is the II type kerogen. It is characterized by the increased hydrogen content (6-9%), high atomic ratio H/C (1-1.52) and HI (300-776 mg HC/g TOC). Petrographic studies have shown that the kerogen is almost totally made up of amorphous mass, of various yellow tints and different luminescence degree. Algae remnants, macerals of the leptinite group, more seldom of vitrinite group, and scraps of coalified fibres are present as a stable admixture. Samples with high HI in the kerogen (HI > 500 mg HC/g TOC) are referred to the II type kerogen, which hadn't undergone much oxidation during sedimentogenesis and bacterial degradation (Espitalie et al., 1985). Particularly in these MS samples the highest H content (7-9.4%), high H/C (1.1-1.52) and HI (515-776 mg HC/g TOC in the kerogen, 345 mg HC/g TOC in the rock) values have been observed. Such OM is mainly confined to the Lower Oligocene deposits of the Prekumsk anteclyse and Azerbaijan and only sporadically occur in the Oligocene and Miocene sediments of Indolo-Kuban Depression. The rocks containing this type of the kerogen exhibit the highest oil-source potential (TOC = 7.2%, $\{S_1+S_2\}=42$ kg HC/t rock, average values).

More often, the MS kerogen throughout the Pre-Caucasus is characterized by lower oil-source properties – H content (6-6.7%), H/C (1-1.1), HI (308-462 mg HC/g TOC in the kerogen and 141 mg HC/g TOC in the rocks), amorphous mass acquires more brown tints and weakly luminescent. According to the classification of Espitalie et al. (1985) this kerogen has been regarded as degraded OM of the II type, or it is of mixed origin – i.e. in any case continental higher plants leave an imprint on the predominantly algal material. This kerogen, despite its sapropelic origin has lower oil-source potential (TOC = 1.6%, $\{S_1+S_2\}=2.7$ kg HC/t rock). The III type kerogen has been characterized by low values of H (3.2-5.6%), H/C (0.54-0.98) and HI (199 mg HC/g TOC in the kerogen, 74 mg HC/g TOC in the rocks). It is typical to the Upper Oligocene and Miocene rocks in particular, but it is also observed in the shelf and deltic Khadum (Kerch peninsula, folded flanks of the Indolo-Kuban and Tersko-Caspian depressions, the north of the Skythian Plate). Petrography of this type kerogen is presented by the admixture of amorphous mass (no more than 30%; usually low) and detrital components, 80% of them being presented by macerals of the inertinite, vitrinite and leptinite groups. Rocks containing such kerogen have been treated, mainly, as gas source ones, with low oil source potential (TOC = 1.6%, $\{S_1+S_2\}=1.5$ kg HC/t rock).

The oil window is placed within the depth interval of 3.5-3.7 to 5.2-5.3 km in the Maikop sediments of the Caucasus region.

Chromatographic analysis show that bitumoids, obtained from different regions, are to a greater extent similar to each other. They are characterized by prevalence of isoprenoids over n-alkanes, high values of $K_i = 1.5-3.7$, Pr/Ph near 1. There the increased naphthene background was established and double-peak distribution n-alkanes with maximum values of $C_{15}-C_{17}$ and $C_{22}-C_{23}$ or $C_{22}-C_{23}$ and C_{29} , as well as slightly increased concentration of odd n-alkanes and high

concentration of steranes and hopanes. Isotop content of oil fraction - $\delta^{13}\text{C}$ -28,1-28,9, i.e. being lighter for marine OM.

The qualitative composition of terpanes and steranes in Maikop series OM does not differ from each other. The sterane distribution is characterized by an essentially uniform distribution on $\text{C}_{27}\text{-C}_{29}$. Such character of steranes distribution prove the OM mixed type and sea sedimentation.(Peters, Moldowan,1993). Sterane distributions of all the studied bitumoid samples not strongly can divided into at least three families: - first group- C_{27} -sterane dominate insignificantly, the sterane- C_{28} has more less concentration; typical distribution- 46:20:34: this type was observed in the OM from the Belaya River, which deep-sea facies predominate. A second group-equal concentration steranes;-typical distribution-36:29:35, such distribution have samples mainly from Azerbaydzhan; a therd type is characterized by domination of sterane C_{29} , such distribution is unique to mainly samples of Kerch Peninsula. This type corresponds maximal share of continental OM. All studied samples contains the sterane C_{30} . Typical distribution of hopanes from Azerbaidzhan - C_{27} : C_{29} : C_{30} : C_{31} =10:17:45:29, whereas the hopanes from the OM of the River Belaya succession have the increased concentrations of C_{31} (43-56%), which is commonly specific of the continental OM of low maturity level. Minor quantities of heilantans and oleanans are present in the low concentration, the latter being practically absent in the OM samples from Azerbaidzhan. The low maturity of OM has been proved by the Tmax pyrolyses date and hopane and sterane maturation indices. C_{27} biohopane has been found in the Kuban deep well at the depth of 3.5 km.

The biomarkers Maikop oils from different regions are rather similar: maximum n-alkanes- $\text{C}_{17}\text{-C}_{19}$, Pr/Ph-1,1-2,2; Pr/n $\text{C}_{17}\text{-0,5-1,4}$; Ph/n $\text{C}_{18}\text{-0,4-1,2}$. The oils and OM of different regions is characterized by relatively equal quantity of steranes HC $\text{C}_{27}\text{:C}_{28}\text{:C}_{29}$, the concentration the sterane C_{28} somewhat higher. In all the samples 4-methylsteranes are present, which peculiar for the marine OM. Distribution of hopanes is similar with OM hopanes of Azerbaidzhan, heilantans and oleanans are present in the extremely low concentration. Sterane and hopane indicators of maturation of oils vary greatly, ratio T_s/T_m varies 0.7-3.5. It is the inconsistency of the modern depths of oil occurrences and sterane maturity indices distribution. The lowest maturation degree has been characteristic of the deeply occuring oils and OM. And one contrary, the more maturity oils occur at lesser depths, which testifies about migration character this oils and presence immature oils in Maikopian Series. In spite of some descrepancy of distribution of steranes OM and oils, stemming from diffrence of maturity, genetic unity of organic matter and oil was established after the biomarkers composition; oils and OM of all regions are found in one field in the trianguar diagram.(Fig.2)

Thus for the MS as a whole, the average TOC content varies widely. The HC potential and HI values of most of the sediments studied are lower than those characteristic for oil prone source rocks. The highest oil source potential and OM content of the MS have been noted in the Lower MS of Prekumsk region (the western part of the Tersko-Caspian Depression) and in Northern-Azerbaijan. Predominance of the OM, degraded and with low generation potential [HI and (S_1+S_2)], in the MS sediments suggests more "modest" scales of oil formation, as it was considered earlier.

The oil-source potential of the MS for liquid HC had been realized to a very small extent -this might be related to both deep location of the oil-window and hard release conditions due to absence of sandy interlayers in the thick clay beds.

Reference

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Type of kerogen

▲ Miocene ○ Upper Oligocene ● Lower Oligocene × non-differentiated MS