

Collector Zones Research of the Crystal Base on the Basis of Deep Well Drilling Analysis Results

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Abstract: The base platform areas geological structure study represents the composite and actual issues, solution of which is directed on knowledge of development and evolution history of crust and sedimentary cover of the studied territories. Exhaustive ideas of the base geological structure make the basis of the formation process exact comprehension for sedimentary cover and regularities of mineral deposits placement in it, first of all, oil and gas. In study results of crystal base study of the Volga-Kamsky anticline central part are considered. Implementation of the deep drilling long-term program allowed to reveal the numerous loosened zones which are characterized by water saturation in crystal base solids. The content of the dissolved hydro-carbonic gases in water as well as oil row bitumoid presence in the loosened zones specifies that through the crystal base there was a migration of oil hydro-carbons, the deep fluids containing hydro-carbons, gases. Solids of the base represent a great interest from the oil fields origin point of view and also in aspect of deep fluid systems migration. Geo-dynamic activity of the loosened zones shows the modern processes of fluid migration and their influence on oil field formation in a sedimentary cover.

Key words: Crystal solids, well drilling, loosened zones, naphtha, gas, deep fluids, well

INTRODUCTION

The problem of settling ponds crystal base study is defined by base solids of the world various basins with over 400 deposits of naphtha and gas being revealed (Plotnikova, 1987, 2004b; Muslimova and Lapinsky, 1996).

The modern geological concepts considering the issue of fissured permeable zones formation and development in the platform crystal basis are in many respects based on interpretation of geophysical yielded super-deep drilling results.

The Crystal Base (CB) of the Volga-Ural central part anticline became object of fissile geologic-geophysical study, since the end of 60th. Since 1975, within the program of deep studying of Tatarstan subsoil, two super-deep wells were drilled: 20000-Minnibayevsky (mine face 5099 m, base footage 3215 m) and 20009-Novoyelkhovskiy (mine face 5881 m, base footage 4077 m) as well as more than thirty wells which opened the base on depth from 100-2432 m.

Crystal base collectors study objects were all deep parametrical, explorative and operational wells drilled within the Southern and North Tatar arches and adjacent territories. On opening depth of Precambrian crystal complex they are sub divided into four categories:

- The wells which opened the crystal base on the maximal depth over 3000 m

- The wells which opened the crystal base on the considerable depth from 200-3000 m
- The wells which opened the crystal base on depth from 50-200 m
- The wells which opened the crystal base on depth <50 m
- Two parametrical super-deep wells, 20000 Minnibayevskaya and 20009 Novoyelkhovskaya, belong to the first well category. Their base footage made, respectively 3215 and 4077 m
- The second category unites 19 wells, with the average depth of crystal section opening of the Precambrian reaching 562,56 m
- The third category includes 55 wells
- The fourth category is the most numerous, in total more than one thousand explorative, appraisal and operational wells

MATERIALS AND METHODS

Priority research and analysis projects were the first three categories of wells and also wells of the 4th category which were drilled in the last decade of the 20th century and for which the express works directed on loosened base zones research were carried out. Situation is that in the Volga-Ural anticline Precambrian crystal massif the considerable size and capacitor properties of natural tanks are developed everywhere. It is based on the following. Zones of deconsolidation and KF jointing are

registered by a complex of geologic-geophysical methods, during drilling and geophysical surveys of wells as well as by result of land geophysical surveys. There is a particular regularity of potential collector zones distribution of the base both in the area and in section.

The geophysical well surveys including reference and padding research types belong to the main direct methods proving it; the geological and technical researches conducted in the course of well drilling; test of the loosened base zones in column and in open hole.

The performed analysis of drilling and research results for wells which opened solids of the crystal base on various depth allowed to establish the following. In general, on the example of well 20009-Novoyelkhovsky, the geological section of the base is characterized by difficult alternation of almost unchanged crystal solids with good safety of high-temperature paragenesis and partially destroyed solids, which underwent multiple manifestations of deformation, diaphoresis, milonitization, etc. with the common tendency of deformation extent increase with depth.

In crystal complex section of the Precambrian intervals collectors have a wide spread occurrence both on depth and by area and are registered according to geologic-geophysical methods. Thickness of the loosened zones varies from the first meters to several tens of meters. Intervals of the base estimated collectors are dated for zones of the secondary imposed processes and also for borders of petrographic differences. Near half of potential collector zones are characterized by apparent, legibly expressed jointing, which was determined by core, schlich and caliper apparatus.

Presence of numerous abnormal zones in rock mass base does not raise doubts, nor does the long-lived geological history of their development. On the example of well 20009-Novoyelkhovsky, the increase in allocated intervals collectors quantity with depth is recorded; that also points to direct dependence of collectors existence on extent of secondary changes and structural and tectonic processes (Plotnikova, 2003, 2004a).

The potential collector zones analysis by results of geophysical surveys located over two hundred twenty operational and prospecting wells allowing to reveal area placement dependence of these zones. The greatest number of the base potential loosened zones is recorded within the central part of the Southern Tatar arch.

Saturation nature of crystal base collector zones study first of all was carried out on the basis of collector zones test data analysis by the verifier of layers. Also, it was carried out on the basis of geological and hydro-geological analysis research results of loosened zones fluids and the bitumin-logic researches of core and schlich, according to high-precision thermometry.

The base section test by means of the layer verifier executed on >130 objects in >30 wells proved existence in base crystal solids of the fluid-saturated zones characterized by various filtration and capacitor properties.

About 10% of the base objects tested on component composition of gas were characterized as petro-saturated, gas-saturated, residually petro-saturated. In 31% of cases the tested objects had an ambiguous saturation characteristic.

Thus, researches of the wells which opened the base on the considerable depth showed that potential crystal solids collector possess filtration and capacitor properties which can be estimated at the semi-quantitative level. At the assessment stage of oil-and-gas content prospects in base section the obtained data unambiguously testify in favor of existence of capacitor space in which fluids can freely circulate and which can be considered as a potential trap a place of oil-and-gas fluids accumulation in crystal solids.

The issue of traces existence in base solids of migration and potential congestions of oil-and-gas fluids was solved on the basis of geological and hydro-chemical study and the bitumin-logic characteristics of base solids (Plotnikova, 2006, 2008; Gottikh, 2003; Rimma, 2014).

The composition of underground waters is a sign and reflection of geological and geochemical processes taking place in crust.

The first data on the water characteristic of the East European platform base were obtained in 1976 on test data of 20000-Mimibayevsky well. During the period from 1988-1994 the characteristic of these waters was added with new data on 14 wells from which reservoir waters were selected in the range of 1793-2028 m depths and were characterized by 40 tests. During the period from 1998-2003, within the comprehensive program of the base study, reservoir waters monitoring of the base loosened zones which was carried out on five wells located in the Southern Tatar arch central part and on its slopes, was organized (Plotnikova, 1987, 2006, 2008).

Precambrian crystal complex waters research, firstly, confirmed existence of high-capacious collectors in it. Secondly, chemical composition of base water, which on chemical composition belong to calcium chloride with density of $1.185-1.2 \text{ g cm}^{-3}$ and the common mineralization of $245-267 \text{ g L}^{-1}$ was characterized. The content of calcium varies from $12-26 \text{ g L}^{-1}$.

With increase in loosened zones development depth the underground waters represent almost clear chloride and calcium brines, which significantly differ from base upper waters. The content of calcium in them reaches $85-94 \text{ g L}^{-1}$ and sodium decreases to $12.4-19.3 \text{ g L}^{-1}$. The

common mineralization thus makes 289 g L^{-1} . The researcher received a number of dependencies (correlation coefficient of 0.7, 0.8) proving mineralization waters connection of the base from depth of deconsolidation zone accommodating them. In particular, it is established by results of the 42 tests analysis from 15 wells.

For prospect assessment of oil-and-gas content of the base gas, chemical and organic and ion-salt possible efficiency assessment criteria were used. Oil-and-gas content gas criterion study including values of the common gas saturation, the sum of hydro-carbonic gases and hydro-carbonic and nitrogen coefficient, showed the following. Composition of water gas in solution of KF upper coal mine is generally, methane and nitrogen and only on Holmovskaya square (Well, 29419) it is nitrogen methane. The content of nitrogen in tests varies from 31 to 76% sp., of methane from 11 to 63% sp. The amount of heavy hydro-carbons varies from 1-2 to 7-8% sp., the amount of helium reaches 5.4-7% sp.

In comparison with gas composition of underground waters according to parametrical wells drilling within the East European platform, gas composition of the Volga-Ural antecline base waters differ considerably by large amount of hydro-carbonic gases.

Gas saturation of Precambrian base under ground waters ($390\text{-}450 \text{ cm}^3 \text{ L}^{-1}$) does not concede to Devonian waters ($298\text{-}476 \text{ cm}^3 \text{ L}^{-1}$) and the Riffean-Vendian deposits ($290 \text{ cm}^3 \text{ L}^{-1}$). Petro-efficiency of the first of these solids is established and studied and of the second it is presumed based on geologic-geophysical data complex. The hydro-carbonic gases sum in base waters makes 12.3-16%, reaching in some cases great values which are comparable to the values received for waters of Romashkinsky field terrigenous Devon (63-73%) and the Riffean-Vendian deposits (446%). Besides, the cooperative amount of hydro-carbonic gases in base waters surpasses the sum of hydro-carbonic gases in Devon solids waters of the western Tataria unpromising regions. Still in crystal Precambrian loosened zones waters propane (23%), butane (11-20%) and traces of other heavy hydro-carbons, which are direct sign of crystal thickness oil-bearing capacity, were discovered.

Chemical and organic research criteria of oil-and-gas content assessment in well 20000 Minnibayevsky allowed to establish that the common maintenance of C_{org} in base waters is much higher than in Southern Tatar arch, background for terrigenous Devon and the Riffean-Vendian deposits over the south east slope.

Such chemical and organic Archaeal solids waters indexes as bituminous carbon, phenols, oxidizability iodate and permanganate are in limits of background

values for waters of Southern Tatar arch terrigenous Devon and in some cases, considerably exceeding them.

Concentration of the common organic nitrogen in Archean waters (0.58 mg L^{-1}) considerably exceeds that of the reservoir waters of the Romashkinsky field Pashiysk-Kynivsk deposits.

Archaeal thickness underground waters gas composition study showed that it is mainly nitric and also contains (in volume %): 67-76.9 nitrogens, 12.3-16.0 hydro-carbons (generally methane), 5,4-8 helium, 2.1-4.5 oxygen and in some cases 8.9 Hydrogeniums, 0.06-1.4 carbon dioxides and 1.4 argon.

Hydro-geo-chemical crystal base waters research showed that they contain organic matters in concentration, close to background, common for underground waters of terrigenous Devon. And concentration of C_{org} and organic nitrogen exceed those.

Presence in crystal base waters of hydrocarbons, organic matters, lack of sulfates and metamorphism of waters form the basis for the assumption of naphtha and gas deposits in a body of Precambrian crystal complex of the Volga-Ural antecline central part. Confirming this conclusion are results of the crystal solids bitumin-logic researches.

RESULTS AND DISCUSSION

The analysis result of base bitumoid study on the example of more than ten wells showed that in the base bitumoid there are most often hydro-carbons from C14- C33, in some cases C9. The set of hydro-carbons extends in cataclyse and milonitization zones. Dominance of pitches in group structure is noted, asphaltenes in trace amounts more often are contained. In studied base bitumoids hopane, adiantane, homologues of naphthalene and chrysene, phenanthrene and pyrene are identified.

The carbonaceous substance of Precambrian crystal solids is interpreted as bitumens of migratory losses that corresponds to feed forward between a bituminosity and degree of base solids jointing.

The geochemical coefficients analysis indicates similarity of the same fractions hydro-carbons relative distribution, despite distinction of bitumoid hydro-carbonic part fractional compositions. The executed comparison of the base bitumoid hydro-carbonic structure and naphthas of Romashkinsky and Novoyelkhovsky fields allowed to establish the very considerable lines of hydro-carbonic composition similarity of extracts and naphthas. Set of the received

conclusions, given on micro-element bitumoid structure of the base and naphthas of sedimentary cover, received by the researcher and results of bio-markers researches as a part of hydro-carbonic base substance, sedimentary cover and naphthas of the Paleozoic allow to consider bitumoid of base solids as traces of oil and gas saturated fluids migration. Therefore, the Precambrian crystal complex of the Volga-Ural antecline is object of fluid systems migration, which were and are the most directly involved in formation of the naphtha production congestions in sedimentary deposits (Muslimov *et al.*, 2004, 2005).

Distribution of hydro-carbons on all base section in small concentration present wide scales of migration taking place under high pressure on the most permeable break and crack zones to base top and further in sedimentary cover. Existence of the highly permeable and impermeable rocks favorable combination in the base body providing formation of hydro-carbon deposits is not excluded.

Summary: Thus, results of well research which opened the crystal base on the considerable depth showed that collectors of KF possess filtration and capacitor properties. In base crystal solids there is a capacitor space in which fluids can freely circulate and which can be considered to be a potential trap a place of naphtha and gas accumulation. Gas-hydro-chemical indexes of Archaean and Proterozoic crystal base solids oil-bearing capacity correspond to oil-and-gas content criteria established for high-perspective and perspective deposits of sedimentary cover (Devon terrigenous deposits). On the basis of chemical bitumin-logic researches in KF solids existence of bitumoid, epigenetic in relation to the containing solids and having migratory character, is established. The component composition of the dissolved fluid hydro-carbonic gases sating the loosened base zones unambiguously testifies about availability of the "heavy" hydro-carbons, which are direct signs of hydro-carbon migration traces of oil row and existence of their deposits.

CONCLUSION

The crystal base of the Volga-Kamsky antecline represents perspective object for hydrocarbon congestions search as well as for fluid systems containing hydro-carbons migration processes study.

Dynamics of gas saturation and gas-hydro-chemical indexes of the crystal base loosened zones testify to the modern geo-dynamic and fluid activity of the last. The block structure of the base defines nature of hydro-carbon distribution in a sedimentary cover.

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REFERENCES

- Gottikh, R.P., B.I. Pisotsky, A.V. Egorkin, I.N. Plotnikova, A. K. Nazipov, 2003. Coherence of geophysical, geochemical and fluid-dynamic data as argument in favor of deep-lying carbon-forming systems, *Georesursa*, No. 4, pp: 33-37.
- Muslimov, R.H., A.V. Postnikov, Plotnikova, 2005. To a question of internal cause role in formation and distribution of oil-and-gas content of settling ponds (on the example of Tatarstan). *Georesursa*, 1 (16): 37-39.
- Muslimov, R.H., I.F. Glumov, I.N. Plotnikova, V.A. Trofimov, D.K. Nurgaliyev, 2004. Oil and gas fields spontaneous and constantly renewable objects. *Geology of Naphtha and Gas* (sp.ed), pp: 43-49.
- Muslimova, P.X. and T.A. Lapinsky, 1996. The crystal base of Tatarstan and problem of its oil-and-gas content. Under editorship of Kazan: PH Denta, pp: 488.
- Plotnikova, I.N., 1987. Oil-and-gas content of Eurasia settling ponds crystal base solids. Institute of Geological Sci. AN USSR (pre-print No. 87-19), Kiev, pp: 52.
- Plotnikova, I.N., 2004a. Features of collector distribution zones of the crystal base in coal mine. *Well. 20009-Novoyelkhovsky. Geology of Naphtha and Gas*, 4 (12): 12-18.
- Plotnikova, I.N., 2004b. Geologic-geophysical prospect prerequisites of oil-and-gas content of the Tatarstan crystal base. St.-Petersburg: Nedra, pp: 171.
- Plotnikova, I.N., 2003. The comparative analysis of the intervals collectors allocated in coal mine. *Well 20009 various geophysical methods. Georesursa*, 4 (12): 11-16.
- Plotnikova, I.N., 2008. New data of the present-day active fluid regime of fractured zones of crystalline basement and sedimentary cover in the eastern part of Volga-Ural region. *Int. J. Earth Sci.*, No. 97.
- Plotnikova, I.N., 2006. Non-conventional hydrocarbon targets in the crystalline basement and the problem of the recent replenishment of hydrocarbon reserves. *J. Geochemical Exploration*, No. 89.
- Rimma, P.G., I.P. Bogdan and I.N. Plotnikov, 2014. A Reduced fluids in the crystalline basement and the sedimentary basin (on an example of Romashkin and Verkhne-Chonskoye oil fields) *ARPN J. Earth Sci.*, Vol. 3, No. 1.