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The Pressure Map Constructing for the Ecological Conduct of Analysis for Offshore Fields with Horizontal Long-Haul Wellbores

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Abstract: The present research is devoted to the substantiation of ecological methods of calculating the dynamic reservoir pressure to build maps isobars used in environmental analysis of field development in the North Caspian shelf. In the ecological process of developing offshore fields with horizontal long-haul wells is necessary to analyze the physical properties of the fluid, temperature and pressure in the reservoir, the productivity of wells and their mutual influence and especially, moving Oil-Water Contact (OWC). For the calculation values of pressure near wells, pressure gradients on the area of the field and are built in these areas of isobar maps with which average dynamic reservoir pressure can be defined. For operational control of the processes occurring in the reservoir and regulation of mining is conducted monthly calculation of dynamic formation pressure formula S. Joshi based on filtration characteristics and physical properties of the fluid hydrodynamic studies and variables measured parameters, fished in the well: the flow rate of the well and the bottom hole pressure. This type of work in the development of the field is necessary for analysis of the energy state of sediments, so need regular work to refine the mathematical model of production wells in Northern Caspian fields.

Key words: Northern Caspian, production well, horizontal tracks, isobar map, well's debit, formation pressure, formation anisotropy, skin factor, hydrodynamic researches, pressure recovery curve

INTRODUCTION

At an ecological assessment of the marine environment reservoir pressures of productive deposits of hydrocarbons are the main geological and geotechnogenic parameter influencing technology of prospecting and operational works, technology of development of fields. The reservoir pressure is put in a basis of calculation of reserves of oil and gas for design of production of raw materials and the ecological direction of its processing (Shurov, 1983). Reservoir pressure, changing on depth (Fig. 1), makes impact on density of hydrocarbons (UV), coefficients of gas saturation oil and reservoir waters, volume coefficients and the UV various properties. Therefore, the assessment of adequacy of design decisions to specific mining-and-geological conditions is the most important task of the geological field analysis of process of development of fields. Estimates of a power condition of deposits, dynamics of change of water content of the got fluids are for this purpose carried out; efficiency of increase of efficiency of wells and increase in oil recovery of layers (skin) (Ministry of Energy of Russia, 2002; Riley and Bryant, 1979).

Currently, special interest is represented by a technique of maintaining the analysis of development of fields of the Northern Caspian Sea in connection with the new technical and technological level at which were carried out investigation, development drilling and geological and technological researches. The acquired research techniques do not allow to make rather precisely necessary calculations therefore correction of many parameters and justification of optimum criteria of their choice is required (Stokes, 1901).

In study are considered a method of calculation of dynamic reservoir pressure for creation of cards of the isobars applied in the analysis of development of a field of name Y. Korchagin on the shelf of the Northern Caspian Sea (Wtavm and Heck, 1971).

In the course of development of sea fields with horizontal trunks of wells of big extent it is necessary to analyze physical properties of fluids, temperature and pressure in layer, efficiency of wells and their mutual influence, character and features of movement of WOC. For this calculated values of reservoir pressure near the wells, reservoir pressure gradients over the area to develop fields and builds a map of the isobars in these areas.

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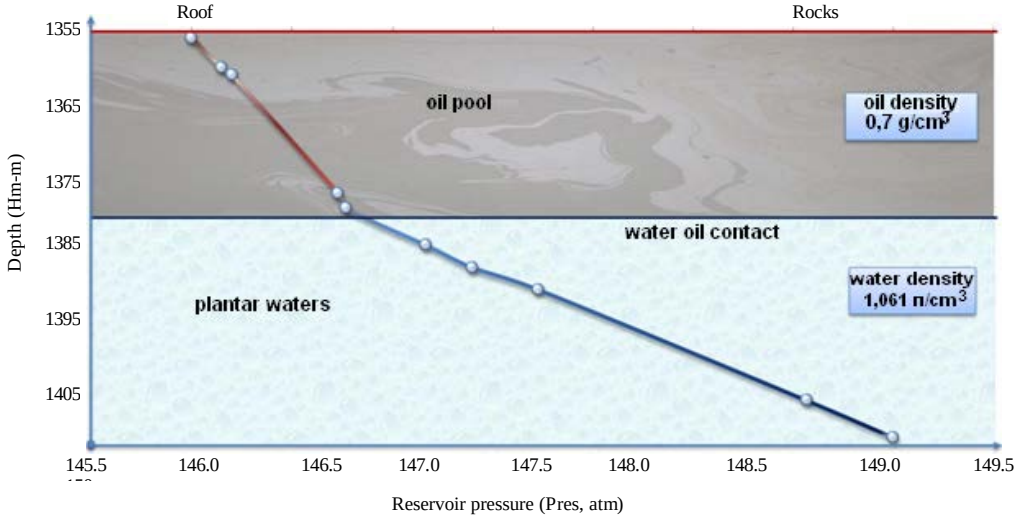

Fig. 1: Dependence of reservoir pressure PS on nanometer depth in system "rocks the oil pool reservoir waters" the Northern Caspian Sea (Giger *et al*., 1984)

The card of isobars: The card of isobars represents system of isolines (isobars) with the directional survey of wells applied on the plan with identical values of reservoir pressure for a certain date on which it is displayed gradients of dynamic reservoir pressure in a lode (Joshi, 1991; Wentworth, 1952).

Also by means of the card of isobars the average dynamic reservoir pressure of a lode as the average weighed on its area is defined (Ovchinnikov *et al*., 2008).

For an assessment of productive characteristics of a well and filtrational characteristics of layer hydrodynamic researches are conducted by method of the Curve of Restoration of Pressure (CRP) which establish interrelation between the production rate of a well and the pressure difference defining it in layer (Serebryakov, 2013; Powers, 1967). This type of research consists in registration of pressure in the stopped well by measurements by deep manometers. Such reservoir pressure around production wells is called formation pressure in a selection zone.

For operational control of the processes occurring in the layer and regulation of field development is carried out monthly calculation of the dynamic reservoir pressure based on the filtration characteristics of layer and the physical properties of a fluid received as a result of hydrodynamic researches and variable trade parameters measured in a well is carried out: the well production rate and bottomhole pressure (Kremeneckij, 2008).

Ways of calculations: At operation of wells with horizontal trunks dependence between formation pressure, production rate of a well and bottomhole pressure can be expressed by the following formulas:

Formula Borisov (1964):

$$\frac{\Delta P}{Q}=\frac{\mu}{2\pi K_h h}\left(\ln\frac{4r_{eh}}{1}+\frac{h}{1}\ln\frac{h}{2\pi r_c}\right) \quad (1)$$

Formula Giger *et al*. (1984):

$$Q=\frac{2\pi K_h h\Delta P}{\mu\left[\ln\left(\frac{1+\sqrt{1-\left(\frac{L}{2r_{eh}}\right)^2}}{\frac{L}{2r_{eh}}}\right)+\frac{h}{L}\ln\left(\frac{h}{2\pi r_c}+S\right)\right]} \quad (2)$$

Formula Renard and Dupuy (1991):

$$Q=\frac{2\pi K_h h\Delta P}{\mu\left[\mathrm{Arch}(\chi)+\frac{h}{L}\ln\left(\frac{h}{2\pi r_c}\right)\right]} \quad (3)$$

where, $\chi = 2a/L$. Formula Joshi (1991):

$$Q=\frac{K_h h\Delta P}{\mu B_0\left\{\ln\left(\frac{a+\sqrt{a^2-(L/2)^2}}{(L/2)}\right)+\frac{\beta h}{L}\ln\left(\frac{\beta h}{(\beta+1)r_c}+S\right)\right\}} \quad (4)$$

Where:

$$\alpha=\frac{L}{2}\left[0.5+\sqrt{0.25+\left(\frac{2r_{eh}}{L}\right)^4}\right]^{-0.5}, \quad \beta=\sqrt{\frac{K_h}{K_v}}$$

In the given formulas the following parameters are used:

μ = Viscosity of liquid (Pa sec)
r_{eh} = The radius of the supply circuit (m)
r_c = Radius of a trunk of a well (m)
B_o = Volume coefficient (m3/m3)
L = Length of a horizontal trunk of a well (m)
S = Skin factor
K_h = Horizontal permeability (МД)
K_v = Permeability vertical (МД)
h = Effective vertical thickness (m)
Q = Production rate of liquid (m3/day)
ΔP = P_{for}-P_{bot} depression of a well (Pa)
P_{for} = Formation pressure (Pa)
P_{bot} = Bottomhole pressure (Pa)

At a calculating of Eq. 1-3 the following assumptions were used (Shagiev, 1973):

- The filtration of formation fluids submits to the linear law of Darci and occurs in the stationary mode
- Productive layer is isotropic
- The lode has a natural diet
- The lode represents the cylinder h height
- The friction in a well can be neglected
- Formation fluid is viscous and incompressible

Unlike Eq. 1-3, the formula Joshi (Joshi) considers anisotropy of layer (parameter β) and a skin factor (parameter S) therefore, it is applied to calculation of dynamic formation pressure of operational wells of fields of the Northern Caspian Sea.

Values of settlement formation pressure for date of map development of isobars are calculated on the following formulas based on a formula Joshi (1991):

$$P_{for} = \frac{ЧС \times P bot + Q \times ЗН}{ЧС} \quad (5)$$

Where:

$$ЗН = \mu B_0 (A + B + S) \quad (6)$$

$$ЧС = cK_h h \quad (7)$$

$$A = In\left(a + \sqrt{\frac{a^2 - (L/2)^2}{(L/2)}}\right) \quad (8)$$

$$B = \frac{\beta h}{L} In \frac{\beta h}{(\beta + 1) r_c} \quad (9)$$

Where:

c = Coefficient of recalculation of trade units in the Russian
Q = Production rate of liquid (m3/day)
P_{bot} = Bottomhole pressure (Pa)

The received calculated values of reservoir pressure of a well are recalculated for WOC surface by the formula:

$$P_{formation\ pressure} = P_{for} + (H_{WOC} - H) g \rho_H \quad (10)$$

Where:

P_{for} = The calculated reservoir pressure on a formula S. Joshi (Joshi) (atm)
H_{woc} = Absolute mark of a surface of WOC (m)
H = An absolute mark in a point of measurement of reservoir pressure in a well (depth of installation of the sensor, manometer)
g = Acceleration of gravity (m/c^2)
ρ_H = Oil density in a well (kg/m^3)

To construct maps isobars use the INC to reservoir pressure which was calculated by the formula S. Joshi (Joshi) and also details of design and directional survey of wells on the situation contours WOC and GOC by seismic exploration (Aziz, 2004). On the basis of these data, the map is structured dynamic isobars in the program GeoGraphix complex (Fig. 2).

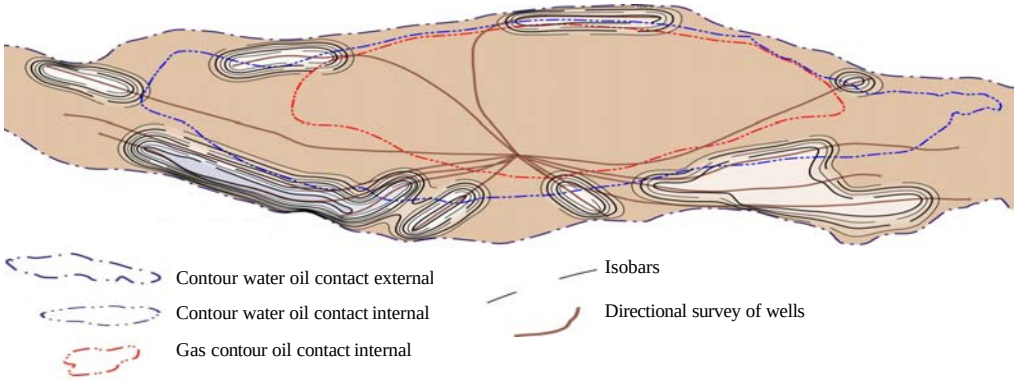

Fig. 2: The card of dynamic isobars of a field name of Y. Korchagin shelf of the Northern Caspian Sea

VALUES OF RESERVOIR PRESSURES

At determination of the parameters used in a formula S. Joshi (Joshi) accepted the basic values of the reservoir pressures received during development of wells or as a result of stops of wells on CRP (from reports on the conducted hydrodynamic researches of wells). In the subsequent, calculations of reservoir pressures of the working operational wells using the parameters received by results of stops of wells on CRP (Koskov *et al*., 2010).

The analysis of cards of isobars of a field of Y. Korchagin shows smooth reduction of the average pressure on a lode and in a selection zone. Thus at calculation of dynamic reservoir pressures for a formula S. Joshi (Joshi) the average pressure on a deposit decreased by 0.024 atm in comparison with initial reservoir pressure and at calculation for Yu.P. Borisov's formula by 0.036 atm. Therefore in practice of calculations of dynamic reservoir pressure of a field of the Northern Caspian Sea decided to use a formula S. Joshi (Joshi) (Rubey and Hubbert, 1959).

Nevertheless, the calculated values of reservoir pressures in certain cases significantly differ from the reservoir pressures received during the analysis of CRP. It can be promoted by imperfection of a well, violation of the law of a filtration of Darci, change of physical properties of layer and liquid, value change a skin factor as a result of pollution of a bottomhole zone and also any other deviations from those assumptions which were made at a conclusion of a formula of calculation of production rate of a well (Orkin, 1967).

It is necessary to consider that the listed parameters aren't the sizes measured directly, therefore, their assessment in dynamics of work of a well is rather complex challenge (Kulpin, 1974).

The analysis of maps of isobars when developing a field plays an important role because the energy condition of a lode is defined by the current values of reservoir pressures and their dynamics of change. On the map of isobars the development of a field given since the beginning about average reservoir pressure on object in general and on a selection zone is given. Thus, cards of isobars are an effective way of the analysis of distribution of reservoir pressure on a lode (Yushkov, 2013).

Specification of mathematical model of work of operational wells of fields of the Northern Caspian Sea has to be carried out taking into account the values of the reservoir pressures which are coordinated with data of CRP and most approached to the real sheeted thermobaric conditions, experienced dependences of density of UV on

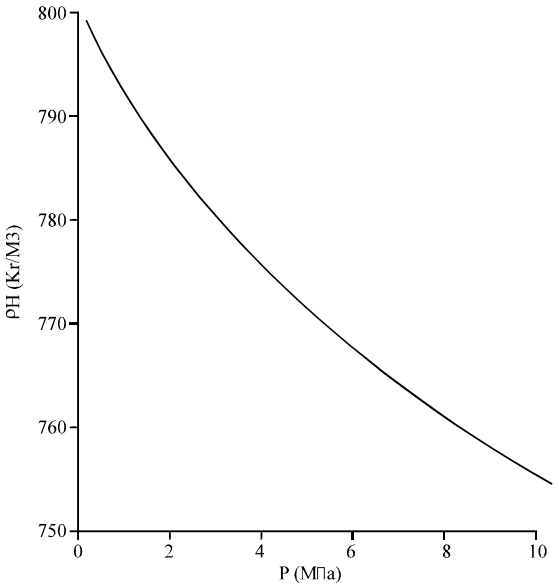

Fig. 3: Dependence of density of oil on pressure at a sheeted temperature

pressure (ρ_H/P_{for}) having in the conditions of the Northern Caspian Sea value ρ_H = -4.07 P_{for}+794 (Fig. 3) (Thesiger, 1959; Whitaker and Thresh, 1916).

Decrease in density of oil (ρ_H) at increase of pressure in the reservoir conditions happens at the expense of increase in gas saturation oils (a gas factor of GF) because with increase of pressure solubility of the gas in the oil. In superficial conditions, density of the oil is increases by degassing and stabilization of parameters (Orkin, 1967; Renard and Dupuy, 1991).

CONCLUSION

Therefore, it is necessary with sufficient degree of accuracy to predict value of the parameters which aren't measured directly on the basis of parameters which values are fixed in real time and depending on types of works which are carried out in a well. Also at calculation of reservoir pressure sufficiency and completeness of the data received following the results of hydrodynamic researches in a well especially this on anisotropy of layer has importance (Wyekoff *et al*., 1934).

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