OIL AND GAS GEOLOGY

Research technique and test experiments for the analysis of petrophysical properties of weak-consolidated and friable rocks

УДК [552.08.53]: 553.98.23.(477)

Vladyka V.M., Nesterenko M.Yu., Dr. of geological

Balatskyi R.S.

Lviv Research Centre UkrNDIGas

With the use of created measuring system for the study of petrophysical properties of incompetent, friable and loose rocks and sludge samples test experiments were performed on pit sand samples of known grain-size distribution, consolidated and disintegrated rock samples of Subbotin oil field of the Maykop formation. It was experimentally established that the shrinkage rate of soft rocks decreases sharply and attenuates at the effective pressure of 30 to 35MPa, which leads to stabilization of their filtration-capacitive and deformation behavior. The research of rocks, which are returned during drilling in the form of sand and cuttings, opens opportunities for using the obtained data for interpretation of production well logging and calculation of hydrocarbon reserves.

Practical experience in research weak-consolidated and friable rocks [1-5] indicates that it is generally impossible to get more information on their filtration-capacitive and electrical properties, since such collectors are destroyed during drilling and brought to the surface as mud or sand.

Preliminary analysis of laboratory studies, carried by V.M. Bortnytskyj , T.S. Izotov and Yu. S. Hubanov for fragile sand and silt rocks of the Middle Mykope deposits in South OGF shows that the decrease of porosity in sandstone unit at full load depends on clay content. At the range from 6.3 to 43.2% its compaction coefficient varies from 1 to 1.76 . [1] Of course, such studies is necessary to fulfill with application of appropriate equipment and devices that con - structive differ from those used to study consolidated collector rocks.

The aim of the Article is the development of research methodology and the creation of multifunctional, simple and reliable installation by which alternately on the same sample can be studied filtration-capacitive, deformation and electrical properties of weak-cemented and friable rocks of oil and gas.

Plant (Fig. 1) contains a sample holder 1, in which case pressed a Teflon bushing 2, all of which placed inside the weak-consolidated or friable sample or disintegrated sludge sample 3. Top and bottom of the sample (pattern) set perforate metal washers with radial grooves and rings of filter paper 4 rods 5 and 6, the perimeter of which is inserted rubber sealing ring 7. The lower 5and upper 6 rods have central and side vents for filing the sample and withdrawal of working agent (gas, reservoir fluids, hexane), supporting that the closing valve can overlap the central rod holes 8, 9..

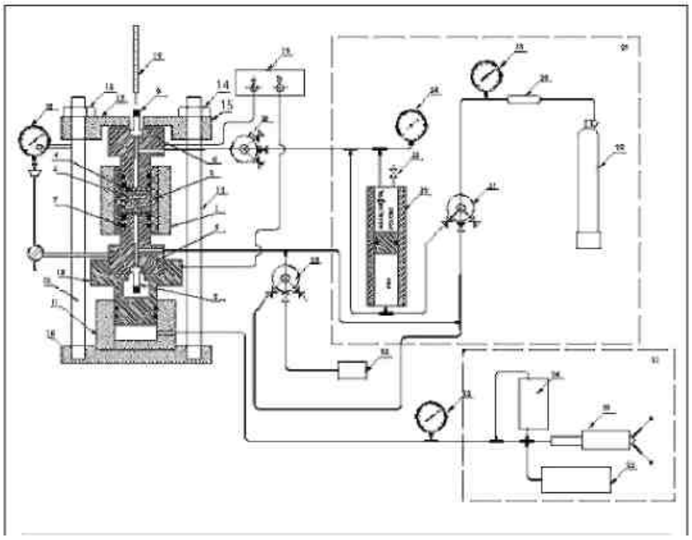

Fig. 1. Principle diagram of the petrophysical parameters tester for weak-consolidated and friable rocks and sludge samples

Lower rod 5 is set on plunger 10, which moves vertically in a supporting cylinder 11. Supporting cylinder 11 together with these components of sample holder 1 through pins 12, sleeve nuts 13 and 14 and the lid 15 is rigidly secured to the base 16. In the center hole of the upper rod 6 connected in capillary (with movable crane)*6*.

To plunger 10 and the upper rod 6 connected unit of measurement of electrical resistance 19. To the side hole of the supporting cylinder 11 through hydraulic line with gauge 20 is connected a hydraulic unit 21. The latter consists of a hand- press 22, filtration units (such УИПК- 1М), which has a plunger pump with electric drive 23 and an additional set accumulator 24 (reduces pulsation pressure), made in form of thick-walled metal cylinder. It is possible to connect through the manifold 25 a vacuum pump 26opening to the side hole of bottom of the rod 5. In addition, to side holes of the upper rod 6 through manifold 36 connected a node 27, containing a gas cartridge 28 (nitrogen) with reducer, drying tube 29 gauges 30, 34, manifold 31, a separator piston 32 filled with mineralized water or its model, crude oil or hexane through the valve 33. In the principal diagram of tester is the opportunity to connect to the manifold device 31 for measurement of open porosity of rocks by the gas volumetryc method [6].

On the developed equipment conducted test experiments: evaluation of the possible error during the study due to shrinkage joints from different materials in sample holder (calibration curve 1 in Fig. 2) change in length (Δ L) disintegrated sample (pattern) during the steplike vertical loading (curve 2 in Fig.2) and the change in absolute penetration in course of above mentioned load (curve 3).

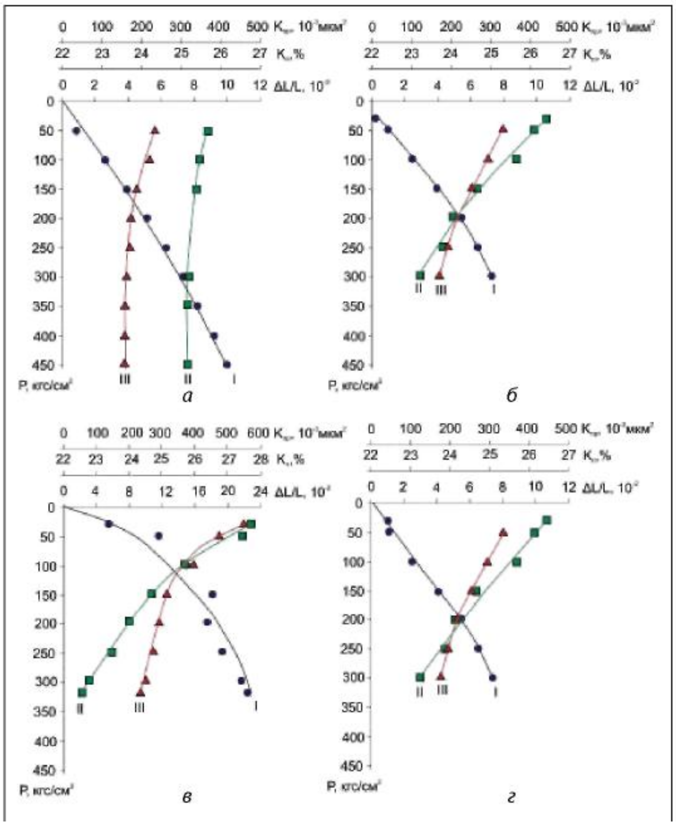

Fig. 2. Change of collecting properties from the vertical compression of friable and disintegrated rocks: and - Sand (pattern 1), b - pit sand (pattern 2), samples from the well of 2-nd Subbotinskyi oil field: b- laboratory number 19.1[1]; g - Laboratory number 19.11a[1]; by numerals I, II, III, marked dependences $\Delta L/L$, $K_П$ i $K_{Пр}$ from P

Even the first test laboratory experiments have shown that the tester is able to work at loads which exceeds 3000 kg/cm² • cm², which corresponds to an effective pressure of over 40 MPa and completely covers the depth interval, on which can occur friable and loose rocks.

For the experiments were selected two samples of pit sand (Lviv) and samples of friable clay sands from the well of 2-nd Subbotinskyi oil field destroyed in the process of reservoir water filling with total mineralization of 30 g/l. On each of the samples studied changes of its length (L/L) and the initial and current values of filtration- capacitive specifications in the process of the vertical loading growth that simulates the compaction of these rocks under effective pressure. In addition, with the help of continuous recording of loading and changing the length of the samples was determined a deformation modulus (Eст), i.e. Young's modulus in the vertical compression [4].

Preparing pit sand to research, it was sieved, dried and a sample of sand was weighed, in the sleeve 2 it was formed a cylindrical pattern with diameter and length of 30 mm. Core samples from the well of 2-nd Subbotinskyi oil field were dried, after that they destroyed in the stamp to the consistency of sand, in the sleeve they were formed in a cylindrical sample of size-defined.

The relative decrease in the length of the sample during researching from the well of 2-nd Subbotinskyi oil field the loading occurred steplike, without any violent changes. Since the vertical pressure of 250-300 kg/cm² (24.5 - 29.4 MPa) rate of shrinkage (contraction) of samples is decreasing (see Fig. 2). At each grade of samples load distribution was calculated a current porosity rocks, while its start value was measured by gas volumetric method [6]. The change of porosity during the research corresponds to the ratio:

$$K_п : \frac{L_0}{L_{пот}} = K_п^{пот},$$

where $K\Pi$ – start porosity value, %; L_0 – start sample length, cm; Lпот – current sample length, cm.

The correctness of this correlation was confirmed during the research of disintegrated samples (cylinders) from the well of 2-nd Subbotinskyi oil field, when during the loading, similar to the depths of their occurrence, the cylinder formed in the unit had similar to that, which was cut from the core of the cylinder. Thus, if a cylinder (sample 19.1) had a primary porosity of 22.9 % and at cylinder (sample 19.11) did not exceed 19.95 %, after compression of disintegrated samples up to 300 kg/cm² (29.4 MPa) porosity was respectively equal to 22.76 and 19.97 %. The match of the matrix - opened porosity and samples porosity (cylinders) formed into the tester, is very high, but it is possible that this accuracy may decrease with increasing research amounts and accuracy of the effective pressure.

Along with porosity was studied change in absolute gas permeability of the pit sand and simulation generated cylinders of sandy-clay rocks of the Subbotinskyi oil field. All disintegrated (bulk) samples characterized a high initial absolute gas permeability within (298-553)•10-3 mkm². During the progressive loading it gradually decreased to 2 times or more. The maximum decrease in permeability occurred within the loads (139-2119,5) kg/cm²•cm², whereas further on an absolute gas permeability decreases slightly. Thus, stabilization of the physical properties of weak-consolidated and friable rocks occurs at effective pressures of 30-35 MPa.

The calculations showed that the deformation module in friable rocks is much lower (samples 1 and 2) than in the disintegrated sandstone of the Subbotinskyi oil field containing a pelitic fraction of 12,9-21,9 %.

Thus, researches of friable rocks showed that using the above tester it is possible to conduct a variety of laboratory experiments to study the petrophysical characteristics of these rocks. This equipment also provides a possibility to make similar studies with consolidated reservoir rocks using standard sample holders.

References

1. Bortnitskaya V.M. Definition of conditional values for parameters of friable sand clay reservoirs/ V.M. Bortnitskaya, T.S. Izotov, Y.S. Wrasse / / Geology of oil and gas. - 1978. - № 4. - S. 48-54.

2. Nesterenko M. Yu. Petrophysical basis for backgrounds of fluid-filling of rocks reservoir: monograph / M.Yu. Nesterenko. - K. UkrDGRI, 2010. – 224p.

3. Shyshyhyn S.I. Method of reservoir properties determining of Cenomanian deposits of the Urenhoy of gas field/ S.I. Shyshyhyn, N.N. Shypovalova // Proceedings of ZapSybNYHNY, 1980. - Vol. 158. – P.62–67.

4. Spivak A.I. Mechanics of rock formations/ A.I. Spivak, A.N. Popov. - Moscow: Nedra, 1975. – 200p.

5. The petrophysical rocks studies of new productive facilities of the West Siberian Plain, in order to justify the calculation parameters: in 2 Vol. - Tyumen ZapSibVNII Geophysics, 1983. – Vol. 1: The petrophysical rocks studies of the new productive facilities of the West Siberian Plain, in order to justify calculation parameters / V.G. Mamyashev, A.M. Verkhpvsky, S.I. Kuvaev [and other] – 223p.

6. Nesterenko M.Yu. On the issue of the total porosity of rocks using the gas volumetryc method/M.Yu. Nesterenko, Ja.A.Philip V.V. Ivanov, Yu.M. Vihot // Oil and gas industry. - 2011. - № 2. -. -P. 17–21.

Vladyka Vitaly Nikolaevich *Head of Lviv complex research center UkrNDIgas. He graduated from the Lviv National University "Lvivska Polytechnika" (specialty engineer) and Ivano-Frankivsk National Technical University of Oil and Gas (specialty mining engineer- oil-and-gas recovery). Research Interests: extraction of hydrocarbon deposits, physics layer.*

Mykola Yuriyovych Nesterenko - *Leading researcher of Lviv complex research center UkrNDIgas, Doctor of Geological Sciences. Graduated from Kyiv Geological College and Ivano-Frankivsk Institute for oil-and gas (Geological Faculty, specialty - Mining Engineer Geologist). The field of scientific interests: oil and gas geology, petrophysics. Author of about 70 scientific publications, 10 patents, six industry standards of Ukraine.*

Balatskiy Roman Stepanovych.

Junior research scientist of Lviv complex research center UkrNDIgas. He graduated from the Lviv National University. n.a. I.Franko (Geological Faculty, specialty - geological survey, surveying and exploration). Scope of scientific interests: oil and gas geology.