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STANISŁAW DUBIEL*, ADAM ZUBRZYCKI*, CZESŁAW RYBICKI*, MICHAŁ MARUTA*

APPLICATION OF DST INTERPRETATION RESULTS BY LOG – LOG METHOD IN THE PORE SPACE TYPE ESTIMATION FOR THE UPPER JURASSIC CARBONATE RESERVOIR ROCKS OF THE CARPATHIAN FOREDEEP BASEMENT

INTERPRETACJA TESTÓW WYKONYWANYCH RUROWYMI PRÓBNIKAMI ZŁOŻA – RPZ W SKAŁACH WĘGLANOWYCH GÓRNEJ JURY PODŁOŻA ZAPADLISKA PRZEDKARPACKIEGO

In the south part of the Carpathian Foredeep basement, between Bochnia and Ropczyce, the Upper Jurassic (Oxfordian, Kimmeridian and Tithonian) carbonate complex plays important role as a hydrocarbon bearing formation. It consists of shallow marine carbonates deposited in environments of the outer carbonate ramp as reef limestones (dolomites), microbial – sponge or coral biostromes and marly or micrite limestones as well. The inner pore space system of these rocks was affected by different diagenetic processes as calcite cementation, dissolution, dolomitization and most probably by tectonic fracturing as well. These phenomena have modified pore space systems within limestone / dolomite series forming more or less developed reservoir zones (horizons). According to the interpretation of DST results (analysis of pressure build up curves by log – log method) for 11 intervals (marked out previously by well logging due to porosity increase readings) within the Upper Jurassic formation 3 types of pore/fracture space systems were distinguished:

- type I – fracture – vuggy porosity system in which fractures connecting voids and vugs within organogenic carbonates are of great importance for medium flow;
- type II – vuggy – fracture porosity system where a pore space consists of weak connected voids and intergranular/intercrystalline pores with minor influence of fractures;
- type III – cavern porosity system in which a secondary porosity is developed due to dolomitization and cement/grain dissolution processes.

Keywords: petroleum explorations, Carpathian Foredeep basement, Upper Jurassic, carbonate rocks, DST tests, pore space systems, hydrodynamic test

W pracy scharakteryzowano metodykę interpretacji testów odbudowy ciśnienia z użyciem krzywych diagnostycznych i specjalistycznych oraz przedstawiono wyniki interpretacji testów złożowych rurowymi próbnikami złoża (RPZ) wykonanych w latach 1995-1997 w 11 profilach serii węglanowych górnej jury (malmu) budujących podłoże zapadliska przedkarpackiego w strefie Bochnia – Ropczyce. Uzyskane

* AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, FACULTY OF DRILLING, OIL AND GAS, AL. MICKIEWICZA 30, 30-059 KRAKÓW, POLAND

wyniki oraz szczegółowa interpretacja krzywych odbudowy ciśnienia dennego w powiązaniu z rozpoznanym rozwojem litofacjalnym utworów górnej jury pozwoliła wstępnie wydzielić charakterystyczne typy wykształcenia przestrzeni porowej, występujące w obrębie interwałów wytypowanych badaniami geofizyki wiertniczej do testów RPZ. Są to: I – typ szczelinowato-porowy z dominującym wpływem systemu szczelin; II – typ porowo-szczelinowaty z minimalnym wpływem szczelin oraz typ III – kawernisty, w którym system wolnych przestrzeni tworzą mikrokawerny, pustki i przestrzenie międzykrystaliczne powstałe głównie wskutek epigenetycznych procesów dolomityzacji i rozpuszczania. Wydzielone systemy można wiązać z facjami skał węglanowych, głównie organogenicznych, występujących w obrębie utworów górnej jury podłoża zapadliska przedkarpackiego.

Słowa kluczowe: poszukiwania naftowe, podłoże zapadliska przedkarpackiego, górna jura, skały węglanowe, testy hydrodynamiczne RPZ, systemy przestrzeni porowej.

Nomenclature

C – wellbore storage coefficient [m^3 / MPa],
x_f – half the length of fracture [m],
h_d – length of the well perforation segment,
ω – rate of fracture capacity and matrix – fracture system capacity,
λ – contrast capacity parameter between the fracture and whole reservoir,
k – effective permeability of matrix + fracture system [m^2],
h – thickness [m],
S – skin-efekt ,
p^* – initial pressure [MPa],
R_{b2} – radius of the investigation during test [m],
L – distance from the well to boundary [m],
p– – average pressure [MPa],
I.A.R.F. – Infinite Acting Radial Flow,
RPZ – DST tester,
t_1, t_2 – time of first and second period of the inflow [min],
Δt_1, Δt_2 – time of first and second build up of the bottom pressure [min],
time of the inflow [min],
n.o. – barefoot segment of the well,
perf. – perforated segment of the well,

1. INTRODUCTION

The Carpathian Foredeep basement particularly its Upper Jurassic carbonate formation is still important zone for hydrocarbon explorations. Significant hydrocarbon accumulations as Brzezówka, Korzeniów, Dąbrowa Tarnowska, Partynia – Podborze oil fields and Dąbrowa Tarnowska, Tarnów, and recently Łapanów gas fields were discovered in carbonate reservoir rocks of this formation. Both hydrocarbon accumulations and perforated intervals of the Upper Jurassic carbonates selected previously by well logging for DSTests are connected with the favorable carbonate facies development. Their pore space systems were modified mainly by diagenetic processes as multistages dolomitization and dedolomitization and dissolution as well. Authors believe that results of DST analysis by the log – log method allow to determine the relationship between pressure build up curves and existed type of pore space systems for selected Upper Jurassic carbonate intervals.

2. Geological setting

The analyzed area is situated in SW zone of the central part of the Carpathian Foredeep basement between Bochnia – Ropczyce where the Upper Jurassic carbonate formation was cut by paleogenic/neogenic erosion and next was covered by molasses of the Autochtonous Miocene formation – Fig. 1.

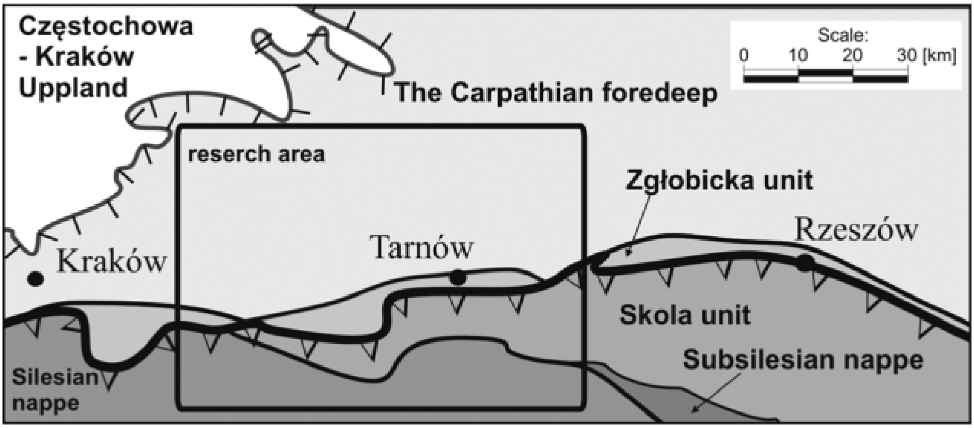

Fig. 1. The study area on the background of the Carpathian Foredeep and frontal units of the Flish Carpatians thrusted northward on the Autochtonous Miocene formation

Different Upper Jurassic formations (Oxfordian, Kimmeridian and Tithonian) are covered there by the Autochtonous Miocene molasses and the frontal Flish Carpatian Thrust – mainly by the Silesian and Skole Units. The Upper Jurassic carbonates extent westward to their outcrops in the Kraków – Częstochowa Upland where their thickness is about 300 m. Maximum preserved thickness of the Upper Jurassic formation occur in the east part between Radomyśl – Ropczyce – Zagorzyce zone reaching more than 1000 m (partly below of the Carpathian Thrust). The sedimentological studies according the facies characterization (Krajewski et al., 2011; Maksym et al., 2001) have revealed strong facies diversifications within the Upper Jurassic carbonates. Their sedimentation was determined by sedimentological environments of shelf margin (outer-mid homoclinal carbonate ramp) shifted during Early Kimmeridian southeasterwards (Gutowski et al., 2007) and next by shallow marine conditions (internal platform – open/restricted lagoons) mainly during Thitonian (Krajewski et al., 2011). During the Upper Oxfordian in the carbonate platform zone the organogenic limestone facies were developed as microbial-coral-sponge bioherms passing into mudstones, micritic limestones and marls. At the turn of the Oxfordian and Kimmeridian the shallow marine facies are dominant as small pinnacles of microbial-coral reefs and biostromes. In the uppermost part of the carbonate formation (Kimmeridian and Tithonian) some facies unification have occurred in the form of limestones (floatstones-grainstones) and marls. Diagenetic processes consist of mainly dolomitization and dedolomitization multistages and dissolution as well of the Upper Jurassic carbonates (Krajewski et al., 2011) were essential factors in theirs pore systems development.

The tectonic structure of the Carpathian Foredeep basement including its Jurassic cover was differentiated into tectonic blocks confined very often by reverse-slip faults during finally in the Early Miocene. Tectonic formation of the foredeep basement was additional factor in processes modifying pore space systems of carbonate reservoir rocks by the formation of fractures. Hydrocarbons accumulations discovered until now confirm the importance of the Upper Jurassic carbonates as the oil and gas bearing formation. Hydrocarbon accumulations occur in traps of different kinds but theirs reservoir rock horizons are genetically connected with type of carbonate facies modified by diagentic and/or tectonic processes.

The DSTests were performed within various horizons of the Upper Jurassic carbonate profile which perforated intervals have been indicated by wireline logs only as increase of porosity. The preliminary analysis of 11 results of DST by log – log method (build up pressure curves vs. time) enable to separate three kinds of pore space systems each marked by characteristic record of pressure build up curves. These are:

- type I – fracture – vuggy porosity system in which fractures connecting voids and vugs within organogenic carbonates are of great importance for medium flow;
- type II – vuggy – fracture porosity system where a pore space consists of weak connected voids and intergranular/intercrystalline pores with minor influence of fractures;
- type III – karst porosity system in which a secondary porosity is developed due to dolomitization and cement/grain dissolution processes. The highest porosity readings on logs are characteristic for this type.

3. Fundamentals of the interpretation of results hydrodynamic tests with classic “log-log” method

Classic method of the interpretation of results of hydrodynamic tests “log-log”, used in the computer system “Saphir 202 B” (Kappa, 1993-1995; Rybicki, 1996), consists in simultaneous marking in the doubly logarithmic system the graph of the pressure increase (Δp) and the graph of the derivative of the pressure ($\Delta p'\Delta t$) in the function of the time. It enables, by fitting model graphs to real graphs, the identification of known kinds of the flows of liquid through porous and porous – fractures media and selection of the appropriate theoretical model (table 1.) of the productive rocks; of contributing towards the well; of boundary shape of the layers (Kappa, 1993-1995).

Doubly logarithmic “log-log” system of coordinates enables usually to fit real curves for theoretical curves, with the accepted model (Dubiel at al., 2003). In most industrial cases influence of well and reservoir conditions for pressures behavior in the accepted model of the reservoir it takes place in different time periods, therefore every of these influences is simple to recognize in the arrangement “log-log” on the graph of the increase pressure derivative ($\Delta p'\Delta t$), based on the characteristic shape or slope the function log $\Delta p'\Delta t$ with regard to the x-axis (fig. 2).

Influence of the reservoir model accepted for the given layer of reservoir (homogeneous or heterogeneous: double porosity, two-layers and others) is marked on the ($\Delta p'\Delta t$) graph after the

TABLE 1

Collection of models of the structure of the productive rocks, models of contributing towards the well and models of the shape boundary of rock layers, according to the “Saphir 202 B” program (Kappa, 1993-1995)

I. Reservoir model	II. Wellbore model (inner conditions and outer conditions)	III. Boundary model (outer conditions)
1. homogeneous; 2. double porosity) (semisteady state); 3. double porosity (transient state): a) block arrangement, b) spherical arrangement; 4. two-layer reservoir; 5. radial composite layer model; 6. linear composite layer model.	1. well with the wellbore storage effect and skin effect 2. well with acting fracture with the high conductivity; 3. well with acting fracture with low conductivity 4. horizontal well; 5. well with variable wellbore storage effect	1. infinity acting reservoir ; 2. reservoir limited by the circle shape boundary; 3. reservoir limited by sealing fault or with constant pressure at the boundary; 4. reservoir with two crossing sealing faults or with constant pressure; 5. folded polygon boundary reservoir; 6. the reservoir limited by the conducting fault.

wellbore storage effect. Information about values of parameters being characteristic of a rock centre about the double porosity (ω and λ) is possible to get much earlier than information about the effective permeability k or the product of the permeability and the thickness (kh), as well as about the change of permeability near the well (skin-effect positive or negative).

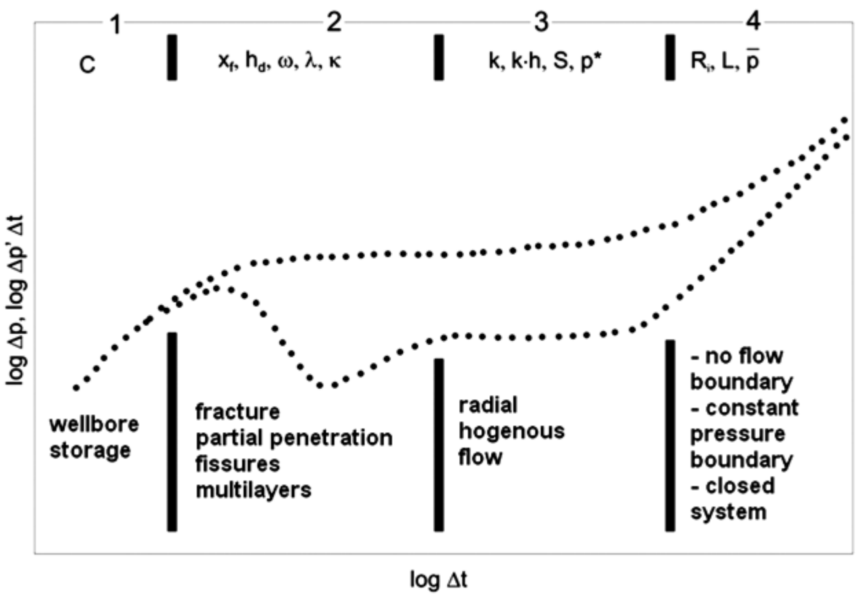

Fig. 2. Diagnostic graph presenting the comprehensive reservoir characterization of tested layers in vertical wells (Kappa, 1993-1995)

4. Analysis of the results of doubly logarithmic interpretations of graphs "log-log" with aim of the determination of reservoir model

For the registration of the bottom hole pressure it has most often used mechanical manometers of the type AK-1 of the Kuster company, as well as electronic manometers of the company GRC-Amerada (Dubiel et al., 1998). Examples of fitting model graphs to real graphs are presented on fig. 3 and 4. In seven cases (table 2) the best fit of representative curves for real curves was get for the reservoir model with the double porosity of rocks – semi steady state (table 2, row 2). The rock of this type is characterized by two basic parameters ω and λ (Dubiel et al., 2003; Kappa, 1993-1995).

Analyzing results of model diagnostics collected in table 2, three characteristic systems of pore space character of carbonate systems of the upper Jurassic period were received:

- pore – fracture system with the dominating influence of the system of fracture on the capacity concern the high values of an omega bigger than 0.1 (table 2, row 5 and 6, column 6) (fig. 3);
- pore – fracture system with the minimal influence of fractures on the capacity; an omega has lower values then 0.1 (table 2, row 1 to 4 and 7 to 11, column 6) (fig. 4);
- karst, in which the reserve system was formed in through epigenetic dolomitisation processes, and processes of dissolving. This type is strongly heterogeneous; it was diagnosed based on the lack of abilities of fitting real curves to model curves, concerning the rock with the double porosity (table 2, row 3, 7 and 9, column 6). It is usually characterized by the highest recommendations of the porosity on curves of profiling drill geophysics.

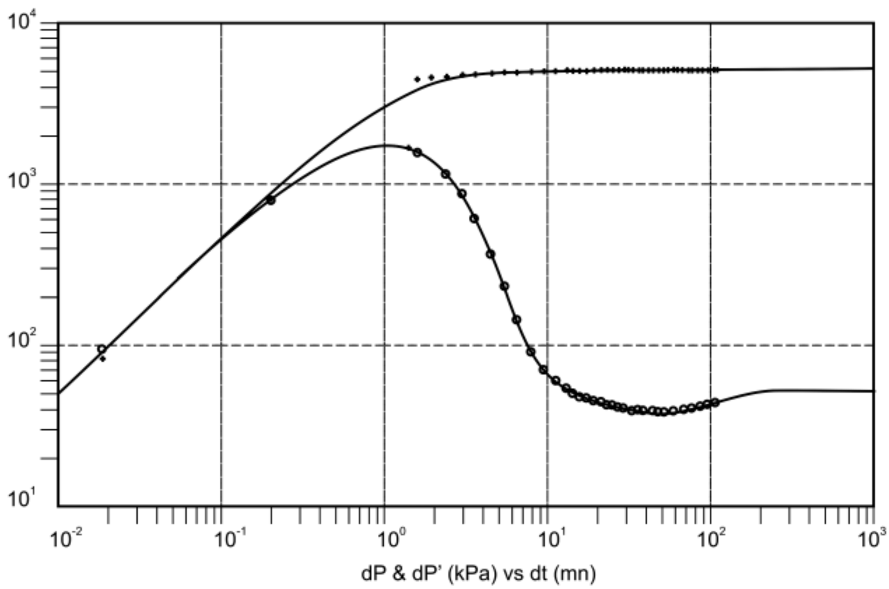

Fig. 3. Example of fitting model graphs (solid lines) to real graphs (dotted lines), based on results of carbonate formation investigations of the upper Jurassic (1868-1904 m) – pore-fractures system – in the W-16 well

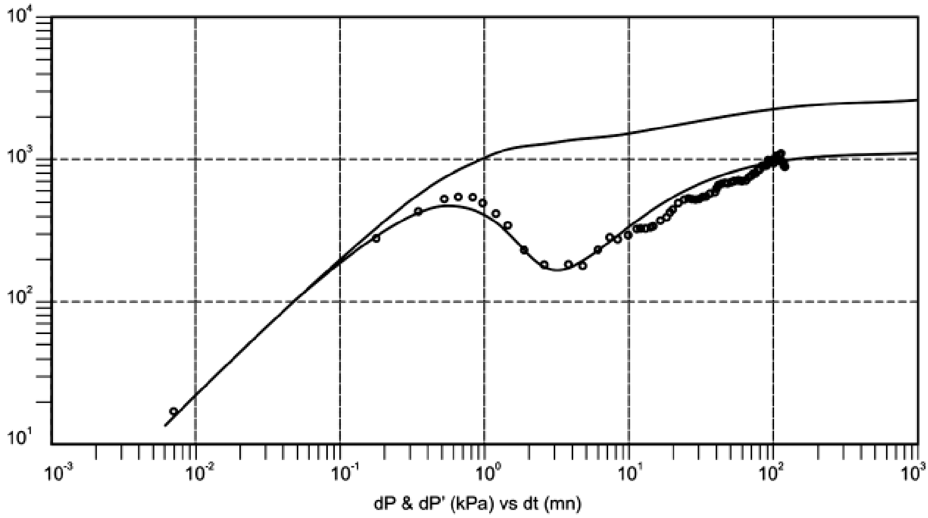

Fig. 4. Example of fitting model graphs (solid lines) to real graphs (dotted lines), based on results of carbonate rock diagnostics of productive rocks of the upper Jurassic (657-702 m) – pore-fractures system – in the K-4 well

Analyzing data has been compared in table 2. it is possible to state, that rocks of the karst type, allocated based on the interpretation of results of reservoir tests, are characterized by a determined using wire logs, being considerable value 9 % of the porosity (table 2. column 5). Remaining types of rocks (fracture -pore and pore - fracture) have a porosity from 3 to 7.5 %. It is worth noting that in cases of improving the primary rock permeability in near well zone at the same time cleaning oneself is appearing of this zone from the drilling fluid (table 2, column 3). In cases of applying salted muds there is possibility creation of the salt crystals and secondary colmatage of the rock (Dubiel & Falkowicz, 2001).

5. Technique of carrying out of tests

Separated with using wire-line logs methods in wells profiles, layers of rocks of the upper Jurassic were subjected to DST tests most often in barefoot segments of wells, and more rarely in lining pipe wells after earlier perforation of the segment. The American tester of the Halliburton company (of type Standard or Ful-Flo) and Baker companies of the type Inflatable were used. During test works of the upper Jurassic generally were applied two cycle technology (Dubiel et al., 1998). Basic technical parameters of DST tests of the upper Jurassic were put together in table 3.

In the case of carrying out DST tests in barefoot segment of the well the time is total limited by the time of safe staying of the sampler, determined every time with relevant preventive test. In these cases (table 3, rows 2-11) it has been made in the first cycle short inflow test (t_1 from 7 to 37 min) and a bit longer test of the first build up (Δt_1 from 18 to 62 min). For this goal relaxing the tested rock layer from the repression of the pressure of the pole of mud was being carried out during of completion its which in analysed cases took out from 0.59 to 4.57 MPa (table 3, col-

TABLE 2

Collection results of carbonate rock diagnostics of productive rocks of the upper Jurassic based on interpretation with method log-log of curves of the buildup of the bottom pressure at using of the program "Saphir 202B"

	Well; No. of the tester fastening; interval from to [m]	Kind of reservoir fluid; – inflow productivity of the, water [m^3/hr] gas, [Nm^3/ min]	Type of rock	Poro-sity from geophysics. [%]	Fitting the model		
					Model reservoir and itsparameters	Parameters of the model of well and near well zone	Model of boundary reservoir
1	2	3	4	5	6	7	8
1	Z - 7; 41 / 97; 2628 - 2645;	Natural gas: 1	Pore-fracture	5	Double porosity model Omega: 0.0535; Lambda 6,5. 10^{-7}	Wellbore storage C = 0.22 [m^3/MPa]; Sin effect = + 21	The layer limited by one sealed fault with the constant pressure; L = 70 m; R_{b2} = 110m.
2	T - 1; 61 / 95; 2696 - 2720;	Reservoir water: 4.8; Natural gas: 0.6	Pore-fracture	8	Double porosity model; Omega: 0.041; Lambda: 4.46 · 10^{-7}	Wellbore storage C = 7.6 x10^{-4} [m^3/MPa] Skin effect = + 5	Lack of information about boundary; R_{b2} = 242 m
3	T - 71; 23 / 95; 1841 - 1864	Reservoir water with traces of oil: 0.5; Natural gas: 0.14	Krast	9	Failure in fitting the double porosity model	Wellbore storage C = 9.6 · 10^{-4} [m3/MPa]; Skin effect. = - 2	Lack of information about boundary; R_{b2} = 25 m
4	Ż - 42; 49 / 97; 1483 - 1492;	Reservoir gassy water 1.08	Pore-fracture	5	Double porosity model; Omega: 0.0535; Lambda: 6.5 · 10^{-7}	Wellbore storage C = 8.32 x10^{-4} [m3/MPa]; Skin effect. = +21	Unrestricted layer in the range of the RPZ examination; R_{b2} = 231 m
5	IN - 16; 52 / 97; 1868 - 1904;	Reservoir gassy water: 2	Fracture-pore	7.5	Double porosity model; Omega: 0.463; Lambda: 1.9 · 10^{-6}	Wellbore storage C = 6.75 · 10^{-3} [m^3/MPa]; Skin effect. = +41	Unrestricted layer in the range of the DST examination; R_{b2} = 165 m

TABLE 2. continued

1	2	3	4	5	6	7	8
6	Ż - 42; 53 / 97; 1635 - 1701;	Reservoir gassy water: 2.5	Fracture-pore	6	Double porosity model; Omega: 0.186; Lambda: $5.8 \cdot 10^{-7}$	Wellbore storage $C = 2.91 \cdot 10^{-3}$ [m3/MPa]; Skin effect. = +50	Unrestricted layer in the range of the DST examination; R_{b2} = 315 m
7	B-5 30 / 95; 1558-1576;	Reservoir gassy water: 2	Karst	9	Failure in fitting the double porosity model	Wellbore storage $C = 6 x10^{-3}$ [m3/MPa]; Skin effect. = + 35	Unrestricted layer in the range of the RPZ examination; Rb2 = 230 m
8	B-5; 25 / 95; 1549-1558;	Reservoir of mud and gassy water: 0.024	Pore-fracture	7	Double porosity model; Omega: 0.0425; Lambda: $9 \cdot 10^{-8}$	Wellbore storage: $C = 9.9 x10^{-5}$ [m3MPa]; Skin effect. = -2.2	Lack of information about boundary R_{b2} = 11 m
9	B - 9; 40 / 95; 1501-1514	Reservoir of mud and gassy water: 0.21	Cavernous	9	Failure in fitting the double porosity model	Wellbore storage $C = 7.6 x10^{-4}$ [m3/MPa] Skin effect. = -0.5	Lack of information about boundary R_{b2} = 10.5 m
10	K - 4; 114 / 96; 657 - 702;	Reservoir of mud and water without traces of gas: 2.8	Pore-fracture	6	Double porosity model; Omega: 0.00455; Lambda: $4 \cdot 10^{-5}$	Wellbore storage $C = 2.2 \cdot 10^{-2}$ [m^3 / MPa]; Skin effect. = - 4.4	The layer limited by one sealed fault; L = 22 m; R_{b2} = 98m.
11	Z- 8 47 / 96; 1280-1299;	Reservoir of mud and water without traces of gas: 1.75	Pore-fracture	5	Double porosity model; Omega: 0.05; Lambda: $4.77 \cdot 10^{-5}$	Wellbore storage $C = 2.36 \cdot 10^{-3}$ [m3 / MPa]; Skin effect. = -2.6	The layer is limited by one boundary; L = 56 m; R_{b2} = 121 m

umn 5). To the other cycle of test much more a time was being set aside (t_2 from 34 to 382 min), without the great risk of seizing the sampler. During the second inflow test it has been aspiring mainly down loadable samples of reservoir fluid about the representative volume (from about 0.3 to 4 m^3), and during the second test of the build up (Δt_2 from 63 to 190 min.) it has been trying, in order to radius of the zone explored with the sampler (R_{b2}) was biggest. The value of investigation radius was in range from 11 to 315 m (table 2, column 8).

In the case of casing well and stated manifestations of the inflow of the natural gas to the tester (table 2, row 1), many hours' tests of the inflow (t_1 = 411 min; t = 1312 min) was applied (table 3), connected from periodic, repeated of the well siphoning and with stabilization of the head pressure, as well as many hours' tests of the build up (Δt_1 = 1630 min; Δt_2 = 817 min). In the result of repeated the siphoning process was being cleaning of well and pore – fracture rocks from mud, applying the more greater value of the initial depression of the pressure (23.25 MPa – watch table 3 row 1, column 6). In the barefoot intervals applied values of the initial depression of the pressure (table 3, column 6) they are appropriately smaller and are taking out from 5.4 to 19.51 MPa.

It should be noticed, that in the case of fracture – pore rocks tests under the influence of the too high depression of the pressure, can be reached tightening of fractures and considerable limiting intensity of the inflow plentiful supply of fluid to the tester. Changes of water saturation in the near well zone and increase of the relative permeability for water can be appeared (Rybicki, Dubiel, et al, 2006). In case of analyzed reservoir tests, in the destination of the decreasing of the initial pressure depression on tested gas and water saturated layers, it was applied in the sampler column post of the water wadding with the height about 100 m to 700 m, depending on the depth of lying tested.

While drilling of productive rocks, under the influence of the pressure repression of the post of the drilling fluid in the well, their permeability is reducing in the near zone in the result of colmatage with solid phase from the mud (argillaceous particles, salt, rust, polymers, bore – dusts). Hence in order to provide good cleaning off rocks of this zone particulates, the value of the initial pressure depression was being selected several times higher than the pressure repression of the post of the mud in the well. In analyzed cases the calculated value of the quotient of depression and the repression had a wide range of the value and took out from about 3 to 9 (table 3, column 7).

6. Conclusions

1. Preliminary analysis of the results of DST tests, carried out in the different carbonate layers of the upper Jurassic allow authors distinguish three characteristic types of the rock system, appointed earlier with research on the drill geophysics of only porosities on the base increased general. They are:

- type I – fracture-pore system, where fractures join spaces of emptinesses and microcaverns existing in organogenic limestones or even biomicrit limestones are playing a dominating role in the flow
- type II – pore-fracture system, in which the reservoir system is creating by poorly conductive emptinesses and spaces between grain and between crystals in limestones of different type, and fractures play a minor role;

TABLE 3

Technical parameters of the DST tests for the upper Jurassic

Sing.	Well; No. of the tester fastening	Interval [m];	Type of rock	Repression [MPa]	Parameters of the DST technology					
					Initial depression [MPa]	Rate of depression and repression	Time of the inflow, [min]		Time of buildup, [min]	
							t_1	t_2	Δt_1	Δt_2
1	2	3	4	5	6	7	8	9	10	11
1	Z - 7; 41 / 97	2628 - 2645; perf. of pipes 7“	Pore-fracture	3.0	23.25	7.8	411	1312	1630	817
2	T - 1; 61 / 95	2696 - 2720; n.o.	Pore-fracture	3.15	19.51	6.2	15	205	37	79
3	T - 71; 23 / 95	1841 - 1864; n.o.	Karst	2.51	13.62	5.4	7	76	18	77
4	Ż - 42; 49 / 97	1483 - 1492; n.o.	Pore-fracture	2.01	12.42	6.2	28	83	61	127
5	W - 16; 52 / 97	1868 - 1904; n.o.	Fracture-pore	2.47	14.56	5.9	37	89	60	125
6	Ż - 42; 53 / 97	1635 - 1701; n.o.	Fracture-pore	4.57	12.82	2.8	30	91	61	153
7	B- 5; 30 / 95	1558-1576; n.o.	Karst	2.32	12.75	5.5	7	57	31	134
8	B-5; 25 / 95	1549-1558; n.o.	Pore-fracture	2.21	13.46	6.1	7	382	26	190
9	B - 9; 40 / 95	1501-1514; n.o.	Karst	2.12	12.25	5.8	15	68	20	63
10	K - 4; 114 / 96	657 - 702; n.o.	Pore-fracture	0.59	5.40	9.0	18	34	62	121
11	Z- 8 47 / 96	1280-1299; n.o.	Pore-fracture	3.22	9.08	2.8	19	51	40	123

– type III, karst system, in which the reservoir system was formed through epigenetic dolomitisation processes, as well as processes of dissolving. It is usually heterogeneous, only diagnosed because it was the lack of fitting real curves to curves model, concerning the rock with the double porosity. It is characterized by mainly highest recommendations of the porosity on curves of profiling drill geophysics.

2. Analysis of the results of reservoir tests it can be formulated the following technological observations:

– time of registration of interpreted curves of the buildup of the DST pressure in barefoot segments of wells, on account of the threat of seizing the sampler column, it was relatively short and took out from one up to three hours.
– permeability of reservoir rocks of the fracture-pore type which is damaged in the near well zone under the influence of the mud while drilling process, comparatively because of closing of cracks during reservoir tests under the influence of the too great the pressure depression;
– during reservoir tests of reservoir rocks of the pore fracture type and karsts little improve permeability have often appeared in the near well zone, with simultaneous cleaning itself of this zone from the mud.

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