Geology of oil and gas

UDC 552.5:550.8 (571.16)

APPLICATION OF THE SYSTEM ANALYSIS FOR FRAGMENTATION AND CORRELATION OF JURASSIC TERRIGENOUS SECTIONS ON HYDROCARBON DEPOSITS OF TOMSK OBLAST

A.V. Yezhova

Tomsk Polytechnic University
E-mail: ezsovaav@ngf.tomsk.ru

The results of interpretation of a complex of logging diagrams for lithologic characteristics of a terrigenous section and allocation of marking horizons (reference points) are examined. Chronostratigraphic subdivisions in the volume of Middle- Upper-Jurassic strata by the wells of Aleksandrovskiy, Srednevasyugan, Pudinskiy and Kazanskiy oil-and-gas bearing areas of the south-east of the Western-Siberian province are allocated. The conclusion drawn, that the method of system analysis of rock associations allows to carry out correlation of polifacies sedimentary strata, tracing complete various ranked systems in time (geochronolites).

For lithologic fragmentation, characteristics and correlation of Mesozoic section of the Western Siberia, a big complex of field-geophysical researches is used: standard logging (KS and PS); induction logging (IL), calipering (CL); acoustic logging (AL). Allocation of layers of various lithology is based on revealing connections of rock physical properties with its composition and reflection on various sorts of logging diagrams [1–3]. In most cases, rock differences have reliable logging standards (Fig. 1).

It is necessary to note, that types of rocks attributive to transitive differences are hard to detect on logging diagrams (for example, aleurolites, sandy clay, carbonaceous argillites etc.). Besides, the presence of clay and argillaceous-silt pebbles in sandstones (even fine-and medium-grained) is fixed on logging diagrams as an increase of clay component. These conglomerate-like (interformational conglomerate-breccias) point to the washout of the earlier-formed deposits. They lie either in the basis of cyclites, or characterize overlapping of several incomplete sequences (Fig. 2).

The analysis of a logging diagram complex by wells, opening terrigenous Jurassic oil-and-gas bearing deposits, allows to define features of the strata structure and to reveal basic intervals which can be used as marking during correlation. Such role at coordination of sections is played by the sustained coal layers. They have the precise geophysical characteristic, borrow the certain position in a cut and consequently serve as the most reliable reference points. A significant extent of coals raises the reliability of correlation of sections. Formation of coals occurred during the epoch of the maximal tectonic rest, minimal dynamics of water environment, they are dated to the most leveled sites of the relief. In this connection, it is possible to consider that coal layers possess attributes of isochronism of these parts of the section, and, in turn, it is the defining factor at correlation of continental strata and their relative stratification.

Besides coals, as a marking reference points, other rocks can be allocated which take a certain position in sections and possess an individual field-geophysical characteristics.

Reference points of the first category of Jurasic section within the limits of the southeast of the Western-Siberian plate are [4]: argillites of Togurskaya suite, clay of Nizhnevasyugan subsuite, coal layers U_{10} и U_1, argillites of Bazhenov suite. These marking horizons are regionally sustained, have significant capacity and are well allocated by all kinds of logging.

The second group of reference points includes coal layers U_8, U_6, U_4, which are being well traced throughout an extensive territory, have rather small capacity. Coal and clay layers, which are being traced only within the limits of separate areas, are attributed to the third group of reference points.

Having allocated along the complex of field-geophysical researches lithologic differences as rock layers, having defined the character of borders between them and having established position of each of the reference points, the studied part of the section is divided on various ranked cyclites [5]. Lithologic features, allocated by the core and logging during fragmentation of the section, are considered within the limits of these cyclites.

Middle- Upper-Jurassic productive deposits of the south-east of the Western-Siberian plate can serve as an example of sedimentary strata fragmentation on chrono-

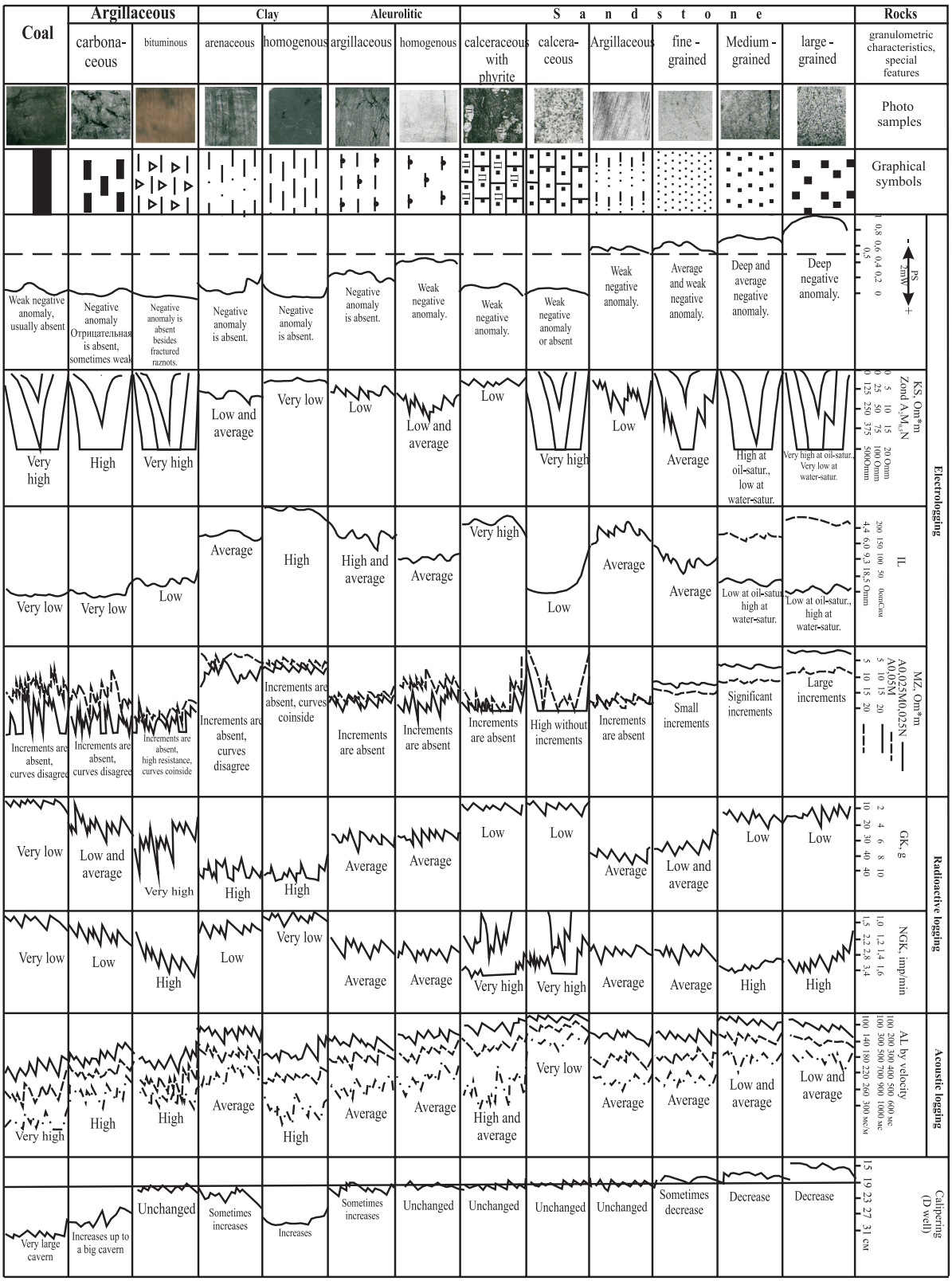

Fig. 1. *Field-geophysical characteristics of a terrigenous section*

stratigraphic intervals on the basis of the system analysis of layer associations in view of biostratigraphic, petrographic-mineralogic, geochemical and facies-cyclic methods. The wells of Kazan, Pudinskiy, Srednevasyugan, and Aleksandrovskiy oil-and-gas bearing basins are examined in the article, and lithologic geophysical characteristics of Middle- Upper-Jurassic deposits on the well 18 of Kalinovoe deposit is given as an example (Fig. 3).

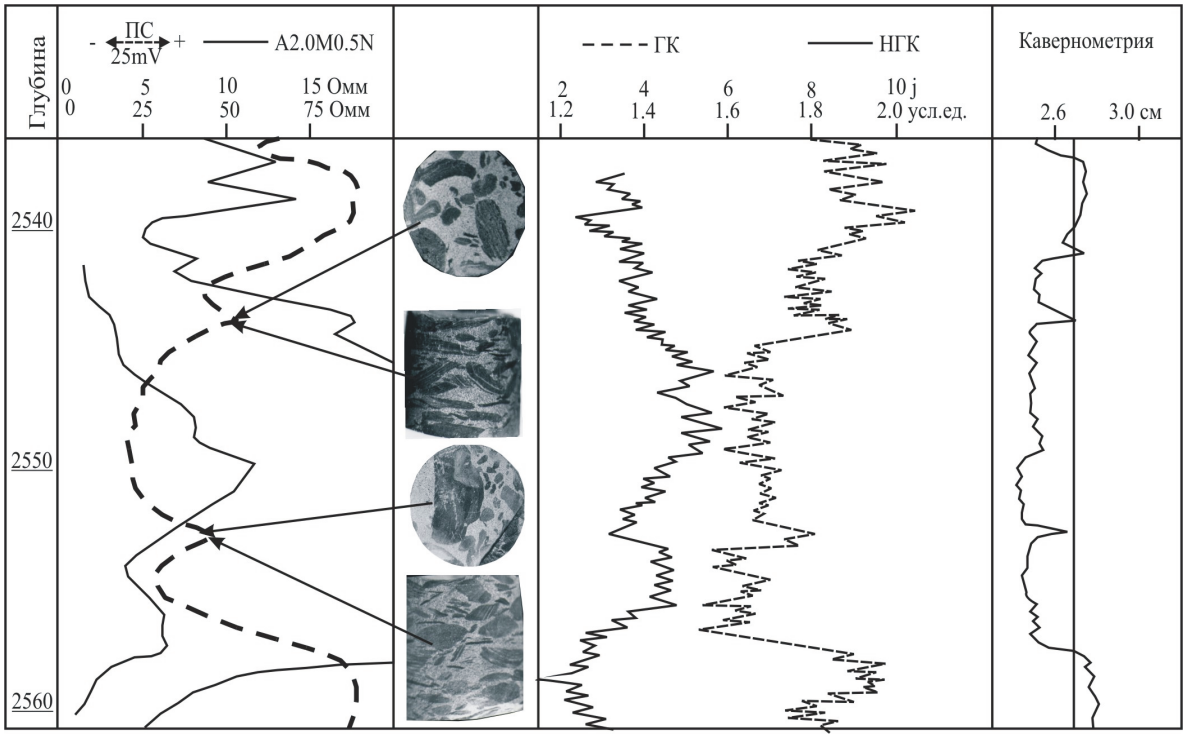

Fig. 2. *Interformational conglomerates characterizing the washout and resedimentation of underlying rocks in cyclite U_1^4 (Gerasimov well № 5)*

Explanation to Fig. 2: Глубина – depth; Кавернометрия – calipering; ПС – PS; ГК – GK; НГК – NGK

Oil-and-gas bearing ability of the studied strata is connected with deposits of Vasyugan suite corresponding to the regional cyclite U_1, in the structure of which zonal and local cyclites are allocated. Vasyugan suite is subdivided on the bottom and the top subsuites.

Nizhnevasyugan subsuite, argillaceous in majority of the areas, is composed of sandstone layers on the uplifts in the bottom part. This part of the section is attributed to sand layers U_1^6 and U_1^5 [6]. According to rules of cyclite allocation, sand layers U_1^5 with argillaceous intercalation in the roof and U_1^5 with clays of Nizhnevasyugan subsuite differentiate into local cyclites U_1^6 and U_1^5, which in turn unite into zonal cyclites $U_{1н}$ (bottom), corresponding to the first transgressive sedimentational cycle at formation of regional cyclites U_1. On finds пелеципод and to a спорово-pollen complex the age of breeds is certain as позднекелловей-раннеоксфордский.

In the structure of Verkhnevasyugan subsuite, one can allocate subcoal, intercoal, and uppercoal strata [4]. Deposits, united in these strata, were formed during a certain time interval, are characterized by chronostratigraphic borders, genetically interconnected and reflect the cyclicity of sedimentation. The volumes of subcoal and intercoal strata in sections of Kazan, Pudinskiy, Srednevasyugan, and Aleksandrovskiy NGR differ a little.

The bottom part of the subcoal strata (cyclite U_1^4) covers the complex of mainly sand rocks, which are being overlapped by a clay intercalation (Aleksandrovskiy and Srednevasyugan Oil-and-Gas Bearing Area) or a coal layer U_1g (Pudinskiy and Kazan OGBA).

Cyclite U_1^3н (bottom), same as the underlaying cyclite U_1^4, is composed mainly of sandstones which are overlapped by the coal layer U_1в or a clay prolayer (Aleksandrovskiy OGBA).

Cyclites U_1^4 and U_1^3н on the territory of Pudinskiy, Kazan and greater part of Srednevasyugan OGBA have a well expressed regressive structure and correspond to uppercoal strata. Formation of this rock complex occurred in conditions of prevailing approach of the coastal line towards the sea at its very brief transgressions.

Cyclites U_1^3с (middle) represents a complex of sand-aleurite rocks divided by intercalations of clay with capacity of 1...2 m. In the roof lies a coal layer U_1б (in sections of Nyurolskiy sedimentary basin) or U_1^2 (Aleksandrovskiy OGBA). On the territory of the latter, the cyclites U_1^3 is the top part of the subcoal strata.

Cyclite U_1^3в (upper) is represented by alternation of sand-aleurite, argillaceous, clay and carbonaceous-argillaceous rocks. In the roof of this strata, the coal layer U_1 (U_1^1 in sections of Aleksandrovskiy OGBA) is allocated. It has well expressed geophysical characteristics (specific electric resistance from 20 up to 375 Om·m, minimal values of NGK and GK, maximal are on the curves AL, an increase in the diameter of the well is up to 32 cm on caliper).

Cyclites Циклиты U_1^3с и U_1^3в correspond to the period of accumulation of sediments in conditions of mainly continental mode and correspond to intercoal strata. The volume of the latter in Aleksandrovskiy OGBA corresponds to local cyclite циклиту U_1^3в.

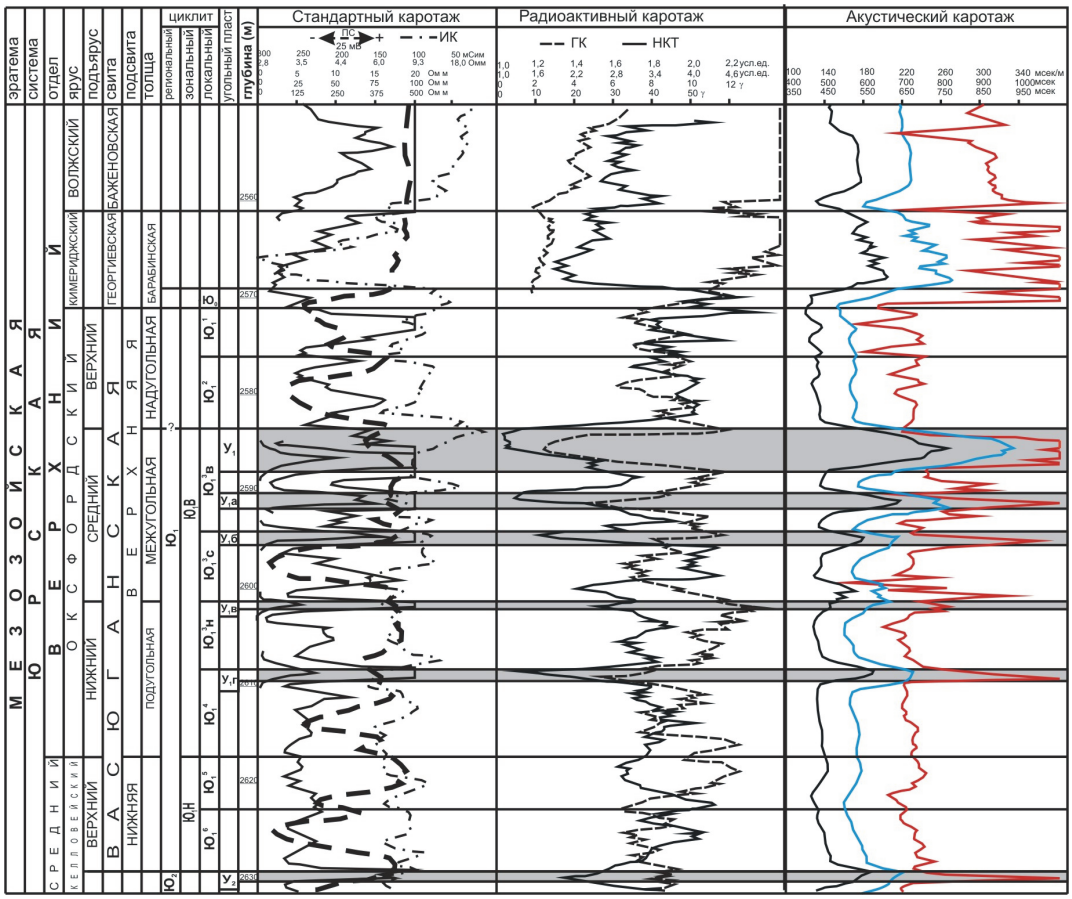

Fig. 3. *Lithologic-geophysical section of Middle- Upper-Jurassic deposits in Kazan oil-and-gas bearing region (well № 18 – Kalinov oil field)*

Explanation to the Fig. 3: Мезозойская – Mesozoic; Юрская – Jurassic; верхний – upper; средний – average; Келловейский – Callovian; Оксфордский – Oxonian; Кимериджский – Kimmeridgean; Волжский – Volga; нижний – lower; Васюганская – Vasyugan; Георгиевская – Georgievskaya; Баженовская – Bazhenov; подугольная – subcoal; межугольная – intercoal; надугольная – uppercoal; Барабинская – Barabinskaya; система – system; отдел – rang; ярус – stage; подъярус – substage; suite ; толща – strata; региональный – regional; зональный – zonal; локальный – local; циклит – cyclite; угольный пласт – carbonaceous layer; глубина (м) – depth (m); стандартный каротаж – standard logging; радиоактивный каротаж – radioactive logging; акустический каротаж – acoustic logging

Based on the data of the floristic and sporo-pollen analysis, the age of deposits of the subcoal and intercoal strata is defined as Lower- Middle-Oxonian [6]. Local cyclites U_1^4, U_1^3н, U_1^3с and U_1^3в unite into zonal cyclite U_1в (upper). Based on facies attribute, local cyclites U_1^6 и U_1^5, characterizing transgressive, U_1^4 and U_1^3н – regressive, U_1^3с and U_1^3в – continental stages of sedimentation, form rock associations (complexes), indexed as U_1T_1, U_1P, U_1K, respectively [6].

The rocks mass between coal layers U_2 and U_1 composes a uniform, complete system in time – regional cyclite U_1, and the overlying deposits should be indexed as U_0. However, following the long-term tradition, overlying rocks have indexes U_1^2 and U_1^1.

Cyclite U_1^2 is represented mainly by sand strata and is separated from the overlying deposits by a clay intercalation.

Cyclite U_1^1 has a very changeable structure and sharp fluctuations of strata. Such change in capacity of deposits is explained not only by sedimentation conditions, but also by the washout of cyclite roof in the beginning of Kimmeridgian century.

The complex of the rocks allocated as cyclites U_1^2 and U_1^1 has a marine genesis, there corresponds to the uppercoal strata, the age of which is defined by the complex of foraminifer and remains of molluscs is defined as Upper-Oxonian.

The presence of conglomerate-like rocks of an original Barabinskaya pack, widespread in the volume of Georgievskaya suite in sections of most of the wells of the studied region, testifies to the washout and resedimentation of the upper part of cyclite U_1^1. In the basis the Barabinskaya packs, in some sections of the wells of Pudinskiy and Aleksandrovskiy oil-and-gas bearing areas, a sand layer U_0 is allocated, and above there is a strata of mainly aleurite-argillaceous rocks, capacity of which sharply varies within the limits of different areas.

The Barabinskaya pack is confidently allocated on diagrams by IL peaks with increased raised electroconductivity of up to 350 mSim, low values of specific electric resistance, not exceeding 5 Om·m on curves KS and increased values of up to 3,0... 3,6 imp/min on curves NGK.

The presence of carbonaceous material in the form of cement and faunistic remains, abundance of phyrite and

glaukonite is characteristic to rocks as a whole. The latter makes the rocks green. The presence of carbonaceous material is reflected by high values in curves NGK and, as it is known [1, 2], should be accompanied by high resistance on curves of electric logging. The observable opposite picture on diagrams KS and IL is caused by the presence in rocks of a significant amount of electrocunductive minerals – glauconite and, especially, phyrite.

The argillaceous part of Georgievskaya suite, represented by dark-grey fine-dispersed clay, is marked only in sections of Kazan OGBA.

Bazhenov suite, represented by bituminous argillites, has a well expressed geophysical characteristic: very high values of specific electric resistance (up to 380 Om·m) and high values of natural radio-activity (up to 60 g). The base of Bazhenov suite is a reference surface on the south-east of the West-Siberian Plate.

Conclusions

1. As a result of system researches of layer associations of Middle- Upper-Jurassic strata, a breakdown of Vasyugan horizon into oil-and-gas bearing areas of the southeast of the Western-Siberian plate is made. Allocated cyclites represent complexes of rocks which formation occurred in certain conditions at consecutive natural change of facies – from transgression of the sea with its maximum during accumulation of clay of Nizhnevasyugan subsuite through the regress which occurred at formation of aleurite-sandy cyclites U_1^4 and U_1^3н up to continental conditions of the lake-alluvial plain when deposits U_1^3с and U_1^3в accumulated with a regionally allocated layer U_1 in the roof.
2. Formation of the uppercoal strata (cyclites U_1^2 and U_1^1) occurred in conditions of new transgression. Thus, cyclicity of sedimentation is broken by the washout and resedimentation in the upper part of cyclite U_1^1. In a number of areas a productive layer U_0 is formed.
3. The maximum of transgression in the Late Jura is characterized by marine, rather deep-water deposits of Georgievskaya and Bazhenov suites.
4. Application of the basic stated methods of the system analysis of rock-layered associations enables to carry out correlation of sedimentary strata, tracing not separate layers or their groups, but complete in time systems of a various rank, i. e. geochronolites. It is especially important for facies changeable on lateral continental deposits, when in practice the sand layers which have formed at various times are compared among themselves.
5. In general, application of the system analysis at studying of polyfacies strata allows carrying out a comparison of oil-and-gas bearing deposits with more confidence; to track their alternation in space and time.

REFERENCES

1. Dakhnov V.N. Interpretation of results of geophysical researches of wells. – Moscow: Nedra, 1982. – 448 p.
2. Latysheva M.G., Vendelshteyn B.Yu., Tuzov V.P. Processing and interpretation of materials of geophysical researches of wells. – Moscow: Nedra, 1990. – 312 p.
3. Karogodin Yu.N., Gaydeburova E.A. System researches of layer associations of oil-and-gas bearing basins (by the complex of field-geophysical data). – Novosibirsk: Nauka, 1989. – 108 p.
4. Belozerov V.B., Danenberg E.E., Ogarkov A.M. Features of Vasyugan suite structure in connection with search of oil and gas deposits of the non-anticlinal type (Tomsk Oblast) // Prospects of oil-nad-gas bearing ability of the southeast of the Western Siberia / Edited by E.E. Danenberg, O.G. Zhero. – Novosibirsk: Publishing house of SNIIGGandMS, 1980. – P. 92–100.
5. Karagodin Ju.N. Introduction in oil lithology. – Novosibirsk: Nauka, 1990. – 239 p.
6. Yezhova A.V. Indexation and correlation of Middle-Upper-Jurassic productive strata of Kazan and Pudinskiy oil-and-gas bearing areas // Mining-geological education in Siberia. 100 years at service of science and production: Materials of the International Scientific-technical conference / Edited by B.D. Vasilyev, I.V. Goncharov. – Tomsk: Publishing house of TPU, 2001. – P. 88–94.