«INNOVATIONS IN GEOLOGY, GEOPHYSICS AND GEOGRAPHY-2018»

The 3rd INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE

Sevastopol Branch of M.V. Lomonosov Moscow State University

04 – 07 July 2018

UDC 55
BBC 26.3
I 46

I 46 Innovations in Geology, Geophysics and Geography-2018. Conference materials of the 3rd International Scientific and Practice Conference. — Moscow. Publishing house "Pero", 2018. — 168 p. – Кбайт. [Электронное издание]. – 1 электрон. опт. диск (CD-ROM). – Систем, требования: процессор x86 с тактовой частотой 500 МГц и выше; 512 Мб ОЗУ; Windows XP/7/8; видеокарта SVGA 1280x1024 High Color (32 bit); привод CD-ROM. – Загл. с экрана.

ISBN 978-5-00122-455-6

The conference proceedings are presented in author's edition.
The Organizing Committee will not in all cases, shared views and ideas of the authors contained in the published conference materials.

The conference proceedings includes the papers presented at the 3rd International Scientific and Practical conference "Innovations in Geology, Geophysics and Geography-2018" held at the Sevastopol Branch of M. V. Lomonosov Moscow State University 04–07 July, 2018. Articles considered achievements for the integrated application of methods at the interface of different areas of Geology, Geophysics and Geography; the methods and approaches that constitute the arsenal of modern research. The conference proceeding will be useful to a wide range of students and scientific employees of the geological and related specialties.

Сборник материалов конференции включает тезисы докладов, представленных на Международной научно-практической конференции «Инновации в геологии, геофизике и географии-2018», проходившей в Филиале МГУ имени М.В. Ломоносова в г. Севастополе с 04 по 07 июля 2018 г. В статьях рассматриваются достижения по комплексному применению методов, находящиеся на стыке различных направлений геологии, геофизики и географии, обсуждаются методы и подходы, составляющие арсенал современных исследований. Сборник будет полезен широкому кругу студентов, аспирантов и научных работников геологических и смежных специальностей.

UDC 55
BBC 26.3

Computer imposition by Natalia Lubnina, Anastasia Agayan and Yulia Popova

ISBN 978-5-00122-455-6

Cover Photo by Elena Kozlova

Dear Participants

Of the International Scientific and Practical Conference "INNOVATION IN GEOLOGY, GEOPHYSICS AND GEOGRAPHY-2018"!

On behalf of the branch of Moscow State University named after M.V. Lomonosov in Sevastopol we welcome you and wish you fruitful scientific work and interesting communication in the circle of enthusiastic professionals.

Our branch has been training personnel in physics and geography for more than 15 years, continuing the traditions of the scientific schools of Moscow University. Some of our graduates will speak at the conference already as young scientists. We continue to develop these areas and invite to cooperation. Already now there is an opportunity to conduct joint marine research, create a laboratory base directly in the water area.

We are sure that joint work with the Geological Department of Moscow State University to hold this conference will be an important step on the way to the emergence of a whole range of new directions and projects in the field of earth sciences in the city of Sevastopol and the South of Russia.

We wish you success!

Director of the branch of Moscow State University named after M.V. Lomonosov in Sevastopol,
Head of the organizing committee
I.S. Kusov

Deputy director of the branch of Moscow State University named after M.V. Lomonosov in Sevastopol,
Deputy Head of the organizing committee
O.V. Krylov

ABOUT THE CONFERENCE

INTERNATIONAL SCIENTIFIC-PRACTICAL CONFERENCE "INNOVATION IN GEOLOGY, GEOPHYSICS AND GEOGRAPHY-2018": GOALS AND OBJECTIVES

O.V. Krylov [1,2], N.V. Lubnina[1], A.Yu. Bychkov[1], M.L. Vladov[1], E.V. Kozlova[3], I.N. Modin[1], I.L. Prygunova[2], I.Yu. Khromova[4]

[1] – Geological Department of Moscow State University named after M.V. Lomonosov
[2] – Branch of Moscow State University named after MV Lomonosov in the city of Sevastopol
[3] – Skolkovo Institute of Science and Technology
[4] – IE "Khromova I.Yu."

Recently, great importance is attached to innovation and innovative development of the economy. In the field of geology, geophysics and geography, innovative technologies are to a greater or lesser extent related to the solution of various important practical problems and tasks, which include the search and exploration of mineral deposits, the assessment of the ecological situation in different regions, including the forecasting of catastrophic geological processes and phenomena. At the same time, innovative ideas are born to a greater degree at the junction of different directions of earth sciences, in combining knowledge of related fields, generalization of already existing reserves and generation of new ideas, including by young scientists. In this regard, the Branch of Moscow State University named after MV Lomonosov in Sevastopol holds the 3rd International Scientific and Practical Conference "Innovations in Geology, Geophysics and Geography-2018" from **04 to 07 July 2018**, the main purpose of which is to highlight innovative achievements in the integrated application of methods located at the intersection of various scientific directions, **modeling of practical innovative educational project for young researchers, students, undergraduates and post-graduate students of different specialties.**

One of the important tasks of the conference is the development of the main approaches, proposals, methodology of application of complex research methods, innovations in geology, geophysics, geography for rational nature management and sustainable development of the coastal zone of the Crimea and Sevastopol.

In 2018, the conference will discuss the following issues:

I. **Various aspects of fracturing;**
II. **Geology and evolution of sedimentary basins;**
III. **Mud volcanism - an indicator of the processes of formation of oil and gas;**
IV. **Hydrothermal processes and fluids in the earth's crust;**
V. **Modern geological-geomorphological processes and dynamics of coastal landscapes;**
VI. **Shallow geological and geophysical research.**

Recently, unconventional traps in fractured reservoirs has attracted an increasing interest in the search and exploration of oil and gas fields, with particular attention to the correctness of the

isolation of structural parageneses from 3D seismic data, VSP and special GIS methods: image, broadband acoustic logging, etc. The increased attention is also given to the technology of extraction of methane from coal seams and shales closely related to the study of the permeability of these rocks. The distribution of zones of increased fracturing and, as a consequence, fluid permeability depends on the latest geodynamic activity of the area, which appear on the Earth's surface in the form of new dislocations reflected in the relief, increased values of heat flow, seismicity, and are often emphasized by the accumulation of oil and gas deposits.

Within the framework of the section *"Various aspects of fracturing"*, it is planned to discuss new methods and approaches for identifying areas of fracture concentration in rocks through which fluids circulate. Special attention will be paid to numerical and physical modeling of deformations in various geodynamic settings. It is also planned to discuss topical issues of petrophysics of complex reservoirs and petrophysical studies of core material. In addition, sectional reports will present complex geophysical studies of various aspects of fracturing.

In the section *"Geology and evolution of sedimentary basins"* the main stages of structural-tectonic reconstructions and the stage of formation of sedimentary basins in various geotectonic regions are planned to discuss. A number of invited papers in this section will be devoted to the methods and practices of conducting geological exploration work on the Arctic shelf, modern methods of studying the geology of oil and gas basins of the land and shelf, and regional geological studies of the aquatorial parts of sedimentary basins. Particular attention will be paid to the conditions of sedimentation within the basin, the material composition of the formed rocks, the time and nature of the tectonic movements that are associated with the internal restructuring of the main structures of the basin, the magnitude of thermal warming and the degree of catagenetic transformation of the oil and gas reservoir strata, the history of the formation of HC traps and possible time their filling. Consideration of the whole complex of problems will be closely linked with modern computer technologies aimed at solving issues of basin modeling.

The section *"Mud volcanism - an indicator of the processes of formation of oil and gas"* is devoted to a unique natural phenomenon widely developed in the Kerch-Taman region. It is planned to discuss the relationship between the oil and gas potential of the region, the form and structure of mud volcanic structures, open and developed deposits in the deposits of the Maikop series and terrigenous and carbonate reservoirs of the Neogene deposits of the Crimea and the Krasnodar Territory. After the field school of the conference "Innovations in Geology, Geophysics and Geography - 2017", dedicated to the oil systems of the Crimea, interest in mud-volcanic provinces of the Kerch Peninsula was activated, and laboratory studies of products of mud volcanoes on modern equipment were conducted, which is expected a number of reports. An interesting historical excursion, sending us two centuries ago, during the discovery of hydrocarbon deposits in the Black Sea-Caspian region, is interesting. Preservation of the deposits, and, at the same time, destroying the actions of mud volcanoes will be presented in the reports of specialists of different directions of geology.

In the section *"Hydrothermal systems and fluids in the Earth's crust"* it is planned to focus on three main scientific topics, which are actively developing today. It is supposed to consider questions about the forms of metals in hydrothermal solutions, including reviews of traditional and modern methods of their study, new results and geochemical consequences for the theory of formation of ore deposits. The theme of the distribution of elements between coexisting phases in

hydrothermal process conditions, including silicate-salt segregation, liquid-gas equilibrium, oil-water and mineral-fluid will be revealed. The third topic is the transformation of organic matter in the hydrothermal process: experimental and theoretical approaches for describing the processes of oil and gas formation, data on the participation of organic compounds in the formation of ore deposits, oil manifestations in endogenous environments (volcanism, magmatic and metasomatic rocks).

As a result of the conference, a new innovative educational scientific and practical course on the integrated application of modern technologies will be prepared, which will be designed for students and young scientists of the Crimea and Sevastopol; as well as aimed to improve the skills of workers in the industry.

The basis of the new innovation course includes acquaintance with the modern equipment complex, obtaining skills of practical field work, **the passage of a continuous cycle from the collection of material, its primary processing to the interpretation of data and, ultimately, the construction of 3D and 4D-models.**

The leading faculty and scientific staff of the Geology Department of the Moscow State University named after M.V. Lomonosov and of the Branch of Moscow State University in Sevastopol participated in the creation and development of the first version of the course. Students and post-graduate students of these universities actively participated in the preparation and conduct of field excursions. A great help in the formation of the course was provided by leading specialists of both Russian and foreign companies and universities. In 2018, the geography of the conference participants expanded. In addition to representatives of the Geology Department of Moscow State University named after MV Lomonosov and the Geography Department of the Sevastopol branch, young employees, post-graduate students and students of the Kazan (Privolzhsky) Federal University (Kazan), the Russian State University of Oil and Gas (NIU) named after I.M. Gubkin (Moscow), Tyumen Industrial University (Tyumen), the Institute of Oil and Gas Geology and Geophysics named after Academician A.A. Trofimuk (Novosibirsk), as well as representatives of academic institutions - the Institute of Earth Physics of the Russian Academy of Sciences (Moscow), the Institute of the Earth's Crust of the Russian Academy of Sciences (Irkutsk), the Institute of Geoecology RAS (Moscow) take part in the conference.

The international conference "Innovations in Geology, Geophysics and Geography-2018" was supported by leading experts of PJSC NK "Rosneft", IE "Khromova I.Yu.", Skolkovo Institute of Science and Technology (Moscow), professors of Carleton University (Canada) and Remote Exploration (Canada), as well as young specialists from PJSC ANC Bashneft, Tyumen Oil Research Center LLC and RN-KrasnoyarskNIPIneft LLC, who made invited presentations.

The conference was also attended by specialists from the Branch of Moscow State University named after MV Lomonosov, Institute of Natural and Technical Systems of the Russian Academy of Sciences, the Marine Hydrophysical Institute of the Russian Academy of Sciences and the Institute of Marine Biological Research of the Russian Academy of Sciences, the Main Department of Natural Resources and Ecology of the Sevastopol City Sevprigorodnadzor. The results of the conference are published in a special collection of scientific papers and are covered in mass media.

This research was financially supported by RFBR Grant №18-45-920073 (headed by O.V.Krylov).

ABOUT FIELD-TRIP SESSION

Pre-Conference Sightseeing tour

FRACTURING OF HERACLAY PLATEAU (South-West Crimea): MULTIDISCIPLINARY APPROACH

Route: Balaklava Bay – t. Sevastopol

Date: July 3, 2018

Duration: 4–6 hours

Cost: 85$ / pers.*, including transportation from t. Sevastopol to Balaklava, cruise on boat from Balaklava Bay to t. Sevastopol, lunch, guide book in English

* *The final cost of the tour can be changed depending on the number of participants*

Max/ Min number of participants: 40/15

Contact information:

Official site: **http://2018.inno-earthscience.com/**
E-mail: **inno.sevastopol@gmail.com**

General information:

Geology of the Crimea Peninsula has been studied about two centuries, but there are at least 50 different tectonic schemes. Alternative tectonic models of the Mountain Crimea are predominantly due to insufficient studies of deformations by structural-geomorphological, tectonophysical and geophysical methods.

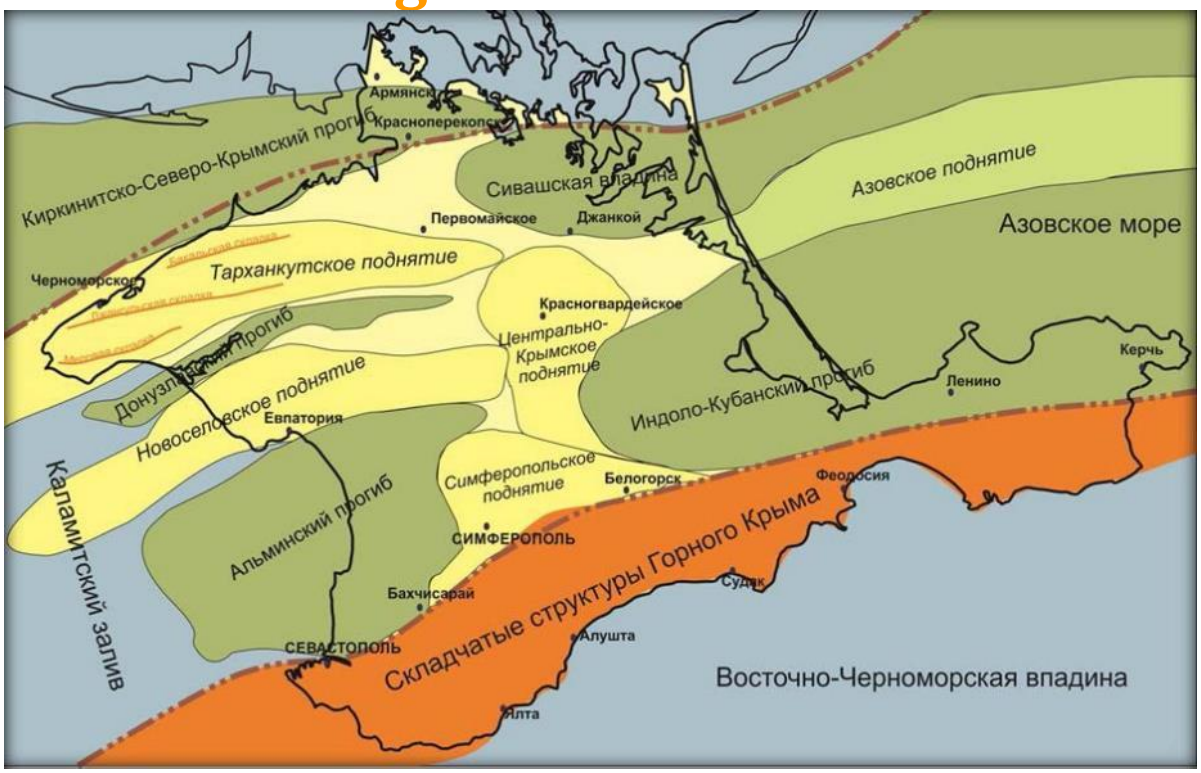
The Pre-Conference Sightseeing Tour will take place within the Heracley Peninsula in the southwestern part of the Mountain Crimea, which is a separate volcanotectonic block in the suture zone between Scythian plate and the Mountain Crimea. From the southeast the Heracley Plateau is limited to the St. George fault zone, active in the Late Alpine stage, and from the northeast – the Early Cimmerian zone of deep faults. The Upper and Lower structural stages composed the Mountain Crimea structure, and those rocks overlook the daily surface and are available for direct study. Thus, the Heracley Plateau is very important and revealing structure for understanding the Geodynamics of the Mountain Crimea.

During the Pre-Conference Sightseeing Tour, the spatial and temporal

patterns of the main types of deformations and stress fields, realized at Meso-Cenozoic time in the coastal zone of the Heracley Plateau will be discussed based on the complex geological, structural and geophysical data and distant method survey.

Post-Conference Training Field

Fractured reservoir: innovative integrated researches



Date: 07 – 10 July 2018.

Cost: 250 $ / person*, including transportation, dinners, guide book in English.

* The final cost of the tour may be adjusted depending on the number of participants

Max/ Min number of participants: 40/15

Contact information:

Official web-site: **http://2018.inno-earthscience.com/**
e-mail: **inno.sevastopol@gmail.com**

General information:

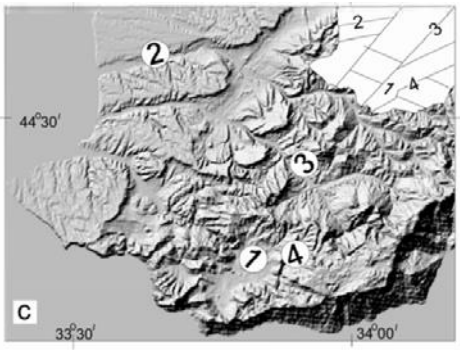
The Crimean peninsula is a natural laboratory for studying of geodynamic processes in the Mesozoic complexes of the sedimentary paleobasin.

The peninsula is the northern half of a large composite uplift, composed of rocks of the Jurassic, Cretaceous and Paleogene-Neogene complexes, the southern part of the uplift falls under the waters of the Black Sea. From the north, the south-western part of the Crimea is bounded by the Simferopol fault in the foothills of this structure. The fault, which is expressed in the form of the Lozov zone of dislocations, is inclined gently to the side of the Scythian plate occupying the entire Plain Crimea north of the described territory. In the east, the structures of the south-western Crimea are cut off by meridional fault-shifts to the west of Feodosia, and in the south they are hidden beneath the sediments of the Black Sea.

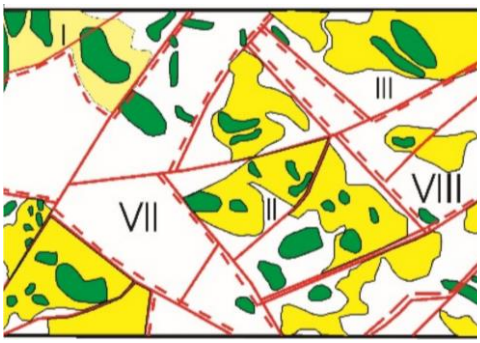
Geodynamic processes are manifested in the fracturing of rocks that serve as potential reservoirs for oil and gas. Fissured reservoirs in the Crimea are associated mainly with carbonate and volcanogenic-clastic rocks. The collector properties vary over a significant range, but are generally small (up to 3-8% porosity, permeability rarely exceed 0.6 mD). The Lower Cretaceous terrigenous complex is most often identified. These reservoirs are connected with oil deposits at Oktyabrsky, with gas and gas condensate in the West-Oktyabrsky, Tatyanovskoye fields, as well as hydrocarbon inflows at Serebryansky, Zadornenskoye and other fields. Type of reservoir is porous and cracked porous. The Paleocene oil and gas complex has a regional distribution in the Crimea, but is productive mainly within the Tarkhankut Uplift. Here, this complex is composed of limestones, marls and clays up to 1.1 km thick. A similar profile was opened and tested by boreholes at the Golitsynsky uplift as well as at the deposits - Glebowskoe, Olenevskoye, Chernomorskoe, Karlavskoe, Kranopolyanskoe, Kirovskoye, Zadornenskoye. The thickness of productive carbonate rocks varies in a large range from 40 meters (Krasnopolyanskoe deposit) to 200 meters (Olenevskoye deposit). The collector usually has a pore-cavernous structure. However, in carbonate reservoirs, fracturing can play a significant role.

Within the framework of the field school, it is planned to comprehensively study mesostructures ** (including fracturing of rocks) of different rank, which arose as a result of various geodynamic processes. During the field excursion, the space-time regularities of manifestation of the main types of deformations and stress fields in sedimentary rocks at the Mesozoic-Cenozoic stage of the development of the Crimean-Caucasian-Black Sea region, based on complex geological, structural-geomorphological, geophysical, petromagnetic and remote research methods.

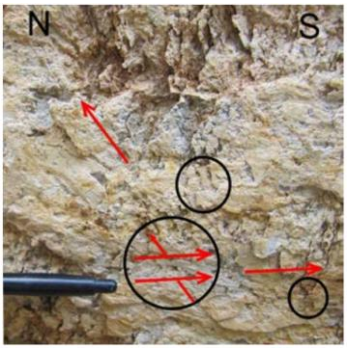
An important aspect of the field excursion will be the refinement of age boundaries of deformations and restoration of the sequence of tectonic and compression-stretching phases.



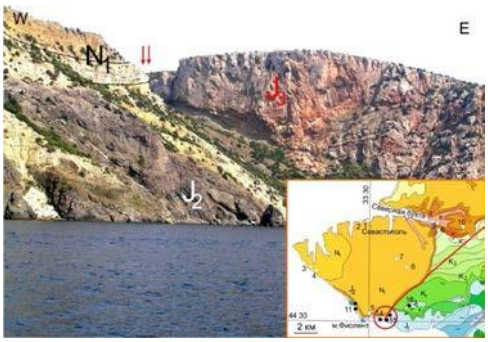
Activated faults visually excavated in relief [Murovskaya et al., 2014]



Structural-geomorphological map of the south-western Crimea [Bryanceva et al., 2018]



Results of tectonophysical studies [Murovskaya et al., 2014]



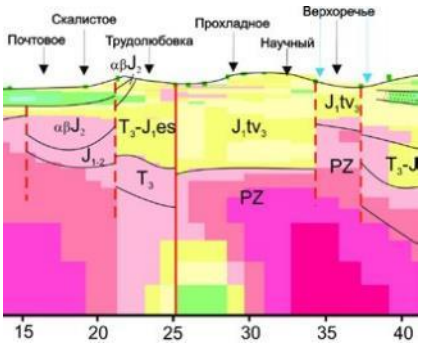


TABLE OF CONTENTS

INNOVATION CENTER OF THE EARTH SCIENCES on the basis of the Branch of Moscow State University named after M.V. Lomonosov in Sevastopol: 3 years

I.S. Kusov[1], O.V. Krylov [1,2], N.V. Lubnina[2]

[1] – Branch of Moscow State University named after M.V. Lomonosov in the city of Sevastopol
[2] – Geological Department of Moscow State University named after M.V. Lomonosov

inno.earthscience@gmail.com

http://2018.inno-earthscience.com/index.php/ru/

The Innovation Center of the Earth Sciences was established on October 15, 2016 by the decision of the Scientific Council of the Branch of Moscow State University named after M.V. Lomonosov in the city of Sevastopol (Protocol No. 5-1) for the coordination and interdisciplinary integration of the educational, research and innovation activities of the Moscow State University divisions and enterprises established by the Moscow State University aimed at solving urgent and promising tasks.

The work of the Innovation Center of the Earth Sciences is mainly attended by staff and professors of the Geology Department of Moscow State University named after M.V. Lomonosov and Geographical Department of the 1Branch of Moscow State University named after M.V. Lomonosov in the city of Sevastopol, conducting scientific research, educational process and innovative activities on the themes of the Center.

Recently, great importance is attached to innovation and innovative development of the economy. In the field of geology, geophysics and geography, innovative technologies are to a greater or lesser extent related to the solution of various important practical problems and tasks, which include the search and exploration of mineral deposits, the assessment of the ecological situation in different regions, including the forecasting of catastrophic

geological processes and phenomena. At the same time, more innovative ideas are born at the junction of different geological directions, when the knowledge of adjacent areas is combined, generalization of already existing reserves and generation of new ideas, including by young scientists.

At present, within the framework of the work of the Innovation Center of the Earth Sciences, there are five main research areas:

- Geodynamic aspects of fracturing (supervisors: Prof. N.V. Lubnina and Associate Professor O.V. Krylov);
- Geology and evolution of sedimentary basins (supervisor: O.V. Krylov);
- Mud volcanism as an indicator of the processes of formation of oil and gas (headed by Leading Researcher E.V. Kozlova and Associate Professor O.V. Krylov);
- Hydrothermal processes and fluids in the Earth's crust (headed by Prof. A. Yu. Bychkov);
- Geophysical research and geomonitoring of hazardous processes (supervisors Prof. I.N.Modin and Prof. M.L.Vladov).

To highlight innovative achievements in the integrated application of methods located at the junction of various scientific directions, the Innovation Center of the Earth Sciences jointly with the Branch of the Moscow State University named after M.V. Lomonosov in the city of Sevastopol held three **International Scientific and Practical Conferences "Innovations in Geology, Geology and Geography"**, in which more than 100 people took part annually.

One of the important tasks of the scientific and practical conferences was the development of the main approaches, proposals, methodology of application of complex research methods, innovations in geology, geophysics, geography for rational nature management and sustainable development of the coastal zone of the Crimea and Sevastopol. Over three years of work, more than 300 scientific articles have been published in conference proceedings in Russian and English, 3 teaching aids and 4 guidebooks for field excursions have been published.

Training of students, graduate students and young employees is one of the main areas of work of the Innovation Center. For three years, five field schools have been conducted to train regional staff and increase the level of training of profile students in leading Russian universities: "Magmatic complexes of the south-western Crimea: multidisciplinary research" (2016), "Geomonitoring of natural processes" (2016), "Oil and gas potential of the Crimea: a multidisciplinary approach" (2017), "Coastal areas: monitoring and innovative complex research" (2017), "Fractured collectors: innovative complex research" (2018), as well as one sightseeing tour this "Fracturing of the rocks of the Heraklei Plateau (south-western Crimea: a multidisciplinary approach" (2018).

Scientific researches in the main areas of the Innovation Center of the Earth Sciences are financially supported by grants from the RFBR projects 18-05-00818 (headed by A.Yu. Bychkov) and 18-45-920073 (headed by O.V. Krylov).

In the near future, the work of the Innovation Center on Earth Sciences will be aimed at creating Programs of additional professional education in combining geological and geophysical research:

- **Courses of retraining of personnel (500+ hours)** *with MSU diploma on professional retraining with the assignment of additional qualifications;*
- **Courses for the re-qualification of staff (144-250 hours)** *with MSU diploma about re-qualification;*
- **Scientific and practical seminars (24-40 hours)** *with the certificate of the MSU responsible structural unit (Department) MSU about the course.*

ROLE OF TECHNOGENIC GEOMORPHOLOGICAL PROCESSES IN FORMATION OF MODERN LANDSCAPES (ON THE EXAMPLE OF THE SOUTHWEST CRIMEA)

I.V. Agarkova-Lyah

Federal state budget scientific institution "INSTITUTE OF NATURAL AND TECHNICAL SYSTEMS" (iva_crimea@mail.ru)

Keywords: *Technogenic landslide, beach, Balaklava mine administration of A.M. Gorky.*

The shape of modern landscapes is formed with considerable participation of a technogenic factor. The greatest transformations of the environment are noted in territories with open-pit mining of minerals. In the Southwest Crimea such area is in vicinities of Balaklava. Here pits of the Balaklava mine administration of A.M. Gorky (BRU) where from 30th of the 20th century extraction of flux limestones is conducted are located. Article purpose – to consider a role of technogenic geomorphological processes in formation of modern landscapes in the neighborhood of Balaklava. For more than 80 years' work of BRU, here in the considerable territory I was it is irreversible the relief, a soil and vegetable cover is changed; technogenic landscapes are created. The heights which were at the place of present West Balaklava, West Kadykovsky and Psilerakhsky pits with thickets of a shiblyak and with an absolute height up to 300 m, are razed to a mark about zero surface. The hollow of the West Kadykovsky pit during development was filled by underground waters, having turned her into a fresh reservoir lake. On step slopes of the West Balaklava and West Kadykovsky pits of BRU sanitary protection forest zones from a pine Crimean are created. At the expense of parameters of a technogenic relief of people can change force, orientation, and sometimes and the nature of processes of the forming relief [2]. Anthropogenic activity is capable to strengthen considerably actions of exogenous factors, causing often catastrophic and atypical types of processes on the concrete site [3]. On the forms of a technogenic relief created in the course of functioning by BRU (terraces, dredging, holes, dumps, embankments and so forth) the corresponding geological and geomorphological processes which have acted as factors of formation of a modern relief and landscapes of this territory have gained development. The major role was played by the geomorphological processes extended on the poured-out dumps from overburden breed. In particular, active development of landslide and landslide processes on dumps at the southern board of the Psilerakhsky pit promoted overlapping by detrital material of a slope and bottom of the Vasilevy beam located in the neighbourhood. As a result here the South careful woods from an oak fluffy, a juniper high, pistachios and pears have been partially destroyed. Today in a beam steppe communities of a wheat grass, a dogrose, an asfodelina, coltsfoot dominate. The periodic descent of collapses and landslides defines frequent successions of vegetation and almost total absence of trees. The largest since the beginning of the 2000th the technogenic landslide in the considered territory has come down from the southern board of the Psilerakhsky pit to Vasileva a beam in December, 2006. His language 200 m wide has moved forward in the sea on 100 m [1]. The landslide was provoked by natural and technogenic factors: incessant rains and loading of a slope dump material. On the mechanism of education and speed of shift it is carried to landslides of a current or visco-plastic type (a subtype – a landslide stream), with exclusively fast speed of the movement. As a result of a landslide nobody has suffered. In the

conditions of a safety of natural landscapes formation of this landslide would be impossible. In the mouth of the Vasilevy beam for these years from the material of dumps which was going down to the sea during landslide and landslide processes, the sea has washed the beach 200 m long and with an average width of 20 m (as much as possible – to 50 m). The beach has sand-pebble and bouldery composition and borders on the site of the washed-away language of a technogenic landslide. After the equipment at the beginning of the 2000th of BRU of a ladder to the sea, the Vasileva Beam beach became the popular place of a bathing and beach recreation of residents of Sevastopol and city visitors. Thus, on the example of modern landscapes in the neighborhood of Balaklava the important geomorphological and the forming landscape role of technogenic geomorphological processes is shown.

The author is grateful to the director of production of JSC Balaklava Mine Administration of A.M. Gorky Evlashkin Yu.A. for consultations on activity of BRU.

Literature

1. *Illarionov V.* Krupnejshij tekhnogennyj opolzen' Kryma. Online version of the information newspaper " Slava Sevastopolya". 12/14/2006 [the Electronic resource]. Access mode:http://slavasev.ru/2006.12.14/ view/14556_krupneyshiy-tehnogennyy-opolzen-kryma.html (date of the application: 12.12.2016).
2. *Kononenko YU.V.* Vliyanie geomorfologicheskih processov na tekhnogennyj rel'ef. Doklad na simpoziume «Nedelya gornyaka-2000». *MGGU*. [the Electronic resource]. Access mode: https://cyberleninka.ru/article/v/vliyanie-geomorflogicheskih-protsessov-na-tehnogennyy-relief (date of the application: 25.05.2018).
3. *Kyuntcel' V.V., Pareckaya M.N.* Izuchenie opolznevyh processov v gorode Moskve // Inzhenernaya geologiya i gidrogeologiya g. Moskvy. M. 1989. p.83-102

MORPHOMETRIC ANALYSIS OF THE RELIEF OF THE REPUBLIC OF KARELIA

A.S. Agayan[1], N.I. Kosevich[2]

Lomonosov Moscow State University, Faculty of Geology ([1]- nastaagaian@mail.ru , [2]- nkosevich@gmail.com)

Keywords: *Morphometric analysis, landforms, GIS, neotectonics, the Republic of Karelia*

The relief of the earth's surface is the result of the interaction of multidirectional processes. Endogenous processes create the primary hypsometric heterogeneity of the crust, i.e. macroforms. Exogenous processes negate the established heterogeneity: the separation of macroform on meso - and microforms. Thus, the earth's landform is a surface which created by the combined activity of exogenous and endogenous factors. The work of endogenous factors comes to the first place, as they form the "primary" relief's forms (morphostructures), which are complicated by various denudation and accumulative forms (morphosculpture). The use of geoinformation technologies at the study of the earth's surface topography allows to conduct research in a new way. The extensive GIS-tools are used at the analysis, modeling and forecasting of geomorphological processes in a particular area. Our research is aimed at identifying the relationship between endogenous and exogenous processes in the Republic of Karelia with the use of GIS technologies. This area is a unique object of study of geological and geomorphological structure. To achieve this goal, it was necessary to perform a number of tasks: - to analyze stock materials on geology, tectonics, neotectonics and geomorphology on the study area; - to conduct a morphometric analysis of the relief of the Republic of Karelia; - to identify the main morphometric and morphological characteristics of the study area. The region of study is located on the Kola-Karelian segment of the Baltic crystalline shield. Karelian block is divided into upper and lower structural floors. The upper floor is formed by rocks of the Lower Proterozoic: in the lower part by acid volcanic rocks, in the upper part – by quartzite-sandstones, basic effusive rocks and gravelites. The ground floor consists of the dislocated volcanic and metamorphic rocks of the Upper Archaean: magnetite-containing hornstones, amphibolites, quartz-mica schists, tuff- schists. Within the framework of our study, a series of specialized morphometric maps was built: hypsometric, slope angles, depth of vertical subdivision of the relief, density of dismemberment of the relief and general dismemberment of the relief, as well as a set of maps of hydrological modeling. Analysis of the height field allows to determine the type of the territory and highlight the general features of its morphology. Characteristics of the slope of any surface determines the speed and dynamics of modern geological processes taking place on it. The depth map of the dismemberment of the relief shows the relative maximum heights above the minimum, which represents the sum of values exceeding the surfaces of the watersheds above the thalwegs. The depth of the dissection of relief is the most important indicator of the differentiation and intensity of neotectonic movements. This map shows the degree of fragmentation of the earth's surface by erosion processes and is a picture of a system of permanent and temporary water streams, cutting through the landforms. The values of the density of the dissection of relief are associated with a large number of conditions, such as climate, rock permeability, landform's shape. A comprehensive analysis of these maps allows to

identify neotectonic structures within the study area and to further compare with the stock materials on geology, tectonics, etc.

WATER SOLUBILITY IN MODEL GRANITE MELTS WITH A HIGH CONTENT OF FLUORINE

Y.O. Alfer'eva, T.I. Shchekina, E.N. Gramenickij

Lomonosov Moscow State University, Faculty of Geology (YanaAlf@ya.ru)

Keywords: *water solubility, granite melt, highly fluorine granite*

According to Holtz et al. (2001), SV Burnham (1975), the solubility of water in quartz-normative silicate melt without Fluorine at 800°C and 100MPa is 3-4 wt%. The addition of Fluorine to the system leads to an increase in its solubility. It increases by about 0.5 wt.% for each added percentage of Fluorine [6]. According to [3], when the fluorine content in the melt is 4wt.%, the water solubility is almost as high as 5 wt%. We carried out experiments to evaluate the solubility of water in a silicate haplogranite melt containing up to 14 wt.% Fluorine. The experiments were carried out at T = 800°C, P = 100 MPa, and the amount of water in the system was 4 or 10 wt. %. As starting materials for the experiments, reagents SiO_2, $NaAlO_2$, AlF_3, NaF, LiF, gel mixture Al_2SiO_5, distilled water were used. The water content in the aluminosilicate glasses was determined at the center of geological studies in Potsdam (Germany) by Raman spectrometry. Raman spectra were recorded using a "Jobin-Yvon LabRam HR800" spectrometer equipped with an optical microscope "Olimpus" with a long-focus "LMPlanFI 100x" lens. An Ar + laser with a wavelength of 514 and 488 nm was used. Each spectrum was taken 11 times, with an accumulation time of at least 20 seconds. As a reference standard, glass with a known water content of 8.06% by weight was used. The calculation of the amount of water in the glasses was carried out by the Doct. R. Thomas by the method described in the works [4,5]. The samples consist of quartz-normative aluminosilicate glass (70-80%), quenching products of aluminum fluoride melt (20%), sometimes quartz (0-5%) and lithium-containing cryolite-simmonsite (0-5%). A detailed description of the phase relations and the features of the structure and composition of minerals and glasses is contained in the works [9,7]. A series of experiments on the diagram of fluorine and water content in aluminosilicate glasses form two groups of points [8]. One, which characterizes silicate glass compositions with an initial 10% water content, almost coincides with the continuation of the trend obtained by Holtz [3]. Perhaps in these experiments, saturation with the aqueous fluid was achieved with the parameters of the experiment, and an equilibrium aluminosilicate (L) melt + aluminum fluoride (LF) melt + aqueous fluid (fl) was realized. For these points, there is a direct correlation between the amount of water and fluorine in the silicate glass. The second group of experiments with an initial water content of 4% lies well below the trend. For this group, there is no correlation between the water and fluorine content. Apparently, a small amount of water did not allow the fluid to separate into its own phase, and it was dissolved in a silicate melt. The increase in the fluorine content in the silicate melt as a result of the crystallization differentiation process is limited by the appearance of fluorine-rich phases. Up to the formation of such highly fluorine phases, it accumulates as an incoherent component, and consequently, up to this point, an increase in the solubility of water in natural melts is possible. On the other hand, saturation with respect to the aluminofluoride phases of silicate melt under relatively dry conditions occurs earlier (at lower fluorine contents) than in systems rich in water.

The work is supported by the RFBR

Literature

1. *Baker D.R., Alletti M.* Fluid saturation and volatile partitioning between melts and hydrous fluids in crustal magmatic systems: The contribution of experimental measurements and solubility models // Earth. Sci. Rev. 2012. Vol. 114. p. 298–324
2. *Burnham C.W.* Water and magmas; a mixing model // Geochim. et Cosmochim. Acta. 1975. Vol. 39, N 8.P. 1077–1084.
3. *Holtz F., Dingwell D.B., Behrens H.* Effects of F, B2O3 and P2O5 on the solubility of water in haplogranite melts compared to natural silicate melts // Contrib. Mineral. Petrol. 1993. Vol. 113, N 4. P. 492–501
4. *Thomas R.* Determination of water contents of granite melt inclusions by confocal laser Raman microprobe spectroscopy // Amer. Mineral. 2000. Vol. 85. P. 868–872.
5. *Thomas R., Davidson P.* Progress in the determination of water in glasses and melt inclusions with Raman spectroscopy: A short review // Z. Geol. Wiss Berlin. 2006. Vol. 34. P. 159–163.
6. *Webster J.D., Rebbert C.R.* Experimental investigation of H2O and Cl — solubilities in F-enriched silicate liquids; implications for volatile saturation of topaz rhyolite magmas // Contrib. Mineral. Petrol. 1998. Vol. 132, N 2. P. 198–207
7. *Alfer'eva Y.O., Gramenickij E.N., Shchekina T.I. Ehksperimental'noe izuchenie fazovyh otnoshenij v litijsoderzhashchej bogatoj ftorom gaplogranitnoj i nefelin-sienitovoj sisteme // Geohimiya. 2011. № 7. S. 713–728*.
8. *Alfer'eva Y.O., Shchekina T.I., Gramenickij E.N., Predel'noe soderzhanie ftora i vody v granitnyh vysoko ehvolyucionirovannyh rasplavah // Vestn. Mosk. un-ta. Ser. 4. Geologiya. 2018. № 3. p. 70-76.*
9. *Gramenickij E.N., Shchekina T.I. Fazovye otnosheniya v likvidusnoj chasti granitnoj sistemy s ftorom // Geohimiya. 1993. № 6. p. 821–840.*
10. *Holtz F., Johannes W., Tamic N., Behrens H.* Maximum and minimum water contents of granitic melts generated in the crust: a reevaluation and implications // Lithos. 2001. Vol. 56, N 1. P. 1–14

METAMORPHIC AND METASOMATIC TRANSFORMATIONS IN THE PALEOPROTEROZOIC COMPLEXES OF THE ONEGA STRUCTURE OF THE KARELIAN CRATON.

T.E. Bagdasaryan [1], N.V. Lubnina [2]

Geological faculty of MSU state university ([1] -tanya.bagdasaryan@yandex.ru, [2] – natlubnina@yandex.ru)

Key words: *metamorphism, Paleoproterozoic, Karelian craton*

Numerous studies have established that most Precambrian stocks underwent metamorphic and metasomatic transformations. They arise in different geodynamic situations and manifest themselves in one or several stages, which can be carried out according to various P-T conditions and fluid relationships. However, so far the distribution of metamorphic and metasomatic transformations has been ambiguously established when accreting orogenic grafts are induced. Thus, the achieved research is the establishment of changes in the mineral composition as a result of tectonothermal transformations in the case of the formation of the Svekofen orogen at the boundary of two blocks, namely along the boundaries of the Karelian craton.

By establishing the degree of transformation, as well as by identifying the number of metamorphic and metasomatic transformations and directions of fluid motion, there are a number of works that consider changes at the micro level (in thin sections). So, to identify the structural parageneses and typify metamorphic and metasomatic transformations, one can study the orientation of the optical axes of quartz (c-axis) and microstructures [1, 2]. In the example of the Himalayan folded system, several stages of transformation have been singled out [3]: the first stage (S1) is established by horizontal orientation and orientation, including in garnet [3], the second stage (S3) is distinguished by the presence of an asymmetric border of the grenade, and the third stage S3) along equally oriented minerals (for example, biotite, plagioclase, muscovite and sillimanite).

To study the tectonothermal transformations in the formation of the Karelian craton, the age of which corresponds to the age of the formation of the Svekofen orogen, objects along its south-eastern boundary are selected for which the following conditions are fulfilled:

1. There is an isotope age
2. Paleoproterozoic, mainly ludicovian age
3. Preference - dikes and sills basic structure
4. The presence of Ar-Ar and Rb-Sr dating for the version of the age of transformations

Based on the study in non-oriented sections and microprobe studies, it was found that they are represented by gabbro-dolerites, converted to the greenschist facies of metamorphism, according to the following mineral parageneses: actinolite-epidote-plagioclase. The rocks also develop chloritization and albitization, the results of which are the rim around the minerals. In the future, it is planned to use oriented samples to establish the direction of fluid motion.

Literature

1. *Ding, H.X., Zhang, Z.M., Hu K., Dong, X., Xiang, H.* P–T–t–D paths of the North Himalayan metamorphic rocks: implications for the Himalayan orogeny// Tectonophysics. Volume 683, 2016. pp. 393-404.
2. *Larson, K.P., Gervais, F. and Kellett, D.*A. A P–T–t–D discontinuity in east-central Nepal: Implications for the evolution of the Himalayan mid-crust// Lithos, 179, 2013. pp. 275-292.
3. *Larson, K.P.* Refining the structural framework of the Khimti Khola region, east-central Nepal Himalaya, using quartz textures and c-axis fabrics// Journal of Structural Geology. Volume 107, 2018, pp. 142-152

GEOCHEMICAL INVESTIGATION OF ORGANIC MATTER IN MUD VOLCANIC DEPOSITS (KERCH PENINSULA)

I.S. Balakin[1], E.A. Leushina[2а], K.V. Maerle, E.V. Kozlova[2б], O.V. Krylov

[1]Lomonosov Moscow State University, Faculty of Geology (igor.balakin.1996@mail.ru);

[2]Skolkovo Institute of Science and Technology ([2а] - e.leushina@skoltech.ru, [2б] - e.kozlova@skoltech.ru)

Keywords: *mud volcanoes, nud volcanic breccia, organic matter, pyrolysis, elemental composition*

The mud volcanoes of the Kerch region were the objects of the geological field-trip in 2017 during "Innovations in geology, geophysics, geography-2017" conference. The mud volcanic deposits consists of fluid-saturated clay matrix with mud breccias rock clasts picked up from the depths of more than 2 km to the surface by mud volcano eraption. Fragments of mud breccias and clay matrix were collected in the Bulgana field and near the Kostyrino Village. The Bulganak field is the largest accumulation of mud volcanic manifestations in the Crimea, which are located in the area of 4 km2, within the depression 25 meters deepere relative to the surrounding terrain. There are several large griffons on the flat bottom of the depression and on the east side, (the hills of Andrusov, Pavlova, Tischenko, Obruchev, Trubetskoi, Shilov and Oldenburgskiy), and the lake called Tsentralnoe occupies the south-western edge. The liquid mud of the lake contains oil films. The Bulganak mud-volcanic field since the beginning of the 20s of the last century attracts the attention of geologists, very detailed studies have been carried out here, both the structures of the volcano itself, and the composition and products of mud volcanic activity [1,2]. Several fragments of mud-volcanic breccias and a modern clay matrix were selected from the crater of the Andrusov hill. Mud volcano near the Kostyrino Village (named Chongelek until 1948) was another object of investigation. The volcano is located onshore of the salt Tobechik Lake. According to archaeological excavations, oil production was carried out here as early as the 4th-5th centuries. On the Chongelek Oil Field in 1866 the first oil well in the Crimea was drilled. Oil deposits were located in the Maikop depositsthe overlying Neogene layers. Due to technical difficulties, in the 60s of the XX century oil production in this region stopped [3]. However, to the present time, hydrocarbon fluids are discharged to the surface through the faults and channels of a mud volcano. During the field excursion, several samples of oxidized oil were taken near the stale deposit, as well as samples of clay matrix and mud volcano breccia from a small crater located within the drained part of the Tobechík Lake. Laboratory investigations of the organic matter of the selected samples of mud volcanic breccia and clay matrix using pyrolytic equipment were carried out using the HAWK (Wildcat Technology) method and the element analyzer (LECO Corporation). The composition and properties of organic matter rocks from different regions are very similar to each other. Samples contain from 0.5 to 1% organic carbon, up to 2.33 mg HC / g rock of light hydrocarbon, a small amount of kerogen (up to 3 mg HC / g rock). The organic matter is predominantly immature, in two samples it is the initial stages of the main oil window zone. In bitumen samples near the Kostyrino Village, the amount of carbon varies from 36 to 55 wt. %, hydrogen 5-6% (according to elemental analyzer data), hydrogen index (according to pyrolysis data) 270-320 mg HC / g TOC, sulfur and nitrogen - percentages. Bitumen contains a large number of light components, it density according to pyrolytic data is 0.89-0.93 g / cm3. According to the molecular composition of the oil films, the oil consists of aromatic compounds, most of which are

poorly identified due to the high degree of oxidation. The result of biodegradation is the almost complete absence of normal alkanes and their homologues. To study the organic matter in products of mud volcanism, modern versions of pyrolytic and chromatography-mass spectrometric methods were used. A comparative analysis of these methods is carried out. The characteristic of biodegraded oils of the Chongelek deposit is given.

Literature

1. *Gubkin I.M., Fedorov S.V.* Gryazevye vulkany Sovetskogo Soyuza i ih svyaz' s genezisom neftyanyh mestorozhdenij Krymsko - Kavkazkoj geologicheskoj provincii. M. - L., 1938
2. *Kayukova E.P., Yurovskij Yu..G.* Nefteproyavleniya u ozera Tobechik (Kerchenskij poluostrov, Krym). / Trudy Krymskoj Akademii nauk. – Simferopol': IT «ARIAL», 2017. – p. 63-76.
3. *Shnyukov E.F., Sobolevskij YU.V., Gnatenko G.I. i dr.* Gryazevye vulkany Kerchensko-Tamanskoj oblasti: Atlas. Kiev:Naukova dumka, 1986. 152 p.

THE RELATIONSHIP BETWEEN OIL AND GAS POTENTIAL AND MUD VOLCANISM IN THE KERCH-TAMAN ZONE

D.E. Beloborodov[1], T.Y. Tveritinova[2]

[1]IPE RAS (DenBeloborodov@gmail.com);

[2]Lomonosov Moscow State University, Faculty of Geology (tvertat@yandex.ru)

Keywords: *mud volcanoes, the Kerch-Taman zone, the oil and gas potential , lithological and structural factors, diapir structures, mud-volcanic breccia, the petroleum potential, clay Maikop, oil and gas deposits, the oil-bearing strata, the compression conditions, oil and gas formation*

The association of mud volcanoes with oil and gas bearing areas has been known for a long time. Mud volcanoes, as well as oil and gas potential, are associated with sedimentary basins, which are mainly sand and clay sediments, not metamorphosed and slightly dislocated. Mud volcanism is one of the most important criteria for the estimating regions' prospects for oil and gas. The Kerch-Taman zone, being a part of the Caucasian-Crimean-North-Caspian province [4,5], is known for its favorable gas generation conditions. It is also widely known for large-scale manifestations of mud volcanism [6,7]. 1. Stratigraphic range of the section: the oil and gas potential is typical for the entire section of the cover of ancient platforms and young plates, while mud volcanoes occur exclusively in the areas of Cenozoic sedimentation. In the case of the Kerch-Taman zone, the issue is that the oil and gas potential is typical for the entire section of the Scythian plateau and the Caucasian marginal troughs. The oil and gas bearing complexes are the Permian-Triassic, Lower Upper Jurassic, Lower Cretaceous, Upper Cretaceous (the most homogeneous), Paleogene (maximum gas-bearing) and Neogene (the most heterogeneous). Mud volcanism is characteristic mainly for the periclinic Kerch-Taman zone with the adjacent parts of the Caucasian marginal troughs. The main stratigraphic levels of mud-volcanic breccia generation are the Maikop (Oligocene-Miocene), Lower Cretaceous and Lower-Middle Jurassic stratums. 2. Lithological factor. The petroleum potential of sedimentary basins depends on the location of rocks with reservoir or shielding properties: oil and gas production occurs in the most permeable rocks (granular, fractured or cavernous), while dense layers, including clay, low-permeable ones, serve the caps for oil, gas and gas condensate deposits. Mud volcanism is associated with the processes of intensive thinning of rocks, primarily of the sandy-argillaceous composition. In the case of the region under consideration, the oil and gas potential is confined to the fissure-cavernous type reservoirs in terrigenous and carbonate P-T sequences; to several productive horizons in terrigenous $J_{1\text{-}2}$ and carbonate-evaporite J_3 sediments; terrigenous-carbonate K_1nc and terrigenous K_1a-al sediments; carbonates K_2; terrigenous-carbonate sediments Pg (mainly, gas deposits), as well as lithologically variable N sediments. It needs to be taken into account that the main productivity is associated with marginal troughs [4,5]. Mud-volcanic breccia is formed in predominantly clay Maikop and sandy-argillaceous strata K_1 and $J_{1\text{-}2}$. Thus, both for the oil and gas potential, and for mud volcanism, the lithological factor is decisive. 3. Structural factor: oil and gas potential is a sensitive indicator of traps of any nature, both lithological (facial transitions of collectors and caps), and tectonic - anticlinal and thrust structures of any size and shape. Mud volcanoes are mostly associated with narrow diapiric anticlines, complicated by discontinuities

(longitudinal, oblique, transverse to the diapir fold), with local mud-volcanic structures (or depressed synclines) forming on them. The manifestation of mud volcanism in the Black Sea, as it turns out, is also associated with the presence of diapir structures in the sedimentary cover [2]. Diapir folds and mud volcanoes can be differentiated mainly by the fact that diapir folds are linear structures, reflecting the effect of regional compressive stresses, while mud volcanoes are local structures, - although indirect connection of these structures with regional compression can be also considered. The proof of the latter is in the linear organization of chains of mud volcanoes. The article [1] notes that "despite certain and important differences, there are similarities between mud volcanoes and clay diapirs. These natural phenomena can occur together, which sometimes leads to some confusion in their study and identification." 4. Gas-fluid flow: oil and gas bearing is a direct expression of the constant migration of the gas-fluid flow and the formation of oil and gas bearing deposits in favorable strata and structures, while mud volcanism is the intermittent process of the formation of moving media (mud breccia) under abnormal structural conditions in the state of constant gas-fluid migration, including hydrocarbon migration. Most mud volcanoes of the Kerch-Taman zone are characterized by signs of oil and gas potential. 5. Heat flow: it is likely that the increased heat flow contributes both to the processes of oil and gas generation and to the mud volcanism. 6. Seismicity: probably plays an important role in both phenomena, but is more evident in the impulsive character of the processes of mud volcanism. Conclusions: both the processes of formation of oil and gas deposits and mud volcanoes occur in conditions of development of thick sedimentary strata. Oil and gas deposits are formed almost constantly everywhere, but it is a slow process, subjected to the influence of lithological and structural factors (with a small amplitude of tectonic movements), which is representing one of the relatively isolated components of the geological environment. Mud volcanism occurs impulsively and relatively quickly in zones of increased dislocations (preferential compression), with a sharp transformation of the non-lithified sedimentary rocks into a liquid state. Although the very phenomenon of mud volcanism in the geological time interval is incommensurable with the process of oil and gas formation, the former often accompanies the formation and migration of the latter. The most favorable conditions for both oil and gas formation and mud volcanism are created by sandy-argillaceous sediments. The location of oil and gas deposits both in the section and in the area is due to a complex of lithological, tectonic, geochemical, hydrogeological and other factors, while the types of traps are determined by the conditions of accumulation of sediments and subsequent development of tectonic movements and discontinuities. Primary migration of oil and gas from the oil-bearing strata occurs from the most submerged synclines (from the depths of at least 1.5-2 km) towards the anticlinal zones, where diapiric folds contributing to mud volcanism are formed in the compression conditions, as well as longitudinal and transverse discontinuities which are greatly influencing the process of formation of oil and gas deposits. The following factors: the intensive growth of anticlinal folds, a sharp increase in the amplitude of longitudinal disturbances, and the formation of numerous transverse and radial fractures all essentially affect the process of destruction of oil and gas deposits. In the oil and gas regions, it was the tectonic development of regions that greatly influenced both the formation and location of oil and gas deposits in local folds, and formation and activity of mud volcanoes. That determines the regional direction of oil and gas migration and lithofacial variability of rocks. Therefore, mud volcanism should be considered as a direct sign of the oil and gas potential of the subsoil.

Literature

1. *Gavrilov V.P., Leonova E.A., Rybal'chenko V.V.* Gryazevoj vulkanizm i neftegazonosnost' Shonghonskogo progiba (severnyj shel'f V'etnama)// Trudy RGU nefti i gaza imeni I.M. Gubkina № 4 (265) 2011. p. 28-37
2. *Leonchik M.I., Senin B.V., Hortov A.V.* Perspektivy gazonosnosti kajnozoya Chernogo morya // Nauchno-tekhnicheskij sbornik VESTI GAZOVOJ NAUKI, 2015, № 2. p. 54-62.
3. *Sokolovskij A.P.* Neftegazonosnye provincii Rossii i zarubezhnyh stran.// «Tyumenskij gosudarstvennyj neftegazovyj universitet». Tyumen', 2015. – 185 p.
4. *Chernova O.S.* Neftegazonosnye provincii Rossii i sopredel'nyh territorij. // Centr professional'noj perepodgotovki specialistov neftegazovogo dela. Tomsk, 2008. – 258 p.
5. *Shnyukov E.F., Sheremet'ev V.M., Maslakov N.A, i dr.* Gryazevye vulkany Kerchensko-Tamanskogo regiona. Krasnodar: Glavmedia, 2006. – 176 p.
6. *Shnyukov E.F., Kobolev V.P., Pasynkov A.A.* Gazovyj vulkanizm Chernogo morya. – K.: «Logos», 2013. – 384 p.

PETROPHYSICAL CRITERIA OF TYPICALIZATION OF ROCKS WITH INHOMOGENEOUS STRUCTURE

E.V. Bryuhanova

Federal State Budget Educational Institution of Higher Education « Industrial University of Tyumen» (ekaterinabriuhanova@yandex.ru)

The aim of the work is to increase the reliability and informative of petrophysical modeling of the geological interpretation of well logging data (GIS), taking into account the degree of their heterogeneity and the criteria for its evaluation. There are different levels of rock heterogeneity, ranging from the size of defects in the crystal lattice of minerals, composing rocks and sizes of mineral grains to the size of individual interlayer`s, inclusions and lenses that are excreted in rock samples, in core, in geological strata and sections. The dialecticity of the concept of heterogeneity and criteria for the heterogeneity of rocks is obvious, depending on the tasks and technology of research. The solution of the inverse problems of geophysical studies requires the justification of the dependencies of the recorded geophysical (petrophysical) characteristics on the geological properties of the objects of research. In the field of geophysical methods of exploration of wells (GIS), the main object of study are geophysical layers and their properties. A direct geological-petrophysical characteristic of geophysical layers is provided by the results of studies of rock material taken from wells, i.e. - core. Corresponding dependencies, necessary for interpretation of GIS data, can be established using comparisons of the type "GIS-core" and "core-core". In both cases, the results of core research should be representative, adequately reflecting the averaged petrophysical characteristics of each formation. One of the defining criteria for the separation of geophysical layers is the condition for the consistency of indications of GIS methods for the thickness of the reservoir, which do not exceed the tolerances for each method of deviation from average reservoir values. For relatively homogeneous rocks whose properties are monotonically fluctuating in the thickness of the formation within the limits determined by the permissible variations in GIS methods, the requirements for representativeness and adequacy of the petrophysical characteristics are provided by the density of the component analyzes, in accordance with the established requirements of the State Reserves Committee, four samples per meter of the section. In this case, each individual sample is represented by a homogeneous rock, but the properties of the samples can differ markedly from each other. It is assumed that the average arithmetic value of a scalar petrophysical characteristic provides a condition of adequacy to its corresponding average reservoir characterization. Note that for samples of standard sizes 30x30 mm, their volume is only 1.08% of the volume of the core column 1 m in length and 100 mm in diameter. In relation to the volume, characterized by the indication of GIS methods, the representativeness of the core data becomes negligible. Nevertheless, fairly stable dependencies of the "GIS-core" type, characterizing sections of the section, represented by relatively homogeneous rocks and geophysical layers, are observed. Not in a small measure this is facilitated by the established practice of determining the sites of sampling (drilling out) samples from the most representative sections of the core column. This practice makes it possible to exclude the selection of the core of their single, non-significant layers and heterogeneities that do not significantly affect the geophysical characteristics of the formation. Further increase in the adequacy of the petrophysical and geophysical characteristics of the "homogeneous" formations can be achieved by differentiating the core column from profile

studies (natural gamma activity, density, permeability) and detailed lithological description into more homogeneous areas and determining the weighted mean values of petrophysical parameters of the formation.If the "homogeneous" geophysical layer is represented by rocks of an inhomogeneous structure (texture), ensuring the adequacy of its petrophysical characteristics is significantly complicated, especially when studying vector parameters, in particular, resistivity (conductivity). The dimensions of the texture heterogeneity (in the "uniform" layer) can vary from fractions of a millimeter to the values determined by the vertical resolution of GIS methods. For methods of apparent (effective) electrical resistance (UES, UEP), it is from 1.6 m. With a larger thickness of a single inhomogeneity, it can be isolated according to electrical methods as a separate geophysical layer and characterized by the values of the UES.Such objects can be classified according to the type (size) of the heterogeneity into three groups (VG Mamyashev, ZapSibNIIGeoofizika, 1987).The first is a group of quasihomogeneous or microinhomogeneous rocks, which are distinguished according to GOST 25494-82, by the criterion limiting the share of a single heterogeneity in the volume of the sample under study not exceeding 10%. The total fraction of this or that heterogeneity in the sample volume does not matter. This means that when examining samples of standard sizes The first is a group of quasihomogeneous or microinhomogeneous rocks, which are distinguished according to GOST 25494-82, by the criterion limiting the share of a single heterogeneity in the volume of the sample under study not exceeding 10%. The total fraction of this or that heterogeneity in the sample volume does not matter. This means that when examining samples of standard dimensions (30x30 mm), the thickness of a single interlayer should not exceed 3 mm. In this case, regardless of the number of interlayers of any lithology, the variations in the scalar petrophysical characteristics will not exceed $\delta <\pm 0.05 * \Delta K$ from the average value of the parameter Kcp in the reservoir. Here, ΔK equals the difference in the values of the parameter K in the interlayers of the first (K1) and second (K2) lithologies: $\Delta K = K1-K2$. For example, with respect to the porosity of rocks represented by interbedding rocks with a porosity of 30 and 15%, we obtain $\Delta K = 15\%$ and the deviation in the unit definition will be $\delta = \pm 0.5\%$. When calculating the average porosity, the deviation of the resulting mean value from the porosity of the object will decrease by "n" times (as an error of the mean). It is of fundamental importance that the specific electric resistance of such a sample will fully reflect the features of stratification (the parallel connection of individual interlayers). The size of the allowable roll non-uniformity can be increased by increasing the dimensions of the test samples. For example, with a core diameter of 100 or 120 mm, the dimensions of the samples cut perpendicular to the core axis are 70 and 85 mm, respectively. This means that rocks with sizes of individual inhomogeneities of not more than 7-9 mm are quasihomogeneous. The second group consists of meson-homogeneous rocks with sizes of inhomogeneities from 3 to 27 mm and more, for samples of standard sizes, or from 7-9 and 63-76 mm for images with a diameter of 70-85 mm. In this case, the adequacy of the petrophysical characteristics of the formation can be ensured only with the use of a layered stack model (Dakhnov-Komarov), with the appropriate justification for the petrophysical characteristics of the lithologic differences of the rock constituents.The third group is macro-inhomogeneous rocks, the sizes of individual inhomogeneities of which exceed 27 mm (for samples of standard sizes). Ensuring the adequacy of the petrophysical characteristics of the layers composed of such rocks also requires the use of a layered pack model. The justification of the petrophysical characteristics of the lithological differences of the rock constituents in this case is facilitated by the fact that the studies of each of these differences can be performed using standard-size samples and taking into account the linear fraction of each

lithological difference from the results of profile studies. The proposed criteria for petrophysical typing of heterogeneous rocks represent a new methodology for petrophysical provision of geological interpretation techniques for GIS data. Scientific adviser of works, associate professor of TIU, V.G. Mamyashev

STRUCTURAL AND GEOMORPHOLOGICAL ANALYSIS OF THE WESTERN COAST OF THE CRIMEAN PENINSULA

G.V. Bryantseva[1], N.V. Lubnina[2], N.I. Kosevich[3]

Lomonosov Moscow State University, Faculty of Geology
[1] – bryan.bryan@yandex.ru,[2]- natalia.lubnina@gmail.com, [3] – nkosevich@gmail.com)

The study area covers the Western coast of South-Western Crimea from the valley of the Chernaya river to the valley of the Bulganak river. This is a zone of articulation of the mountain structure of the Crimean Mountains and the Scythian plate.

To study the latest tectonics of the Western coast of Crimea, structural and geomorphological studies were carried out with the highlighting of plicative и modern fault structures by the technique developed by Kostenko (1999). These studies allow analyzing the late Cenozoic deformations of the earth's crust, i.e. deformations formed during the neotectonic stage of development and manifested differently in the relief. The study of such orographically expressed developing deformations were carried out in the plan by specialized decoding of topographic maps and in vertical sections, implemented by the construction of geological and geomorphological profiles. As a result, a structural-geomorphological scheme of the Western coast of Crimea was constructed, on which a number of structures, discontinuous faults, as well as fracture zones manifested in the relief over the currently activated discontinuous faults of the lower structural floors were identified. The dynamic activity of the faults is determined by a set of orographic features: deformation of the plane denudation zone, distortions of the valleys separating the blocks, different heights of the blocks composed of rocks of approximately same denudation stability, or by their different slope, a sharp change in the steepness of the slopes, etc.

Within the Western Crimea the block structure of the territory is distinctly shown in the newest structure, and structures of the first order are accurately allocated – Heraclea uplifting, Alma depression and ridges of the Crimean mountain structures. Within these major neotectonic structures, smaller structures are identified.

Heracleay Plateau, located within the Heraclea Peninsula has a complex structure. On the surface it is composed of Miocene Sarmatian limestone, falling to the North-West at a dip of 2-3°, reaching a height of 200-250 m in the East. Limestones broken by West-North-Western faults, generated by gully-girder systems.

Eastern-North-Eastern fault system deform gullies and girders valleys, changed their directions. To the west the Heraclea Plateua borded byNNE Georgievsky Fault and representing a fairly wide, up to 1 km, zone echeloned tectonic faults (Lomakin et al., 2010), well expressed in relief, which differ in kinematics and amplitude and repeatedly revived during periods of tectonic activation of the territory (Ivanov et al., 2009). The compression processes have been dominating in the zone of the Georgievsky Fault since Albian (Lomakin et al., 2010).

A large sub-latitudinal fault is developed in the lower reaches of the of the Chernaya river (which formes the Sevastopol Bay) and separates the Heraclea uplift from the Scythian plate. This fault is correlated with the Simferopol fault, which originally has a sub-latitudinal strike and passes through the valley of the Chernaya River, and then changes its strike to NE (Hain, 1984).

Alma depression is located within Zuevsky ledge on the South of the Scythian plate. This is a large relatively weakly bent platform structure, the formation of which is associated with a

very slow deflection of the surface of its base. It is made by deposits of middle Jurassic, upper and lower Cretaceous, Paleogene, Neogene and Quaternary system. The thickness of Neogene-Quaternary deposits does not exceed 200 m. The surface of the depression is quite flat, the highest heights do not exceed 170-180 m. Coastal cliffs from the valley of Belbek river up to Margopulo Cape, and to the South from Lukull Cape represent, most likely, tectonic structures.

Pre-Cretaceous rocks are dissected by faults detected by geophysical studies (Geology of USSR, 1969). The lower reaches of the Belbek, Kacha and Alma rivers passes through the Alma depression and have a sublatitudinal, sometimes WSW or WNW strike. The same strikes are typical for gully-girder systems. Sub-latitude faults are confined to the river valleys of the Western Crimea in its lower reaches, in most cases are right-hand shifts (Lomakin et al., 2014). To the East both river and ravine-beam network has sharp bends of riverbeds. Their strike changes to NW. This occurs at the intersection points of an ancient fault network that is inherited and developed as a result of neotectonic processes or in the areas of intersection of faults of different orientation.

Crimean fold-napped system formed in Late Cimmerian (the Alpine tectonic era). Forms of relief are determined mainly by the ancient system of faults, currently activated. This region is mainly characterized by a system of diagonal fault, mainly NW direction. In the modern structure in the study area there are two ridges – Inner and Outer, separated by a graben-shaped cavity, presented in a modern topography as Northern inter-row depression.

Outer ridge extends form the Heraclea Peninsula to the North-East. On the surface it is composed of Miocene limestone and sandstone, dipping NW at 2-5°. Generazione total uplift reaches up 300-350 m. Monoclinally deposited rocks are broken by NW fault system.

Inner ridge with heights up to 400-500 m is composed of rocks of Cretaceous and Paleogene systems, dipping NW at 7-10°. *Northern rift valley depression* strike along ridges and composed of rocks Maikopian series and limited by NE striking faults. It has a complex structure, varying width, and is broken by a system of cracks with NW and WNW strike.

Zone of articulation of the fractured zones create different directions of tectonic knots. A large tectonic node is located in the area of Inkerman heights, where sublatitudinal Sevastopol fault, developed by Chernaya River, and several faults NE (Heraclea fault) and NNE strike.

Thus, as a result of structural and geomorphological studies revealed three systems of cracks: sublatitudinal, NE and NNW. Fractures of NNW and NE strikes are the most active present days. The coastal zone from Cape Kosa Severnaya to Cape Margopulo is are of danger since it coincides with fracture zones of NNW strike, and a significant abrasion of the shore, composed of sand and loamy rocks of Tauric Formation leads to the formation of numerous subsidence faults, stretching parallel to the shore and leading to landslides. Identified fractured zones can inherit the ancient faults from the basement which are active at the time.

This research was financially supported by RFBR grant №18-45-920073 (headed by O.V. Krylov)

References

1. Geology of UUSR. Vol.8. Geological description. Crimea *(In Russian)* Moscow, Nedra. 1969. 576 p.
2. *V.E. Ivanov, I.E. Lomakin, A.S. Topolyuk et al*. Features of tectonics of South-Western Crimea (*In Russian)*// Geology and minerals of the world ocean. 2009, № 4, p. 27-39.
3. *N.P. Kostenko,* Geomorphology *(In Russian)*. Moscow. MSU. 398 p.
4. *I.E. Lomakin, V.E. Ivanov, V.V., Kochelab.* Tectonic factors of development of the latest geodynamic processes in South-Western Crimea *(In Russian)* // Geology and minerals of the world ocean. 2014. № 3. P.61-74
5. I.*E. Lomakin, V.E. Ivanov, V.V., A.S. Topolyuk, L.L. Efimceva.* Новые данные о геологическом строении побережья Юго-западного Крыма *(In Russian*// Geology and minerals of the world ocean, №4. 2010. P. 30-39
6. *V.E. Hain.* Regional geotectonics: Alpine Mediterranean belt *(In Russian)*. M.: Nedra. 1984. 341 p.

PARAGENETIC ANALYSIS OF FRACTURING IN FAULT ZONES

Y.P. Burzunova

Irkutsk Earth's Crust Institute SB RAS (bourz@mail.ru)

Keywords: *joint, fracture, fault, fault zone, fracture paragenesis, stress field*

Analysis of rock jointing is widely used in studying the fault structure of upper part of the earth's crust. The result of long-term investigations of near-fault fracture systems is the method of specialized mapping of crustal fault structure and stress fields [4; 5], based on the paragenetic analysis of fracturing. The starting data is statistical mass measurements of tectonic fractures attitude. The method consists in comparing natural joint systems with standard ones. The standard patterns used in new paragenetic approach are models of fracture systems in fault zones for compression, strike-slip and extension dynamic settings. A fault zone on the earth surface is a plane section of the fault impact zone, which has heterogeneous deformations genetically associated with fault formation, including fractures of the smallest scale rank – joints. The standard pattern includes a main fault and early minor faults of the 2nd order, and parageneses of smaller fractures in the form of triples of perpendicular early joint sets [4]. In case of not available fault plane in the visual study, or fault absence at first stage of fault zone development, or absence of shear-sense marks, the system of early fractures serves as the main source of information. It is one of the method advantages. Comparison of fracture systems is done by stereographic projection. The most suitable standard pattern for a group of coincidental joint sets determines the solution (1-3 sol. and more) for the fracture stereogram. The method makes it possible to reconstruct a rock stress of local rock volume and to establish belonging of this outcrop to local fault zone. In addition, using a network of observation points and the principles of genetic subordination, during the rank analysis we can obtain a regional level and determine the location and boundaries of fault zones, and the type and orientation of corresponding stress fields. The method allows a study of various genetic types of joints on condition of primary participation of tectonic stresses in their formation. It is determined by special features, the main ones are set or chaotic (multi-set) structure of fracture system and shear type of joints [3]. The method is especially effective in areas with high tectonic activity (or formerly active ones). The evaluation of fracture system involves outcrop structural features data. The growth of total number of geological-structural observations points increases method effectiveness, and the statistical format of source data increases method reliability. An example of jointing paragenetic analysis with the profile location of observation points is the study of paleostress fields at the Mogod polygon (Central Mongolia) [1]. Mass measurements of joints were made in 22 points on profiles crossing two large fault branches (N and NW strike) of the seismic dislocation network of 1967. As a result of fracture systems analysis, 62 local fault zones and corresponding stress fields for individual rock outcrops were reconstructed. Then on their basis, in a process of rank analysis, five regional stress fields and fault zones were identified, in which a fractured-discontinuous structure was formed. The reconstructed regional fields from two profiles are paragenetically related. It allowed us to characterize the general history of tectonic development for Mogod test site as two main stages (Late Paleozoic-Mesozoic and Cenozoic). At second stage the observed seismotectonic faults are activated, and the stress fields obtained from fracture analysis coincide by type and orientation with earth focal

mechanisms of the Mogod event of 1967. The area location of observation points makes it possible to carry out the specialized mapping process completely and restore not only regional stress fields, but also a network of fault zones on studied site, for example, when researching fracturing of the Tazheran syenite massif (Pribaikalye) [2]. In analysis process of 108 mass measurements of joints, 308 local solutions were obtained, and five different-age regional stress fields were established as a result of rank test. Then, on the basis of local shear zones reconstruction, a fault zones map of the site and a scheme of their sequential activation from Early Paleozoic to Cenozoic were constructed. Compression (NW-SE) and extension (NW-SE) fields are the most representative and claim to belong to a larger rank. The types and relative age of regional fields do not contradict the known data from scientific publications about formation stages of earth's crust structure of Baikal region, and in some cases coincide with it. The reconstructed fault zones are presented by zones of more density fracturing, and in some cases by tectonite zones. Their orientations are similar to major faults directions in the central part of Baikal rift. Thus, the fracturing paragenetic analysis method within specialized mapping is an effective tool to identify a fault-block structure of regions and determine local and regional different-age rock stress. The technique successfully complements traditional ways of studying earth's crust faults, and its reliability is confirmed by coincidence of its results with conclusions of previous authors. The information obtained about fault zones is used in a fundamental aspect – for geodynamic reconstructions, as well as in solving applied problems in engineering geology, seismology, ore and oil-gas geology, the possibility of applying the method for interpretation of 3D seismic data has recently become especially relevant.

The studies were carried out with the partial financial support of the RFBR (project No. 16-05-00154A).

Literature

1. *Burzunova Iu.* Stress fields in the area of the Mogod earthquake in Mongolia from the structural paragenetic analysis of tectonic fracturing // Book of extended abstracts: The International Conference on Astronomy & Geophysics in Mongolia (20-22 july). – 2017. – P. 88–93.
2. *Burzunova Yu.P.* Razlomnye zony Tazheranskogo massiva sienitov (Zapadnoe Pribajkal'e) po rezul'tatam strukturno-parageneticheskogo analiza treshchinovatosti // Izvestiya Sibirskogo otdeleniya Sekcii nauk o Zemle RAEN. – 2015. – №1 (50). – p. 58–67.
3. *Burzunova, Yu.P.* Treshchiny gornyh porod vblizi razlomov: osobennosti primeneniya strukturno-parageneticheskogo analiza // Geodinamika i tektonofizika. 2017. T. 8. № 3. p. 673–693.
4. *Seminskij, K. Zh.* Speckartirovanie razlomnyh zon zemnoj kory. Stat'ya 1: Teoreticheskie osnovy i principy / K. Zh. Seminskij // Geodinamika i tektonofizika. – 2014. – T. 5, № 2. – p. 445–467.
5. *Seminskij, K. Zh.* Speckartirovanie razlomnyh zon zemnoj kory. Stat'ya 2: Osnovnye ehtapy i perspektivy / K. Zh. Seminskij // Geodinamika i tektonofizika. – 2015. – T. 6, № 1. – p. 1–43.

THERMODYNAMIC MODEL OF MUD VOLCANISM

A.Y. Bychkov[1], N.V. Lubnina[2], O.V. Krylov

Lomonosov Moscow State University, Faculty of Geology ([1]- andrewbychkov@rambler.ru , [2]-natalia.lubnina@gmail.com)

Keywords: *mud volcanism, oil formation, fluid migration, thermodynamic modeling*

The nature of mud volcanism still raises controversy among scientists. Some researchers follow the ideas put forward by G.V. Abich, S.A. Kovalevsky, P.N. Kropotkin, who associated it with deep magmatism and unloading of abiogenic hydrocarbons. On the contrary, N.B. Vassoevich, I.M. Gubkin, M.F. Mirchink, A.A. Trofimuk, N.S. Shatsky, V.N. Kholodov and many others defended the organic origin of methane and oil from mud volcanoes, which are generated in sedimentary rocks containing organic matter. A sufficient amount of geochemical data has been accumulated. In the works of V.Yu. Lavrushin and O.Y. Kikvadze it was shown that isotopic and chemical data indicate the heterogeneity of mud volcanic fluids from their water supply from deepwater sources. D.V. Golubyatnikov, aptly called the mud volcano "free exploratory drilling", because the products of mud volcanism brought to the surface give an idea of the processes taking place in the depth of the oil-forming system. Therefore, it is logical to create a quantitative physicochemical model for the formation of oil and gas starting from a model of mud volcanism. The receipt of reactions to the surface of the products makes it possible to verify the models, which is extremely difficult for those cases of modern oil-forming systems. The study uses methods and approaches developed in several directions of geology, but not previously used to study mud volcanism. The first such approach is quantitative geodynamic modeling. Modern methods using supercomputers allow us to calculate the change in physical and mechanical properties of rocks during geological processes and determine the evolution of thermodynamic parameters in the interior of the mud volcanic strata. As a rule, problems were solved for collision situations; the experience of using this approach for foothill troughs is very limited. The second approach is the using of experimental modeling methods of natural processes. The modern experimental technique makes it possible to carry out investigations of the behavior of the system with the necessary thermodynamic parameters. However, direct experimental modeling, as usual, is impossible because of the long duration of natural processes. Therefore, the problem reduces to determining the fundamental thermodynamic reaction constants (equilibrium and kinetic), which can then be used for thermodynamic calculations. The third approach is thermodynamic modeling of phase equilibria. This method has been widely developed for many geological processes, in particular, for modern hydrothermal systems. For the construction of quantitative models of processes occurring in the mud volcanism focus, it is required to take the rates of reaction, which requires the development of new methods and knowledge of kinetic constants. The fourth approach is geochemical research of mud volcanism. Standard field research methods will be used to measure the fluid parameters (t, pH, Eh) and sampling, as well as newly developed ones. In particular, it is supposed to use the experience of testing modern thermal sources, pore solutions, dialysis, ultrafiltration and other technologies for studying heterophase systems. Thus, the classical scheme of modeling is realized: the geological model - the thermodynamic model - the results of

calculations and comparison with natural data. The possibility of implementing such a set of works is that the team has the necessary specialists in each part of the study

The work was supported by the Russian Foundation for Basic Research project 18-05-00818

REGULARIZATION OF THE INVERSE DYNAMIC SEISMIC PROBLEM BY TRUNCATED SVD

A.A. Vasilenko

Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch of Russian Academy of Sciences (IPGG SB RAS), NST (alexvas1996@ya.ru)

Keywords: *geophysics, full waveform inversion, SVD*

The inverse dynamic problem of seismic consists in recovering the velocity model of elastic medium based on the acquired (observed) seismic data at the receiver point. Thus, here appears the so-called forward map B(c) which transforms a wave propagation velocity c to data d and one should invert this forward map to recover wave propagation velocity. In other words, one should resolve nonlinear operator equation where operator itself means computation of the solution for a current velocity on receiver coordinate.

We use local gradient type technique to solve this nonlinear least squares problem. It consists in minimizing the difference between observed and modelled seismic data in the mean-square sense. That is, it is necessary to minimize some functional which is a square of the norm of the residual in a Hilbert space.

The standard approach involves the organization of iterative process of finding the minimum point. In our considerations, we apply two well-known implementations of local gradient techniques to search for the minimum point: conjugate gradient and modified Newton. Both of them needs numerical computations of gradient and Hessian of the original nonlinear least squares functional. In the discrete case, there appears a system of linear algebraic equations, which should be resolved to find the next approximation. As a rule, this matrix is ill-conditioned and needs SVD-analysis to perform correct pseudoinversion.

The Hessian doesn't have a bounded inverse since it is compact. It follows that the matrix of the system in any case will be ill-conditioned in approximating. Therefore, in order to construct a numerical solution a regularizing procedure in the form of a truncation of a singular value decomposition is applied. That is, the structure of stable subspaces in the model space is determined.

Since the operator under consideration is compact, the condition number of the matrix of the system is large enough. But it is possible to choose some number of the right singular vectors corresponding to elder singular values that form the basis of a stable subspace in the model space. It is for this reason that we can make the pseudoinversion of the matrix and find a solution in the stable subspace.

This paper also presents and discusses the results of numerical experiments. In practice it is quite difficult to obtain data for low frequencies, so there is a need to research the influence of the frequency range of seismic data on the quality of recovery of the velocity model.

This research was supported by Russian Science Foundation, project 17-17-01128.

Literature

1. *Gadylshin K.G., Cheverda V.A. (2017):* Reconstruction of a depth velocity model by full waveform inversion // Doklady Akademii Nauk, 2017, Vol. 476, No. 6, pp. 693–697
2. 2. *Silvestrov I., Tcheverda V. (2011):* SVD analysis in application to full waveform inversion of multicomponent seismic data // J. Phys.: Conf. Ser. 290 012014
3. Linearized inversion of data of multi-offset data for vertically inhomogeneous background / V. Cheverda, F. Clement, V. Khaidukov, V. Kostin // J. Inv. Ill-Posed Problems. – 1998. – Vol. 6, no. 5. – P. 453-484.
4. *Kostin, V. I., Cheverda, V. A.* (1997). r-reshenija uravnenija pervogo roda s kompaktnym operatorom v gil'bertovyh prostranstvah: sushhestvovanie i ustojchivost'. Doklady RAN, Vol. 355, № 3 [in Russian].

EXTREME PRECIPITATION ON THE BLACK SEA COAST

E.V. Vyshkvarkova

Institute of natural and technical systems (aveiro_7@mail.ru)

Keywords: precipitation, extremes, Black Sea coast, trends

Events with extreme precipitation may lead to catastrophic effects significantly influence on the efficiency of the activities in many sectors of economy. The precipitation behavior has significantly changed during past centuries. It is confirmed by IPCC report [1]. This also applies to the extreme values of precipitation. There are many techniques for analyzing extreme precipitation. Majority of them based on calculating of all or several climate extremes indices developed by the joint World Meteorological Organization (CCL/CLIVAR/JCOMM) and Expert Team on Climate Change Detection and Indices (ETCCDI) [2]. These indices have been used in many studies for different regions around the world. The aim of the paper is to study spatial-temporal distribution of extreme precipitation on the Black Sea coast in period 1970-2015. Data and method. Daily precipitation data from 9 meteorological stations over the Black sea coast were analyzed. The period of observation is 1970-2015. Data were taken from the website of the European Climate Assessment & Dataset project. To characterize the possible change in extreme precipitation climatic extreme indices were calculated. Data quality control and indices calculation were performed by means of RClimDex software [3]. The slopes of the annual trends and their statistical significance to climate indices were calculated based on least square method (p-value < 0.05). The following indices were used: RX1day - Monthly maximum 1-day precipitation (mm); Rx5day - Monthly maximum consecutive 5-day precipitation (mm); SDII - Annual total precipitation divided by the number of wet days (defined as PRCP>=1.0mm) in the year (mm/day); R10 - Annual count of days when PRCP>=10mm (days); R20 - Annual count of days when PRCP>=20mm (days); CDD - Maximum number of consecutive days with RR<1mm (days); CWD - Maximum number of consecutive days with RR>=1mm (days); R95p - Annual total PRCP when RR>95th percentile (mm); R99p - Annual total PRCP when RR>99th percentile (mm); PRCPTOT - Annual total PRCP in wet days (RR>=1mm) (mm). Results. The values of the CDD index vary from 21 days in the Sochi region to 40-41 days on the western coast of the Crimea. The CWD index is characterized by the opposite picture - from 5 days on the western coast of Crimea to 8.6 days in the Sochi region. R10 and R20 indices are characterized by an increase in the Black Sea coast of the Caucasus (up to 52 and 26 days, respectively), in the Crimea indices are 9-15 days per year and from 2 to 5 days for the R20 index. The values of the R95p index vary between 83-365 mm with the maximum values in the Sochi region. The values of the R99p index are from 24 to 113 mm. The distribution is similar to the other indices. The annual values of the indices RX1day and RX5day are 29-89 mm and 46-158 mm per year, respectively. The RX5day index can serve as an indicator of events related to flooding. The indices PRSPTOT and SDII provide useful information on the relationship between changes in extreme conditions with other aspects of the distribution of daily precipitation. The annual precipitation (index PRSPTOT) varies from 1600 mm on the Black Sea coast of the Caucasus to 360 mm on the western coast of the Crimea. The intensity of precipitation (index SDII) is in the range from 5 to 13 mm/day. All indices except

CWD are characterized by the maximum values on the Black Sea coast of the Caucasus, which is explained by the features of the atmospheric circulation over this region. Most of the precipitation in the winter season in the study area is brought by cyclones from the Atlantic. Slopes of the Caucasus Mountains, facing the sea, retain moisture. Now consider the distribution of linear trends of the described extreme precipitation indices on the Black Sea coast for the period 1970-2015. The CDD index is characterized by positive significant trends in the Crimean peninsula. For the CWD index, there is a significant decrease in the values in the Crimea. Indices based on the absolute threshold (R10 and R20) tend to reduce the number of days in the Crimea. The index R99p is characterized by a decrease in the Crimea. The intensity of daily precipitation has a negative tendency in the Crimea. Indices RX1day and Rx5day did not show a clear pattern in the distribution of linear trends. Conclusions. The spatial-temporal distribution of extreme precipitation indices on the Black Sea coast for the period 1970-2015 was studied. For this purpose, 10 indices recommended by WMO were used. The analysis showed that the maximum values of the indices (except CDD) are located on the Black Sea coast of the Caucasus, which is due to the features of the atmospheric circulation over this region. Analysis of linear trends revealed a statistically significant increase in the CDD and CWD indices, and a decrease in R95p and SDII.

The reported study was partly funded by RFBR according to the research project № 18-35-00325.

Literature

1. IPCC, 2013. Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013. 1535 pp
2. *Karl T.R., Nicholls N. and Ghazi A.* CLIVAR/GCOS/WMO workshop on indices and indicators for climate extremes: Workshop summary. Climate Change. 1999. 42. P. 3-7.
3. *Zhang X., Yang F.* RClimDex (1.0) User Guide. Climate Research Branch Environment Canada. Downsview, Ontario, Canada, 2004. 22 p

EVALUATION OF PERMEABILITY FIELD OF MINING PROPERTIES BY COMBINATION OF STRUCTURAL ANALYSIS OF EARTH'S SURFACE FEATURES AND ANALOGUE PHYSICAL MODELING

V.A. Galkin

The interplay between the uppermost crust's permeability, fluid's volume, and composition variations determines whether the concentration of the valuable component occurs or not, i.e. whether mineralization traps (occurrences/deposits) form or not. Although this statement is a bit of an oversimplification, it is evident that for a given geological area the greater probability of mineralization may be expected within the more permeable zones of the area. This is particularly true when dealing with structurally controlled mineralization (*we put aside a geochemical barriers concept and permeable/impermeable rock contacts at this time*). Therefore, the search for potentially high permeability zones should be an important part of **greenfield and brownfield exploration.** Permeability is a 3D characteristic which is manifested (projected) on the surface (2D) mainly as linear features – faults, fractures, fracture assemblages, veins and vein stockworks, joints, geological contacts, water-channels, erosional landforms of various scales. Consequently, evaluating spatial distribution of the densities of all natural linear features and their intersections (weighted according to their importance) would give us ***General Exploration Target Maps***. The areas with the highest densities of these features would be the ***Targets*** for further exploration. Such study is conducted by ***Hierarchic Structural Lineament Analysis*** **(HSLA)** using satellite, aerial, radar, hyper-spectral images, topography, DEM, geophysical, geochemical, geological maps/data etc.

All the analyzed features have been forming during long geological history, and at each "moment" of their emerging they represented the potential pathways for the fluid flow. After their formation, they might have stayed active, or might have become inactive, sealed, or have been rejuvenated a number of times depending on their dimensions and their spatial positioning relative to the tectonic stress-field. *Fractures become opened (fluid pathways) or sealed (no fluid pathways) depending on their orientation to the main differential stress* Thus, the Maps generated by **HSLA** represent only a ***Cumulative Potential Permeability Field***. We need to go further and try to understand the ***interaction*** of the main structures, to examine and learn if there exists any repetitive pattern of dilation zones/ shearing/fracturing – ***Attractors of Deformation (Tectonic Concentrators).*** This examination is run by ***Analogue Physical Modeling (APM)***. The simulating (analogue) models of the geological block, with the cuts representing the main linear structures, are deformed repeatedly in different loading setups.

The photographs of the experiments (12 in elastic and 12 in plastic/rapture field separately) are analyzed. Dilation zones are outlined in each experiment. The stacking of the outlines of such zones onto each other gives us the opportunity to identify the areas with the highest proportion of the openings and fracturing (dilation). We call these zones ***Attractors of Deformation (Tectonic Concentrators).*** They also represent the most permeable zones in the area under study. As a result, the ***Modeling–Based Exploration Target Maps*** (separately for elastic and plastic/rapture fields) are built.

The final stage of the permeability field evaluation is to combine any available data (such as geological, geophysical, geochemical, prospecting and drilling) with our initial Target Maps to

produce ***Principal Exploration Target Map***. A resulting map (maps) outlines the priority areas where further exploration activities should be planned.

GEOLOGICAL INTERPRETATION OF DATA OF MAGNITOTELLURIC SOUNDINGS ON A PROFILE YALTA-NOVOSELOVKA

D.O. Desyatov, A.N. Stafeev

Lomonosov Moscow State University, Faculty of Geology (desyatovdm@rambler.ru)

Keywords: *Magnetotelluric soundings, Crimea, geologic-geophysical cross-section*

The Crimea is a complex structure in terms of geology. To date, the Crimea remains a geodynamically active zone, which necessitates the study of its deep structure, the identification of faults, and the evaluation of fluid and rheological subsurface regimes. The electromagnetic sounding method successfully solves structural problems. The equipment, methods and programs used for the processing and analysis of MT data, as well as for solving direct and inverse problems, correspond to the current world level. From January 28 to February 16, 2016, the geophysical company OOO North-West, in conjunction with the department of Geophysical Methods of Earth Crust Research at the Lomonosov Moscow State University, carried out experimental work using the method of magnetotelluric sounding (MTS) in the Crimea. The soundings were performed on a reconnaissance profile Yalta - Novoselovka in a volume of 30 physical points. The aim of the research is study of the geological structure of the Mountainous Crimea. Based on the results of the study, a geological and geophysical interpretation of the MT data was carried out with the use of a priori geological and geophysical information. The Bodraksky fault has been tracked according to geoelectric data up to the depths of 4-5 km earlier, on a fault the roof of high-resistance Paleozoic rocks of the Lozovsky zone is lowered by 1 km in relation to the Mountainous Crimea area [3] According to new data of MTS the fault is traced on depth over 30 km, he abruptly falls on the northwest at an angle the 80-85 deg. At depths of 4-15 km in the Lozovsky zone near the Bodraksky fault the anomaly of conductivity is found, which is presumably caused by a zone of cracking with fluids. The mountainous Crimean structural area is divided a Paleozoic ledge into two unequal parts in interfluve of Marta and Kacha rivers. In the northwest the Prokhladnensky upper-Tauric ($J_{1\text{-}2}$ tv_2) basin is located on the Paleozoic basis. In the southeast the Southern Crimean basin with a full section of the Tauric series (T_3-J_2tv) is located. Early-middle Jurassic upper Tauric suite contains lentyform bodies of the increased conductivity probably caused by fluids in pore space. These lentiform bodies should be considered as the facies of deltoid sandstones of large river system-Paleodon [2]. Except detrital cones of a northern slope of the Kachin basin, on his southern slope the independent detrital cone is allocated. In 5-7 km to the west of Yalta the zone of high conductivity is observed at a depth about 3 km under the Main Ridge of the mountainous Crimea, presumably it is early Pliensbachian deltoid deposits. Sediments presumably came from southwest direction. It is offered to allocate transitional (eskiorda?) suite between lower and upper Tauric suites with geoelectric parameters close to upper Tauric suite. The suite was formed since a salgyr phase of deformations [1] and partial closing of the late Triassic Southern Crimean flish basin in the second half of the Rhaetian.

Literature

1. *Moiseev A.S.* Novye dannye o verhnem triase Severnogo Kavkaza i Krymskoj ASSR // Dokl. AN SSSR. 1939. T.23. №8. p. 816-*817*
2. *Stafeev A.N., Suhanova T.V., Latysheva I.V., Kosorukov V.L., Plechov P.Y., Rostovceva Y.I.,* Smirnova S.B., Moroko A.A. Chenkskaya tolshcha peschanikov (nizhnyaya yura) Gornogo Kryma: stratigrafiya i usloviya osadkonakopleniya // Vestn. Mosk. un-ta. Ser. 4. Geologiya. 2014. № 5. p. 40-48.
3. *Hmelevskoj V.K., Kuz'mina Eh.N.* Glubinnoe stroenie Gornogo Kryma po dannym ehlektrorazvedki. // Ocherki geologii Kryma. Vyp. 1. – M.: izd. Geol. F-ta MGU. 1997. p. 177-1864.

THE KERCH AND TAMAN PENINSULAS COASTS UNDER ANTICIPATED SEA-LEVEL RISE

V.A. Dikaryov

Lomonosov Moscow State University, Faculty of Geology (dikarev@rambler.ru)

The World Ocean level observations show us that in recent decades it has been increasing at a rate of about 1.5 mm per year. The greatest estimates of its rise over the last century are 15-20 cm. During the same period, the average global surface air temperature rose by 0.55 C. Further, the growth rate of air temperature can significantly increase due to the accumulation of carbon dioxide, methane and some other "greenhouse" gases in the atmosphere. The United Nations Intergovernmental Panel on Climate Change issued a report in 2001 assessing the rise in the World Ocean level by 3-4 m till the end of the century [5]. At the same time a sea level change of even a few dozen centimeters will lead to catastrophic consequences for sea shores in certain regions [1]. One of the most revealing examples of the destructive effect on the sea coast is the coastal zone of the Taman Peninsula. The rate of retreat of the coastal ridges composed of loesslike loams in the northeastern part of the Azov Sea now reaches 5-8 m per year. The high sensitivity of the coasts to sea level changes in this region is due to several reasons [2]: • high level of economic development of coastal zones and concentration of population and economic objects directly on the sea coasts; • the predominance of sinking at a rate of 0.5 to 3 mm / year and, correspondingly, an increase in the influence of the rise in relative sea level in comparison with globally averaged estimates; • intensive retreat of coastal ridges formed by loesslike rocks, significantly enhanced landslides and other slope processes, as well as destruction of coastal accumulative forms of relief composed of detritus (shell) sand; • High sensitivity of natural steppe and meadow ecosystems and even higher sensitivity of anthropogenically altered ecosystems to changes in soil moisture, flooding and other processes associated with rising sea levels. Degree of stability of the coast in the studied area can be divided into the following categories: stable, relatively stable, unstable, extremely unstable. The general formula for the stability of the sea coasts: $A = V * (R_1 + R_2 + R_3 ... + R_n)$, where V - index of natural coast stability; R_n - various factors affecting the stability, such as anthropogenic load, the degree of processing of the primary relief, dangerous geomorphological processes taking place on this part of the shore, etc. [4]. In the aggregate of the above indicators, we have identified the following areas of greatest risk associated with expected sea level changes and its indirect consequences: (1) North-western part of the Taman Peninsula, "Chushka" spit; (2) The southern part of the Taman Bay, "Tuzla" spit; (3) The eastern coast of the Kerch Peninsula to the south from the "Kamysh-Burun" spit; (4) The northern part of the Arabat Bay; (5) "Arabatskaya Strelka" spit

This work was supported by Russian Foundation of Basic Research grant no.18-05-00296

Literature

1. Climate Change: The IPCC Scientific Assessment /Ed. by J.T.Houghton et al. N.Y. e.a.: Cambridge Univ.Press. 1990. 365 p.

2. *Selivanov A.O.* Possible future coastal evolution of the north Black Sea and the Sea of Azov coasts under greenhouse-induced sea-level rise: Quantitative estimates of shoreline retreat and risk assessment analysis //Proc Int. Conf. Coastal Change'95. Bordeaux: Bordomer-IOC, 1996. V.1. pp. 44-59
3. *Zenkovich V.P.* Morfologiya i dinamika sovetskih beregov Chernogo morya. M.: Izd-vo AN SSSR, 1962. 710 p
4. *Kaplin P.A.., Selivanov A.O.* Izmeneniya urovnya morej Rossii i razvitie beregov: Proshloe, nastoyashchee, budushchee. M.: GEOS, 1999. – 299p.
5. *Selivanov A.O.* «Beregovaya katastrofa» na Azovskom more: Mif ili real'naya ugroza? M.: GEOS, 2001. – 84 p

TRANSFORMATION OF BIOMASS OF ALGAE CHLORELLA SP. IN HYDROTHERMAL CONDITIONS

O.S. Ermina

Lomonosov Moscow State University (oermina6@yandex.ru)

Keywords: *bio-oil; algae; Chlorella Sp.; elements;, XRF; nickel; mineral phases.*

In recent years development of fields of non-conventional hydrocarbons is actively stepping up. A lot of research of transformation of various types of algae into oil has been carried out. Optimal temperature of hydrothermal treatment [4,5,3], effects of added catalysts [1], increased oil output by risen heating rate [2] were studied, also oil production from different algae species and differences of output were investigated [5,6]. In these papers the possibility to obtain a mixture of hydrocarbons similar in composition to natural heavy oil or bitumen from algae biomass has been demonstrated. In this research organic composition of products was not studied in details. The mixture of hydrocarbons obtained from hydrothermal treatment of algae biomass in this paper is called "oil". Algae Chlorella sp. were used as precursor. This type of organic matter was chosen due to algae being a major source of organic compounds for oil formation in nature. Chlorella sp. is easily cultivated and thus readily available. Main objective of this research is to study peculiarities of oil production from biomass of algae Chlorella sp. using hydrothermal treatment and the distribution of elements in water-biomass-oil system. Experiments on hydrothermal treatment of algae Chlorella sp. were carried out. The effects of duration of treatment, minerals and solution composition on oil production were studied, also elemental analysis of algae and obtained oil was made. Total of 22 experiments were conducted, obtained oil from 8 of them was analyzed via X-ray fluorescence method using Niton FXL-950. All experiments were carried out in Experimental geochemistry lab of Faculty of geology of MSU. Samples undergone treatment at 300°C and water vapor pressure. These values were used in consideration of previous work [7] where parameters of maximum oil production by hydrothermal treatment of rocks were studied. All experiments were conducted using 20 ml titanium crucibles. Aqueous solution and algae tablets (in some experiments with mineral phases) were placed in crucibles. Then closed, they were put in preheated to 300°C furnace for a certain amount of time (1, 3, 7 and 28 days), after that they were taken out, cooled off and opened. To extract oil, 5 ml of hexane were poured into crucibles, and then their contents were washed off with distilled water. In separatory funnel, the organic layer with hexane was separated from the aqueous solution. After evaporation of hexane, the mass of oil was determined. Then, forty-fold volume of hexane was poured into the glasses with oil, then, after 24 hours, everything was filtered through a paper filter into the weighing bottles, and the rest was filled with chloroform and filtered into another weighing bottles. The extracts were then evaporated at room temperature under fume hood and the amounts of maltenes and asphaltenes were determined. A total of 5 series of experiments (4-5 experiments in each) on hydrothermal transformation of algae Chlorella sp. were conducted. The first series (C-1) was kinetic, the second (C-3) - with different mineral phases, the third (C- 4) - with the addition of hematite and magnesium sulfate, the fourth (C-5) - with a multi-element standard solution for ICP: ICP-MS-68A-A, Solution A, and the the (C-6) - with an acidified solution of nickel chloride. According to results, time of exposure affects the composition of obtained

hydrocarbons: malten part increases while asphalten part decreases. Also, it has been shown that mineral phases slightly reduce the yield of oil but at the same time accelerate the process of oil ripening. The study of occurring sulfate-reducing process allowed us to conclude that, in the presence of hematite, sulfate ion at certain concentration increases the yield of oil, and at concentration higher than this sulfate reduction inhibits oil formation. A series of experiments with multi-elemental solution was carried out to study distribution of elements between aqueous and hydrocarbon phases. Elemental analysis of products showed that Zn, Ni, Fe, Ca, K, S and Cu are distributed in oil. Biomass of algae Chlorella Sp. contains Zn, Fe, Ca, K and S. Thus Ni and Cu concentrate in oils from solution. Also, a series of experiments using acidulous solution of $NiCl_2$ was conducted. Elemental analysis of output oil showed that concentration of Ni rises along with increment of added Ni in solution.

The work was supported by the Russian Foundation for Basic Research, project 18-05-00818.

Literature

1. *Anastasakis K., Ross A.B.* Hydrothermal liquefaction of the brown macro-alga Laminaria Saccharina: Effect of reaction conditions on product distribution and composition // Bioresource Technology 102, 2011, pp. 4876–4883
2. *Bach Q.-V., Sillero M.V., Tran K.-Q., Skjermo J*. Fast hydrothermal liquefaction of a Norwegian macro-alga: Screening tests // Algal Research 6, 2014, pp. 271–276
3. *Biswas B., Kumar A.A., Bisht Y., Singh R., Kumar J., Bhaskar T. Effects* of temperature and solvent on hydrothermal liquefaction of Sargassum tenerrimum algae // Bioresource Technology 242, 2017, pp. 344-350
4. Chen W.-T., Zhang Y., Zhang J., Yu G., Schideman L.C., Zhang P., Minarick M. Hydrothermal liquefaction of mixed-culture algal biomass from wastewater treatment system into bio-crude oil // Bioresource Technology 152, 2014, pp. 130–139
5. *Chiodo V., Zafarana G., Maisano S., Freni S., Urbani F.* Pyrolysis of different biomass: Direct comparison among Posidonia Oceanica, Lacustrine Alga and White-Pine // Fuel 164, 2016, pp. 220–227
6. *Reddy H.K., Muppaneni T., Ponnusamy S., Sudasinghe N., Pegallapati A., Selvaratnam T., Seger M., Dungan B., Nirmalakhandan N., Schaub T., Holguin F.O., Lammers P., Voorhies W., Deng S.* Temperature effect on hydrothermal liquefaction of Nannochloropsis gaditana and Chlorella sp. // Applied Energy 165, 2016, pp. 943–951
7. *Bychkov A.Y., Kalmykov G.A., Bugaev I.A., Kozlova E.V.* Ehksperimental'nye issledovaniya polucheniya uglevodorodnyh flyuidov iz porod bazhenovskoj svity pri gidrotermal'nom vozdejstvii // Vestnik Moskovskogo universiteta. Seriya 4: Geologiya, 2015, № 4, p. 34-39

THE MODERN GEODYNAMICS AND ITS INFLUENCE ON THE COLLECTOR SECONDARY FILTRATION CHARACTERISTICS

V.A. Zaitsev[1], L.V. Panina[2]

Lomonosov Moscow State University, Faculty of Geology ([1]- v.zaitsev@mail.ru,[2]- panina53@mail.ru)

Keywords: *geodynamics, oil and gas fields,fluid permeability*.

Distribution of increased fractures zones and because of a fluid permeability depends on the modern geodynamic activity, which usually shown in the form of the latest dislocations reflected in a relief, the increased values of a heat flow and seismicity. The main goal of this project is the detection technology development to find out of the increased fracture and permeability zones in the young and ancient platform sedimentary basins. 3D geodynamic modeling allows estimating deformation process at the quantitative level. Experience of works allows saying that when developing many oil and gas fields it is necessary to consider existence of natural fractures of productive layers. At the same time, there is a need to define which share of a fluid stream will filtered through fractures (a secondary permeability) and which part from an intergranular porosity (matrix permeability of a classical collector). In case when fractures have the considerable thickness and degree of aperture, their influence can be defining for the layer fluid permeability. A ratio of a matrix and secondary permeability is individual for each oil and gas tank. Let us especially note the importance of studying of the modern tension field as it often imposed. To estimate the elastic and plastic deformations we used the specialized program RMSFracture module of the ROXAR company. Using this technology allowed to integrate various structural and geological information to construct physically reasonable discrete model of fractures and then apply of the double space method to predict of the filtration and capacitor rocks properties. Let us review examples of the secondary permeability estimates executed for various types of the deposits. Beginning to estimate of the Northern Buzachi (Prikaspy), oil and gas deposit [1]. As the result of the executed researches established that this deposit is under the modern shear tension field with southeast orientation of the maximal compression axis. It was succeeded to set eight parameters defining emergence of the new fractures or change of the aperture of the existing ones by means of geomechanical model. Using these parameters, the analytical model of fractures was constructed and then a fracture permeability forecast was made. The executed comparison of the obtained data with mining characteristics of 220 wells allowed establishing that the fracture permeability makes considerably a larger contribution to the common permeability than porosity. Let us note that data received by of the double space method added by the effective layers thickness have quite high correlation with the maximal naphtha outputs - K=0.6. This circumstance proves reliability of the offered fractures model and therefore assessment of the rocks secondary fluid permeability. The Danilovsky oil-gas condensate field (Irkutsk region) belongs to the complicated structures where outputs of the close located wells differ markedly from each other. The revealed correlation between geodynamic parameters and character wells work allows assuming that for this field the secondary (fracture) pore permeability is very significant so underestimation of these parameters can lead to serious mistakes when developing a deposit. Thus, efficient filtration and capacitor properties of this field collector represent "sum" of primary and secondary pore system

and permeability. The key moment for a comprehension of the fluids migration nature within Eastern part of the Danilovsky field are faults which can be the hydrogeological barriers defining the VNK position on the one hand or create channels of the hydrocarbons migration on the other hand. The research of filtration streams executed by method of pumping labeled liquids allowed to install the main channels of migration however did not explain the reason of their emergence. The constructed of the secondary permeability map allowed explaining location and a channel capacity of these channels more reliable. The complicated tectonic structure of the Okhotsk Sea shelf and high geodynamic activity with presence of not anticlinal type productive complexes traps make necessary to use the express technologies for studying of the secondary filtration and capacitor properties of collectors. For example, the technology of assessment of the secondary fluid rocks permeability realized in the Kirinsky, Ayashsky and East Odoptinsky site of license blocks [2]. Because of researches, it was established that the contribution of the secondary permeability values into total (or efficient) permeability of the different layers is unequal. So for example, it supposed that Cretaceous basement is characterized by presence of the cavernous and fracture tank where the secondary permeability is equal to the total one. A contribution of a secondary permeability of The Eocene- Late Oligocene Machigarsko-Dayekhuriinsky complex with the crack-pore tank prevails and therefore the areas with high values of the secondary permeability are perspective for searching of oil and gas fields. The component of the secondary permeability becomes less in the lying above Early-Middle Miocene layers also characterized by a fracture-pore collector. A role of a secondary permeability significantly below for mainly terrigenous Upper Miocene-Pliocene layers with the pore tank nevertheless it needs to be considered. Development of the shale formations hydrocarbons resources is one of the perspective directions of the modern world oil and gas branch. Shale collectors are characterized by a dispelled state of the hydrocarbons in the rocks with very low matrix permeability. Degree of the permeability of the Hadumsky layers in the Central and Eastern Ciscaucasia is dependent on their fractures determined by the deposits type, degree of their disturbance and tectonic tension [3]. 3D geodynamic model of the studied territory allowed executing assessment of the secondary permeability of the Hadumsky petromaternal strata. The revealed sites of the increased values of a permeability are optimum for extraction of slate naphtha and gas.

Literature

1. *Zajcev V. A.* Ispol'zovanie geomekhanicheskoj modeli neftegazovogo mestorozhdeniya dlya ocenki vtorichnoj pronicaemosti // Tezisy nauchno-prakticheskoj konferencii "Problemy razrabotki neftyanyh mestorozhdenij v usloviyah sil'nyh plastovyh i flyuidal'nyh neodnorodnostej. Tyumen', 2015. p.1-2.
2. *Zajcev V. A., Kerimov V. Y., Ryabuhina S. G., Bondarev A. V.* Sovremennaya geodinamika i ee vliyanie na vtorichnye fil'tracionnye svojstva kollektorov severo-vostochnoj chasti Sahalinskogo shel'fa //Vestnik Moskovskogo universiteta. Seriya 4. Geologiya. № 5. M.: MGU, 2017. p.16–23.
3. *Kerimov V. YU., Mustaev P. H., Dmitrievskij S. S., Zajcev V. A.* Ocenka vtorichnyh fil'tracionnyh parametrov nizkopronicaemyh slancevyh tolshch majkopskoj serii central'nogo i vostochnogo Predkavkaz'ya po rezul'tatam geomekhanicheskogo modelirovaniya // Neftyanoe hozyajstvo. № 9. M.,2016. p.18–21.

EVOLUTION AND RECENT STRUCTURE OF THE EASTERN PART OF THE INDOLE-KUBAN FOREDEEP

V.A. Zaitsev[1], L.V. Panina[2]

Lomonosov Moscow State University, Faculty of Geology ([1]- v.zaitsev@mail.ru,[2]- panina53@mail.ru)

Keywords: *Structural and geomorphological research, subsidence curves,back-stripping analysis,tectonic movements, faults*

The study area covers the West-Kuban part of the extensive Indol-Kuban foredeep traced from the south - eastern part of the Crimea through the Azov Sea to the Western Ciscaucasus. The boundary between the western Indolian part of the foredeep and the eastern West Kuban one is the submeridional Kerch-Taman fault. The south border of the West-Kuban depression with the Great Caucasus orogen is the Akhtyrsky fault expressed in a relief, the Novotititarovsky (Timashevsky) fault is the northern boundary of it with the Timashevsky Step. The eastern limitation of the West-Kuban depression is the submeridional fault separating it from the Maikop (Adyghe) uplift and in the west it opens into the Azov Sea. Its relief is a plain with absolute elevations from 0 to 200 m decreasing towards the Azov Sea. The depression inherits the Slavyan-Ryazan trough with Paleozoic basement top more than 11.5 km. The deep structure is complicated in the central part by the Anastasievo-Krasnodar anticline and the Shapsugo-Absheron swell in the east. The depression is filled by multi-kilometer Mesozoic and Cenozoic deposits. The Cenozoic deposits are represented by the lower thin Oligocene-Lower-Miocene (Maykopian) molasses and the upper coarse (Midlle Miocene-Quarter) one. The thickness of the molasses formations is more than 6 km in the central part of the depression. According to the geological and geophysical data, the Maykopian (Oligocene-Lower Miocene) base stepped falls from 2 km in the east to 6 km and more in the west. Structural and geomorphological research added by back-stripping analysis carried out to study the evolution of the West-Kuban basin and its modern structure. Back-stripping method allowed us to estimate the tectonic movement amplitudes as for geological history intervals as for entire new stage to construct the newest tectonics map and to show the evolution of the West Kuban basin development and its complicated structures. The existing geological and geophysical materials added with the tectonophysical modeling used. The subsidence curves show that starting from the Oligocene a general North Caucasus trough stretching from the Black to the Caspian Sea occurred on the southern edge of the Scythian plate in front of the rising the Great Caucasus mountainous structure. Later the evolution and complication of its structural plan took place resulted in the Western part of the Kuban trough formation and separated the West Kuban depression from the East Kuban one in the Late Miocene (Meotian - Pontian). In the Early and Middle Miocene (Tarkhanian - Konkian) subsidence rate decreased and the elevation took place. In the Early and Middle Miocene (Tarkhanian - Konkian) during the Chokrakian - Karaganian the territory of the West Kuban basin experiences subsidence especially in the Late Sarmatian when rates increase. In the Late Miocene (Meotian-Pontian) the subsidence rate decreases in the central part of the depression, while the area in the east (the East Kuban basin) is involved in a raising. In the Pliocene- Anthropogene the subsidence rate increases and the West-Kuban depression takes a modern outlines. It is established earlier that the impulses of slowing down subsidence or uplift

correlate well with the phases of the Great Caucasus compression [1]. The late orogenic structure of the West Kuban basin is a combination of the local uplifts and depressions of different rank and amplitude complicated by the submeridional and sublatitudinal orientations lineaments and faults described earlier [4]. According to back-stripping analysis, the maximum amplitudes of the latest tectonic movements (from the Late Sarmatian to the Quarter) reach 1500 m and are located in the southwestern region bordering the Azov Sea [2]. A feature of the modern structure of the West Kuban trough is its "gradation" both in latitudinal (from the south to north) and in the meridional (from east to west) direction which expressed in relief in the form of the relative to each other raised and lowered blocks involved into moving at least from the Middle Miocene [4]. The blocks divided by faults, fracture zones so called lineaments or "weak zones" (the term of N.P. Kostenko) of sublatitudinal and submeridional strike. These zones inherit more deep complexes ancient dislocations of the West-Kuban depression itself and cross the mountain structure of the Greater Caucasus. Among the submeridional we identified Ust-Kuban, Novorossiysk, Divnomorsky, Krasnodar, Novomikhailovskaya, Ust-Labinskaya and Maykopskaya ones which can be interpreted as the faults with a shear component as evidenced by tectonophysical modeling [3]. Many of them correlate with the basement faults. The modern structure of the West Kuban basin is forming with the Greater Caucasus orogen under stress on the background of its growth while the compression axes have a north -eastern strike resulting in the renewal of the ancient dislocations and the formation new ones. The activation of deformations indicated by such geodynamic processes as horizontal and vertical tectonic movements, seismicity, increased of the heat flow values especially in the east of the depression. It is established correlation of the modern dislocations with the oil and gas field location too.

Literature

1. *Mikhailov V.O., Panina L.V., Polino R., N.V. Koronovsky, E. A.Kiseleva, E.I.*Smolyaninova Evolution of the North Caucasus foredeep: constraints on the analysis of subsidence curves // Tectonophysics. № 307. Elsevier BV,1999. Pp. 361 – 379
2. *Panina L.V.* Modern structural patten of the Scythian Plate // Moscow University Geology Bulletin.V.64. № 1. Allerton Press, INC, 2009. Pp. 21-29
3. *Zaitsev V.A., Zlatopolsky A.A., Panina L.V*. Modern Topography of the Scythian Plate as Evidence for Deformations in the Crystalline Basement // Moscow University Geology Bulletin.V.68. № 6. Allerton Press, INC, 2013. Pp.339-344
4. *Kostenko N.P., Panina L.V.* Pozdneorogennaya struktura Predkavkaz'ya // Vestnik MGU. Ser. 4. Geologiya. № 1. M.: MGU, 2001. p.11-20

DANGEROUS GEOLOGICAL AND GEOMORPHOLOGICAL PROCESSES ON THE TERRITORY OF SEVASTOPOL

V.V. Zorina

Moscow State University Branch in Sevastopol (victoria.zorina10@gmail.com)

Keywords: *relief, dangerous processes, morphometric analysis, GIS-technologies, natural resource management*

Often a human, transforming the territory to form an environmental management system, does not try to take into account its features, which then may negatively affect not only the appearance of the area, but also affect the life and safety of the person. A competent analysis of these features is able to suggest how the chosen territory will behave when transformed and used. Particular attention should be given to the relief. Relief is one of the main factors that determine the landscape differentiation of the territory and determine the potential structure of land categories. It plays a huge role in shaping the external appearance of the territory: both natural processes that change the terrain, and the transformations carried out by man make it unique [1]. Because of the diversity of the relief forms on the territory of Greater Sevastopol, the geological and geomorphological dangers of the region are a significant part of all natural disasters. Among them is worth highlight: gravity processes (landslide, scree, landslide), abrasion, karst, mudflows, earthquakes and others [2]. This served as the basis for the separation of engineering and geographical areas. Also, for zonation, the morphometric characteristics of the relief were taken into account: the slope angles of the surface, the slope exposition, the intersection index, the relief subdivision, and many others. The morphometric analysis was carried out using the digital relief model (DEM) and the model processing modules in the GIS. Technologies of geographic information systems greatly enriched the tools of morphometric analysis, especially on the basis of detailed topographic data, which allow building qualitative digital terrain models (DEM). The development of morphometric analysis tools is conditioned by the needs of structural-geomorphological mapping, which are formalized in the presence of qualitative topographical data that allow analysis of relief characteristics, generalize characteristics for identifying typical forms and typological zoning of the terrain [3]. Also, the application of GIS gave impetus to the development of modern explanatory morphometry of the relief, which is aimed at revealing the connections between the quantitative characteristics of the relief and its origin. For the sake of completeness of the idea of the activities already underway, the following types of nature use have been identified and analyzed in the coastal areas of the Sevastopol region: mining land, water supply, road, forestry, hunting sea, transport and marine, residential, cultural and memorial, sports and health, medical and health resorts , recreational, water protection, nature protection, special [4]. The use of coastal areas requires an integrated approach to the consideration of its various aspects, including the special features of the formation of the relief (the geographical aspect of nature management). In accordance with the allocated engineering and geographical areas, an assessment was made of the appropriateness of carrying out human activities within their boundaries.

Literature

1. *Zvorykin K.V.* Geograficheskaya koncepciya prirodopol'zovaniya / K.V. Zvorykin // Vestn. Mosk. un-ta. Ser. 5. Geografiya. 1993. №3. p. 3 – 15.
2. *Makeev V.M., Karfidova E.A., Makarova N.V.* Instrumental'nyj blok morfometricheskogo analiza v modeli strukturno-geomorfologicheskogo kartografirovaniya (na primere Ostroveckogo rajona Belarusi) / Makeev V.M., Karfidova E.A., Makarova N.V. // Geologiya i poleznye iskopaemye chetvertichnyh otlozhenij: materialy VIII Universitetskih geologicheskih chtenij, Minsk, 2014.-82 p.
3. *Novikov A.A., Kashirina E.S., Belokon' V.V.* Geologo-geomorfologicheskie opasnye processy kak faktory ugroz dlya osobo ohranyaemyh prirodnyh territorij g. Sevastopolya / A.A.Novikov, E.S.Kashirina, V.V.Belokon' // EHkologicheskaya bezopasnost' pribrezhnoj i shel'fovoj zony i kompleksnoe ispol'zovanie resursov shel'fa. – 2014. – №29. – p. 61-70.
4. *Simonov Y.G.* Ob"yasnitel'naya morfometriya rel'efa: uchebnoe posobie / Moskovskij gosudarstvennyj universitet im. M.V. Lomonosova. Moskva, 1999. 263 p.

A GENERALIZED MODEL OF THE "POROSITY-CLAYINESS" COMPARISON OF TERRIGENOUS SEDIMENTARY ROCKS OF THE WEST SIBERIAN OIL AND GAS PROVINCE

K.K. Izmajlov

Federal State Budget Educational Institution of Higher Education « Industrial University of Tyumen» (ikka36@mail.ru)

Clayiness is one of the most significant characteristics that affects on the filtration-capacitive and physical (petrophysical) properties of sedimentary rocks. The presence of clay material degrades the filtration and capacitance properties of rocks: reduces porosity and permeability and leads to an increase of residual water saturation. Clay minerals have a high specific surface, which determines their high adsorption capacity and causes the clay influence on such petrophysical characteristics of rocks as specific electrical resistance (surface conductivity), natural electrochemical, filtration and induced electrochemical activity, natural radioactivity, and neutron characteristics of rocks. The purpose of this work is to identify the main regularities of the influence of clayiness on the porosity of rocks that form a section of the West Siberian Plain and assessment of applicability of the known models of "clayey-porosity" comparisons. The first ideas about the interconnection between porosity and dispersed clay were formulated by V.N. Kobranova in 1962 on the basis of experimental data obtained by V.V. Okhotin back in the 30s. These representations served as the basis for further modeling of the clayiness of sedimentary rocks. In particular, V.N. Dakhnov (1975) presented an empirical equation describing these experimental data. Where Кр.cl=0, и Кр.cl – are porosity coefficients of the "clean" non-clay rock and "pure" clay; Кcl* is the clayiness, including the volume of pores in clay. Bulk clayeyness is Кcl=Vcl/V, where Vcl – volume of clay fraction (without pores) and V is the total volume of rock. The development of this model for dispersed, layered and aggregate clay was considered by B.Yu. Wendelstein (1966), incl. in co-authorship with Kosterina (1998), as well as R.A. Rezvanov (2002) and other blighty specialists. As a result, the notions of relative clayiness were introduced: ηcl= Кcl/(Кcl+Кр), where Кп is porosity) and the relative content of clay interlayers χcl=Σhcl/htot in the thickness of the layered pack (where hcl is the thickness of the clay interlayers, htot is the total thickness of the layered pack). The type of the «porosity– clayiness» comparison model for a layered pack and the identity of this model for the case of aggregate clayiness were substantiated. Similar researches were conducted by foreign specialists. We note the "Thomas-Stieber" cross-plot «porosity-clayness» comparison, proposed in 1975 by E.C. Thomas, S.J. Stieber. It is built for specific object with the parameters pure Кр.cl=0 = 34%, and Кр.cl = 16%. In this case, the proposed cross-plot violates the condition of material balance, according to which the sum of the volumes of the solid phase (Vsf) and pore space of rocks (Vp) can not exceed the volume of the rock (V). In addition, the area of aggregate-layered clayiness allocated on it contradicts the obvious physical concepts of the strength properties of clay aggregates, which, in the opinion of the authors of the cross-plot, make it possible to ensure that the rock porosity is up to 40-45%. To solve the problem under consideration, the results of petrophysical core researches (more than 4 100 samples) covering the entire sedimentary cover of Western Siberia ranging from 800 to 3000 m, were summarized. An analysis of this data was carried out for 200 m section intervals. In total, 11 such intervals were allocated. The results of the performed comparisons and their analysis made it

possible to establish the main characteristics of the rocks of the section and the regularities of the "porosity-clayeyness" model. The porosity of pure rocks from top to bottom along the section under consideration decreases from 40-42% to 20-22%; The porosity of "pure" clays varies from 24% to 7%, respectively. The minimum clay content of rocks is in the range from 1.5% to 2%, regardless of the depth of occurrence of rocks, its maximum values are 60 -70% and somewhat decrease with the growth of the depth of occurrence of rocks. At low values of clayiness (Kcl<5%), the primary effect on the porosity of pure rocks is provided by the grading coefficient of the grains of the rock. In this case, the porosity of "pure" non-clay rocks can be reduced by 2-2.5 times the maximum value. The parameters of the following clay models of sedimentary rocks are substantiated: a) dispersed, with the distribution of clay material within the pore space (between the grains of the rock), described by the size of the porosity of the skeleton (Kp.sk= Kp.cl*Kp); b) dispersed, with the distribution of clay material in the contact areas of the grains of the rock skeleton (with intercontact clay) leading to an increase in the porosity of the skeleton; c) dispersed, with a mixed character of the distribution of clay material both in the intergranular space and at the contacts of grains; d) layered clay, the properties of which are determined by variations in the thickness of the interlayers of "clays" and "sandstones". The concept of "basal" clayeyness and its correspondence to the minimum values of the porosity of the clay rock are substantiated. The range of the boundary clayeyness of reservoirs is substantiated, the possibilities of its determination are demonstrated. The revealed features of the clay model allow to increase the reliability of petrophysical modeling in the geological interpretation of GWL (Geophysical well logging) materials. Scientific adviser of works, associate professor of TYIU, V.G. Mamyashev

THE METHOD OF INTEGRATION SEISMIC DATA AND AEROGEOPHYSICAL SURVEY TO ANALYZE THE PROSPECTS OF OIL AND GAS POTENTIAL OF VOLGOGRAD REGION.

R.I. Kamaleeva, O.V.Krylov

Lomonosov Moscow State University, Faculty of Geology (kamaregina@yandex.ru)

Keywords: *integration, aerogravimetric survey, aeromagnetic survey, seismic data, oil and gas prospects*

The study of unexplored territories of our country began in the middle of the last century, and by now almost all oil and gas prospective areas in Russia have been studied in detail. In this regard, the main geological tasks need to be addressed not in the direction of the accumulation of new information, but in the direction of further more in-depth study of the already available data. It is important to emphasize that the joint use of geological and geophysical data greatly increases the reliability of forecasting the main promising oil and gas structures. The integration of seismic exploration with other geophysical methods is an effective solution to such problems. The aim of the work is to identify the prospects of oil and gas content of the subsalt deposits of the northwest side of the Caspian depression by complex interpretation of aerogravimetric and aeromagnetic metods together with seismic data of 2D and 3D. The subject matter for the forecast of hydrocarbon deposits location is the territory belonging to the Volgograd area. The investigated territory in the regional tectonic plan is located within the Caspian depression, and only a small west part of the area is in the zone of its junction with the southeast end of the East European platform. The area of work is characterized by a complex geological structure (the presence of large tectonic elements with an unequal history of development and active salt movement) [1]. The sedimentary cover is divided into three structural floors: subsalt, salt and suprasalt. The following oil and gas complexes of the Paleozoic are distinguished at the Volgogradsky site as the most prospective : Middle-Upper Devonian; Vise-Bashkirian stage; Lower Permian carbonate-sulfate and carbonate deposite. One of the areas of exploration is lithological and stratigraphic traps, but the main prospects for the oil and gas potential of the area are associated with reef-building structures, which were outlined according to 2D seismic data. But within the limits of reefogenic objects, there are usually no clear reflecting boundaries on seismic data. The wave pattern is often fuzzy. In such conditions, anomalies of fields obtained from gravimetric and magnetic survey data may become an alternative to seismic attributes. 2D seismic profiles were compared with maps of gravity and magnetic anomalies. Structural construction were made on the main reflecting horizons characterizing the subsalt complexes of deposite: P1ar; C2b1; C1bb; D3fm. Within each structural floor, prospective structural and non-structural objects have been identified, the ranking of objects has been done by reliability, the main directions of geological exploration have been determined.

Literature

1. *Aleshin V.M., Ermakov V.A.* O prirode bortovogo ustupa Prikaspijskoj vpadiny// Geologiya nefti i gaza. M., 1975.

THE METHOD OF PHYSICAL MODELING IN THE STUDY OF THE PATTERNS OF DEVELOPMENT OF DESTRUCTIVE ZONES OF THE LITHOSPHERE

A.A. Karimova, S.A. Bornyakov

Institute of the Earth's Crust SB RAS (tarasova2712@gmail.com)

Keywords: *physical modeling, fault, faulting, deformation, shear zone*

Various problems of fault formation have been studied for a long time. If we talk about the study of destructive zones of the lithosphere (DZL), then general representations about the laws of their development are presented in a series of experimental works [7,9, and others]. As for determine the deformation patterns in the dynamics the patterns of the deformation development dynamics of individual fracture in DZL and the factors that determine them, today the development of these issues is at an early stage [2,3]. To date, the study of deformation dynamics of destructive zones through instrumental observations of specific active faults is unpromising due to the long duration of their development, insufficient level of the instrument base and a number of other objective reasons, and therefore, to obtain the necessary information, it is preferable to use different types of modeling [4,8,3]. The physical modeling of the process of formation of the destructive shear zone is carried out and a detailed study of the deformation dynamics of the internal structure of the fracture systems is carried out in order to clarify the conditions and mechanisms of selective activation and to study the wave dynamics of deformations in a large shear zone. The standard procedure of preparation and carrying out of experiments described in [3] was used in the simulation. A water paste of montmorillonite clay was used as a model material, the rheological properties of which have been studied in detail and described in a special edition [6]. Experiments on the modeling of the formation of DZL have been carried out with observance of similarity conditions [5, 8]. Based on the results of experiments involving several series of experiments with different boundary conditions, the deformation dynamics of the internal discontinuous-block structure of shear zones formed in elastic - viscous - plastic models of the lithosphere was studied. According to the results of processing and interpretation of the results, the following conclusions are obtained: 1) Each separate fracture in the shear zone has a segment deformation activity varying along the strike, the reason for which is the different deformation dynamics of deformations in the adjacent blocks due to the transit slow deformation waves. 2) The deformation evolution of the internal discontinuous-block structure of the shear zone occurs as a periodic process represented by a different-scale time sequence: stage-phase-periods-single variations. 3) Deformation waves, that originate outside the shear zone in the form of localized fronts, enter the fault zone and, as they move along it, disintegrate into a series of separate wave fragments moving to blocks at different speeds. The discrepancy at the time of displacement of fragments deformation waves in a contiguous block generates the complex dynamics of differently directed shifts in the interblock fracture. 4) The dimensionally-temporal dynamics of deformation waves in the shear zone is determined by the degree of development of its internal discontinuous-block structure, the level of stresses accumulated in it, the viscosity of the model material, and the rate of its deformation.

Literature

1. *Bornyakov S.A., Semenova N.V.* Dissipativnye processy v zonah razlomov (po rezul'tatam fizicheskogo modelirovaniya) // Geologiya i geofizika. 2011. T. 52. № 6. p. 862-870.
2. *Bornyakov S.A., Seminskij K.Zh., Buddo V.Y., Miroshnichenko A.I., Cheremnyh A.V., Cheremnyh A.S., Tarasova A.A.* Osnovnye zakonomernosti razlomoobrazovaniya v litosfere (po rezul'tatam fizicheskogo modelirovaniya) // Geodinamika i tektonofizika. 2014. T. 5. № 4. p. 823–861.
3. *Bornyakov S.A., Truskov V.A., Cheremnyh A.V.* Diccipativnye ctpuktupy zon pazlomov i kpitepii ix diagnostiki (po rezul'tatam fizicheskogo modelirovaniya) // Geologiya i geofizika. 2008. T. 49. № 2. p. 179-187.
4. *Bykov V.G.* Deformacionnye volny Zemli: koncepciya, nablyudeniya i modeli // Geologiya i geofizika. 2005. T. 46. № 11. S. 1176-1190.
5. *Gzovskij M.V.* Osnovy tektonofiziki. M.: Nauka. 1975. – 536 p.
6. *Seminskij K.Zh.* Vnutrennyaya struktura kontinental'nyh razryvnyh zon: tektonofizicheskij aspekt. Novosibirsk: Izd-vo «GEO». 2003. – 244 p.
7. *Seminskij K.Zh.* Strukturno-mekhanicheskie svojstva glinistyh past kak model'nogo materiala v tektonicheskih ehksperimentah. Irkutsk. 1986. – 130 p.
8. *Sherman S. I.* Fizicheskij ehksperiment v tektonike i teoriya podobiya // Geologiya i geofizika. 1984. № 3. p. 8–18.
9. *Sherman S.I., Seminskij K.Zh., Bornyakov S.A.* i dr. Razlomoobrazovanie v litosfere: zony sdviga. Novosibirsk: Nauka. 1991. – 261 p.

APPLICATION OF FULL WAVEFORM INVERSION METHOD FOR RECONSTRUCTION OF SEISMIC WAVE ABSORPTION IN VISCOELASTIC MEDIA

A.V. Kirilenko

IPGG SB RAS (alexkirnsu@gmail.com)

Keywords: *forward modeling in viscoelastic media, inverse seismic problem, generalized standard linear solid, tau-method, quality factor*

In and out of laboratory experiments (such as field investigations) confirm the existence of seismic wave absorption. This makes a significant contribution to peculiarity of development and wave propagation. Kramers-Kronig fundamental law states that the existence of absorption leads to wave package dispersion for any physical process, which satisfies causality principle. Therefore, incorrect description of observed wave fields is the result of ignoring absorption. For this reason, finding the correct inverse problem solution in case of real data without taking absorption into account is absolutely impossible. Real data always involves wave field absorption and dispersion. At the moment there are vast range of rheological models, which take absorption into account in viscoelastic media. Most popular of them are the Kolsky-Futterman model [1,2], the Kelvin-Voigt model [3], standard linear solid (SLS) [4] and its generalization (GSLS) [5]. Absorption and dispersion effects usually are characterized by the value of quality factor Q. The quantity is loosely defined as the number of wavelengths a wave can propagate through a medium before amplitude has decreased by $e^{-\pi}$. In the work [6] was shown that quality factor is essentially constant as a function of frequency (in case of low frequency 1-200 Hz). Consequence of this fact is dispersion relation from the article [2]. It is a basic relation for the forward modeling.

In this work we perform possibility analysis of quantity factor and corresponding parameters of viscoelastic model reconstruction by observed wave fields. Description of absorption in the media is performed by one of the most popular rheological model, which is general standard linear solid model (GSLS). Numerical experiments based on applying of tau-method modification from the article [7]. This modification allows us to increase accuracy of quality factor modeling, while tau-method [8] tends to decrease computational resources. Reconstruction of Q is replaced by the finding of inverse seismic problem solution in linearized representation. Analysis of inverse problem solution is made using singular value decomposition of matrix, which approximates operator of forward modeling. To find the solution of non-linear inverse problem we use full waveform inversion method [9], which is one of the efficient instruments for high-accuracy reconstruction of the model parameters in complex geological structures by step-type minimization of misfit between synthetic and observed data.

There are numerical experiments results on synthetic data in this work, which perform work capacity and efficiency of developed numerical algorithm.

The research was done under financial support of Russian Science Foundation grant no. 17-17-01128

Literature

1. *Ben-Menahem, A., Singh, S.,* Seismic waves and sources, Springer-Verlag, New York, 1981.
2. *Blanch J., Robertsson O., and Symes W.* Modeling of a constant Q: Methodology and algorithm for an efficient and optimally inexpensive viscoelastic technique // Geophysics. -1995. -V.60. -P.176–184.
3. *Carcione, J. M., Kosloff, D., Kosloff, R.,* Wave propagation simulation in a linear viscoacoustic medium, Geophysical Journal International, - 1988, 93(2), 393–401.
4. *Casula, G., Carcione, J.,* Generalized mechanical model analogies of linear viscoelastic behaviour, Bollettino di geofisica teorica ed applicata, -1992, XXXIV(136).
5. *Futterman, W.,* Dispersive body waves, Journal Geophysical Research, - 1962, 67, 5279–5291.
6. *Hestholm S., Ketcham S., Greenfield R., Moran M., McMechan G*. Quick and accurate Q parameterization in viscoelastic wave modeling // Geophysics. -2006 -V.71. - P.147-150.
7. *Kolsky, H.,* The propagation of stress pulses in viscoelastic solids, Philosophical Magazine, -1956, 1, 693–710.
8. *McDonal F.J., Angona F.A., Mills R.L., Sengbush R.L., van Nostrand R.G., White J.E.* Attenuation of shear and compressional waves in Pierre shale // Geophysics. -1958. -V.23. -P.421-439.
9. *Virieux, J., Operto, S.,* An overview of full waveform inversion in exploration geophysics, Geophysics, - 2009, 74(6), WCC1–WCC26.

STRUCTURAL-GEOMORPHOLOGICAL CHARACTERISTICS OF THE HERACLES PENINSULA

A.V. Kiryanina[1], N.I. Kosevich[2]

Lomonosov Moscow State University, Faculty of Geology ([1]- mi9292@yandex.ru, [2]-nkosevich@gmail.com)

Keywords: *Structural-geomorphological analysis, neotectonics, Crimea, the Heracles Peninsula, GIS*

Information technology has long been used in various areas of human activity. The automated methods of research has long been using in geology. This significantly speeds up and improves their quality, especially when performing operations with a large amount of data. The advantages of studying the earth's surface using IT are obvious. In this regard, nowadays innovative methods of research and analysis are actively improved and developed, based on the use of geographic information systems. In the structural geomorphology and geology is also a rapid development of research, with using GIS technologies. The goal of this work is to characterize the structural-geomorphological structure of the Heracles Peninsula with using GIS-technologies. The following tasks must be performed during the work: * to analyze geological and tectonic materials on the area of the Heracles Peninsula; • to conduct analysis of materials on the history of the development of the area of the Heracles Peninsula; * to create morphometric maps of the study area; * to identify the main morphometric and morphological characteristics of the study area. The Heracles Peninsula is located within the Piedmont Crimea on the border with the The Crimean Mountains. In this regard, in its structure are involved, as deposits are strongly folded foundation, and discordantly overlying of the cover's rocks. The Heracles plateau is divided into smaller blocks by systems of orthogonal and diagonal faults. The main among them are considered faults of the North-West and North-East stretches. Major East-West trending shift deformation in the district of Heracles plateau are virtually absent. The morphometric method is based on the fact that most of the latest tectonic movements are inherited. Thus, at comprehensive consideration of the territory, it becomes possible to obtain the information about the deep processes and history of development. The result of our study was the construction the series of morphometric maps on the research area: hypsometric, angles of inclination, vertical the dissection of relief and the density of the dissection of relief. Analysis of the constructed maps showed that the distribution of the main morphometric characteristics of the relief of the Heracles Peninsula clearly shows the relationship with the geological, tectonic and neotectonics structure of this region.

ANTICYCLONES AND EXTREME TEMPERATURES IN THE SOUTHERN RUSSIA

O.Y. Kovalenko

Institute of Natural and Technical Systems (kovalenko_olga89@mail.ru)

Keywords: *anticyclone, extreme air temperature, the North Atlantic Oscillation,types of El Niño events, the Pacific Decadal oscillations, the Atlantic Multidecadal oscillations, the Sourthern Russia*

The changes of anticyclone and extreme air temperature characteristics, associated with different phases of the North Atlantic Oscillation, the Pacific Decadal oscillations, the Atlantic Multidecadal oscillations and types of El Niño events, in southern Russia are investigated in this study. The following data for 1950 – 2014 were used in present analysis: the 1000-hPa geopotential height fields from NCEP/NCAR reanalysis. Its temporal resolution is four time intervals (00, 06, 12, 18 UTC) and spatial resolution – 2.5° latitude × 2.5° longitude; daily data of air temperature observations from [1] at 13 stations in the Southern Russia (Anapa, Armavir, Feodosiya, Gelendzhik, Henichesk, Izmail, Kerch, Krasnodar, Odessa, Rostov-on-Don, Simferopol, Sochi, Tuapse); monthly indices of global climate processes from [2]. The frequency, depth and area of anticyclones were calculated by using a methodology [3]. The 5th (P5) and 95th percentile of the intraseasonal air temperature anomalies [4] and number of days with extreme air temperature were obtained. The manifestations of global climate processes in analyzed climate characteristics were studied using composite analysis. Composite significance was estimated by the Student's t-test The findings reported below. The most intense manifestations of global climate processes in the anticyclone extreme air temperature characteristics are found in coldest period of the year. The positive phase of the North Atlantic Oscillation and the Pacific Decadal oscillation, relative to the opposite phase, is accompanied by a statistically significant increase in the anticyclone frequency and the values of 5th percentile of temperature anomalies. El Niño types explain significant changes in the anticyclone frequency and the values of 5th percentile of temperature anomalies in the analyzed region. Significant manifestations of the Atlantic Multidecadal oscillations are found only in the extreme air temperature. In this case, the positive phase of this climate process is accompanied by an increase in the extreme low temperature frequency.

Literature

1. *Bardin M.Yu. and Polonsky A.B.* North Atlantic oscillation and synoptic variability in the European–Atlantic region in winter // Izv. Atmos. Oceanic Phys. – 2005. – Vol. 41. – P. 127–136 KNMI Climate Explorer [Electronic materials]. – Available: https://climexp.knmi.nl
2. *Bardin M.YU., Platova T.V.* Izmeneniya porogov ehkstremal'nyh znachenij temperatur i osadkov na territorii Rossii v period global'nogo potepleniya // Problemy ehkologicheskogo monitoringa i modelirovaniya ehkosistem. – 2013a. – T. XXV. – p. 71–93.
3. European Climate Assessment & Dataset project [Electronic materials]. – Available: http://eca.knmi.nl/

MUD VOLCANISM OF THE KERCH-TAMAN PENINSULA

E.V. Kozlova[1а], O.V. Krylov, N.V. Lubnina[2а], E.A. Leushina[1б], A.Y. Bychkov[2б], R.A. Hamidullin

[1]Skolkovo Institute of Science and Technology ([1а] - e.kozlova@skoltech.ru,[1б] - e.leushina@skoltech.ru);

[2]Lomonosov Moscow State University, Faculty of Geology ([2а] - natalia.lubnina@gmail.com, [2б]-andrewbychkov@rambler.ru)

Keywords: *mud volcanoes, organic matter, Maikop Series*

Lower Paleogene-Neogene Maikop Series is one of the most important oil-bearing formation of the Black -Caspian Seas region. Oil and gas deposits of the Terek-Caspian and Azov-Kuban petroleum basins contain Maikopian fluids generated by a thick (up to 5-6 km) clayey formation of initial marine genesis. Mud volcanism, the natural phenomenon is also connected with the same formation. The famous oil-man I.M. Gubkin said, that mud volcano is "a direct evidence of the oil and gas potential of the geological strata". One of the first oil fields being developed in Azerbaijan - Baby-Eybat and Lok-Batan, are adjacent to mud volcanoes of the same name, which are active till now. The Kerch-Taman region is well known as mud volcanism area. Mud volcanoes are a popular tourist places, clayey material of volcanoes has the balneological properties. To study the petroleum systems of the Black Sea region, mud volcanoes are invaluable helpers. Products of mud volcanism carry out information about the structure of the Maikop layer and the composition of the hydrocarbon products that it generated. The oil and gas potential of the Black Sea is primarily associated with the oil-generating Maikop series, which occupies the bulk of the sedimentary section.the Subbotin deposit was discovered In the sand lenses of Maikop on the Crimean continental margin. Mud volcanoes of the Kerch-Taman region has a variety of morphological forms. Mud-volcanic clays have a mixed-layer composition, inherited from Maikop clays. In the mud volcanic breccia, fragments of rocks contain organic carbon of up to 7-10 wt. %. A specific feature of the organic matter of Maikop deposits is a very low degree of maturity and an underestimated hydrogen index due to the adsorption capacity of the mineral matrix. In the composition of Maikop oils, biomarkers are identified that help in the identification of reservoir hydrocarbon fluids. The study of the Kerch-Taman mud volcanism was started in the 18th century, but up to the present time its study is relevant and informative for understanding the problems associated with the oil systems of the Black Sea region.

KANDALAKSHA BAY'S ISLANDS OF THE WHITE SEA: GEOLOGICAL AND GEOMORPHOLOGICAL CHARACTERISTIC BY TOOLS OF GIS-TECHNOLOGIES.

N.I. Kosevich, M.A. Novikova

Lomonosov Moscow State University, Faculty of Geology (nkosevich@gmail.com)

Keywords: *Kandalaksha Bay's Islands of the White Sea, geology, geomorphology, morphostructure, GIS-technologies*

Geographic information systems (GIS) are now an integral part of geological and geomorphological research and presentation of their results. On the basis of GIS-technologies, an inventory of available data for the region of study is carried out, and then the processing of the obtained field materials and carrying out thematic and spatial analysis of all the collected information.Thus, at our disposal is a huge array of geological and geomorphological information, which has become possible to analyze by the tools of GIS-technology. In this work, by the example of the Kandalaksha Bay of the White Sea, the possibilities of using GIS to represent geological and geomorphological information in graphical form are considered. The geological and geomorphological information was collected during the expedition research on the Kandalaksha Bay's Islands of the White Sea in 2007-2018: the contours of geological and geomorphological objects, high-altitude position of objects, landscape characteristics, composition of the underlying surface, etc. GIS "Geology and geomorphology of the White Sea's Islands" is developed in two directions: * collection, expert's report and preparation for the data input of the cartographic, literary, archival materials and new data collected and submitted by the project participants; * creation of specialized software for data input, editing and storage of cartographic information, construction of digital models, creation of maps of the island relief and adjacent mainland land, as well as the bottom relief of the water area of the studied areas, i.e. for data visualization. The main element in the GIS "Geology and geomorphology of the White Sea's Islands" is a map with a legend, text description and additional information about the objects to be mapped. A map is represented by a set of layers that are overlaying one on the other. Each layer contains a specific set of attributes: layer name, layer extent, activity, etc. The "Geography" block contains general information about the White Sea's Islands and the White Sea's water area, presented on the overview maps. The main source is topographic maps of scales 1:50 000 – 1:1 000 000, bathymetric maps (scales 1:500 000 – 1 200 000). The "Geology" block includes the series of maps reflecting the tectonic structure, geological structure, geomorphological zoning of the White Sea's water area and land. The "Geomorphology" subunit contains data obtained during field studies on the White Sea's Islands, on which large-scale maps are built. The subunit "Morphostructure" contains maps constructed in the course of morphostructural analysis of bathymetric and topographic maps for the research area. Further processing of materials for the research region is performed in the software environment ArcGis 10 company ESRI. With this complex in a single map scale, you can visualize the collected data (interactive data presentation), data analysis by geoprocessing and editing the data (creating, updating and maintaining geospatial information). The use of modern methods of geoinformation technologies allows to monitoring of the geological environment with the use of both tools and software-technology.

The work was supported by Russian Foundation for Basic Research grant no. 18-35-00666

CHARACTERISTICS OF SURFACE WAVES IN SCATTERING BY TERRAIN FEATURES

A.N. Kotov, R.A. Zhostkov, A.S. Numalov

IPE RAS (and250195@yandex.ru)

Today, in connection with the need to improve the efficiency of reconnaissance geophysical work, many seismic methods are being improved both in terms of equipment and methods for conducting and processing field measurements. To increase the accuracy of the analysis of the data obtained, it is necessary to study the fundamental processes associated with the propagation of geoacoustic waves in a complex heterogeneous geophysical medium. In recent years, sounding technologies associated with the use of surface waves have been gaining increasing popularity [1, 7]. Since the purpose of applying geophysical prospecting is to determine the heterogeneous structure of a geophysical environment, most of the scientific work, for example, [6-8] is connected with the study of this particular problem. Not only the physical inhomogeneity of the medium under investigation distorts the field of surface waves, but also the geometric features contribute, but much less research has been devoted to the study of this problem [4, 5], the results of which can be used in some cases to process real field data. Therefore, this study is relevant. The results of this paper were obtained using numerical finite element modeling in the Comsol Multiphysics 5.3a software [2]. A universal two-dimensional model has been designed to calculate the field of surface acoustic waves (SAWs) propagating along curvilinear boundaries of arbitrary shape. In this model, an algorithm for automatically constructing a computational grid is implemented, which provides both sufficient accuracy of calculations (an error of less than 0.5%) and a high computational speed for various model parameters. As a local feature of the relief, a Gaussian with a characteristic horizontal dimension s and various vertical dimensions (from 0.17 to 1 s) was investigated. Numerical simulation allowed us to determine the coefficients of change in the relative amplitude of the surfactant when scattering on the features of the relief, depending on the distance to the center of the singularity and the length of the probing wave. It is shown that appreciable distortions undergo surfactants, whose lengths range from 0.1 to 50 s. Moreover, these distortions are observed even for relatively smooth relief. The scattering of surfactants on a relief approximating actually existing geophysical objects, namely the Jau-Tepe volcano and the Elbrus volcano is investigated, in these cases the surface wave amplitude change reaches 20-50%, which indicates the need to take into account the data obtained in the present project when real geophysical works. These results can be used in processing the data of amplitude geophysical methods [1]. The coefficients of passage, reflection and transformation of surfactants into bulk waves during their scattering and the distribution of the total energy of the surfactant along the curvilinear boundary are determined. It is shown that they have the lowest energy near the slopes of the gaussoid, which can be used to increase the seismic stability of the objects under construction. The excess of the effective surfactant velocity associated with the transformation into a body wave at a certain ratio of the characteristic dimension of the relief feature to the wavelength is revealed. As a result of the carried out dispersion analysis, it was revealed that the surface-wave tomography method [7] near the considered feature of the relief can have errors in a wide range of frequencies. The case of negative relief is also considered. In this case, the scattering

of the surfactant occurs much more efficiently. It was found that the liquid half-space, which loads an elastic medium with a relief modeling the roughness of the deep sea, greatly influences the scattering of surfactants. This effect is explained by the fact that the basic energy of the Stoneley wave is concentrated in the liquid, and in a layer of higher power than for the Rayleigh wave, so the energy concentration near the center of the relief feature is stronger in the presence of a liquid half-space, because in this case, the positive relief of the seabed corresponds more to the negative relief of the free surface.

The work was supported by the Russian Foundation for Basic Research (project 16-35-60109), as well as a grant from the President of the Russian Federation to support scientific schools No. NSh-5545.2018.5

Literature

1. *Gorbatikov A.V.* Pat. RF № 2271554. Byull. izobretenij. 2006. № 7.
2. *Adams S.D.M., Craster R.V., Williams D.P.* Rayleigh waves guided by topography // Proc. R. Soc. A (2007) 463, 531–550.DOI:10.1098/rspa.2006.1779
   COMSOL Multiphysics 5.3a License №9600341.
3. *Gorbatikov A.V., Cukanov A.A.* Modelirovanie voln Rehleya vblizi rasseivayushchih skorostnyh neodnorodnostej. Issledovanie vozmozhnostej metoda mikrosejsmicheskogo zondirovaniya // Fizika Zemli. 2011. № 4. p. 96-112.
4. *Gulyaev Y.V., Plesskij V.P.* Rasprostranenie poverhnostnyh akusticheskih voln v periodicheskih strukturah // UFN. 1989. T. 157. № 1. p. 85-127.
5. *Zhostkov R. A., Presnov D. A., Sobisevich A. L.* Razvitie metoda mikrosejsmicheskogo zondirovaniya // Vestnik KRAUNC. Seriya nauki o Zemle. 2015. T. 2. № 26. p. 11–19.
6. *Yanovskaya T.B.* K teorii metoda mikrosejsmicheskogo zondirovaniya // Fizika Zemli. 2017. № 6. p. 18–23.
7. *Yanovskaya T.B.* Poverhnostno-volnovaya tomografiya v sejsmologicheskih issledovaniyah SPb.: Nauka, 2015. 164 p.

NEW IDEAS ABOUT THE INFORMATIVENESS OF THE PARAMETERS OF THE ARCHI-DOHNOV EQUATION

A.M. Kuznetsova, V.M. Shkilev, M.A. Fedoreeva

Federal State Budget Educational Institution of Higher Education « Industrial University of Tyumen»(anytka-97@mail.ru)

The Archie-Dakhnov's equation establishes the dependence of the specific electrical resistivity (SER) of ion-conducting rocks (ρr) on the content of the conducting aqueous phase in them and rock's SER (ρw). High information content of the SER of ion-conducting rocks is due to its dependence on the content of the conducting water phase and on its resistance in the pore space of the rocks. The general form of this dependence was substantiated by VN. Dakhnov in 1941, the same equation was published by G. Archie in 1942. Ion-conducting rocks include all sedimentary rocks characteristic of oil and gas bearing objects. Specific electrical resistivity is one of the most informative geophysical and petrophysical parameter, allowing to solve such problems as lithological dissection of the section, separation of reservoir intervals, estimation of the nature of their saturation, determination of porosity coefficients (Kp) and oil and gas saturation (Ko, Kg). These features of SER determine the continuing relevance of the application of the Archie-Dakhnov equation in interpreting data corresponding apparent and effective specific electrical resistivity in prospecting, exploration and development of oil and gas fields. This equation has the following form: : ρr = ao * ρw* W-n, where W = Kp * Kws - bulk water saturation of rock, "ao" and "n" are empirical constants. It was assumed that with an increase in the degree of carburization, the exponent "n" increases in absolute value. In the case of completely water-saturated rocks, the equation under consideration is written as ρwr = ap * ρw * Kp-m, where Kws is the water saturation coefficient of rocks, "ap" and "m" are empirical constants. The constant "m" was determined by V.N. Dakhnov as "a structural indicator, the value of which is directly dependent on the degree of cementation of the rock." Numerous attempts at theoretical modeling of the specific electrical resistivity of rocks did not lead to the establishment of acceptable analytical models, primarily in connection with the impossibility of a formalized description of the geometry of their porous space. The most well-known generalized Hanoi-Bruggeman's equation includes a series of physical parameters and geometric characteristics of rocks, which, unfortunately, can only be established with the help of rather laborious experimental investigations of rock samples. That is significantly more complex than direct measurement of the SER of these samples. In other models based on simple geometric analog of pore space, the approximation of the SER of the rocks was provided by introducing such characteristic as tortuosity (T). It was not possible to formulate more or less definite views about the physical meaning of the empirical coefficients of the equation: "a", "m" or "n". V.G. Mamyashev in his works gives a general characteristic of these coefficients, as the values determined by the structure of the conducting space. In the logarithmic coordinate system there is a straight line approximation of the Archie-Dakhnov's equation. However, the results of laboratory modeling of the SER of rocks indicate that the character of the dependence of the SER on the porosity in the field of the collectors and in the field of not the collectors often differs, and with a decrease in the porosity, the line of approximation of the porosity parameter (Pp = ρwr / ρw) from the porosity coefficient deviates from the rectilinear dependence towards the smaller degrees of the value of Pn, that is, "flattened out". All this served

as the basis for carrying out experimental studies of the influence of the pore space structure on rock resistivity. On that purpose we carried out simulation of the SER using a flat two-dimensional model of the rock. The rock model is a square with the length of each side equal to L = 200 mm. Its pore space is represented by a pore with a diameter "D" and a length "C" and it's co-axial pore channels with a diameter "d" and a length (L-C) / 2. The pore channels adjoin the pore from two opposite sides. Measurement of the SER of the model was performed between two opposing sides of it in the direction coinciding with the axis of the pore and the pore channels. For d = L and C = L, the porosity of the rock model equal Kp = 100%, respectively, the electrical resistivity of the model (Rw) is determined by the SER of the water filling it: Rw = ρw * (a / S), where a is the cell length, S - the cross-sectional area of the conducting aqueous phase (S = h * a), and h is the height of the water layer in the cell, hence Rw = ρw * 1 / h. The height of the water layer during the modeling of pores of different sections was ensured constant. It was controlled by the volume of water and the pore area: h = Vp / Sp, where Vp and Sp are the volume and area of the pores, respectively. For a constant value of "c," the ratio D / d characterizes the degree of difference in the cross section of the pore and the pore channel, the larger this ratio, the "more complicated" the pore structure. For D / d = 1, the model degenerates into a pore with a constant cross section. Thus, an increase in the pore size represented a complication of the model of the pore space structure. The results of our experimental studies made it possible to base the dependence of the SER and the porosity parameter on the porosity of the model and on the structure of the pore space. It states that the value of the SER in model is controlled mainly by the diameter of the pore channels; the influence of the pore sizes (pore diameter) on the SER model does not exceed 5-6%. Based on the results of the experiments, a generalized reticulation was constructed to represent the dependence of the SER of the rock model on the geometric characteristics of pore space, expressed in units of the length of the model side, that is, on the parameters "d / L", "D / L" and "C / L". When compared with the actual experimental dependencies, it was found that in the porosity area typical for reservoirs the change of porosity (decrease) in it reflects on the constructed reticulation with opposite effect to character to the change in the ratio D / d (that increases). In the porosity area characteristic of non-reservoirs, the degree of change of D / d decreases under the same conditions. This explains the "flattening" of the dependence Pp = f (Kp) in the transition area from collectors to non-collectors. Based on the conducted experiments and comparing their results with the behaviour of SER in real rocks, we can suppose that "m" reflects the degree of complexity of the pore structure. At the same time, this factor is affected by the degree of carburization, the increase of which leads to a decrease in "m". The determining influence of the size of the pore channels assumes an analogy between the influence of the pore space structure on the permeability of rocks and gives the possibility of applying SER data in assessing permeability. At least in the scientific field of collectors, it is possible to differentiate the comparison of porosity and permeability by the value of the "m" index. Scientific adviser of work, associate professor of TIU V.G. Mamyashev

PHYSICAL MODELING OF DEFORMATIONS AND THEIR EFFECT ON ANISOTROPY OF MAGNETIC SUSCEPTIBILITY (AMS).

I.E. Lebedev [1], N.V. Lubnina [2]

Geological faculty of MSU state university

[1] –lebedev232@ya.ru, [2] – natlubnina@yandex.ru

Key words: *structural geology, AMS, Physical modeling*

Structural parageneses are distinguished to study deformations in structural geology. Often this can be difficult to distinguish structural parageneses in outcrops due to insufficient exposure or overlapping of several stages of deformation. A certain situation is set in physical modeling. All parageneses can already be easily distinguished in experiments. In addition, we can observe in experiments in detail how this situation will be reflected in the values of the anisotropy of the magnetic susceptibility. Therefore, the purpose of this study is to clarify the relationship between the two methods: structural and AMS. It is important to establish how ellipsoid of the anisotropy of the magnetic susceptibility depends on the structural elements of the deformation settings.

There are a number of studies on the relationship between the deformation ellipsoid and the ellipsoid of the anisotropy of the magnetic susceptibility. There is a certain positive correlation of the stress ellipsoid with the ellipsoid of the anisotropy of the magnetic susceptibility is established in physical modeling in terrigenous and carbonate rocks [2,3,4]. There are also works on the correlation of the same parameters with samples taken from real rocks [1, 3].

There is another method that makes possible to obtain an ellipsoid of deformations. This method is the strain analysis. In contrast, the method of studying AMS is less time-consuming. It is important in research enough.

Physical modeling is carried out in the tectonophysical laboratory of the Moscow State University to establish the connection of the parameters. The results are presented in this research.

A pure shear and horizontal stress was modeled in the first experiments. In experiments we used kaolin clay with an iron powder uniformly mixed in it (ПЖР 3.200.28). The shortening was 30-40% at a speed of about 30 cm / h. After the deformation, samples were taken from the model for the measurement of anisotropy of the magnetic susceptibility.

In the course of the experiments, the minimum axis of the anisotropy of the magnetic susceptibility and the axis of maximum compression were co-directional. The deviation of values from this direction can be explained by uplifting when the formation of structures similar to the fold-thrust-belts.

As a result, we can establish the existence of a relations between the distribution of the values of the ellipsoid AMS and the ellipsoid of deformations. In the future, these results can help in distinguished the stages of deformation of the real objects.

Literature

1. *Voitenko V.N.* Korrelyaciya parametrov konechnoy deformacii I anizotropii magnitnoy vospriimchivosti: sravnenie rezultatov issledovaniya metaturbiditov severo-zapadnogo Priladozhya. Materiali Vtoroy tektonofizicheskoy konferencii "Tekotonofizika I aktualnie voprosi nauk o zemle", 451
2. *Borradaile, G.J. and McArthur, J.,* 1991. Tests of strain analysis by experimental deformation. Tecronophysics, 185: 325-333.
3. *Borradaile. G.J .•* 1988. Magnetic susceptibility, petrofabrics and strain-a review. Tectonophysics. 156: 1-20.
4. *R. Lanza, A. Meloni*. The Earth's Magnetism. - Springer-Verlag Berlin Heidelberg, 2006 – 280 p.

WHAT IS THE PROBABILITY FOR THE TECTONIC BLOCK TO GET INTO THE SAME AREA ON THE SURFACE OF THE EARTH DURING GEOLOGICAL HISTORY?

N.V. Lubnina[1], V.S. Zaharov[2]

M.V. Lomonosov Moscow State University, Faculty of Geology
[1] – natalia.lubnina@gmail.com; [2] – vszakharov@yandex.ru

Paleomagnetic poles are traditionally used for the construction of the magneto-tectonic reconstructions and the calculation of kinematic parameters of plate movement (speed of movement and rotation on the sphere). At the same time, the correct correlation of magnetic-tectonic reconstructions with geological data largely depends on the quality of the paleomagnetic poles used.

Currently, criteria for reliability of paleomagnetic poles for Phanerozoic [3] and Precambrian [1] have been developed. The proof of the time of acquisition of magnetization components by rocks of different age is important criteria of paleomagnetic data quality. Paleomagnetic reliability tests are taken to prove the time of different magnetization. For magmatic complexes, it is, first, contact and reversal tests, and for sedimentary rocks, in addition to the reversal test usually used fold and conglomerate tests. Positive contact and conglomerate tests show that the high-temperature component of magnetization was formed at the time of formation of rocks. By determining the age of rocks based on independent isotopic data, we obtain reliable information about the time of acquisition of magnetization components by rocks. In addition, having tested a sufficient number (not less than 10, according to the criteria of paleomagnetic reliability) of complexes close in age (for example, dyke bodies), it is possible to calculate a reliable or key paleomagnetic pole [1].

It is believed that the older paleomagnetic poles for one tectonic block should not coincide with the younger poles for him. The coincidence of different age poles for the same block indicates the remagnetization of rocks, and the time of acquisition of these magnetization components by rocks is correlated with the youngest poles for the same block.

At the same time, the analysis of the secondary (metachronous) components of magnetization, isolated in Precambrian complexes of the Karelian craton, showed the coincidence of the primary magnetization in the most reliable Precambrian key objects with the vector sum of different age Phanerozoic magnetization components. This conclusion completely refutes the significance of test of paleomagnetic reliability (first of all contact test) to prove the primary / secondary nature of the isolated high temperature magnetization components.

Let's estimate the probability for a tectonic block to hit the same area on the earth's surface in the course of geological history.

To do this, we will assess the area of the strip S, which "sweeps" on the surface of the earth such a block, taking into account the characteristic (average) values of the speed of horizontal movements, the size of the block and the error in determining the position of the paleomagnetic poles used in paleogeodynamic reconstructions. The ratio of this area to the surface area of the whole Earth S_E allows to evaluate the desired probability.

1. Primary data

Consider the possible movement of the block starting with the Paleoproterozoic, i.e. during t = 2.5 Ga.

The velocities of horizontal movements in the Precambrian were higher than modern ones, so we take a range of values $v = 5 \div 10$ cm/year [2, 4 and references therein].

For our calculations, we accept the size of the tectonic block in the range $d = 500 \div 1000$ km.

In paleomagnetic reconstructions, the position of the paleomagnetic pole is determined with a confidence interval α_{95}. The same value is actually a measure of the accuracy of determining the position of specific reconstructed blocks [5]. For further assessments, we take a characteristic value $\alpha_{95} = 10°$.

The surface area of the Earth $S_E = 5.1 \cdot 10^8$ km^2.

2. Estimation of total length of the path, L, passed by the tectonic block*:*

$L = v \cdot t = (5 \div 10)$ cm/year $\cdot$ 2.5 Ga $= (5 \div 10) \cdot 10^{-5}$ km/year $\cdot$ $2.5 \cdot 10^9$ year $= (1.25 \div 2.5) \cdot 10^5$ km $= (125 \div 250) \cdot 10^3$ km.

2. Estimation of the area of the strip that the block "sweeps" on the surface of the Earth.

$S = d \cdot L = (500 \div 1000)$ km $\cdot$ $(125 \div 250)$ 10^3 km $= (0.63 \div 2.5) \cdot 10^8$ km^2.

3. The proportion of the area of the strip and the surface of the Earth.

$$S/ S_E = ((0.63 \div 2.5) \cdot 10^8 \text{ km}^2)/ 5.1 \cdot 10^8 \text{ km}^2 = 0.12 \div 0.49.$$

Thus, even if we do not take into account the error of paleomagnetic reconstructions, the probability for the block to get to the same area of the Earth is from 12 to 49 %, i.e. such an event is quite likely.

4. Assessment of the error of determining the position of the reconstructed unit.

At $\alpha_{95} = 10°$ for the paleomagnetic pole, the error in determining the ancient position of the block is of the order of magnitude 1000 km. Then the width of the strip in which the block can move increases to $d = 1500 \div 2000$ km. In this case, the area that the block "sweeps" on the surface of the Earth can be estimated as

$$S = (1.5 \div 2) \cdot 10^3 \text{ km} \cdot (1.25 \div 2.5) \cdot 10^5 \text{ km} = (1.88 \div 5) \cdot 10^8 \text{ km}^2.$$

Then the share of such a strip of the total surface area of the Earth is

$$S/ S_E = (1.88 \div 5) / 5.1 \cdot = 0.37 \div 0.98.$$

Thus, despite the sufficient roughness of the estimates, it is shown that the probability for the block to get to the same area on the earth's surface is from 37 до 98 %, i.e. such an event is very likely.

This research was supported by RSF (project №18-17-00170).

Literature

1. *Buchan K.L., Mertanen S., Park R.G., et al.* Comparising the drift of Laurentia and Baltica in the Proterozoic: The importance of key paleomagnetic poles // Tectonophysics. 2000. Vol. 319, N 3. P. 167–198.
2. *Korenaga J.* Urey ratio and the structure and evolution of Earth's mantle // Rev. Geophys., 2008, № 46, p. 1–32.
3. *Van der Voo R.* The reliability of paleomagnetic data // Tectonophysics. 1990. Vol. 184. P. 1–9.
4. *Van Kranendonk, M.J.* Two types of Archean continental crust: plume and plate tectonics on Early Earth. American Journal of Science, 2010. 310, 1187–1209. DOI 10.2475/10.2010.01
5. *D.V. Metelkin, A,Yu. Kazanskiy.* The Basics of Magnetotectonics: Study Guide (*In Russian*) / Novosibirsk State University, Novosibirsk, 2014. 127 pp.

PRACTICAL APPLICATION OF PETRO-PALEOMAGNETIC RESEARCH RESULTS

N.V. Lubnina

natalia.lubnina@gmail.com

Petro-paleomagnetic studies are widely used in various fields of the Earth Sciences. The problems solved by Petro-paleomagnetic methods can be classified as follows:

1) Global research

A) The reconstruction of paleogeography of the regions, restoration of paleolflows, determination of paleolatitudes, drift speeds of the plates and geodynamic (magneto-tectonic) reconstructions.

Currently, there are reliably justified reconstruction for ancient cratons based on the key paleomagnetic poles. The underlying methods of Apparent Pole Wander Path (APWP), constructed for the almost all cratons for the Middle Paleozoic–Cenozoic.

However, paleomagnetic studies within orogenic structures and young plates are still under development. There are only individual paleomagnetic poles for a particular time slice, which do not allow to trace the kinematics of movement of individual blocks within folded belt.

B) Assessment of integrity (rigidity) of the foundation within the regions. The allocation of macroblocks of the foundation, determination of their boundaries and quantification of the extent of the possible relative rotations;

C) Correlation of wells both within individual search areas and in the scale of sedimentary basins.

In addition to classical magnetostratigraphic methods, magnetic susceptibility profiles, Koenigsberger parameters, magnetic saturation and magnetic rigidity are used along the borehole profiles, etc;

Traditionally stratification of geological sections and wells is carried out based geological, lithological-stratigraphic and geochronological data. However, unambiguous correlation of lithological similar sections (often without leading groups of fauna) and bind them to the absolute geochronological scale is quite a difficult task. At the same time, there is a complex of methods, which is based on a global phenomenon - the inversion of the Earth's magnetic field, clearly allowing to correlate the features and frequency of the Earth's magnetic field reversals in a precise time interval of geological history, and thus correlate the "mute" intervals of sections.

2) Regional studies.

A) Express-separation of borehole sections and their correlation;

In recent years, a complex of Petro-paleomagnetic studies has been developed, which allows for a more skillful correlation of sections. In contrast to the paleomagnetic properties of rocks, the basis of which is determined by the geomagnetic polarity of the magnetic field of the Earth, petromagnetic features are not directly related to the nature of the regime of the ancient magnetic field, but due to the composition, concentration and structural-textural features of the ferromagnetic fraction in the sediments. Modern studies show that the study of the type and genesis of carrier minerals of magnetization, as well as detailed measurements of the anisotropy of magnetic susceptibility of sedimentary rocks (AMS) allow for rapid analysis and reconstruction of paleotectonic, paleogeographic and paleogeochemical conditions of sedimentation.

B) Restoration of orientation of magnetic texture of rocks and their elements. The interaction of intergranular and intergranular deformation mechanisms creates a new look of the rock. Depending on the conditions and duration of the processes, these changes can be almost imperceptible or completely transform the rock beyond recognition.

The look of the rock is determined by its structure, texture and mineral composition of its composing grains and crystals. In modern English literature, the structure is understood as a pronounced geometric feature of the constitution of the rock, texture – microconstitution or microstructure, while the complete spatial morphological system of rock composing elements characterized by penetrating and repeated development of them throughout the volume is called structure or addition of rock (*rock fabric*). The elements of the constitution include shale, linearity, preferred crystallographic orientation, size and / or shape of the grains. Since magnetic minerals, along with the rest, are involved in deformation processes and secondary alteration, the measurements of magnetic parameters allow to quickly and effectively quantitatively reconstruct the direction and orientation of secondary processes. The basis of these studies is the study of magnetic anisotropy (AMS) – the dependence of the magnetic properties of matter on the direction.

C) Express selection of zones of increased fracturing and cavernosity, including homogeneous rocks that do not bear obvious signs of mechanical or chemical treatment;

Currently, a significant part of hydrocarbon reserves is associated with rocks with different natural fractures. At the same time, it is important to separate not only the orientation of the modern regional stress of the study area, as well as the deformation history of the studied complexes at the time of their formation, but also to distinguish artificial fracturing from natural. Very often, the natural fracture is strongly masked by artificial destruction of different nature.

D) The estimation of the age of transformation/process.

During the formation of rocks, they acquire magnetization (magnetic minerals fix the direction of the magnetic field of the place and time of their formation). If rocks had undergone any secondary changes/deformation, their magnetic fraction has also undergone these changes – remagnitization. Under the remagnetization of rocks is traditionally meant a process in which their ferrimagnetic fraction is magnetized under the influence of an external magnetic field in the direction corresponding to the time and place of application of the external magnetic field. The main factors determining remagnetization are *P-T* regimes and the presence of fluids leading to either partial or complete disintegration of the carrier mineral and/or the formation of a new mineral fraction. Depending on their combination, **thermoviscous** and **chemical** remagnetization of rocks is distinguished.

Thermoviscous remagnitization – thermal effect, part of the magnetic moments is reoriented in the direction of the "new" external magnetic field, and there is no formation of a new mineral phase. A characteristic feature of the thermoviscous magnetization is uniform distribution of the secondary component, in which different carrier minerals of magnetization show the same average direction.

Chemical remagnetization is associated with the formation of secondary carrier minerals of magnetization under the influence of fluids, as a result of which there is a complete replacement of the primary carrier minerals of magnetization. In this case, a new mineral fraction is necessarily formed. The characteristic features of chemical remagnetization are a selective remagnetization of the rocks within a single section with the same properties and the unevenness of remagnetization

within the same. Because of chemical remagnetization, a bipolar secondary component of magnetization is formed, which clearly depends on the magnetization carrier mineral.

Since the magnetization-carrying minerals were formed / transformed at different times, the magnetization components they fix differ mainly in the direction of the natural residual magnetization vector.

The average directions of magnetization paleomagnetic poles are counted after correctly dividing the components of the magnetization. Currently for each major Phanerozoic tectonic unit, there are Apparent Polar Wander Path (APWP) – this is a graph of the sequential positions of the most reliable paleomagnetic poles calculated for a single lithospheric block, averaged within a certain time boundary.

By comparing, the obtained poles recalculated from the secondary magnetization components with APWP we can only estimate the time of secondary rock transformations.

E) Well core orientation is is measured using special magnetic equipment without sinking it into the well; the anisotropy of permeability and stress state of reservoir rocks on the oriented core is estimated;

Traditionally, the orientation of borehole cores was carried out according to modern (viscous) component of magnetization. However, due to the arising in the process of drilling secondary (drilling) magnetization components, this method is ineffective. Significant problems also arise when trying to orient the core of wells in high latitudes, where the inclination of the modern magnetization component is of great importance. In this case, due to the natural spread of magnetization vectors, some of them may have declinations that differ from the declination of the modern geomagnetic field at angles up to 180°. In recent years, a method has been developed to Orient the core of wells in the direction of the ancient magnetization components and data on the anisotropy of magnetic susceptibility [Popov, Khramov, 2002].

This research was supported by RFBR (project №17-05-01270).

Literature

Popov V.V., Khramov A.N. Paleomagnetism of the Upper Vendian sedimentary rocks of the Winter Coast of the White Sea from the results of the boreholes; new method of orienting the core of boreholes in space // Palemagnetism and magnetism of the rocks: theory, practice and experiment. Borok. M:Geos, 2002. P. 74-76.

EXPRESSION OF THE MUD VOLCANISM IN WEST PART OF MOUNTAINOUS CRIMEA.

V.I. Lysenko, T.K. Triboj

Moscow State University Sevastopol Branch, Sevastopol (niagara_sev@mail.ru)

The expression of the mud volcanism in West part of Mountainous Crimea. Mud volcanism -unique geologic phenomenon of nature. In our time there are about 2000 above and underwater dirt volcano constructions, but from the low knowledge of sea deeps we should suggest that their number is in on order higher. Besides active and extinct modern mud volcanoes there are buried structures and complexes of ancient brecciated rocks, which show us the time period of existence of this geological phenomenon. Mud volcanoes, as well as magmatic ones, are located on the border of lithospheric plates, in narrow zones of folding of modern tectonic activation. The main condition of mud-volcanic processes is the presence of dislocations and crumpled into folds of powerful complexes of terrigenous strata with plastic clay rocks. Underwater mud volcanoes are quite widespread on the shelf of the seas and often near sources of cold hydrocarbon flows ("SIPS"), which indicates the unified nature of their recharge from the depths due to deep hydrocarbon degassing. Academician E. F. Shnyukov suggested that deep, cold degassing occurs not only in the depths of the Black sea, but also in the territory of the Mountainous Crimea[3,4]. In the Crimean-Caucasian fold belt, almost all mud volcanoes are concentrated within the Apsheron, Taman and Kerch peninsulas. S.P. Popov suggested that the mud volcanism zone from the Kerch Peninsula continues to the Western coast of the Black sea through the Mountainous Crimea[1]. While conducting a geological survey at village Krasnopisherskoe (Mountainous Crimea, region of mountain Chatyr Dag) in water sources of this area by Abashin A. A. and A. S. Borisenko was marked the high content of helium, which indicates the relationship with the deep nourishment from the subsoils. This area was researched and studied in more details by V.V.Yudin. He found and described several products of modern mud volcanism. These formations are associated with clay diapirism and confined to linear weakened tectonic zones[6]. The age of clay sediments on the fauna is lower Cretaceous, and the process of bringing them to the surface is modern. Also were found traces of mud volcanic processes in the past. Mud volcanism confirms the modern tectonic activity of the Mountainous Crimea. The author in the area of the village Vysokoe of Bakhchisarai area was discovered and researched from the surface of the output of the alleged field of the mountain clays of breccia form texture, similar to the release of a mud volcano. The outcrop is located on the Western slope of the nameless mountain, with an angle of about 30°, norther then village Vysokoe, 250 m south of the famous source of Kuzma and Damian. The exit is ellipsoidal, about 30 meters wide, and down the slope – about 40 meters. The upper border is clear, arcuate, the lower one is winding, complicated by numerous washouts passing into ravines. Glade covered with clay breccia, characterized by the absence of vegetation, although a number of slopes are covered with continuous herbaceous and shrub vegetation. Water clay extract has a bitter-salty taste, typical for Mg, Ca and Na sulfates. Minerals that fell out of these salts are described in the study of mud volcano emissions on the Kerch Peninsula[4,5]. At the top of the square is a hilly ledge about two meters high. Presumably, it is associated with the processes of draped extrusion of clay breccia from the bowels. On the surface of the field there are no griffins, mud keys and weakly aerating salsa, perhaps this is due to modern exogenous slope weathering

processes. The proposed field of the hill is composed of breccia brownish-grayish clay, cement is grayish-white clay. In the upper part of the estimated field of the hill there are areas of rounded shape, where the clay has a brownish-brown color, which is associated with the oxidation of sulfides. The findings of numerous fragments of belemnites (Neohibolites Semicanaliculatus Blainv) in the clays indicate the aptic age of the clay strata. On the surface of the slope there are numerous fragments of tiled vein calcite with sliding mirrors, lower Cretaceous quartz sandstones, nodules of siderites and quartz pebbles. Sizes of fragments – 1.0 to 10.0 cm. This foreign clastic material is 5-10% of the total area. Distribution in the volcanic field is uniform. Within the slope there is no differentiation of its size and number of fragments. Platy angular fragments of vein calcite have sizes from 3.0 to 10.0 cm and a thickness of from 2.0 to 15.0 mm. On their surface on both sides are marked rectilinear grooves of slip. There are fragments on which two hatching systems are applied at an angle of 30-60° to each other, which indicates several stages of deformation and the chaotic movement of the material when it reaches the surface. In large calcite veins small angular fragments of clay and traces of sulfide mineralization are noted. Fragments of grey-brown sandstones of the lower Cretaceous (probably Valanginian) have a flat uncut shape and size from 5.0 to 10.0 cm them often there are layers of quartz gravelites, conglomerates and carbonate-clay cement, as well as numerous prints of vegetation. Brown fragments siderite nodules have an angular shape and sizes from 3.0 to 10.0 cm. Often in the Central part there are the marcasite concretion, which is typical for mud volcanic emissions on the Kerch Peninsula[5]. Quartz pebbles and gravel occur in the upper part of the volcanic field and represent a smaller percentage of the total volume. It is the product of destruction of lower Cretaceous sandstones and conglomerates that lie deeper than the clay strata. The expression of the alleged mud volcanism is confined to the Western slope of the anticlinal fold, composed of rocks of the upper Jurassic and lower Cretaceous and complicated by tectonic disturbances, meridional strike. The connection with tectonics is also confirmed by the presence of the source of Cosmas and Damian in the fault zone. According to our assumption, tectonic disturbances are a part of the zone of exploit in this region, and the supposed mud volcanism testifies to the modern tectonic activity of the Mountainous Crimea. The assumption that in the above plot we have a system of oplivin in the Aptian clays, refuted by the shape of the dip clay mud breccia, the lack of differentiation of clastic material by slope processes and as a source of surface water for erosion of sediments, the presence of efflorescence of clay in the upper part of the field and the numerous fragments of calcite with gliding sulfate mineralization in clay breccia. This is proof that in the area of the village Vysokoe processes of mud volcanism manifest themselves. The processes of mud volcanism on Earth are very diverse and, despite the large number of scientific papers on this issue, this phenomenon is not fully understood. The data presented in the article prove the assumption made by S.P.Popov, E. F.Shnyukov and V.V Yudin about the presence of mud volcanism in the Mountainous Crimea [1,2,5,6]. Due to the small size of the exits and the rapid erosion of rocks, the manifestations of mud volcanism were not mapped on geological maps. The data obtained allow us to assume a wide spread of mud volcanism in the mountainous Crimea, and possibly in other mountainous areas of Alpine folding. It is necessary to further study these processes in order to know the degassing of the subsoils, modern seismic activity and prospects of oil and gas industry in the region.

Literature

1. *Popov S.P.* Mud volcanoes // Nature. 1928- №6- p.541-554
2. *Shnyukov E.F., Sobolevskiy U.V., Gnatenko G.I.* Mud volcanoes of Kerch-Taman region. Atlas. Kiev: Naukova Dumka, 1986, p.150
3. *Shnyukov E.F.* Mud volcanism in Black sea//Geological journal.-1999.-№2.-p.38-47
4. *Shnyukov E.F., Kutniy V.A., Naumenko S.P.* Travertines and other mineral formations of gas sources of Kerch peninsula// Geology and minerals of World ocean, 2007.-№3.-Kiev.-p.5-14
5. *Shnyukov E.F., Sheremetiev V. M., Maslakov N.A.* Mud volcanoes of Kerch-Taman region.-Krasnodar,2005.-p.176
6. *Yudin V.V.* Mud volcanism in Mountainous Crimea// Reports of RAS,1995.-t.341.-№3.-p.395-398

FINDINGS OF THE CONSTRUCTION OF "GRAY SMOKERS" IN THE SOUTH-WESTERN PART OF THE CRIMEAN MOUNTAINS

V.I. Lysenko, A.S. Silevich

Moscow State University Sevastopol Branch, Sevastopol (niagara_sev@mail.ru)

Keywords: *Crimea, geology, paleogeology, volcanic activity, carbonate constructions, Taurian series, black smokers*

Many researchers have studied the paleovolcanism and intrusive magmatism of the Mountainous Crimea. It was established that the outcrops of igneous rocks form two discontinuous strips - the northern and southern ones. Within the northern belt, there are effusive and intrusive formations of the Upper Triassic, Lower Jurassic and Middle Jurassic age. The southern zone is large and its intrusive and effusive rocks have Middle Jurassic (Bajos) age. The sulphide-carbonate tubes found on the surface of lava paleocounts allow a new interpretation of the conditions of formation and age of igneous rocks in the region of the western part of the southern coast of the Crimea. The purpose of this study was to study the structural features of sulfide-carbonate structures and the reconstruction of their formation conditions. The magmatic bodies studied by the authors are at a distance of 3-6 km from the known volcanic paleolithic structures and the intrusive massifs of Foros and Melas, and are the westernmost outcrops of the magmatic bodies of the South Coast. According to the conditions of occurrence, the forms of exits, mineral composition, structural and textural features, it can be assumed that the magmatic bodies studied are parts of large underwater lava paleostreams. Sulfide-carbonate constructions occur on magmatic bodies in the central part of the study area and have a growth direction perpendicular to the surface of the lavas and stratification of the enclosing strata. Their appearance is represented by vertical or slightly curved pipes up to 80 cm in length and up to 10 cm in diameter. Quite often at some distance from the effusive surface, lateral cone-shaped processes and horizontal thickenings appear on the pipes, according to the stratification of the containing siltstones. Sulfide-carbonate pipes have fairly sharp contacts with the host rocks of the Taurian series and effusions of the lava flow. The diameter of the tubular structures may increase or decrease with their growth. Fragments of pipes were identified, on the surface of which slip mirrors and healed open fractures of the rupture tracks were observed, which proves their formation prior to the phase of the ancient Cimmerian folding. In addition to the morphological diversity of buildings, there are differences in the coloration of the carbonates that make up them. There are pipes, folded greenish-white, gray, brown-black and black-gray carbonate. Coloring is associated with the presence of chlorites, carbonaceous and bituminous substances. Concentric and vertical zoning in sulphide-carbonate buildings is emphasized by the color spectrum of carbonates and sulphides. With some conventionality, it is possible to distinguish the following zones in the buildings: central; intermediate; lateral and bacterial overgrowth zone. The zones are characterized by intermittent structure and variable power, which differ from the structure of concentric concretions and concretions. In the central part of the buildings there is a zone with intermittent sulphide mineralization of the fluid channel. It has a wavy uneven structure and a thickness of 5 to 20 mm. The central zone is composed of coarse and medium crystalline anthraconite or greenish calcite,

where impregnations of fine-grained galena, sphalerite, chalcopyrite, and pyrite occur. The boundaries of the central zone with the intermediate ones are rather uneven and vague. The zone of bacterial overgrowth consists of several layers separated by micro-primings of clay material. In some places, on the surface of bacterial overgrowth, rectilinear and differently oriented casts of tubular worms made with carbonate are noted. The results obtained by us in the study of sulfide-carbonate pipes and magmatic massifs on the slopes above the village of Tesseli prove that the volcanism of the region is of an earlier age than anticipated. The rocks of this submarine lava paleopotok were formed simultaneously and together with the terrigenous thickness of the Taurian series. For a single time and the genesis of lava formation in rocks of the Taurida series, the following facts indicate: the presence of a zonal mineralogical differentiation of rocks in all flow blocks; fragments of the autobricky texture on the surface of the lava; sharp and uneven contacts of igneous rocks with the overlying terrigenous thickness; Finds of sulfide-carbonate pipes in flysch sedimentary rocks. The formation of sulfide-carbonate-tube bodies occurred with some advance in the formation of the terrigenous material of the rocks of the Taurian series. In the western part of our zone, carbonate biogerm was found on one of the outcrops of the lava palaeopost. In it the clastic material of lavas is cemented by the construction of banded stromatolites and shell material of brachiopods, which have an external similarity to the species Terebratula praepunctata Bitt [3]. Above the section in the interlayer of black lumpy limestones, the author discovered brachiopod prints and an ammonite shell. Found ammonite, according to the results of the definition of the professor of the doctor of geological and mineralogical sciences V.V. Arkadyeva from St. Petersburg State University, refers to Megaphyllites insectus (Mojsisovics). Collected fingerprints of fauna have Norian age [1]. We can assume that the volcanism of the surroundings of the village of Tesseli is of the late Triassic age, as similar processes in the northern part of the Mountainous Crimea. Crimean sulphide-carbonate constructions have some morphological similarities with the sulfide pipes of the Mid-Atlantic Ridge and the Urals, but differ in mineralogical composition and the presence of a zone of bacterial overgrowth. The significant difference in the mineralogical composition of the Crimean sulphide-carbonate constructions from the sulphide pipes of the "black smokers", in our opinion, is associated with the various physical and geographical conditions of their formation.

Literature

1. *Astahova T.V.* Paleontologicheskaya harakteristika triasovyh otlozhenij Kryma // Paleontologicheskij sbornik.1972 Vyp. 2 № 9 p. 57-63
2. *Maslennikova S.P., Maslennikov V.V.* Sul'fidnye truby paleozojskih «chyornyh kuril'shchikov» (na primere Urala). Ekaterinburg–Miass.: UrO RAN. 2007 312 p.

HIGH-IRON LATERITES - FERRYPLANTITES - CHARACTERISTIC FORMATIONS FOR THE LATERITIC WEATHERING PROFILE

M.A. Makarova, Y.O. Kovaliv, E.S. Shipilova

Lomonosov Moscow State University, Faculty of Geology (frolikovam@gmail.com)

Keywords: *ferryplantites, high-iron laterites, laterites, bauxites, Guinea, hematite, goethite, gibbsite, REE, volumetric mass*

In the vertical section, the bauxite-bearing weathering crusts have two generalized lithologic horizons. The lower horizon mainly consists of clays from polymineralic, with fragments of slightly weathered parent rocks, in the lower part (saprolite) to essentially kaolinitic, with increasing iron, in the upper part (lithomarge). The upper horizon is mainly composed of iron and aluminum oxides and hydroxides and includes the laterites of transition zone, the bauxite horizon, and the cuirass. This horizon can be considered as the lateritic cover. The lateritic cover is an ore-bearing stratum, inside which bauxites usually form the major part of the section, or individual lenses and horizons laterally alternating with glandular laterites (Al_2O_3 <40%). Characteristically, between bauxites and below clays litomarzha everywhere is detected ferruginous laterite horizon. The regime hydrogeological observations at several deposits of the region showed that this part of the weathering profile coincides with the hydrogeological zone of the fluctuation of the groundwater table during the rainy season. It is also important to note that in the zone of infiltration of the weathering profile, zoning is observed in the composition of the underground atmosphere. The monitoring carried out [1] made it possible to accurately determine the composition of the gas in different parts of the zone. In the lowest part (above the mirror of groundwater) after rain, carbon dioxide accumulates, the maximum concentration of which can reach 12-14%. Accordingly, the oxygen content drops to 5-6%. It is obvious that an oxidative geochemical barrier takes place in the zone of fluctuations in the level of groundwater, thanks to which the accumulation of Fe_3 + takes place in the form of goethite and less often hematite. In general, from the bottom up, within the transition zone, kaolinite ceases to be a rock-forming mineral, and this role is completely passes to oxides and hydroxides of aluminum (mainly gibbsite) and iron (goethite and hematite). That is, it is within this zone that a complete lateritization takes place, and the rocks are lithified - they pass from the clay state to semi-stony and stony. The volumetric mass of rocks is increased to 1.85-2.1 g / cm3. In the lower and, especially, in the middle part of this zone, iron is sharply concentrated to form high-iron laterites, in which the Fe_2O_3 content exceeds the Al_2O_3 content. Very often lenses, interlayers and plates are formed, width from the first centimeters to 40-50 cm, high-irons, mainly getite and hematite-goethite rocks, with gibbsite and residual kaolinite. These are very strong, lithified rocks, called ferryplantites [2]. This name reflects the oxide forms of the main rock-forming element-iron, and the plate-like form of the manifestation of these rocks. The volumetric mass of ferryplantites is 2.8-3 g / cm3. Calculations on an isovolumetric basis show that when ferricplantites are formed, the concentration of iron is increases fivefold (1742/385) compared to parent rocks, while for the transition zone as a whole it is about 2 (799/385). There are 2 types of ferryplantites - wax-red ferryplantites and tobacco-yellow ferryplantites. The wax-red ferryplantites considered by us have a massive or pseudo-brecciation texture (due to brecciation and replacement of the ferricplantite

material with a light material) and colloform-afanite structure. They are composed mainly of hematogel, which has a very dense red color. In some places developed ferrigel. Light material, cementing fragments of red ferryplantites is composed of ferrialumogel, in which gibbsite concretions are often present. Ferroplantites tobacco (brownish) -yellow have a massive or banded texture (due to the presence of white veins) and a thin-microcrystalline less often collomorphic-afanite structure. They are mainly composed of a thin aggregate of crystals of goethite, gibbsite and kaolinite. Gibbsite and kaolinite consist the first percentages. In some places the tobacco-yellow ferryplantites are composed of an amorphous ferrigel mass. In yellow ferryplantites, veins with a thickness of up to 3 mm are developed, composed of alumogel or ferrialumogel, or well-crystallized gibbsite. According to the chemical composition, there are no sharp differences for tobacco-yellow and wax-red ferryplantites: SiO_2 4.5-5.5%, Al_2O_3 18.5-20.5%, Fe_2O_3 56-57.5%. But there are significant differences in the content of impurity elements. Without dwelling on a detailed description, let us note only the main trend: waxes-reds are enriched 2-3 times with the whole spectrum of small elements in comparison with tobacco-yellow ones. This trend is especially evident for REE. In general, for ferroplantites are characteristic of the maximum concentrations relative to other horizons of the weathering profile is V, Sc, Cr, U, Mo, Te, Sb, Ge, Be, Cu, HREE [3]. There are also some differences in the mineral composition. X-ray phase analysis revealed the following differences: in yellow ferryplantites, more gibbsite (24.38% against 14.58% in red), goethite / alumogoethite(21.75 and 9.43, respectively), while the content of boehmite, anatase, rutile, kaolinite almost at the same. But the data of the phase analysis can only be regarded as approximate, since the fraction of the amorphous phase is very high, up to 50%, irrespective of the type of ferryplantites. Therefore, in our opinion, it is more expedient to use a mineralography description to understand the differences in the composition of ferriplantites. Here is a typical example of a mineralography description of tobacco-yellow ferryplantite (the N'Dangar deposit): Hematite 1 (5%) performs individual grains with a size of not more than 50 microns. Hematite 2 (3%) gives thin bands (up to 10 μm) in the composition of collomorphic getite bands. Goethite 1 (77%) in the form of a finely dispersed and fine-grained aggregate with hydroxides Al performs the bulk of the clasts, and also performs gaps between clasts and gives borders around relicts of silicates substituted with alumina. Goethite 2 (10%) forms collomorphic bands to 150 μm around the clasts together with hematite 2. Goethite 3 (5%) performs veins of a centrally symmetric structure with a thickness of 1050 μm secant of the main mass of goethite 1. Also need to pick out large amount of alumina or a clay substance that forms separate, rounded clasts and forms the bulk of clasts in a fine-dispersed mixture with goethite 1 and collomorphic bands flowing around these fragments. Wax-red ferryplantite (Paravi deposit): hematite 1 (7%) forms complete and partial pseudomorphs in ilmenite (grains and their fusion up to 300 μm) often with preservation of the relict lamellar construction; hematite 2 (40%) - thin fringes (1-10-15 microns) and lacy secretions in fine-grained goethite 1, as well as cementing and loop masses between clasts and oolites of 1-5 microns. Hematite 3 (3%) performs cavities in the form of borders, represented by the crystals up to 50 microns in length. Goethite 1 (15%) together with hematite 1 performs intergranular space between radiant gibbsite crystals in pseudomorphs on silicate. Goethite 2 (35%) performs separate bands (from 20 to 500 μm in thickness) in oolites in the form of a fine aggregate mixed with aluminous material. Gibbsite forms pseudomorphs (elongated crystals up to 500 microns in length) together with aluminous matter over radial-radiant, leafy and acicular silicates. Alumina substance - forms oolites in a mixture with

gelomorfnyh hydroxides of iron in different proportions (size from 100 microns to 1 cm). It should be noted principal possibility of revealing the differences in the mineral composition of tobacco-yellow and the wax-red ferryplantites with the help of mineralography, since in the first case the predominance of getite phases over hematite is evident.

Literature

1. *Mamedov V.I. and Vorob'ev S.A.,* "Ground Air of the Bauxite-bearing Lateritic Weathering Crust (Republic of Guinea)," Vestn. Mosk. Gos. Univ., Ser. 4 Geol., No. 6, 2011, pp. 28-36.
2. *Mamedov V.I., Makarova M.A., Shipilova E.S.* Behavior (output and accumulation) of chemical elements in bauxite-bearing weatherin profile at sangaredi deposit, Republic of Guinea // 17th International Multidisciplinary Scientific Geoconference SGEM 2017. Conference proceedings,. — Vol. 17 of Science and Technologies in Geology, Exploration and Mining. — STEF92 Technology Ltd Sofia Bulgaria, 2017. — P. 35–48.
3. *Mamedov V.I.,* "The Separation between Al and Fe in the Supergene Zone as the Determining Factor of Premium Bauxite Formation," in Status of Bauxite, Alumina, Aluminum, Downstream Products and Future Prospects, Proc. XVI Int. Symp. ICSOBA-2005 (Nagpur, 2005), pp. 84-96.

REGIONAL GEOLOGICAL STUDIES OF THE SEDIMENTARY BASINS ON THE RUSSIAN FEDERATION SHELF

N.A. Malyshev, V.E. Verzhbitsky, D.K. Komissarov, V.V. Obmetko, A.A. Borodulin, Yu.V.Reydik, B.I. Ihsanov

Rosneft

Rosneft Oil Compny is the largest subsoil user on the Russian shelf conducting offshore operations in 11 seas and 55 blocks with a total area of 1.4 million km^2. As of 01.01.2018, the total recoverable resources for all licensed blocks are estimated as more than 41 billion TOE.

Initially, the regional works were initiated by Rosneft in 2006 in order to identify prospective areas. Starting from 2014, the exploration works were carried out offshore in the water areas of almost RF seas: Southern, Far East, Western and Eastern Arctic, determined by geological and geographic features of each region and aimed both at creating relevant reliable geological models of large sedimentary basins on the sea shelf, assessing their oil and gas potential and developing the exploration strategy and tactics for the licensed areas.

A key element of regional studies is the geological, geophysical and geochemical data integration applying modern laboratory-analytical methods and technologies, including basin modeling. An integrated approach to the offshore sedimentary basin studies implies the G&G information collection and analysis, structural and sedimentation consolidated model construction, geological history reconstruction, oil and gas system modeling, petroleum zoning, determination of exploration directions and targets, resources estimation and geological risk assessment.

The most important element of regional, as well as exploration works in the specific blocks licensed to Rosneft, is field geological works on the mainland and islands framing the water areas with subsequent laboratory and analytical data studies.

The results of regional works are used to select new license blocks, as well as to reduce geological risks of exploration works (including the determination of exploration well drilling locations) and to plan oil and gas prospecting and exploration for the licensed blocks.

The large-scale development of the Rosneft offshore exploration projects determines the importance of further regional geological and geophysical studies, creation and permanent update of the sedimentary basin structure models (including the G&G database development) for the Russian Federation water areas.

METHODS AND PRACTICES OF THE OFFSHORE EXPLORATION WORKS ON THE EASTERN ARCTIC SHELF

N.A.Malyshev, V.V. Obmetko, A.A. Borodulin, V.E. Verzhbitsky, E.A. Bulgakova, A.A.Kolyubakin, S.V. Gorbachev, V.S. Chibisov, D.V. Paramonov

Rosneft

On the Eastern Arctic shelf, Rosneft Oil Company conducts the geological exploration on 9 blocks of total area 659 thousand km^2. As of 01.01.2018, total recoverable resources for all blocks are estimated as 18 billion toe.

The Eastern Arctic shelf is one of the least studied regions in Russia. To date, the density of seismic lines in some seas does not exceed 0.1 km/km^2. Until 2017, no deep wells were drilled in the Russian sector of the Eastern Arctic.

Rosneft started the regional works on the Eastern Arctic shelf in 2007. As part of pre-licensing assessment, the vintage seismic data were purchased and reinterpreted, the archive and published data on the geological structure of the shelf and its surroundings were summarized. As a result, the most prospective areas were identified. In 2013, Rosneft received first 6 licenses on the Eastern Arctic shelf.

The main method of offshore prospecting and prospect preparation for drilling is seismic survey. During 2014-2017 on the Eastern Arctic shelf, Rosneft acquired more than 73 thousand line km of 2D seismic, which is comparable to the volume of seismic surveys for the entire period of the Eastern Arctic exploration. Based on the interpretation results of the obtained data, the geological models of the licensed blocks were substantially updated, and about 250 prospects were identified. The seismic and sequence-stratigraphic analyzes made it possible to distinguish structural-lithological and lithologic-stratigraphic traps in addition to structural-tectonic ones and to predict the reservoir and fluid distribution in the geological section of the Laptev and East Siberian seas.

One of the key features of seismic exploration in the Eastern Arctic is extremely harsh ice conditions. The duration of the open-water field season generally does not exceed 60 days, and in some years the ice in the East Siberian Sea does not melt out at all. To optimize costs and to solve geological tasks, Rosneft practices two-year contracts for seismic exploration in several license areas. This approach allows the operative redistribution of work scope from the ice-covered areas to open water areas, to carry out large amounts of work in the "easy" years due to longer duration of the field season. For the ice conditions monitoring, Rosneft developed and implemented the online module for monitoring vessel locations in a given water area. A continuous monitoring of vessel and ice edge positions, advanced ice reconnaissance from escort vessels and constant interaction with contractors allowed in the 2016 and 2017 field seasons timely update the seismic lines shooting priorities and perform seismic operations in the highest latitudes.

In addition to seismic methods, the airborne gravity-magnetic survey is broadly used for work planning and implementation in the Eastern Arctic. The advanced application of airborne gravity-magnetic works makes it possible within the license areas to distinguish the low-potential parts on the basement highs, to determine the position of main faults and to predict the regions with possible prospect development. In addition, the airborne gravity works allows adjusting the layout of seismic lines, avoiding non-productive shooting and concentrating on the most promising

explorations directions and plays. In 2014-2016, Rosneft conducted 242 thousand line kilometers of airborne gravity-magnetic survey in 8 license areas.

In the absence of deep drilling data, the primary way to obtain geological information on the rock material composition in the sedimentary cover is to carry out field geological studies on the land and island framing the water area, following by laboratory-analytical studies. From 2008 to 2017, Rosneft organized 10 geological expeditions. The most important result of these studies and using modern analytical techniques was a detailed description of the Cretaceous-Cenozoic section, which forms the main part of the sedimentary cover on the Eastern Arctic shelf.

Along with the exploration works on the existing licenses, Rosneft continues regional studies of the entire Russian water area of the Eastern Arctic, which are aimed both at obtaining valid geological models of large sedimentary basins and assessment of their oil and gas potential and planning the exploration works in the blocks licensed to Rosneft. Within the framework of these activities Rosneft cooperates with Russian leading scientific organizations, universities and industry R&D institutes.

ERT FOR THE LANDSLIDE SLOPE STUDY ON THE SOUTHERN CRIMEA BEARCH

I.N. Modin

Lomonosov Moscow State University, Faculty of Geology (imodin@yandex.ru)

Keywords: *ERT, landslide, Crimea*

Introduction To clarify the structure of the landslide slope electrical resistivity tomography (ERT) researches were conducted on the southern coast of Crimea. The method underlying ERT is based on the study of the spatial distribution of the electrical resistivity in the soil when current is passed through it[4]. Currently the ERT is the leading method for shallow Geophysics. The experience gained allows us to judge the high reliability of the results [2]. ERT is a complex of two-dimensional electrical prospecting, including special equipment, methods of observation, processing technology and field data interpretation [5]. The main features that distinguish ERT from other modifications of electrical exploration are: • technology of shooting using multielectrode cables, in which the electrodes are located along the profile with a linear step; • use of a wide variety of electrical exploration arrays; • 2D data inversion. A feature of ERT is repeated use as a current and measurement electrodes of the same electrodes connected to the cable. The total number of measurements on one profile can be several thousand samples. Research technique and ERT data processing On the studied territory the ERT was done on profiles with a total length of over 2 km. Step between the electrodes was 2.5 m and the maximum spacing is 106.5 m, which ensured the investigation depth of about 40 m. At the first stage of field data processing, the calculation of the values of apparent resistance and the construction of pseudo-sections of apparent resistance were performed. Within this stage, data rejection was done due to the influence of strong interference. The second stage is a automatic conversion of the observed apparent resistivity into a 2D geoelectric section. The program Res2DInv 3.59 [1] (GeoTomo, Malaysia) was used to perform the 2D inversion. Results electrotomography research Geoelectric sections were obtained for 13 profiles. Geoelectric sections are quite contrast, the range of specific electrical resistances is from 10 to 3000 Ohm•m. The zones of influence of surface waters, which appear as zones of low resistance, are found. The resistivity of the surface water is about 9-10 Ohm•m. The surface water percolates to a depth of 15 m, which led to a partial wetting of the soil mass. Starting from the depths of 10-15 m, there are areas of decreasing resistance, which can be explained by the injection of sea water. This was clearly appeared in the profiles close to the sea. Here, in the lower part of the section at depths of more than 10 m, abnormally low soil resistances are observed, which are not typical for local types of rocks. All the geoelectric sections indicate a complex structure of the investigated area. On geoelectric sections and horizontal sections can be identified Western (I), Central(II) and Eastern zone(III). The Western zone is characterized by high resistances. Within its limits there are high-resistance blocks associated with large olistolites, which are outcrops of rocky soils ranging in size from several meters to hundreds of meters. In the past, they moved down the slope under the influence of gravity, earthquakes and moisture. The olistolite roots go to a sufficiently large depth and are embedded in the roof of the bed of the landslide for 10-15 meters or more, forming a powerful fixed frame. In General, the surface soils

on the study area are mainly boulders in the loamy matrix, below is a gravelly soil in the loamy matrix, which is represented by different degrees of salted rocks of the flysch layer of Triassic and Jurassic. High resistance zones correspond to the accumulation of lump material, which can contain very large blocks of olistolites. The Eastern, mainly low-resistance zone is characterized by almost complete absence of coarse-grained material. The landslide has a complex structure and consists of two parts. Its lower part, folded with olistolites, is at absolute marks from 10 to 20 m. the level of the roof of the ancient landslide mainly falls towards the sea. Olistolite sizes can be quite large – up to 50-70 m, and a maximum width of about 20 m. Most of them located in the Western part of our area and partly in the South, covering and holding the steep coastal slope. Probably the lower edge of the largest blocks of olistolites is at absolute levels below sea level at 20 m – 30 m. Probably an ancient landslide body isn't moving. But on the surface, especially in the Central and Eastern parts of the study area is a modern landslide layer. His bottom is located at a depth of about 10 m. Here there are" floating " on the surface of the old landslide small olistolites with a thickness of 5-7 m and with horizontal dimensions of several tens of meters. However, these olistolites also have some stabilizing ability, being in contact with the lower olistolites. On geoelectric sections in the upper part it is seen that the landslide masses of the two soil floods are directed to the sea. The first soil flood is located in the center of the site and is oriented in the meridional direction, and the second soil flood is oriented in the South-East direction. Summary The studied landslide body in the plan can be divided into three zones: the Western, saturated with olistolites; the Eastern, in which there is a block structure consisting of olistolites in the lower part and the dispersed material in the upper part and the Central with a transitional structure. The Western area of the landslide body are fixed by olistolites. The Eastern zone is a modern landslide, modern separate relatively small blocks of material, probably of carbonate composition, slide along its sole. Flooding the upper part of the section is indicated by the low resistivity of soils and anomalous conductive zones, which are a result of infiltration of surface waters in the geological section and wetting of the landslide body.

This κesearch was financially supported by RFBR grant №18-45-920073 (headed by O.V. Krylov)

Literature

1. *Loke, M.H. and Barker, R.D.,* 1995. Least-squares deconvolution of apparent resistivity pseudosections. Geophysics, 60, 1682-1690.
2. *Bobachev A. A., Gorbunov A.A., Modin I.N., Shevnin V.A.*. Ehlektrotomografiya metodom soprotivlenij i vyzvannoj polyarizacii. Pribory i sistemy razvedochnoj geofiziki. 2006, N02, 14-17.
3. *Dahnov V.N.* Interpretaciya rezul'tatov geofizicheskih issledovanij skvazhin. Moskva, «Nedra» 1982 y.
4. Instrukciya po ehlektrorazvedke. M. Nedra. 1984.
5. Ehlektrorazvedka. Posobie po ehlektrorazvedochnoj praktike dlya studentov geofizicheskih special'nostej. Po red. prof. Hmelevskogo V.K., doc.I.N.Modina i doc.A.G.Yakovleva. Moskva, 2005.

OVERVIEW OF GEOMORPHOLOGICAL HAZARDS OF THE TAIMYR PENINSULA

M.S. Myshenkova

Lomonosov Moscow State University, Faculty of Geology (zf12@rambler.ru)

Keywords: *Taimyr, geomorphological hazards, permafrost processes*

The Taimyr Peninsula is not economically developed due to the extreme severity of local climate and the active development of processes associated with a propagation of continuous permafrost, the flooding and formation of marshes. On the peninsula there are only a few settlements and polar stations, and even a some of them, such as the station "Sopochnaya Karga", which is located on the bank of the Yenisei River at the place of its confluence into the Yenisei Gulf, are suffering from active exogenic geological processes [2]. The processes which are caused by a freezing and thawing of rocks represent the most great geomorphological hazard on the Taimyr Peninsula. Permafrost rocks are widespread everywhere, the thickness of permafrost develops up to depths of 500-600 m. The thickness of permafrost is decreasing in the areas adjacent to the coast, and directly on the shore of the Kara Sea. The thawing of soils in the summer period occurs up to depth of 0.6-1.0 m. The maximum thawing is observed in the depressions and rivers' valleys, in the valley of the Pyasina River - up to 2 m [4]. In connection with continuous development of permafrost rocks the processes of thermokarst and solifluction are actively proceeding here. On the dense rocks are proceed a thermodenudation, thermal planation, associated with subsidence, leveling of the surface during seasonal thawing of frozen soils and ice in them, and solifluction. Thermokarst, solifluction forms, frost blister and hydrolaccolits are prevail where mouldy deposits are common. On the rivers' terraces in intermontane valleys of the Gorny Taimyr there are a development of cavern-load ices and polygonal relief accompanying them, a saucer-shaped thermokarst. On the slopes are common the manifestations of linear thermokarst. The territory of the North Siberian Lowland is characterized by the presence of wide boggy valleys and extensive lakeside marshy depressions, which are located between hilly plains and shallow-ridged ridges. Active formation of marshes, peatlands and lakes on this territory is promoted by positive water balance. This positive water balance is conditioned by the excess precipitation over evaporation with insufficient drainage in low relief's elements, and cryogenic geological factors. The latest lead to the formation of hillocks on the surface of peat massifs alternating with thawed depressions. The lakes here often are surrounded by steep and precipitous slopes, their origin is conditioned in most cases by subsidence of soil due to thermokarst. The territory of the Gorny Taimyr is characterized by regular flooding of riparian of rivers' valleys during the rapid short spring flood, which begins in late June - early July. The rise of water in large rivers reaches 8-10 m [4]. In autumn, during prolonged rains, there is autumn flood. Abrasion processes occur in the coastal areas of the Yenisei Gulf, the water areas of the Kara Sea and the Laptev Sea during the ice-free period. The shore of the Taimyr northern coast collapses at an average rate of 0.2 m/year, the northwest coast - at an average speed of 0.3 m/year, the Yenisei Gulf - from 0.2 to 0.7 m/year [1]. The coastal thermocircuses are timed to the sections of the ripping-up of interbedding ice, the speed of the retreat of the rear walls is much higher than the rate of the thermoabrasive retreat of the coastal strips of neighboring sections. Thus,

geomorphological hazards of the Taimyr Peninsula are mainly conditioned by the activity of surface waters, the freezing and thawing of rocks. These processes make it difficult to use the territory for construction, tracing roads, etc. With the difficulties which are caused by the development of permafrost processes, were encountered during the construction of sites of the Norilsk industrial region, located to the south; the Dudinka-Norilsk railway demands constant monitoring and reconstruction. At the present time there is a tendency to increase the depth of soil thawing on the Taimyr Peninsula, which contributes to the intensification of solifluction and thermokarst processes [3].

Literature

1. *Vasil'ev A.A., Streletskaya I.D., CHerkashev G.A., Vanshteyn B.G.* Dinamika beregov Karskogo morya // Kriosfera Zemli, 2006. T. 10. № 2. p. 56-67.
2. *Gusev E.A.* Nablyudeniya za geomorfologicheskimi protsessami na severe Zapadnoy Sibiri (na primere rayona Sopochnoy Kargi) // Uspekhi sovremennogo estestvoznaniya, 2011. № 9. p. 19-22.
3. *Im S.T., Haruk V.I.* Izmenenie vodnoy massy v kriolitozone Sredney Sibiri po dannym distantsionnogo zondirovaniya GRACE // ZHurnal Sibirskogo federal'nogo universiteta. Tekhnika i tekhnologii, 2015. T. 8. № 6. p. 735-743.
4. *Kachurina N.V., Makar'ev A.A., Makar'eva E.M. i dr.* Gosudarstvennaya geologicheskaya karta Rossiyskoy Federatsii. Masshtab 1 : 1 000 000 (tret'e pokolenie). Serii Severo-Karsko-Barentsevomorskaya i Taymyrsko-Severozemel'skaya. List T-45−48 − m. CHelyuskin. Ob"yasnitel'naya zapiska. SPb.: Kartograficheskaya fabrika VSEGEI, 2013. 568 p.

OVERVIEW OF GEOMORPHOLOGICAL HAZARDS OF THE CENTRAL PART OF THE NORTH CAUCASUS

M.S. Myshenkova

Lomonosov Moscow State University, Faculty of Geology (zf12@rambler.ru)

The North Caucasus is a densely populated and dynamically developing region located on the territory of actively proceeding geomorphological processes, some of which are catastrophic. The high dynamism of modern exogenic processes is due to the high degree of landscape dismemberment and the belonging to the zone of the young actively forming alpine folding. In this paper are considered the geomorphological hazards of the central part of the North Caucasus, including the Karachay-Cherkessia, the Kabardino-Balkaria, the North Ossetia-Alania, the Ingushetia and the Stavropol Territory. Landslide processes occur in all the above-mentioned regions, most actively - in the territory of the Karachay-Cherkessia and the Stavropol Territory. The main causes of activation are the atmospheric precipitation, groundwater, erosion on river slopes, and in the mountain zone large ice-stone rockfalls. Large block landslides and landslide massifs often occur in the near-fault zones and have a seismogenic origin. In the high-mountainous zone of the North Caucasus there are several pulsating glaciers; the glaciers with movements fixed in them or its tracks. When the ends of such glaciers emerge on steep cliffs of the estuary step, at the shifts, the series of earthquakes or powerful rockfalls on the glacier, ice falls or the glacier ejection from its bed occur, as happened in September 2002 with the Kolka glacier [4]. Also, the high-mountainous and mid-mountainous zones of the North Caucasus are avalanche active territory. Here, the lowest boundary of the avalanche zone, with the exception of the slopes of the Skalistyy Ridge, lies at an altitude of 1350-1100 m. The duration of the avalanche period can vary from 2-3 days at the lowest boundary to 200-300 days or more in areas with a long period of stable snow cover [3]. In the high-mountainous zone of the North Caucasus there are also the rockfall and talus processes, the activation factors of which are the warming of the climate, thawing of frozen rocks and endogenous processes. At the moment more than a ten modern manifestations of the rockfall processes on the territory of the central part of the North Caucasus have been identified and cataloged based on the interpretation of aerospace information, aerovisual and route observations [2]. Repeated rockfalls are fixed on the interfluve of the Fiagdon River and the Terek River on the Georgian Military Road below Lower Lars Village on the left and right sides of the Terek River. As a result of the rockfall in 2007, the road was blocked for 50 m [1]. In the mountainous zone mudflows are formed everywhere. The mudflows are observed in the altitude range from 400 to 4000 m. The main part of the mudflows originates above 2000 m. In the high-mountainous zone the mud-and-stone flows prevail, in the mid-mountainous and low-mountainous zones - the torrents. Mud streams are rare. Catastrophic mudflows lead to changes in the morphology of the mountain valleys' bottoms and cause significant damage, as, for example, in the valley of the Baksan River in Tyryauz in July 2000 and August 2017, the valley of the Birdjalysu River in August 2006, the valley of the Bulungusu River in August 2007, etc. The formation of mudflows is caused by the breakthroughs of the interglacial cavities and preglacial lakes at the edges of glaciers, torrential precipitation, landslides to channels with the formation of short-lived blockage reservoirs. Most often catastrophic mudflows occur in the territory of the

Kabardino-Balkaria, but large mudflows sometimes occur in the Predgornyy region of the Stavropol Territory. As a result of the precipitation of intensive prolonged rains during flood periods in valleys of mountain rivers, rain floods occur, leading to flooding of settlements. They occur on average 3-4 times in 10 years. Thus, the geomorphological hazards of the central part of the North Caucasus are mainly due to the energy of the relief and the activity of surface waters. As the region is densely populated and actively develops, active measures are taken to predict and prevent dangerous exogenic processes. A set of various anti-mudflow measures is carried out to ensure the safety of settlements and infrastructure from the destructive impact of mudflows. After the Karmadon disaster, a systematic study of pulsating glaciers is carried out. Flood monitoring is carried out to forecast and prevent landslides, active measures are used in the fight against developing landslides. Avalanche devices are detected in the mountains on the basis of geomorphological and geobotanical features. Also is carried out the forecast of time of descent of the avalanches, artificial descents of avalanches by artillery bombardment of avalanche slopes at night.

Literature

1. *Asoyan D.S.* Dinamika opasnyh geomorfologicheskih protsessov v tsentral'noy chasti Severnoy Osetii-Alanii // Geomorfologiya, 2011. № 4. p. 58-72.
2. *Dokukin M. D., Savernyuk E. A., CHernomorets S. S.* Obval'nye protsessy vysokogornoy zony Kavkaza v xxi veke // Geomorfologicheskie resursy i geomorfologicheskaya bezopasnost': ot teorii k praktike: Vserossiyskaya konferentsiya VII SCHukinskie chteniya. Moskva, MGU imeni M.V. Lomonosova, 18–21 maya 2015 g.: Materialy konferentsii. — MAKS Press Moskva, 2015. — p. 79–82.
3. *Zalihanov M.CH.* Snezhno-lavinnyy rezhim i perspektivy osvoeniya gor Bol'shogo Kavkaza. M.: Ofitsial'naya i delovaya Rossiya, 2014. 611 p.
4. *Kotlyakov V.M., Rototaeva O.V., Osokin N.I.* Pul'siruyuschie ledniki i lednikovaya katastrofa na Severnom Kavkaze // Vestnik Vladikavkazskogo nauchnogo tsentra, 2004. T. 4. № 3. p. 65-71.

PROBLEMS OF ENVIRONMENTAL SAFETY IN OIL AND GAS PRODUCTION ON THE SHELF OF THE BLACK SEA

M.V. Nacheva

Federal state budget scientific institution "INSTITUTE OF NATURAL AND TECHNICAL SYSTEMS" (mari.nacheva@mail.ru)

Keywords: *oil production, utilization, waste, drilling mud, ecological situation, monitoring*

The objects of oil production by the degree of impact on the environment are leading in many regions of the Russian Federation. When extracting and preparing oil prior to its supply to the main oil pipeline, high-active formation water, associated petroleum gas, and many chemical reagents that are used in drilling wells and intensifying the extraction of hydrocarbons (other than oil) fall into the natural environment. Annually more than 2.5 million tons of polluted substances are emitted into the atmosphere, about 6 billion m3 of associated gases are flared at the flares, dozens and hundreds of borers with drill cuttings remain unapproved, and about 740 million m3 of fresh water are collected [1]. Negative impact on the environment begins already at the stage of exploratory drilling. Therefore, the first thing to start with is to change the technology of drilling exploration wells to a more precise one in order to ensure 100% penetration into the oil and gas reservoir and not to drill several wells, but to drill one, thereby reducing the level of pollution of the marine environment and saving colossal funds in hundreds filtration of contaminated water from drilling sites and barns; injection of industrial waste into the cavernous space of drilled wells; contamination with garbage dumps and domestic wastewater. In the literature, various data are given on the conditions for storage of drill cuttings, drilling wastewater and drilling muds in open earth pits (barns). It is assumed that each pit of a single well may contain from 60 m3 and more drill cuttings and 200-30 m3 of drilling mud, in of millions of rubles. Another important aspect is the use of chemical reagents that are safer for the environment, which are part of drilling fluids. For example, some oil-producing enterprises still use highly toxic ferrochrome lignosulfonate (FHLC), which is banned in many countries of the world. Its maximum permissible concentration (MPC) is 0.2 mg / l. Ferrochrome lignosulfonate (FHLC) - reduces the level of primary production by 51%, leads to a decrease in the survival of embryos of flounder and increases the percentage of various types of malformations. Individual organs develop disproportionately, cyclops, dwarfs, larvae with curvature of the axial structures of the body are encountered [2]. Among the main sources of pollution of the earth's surface and geological environment there are drill cuttings, oil wells, including petroleum-based with chemical additives, natural which up to 20 m3 of oil and 1 m3 of reagents can be present [1], therefore it is necessary to utilize the accumulated drilling waste to avoid further pollution of the environment, to liquidate sludge barns , and to recultivate mined quarries. If possible, thermal utilization should be carried out directly on the drilling platform [3], when waste is received, so that they do not accumulate, which in turn will reduce negative impact on the environment at the chain of transportation of the waste to the storage location, reduce the use of land resources for storage of drilling wastes and to reduce the probability of emergency situations when transporting wastes by sea and land to the final location. The final stage for the normalization of the environmental situation will be conduction by the enterprise ecological and

geodynamic monitoring several times a year. This monitoring system in accordance with the Concept [4] and the Guidelines [5] should ensure ecological and geodynamic safety in long-term development of hydrocarbon deposits of a polycomponent composition. Monitoring should be carried out in accordance with the program envisaged in each specific project, containing the justification for the organization of observing systems for seismic and deformation situations, the optimal composition of methods, as well as instrument-methodical support and observation regime adequate to monitoring tasks. The introduction of the proposed recommendations will significantly improve the ecological state of the environment in the areas of oil hydrocarbon production, reduce the anthropogenic load on the natural ecosystem, and improve the quality of life and health of people living in the region of deposits.

Literature

1. Kontseptsiya – geodinamicheskaya bezopasnost' osvoeniya uglevodorodnogo potentsiala nedr Rossi. – Moskva: Izd-vo IGiRGI, 2000. – 56 p.
2. *Moyseychenko, G.V.* Rezistentnost' molodi lososevyh i ih kormovoy bazy k vozdeystviyu burovyh komponentov / G.V. Moyseychenko, V.L. Abramov // 5-e Vserossiyskoe soveschaniya po sistematike, biologii i razvedeniyu lososevyh ryb: materialy. – Sankt-Peterburg, 1994. – p. 126–127.
3. Rukovodstvo po geodinamicheskim nablyudeniyam i issledovaniyam dlya ob"ektov toplivno – energeticheskogo kompleksa. – Moskva: Izd-vo IGiRGI, 1997. – 12 p.
4. *Nacheva M.V., Voskresenskaya E.N*. Analiz sovremennyh metodov utilizatsii burovogo shlama // Byulleten' «Ispol'zovanie i ohrana prirodnyh resursov Rossii». M., 2017. № 4 (152). p. 81–93.
5. *Haustov, A.P*. Ohrana okruzhayuschey sredy pri dobyche nefti: monografiya / A.P. Haustov, M.M. Redina. – Moskva: Delo, 2006. – 551 p.

DISTRIBUTION OF BORON BETWEEN GAS AND LIQUID IN KAMCHATKA HYDROTHERMS

I.Y. Nikolaeva[1], A.Y. Bychkov[2]

МГУ имени М.В. Ломоносова ([1]- niko-geo@mail.ru,[2]- andrewbychkov@rambler.ru)

Keywords: *distribution of components, hydrothermal fluid, transfer forms, thermal systems*

The nature of the distribution of boron between the thermal solution and the gas phase of various hydrothermal systems is very different. For the wells of the Mutnovsky Geothermal Station, the distribution of boron corresponds to the theoretical dependence. The same regularities are observed for the springs of the Donnoe Field of the Mutnovsky volcano, the Valley of Geysers, the Caldera Uzon and the Verkhne-Apapel springs. For thermal springs of the Akademii Nauk, Dachnye, Medvezh'i, and partly springs of Caldera Uzon, the concentration of boron in the condensate exceeds the equilibrium value at the boiling point of water by orders of magnitude. This may be due to two reasons: the presence of unknown readily volatile forms of boron transfer or the lack of equilibrium between the liquid and the gas. Since other components in concentrations comparable to boron concentrations are not found in high-boron condensates, we believe that the first reason has not yet been proved. Boron forms many volatile compounds: hydrides, fluorides, chlorides, organic esters of boric acid and organoboron compounds. All these substances are easily hydrolyzed, so it is difficult to assume their predominance in water vapor. The diagnosis of new volatile forms of boron in natural gases requires special research methods. It seems to us that a more convincing reason for the high values of the boron distribution coefficients is the lack of equilibrium between the vapor-gas phase and groundwater on the surface. Although in most thermal springs we can observe the bubbling of gas through the solution ("boiling springs"), only the vapor-gas jet comes from the depths. At the surface it interacts with ground and surface waters. In this case, condensation of steam or evaporation of groundwater occurs depending on the enthalpy (heat content) of the vapor-gas mixture. If a two-phase mixture of a hydrothermal solution with steam rises to the surface, the boron distribution coefficients will be close to equilibrium. If, on the other hand, dry steam arrives at the surface, the temperature of which is higher than that of equilibrium water with liquid water at a given pressure, then we observe anomalous distribution coefficients. Such features of the gas phase are characteristic for the parodominant systems. Experiments on thermal springs have shown that the interaction of superheated water vapor with groundwater does not lead to an equilibrium exchange of components. The more the steam is overheated, the further the system leaves the balance. The distribution coefficient shows the degree of nonequilibrium and is a function of the enthalpy of the vapor-gas phase. The formation of superheated or dry steam occurs when the deep solution in the formation boils at high temperature and pressure. If such a vapor rises to the surface without experiencing heat loss, its temperature is reduced only by adiabatic expansion and on the surface exceeds 100 ° C. Such steam jets are known on the Dachnye, Severo-Mutnovsky springs and on the springs of the Akademii Nauk. Apparently, the condensate of the gas phase obtained from these jets and the spontaneous gases of the surrounding springs corresponds to the gas-liquid equilibrium in the conditions of the formation. Knowing the boron content in the deep thermal water and the concentration in the condensate, it is possible to estimate the boiling point in the reservoir from experimental data. We

assumed that the deep hydrothermal solution for the Severo-Mutnovskye and Dachnye springs is the same and corresponds to the open hole. Then, for the Severo-Mutnovskye springs, an estimate of 310 ° C was obtained, for the Dachnye - 260 ° C, these temperatures are in good agreement with the values calculated from gas geothermometers. For the Donnoe Field, the same estimate can be made, based on the assumption of a single source of deep fluid. Then the boiling point of the bottom fluid of the Donnoe Field is 244 ° C. For the hydrothermal system of the Caldera Uzon, an estimate of the composition of the deep fluid can be made using solutions opened by the wells. The calculated temperatures are 250, 160 and 290 ° C for the I, II and III sections of the Eastern thermal field, respectively. These temperatures are also close to the estimates obtained from gas equilibria. The highest temperature was obtained for the hydrothermal springs of the Academii Nauk - 320 ° C, where the estimate of the composition of the deep fluid is made according to the composition of the geyser Noviy solution. This may be a consequence of the activation of the hydrothermal system after the 1996 eruption. The coefficient of distribution of boron between the gas and liquid phases in thermal springs can serve as a geochemical indicator of the heat content of the vapor phase, but further studies are needed to use it. Condensates from superheated steam jets are important indicators of processes occurring in the bowels of hydrothermal systems. The content of other elements in them should be interpreted not as a consequence of equilibria on the surface, but as a result of the boiling of the hydrothermal solution at a higher temperature and pressure.

The paper was completed with the support of the Russian Foundation for Basic Research, Project No. 17-05-00257

NUMERICAL MODELING OF SEISMIC WAVEFIELDS IN FRACTURED POROUS FLUID-SATURATED MEDIUM – ANALYSIS OF FRACTURE CONNECTIVITY EFFECT ON WAVE ATTENUATION

M.A. Novikov

IPGG SB RAS (mishutikrus@yandex.ru)

Keywords: *Biot model, poroelasticity, wave-induced fluid flow, seismic attenuation, wave propagation, discrete fracture network*

Study of seismic attenuation mechanisms in fractured porous fluid-filled rock is quite popular research area at modern geophysics. One of these mechanisms is wave-induced fluid flow (WIFF), which is typically divided on two types. First type, fracture-to-background wave-induced fluid flow (FB-WIFF) between fractures and background, have significant effect at low-frequency range and depends mostly on physical properties contrast between fracture-filling material and host rock. Second type, fracture-to-fracture wave-induced fluid flow (FF-WIFF) is most active at high frequencies up to 10 kHz, and dominantly affected by systems of connected fractures. So, frequency-dependent attenuation of seismic waves in fractured porous fluid-saturated medium may be the indicator of hydrocarbon reservoirs transport properties. Over the last years, numerous studies on wave-induced fluid flows were reported, including theoretical investigations [1], numerical analysis on the base of quasi-static tests [2], and full waveform simulation [3]. However, FF-WIFF investigations usually restricted by relatively simple models of the fractured media – two sets of fractures with restriction so that every fracture must have at least one intersection with another fracture from other set, or fractures should not intersect at all. In that case, intersecting fractures do not form mesoscale percolating systems. The only known attempt to overcome this restriction was in [4], where the authors studied dependence of the attenuation on the fractures length and number of intersections.

Main object of this study is investigation of fracture connectivity influence on seismic waves attenuation at fractured fluid-saturated medium with more complex fracture system structure. Fractured domain was modelled using simulated annealing approach with percolation in maximized functional. Initial model is uniformly distributed fractures of two types – perpendicular and parallel to wave propagation direction. There is 10 realizations with 6 different percolation stages each. Statistical analysis of fractures systems included constructing medial axis of fractures systems, and obtaining average values of number, length, distance between endpoints, integral curvature, tortuosity of its branches depending of branches direction. Constructed fractured domain models were applied to the set of numerical experiments based on full waveform simulation with finite-difference approximation of Biot dynamic equations. Central frequency of signal varied from 1 to 10 kHz Resulting wavefields show sufficient influence of fracture connectivity on seismic energy dispersion. Next deconvolution of averaged traces registered before propagating in fractured domain and after it is used to obtain frequency-dependent wave attenuation estimations. Also estimations of wave attenuation associated with scattering on fracture system is constructed [5] and demonstrated dominant influence of this attenuation mechanism at high frequency range. Obtained estimations demonstrate direct correlation between fracture connectivity and wave attenuation.

The research was done under financial support of Russian Science Foundation grant no. 17-17-01128.

Literature

1. *Guo J., et al.* Effects of fracture intersections on seismic dispersion: theoretical predictions versus numerical simulations // Geophysical Prospecting. - 2017. - V. 65. - N. 5. - pp. 1264-1276.
2. *Rubino J. G.,* et al. Seismoacoustic signatures of fracture connectivity // Journal of Geophysical Research: Solid Earth. - 2014. - V. 119. - N. 3. - pp. 2252-2271.
3. *Novikov M., et al.* (2017), Numerical study of fracture connectivity response in seismic wavefields, in SEG *Technical Program Expanded Abstracts 2017, edited, pp. 3786-3790.*
4. *Hunziker J., et al.* Seismic attenuation and stiffness modulus dispersion in porous rocks containing stochastic fracture networks // Journal of Geophysical Research: Solid Earth. - 2018. - pp. n/a-n/a.
5. *Rytov S. M., Kravtsov Y. A., and Tatarskii V. I.* Principles of Statistical Radiophysics 2. Correlation Theory of Random Processes. - Springer-Verlag Berlin Heidelberg. - 1988. - 234 pp.

EXPERIMENTAL MODEL STUDIES OF CRYSTALLIZATION OF ONGONITE PRODUCTION MELTS FROM THE ARY-BULAK INTRUSION.

A.S. Novikova[1], Y.O. Alfer'eva[2]

Lomonosov Moscow State University, Faculty of Geology ([1]- novikova-a-s@yandex.ru,[2]- YanaAlf@ya.ru)

Keywords: *ongonites, experiment, Ary-Bulak intrusion*

The Ary-Bulak intrusion consist of subvolcanic analogue of rare metal Li–F granites – ongonites. There is a facies zonation in massive. The central zone, that occupies a large area, composed of porphyritic ongonites, the intermediate zone, forming the ring-structure, 50-100 meters wide, previously consist of high Ca and F porphyritic ongonites, and the marginal zone, situated at the southwestern flank of massive, composed of aphyric rock with rare xenolith parts of hornfelsed pelitic killas. Mineralogical, petrochemical and petrological facies zonation in massive was explored from literature data sources (Gayvoronsky B. A. et al., 1973, Kovalenko V. I et al., 1976, 1999, Antipin V. S., Peretyazhko I. S. et al., 2010, 2011, Peretyazhko I. S, 2006) and was generalized. Also there were substracted three theories of massive formation, made by Kovalenko V. I., Antipin V. S. and Peretyazhko I. S. And were explored experimental works in high – fluoric granite systems, made by Kovalenko V. I and Manning, D.A. Samples from nature rocks were analyzed by X-ray diffraction methods in Institute of Geology of ore deposits (value composition) and by ICP MS in Department of Geochemistry of Moscow State University of M. V. Lomonosov. (value composition on all elements). Samples from three several zones were explored by the temperatures 700 and 800 Calcium degrees and pressure 1 kBar by different amount of water 3, 5 10 per cent on hydrothermal high-pressure plant. Experiments (800 °C) have lasted by 7 days, and by 700 °C – by 14 days. Products were analyzed by local methods on energy-dispersion spectrometer INCA-Energy 350 in the laboratory of local methods of studying the substance of the Moscow state University of M. V. Lomonosov. The results of the experiment have showed that different amount of water gives the same results and doesn't influence on mineralogical phases and order of crystallization of rocks. Liquidus was attained for marginal zones - of high Ca and F porphyritic and aphyric ongonites. Liquidus phases for them are fluorine and topaz. By 800 Calcium degrees stable marginal zones of high Ca and F porphyritic and aphyric ongonites. Central zone in that conditions is not stable. By 700 Calcium degrees the mineral composition in marginal zones changes: accept fluorine and topaz, liquidus is attained for plagioclase. In central zone there is also a melt. The common trend in crystallization of ongonite melt is directed towards decreasing content of F in residual liquor and rising content of alkalies and silicium.

MECHANICAL STRATIGRAPHY IN DOMANIK SHALE FORMATIONN (UNCINVENTIONAL OIL SOURCE)

I.I. Nugmanov, E.R. Ziganshin, D.N. Zaitsev, F.F. Husnutdinov

Kazan (Volga region) Federal University (ilmir.nugmanov@kpfu.ru)

Keywords: *geomechanics, unconventional oil, carbonates, lithological facies, laboratory core analysis*

The Volga-Ural petroliferous basin is the oldest oil producing region of Russia. Therefore, most of the major oil and gas fields of traditional types here are already at the final stage of production. This provides for the increasing interest to develop unconventional resources of hydrocarbons associated with potential resources of the Upper Devonian-Lower Carboniferous (Tournaisian) Domanik-type sedimentary formations. This study focused on the geomechanical and petrophysical evaluation of the Domanik Formation and Domanikoids (younger rocks overlying the Domanik Formation) rocks. These are low-permeable cherty limestone or organic-rich mudstone rocks. This paper presents core analysis from the boreholes of Mamadysh, Upper-Garey, Chishminsk, Bondyuzhsk areas located within the Kama-Kinel Throughs System (KKTS), as well as Bavly's area in the South-East of the South-Tatar arch (STA) of the Republic of Tatarstan, Russia. We have investigated core samples from 6 wells from several oil-bearing areas. Laboratory studies of intact rock core specimens were carried out to determine rock failure parameters, cohesion and angle of internal friction under representative reservoir loading/stress conditions; and to estimate static and dynamic elastic modulus (Young's modulus and Poisson's ratio) under representative reservoir loading/stress conditions. Samples porosity, permeability and volumetric bitumen content were obtained by routine core analysis (RCA) technics. End faces of the specimens were used for mineralogical thin section optical analysis, X-ray diffractometry and X-ray fluorescence spectroscopy. Inferred from the results, we have distinguished three mechanical facies of the Domanik Formation and Domanikoids rocks substantially different in terms of chemical, mineralogical composition and petrophysical properties. The patterns of distribution of facies and main accumulations of hydrocarbons in domanikites indicate a strong influence of the Ural deep-water basin and the rifting activization processes of the East European platform, accompanied by volcanism and periodic input of deep fluid systems into the sedimentation basin on the biogenic sedimentation. The results of lithochemical studies have provided data on trace element composition of domanikits which is important for environmental risk assessment in the development of shale formations. High nickel and uranium contents, which are significantly higher than clarks, represent a potential environmental hazard in the production of shale hydrocarbons. We assumed that outcomes can be used to optimize the development of multistage hydraulic-fracturing technology in horizontal wells.

The work was supported by the Ministry of Education and Science of the Russian Federation (project No. 02.G25.31.0131)

Literature

1. *Fadeeva N.P., Kozlova E.V., Poludetkina E.N., Shardanova T.A., Pronina N.V., Stupakova A.V., Kalmykov G.A. and Khomyak A.N.,* The hydrocarbon-generation potential of the Domanik rocks in the Volga-Ural petroliferous basin, Moscow University Geology Bulletin, vol. 71, issue. 1, pp. 41-49., 2016.
2. *Peterson J.A. and Clarke J.W., ,* Geology of the Volga-Ural petroleum province and detailed description of the Romashkino and Arlan oil fields, U.S. Geological Survey Open-File Report 83-711, 90 p., 1983.
3. *Voitovich S.E., Dusmanov E.N., Khamidullin D.N., Mikulinskii E.V.,* The results generalization of special studies of domanic sediments of the 444 deposit of the Romashkino field, Georesursy, Special issue, pp. 14-21, 2018, doi: https://doi.org/10.18599/grs.2018.SI.14-21
4. *Zaydelson M.I., Surovikov E.Ya., Vaynbaum S.Ya., Bellerova V.A. and Ashirov K.B.,* Oil and gas potential of the Domanikoid associations of the Volga-Ural Province, International Geology Review, vol. 33, issue 3, pp. 243-262.
5. *Onishchenko Y.V. , Vakhin A.V. , Gareev B.I. , Chemodanov A.E. , Morozov V.P.* Oil sourcemass and oil generation phase of Domanic deposits of Tatarstan: biomarker data, Proceeding in 17th International Multidisciplinary Scientific GeoConference. - SGEM 2017. - V. 17. - Is. 15. - P. 373-380.

FORECAST OF THE FRACTURED CARBONATE RESERVOIRS OF THE SEMILUKI DEPOSITS

N.V. Nugumanova, S.P. Novikova, S.V. Sidorov, L.I. Minihairov, I.I. Bagmanov

Kazan (Volga region) Federal University (natalya.bokova.kazan@gmail.com)

Keywords: *fractured carbonate reservoirs,Semiluki horizon, water invasion analysis, lineament analysis, reservoir simulation*

At the present-day the stage of development of the oil industry of the Republic of Tatarstan is dependent on the replacement and growth of the oil reserves in non-traditional reservoirs. Prospects that are widespread on the territory of the Volga-Ural oil province includes sediments of the Semiluki horizon of the Frasnian Stage of the upper Devonian. The presence of oil indicators and production data make it possible to consider this interval as promising for oil reserves replacement [4]. The purpose of this work was the analysis of the fracturing and the forecast of its distribution in the area of the oil deposit of the Semiluki age by the example of the Shugansk uplift of the Muslyumovsky oil field. Oil is accumulated in the fissured-porous-cavernous carbonate reservoirs. Despite the fact that this reservoir was under production, these deposits remain one of the most underexplored in the territory of Tatarstan. The results of the studies conducted can be useful in carrying out the reservoir simulation. The Shugansk uplift is confined to the northeastern slope of the South Tatar arch according to the tectonic plan. Also, the research area covers the side zone of the Kamsko-Kinel system of the Aktanysh-Cheshmin trough. Within the field area, crystalline basement surface has general dip in the north-easterly direction towards the Kamsko-Belsky aulacogen. The surface is complicated by a number of low-amplitude local positive and negative structures. The system of faults of the north-western strike forms a stepped plunge, which led to the formation of basement highs and the creation of draping structures in the overlying Semiluki deposits [3]. According to seismic survey data for reflection surface "A", the uplift is confined to the zone of a trough fault and represents an elevated block between Grachevsky and Shugansk troughs. The uplift is small and has a low amplitude and the troughs have east-west trending. The structure plan of the reflection surface "D" inherits the features of the crystalline basement. Troughs in the basement are also traced. The amplitude and size of the uplift increase, but in overall it remains low-amplitude. Conditions of the sedimentation of the Semiluki deposits belong to the zone of the deep marine shelf. The geological section is characterized by an alternation of dark gray to black clay-bituminous limestones and marls, sometimes with interlayers of bioherm and dolomitized limestones and dolomites, as well as silicified, argillic-bituminous shales. The porosity coefficient of the reservoir rocks by well logging and core data varies in a wide range from 4 to 20.9% (average value - 10.9%). The value of the lower limit of porosity coefficient for the reservoir rock of Semiluki horizon is 4%. According to the macro-description of the core of the production well of the Bukhara field, horizontal fractures are mainly developed in the formations, which determine the reservoir properties. Along these fractures the cavities and leached pores are developed, the size of which can reach up to 3.5 cm in lateral and up to 1-1.2 cm in vertical direction. These voids are often filled with oil [1,11]. According to the macro-description of the core of the exploration well of the Muslyumovsky deposit, the formation is dense, characterized by aphanite structure, banded and horizontally layered texture due to the

unevenly laminated distribution of organic matter and light-gray lime material layers. There are rare fractures, healed by authigenic calcite. Electron microscopic analysis showed that in visually-dense carbonate-siliceous rocks enriched with organic matter, the void space is represented mainly by subcapillary pores and channels, whose radius is comparable to the inter-crystalline pores. In the water cut analysis based on the comparison of the time of water invasion to the wells with the lowest perforation elevation, two groups of wells were identified: 1 - The higher the elevation of the lowest interval of perforation, the later the water invasion takes place, a gradual increase in the water cut of the production is observed (blanket deposit); 2 - Water invasion begins immediately after opening the well for production, which indicates that the proximity of the formation water to the lowest perforation or the presence of a potential fractured zone (massive deposit). Basing on the results of the water cut analysis, it can be assumed that the southern part of the pore-type reservoir is mainly developed, while in the northern part of the deposit it is mainly fractured type. Thus, it is possible to divide the deposit into two blocks according to the types of reservoirs. The effect of fracturing on the reservoir properties of the reservoirs of uplift considered increases from the southwest to the northeast. The above mentioned data from core studies confirm that carbonate rocks are complex-structures and heterogeneous in terms of reservoir properties and oil saturation [7,9]. While comparing two closely located uplifts, Shuganskoye and Nurievskoe, it can be assumed that oil accumulations in the Semiluki deposits have connections not only with the structural elements of the local uplifts. Permeability is determined mainly by fracturing, which forms small-capacity disconnected reservoirs, thus high initial oil production rates decrease rapidly, and new wells drilled at a short distance from producer well, have small oil rate or no flow rate at all [2,5]. To produce non-conventional reservoirs of hydrocarbons, hydraulic fracturing and bottom hole treatment of formation zone by a hydro-acoustic generator are used. The effectiveness of these methods depends on the existing natural fractures, the anisotropy of the current stress-strain state and the static geomechanical parameters of the formation [8,10]. For the analysis of tectonic fracturing, the aerospace-geological investigation method was used for lineament analysis in "WinLESSA" software basing on topographic map with a scale of (1: 25000) [6]. When analyzing the spatial distribution of lineaments, two lineament systems were distinguished, whose density increases in the eastern part of the uplift considered. An analysis of the relative orientation of the rose diagram shows that the first system of fractures coincides with the direction of river beds, the second system of lineaments has the same direction as trough faults of the basement. Lineaments of this direction are supposedly associated with geological structures and a system of fractures of tectonic origin. The results of the work done were used during the reservoir simulation model construction to match the historical oil rates. Because, of the lack of data, the production rates matching in the reservoir simulation model is considered as an important criterion for the acceptability of the geological structure proposed. The good match of calculated rates versus historical was obtained after taking into account the fractures distribution discussed above. Following properties of fractures were predicted: strike, extension, aperture, plunging angle, permeability. The approach proposed in the article aimed to investigation of the fracturing allows obtaining information for forecasting the potential reservoirs and reducing risks in their exploration and development. Information of fractures orientation allows drilling directional and horizontal wells crossing a large number of fractures to achieve high production rates. Moreover, the detection of the natural fractures will increase the efficiency of hydraulic fracking.

We Express our gratitude to the JSC "Mellyaneft" and to chief geologist of JSC "Mellyaneft" R. R. Galeev. The work was supported by the subsidy allocated to Kazan Federal University as part of the state program for increasing its competitiveness among the world's leading centers of science and education.

Literature

1. The first data on the porous space structure of the Domanik shales as a potential object for EOR applying. R Kadyrov and E Statsenko 2018 IOP Conf. Ser.: Earth Environ. Sci. 155 012022
2. *Belonovskaya L.G., Bulach M.H., Gmid L.P.* Rol' treschinovatosti v formirovanii emkostno-fil'tratsionnogo prostranstva slozhnyh kollektorov. //Neftegazovaya geologiya. Teoriya i praktika. 2007. T. 2. p. 28-116.
3. *Larochkina I.A.* Kontseptsiya sistemnogo geologicheskogo analiza pri poiskah i razvedke mestorozhdeniy nefti na territorii Tatarstana. Kazan': Izd-vo «Fen» Akademii nauk RT, 2013. 232p.
4. *Muslimov R.H., Abdulmazitov R.G., Hisamov R.B. i dr.* Neftegazonosnost' Respubliki Tatarstan. Geologiya i razrabotka neftyanyh mestorozhdeniy. Kazan': Izd-vo «FEN» Akademii nauk RT. Tom 1, 2007. 316 p.
5. *Plotnikova I.N., Ostrouhov S.B., Laptev A.A. i dr.* Migratsionnyy aspekt formirovaniya neftenosnosti domanika Tatarstana. // Georesursy. 2017. T. 19, №4, CH. 2, p. 348-355.
6. *Sungatullina R.R.* Opyt i perspektivy izucheniya treschinovatosti karbonatnyh kollektorov na primere skvazhiny №315 YAurkinskogo mestorozhdeniya. [Elektronnyy resurs]: http://www.tatnipi.ru
7. *Hisamov R.S., Bazarevskaya V.G., Mihaylova O.V., Podavalov V.B.* Domanikovye produktivnye otlozheniya tatarstana - analog «slantsevyh pleev» SSHA. //Nedropol'zovanie - HKHI vek. 2016. №3 (60). p.84-93.
8. *Hisamov R.S., Bazarevskaya V.G., Tarasova T.I., Gibadullina O.G., Ziyatdinov A.G.* Analiz rezul'tatov opytno-promyshlennyh rabot v skvazhinah na domanikovye otlozheniya na mestorozhdeniyah Respubliki Tatarstan. Sbornik nauchnyh trudov TatNIPIneft'. Vypusk №LXXXV. Naberezhnye CHelny, OOO «Ekspozitsiya Neft' Gaz». 2017. p. 78-85.
9. *Hisamov R.S., Gubaydullin A.A., Bazarevskaya V.G., Yudintsev E.A.* Geologiya karbonatnyh slozhno postroennyh kollektorov devona i karbona Tatarstana / Kazan', 2010. 283 p.
10. *Husainov R.F., Nazimov N.A., Gumarov N.F., Ganiev B.G., Shvydenko M.V., Absalyamov R.Sh.* Razrabotka zalezhey nizkopronitsaemyh Domanikovyh kollektorov s primeneniem massirovannogo gidrorazryva plastov na primere NGDU «Al'met'evskneft'». // Georesursy. 2015. T. 2. p. 14-16.
11. *Shakirov V.A.* Izuchenie geologo-promyslovyh osobennostey slozhnopostroennyh karbonatnyh kollektorov semiluskogo i mendymskogo gorizontov (Na primere Romashkinskogo mestorozhdeniya) Diss. kand. geologo-mineralogicheskih nauk, Bugul'ma, 2006.

COMPARISON OF NATURAL FRACTURING OBTAINED BY GEOPHYSICAL INVESTIGATION IN DIFFERENT SCALES

E.V. Nugmanova[1], I.I. Nugmanov[2]

Kazan (Volga region) Federal University ([1]- Ekaterina.Eronina@kpfu.ru,[2]- ilmir.nugmanov@kpfu.ru)

Keywords: *World Stress Map, hydraulic fracturing, microseismic monitoring, well logging, fracture, remote sensing*

The aim of this work was to determine the objective parameters of hydraulic fracturing (length, height, asymmetry, azimuth) and the analysis of fracture system dynamic development in the process of multi-stage hydraulic fracturing. The poster presents the solution of a technological problem concerning the localization of three-dimensional coordinates of microseismic emission sources, as well as the post-processing techniques using the tools of spatial statistics from geographic information systems. It was suggested to use the correlation functions of complex variables for the processing of these wave forms of three-component broadband seismic stations. The geographic information system Arc GIS Systems ESRI was chosen as the tool of spatial statistical analysis. The geological interpretation of the results and their linkage with the results of regional tectonic stress field of research were the main ones for the study. According to the results of these microseismic research data for five fields of Timan-Pechora gas-oil province the peculiarities of hydraulic fracturing (HF) main fracture development were established for the multi-step process, reflecting local conditions of rock stress-strain state. The main fundamental conclusion is the conclusion about the possibility of using the results of HF microseismic study and the hydraulic fracture parameters as a reliable source of information on modern tectonic stress field at a regional level. The report briefly gives an estimation of tectonic fracturing role in terrigenous and carbonate blocks containing hydrocarbon deposits. Geological and geophysical datasets of different scale were used to characterize the fracturing of rocks. The good convergence is found between the orientation of natural fracturing by formation microimagers in wells, three-dimensional surface seismic survey, microseismic monitoring of hydraulic fracturing propagation and regional lineament analysis by satellite imagery. The article contains examples of comparison between the direction of maximum horizontal stress axis and stress state and the direction of horizontal wells and fluid flow. New factors of unsuccessful multistage hydraulic fracturing operations in carbonate rocks are considered in the context of natural fracturing systems' kinematics. The main fundamental conclusion obtained as a result of studies is a justification of the leading role of modern tectonic stress field in the fracturing kinematics. The practical conclusion is a necessity of a selective stimulation of fractured rock blocks to achieve the maximum production for the redeveloped of oil fields.

The work was supported by the Ministry of Education and Science of the Russian Federation (project No. 02.G25.31.0131)

Literature

1. *Nugmanov, I. I. et al*. Morphological characteristic of hydraulic fracturing according to the results of microseismic research / I. I. Nugmanov // (2015) International Journal of Applied Engineering Research. - 10 (24). - 2015. - P. 45214-45223.
2. *Shafiei, A. & Dusseault, M. B.* Natural Fractures Characterization in a Carbonate Heavy Oil Field / A. Shafiei, M. B. Dusseault // ARMA 12-443. - Presented at the 46th US Rock Mechanics / Geomechanics Symposium, 24-27 June 2012, Chicago, IL, USA.
3. *Sim, L. A.* Some methodological aspects of tectonic stress reconstruction based on geological indicators / L. A. Sim // C. R. Geoscience - V. 344 - 2012 - P. 174-180.
4. *Lorenz, J.* C. Stress-sensitive reservoirs / J.C. Lorenz // SPE 50977. -JPT. -January 1999. - P. 61-63.
5. *Sperner, B.* et al. Tectonic stress in the Earth's crust: advances in the World Stress Map project. / In: Nieuwland, D. A. (Ed.) // New insights into structural interpretation and modelling, (Geological Society special publications, Vol. 212). - London : The Geological Society. - 2003. - P. 101-116.

QUESTIONS TO THE STUDY OF MARINE LANDSCAPES

T.V. Pankeeva , N.V. Mironova, A.V. Parhomenko

Moscow State University Sevastopol Branch, Sevastopol (geoeco@sev.msu.ru)

Keywords: *macrophytes, cystoseira, phyllophora, landscape, bottom natural complexes, Black Sea*

The necessity for developing of scientifically based recommendations aimed at the preservation and restoration of shelf resources has led to intensive formation of theoretical and methodological foundation of marine landscape studies. As the direction developed, the researchers has been submitting various definitions and interpretations of the sea landscape: «aquatic landscape», «submersed landscape (underwater landscape) », «subaquatic landscape», «natural marine complex» and «seabed natural complex». Subsequently, the accumulated information about subaquatic landscapes set the commissioning of cartographic methods into their practical use and formed the concept of the morphological structure of various types of seabed [1]. To date a number of authors have led studies of the landscape and morphological structure of the coastal zone of the Black Sea: K.M. Petrov (1989, 1999), N.N. Mitina (2005), T.V. Pankeeva et al., (2014), Its physical-geographical zoning is shown by N.N. Mitina, E.V. Chuprina (2012); A.N. Tamaychuk (2009), the characteristics of deep sea landscape of the continental slope made by L.A. Pasynkova (2008), approaches are examined to the determination of the stability of the Black Sea submersed landscapes to natural and anthropogenic factors are consider by N.N. Mitina (2005), L.A. Pasynkova (2010), introduction of "marine anthropogenic landscape" as a concept and propose of standardization by the prevailing types of economic activities by E.A. Pozanenyuk, M.V. Penno, (2013), an assessment of ecosystem functions of bottom landscapes made by T.V. Pankeeva, N.A. Milchakova (2013). Nevertheless, there is a lack in amount of studies devoted to the Black Sea submarine landscape and especially the coastal zone of the Crimean peninsula, considering that the Crimean coast is characterized by significant species diversity, habitats uniqueness and high degree of preservation of water areas. Laspi Bay water area may be taken as an example for (South-West coast region of Sevastopol area), the features distribution of macrophyte stock and their dominant species, taking into account the seabed landscape structure. Based on of the hydrobotanic survey conducted in the bay in the summer of 2016, seven types of submersed natural complexes were identified in the landscape structure of the seabed. Complexes were highlighted by taking into account the dominant Black Sea macrophytes species: cystoseira, phyllophore and zostera. It is shown that the typical seabed natural complex in the Laspi Bay is a steep underwater abrasion slope, composed of blocky boulder sediments with a predominance of cystoseira species, which are distributed at a depth from 1 to 5 m. This seabed natural complex has a latitudinal spread and a maximum area indicator of 15.2 hectares (27.8%). A unique type of seabed natural complex has been formed in the Lapsi Bay – a slightly inclined accumulative plain, composed of aleuritic-psammitic deposits with a predominance of zostera species, which is widespread in the central part of the bay at a depth from 9 to 12 m, with total area of 13.6 hectares (25.0%). The submersed natural complex in the central part of the Laspi Bay (approximately at a depth of 3 to 10 m) is characterized by a slightly inclined accumulative plain, composed of psammite deposits with well-defined ripheans and devoid of benthic vegetation. It has been

revealed, that the sections of transition seabed natural complex are located at the submersed (underwater) abrasion slope at depths from 5 to 10 m. Thus the seabed natural complex was formed in the northwestern part of the bay - an (submarine) submersed coastal abrasion slope composed of psephitic sediments with predominance of cystoseira species and aleurite-psammitic sediments predominantly formed with zostera species. In the southeastern part there is an (submarine) submersed coastal abrasion slope composed of psephitic sediments with domination of cystoseira species, and alternating pebble-gravel sediments with a bit of shells, with predominantly phillophora crispa [2]. The obtained data about the landscape structure of the Laspi Bay can be used to justify the priority territories and water areas that require commandment.

Literature

1. *Mironova N.V. Pankeeva T.V.* Mnogoletnie izmeneniya zapasov makrofitov i ih svyaz' s landshaftnoy strukturoy dna (Buhta Laspi, Krym, CHernoe more) / N.V. Mironova, T.V. Pankeeva // Sovremennye kontseptsii ekologii biosistem i ih rol' v reshenii problem sohraneniya prirody i prirodopol'zovaniya: materialy Vseros. (s mezhdunar. uchastiem) nauch. shk.-konf., posvyasch. 115-letiyu so dnya rozhdeniya A. A. Uranova (g. Penza, 10–14 maya 2016 g.) / pod red. N. A. Leonovoy. – Penza: Izd-vo PGU, 2016– p. 389-394.
2. *Petrov K.M.* Podvodnye landshafty: teoriya, metody issledovaniya / K.M. Petrov – L.: Nauka, 1989. - 124 p.

INNOVATIVE APPROACHES TO EVALUATION OF GEOMORPHOLOGICAL SPECIFIC FEATURES AND GEOMORPHODYNAMICS OF SEA SHORES FOR THE NEEDS OF NATURE MANAGEMENT THROUGH THE EXAMPLE OF THE CRIMEAN COASTLINE

N.G. Pashkova

V.I. Vernadsky Crimean Federal University (pashkovanataly@mail.ru)

Keywords: *Geomorphology, geomorphological features, coastal zone, coastal areas, abrasion, erosion, accumulation, coast stability, recreational potential.*

Taking into account the increasing human-induced impact on the southern coast of the Crimea, which contributes to the increasing erosion of beach areas by soil slip, landslide, rockslide and other processes, it is becoming increasingly clear that the development of less developed but no less attractive shores is an important task for the peninsula today. If the coastline of the South-Eastern part of the Crimean peninsula is developed properly it can not only contribute to stabilizing the recreational environment of the Crimea, but it can also become a very competitive recreational area. However, it is worth noting that the geomorphologic aspects make significant allowances for the possibility of using these territories for recreational purposes. Recreational facilities of the North-Western coasts of Crimea are characterized by almost complete absence of an operating full time organized recreation complex. The beach is the most attractive part of the coast for the development of recreational activities, however, the growth of technogenic impact within the coasts greatly intensifies the negative development of coastal processes. A combination of many factors contributes to the general degradation of the coastal zone, which largely relates to the territory of the beaches, which are one of the main recreational resources of the Crimea [1]. At present the lack of information about the state of the coastal areas of the peninsula makes the process of planning the development of the Crimea as a recreational complex more difficult. For that reason the study of the sea shore dynamics is an extremely important task, especially in less developed areas of the coastline. It is necessary not only to develop the system of evaluation of the peninsula shores and beaches, taking into account geomorphologic features, but also to implement its application extensively. We conducted an assessment of the recreational potential of the coasts, taking into account the geomorphological features of the study area [2]. As a model range, we chosen a section of the North-Western coast of the Crimean peninsula. Comprehensive and in-depth evaluation of the sea shores has been carried out in the course of the study for the purpose of understanding the interrelation of the shore dynamics and the development of recreation within their borders. As a result, three genetic types of shore were identified in the study area: 1) abrasion - the most common; 2) abrasion-accumulative - are poorly developed and have a small extent; 3) accumulative - are confined to the territory of the Bakal spit and the spit Belyaus. Basis on the study of the geomorphodynamics of the sea coasts of the investigated area, the stability of all types of shores to abrasion and erosion was determined. As a result, 2 types of coast were distinguished: 1) moderately stable and 2) unstable. After that we carried out an assessment of the attractive properties of the relief of each of the identified types of shores. Each genetic type of the shore has

certain properties that contribute to increasing or decreasing the level of attractiveness in certain directions. The next step was the compilation of a list of geomorphological risks, the manifestation of which is characteristic of the study area and whose influence is most strongly reflected in the development of recreational facilities within the shores of the North-Western part of the Crimean peninsula [3]. Among all the set of geomorphological risks, special attention should be paid to: 1) Active abrasion processes; 2) Gravitational-collapse processes; 3) Steep slopes of the underwater coastal slope; 4) Steepness of the coast; 5) Significant height of coastal cliffs; 6) Slight width or lack of beaches. Based on the studies of stability of the coasts to abrasion and erosion, we established the degree of impact of each of the six geomorphological risks on the development of the recreational economy of the study site [5]. Based on the studies carried out to determine the stability of the coasts to abrasion and erosion, we established the degree of impact of each of the six geomorphological risks on the development of the recreational economy of the study site. Having established the genetic types of the shores of the study area and determined their stability, based the attractive properties of the shores and taking into account the degree of influence of geomorphological risks on each site of the study area, we created a typification of the shores of the model site according to the possibility of their recreational use. The obtained data were reflected on the map of the geomorphological and recreational characteristics of the coastline of the North-Western section of the Crimean peninsula. As a result of the study, five types of banks were identified, reflecting the types of recreational use of the territory, which is most desirable for the development of recreational facilities in a certain part of the coastal zone, taking into account its geomorphology. It is established that abrasion shores are most favorable for the development of a sportive kind of recreational activity. The accumulative shores are more favorable for the development of therapeutic and recreational types of recreation. The highest degree of impact of geomorphological risks is typical for aesthetically attractive abrasion unstable coasts, favorable for the development of extreme sports tourism. The lowest degree of impact of geomorphological risks is typical for accumulative moderately-stable coasts, favorable for the development of the therapeutic type of recreation. Geomorphological risks have a significant impact on the development of the recreational economy of the territory. It is necessary taking these risks into account for the most favorable development of recreational system [4]. The process of further development of the recreational economy of the south-east and north-west coast of the Crimea must be based on the degree of impact of the listed geomorphological risks characteristic of the study area. An important practical importance has the above-described typing of shores according to the possibility of their recreational use, which is universal in nature and can be applied in a comprehensive study of the coastal zone of the Crimean peninsula. The obtained data can be used as the source of information for decision-making in the management of the coastal areas recreational potential. Taking into account the geomorphologic component is important not only when the recreational potential of the seashores is evaluated, but it is also necessary for developing the most effective system for their recreational use.

Literature

1. *3enkovich V.P.* Morfologiya i dinamika beregov Chernogo morya. T.2.M.:Izd-vo ANSSSR, 1960. 216 p.
2. *Zenkovich V.P*. Osnovy ucheniya o razvitii morskih beregov. M.: Izd-vo AN SSSR, 1962. 416 p.
3. *Leont'ev O.K., Nikiforov L.G., Safonov G.A.* Geomorfologiya morskih beregov. M.: Izd-vo MGU, 1975. 385 p.
4. *Saf'yanov G.A.* Dinamika beregovoy zony morey. M.:Izd-vo MGU, 1973. 174 p.
5. *Simonov YU.G*. Ball'nye otsenki v prikladnyh geograficheskih issledovaniyah i puti ih sovershenstvovaniya. Vestnik MGU. Ser.5. Geografiya. 1997. Vyp. 4. p. 7–10.

DYNAMIC CONVERSION OF HEAD WAVES TECHNIQUE IN PROBLEM OF RESEARCH OF REFRACTION HORIZONS ON THE UPPER EARTH CRUST ON TRAVERSE 3-DV

P.O. Polyansky

Altay-Sayan Branch of Federal Research center (PPavel6.10@gmail.com)

Keywords: *Geophysical profile 3-DV, Siberian Platform, head waves, Earth crust, time section, digital processing of seismic data.*

Solution of fundamental problem of Russian Federation in our own time - it is increasing of mineral and raw materials potential. This is connected with research of the Earth crust interior structure and material composition. For this purpose, importance of geophysical techniques which are allow to prepare information base of mineragenetic areas, ore deposits and hydrocarbons reservoirs in the upper Earth crust, is essentially increasing. In that context, exploration of the Earth crust, which are conducted on reference geophysical traverses, are some of the most important focus areas of federal level. Usually, length of reference geophysical traverses are more than one thousand kilometers [3]. Source-receiver configurations with multiple coverage are used to solve problems are described above with seismic methods. Digital processing of head (refracted) waves data is essential for wavefield analysis. The wavefield are registered on source-receiver configurations with multiple coverage are located on reference geophysical traverses. Manual processing of refracted waves data is impossible because of big folding of recording and because of significant number (a few millions) of seismic traces are registered. Consequently, head waves data are not used litle if any, in process of interpretation of wavefield which are registered in geophysical researches of Earth crust by CDP method. Head waves data contain geologic area information, which are not contained on reflected waves data. Because of that, methods of reflected waves and refracted waves complement each other. Development of automated digital data processing techniques is very important at this level. These techniques are useful in processing of data are registered on reference geophysical traverses. Report which is presented, is dedicated to results of research of characteristics of refracting interfaces on the upper Earth crust on traverse 3-DV. Total length of 3-DV traverse is 3000 km. 3-DV traverse line crosses some areas of Russian North-East. These areas are Amur region, Yakutia republic and Magadan region. Reference traverse 3-DV crosses some large tectonic structures of Siberian platform and Verkhiyan-Kolymskaya fold area. Seismic data are registered was processed by dynamic conversion of head waves technique which was established in [2] and advanced in [1]. This technique is unrivaled throughout the world. Dynamic conversion allows to do automated processing of head waves data, which are registered on source-receiver configurations with multiple coverage. Refracted waves signals are substracted from primary registered wavefield are result from technique of dynamic conversion. Other seismic waves and random noises are refined by this method. Results would be presented in the form of time sections of head waves and in the form of common source point seismograms. Time section is image of geologic structure in the wavefield of head waves. By analyzing of time sections, we have possibilities to find out some lateral variations of these sections and to connect in with properties of geologic structure. This is allow to get detailed information

about structure and velocities of seismic waves of refraction boundaries on the upper Earth crust. Results which are described in [4, 5, 6] are summarized on report is presented. Information of upper Earth crust structure on depth interval of 0-3 km on different geologic areas is achieved. Mechanisms of flat-lying refraction horizons formation on fold areas with complex geology are established.

Research is done with the assistance of Russian Fountation for Basic Research and supporting Foundation of students PhD-students and young scientists "National intellectual development" as part of the project №17-35- 80026.

Literature

1. *Emanov A. F, Celeznev V.C, Kopshik N.A.* Dinamicheskiy pereschet golovnyh voln pri obrabotke dannyh seysmorazvedki // Geologiya i geofizika, 2008. - t. 49, - № 10, - p. 1031-1045.
2. *Krylov S.V., Sergeev V.N.* Svoystva golovnyh voln i novye vozmozhnosti avtomatizatsii ih obrabotki. // Geologiya i geofizika, 1985. - №4, - p.92-101.
3. *Morozov A.F., Chepkasova T.V., Petrov O.V., Kiselev E.A., Erinchek YU.M.* Sostoyanie i perspektivy razvitiya rabot obschegeologicheskogo i spetsial'nogo geologicheskogo naznacheniya v Rossii. // Razvedka i ohrana nedr, 2011. - №5, - p.8-14.
4. *Polyanskiy P.O., Emanov A.F., Sal'nikov A.S.* Osobennosti metodiki dinamicheskogo perescheta golovnyh voln na opornom geofizicheskom profile 3-DV // Materialy nauchno-prakticheskoy konferentsii "Interekspo Geo-Sibir'". - 2017. - T.2, №4. - p. 28-23.
5. *Polyanskiy P.O., Sal'nikov A.S., Emanov A.F., Zhabin V.V.* Vremennye razrezy golovnyh voln verhney chasti zemnoy kory na opornom profile 3-DV (Severo-vostochnyy uchastok) // Geologiya i mineral'no-syr'evye resursy Sibiri, 2016, №2, - p.86-95.
6. *Polyanskiy P.O., Sal'nikov A.S., Emanov A.F., Zhabin V.V.* Vremennye razrezy golovnyh voln verhney chasti zemnoy kory na opornom profile 3-DV (Severo-zapadnyy uchastok) // Geologiya i mineral'no-syr'evye resursy Sibiri. 2017. - № 2. p.112-122.

EXPERIMENTAL STUDY OF THE DISTRIBUTION COEFFICIENTS IN THE SCHEELITE-SOLUTION SYSTEM AT 96 ° C

Yu.A. Popova [1а], A.Yu. Bychkov [1,2в], S.S. Matveeva [1], N.D. Nikishaeva [1]

[1]- Lomonosov Moscow State University,[2]- GEOKHI RAS

[а]- julka_p@rambler.ru,[в]- andrewbychkov@rambler.ru

Keywords: *scheelite, experiment, hydrothermal deposits*

REE is traditionally used as indicators of ore formation. Using the distribution coefficients of lanthanides between hydrothermal minerals and solution will significantly increase the possibility of using REE as tracers in the formation of the scheelite, since it becomes possible to operate with comparable values, it becomes possible to use the lanthanide spectra of mineral-forming solutions [2].

The distribution coefficients of the lanthanides between the mineral and the aqueous solution were investigated by crystallization of scheelite from the solution. Synthesis of scheelite under hydrothermal conditions was carried out by mixing equivalent solutions of sodium tungstate and calcium chloride. The multielement standard ICP-MS-68A-A, which was added to the calcium chloride solution, was used as a source of REE. Solution A contains an equal concentration of 48 elements, including lanthanides, at a concentration of 1 mg/l. The experiments were carried out in polypropylene vials at a temperature of 96°C and saturated vapor pressure. Control of precipitation pH (compliance with the natural conditions of crystallization of scheelite), for which an acetate-ammonium buffer solution was used to obtain pH = 5 at 25 ° C. The experiment was set as a kinetic series with 5 vials under the same conditions. The vials were removed from the experiment on the 1st, 2nd, 3rd, 6th and 10th day. After the experiment, the vials were quenched in cold water and opened. The experimental solution was then filtered with a 0.45 μm filter using a syringe nozzle. The scheelite crystals were washed and dried for further investigation. Investigations of experimental solutions and synthesized scheelite were carried out using an inductively coupled plasma mass spectrometer Element-2. Quality control of the synthesized scheelite was carried out using X-ray phase analysis. According to the data obtained, the distribution coefficients of a number of lanthanides for the scheelite-hydrothermal solution system for low-temperature conditions were established, which correlate with the previous data [3]. Similarly, the coefficients obtained do not contradict the literature data [1], carried out at T = 350 ° C. The maximum values of the coefficients are observed for light lanthanides, decreasing with the transition to heavy lanthanides, but the numerical values have a significant difference in the order of magnitude.

The closest and well correlated values to the previously described experiment and the literature data are obtained in the experiments taken on the 3rd and 6th days. Significant increases in the values of the coefficients for some elements (for example, cerium and europium) can be explained by the presence in the low-temperature conditions of a higher valence of the elements themselves (for cerium - 4+, for europium - 3+, since the more stable state for it is valence 2+) .

Literature

1. *Raimbault L.* Utilization ds spectres de terres rares des mineraux hydrothermaux (apatite, fluorite, scheelite, wolframite) pour la characterisation des fluids mineralisateurs et l'identification des magmas sorses et des processus evolutifs//Bull. Mineral.1985. V. 108. P.737-744.
2. *Matveeva S.S.* Rare-earth elements as geochemical indicators of ore-bearing fluids at the greisen formation deposits // Reports of the Academy of Sciences. 1996.T.351. №2. P. 249-252.
3. *Popova Yu.A.*.Geochemical model of the behavior of lanthanides in the formation of wolframite deposits // PhD Thesis, 2015, Moscow.

THE NEOTECTONIC STRUCTURES OF THE HERACLION PENINSULA, SOUTHWESTERN CRIMEA

M.Y. Promyslova[1], G.V. Bryantseva[2], L.I. Demina[3], N.I. Kosevich[4]

Moscow State University Sevastopol Branch, Sevastopol ([1]- mary.promyslova@gmail.com, [2]-bryan.bryan@yandex.ru,[3]- lidem06@rambler.ru,[4]- nkosevich@gmail.com)

Keywords: *neotectonics, structural-geomorphological analysis, fault, fracture zones, Heraclion peninsula, South-Western Crimea*

The neotectonic stage in the Crimea Mountain began according to various data in the Oligocene [3; 8], Pliocene [7]. Cenozoic structures have been formed and continue to form at the present time due to the underthtrust of the Black Sea sub-oceanic crust under the Crimean peninsula [8]. The upper structural floor of the Heracleian Peninsula is composed of limestones and Neogene clays lying subhorizontally and forming a plateau. They are underlain by a thin layer of Cretaceous and Paleogene wedged out to SW. Formations of the middle structural floor are exposed in the coastal cliffs of the Cape Fiolent area and represent a melange consisting of clastolites and a matrix of Jurassic magmatites. The lower structural floor, distinguished by geophysical data, is represented by a layered sedimentary strata, crushed into a large anticline. Structural-geomorphological analysis showed that within the Heracleian peninsula two systems of fault zones predominate: the first changes its direction from almost sub-meridional to NW, the second - from NNE to NE. The coastline of the northern and northwestern boundaries of the peninsula coincides with the fracture zones. Heracleian peninsula is divided into three segments: Western, Central and Southeastern, differing in density and direction of fracture zones, faults, the nature of the ravine-gulch net, and the structure of the coastal zone. There are structures of the second order distinguished in the Western segment: the Coastal plain with a predominantly accumulative relief and the signs of the coast lowering and the Nikolaev uplift with a fracturing system of NW and NNW-strike, intensively developed by the ravine-gulch net. The fracturing system of NNE-strike deforms the valleys of ravines and gulches, changing their strike. These fractures could have arisen in the Cenozoic shear stress field with the NE orientation of the compression axis and the NW stretching [2]. ENE-strike zone of tectonic disturbances has a wide development in the Central segment. A particularly dense network of faults is observed to the north and North-East of Cape Fiolent. It records, probably, neotectonic movements within the Piedmont suture located under the Cretaceous-Cenozoic deposits, which is interpreted by V.V. Yudin [8], as a collision suture due to Mesotetis oceanic crust subduction. These formations are assigned by M.Yu. Promyslova et al. [4] to fragments of the ophiolitic association formed in a back-arc spreading basin. Fracturing zones of the sublatitudinal orientation have a minor spread. The southern coastal zone with a cliff height reaching 100 m and more, apparently, is currently undergoing considerable uplift. A large fracturing zone of the ENE strike is allocated, originating from Cape Fiolent. It is the boundary of two types of relief: dissected by a ravine-gulch net to the west, while to the east such a dissection is practically absent. There are several parallel fracturing zones of NE-strike are distinguished to the East of Cape Fiolent. The subvertical fault at the base of Lermontov cape, along which a massif of highly fractured gabbro-dolerites is uplifted, can also

be traced in the overlying limestones of the Neogene, which indicates this fault activity in recent times. In the vertical walls of the 100-meter height near the Sphinx Cape there are clearly visible subvertical fractures, dividing the pillow lavas stratums and forming the so-called flower structures which arise under shearing strains [6]. This NNE shearing is well manifested within the carbonate plateau also. The southeastern segment includes the Georgievskoe and Kayabash uplifts and the Balaklava depression. Georgievskoe elevation with altitudes of more than 250 is not practically dissected by a ravine-gulch net, and the strike of fracturing changes to the North-East in comparison with the Central sector. V.V. Ivanov et al. [1] believe that this part of the Heracleian plateau is located in the zone of the Georgievsky fault influence. Neogene limestones, which lie gently on practically the entire area of the peninsula, get a steep fall angle on the west side of the Marble gulch and around the Cape Aya-Burun, which indicates active deformations in recent times. There are a large number of vertical fractures are observed, both in Neogene limestones and in underlying pillow lavas and breccias of the ophiolitic association [5]. The most intensive collapse processes occur in this area. The Kayabash uplift with total conerosional heights of 200-250 m is located between the Marble gulch and the Balaklava Bay, composed of marbleized Tython limestones and dissected by NNE-strike faults. The coastal zone coincides with the NW and NE-strike faults. V.V. Yudin [8] distinguishes in this area the Kayabash olistolite, bounded by the Marble retro-motion thrust with the southern fall of the displacer at an angle of 20-30 °. The Balaklava depression extends from the Balaklava bay to the Chernaya river valley and has a width of more than 4 km. It is complicated by numerous particular elevations with altitudes not exceeding 100-150 m. In the Balaklava Bay area there are several sublatitudinal faults, which, according to VA. Ivanov et al. [1] have a shear component. According to horizontal dissection analysis data the elements of the structurally-related relief are confirmed in the study of vertical dissection. The Balaclava depression is well interpreted on the transverse profile. There are cyclic valleys are observed on the depression slopes, preserved in the form of ledges. Changes in the valleys structure reflect an uneven and rapid increase in the rate of the southeastern part of the Heracleian peninsula uplift, which generally tilts to the North-West. The uniqueness of the Heracleian peninsula is that the connection of the newest structures with the activated ancient faults can be observed in field studies directly in outcrops of coastal cliffs. The revealed faults and fracture systems play an important role in the seismic zoning of the peninsula.

Literature

1. *Ivanov V. E., Lomakin I.E., Topolyuk A.S. et al.* Features of the tectonics of the South-Western Crimea // Geology and minerals of the World Ocean, 2009. No. 4, pp. 27–39.
2. *Murovskaya A., Hippolite J.-C., Sheremet Ye. et al*. Recent and paleo-stresses at the northern margin of the Black See and Crimea Mountain in Mezo-Cenazoic – Quarter (according to mechanism of earthquakes foci and field tectonophysical data) // Geophysical J., 2018. No. 1, vol. 40, pp. 42–65.
3. *Nikisin A.M., Wannier M., Alekseev A.S. et al*. Mezozoic to recent geological history of southern Crimea and the Eastern Black See region // Geol. Soc. London Spec. Publ., 2017. V. 428. P. 241–264.
4. *Promyslova M. Yu., Demina L. I., Bychkov A. Yu. et al.* Ophiolitic Association of Cape Fiolent Area (Southwestern Crimea) // Geotektonika, 2016. No. 1, pp. 25–40.
5. *Promyslova M. Yu., Demina L. I. , Gushin A. I. et al.* The Types of Breccia of the Ophiolite Assemblage of Southwestern Crimea and their Significance for the Paleogeodynamics of the Region // Vestnik Mosk. Un-ta, Seriya 4: Geologiya, 2017. No. 3, pp. 35–40.

6. *Sylvester A.G.* Strike-slip faults // Geological Society of America Bulletin, 1988, V. 100. P. 1666–1703.7. Wolfman Yu. M. Deformation modes and kinematic conditions of the newest tectonic fracturing within the Mountainous Crimea // Geophysical Journal, 2015. V. 37. No. 1, vol. 37, pp. 100–120.
7. *Nikisin A.M., Wannier M., Alekseev A.S. et al.* Mezozoic to recent geological history of southern Crimea and the Eastern Black See region // Geol. Soc. London Spec. Publ., 2017. V. 428. P. 241–264.
8. *Yudin V. V.* Geodynamics of Crimea. Simferopol: DIAIPI, 2011. 333 p.

THE ESTIMATION OF THE SEVASTOPOL BAYS ECOLOGICAL STATE ON BASIC CHEMICAL-BIOLOGICAL CRITERIA

S.I. Rubtsova

Sevastopol campus Lomonosov Moskow State University (rsi1976@mail.ru)

Keywords: *oil hydrocarbons, chloroform-extracted substances, bacteria, coastal zone, bottom sediments, Black sea*

Ecological investigations turned to be the inalienable and obligatory for studying Black and Azov seas aquatoria, and estimation of the ecological state is, as a rule, its final purpose. Such investigations are especially urgent for the marine coastal zone, which has complex geographical structure, extraordinary diverse natural processes and undergoes heavy anthropogenic pressure. However, there is no any methodical approach to determining the criteria of the coastal zone ecological state estimation, up to the present time. Revealing the ecological disaster zones and emergency in ecological situations zones is carried out with the purpose to determine the sources and factors of the ecological situation worsening and to work out the grounded program of emergency measures for ecological troubles stabilization and reduction at the investigated territory. Ecological situation may be classified according to the increase of the ecological ill-being degree as following: 1. relatively satisfying; 2. stressed; 3. critical; 4. crisis (or zone of emergency of ecological situation); 5. catastrophe (zone of the ecological disaster). Finding out the emergency of ecological situation zones and ecological disaster zones for marine aquatoria is carried out according to the basic chemical and biological indices, obtained on the base of analysis and generalization of the many year observations results. Structural and functional characteristics of bacterio-, phyto- and zooplankton, benthos and ichthyofauna as well as of some taxons and hydrobionts species are used for the emergency of ecological situation estimation according to the biological indices. Concentrations of different chemical substances are optimal, for the ecosystems normal activity in different mediums and limiting values of which are the limiting factors of ecosystems and serve as a ground for the estimation criteria determination. Factors, affecting the ecosystems vital activity, are included into the criteria group only. This can be referred to the human being and all types of his interactions with the coastal zone, with the human environment as well as with objects of his economical activity. The following criteria complex, which includes biodiversity reduction (Simpson index), negative and positive indicator of species population density, radical associations square, species composition change, coefficient of pollutants accumulation in hydrobionts, age range of dominant genopopulations, renewal, correlation of associations with different ecosystems violation degree, structural-functional characteristics of their state and ecosystems trophic structures may be used for the ecosystems ecological state estimation. Any other criteria, which give additional information about character, causes and degree of the unfavorable situation, are recommended to be used. The following ones were referred to the recommended criteria: 1. Integral estimation of the marine waters and bottom sediments contamination by the substances, which have mutagenic impact on the test-objects (standard microorganisms strains). Mutagenic effect is observed in the rate of samples, causing mutations of the standard strains. Relatively satisfying situation is characterized by the level of less than 5%. Emergency ecological situation is - 20 – 30%, ecological disaster is – more than 30%. Estimation

of the bottom sediments pollution by compounds with mutagenic activity shows the duration of the ecological situation in water area. 2. Critical concentrations of the pollutants effect (CCPE). CCPE values characterize minimally allowed pollution level (mcg/l) of the toxic substances in the water medium. CCPE from 1 to 2 denotes the emergency ecological situation, when changes in the marine ecosystems functioning are still reversible. CCPE of more than 2 - 3 denotes the ecological disaster, when marine ecosystems degrade sharply. Thus, marine aquatoria ecological state estimation criteria are: Chemical substances under stable preserving the chemical contamination for three years; Formalized summarized index of the waters chemical pollution for 10 pollutants; Dissolved oxygen; Plankton and macrozoobenthos biomass; Species number in the plankton communities (species diversity); Ichthyofauna and trade invertebrates stocks; Zoobenthos communities state; Microorganisms indicator species abundance; Alien-species share; The initial production level; Macrophytes state; Hydrobionts morphological changes (body sizes and mass, deformed shapes etc). Result: 1. Criteria of the ecological state of marine coastal areas by means of the main chemical and biological indicators were assessed. On the base of the current and long-term data ecological condition of Sevastopol bays and interaction of marine organisms and their communities with pollution were studied. 2. Bottom sediments at the stations in the Sevastopol bay were presented by III, IV (in the output and apex of the bay) and the highest - V (the central part of the bay) pollution levels. The rest of the bays had I-III contamination levels. Most of the studied sediments had reducing conditions (negative Eh index) and low pH. In the bottom sediments with the V pollution level the highest negative red-ox potential (from -114 to -174 mV) has been found. This pollution level and Eh were detected in the Yuzhnaya bay. 3. In the bottom sediments at the apex and the center of Sevastopol bay number of heterotrophic bacteria ranged from 95000 to 1500000 cel./g, oil-oxidizing - from 95 to 45000 cel./g [1]. At the station, located at the entrance to Sevastopol bay, the number of analyzed bacteria was comparable to that in the bay. Abundance of bacteria in the output from the Yuzhnaya bay (waters of Sevastopol bay) was in same order with the number obtained at its apical part. The highest number of heterotrophic and oil-oxidizing bacteria was found in the sediments of the most contaminated stations - in the apical parts of the Kruglaya, Artillerijskaya and Yuzhnaya bays. The purest sediments were found in the Kazachya bay: they were characterized by low levels of chemical contamination and high biodiversity.

Tthanks for the help and valuable comments to Doctor of biological sciences, professor, head of the Department of marine sanitary hydrobiology of the Institute of marine biological research of RAS Oleg Glebovich Mironov

CONDITIONS OF FORMATION AND REGULARITIES OF DISTRIBUTION OF OIL AND GAS RESERVOIR IN THE BASEMENT ROCKS AND WEATHERING CRUST OF THE VOLGA-URAL PROVINCE

I.A. Sabirov

Federal State Budgetary Educational Institution of Higher Education
«Gubkin Russian State University of Oil and Gas (National Research University)» (sabirov.i@gubkin.ru)

Keywords: *Basement, weathering crust, fracturing, reservoir, petroleum potential, lineament*

Given the deteriorating situation with the resource base in the Volga-Ural region and the depletion of the fund of traditional oil and gas facilities, it is necessary to increase industrial oil and gas reserves, in particular, due to non-traditional facilities. One of them is the Precambrian crystalline basement. The solution of the problem of forecasting and localization of promising objects in the crystalline basement and in the sedimentary cover overlying its sediments is a very relevant topic. The main features of the internal structure of the basement of the Volga-Ural segment of the East European platform have developed over three main tectonomagmatic cycles: early Archean, late Archean, early Proterozoic, characterized by different modes of endogenous processes, which determined the originality of the structural plans of individual tectonic elements. These cycles are responsible for the formation of two major metamorphic complexes - granulite and amphibolite. At the end of the first cycle, a granulite metamorphic complex was formed, which had an areal distribution within the entire considered segment. On the modern denudation section of the basement, these formations make up extensive blocks, the total area of which is not less than half of the Volga-Ural segment. The main features of the amphibolite metamorphic complex were formed during the second and third tectonic-metamorphic cycles, at the end of the late archaea and in the early Proterozoic. At these stages, the modern folded structure of the Basement was finally formed. Since the early Cambrian magmatic and metamorphic formations (rocks) initially did not have open porosity and did not have permeability for mineralized waters and hydrocarbon fluids, their void space arises only as a result of superimposed transformations. In the final stages of forming the Basement of the manifested local processes change basement rocks– blastocatalase and catalase. The definition of the zones of destruction of the basement allow to predict faults. As for faults is the most intensive flow of fluids, potassium metasomatism of the oldest rocks and Intrusive magmatism. One of the obvious blastocatalase fields transformations in the territory of Samara region is an area of Samara dislocations and related Zhiguli shaft. Here the crystal basement is opened by more than a hundred wells. The basement that controls the Zhiguli shaft is composed of a complex of metamorphic and igneous rocks. Dominated by enderbites gneisses from the granulite complex, charnockite, gabbro-nority, diorite, microcline granites of the amphibolite complex and migmatite of crystallomancy and enderbites, amphibolites and plagiogranites. There is a clear correspondence between the spatial distribution of zones blastocatalase transformations and Zhiguli shaft. Zhigulevsky shaft, in turn, is a direct expression in the relief and prevents the shift to the West of the Volga river bed. The movements of the crystal Basement blocks played a decisive role in the formation of the sedimentary cover at all stages of its development. To predict the fault zones, a map of catalase and blastocatalase transformations

of the Samara region was constructed. When analyzing this map was marked with areas of overlap along strike blastocatalase and catalase transformation with a modern linear shafts. So, in addition to the Zhiguli shaft marked Kurumoch-Chelkowski, Rakowski and partly Shugurovsk and East-Medvedev shafts. In other cases, no spatial correspondence between modern structures and imposed blastocatalase transformations. This is due to the fact that here could play a major role other superimposed processes taking place in the subsequent stages of the evolution of the basement, creating a field of stress, different from the processes of blastocatalase and catalase. To date, a large amount of material has been accumulated, indicating the possibility of the existence in the basement of the development zones of different types of reservoirs, for which the possibility of extracting hydrocarbons is proved, respectively, dispelled the idea of the basement as a monolithic base. Void space in the rocks of the basement may be associated with the development of fracturing and with the weathering crust of the crystal basement. The development of fracturing is the result of the interaction of tectonic movements and hydrothermal transformations. The filtration-capacitive properties of the basement rocks are determined by the degree of crack opening, their connectivity and mineral performance. Weathering crust formed as a result of removal to the surface of the basement blocks, which are subjected to hypergenic processes. Under these conditions, as well as a result of physical weathering, favorable conditions for chemical transformations are created and, as a result, a void space is formed. According to the morphology of weathering crusts, areal and linear types are distinguished. Thickness, mineral composition and structure of weathering crusts depends on paleoclimatic and paleogeographic conditions, as well as on the composition of the initial rocks. Area weathering crust have a small thickness (up to 4 meters), or completely washed away in the raised areas of the arches. Linear weathering crusts are controlled by the tectonic factor and can be traced to a depth of several tens of meters. Based on the experience of researchers involved in the description of the profile composed of weathering crustal rocks, it was noted that in the lower part of the profile there is a significant fracture caused by tectonic and digenetic processes, as well as porosity formed as a result of leaching. The upper part of the profile, enriched with clay minerals, forms a local coating. The identification of zones of weathering crust spread with compaction in the upper part of the profile, as well as the search for weathering crusts with overlapping poor permeable sedimentary rocks serving as fluid traps can become the main focus of the search for traps. Mapping of zones of development of linear weathering crusts was carried out as a result of the analysis of space images and topography, with the involvement of maps of gravity and magnetic exploration. The developed lineament schemes should be used both for more adequate tracing of flexur-discontinuous zones of different rank and for refinement of the configuration of plicative structures in the sedimentary cover and for modeling of the structural – facies zoning of the territory. A comprehensive analysis of the geological structure of hydrocarbon deposits in different regions shows the significant role of fault-block structures in the structure of oil and gas complexes. There is no doubt that the structure-forming effect on the sedimentary cover of the discontinuous tectonics of the basement, which determines not only the morphology of plicative and disjunctive forms in the sedimentary cover, but also the distribution patterns of reservoirs of various types, especially fractured ones, as well as the controlling boundaries of deposits. Long-term exploitation of a number of fields, dedicated to the Zhiguli fault and excess of accumulated production over the originally calculated geological reserves, may indicate the current flow of hydrocarbons into the traps of these fields.

Literature

1. *Goryunov E.YU., Ignatov P.A., Trofimov V.A., Sabirov I.A. i dr*. Perspektivy neftegazonosnosti fundamenta ZHigulevskogo vala. Geologiya nefti i gaza №2, 2017 y. p. 25-35.
2. *Postnikov A.V, R.H.Muslimov, I.N.Plotnikova.* K voprosu o roli endogennogo faktora v formirovanii i raspredelenii neftegazonosnosti osadochnyh basseynov (na primere Tatarstana). Georesursy 1(16) 2005. – p. 37-39.
3. *Postnikov A.V.* Fundament vostochnoy chasti Vostochno-Evropeyskoy platformy i ego vliyanie na stroenie i neftegazonosnost' osadochnogo chekhla. Dis. d.g.-m.n., Moskva 2002 y.
4. *Sabirov I.A.* Proyavlenie neftegazonosnosti v enderbito-gneysah fundamenta yuzhnoy chasti Buzulukskoy vpadiny. Tezisy konferentsii «Neft' i gaz» 2012 y.
5. *Trofimov V.A., Goryunov E.YU., Sabirov I.A.* Innovatsionnye podhody k resheniyu problemy poiskov uglevodorodov v glubokozalegayuschih gorizontah Volgo-Ural'skoy neftegazonosnoy provintsii. // Georesursy. 2017. T. 19. №1. p. 59-68.

THE ALLOCATION OF FRACTURED RESERVOIRS ZONES IN THE OLIGOCENE-MIOCENE SEDIMENTS OF THE EASTERN CISCAUCASIA

I.A. Sabirov[1], A.V. Postnikov[2], A.S. Rahmatullina[3], L.V. Miloserdova

Federal State Budgetary Educational Institution of Higher Education
«Gubkin Russian State University of Oil and Gas (National Research University)»
([1]-sabirov.i@gubkin.ru, [2]- apostnikov@mtu-net.ru, [3]- rakhmatullina.a@gubkin.ru*)*

Keywords: *Fracture reservoir, unconventional object, East Caucasus, lineament, remote methods*

Exploration of hydrocarbons in unconventional reservoirs require innovative approaches to determine their accumulation and distribution, which ultimately has a crucial role in their development and reserves calculation. Provided insufficient geological and geophysical data, indirect methods of determining reservoir zones can be useful for perspective oil and gas objects determining. The basis is the comparison of direct methods of fractured/decompaction zones detection (seismic data) and indirect methods aimed at the allocation of modern fault-block structures zones. A comprehensive analysis of the hydrocarbon deposits geological structure in different regions shows that the fault-block structures have decisive role in the oil and gas complexes structure. There is no doubt that disjunctive basement tectonic has structure-forming effect both on the morphology of plicative and disjunctive forms of the sedimentary cover and on the different types of reservoirs distribution. Thus, the analysis of fault-block structures is used to identify the zones of fractured reservoirs development, which is especially important for Ciscaucasus, when oil and gas potential is associated with carbonate-siliceous-clay reservoirs of the hadum horizon and batalpashin formation (Oligocene-myocene). Due to lithological data, there are seven main rock types, consist of clay, carbonate and mixed components, but significant layers thicknesses of rocks with an open porous space were not found in the well-sections. Thereby, the available data of these deposits productivity can only be explained by the fractured reservoirs. Due to limited amount of core material and GIS data, it is necessary to develop an appropriate technique for confident allocation of fractured zones, which provides the widespread use of indirect methods and data of gravity, magnetic and seismic exploration. The basis of allocation of fault-block structures and fracture zones is based on the analysis of the modern earth surface fault-block tectonics using space and topograhical interpretation. Because of such decoding, lineaments are distinguished – linearly elongated elements of the relief, which length is much greater than their width, and the geological position reflects the internal heterogeneity of the lithosphere. For the execution of the works factual material, including satellite images, topographic maps, structural maps, built according to seismic and drilling, representation of relief (DTM) was collected and systematized. The length of the lineaments, as a rule, was not less than 10-20 km. Significant length of these structures, as a rule, exceeding the thickness of the sedimentary cover, which is an additional argument in their assessment as the most important tectonic elements of the upper part of the lithosphere, including oil and gas complexes. At this level of averaging straight of the regional lineaments of the same system are lower ranks slip-fault areas. Four diagonal and one meridional-latitudinal mutually orthogonal lineament systems was mapped in the Caucasus, which

is the maximum possible number disjunctive grids within the same region. The distinct attachment of space and topolineaments to the high gradients zones and the change of gravitational anomalies and magnetic fields sign indicates their deep laying, which, in turn, allows us to consider the forms fixed on the earth's surface as the main structure-forming fault-block structures of the inherited evolution. Azimuth of mutually orthogonal lineament systems (in grad): 0-90; 29-119; 44-134; 60-150; 73-163. The various systems elements generally have unevenly area distribution. The zones of their concentration are clearly traced, the combination of lineaments of different length is noted, the distances between parallel lineaments are reduced. The elements with a length of 12-40 km are dominated. The major lineaments have a length of up to 160 km. The distance between lineaments also vary widely, accounting for elements of the same rank value, approximately in 2 times less of their length. The interpretation of the area seismic data allowed to compare the elements of the observed lineament systems to the data of seismic materials interpretation and thus allowed to rank the fault-block structures (axes of flexural-discontinuous zones) in terms of the degree of severity at depths corresponding to the hadum horizon, to determine their spatial orientation and detail their geological position. Marking of flexure-disjunction zones were based on 2D seismic data, mainly by the presence of violations of the axes of the common phase of the traced horizons in the wave field, as well as by changes in the amplitude-frequency characteristics along the traced reflection (interval). Bassets of flexure-disjunction zones were observed on the surface and compared to the positions of the lineaments, marked by space photo and topo data interpretation and gravity-magnetic data. In general, the region showed an elevated level of compliance of the results of the selection of the elements under consideration on various data, which allowed to identify the flexure-disjunction zones system of high rank with a high degree of confidence. In the conditions of a relatively rare seismic profile grid, this technique allows to mark out violations with a length of more than 10 km. The largest violations and their orientation are of regional importance and correspond to the boundaries of structural-tectonic zones. For the statistical processing of visually selected (expert and computer method), as well as reduced to a single scheme of lineaments and flexure-disjunctive zones systems, a package of computer programs LESSA (Lineament Extraction and Stripe Statistical Analysis) was used, one of the possibilities of which allows you to work with the resulting schemes and build on them a variety of maps and schemes of statistical characteristics. In this case, the density map of the lineaments and flexure-disjunctive zones was constructed, the maxima of which we called "nodes", as they are confined to the main intersections of the lineament systems or axes of flexure-disjunctive zones. Perspective zones of fractured reservoirs development are distinguished by comparing the areas of maximum lineaments and flexure-disjunctive zones densities, based on the idea that the places of the greatest violations concentration correspond to the places of fracture development, and the most perspective areas are the places of the maximum of nodes and those and others coincidence. Thus, in case of insufficient lithological and petrophysical data, the analysis of fault-block tectonics can predict fractured zones, which play a significant role in improving of reservoir quality by creating additional capacity and formation of permeable zones. A similar approach to the allocation of fault zones can be extended to the entire Scythian plate, including the territory of the Crimea.

Literature

1. *Postnikov A.V., Rahmatullina A.S., Miloserdova L.V., Varov YU.E., Sabirov I.A.* // Metodika vydeleniya zon razvitiya treschinnyh kollektorov v hadumskih otlozheniyah Vostochnogo Predkavkaz'ya po kompleksu geologo-geofizicheskih dannyh. - Geofizika. 2016. № 6. p. 53-60.
2. *Amurskiy G.I., Abramenok G.A., Bondareva M.S., Sovol'ev N.N.* // Distantsionnye metody izucheniya tektonicheskoy treschinovatosti porod neftegazonosnyh territoriy – M.: Nedra, 1988. – 164 p.
3. *Gavrilov V.P.* // Vliyanie razlomov na formirovanie zon neftegazonakopleniya. – M.: Nedra, 1975. -269p.
4. *Musihin A. D., Postnikov A.V., Sival'neva O.V., Rahmatullina A.S., Sabirov I.A.* // Svyaz' pustotnogo prostranstva porod s razrabotkoy zalezhey UV v hadumskih otlozheniyah Vostochnogo Predkavkaz'ya (Sovmestnyy seminar EAGE/SPE 2017: Nauka o slantsah)
5. *Shul'ts S.S.* Planetarnaya treschinovatost' // Planetarnaya treschinovatost'. – L.: Izdatel'stvo LGU, 1973. p. 5-57.

DELINEATION OF PORE-CRACK TYPE RESERVOIRS IN THE CARBONATED SEDIMENTS OF THE BAZHENOV SUITE

A.V. Sivkova

Federal State Budget Educational Institution of Higher Education « Industrial University of Tyumen» (sivkova_a_v@mail.ru)

Keywords: *silicide,gas logging, core,reservoir rock,bazhenov suite,porosity, kerogen.*

The deposits of the bazhenov suite have been most thoroughly studied in the areas of the Salym region, where a continuous core sampling was performed in the numerous wells, which allowed studying not only the lithological features of the rocks, but also evaluating their reservoir properties. In the bazhenov suite deposits of the Verkhne-Salym region and its analogs, three isolated reservoirs are distinguished according to the gas logging data: in the upper unit of the bazhenov suite, in its middle and the reservoir on the border with the underlying Abalak suite. The middle reservoir is the best of them. It is represented by a silicified aporadiolarite (silicide) with insignificant clay impurities and characterized by a significant variability of the drilling velocity. At the Imilorskoye field, there is also a change in the indications of geological and technical studies (GTI): gas logging, detailed mechanical logging, a change in the flow rate for the middle part of the bazhenov suite, where a potential interval of the collectors is possible. Because all researchers assume a fractured and fissure-porous reservoir type, then productive intervals of the deposits of the bazhenov Formation of the Imilor deposit can be both fractured-pore carbonate deposits and fractured or foliage basilites composed of kerogen and silica. According to the description of the core, the proposed reservoir in the middle unit of the bazhenov suite is represented by silicites with secondary dolomitization and secondary limestones, on the GIS diagram, which are similar to the characteristics of dense carbonate interlayers The maximum values of porosity by core (kerosene saturation) for the deposits of the bazhenov suite were: for secondary limestones - 3.24%, for dolomitized silicites - 5.92%. In connection with the obtained low values of matrix porosity, it is necessary to assume the presence of an influx only under the condition of the development of secondary (fractured) porosity. To date, it is possible to really detect the presence of effective thicknesses in these sediments only by direct investigations-the conduct of qualitative tests in a column or in an open trunk. The use of a standard GIS complex has limitations. For example, the hydrophobization of the deposits of the bazhenov suite associated with the presence of organic matter leads to the absence of diffusion-adsorption exchange in the "formation-wellbore" system, which is a prerequisite for the informative nature of the method of spontaneous polarization. The abundant content of organic matter with anomalous uranium concentrations makes a significant contribution to the total radioactivity and does not allow the use of integral gamma-ray logging as a function of clayiness. The thin-layered structure of the bazhenov suite, determined from detailed lithological studies, distorts most of the methods with low vertical resolution, and significantly increases the error in the quantitative interpretation of GIS data. In addition, iron-pyrite and siderite compounds are present in the section. In a number of cases, the thickness of the pyrite veins reaches several centimeters. The nuclei of iron atoms capture neutrons, which leads to a decrease in neutron logging, which in turn leads to an apparent overestimation of hydrogen content. Therefore, to take

into account all features of the section, it is necessary to use the maximally extended GIS complex, including such special methods as CMR, Scanners, Sonic, GGKLP, HNGS and APS. In this paper, we considered various petrophysical models of reservoir separation based on the use of a standard and extended GIS complex. The main features of the methodical approach Dyakonova T.F. consist of three types of reservoirs: pore-cracked, fractured, fractured-cavernous and detailed lithologic dissection. For the calculation of parameters, radiometry and lateral logging methods are used. As a result, the intervals in which the open porosity exceeds 3.5% are considered effective in the collectors of the pore-crack type. In the reservoirs of the fractured and fissured-cavernous types, the intervals in which there is a secondary porosity Kp. vt> 0, are considered effective. The method of separation of reservoirs in the rocks of the bazhenov suite, developed by V.V. Khabarov and V.P. Sonic, is based on indications of gamma and neutron logging and readings of focused lateral logging (BC). Collectors include interlayers with a thickness of more than two meters and a porosity of more than 10%, the fractured component is not taken into account. Temporary methodological guidance on the calculation of oil reserves in fractured and fissured-porous reservoirs in the sediments of the bazhenov strata of the West Siberian oil and gas province "proposes to distinguish three classes of lithology: 1. Siliceous radiolarites (Neffn = Ntotal); 2. Carbonatized radiolarites (Neffn =1/2Htotal); 3. Clay-bituminous rocks (reservoir rock). Western researchers use the method of K. Passy, in which the normalization of indications of methods of porosity (acoustic, neutron or density) and rock resistance is used. The rescaling of the curves is carried out in such a way that their coincidence is observed in the intervals of rocks with different porosity, but with a low content of organic matter, while the excess of the resistance curve over the normalized porosity curve is noted in the interval of oil and gas rocks. The conducted study showed that methods based on the calculation of the content of kerogen, as well as using pyrolytic coefficients, give extremely optimistic values of effective capacities. The approach of Dyakonova T.F. identifies the fractured component and separates the interlayers available for filtration, whereas the Khabarov V.V. approach allows to allocate a potential collector in the silicite upper and middle unit of Bazhenov's strata. Calculation of the pyrolytic coefficients (VMR) increases the oil-saturated capacity due to the addition to the reserves of the power of the entire upper part of the bazhenov unit, characterized by high gamma-ray readings. The most adequate results were obtained by comparing the core data (glow in ultraviolet light, the presence of a ratio of the pyrolytic coefficients responsible for mobile hydrocarbons), the GTI and the methodology of K. Passy. The effective capacities of the collectors of the pore-crack type predicted from them coincide, which can be trusted According to the technological parameters of the GTI, the intervals of the carbonate interlayers are fixed unambiguously by the increased values of the DMC (decrease in the rate of penetration), and the pressure decrease and the increase in the productivity of the drilling pumps indicate the fracturing and permeability of these deposits. Based on the results of the full GTI complex, it is possible to correlate wells with the standard GIS complex, which also noted the listed characteristics. This will make it possible to trace the long-range interval of the bazhenov suite for the area of the deposit

46/5000 Gil'manovoy N.V, Moskalenko N.V, Smolyakov G.A. Gilmanova NV, Moskalenko N.V., Smolyakov G.A.

MODERN STRUCTURAL PLAN OF THE FRATERN CRIMEA AND ITS IMPACT ON DISTRIBUTION OF SURFACE AND UNDERGROUND DRAIN

T.V. Syhanova, N.V. Makarova, V.M. Makeev

Lomonosov Moscow State University, Faculty of Geology (tanikamgu@mail.ru)

Keywords: *zones of newest uplifts and subsidence, structural plane, active faults, Plain Crimea, groundwater*

On the territory of the Plain Crimea, the newest structures of different rank are distinguished. The modern structural plan is determined by three large sublatitudinal blocks separated by deep faults. From North to South - this is Tarkhankut-Dzhankoysky, Novoselovsky and Kalamitsko-Arabatsky blocks [2, 3]. Their structure is the same: the southern parts are raised relative to the Northern, and the Eastern - below the Western. This asymmetry repeats the structure of the newest Crimean structure, which assumes similar conditions of formation: the influence of deep processes occurring when the Black Sea plate is pushed under the Crimean Peninsula. The boundary between the western raised and the eastern relatively lowered parts is the meridional Central uplift (Central Crimean lineament), developed over the deep fault zone. Within the blocks, there are zones of uplifts and subsidence, represented by chains of anticlinal and synclinal folds, often broken by ruptures. This is especially true for the Tarkhankut and Novoselovo uplifts, where several latitudinal rows of folds are distinguished. The folds are articulated, their axes are undulated, mostly they are asymmetric in accordance with the general asymmetry of the blocks. They had developed consedimentationally in marine conditions, with interruptions, some since the late Cretaceous, but the main impulse of tectonic movements occurs on the Pliocene-Quaternary time. Ascending movements are also manifested at the present time, activating karst-suffosion, landslides and other processes. Only in the North-Western part of the Alminsky basin and in the East within the North Sivash and Indolo-Kuban basins there is still dounwarping. The blocks and local structures planned location indicates the wide participation of shear stresses and movements during their formation. The left shifts were most clearly manifested, which could have been formed under regional compression originating from the South-West, possibly from the West-Black Sea microplate. All the latest regional and local structures have an impact on the state of freshwater and individual aquifers. The uplifts developed both in the foothills and in the Plain Crimea are areas of subsidence of the horizons of groundwater emerging at the surface, including in river beds, or overlain by thin coverings. Here, the increased fracturing of rocks improves the conditions for infiltration of atmospheric precipitation and river water into the aquifers. Upliftes and subsidense are contained of groundwater. They are associated with artesian basins of the Plain Crimea (Alminsky, North-Sivash and Belogorsky) and other deposits. The Central uplift serves as a watershed of surface and underground runoff, directed toward the West and East. The asymmetry of the structures determines the position of the different-age aquifers, the discontinuity of their development, the movement of groundwater along the slopes of the uplifts into the basins, which concentrate the surface runoff. The location of local uplifts and depressions creates a complex internal relief structure similar to cellular or latticework. This structure is typical for the Alminsky depression and the relatively low Eastern part of the Plain Crimea, where the North Sivash and

Belogorsky artesian basins are located. Within them, internal uplifts, still unclear in the relief, but affecting the surface and underground run-off of water, develop. On the coasts, where there is a warping, salinization of aquifers occurs. All these features of modern tectonic structure create a complex hydrogeological situation. The main source of water supply to the population with fresh water is the Middle Sarmatian-Pontic complex, represented by karsted and fractured limestones, sandy limestones and sandstones. The sediments thickness increases from South to North from 135 to 245 m [1]. The position of the complex and individual horizons, the thickness and depth of their occurrence largely depends on the direction of the Pliocene-Quaternary movements: so on the uplifts the roof of the pontine deposits is raised to 50-60 m and more, and in the depressions it is lowered to sea level and deeper. Accordingly, the aquifer is also deformed. Interest in the search for new sources of fresh water is the investigation of active fault zones. Deep faults of the foundation are active at the present time. It is assumed that fresh groundwater coming from deeper horizons of the sedimentary cover to the surface may be confined to the zones of some of them. In addition, the faults zones transit of fresh groundwater from the foothill part of Crimea to Plain Crimea takes place. On the Northern slope of the Tarkhankut Upland on the Pervomayskiy rigion, there is an identification of several wells with the mineralization of water permissible for use in water supply to the zone of latitudinal fault. And although this does not prove the possibility of connecting groundwater with all deep faults, the latter must be investigated more thoroughly.

Literature

1. Gidrogeologiya SSSR. Tom VIII. Krym (red. V.G. Tkachuk). M.: Nedra. 1970. 364 p.
2. *Kats YA.G., Makarova N.V., Kozlov V.V., Trofimov D.M.* Strukturno-geomorfologicheskiy analiz Kryma po deshifrirovaniyu kosmosnimkov // Izv. Vuzov. Geol. i razv. 1981. №3. p. 8-20.
3. *Makarova N.V., Suhanova T.V.* Neotektonicheskoe stroenie Ravninnogo Kryma // Tektonika i geodinamika kontinental'noy i okeanicheskoy litosfery: obschie i regional'nye aspekty. Mat-ly XLVII Tektonich. sovesch. M.: GEOS. 2015. T. 1. p. 276-280.

PETROMAGNETIC STUDY OF THE PALEOPROTEROZOIC MAGMATIC COMPLEXES REMAGNETIZATION WITHIN THE KARELIAN CRATON.

N.A. Tarasov [1], N.V. Lubnina [2]

Geological faculty of MSU state university ([1] --tarasovnik12@gmail.com, [2] – natlubnina@yandex.ru)

Key words: *AMS, remagnetization, dykes, Karelian craton*

Anisotropy of magnetic susceptibility (AMS) has many applications. AMS is usually estimated by comparing the magnetic susceptibility in three mutually perpendicular directions: k1 is the axis of the maximum magnetic susceptibility; k2 - intermediate; k3 minimum. These quantities characterize the ellipsoid of the magnetic susceptibility. Under the influence of tectonic load, the elongated ferromagnetic grains passively rotate under the influence of the stress acting on the rock, which is fixed by AMS. Since AMS can be measured faster and easier than, for example, the distribution of mineral axis orientations by optical analysis, AMS is used to study the formation of structures in a rock. AMS also makes it possible to determine the presence of possible secondary mineralization, which are revealed by an increased (more than 10-15%) degree of anisotropy of the magnetic susceptibility and high degree of clustering of the principal axes of the ellipsoid of magnetic susceptibility [2].

According to [1], the oblate ellipsoids of magnetic susceptibility are often observed in volcanic rocks with flow textures; k3 is perpendicular to the surfaces of the streams. Sometimes there are also elongated ellipsoids of magnetic susceptibility with k1 parallel to the flow lines of volcanic rocks. According to [2], the dyke model assumes a laminar motion parallel to the body, which directs the crystals in accordance with the flow direction. The model mostly works normal: the axes k3 and k1 are respectively orthogonal and parallel to the dyke plane. On the other hand, a systematic study of the dykes showed that both the reverse and chaotic distribution of the axes is possible, but in a much smaller number of cases. However, all minerals contribute to the AMS of the rock. Therefore, it is important to determine the mineral composition of the rock. In rocks with a magnetite content > 1%, the greatest contribution to AMS is made by magnetite crystals, and the influence of other rocks becomes insignificant. A thermomagnetic analysis helps to verify this, which allows us to identify the main minerals carriers of magnetization.

Analysis of AMS can also help in the study of dyke swarms within Precambrian blocks of the earth's crust, which allow making paleotectonic reconstructions of the Early Precambrian. To reconstruct the position of the Ilomantsi-Voknavoloksky terrane as part of the Karelian craton in the Paleoproterozoic, we tested dykes of dolerites and gabbronorites, as well as the Archean host granite gneisses. By the similarity of the composition and the extent of the dykes, it was determined that the selected bodies belonged to the dyke swarm with an age of 2450 Ma [4]. One of the defining conditions of paleomagnetic reconstructions is the primacy of the natural remanent magnetization components. To determine the presence of secondary changes, we selected AMS analysis in combination with petrographic analysis. Magnetite was identified as the main mineral carrier of magnetization in result of thermomagnetic analysis. The degree of anisotropy in dykes did not exceed 8%, in the host granite-gneiss it reached 40%. The directions of k1 in the dolerite

dykes parallel to the strike of the dykes, the ellipsoid AMS has an isometric shape. The directions of k1 in dykes of gabbronorites are mainly perpendicular to the strike of the dykes, the ellipsoid AMS has a flattened shape and can move to the elongated in the contact area. The directions of k1 in the enclosing granites at a distance from the dykes are different from the directions in the dykes themselves. In the case of secondary changes after the introduction of the dyke, the directions of the maximum axis of the ellipsoids of the magnetic susceptibility in the dyke and in the surrounding rocks would coincide, and the degree of anisotropy in these rocks would coincide. Thus, the absence of secondary changes in the rocks after the time of the dolerite and gabbronorite dykes intrusion was confirmed. Various forms of AMS ellipsoids in close-by-age dykes determine the various conditions for the formation of these bodies.

Petrographic study of the intrusions of Kenasozero Lake agrees with the AMS data and indicates a high degree of preservation of the rocks. The predominant amount of fine-grained two-pyroxene dolerites and olivine-containing gabbronorites retain primary mineralogy, but reactionary amphibole rims around olivine grains and weak amphibolization of pyroxenes are developed in some of them. The presented data indicate the preservation of the primary magnetization and allowed the use of selected rocks for the paleomagnetic study.

Supported by RSF (№181700170)

Literature

1. *Butler R.F.* Paleomagnetism: Magnetic Domains to Geologic Terranes. Oxford: Blackwell, 1992. – 319 p.
2. *Lanza R., Meloni A.* The Earth's Magnetism: An Introduction for Geologists. – Berlin: Springer, 2006. – 278 p.
3. *Merrill R.T., McElhinny M.W., McFadden P.L*. The Magnetic Field of the Earth. Paleomagnetism, the Core, and the Deep Mantle. International Geophysics Series, Volume 63. Academic Press, New York, London, 1996. - 531 p.
4. *Stepanova, A. et al.* The 2.31 Ga mafic dykes in the Karelian Craton, eastern Fennoscandian shield: U–Pb age, source characteristics and implications for continental break-up processes // Precambrian Research. 2015. №259. P.43–57.

STABILITY OF FLUORIDE COMPLEXES OF ZIRCONIUM IN HYDROTHERMAL SOLUTIONS

M.E. Tarnopolskaya[1], A.Y. Bychkov[2]

Lomonosov Moscow State University ([1]- mashatarnopolskaya@yandex.r ,[2]-andrewbychkov@rambler.ru)

Keywords*: zirconium, hydrothermal solutions, transport species, fluoride complexes*

Zircon is an important mineral for geochronological research, it is stable in a wide range of natural conditions. Under the influence of fluids, zircon can be redeposited and the isotope ratios can change. Therefore, it is important to predict the forms of zirconium transport in hydrothermal solutions. The purpose of our work was the experimental determination of the stability constants of fluoride complexes of zirconium at 90-255 °C (saturated water vapor pressure). At higher temperatures, the solubility of baddeleyite in HF solutions was investigated, and the stability constants of the $Zr(OH)_3F$ and $Zr(OH)_2F_2$ complexes were determined by Ryzhenko et al. (2008) and [2]. In works [5,3] there are data on the stability of complexes $ZrFn_{4-n}$, where n=1-6 at 25 °C. Experimental study of zirconium speciation was studied in the $ZrOCl_2$-HCl-HF-CaF_2 system at 90, 155, 210 and 255 °C (saturated water vapor pressure). The study was based on measuring the solubility of fluorite in acidic solutions with the addition of a different amount of zirconium. For the experiments, we used fluorite from Kalanguy deposit. We produced cylinders from a single crystal fluorite (diameter-8 mm, hight-5 mm and weight about 0.7 g). Before using the cylinders, fluorite was weighed on an analytical balance Mettler Toledo AG204 DeltaRange. We used steel autoclaves with PTFE inserts. Fluorite cylinders was fixed on the cover of autoclaves with the PTFE tape. Autoclaves was placed in a preheated oven lid down for the contact of crystal and solution. The time of the experiment was from 4 to 10 days for different temperatures. Autoclaves were quenched in cold water, pre-inverted lid up. This contact with a solution of fluorite was interrupted to avoid dissolution or deposition of material. Fluorite cylinders was recovered, washed with distilled water, dried to constant weight over silica gel, and weighed. [6] The solubility of fluorite increases with increasing of zirconium concentration. With increasing temperature, the solubility of fluorite also increases (an average of 0.4 logarithmic units with an increase in temperature of 60 ° C). For calculating the results of experiments, we used the program OptimA. The OptimA program is intended to refine and estimate the accuracy of the free Gibbs energies of a small number of species of an aqueous solution from experimental data. The solution of the direct thermodynamic problem of calculating chemical equilibria in aqueous solutions is performed using the HCh package for Windows. As a data source, the OptimA program uses the workbook of the MS Excel program, and writes the results to it. The program can process data simultaneously for several experiments performed in the same chemical system (but with different compositions) under the same conditions (temperature, pressure and chemical potentials of completely mobile components). By results, it was determined that at a temperature of up to 100 ° C the solubility of fluorite is described by the formation $Zr(OH)_3F$ and $Zr(OH)_2F_2$ complexes [2]. However, at higher temperatures, under the conditions of our experiments, the ZrF_6^{2-} complex predominates. The stability constant of this complex was determined using the free energies of fluoride and zirconium ions from the SUPCTR92 database [1]: $Zr^{4+} + 6F^- = ZrF_6^{2-}$ At 90, 155, 210, 255 ° C and the

saturated vapor pressure of water, the constant of this reaction was lgβ = 30.7, 33.9, 37.8, 40.9, respectively.

The work was supported by the RFBR project №.18-35-00075

Literature

1. *Johnson J.W., Oelkers E.H., Helgeson H.C.* SUPCRT92: a software package for calculating the standard molal thermodynamic properties of minerals, gases, aqueous species, and reactions from 1 to 5000 bars and 0 to 1000°C// Comput Geosci.1992. 18 (7), p.899-947
2. *Migdisov Art. A., Williams-Jones A.E., van Hinsberg V., Salvi S.* An experimental study of the solubility of baddeleyite (ZrO2) in fluoride-bearing solutions at elevated temperature// Geochimica et Cosmochimica Acta. 2011.№75, p. 7426–7434
3. *Buslaev YU.A.* Konstanty nestojkosti kompleksnyh ftoridov cirkoniya// ZHurn. neorg. himii.1962. №5. p.1204-1206.
4. *Ryzhenko B.N., Kovalenko N.I., Prisyagina N.I., Starshinova N.P., Krupskaya V.V.* Ehksperimental'noe opredelenie form sushchestvovaniya cirkoniya v gidrotermal'nyh rastvorah // Geohimiya. 2008. № 4. p. 364-375.
5. *Hevesy G., Christiansen J. A., Berglund V.* Die Loslichkeit der Doppelfluoride des Zirkons und Hafniums // Zeitschrift fuer anorganische und allgemeine Chemie.1925. №144, p. 69-74.
6. *Tarnopolskaia M.E., Bychkov A.Yu, Shvarov Yu V., Popova Yu A.* Experimental study of fluorite solubility in acidic solutions as a method for boron fluoride complexes studying// Geochemistry International.2017. № 4, p. 355-359

DISTRIBUTION OF THE ORGANIC MATTER IN BAZHENOV HIGH-CARBON FORMATION.

M.S. Topchii[1], N.V. Pronina, A.G. Kalmykov, G.A. Kalmykov, M.M. Fomina[2], Y.A. Karpov[3]

Lomonosov Moscow State University, Faculty of Geology ([1]- m.s.topchiy@gmail.com, [2]- fomina-msu@mail.ru, [3]- y.a.karpov@yandex.ru)

Keywords: *Bazhenov formation, organic matter, Bazhenov high-carbon formation*

One of the most famous and promising shale formations in Russia is the Bazhenov formation. The ambiguity of ideas about its geological features, caused by the complex, heterogeneous structure of the strata, attracts the attention of many researchers. In this work, the Bazhenov formation is singled out in conjunction with its stratigraphic counterparts in the Bazhenov high-carbon formation (BVCHF). In this were concidered the main characteristics of its allotment and distribution over the area, as well as the geological structure. Being an unconventional reservoir of hydrocarbons, BVCHF has the properties of a petroleum-bearing rock, one of the main characteristics of which is organic matter, its type and maturity. The paper presents the results of the study of organic matter by various methods at the microlevel, as well as their integration with larger-scale studies. The need for detailed consideration of the organic matter of the BVCHF is justified by the fact that it has a mixed composition and, as a consequence, a different degree of transformation and spatial distribution.

DO WE KNOW EVERYTHING ABOUT THE ORGANIC MATTER OF THE BAZHENOV FORMATION OF WESTERN SIBERIA?

M.S. Topchii[1а], N.V. Pronina, A.G. Kalmykov, G.A. Kalmykov, E.V. Kozlova[2], M.M. Fomina[1б], Y.A. Karpov[1в]

[1]- Lomonosov Moscow State University, Faculty of Geology ([а]- m.s.topchiy@gmail.com, [б]- fomina-msu@mail.ru,[в]- y.a.karpov@yandex.ru);
[2]- Skolkovo Institute of Science and Technology (e.kozlova@skoltech.ru)

Keywords: *Bazhenov Formation, organic matter, microscopic studies*

For more than half a century the main oil and gas-bearing basin of Russia is considered to be West-Siberian, and its main oil-producing and productive suite is Bazhenov formation (J_3-K_1). This formation with a small thickness (20-30 m, and in some areas of the anomalous section - up to 100 m) is widespread throughout almost the entire area of Western Siberia. The accumulation of deposits of the Bazhenov formation occurred in the marine, relatively deep-water (200-400 m) basin with rich fauna and various abundant algae, which contributed to the accumulation of enriched organic matter (OM) deposits. The content of OM in the rock can reach 20-25%, but more often, it is 6-12%. Is this organic matter homogenous and what products can it generate, what conditions are necessary to start and continue the process of oil and gas generation? The general scheme of this process was repeatedly considered in the works of N. Vassoyevich, D. Welte, B. Tissot, J. Hunt, and others. The main transformations take place with an organic substance, which is very sensitive to temperature changes, and, to a lesser degree, pressure, in narrow thermo-baric interval. The step of transition of OM from the initial solid state to liquid and / or gaseous is called oil and gas generation, which occurs in the Main Phase of Oil Formation - MPOF (according to N. Vassoyevich), or Oil Window-Oil Window, as is customary in international terminology. Determination of the position of the MPOF in the section and on the area is one of the most important tasks of petroleum geology, which is solved by various methods. Each type of analytical research complements this complex, multicomponent picture. The study of the organic matter itself by petrographic and geochemical methods also contributes to the understanding of the process of oil and gas generation, so the integration of various methods is the main feature of modern research on OM. Microscopic studies make it possible to observe the natural distribution of organic matter in the rock, its relationship with mineral constituents. Organic components are called macerals. The most common macerals of oil-rock breeds are those that were formed from algae - the most diverse. While such macerals retain elements of the structure of the original organisms, they are called alginites, but when they lose their primary structural features and become structureless, they are already referred to as bituminites. By their size and shape, bituminites are very diverse. They can form extended puffs and lenses of different thickness, emphasizing the bedding of the rock, and can have a very whimsical shape, filling the voids, the gaps between the mineral grains. Being relatively soft substance, OM undergoes different pressure from the mineral grains of the rock and therefore the puffs and lenses of bituminite are wavy, ruptured and "squeezed" into intergranular space. Single plankton algae can be preserved in the form of very small inclusions of bituminite, mixed with clay minerals and representing a finely dispersed organomineral mixture in which individual macerals are difficult to recognize. In the Bazhenov formation all the described varieties

of bitumenite and alginate are present. In addition, redeposited macerals of humic coals are found - sporinites, vitrinites and inertitinites, but they are so rare and insignificant in size that it is not necessary to talk about their "contribution" to the composition of OM of these sediments. The first feature of the Bazhenov formation is that its organic matter is very homogeneous, it belongs to the I-II type of kerogen (this is evidenced by the geochemical characteristics of OM). However, the diversity of bituminites that make up this kerogen suggests a certain spread of both petrographic and other characteristics during the investigation. Microscopic studies of a large number of samples of the Bazhenov suite from different regions of Western Siberia enabled the authors to see examples of transformation of OM, changes in its primary structure, and the appearance of newly formed macerals in the form of bitumen films and solid bitumens, which in the English literature are very accurately called post-mature bituminite, e. postgeneration bitumenite. The presence in the rocks of the Bazhenov formation at the same time macerals with signs of primary structure and newly formed indicates that different in nature bitumenites begin to generate liquid and gaseous products at different times.Close to heavily altered macerals can be bituminites or almost alginites, in which the transformations have not yet begun. The second feature of the Bazhenov formation, which is demonstrated by microscopic studies, is the non-simultaneous transformation of the organic matter entering into its composition. A large spread of such indicators as RB,% (the indicator of the reflection of bitumenite, comparable to the vitrinite reflection index), Corg,% and a set of pyrolytic parameters - S1, S2, Tmax, HI, PI, etc., testifies to this. Further analytical studies of the organic matter of petroleum deposits of similar Bazhenov formation focus on such subtle methods as electron microscopy in all its diversity. Active organic porosity and its role in the dynamics of the process of oil and gas generation are actively studied. But traditional petrographic and geochemical studies not only remain basic, but continue to please their new achievements

TWO-PHASE DEFORMATION INFLUENCE ON THE FORMATION OF TENSION FRACTURES IN STRIKE-SLIP ZONES: RESULTS FROM PHYSICAL ANALOGUE MODELLING ON WET CLAY

N.S. Frolova, A.F. Chitalin, T.V. Kara, A.N. Korbutyak, A.A. Mishakina

Lomonosov Moscow State University, Faculty of Geology (n.s.frolova@mail.ru)

Keywords: *analogue modelling, strike-slip zones, two-phase deformation, tension fractures, Baimskaya shear zone*

The problem of formation of the open-fractures is of interest for both oil-field geologists and mine-geologists, since it determines the deformational fluid permeability of rocks. Usually it is considered that open fractures are tension fractures. Starting with the experiments of G. Cloos and W Ridel (20s of the last century), many experiments of the reproduction of strike-slip zones were carried out on the wet clay as equivalent material. Subsequently, it began to use predominantly dry sand abroad, but clay models are better suited to study various aspects of fracturing. With the strike-slip in clay models the shears (Riedel shears) are usually formed; the tension fractures occur only in case of heavy wetting the surface of model with water or glycerin [1] , leading to increased brittleness of the material (vol. Rebinder effect). Nevertheless, even without wetting, the open-fractures in the experiments is still formed, since the Riedel shears are formed by combining of small fractures, arranged in an echelon manner, and after that the shearing along the large fractures is already taking place over an uneven surface, which entails the formation of "gaps". The component of the stretching in strike-slip zone leads to an increase of opening of the formed R-shears (synthetic Riedel shears). Under certain conditions, small tension fractures can also occur at the ends of these shears. We obtained all these effects in the experiments of the Laboratory of Tectonophysis and Geotectonics of the Lomonosov Moscow State University.

In natural shear zones, more complex structural parageneses are often observed, than those, studied in analog models. In addition, geologists often record movements in two opposite directions for different diagnostic properties. A.V. Cheremnykh and co-authors [2] carried out experiments with reverse motions on the strike-slip zones in the Institute of the Earth's Crust SB RAS. In this case, the "foundation" consisted of a series of linearly stretched blocks with flat boundaries simulating the fault-block structure of the Vilyuisk-Markhinsky zone of the Yakut diamond-bearing province. Each of the blocks was connected to the rest and moved relative to neighboring ones at a constant speed; the wet clay served as a cover. In the first phase of deformation Riedel shears were developed. In the second – with a change of the displacement direction - between these shears the tension fractures were formed. Such effect was observed at a low (3 cm/h) deformation rate. We obtained a similar picture with a two-phase strike-slip deformation in the cover above the curvilinear fault of the basement. During the second phase, well-pronounced tension fractures developed between the early fractures. The shear rate was the same - 3 cm/h. The tension fractures are structures of a higher rank than the Riedel shears. They are always located between them and associated with the redistribution of stress on the structural heterogeneities formed in the previous stage.

More complex experiments with two-phase deformation were carried out for modeling of the Baimskaya ore-bearing shear zone of Western Chukotka. On the basis of geological and structural data A.F. Chitalin came to the conclusion that in this zone not only the dextral strike-slip fault was realized, as previously thought, but also the sinistral one preceding the dextral. The Baimskaya zone is rather complicated – it consists of a series of meandering intersecting faults.

We proposed a technique and constructed a special equipment to the main setup for tectonophysical modeling in order to be able to carry out experiments with such objects.

At the bottom of the device (it consists of 31 plexiglass bars, which can be evenly displaced relative to each other), a layer of silicone is applied, and a sample of wet clay is placed on top of it. In the sample, we made cuts according to the pattern, so that it is divided into blocks corresponding to the block structure of any complex shear zone, in this case Baimskaya zone. For experiments in which the foundation and the cover are provided, a "cover" made of less viscous clay is placed on top of the blocks of the "foundation" made of clay that is more viscous. Since there is no clear division into the foundation and cover in the Baimskaya zone, part of the experiments were carried out with single-layer samples (kaolin clay 40% moisture, 3 cm thick); the displacement velocity was 3 or 5-6 cm/h.

In the first phase of deformation, the blocks only slipped relative to each other with the formation of narrow pull-apart structures on favorable knee-like bends of the fault planes. With reverse displacement (in the second phase of deformation), apart from the slip of the blocks, distinct tension fractures formed mainly in the central part of the experimental strike-slip zone (the so-called decompression zone); probably, this involves the intrusion of the body into a similar space in nature. In the Baimskaya shear zone are located a number of ore-bearing intrusions, with which copper-porphyry systems, gold-silver and polymetallic occurrences are parageneticaly linked [3]. Because of that, experiments were also performed to reveal the tension fractures, linked to the presence of more rigid bodies. In one of them, the phase of the sinistral shearing was absent – according to the previously existing ideas.

Under the conditions of the dextral strike-slip fault, the blocks moved along the specified discontinuities with the formation of narrow pull-apart structures on the sections with the stretching component. Rare underdeveloped Riedel shears and several small tension fractures were also formed. At some boundaries of the intrusive bodies, slight extensional structures were appeared.

In another experiment, a two-phase deformation was performed. Bodies of plasticine were placed in a sample of clay after the implementation of sinistral strike-slip fault (structures were similar to those just described). During the second phase of deformation – dextral strike-slip – the deformation pattern changed dramatically. Many extensional structures were appeared. First of all, they are associated with the shadows pressure of intrusions. Furthermore, the tension fractures develop on those sections of the pre-cut gaps, where the dextral-sided displacement is difficult (these segments are inclined in the opposite direction to the shearing). All the described structures are potentially fluid-permeable zones; their analogues in nature are associated with many deposits and ore occurrences. In such a way, our experiments show that the strike-slip deformation in the Baimskaya zone was indeed a two-phase deformation, and that the open- fractures of the second phase was formed with a large extent due to the presence of the first phase.

Literature

1. *Stoyanov S.S.* The mechanism of fault zone formation. Moscow, Nedra Publ., 1977. 144 p.
2. *Cheremnykh A.V., Gladkov A.S., A.S. Cheremnykh A.S.*Experimental investigation of fault network formation in the Nakyn field of the Yakutsk diamondiferous province // Proceedings of the Siberian Department of the Section of Earth Sciences of the RAEN. Geology, Exploration and Development of Mineral Deposits. 2017. Vol. 40. No. 1. P. 66-82.
3. *Chitalin A., Fomichev E., Usenko V., Agapitov D., Shtengelov A.* Structural Model of Peschanka Porphyry Cu-Au-Mo Deposit ,Western Chukotka, Russia // Structural Geology and Resources. 2012. P 21-l27.

EFFECT OF ACIDITY ON THE MERCURY ADSORPTION FROM A SOLUTION ON THE ORGANOSILICON SORBENT PSTU-3F

R.V. Fiaizullina[1], E. V. Kuznetsov[2]

Lomonosov Moscow State University ([1]- fiaizullina@geol.msu.ru,[2]- skiff727@rambler.ru)

Keywords: *mercury, mercury adsorption, organosilicon sorbent, water treatment.*

Mercury and its compounds are an integral part of the environment, where they tend to be in extremely low concentrations. Analytical chemistry of mercury has significantly stepped forward in recent years. However, until now there are such natural reservoirs, concentrations in which can not be directly determined. In such cases, one of the solutions is the use of various kinds of synthetic sorbents, significantly lowering the limit of detection of mercury. An additional advantage of using them is the possibility of transporting the mercury accumulated on the sorbent from the point of extraction directly to the measurement site, i.e. in the equipped analytical laboratory.

In areas with increased anthropogenic load, another problem is particularly acute, related to the increased concentrations of this element. A large amount of data on the negative impact of mercury on the environment indicates the need for industrial and sewage treatment. In the absence of control and reliable protective devices, it enters the soil, surface and groundwater, bottom sediments, having an extremely negative impact on the environment. In particular, when entering the aquatic ecosystem, mercury accumulates and is transformed in each subsequent link of the food chain, reaching the maximum content at its apex. An analysis of the currently available methods for purifying natural and waste water from heavy metals has shown that one of the promising methods is the sorption method.

As a sorbent capable of providing solutions to these two diametrically opposite problems, we chose the synthetic sorbent PSTU-3, synthesized by a group of scientists from the A.E. Favorsky Irkutsk Institute of Chemistry of the SB RAS under the guidance of Academician Voronkov M.G. [4]. Originally it was created for the post-treatment of water from mercury. PSTU-3 is a spatially crosslinked organosilicon polymer with thiourea groups. Its distinctive feature is the increased thermal and chemical stability, which makes it possible to operate in corrosive environments, as evidenced by the absence of a change in mass and static sorption capacity when exposed to ammonium hydroxide, sulfuric acid and hydrochloric acid at 100°C for one hour. The destruction of the polymer occurs when exposed to it by concentrated solutions of sodium or potassium. High chemical stability allows this sorbent to function in a wide range of acidity of the medium: from 12 pH to strong concentrated acids (Vasilieva et al., 2010). There are no more detailed studies devoted to the influence of various factors on the adsorption of metals on PSTU-3T in the literature.

As is known, a number of factors can affect the course of adsorption: the amount of adsorbent, the time of its contact with the solution, the temperature and the pH value. The present work is devoted to the study of the effect of acidity on the adsorption of mercury from solutions.

Tube from polyethylene terephthalate (PET) (Greiner, Germany), volume 50 ml and Teflon bottles (VitLab, Germany), meeting the necessary characteristics for storage of diluted samples, were used as sample containers.

As an adsorbent, PSTU-3F (a fine fraction of the PSTU-3 sorbent described earlier) was used in the form of pellets of spherical shape with 0.7-0.15 mm particle size of white color. Immediately prior to the start of the experiment, the sorbent was kept in a drying cabinet (SNOL 58/350, Lithuania) for 15 hours at a temperature of 70°C, to remove physically sorbed mercury from the air.

A sample of sorbent was taken into 50 ml tubes, further distilled water and certain aliquots of concentrated nitric acid of special purity classification ("Chemmed", Moscow) were added. The source of Hg (II) ions was state standard sample 9K-1, which is an aqueous solution of mercury of nitric acid with a concentration of 0.964 ± 0.5 g/dm3, acidified with nitric acid (the molar concentration of acid in the standard sample is 0.1 mol/dm3) . All weights were taken on the AP210 Analytical plus scales (OHAUS, USA). Thus, the volumes of the experimental solutions were approximately 30 ml.

After setting up the experiment, an obligatory condition is the establishment of adsorption equilibrium. Based on a number of works on the study of adsorption on both natural and synthetic sorbents, it can be concluded that equilibrium is sufficient from the first hours to three days. In the framework of this work, for objective reasons [5], it was decided to increase this period to one week.

The laboratory air temperature during the experiment was 21.0±0.5°C.

The samples were filtered through an acetate-cellulose membrane (ACM) ("Vladipor", Russia) with a pore size of 0.45 μm using a syringe in tubes (PET) (Greiner, Germany). After that, the pH of the filtrates was measured. As a pH electrode, the combined glass electrode "EGC-10601" was used.

The equilibrium concentration of mercury was analyzed by "cold vapor" atomic absorption spectrometry using Portable Mercury Analizer PMA-1 (EcON, Moscow) with a PAR-3m attachment. The reducing agent was a 1% solution of sodium borohydride in a 1% solution of sodium alkali [3].

According to the results obtained, it is obvious that the process of mercury adsorption is most significant in the region of more acidic pH values. This is due to the dominance of the cationic form of divalent mercury Hg (II) in the region of strongly acidic solutions. This fact can be judged on the basis of studies [1,2] on the study of the forms of mercury in water. It should also be noted that pH (PZC) (point of zero charge) is probably in a near-neutral medium, and the sorbent PSTU-3F, in the region we are studying, is a cationite (negatively charged).

Therefore, in the formation of a double electric layer, the cations Hg (II), which are the result of competing adsorption, participate in the absolute majority of adsorption centers.

The decrease in the amount of the adsorbed substance, when shifted to the near-neutral and slightly alkaline zone, is associated with a decrease in the concentration of the Hg (II) a particle in the region near the pH value of 3, the isoelectric point is located in which the dominant form changes: the concentration of Hg (II) hydroxide, which does not have a charge, and, therefore, is not capable of sorbing to the negatively charged surface of the sorbent.

It was also found that the sorbent itself can significantly change the acidity of solutions. The results of experiments to study the effect of the PSTU-3F sorbent on the pH of solutions showed that with an increase in the amount of sorbent in solution, the pH of the latter shifts to a more alkaline region. This can be explained by the formation of a double electric layer consisting of a negatively charged sorbent surface and attracted positively charged protons. It is quite obvious that with the increase in the amount of sorbent in the solution, adsorption also increases, due to an increase in the sorbing surface. Consequently, by increasing the content of OH- groups in the solution, the pH shifts to the alkaline region. This fact must be taken into account when working with the sorbent. According to our research, the optimal ratio between the sample of the PSTU-3F sorbent and the solution is 1/1000.

This work was supported by the Russian Foundation for Basic Research (project No. 17-05-01055-a).

Literature

1. *Anbia M., Amirmahmoodi S.* Removal of Hg (II) and Mn (II) from aqueous solution using nanoporous carbon impregnated with surfactants // Arabian Journal of Chemistry, 2016. Vol. 9. P. 319−325.
2. *Arshadi M., Faraji A.R., Amiri M.J.,* Modification of aluminum-silicate nanoparticles by melamine-based dendrimer L-cysteine methyl esters for adsorptive characteristic of Hg(II) ions from the synthetic and Persian Gulf water // Chemical Engineering Journal, 2015. P. 1–39.
3. *Mukhamadiyarova R.V., Smirnova A.S.* Study of the mercury content in solid natural samples // Moscow University Geology Bulletin, 2014. Vol. 69. No. 1. P. 36–40.
4. *Voronkov M.G., Vlasova N.N., Pozhidaev Yu.N., Pestunovich A.E., Kirillov A.I*. Highly effective complexite and ampholyte - poly [N, N'-bis (silsesquioxanilpropyl) thiourea] // Reports of the USSR Academy of Sciences, 1991. Vol. 320. No. 3. P. 658-662. In Rus.
5. *Fiaizullina R.V., Makarova M.A., Abrosimova N.A.* The possibility of wastewater treatment of heavy metals by natural sorbents // Proceedings of 17 international multidisciplinary scientific geoconference SGEM 2017. Vol. 52 of Soils, Forest ecosystems. STEF92 Sofia, Bulgaria, 2017. P. 1027–1034.

LARGE FRACTURED ZONES OF NON-TECTONIC GENESIS WITHIN THE DEEP HORIZONS OF OIL FIELDS

I.Y. Hromova

*I.E. "Hromova I.Y." (*ingakhr@inbox.ru*)*

Keywords: *Fracture, fracture corridors, differential compaction, seismic interpretation, duplex wave migration.*

Numerous petroleum geology researchers have been discussing the issues of rocks fracture within the platform areas for over a century. A number of assumptions made in the early studies have not been refuted so far. For example, in the middle of the previous century, the fundamental conclusions on impossibility of large fractured (macro-fractured) zones existence at the depths exceeding one km were made, which are widespread today; it was deemed that only micro-fracture is developed there. However, drilling of deep wells together with production data and special seismic data show that at greater depths the narrow permeable zones exist, which are hundreds of meters long and have no displacement, i.e., they are large fractures or fractured corridors. Another entrenched opinion is that tectonic movements are the main cause of fractures formation in oil and gas reservoirs [1], even though the recent tectonic events in the settings of sedimentary basins, such as Volga-Urals and Timan-Pechora, have finished long ago even in terms of geological time (in the Jurassic, Cretaceous time), and these regions are tectonically stable now. Present-day deformation monitoring investigations in the south-eastern Tatarstan allowed detecting seismicity near the Altunino-Shunaksky deep regional fault [2]. Despite this fact, it is unlikely that residual tectonic movements along single fault can explain the widespread fracture development in the rocks of sedimentary cover all over the Tatarstan territory. In recent years, there has been extensive development of special seismic data processing techniques, in particular the duplex wave migration (DWM), which allows to identify reflections from sub-vertical boundaries in the wavefield of conventional seismic data. The most common type of sub-vertical boundary in the column of sedimentary basin is fractured zone. Similarly to the case of sub-horizontal boundaries, where the contrast of layers' elastic properties is needed to form reflection from them, the sub-vertical boundaries also form a reflection only in the case where there is a contrast between the properties of undisturbed rocks surrounding the fractured zone and rock properties inside the destruction zone. The greatest contrast typically occurs on the boundary of open fractured zones filled with rock fragments and fluid. Putting it another way, physical basis of the method predetermine properties of the discoverable geological object - large open fractured zones. The use of DWM to investigate fracture in the deep oil and gas reservoirs in the numerous fields of the Timan-Pechora Province allowed gathering the considerable amount of information indicative of the fact that large open fractured zones are well represented everywhere. Moreover, fractured zones within the regional ridge-like structures such as Kolvinsky mega-swell or the Sorokin swell, are of tectonic genesis: they are contemporaries of structure-forming tectonic movements caused by the Ural-Pay-Khoy orogeny. But as for the flat areas of the Khoreiversky depression having the ancient rigid Bolshezemelsky block that underlie them, the active fracture development can hardly be explained by the tectonics. Ring-radial ("spider") structure of the fracture systems identified using the DWM within the Famenian layers is very similar, almost identical to the pattern found

at the growing structural highs; e.g., in the regions with the salt-dome tectonics. However, the cause of ring-radial structure formation in this case is not tectonic growth of the high, but differential compaction of clay rocks that host the Frasnian reef structure. In the course of compaction of subjacent mostly argillaceous inter-reef deposits, the horizontally accumulated Fammenian shelf carbonate beds downwarp in the same manner as the beds are bending in the course of tectonic growth of the highs. The same trends are observed in the Domanic-type formations. As a rule, the deepwater Domanic formations overlap the transgressive Early-Middle Frasnian terrigenous formations as a flat blanket. The terrigenous formations in turn have levelled and buried the highly dissected surface of much older rocks over the most part of the Timan-Pechora Basin, namely: Lower Devonian, Silurian, and Ordovician. As a result of transgressive sedimentation, the pre-Frasnian relief divided into blocks by ancient tectonic faults was filled by mostly argillaceous Frasnian sequences of various thicknesses. Differential compaction of the Early-Middle Frasnian argillaceous complexes has determined association of the large fractured zones within the Domanic beds with the boundaries of the old tectonic blocks. It is differential compaction that causes fracture formation but not reactivation of tectonic movements; lack of tectonic disturbances in the Timan-Sargayev formations evidenced this fact. Mechanism of large fractured zones formation due to differential compaction of the Tyumen formations (which in turn have buried ridges of pre-Jurassic basement) is also valid for the West Siberian Bagen formations. Thus, the recent seismic and borehole studies refute well-established perceptions of the absence of large fractured zones of non-tectonic genesis within the sediment cover.

Literature

1. *Permyakov E.N.* Tektonicheskaya treshchinovatost' Russkoj platformy. BMOIP. 1949 g.
2. *Hisamov R.S.* Geodinamicheskij poligon deformacionnogo monitoringa territorii neftedobychi Respubliki Tatarstan. // Neftyanoe hozyajstvo 2015 №10.

ROLE OF NATURAL FRACTURE IN THE BAZHENOV RESERVOIR QUALITY (ON THE RESULTS OF HORIZONTAL WELLS DRILLING AND COMPLETION)

I.Y. Hromova

*I.E. "Hromova I.Y." (*ingakhr@inbox.ru*)*

At times of the increasing interest in the deposits that previously left out of close attention that was fixed only on reservoirs in the course of reserves assessment, the development of new technologies for well log studies resulted in new understanding and wider knowledge of architecture and depositional environments of the complex rocks, such as the Bazhenov formations. Of course, the Bazhenov formations were never ignored: 50 years passed since the beginning of the Bazhen studies, and at least 10% of all the theses maintained in petroleum geology are devoted to the Bazhenov Fm deposits [1]. But this attention was mostly focused either on studies of their source potential or attempted to put the arms around the scattered scraps of information about lithologic composition of very small amount of core recovered.

Core sampling into fiberglass or aluminium pipes allowed recovering core in full and thoroughly analysing it using both standard and exotic innovative methods. The result of this analysis in vertical wells was detailed breakdown of the section, identification of different rock lithotypes, and, most importantly, discovery and detailed studies of reservoir rocks within the Bazhenov sequence.

Careful analysis of lithologic composition of the different well columns showed not only general patterns but also local distinctions. Presence of siliceous-argillaceous-bituminous rocks is common for all the wells, while carbonate rocks amount and composition are the local features. Since Bazhenov carbonate rocks are definitely reservoirs, their special features and common factors of distribution are of particular interest.

Let us consider the Bazenov section in the context of sedimentogenesis, subsequent diagenesis, and catagenesis conditions. Relatively deepwater conditions were the most common during accumulation of the Bazhenov sequences. In the opinion of researchers who estimate the Bazhenov sea depth reasoning from the Achimov clinoforms height, the depth was not exceeding 200 to 300 meters [1]. We can assume that these values are closer to the minimal depths in the stages of greatest fall of sea level, while in the times of the maximal rise of sea level these values could be twice as big. Though, these values do not make the Bazhenov sea bottom closer to the current oceans that are many kilometres deep. However, as opposed to its age equivalents (Danilovsky in the north-west, Yanovstansky in the north-east, Maryanovsky in the east, and the other formations), areas of the Bazhenov sequences accumulation were considerably distant from the provenance areas. This resulted in the definite limited nature, specific composition of initial components of the future rocks (Fig. 1); the key elements of sedimentogenesis were as follows: 1) phytoplankton coming down from the surface; 2) benthos

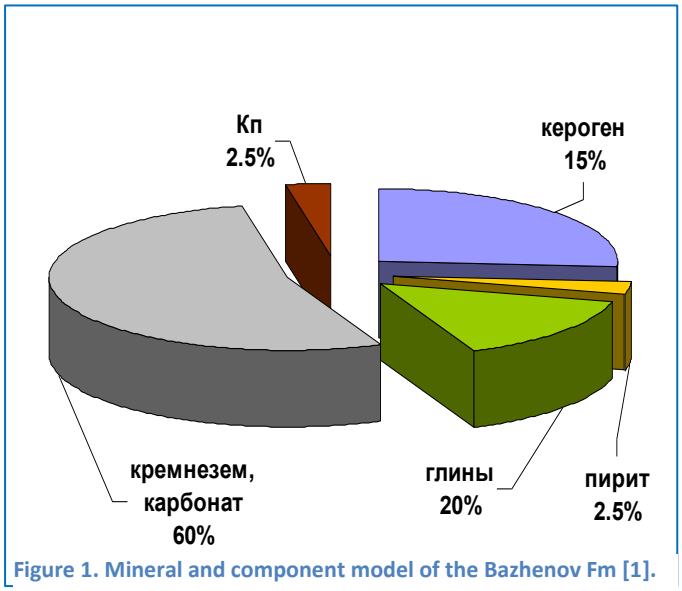


Figure 1. Mineral and component model of the Bazhenov Fm [1].

migrating near the bottom; 3) argillaceous material periodically coming both from the distant provenance areas and, similar to the eolian component, from the water surface. Phytoplankton, mainly radiolarias with siliceous skeleton and cytoplasm, was a supplier of siliceous material and bitumoid. Benthos with calcitized shells was the supplier of primary carbonates.

Different processes, both interdependent and independent, controlled the balanced content of the mentioned initial components in the sediment during the sedimentogenesis stage. Let us consider the main types of rocks and conditions for their sedimentation:

1) Siliceous-bituminous source rock with a high proportion of organic matter could be formed in the conditions of maximal sea level, most distant provenance areas; argillaceous material supply was minimal there, biocenosis level was constant, so the proportion of biogenic material in the sediment was increasing; i.e., proportion of silica, primary calcite, and bitumoid many times exceeded the argillaceous component.
2) Mainly argillaceous rock was formed at the minimal sea level, when the provenance areas became closer (and islands came out to the day); and with the constant level of biocenosis, the proportion of biogenic material in sediment decreased.
3) Different intermediate siliceous-argillaceous-bituminous rocks were formed at the intermediate sea levels, but with stable level of biocenosis.
4) In order to accumulate the mainly siliceous rocks predominantly consisting of radiolaria siliceous skeletons, which made a basis for carbonate rocks formation in the stages of dis- and catagenesis, the manyfold increase in biocenosis relative to the background level (described in the first three items) and an increase in the activity of cytoplasm-reworking bacteria were necessary. Causes of periodical biocenosis "heydays" in the offshore areas remote from the coastline and, respectively, from the upwelling and estuarine zones, should be the repeated nutrient supply from the very different sources. Considerable difference in the number of carbonate and siliceous-carbonate partings in the neighbouring wells is indicative of the fact that nutrient supply was not a regional event such as a middle-ocean current. These zones were narrowly contained and most likely associated with the fractures in sedimentary cover; and mineral-rich hydrothermal fluids were coming from the subsoil through them. Actualism principle allows us to rely on today's environments: the so-called "oases" of life were found in 1979 in some of the eastern Pacific Ocean regions at the depths of 2,5—3 km; they were centered around the hot groundwater seepage (thermal springs). Benthos biomass in these areas reaches several kilograms per square meter (to compare, biomass amounts to 5—10 kg/m^2 or more in littoral and upper sublittoral zones, hundreds and tens g/m^2 in deeper sublittoral zones, grams in bathyal, less than 1 g/m^2 in abyssal zones, and in the life-poor central ocean regions — 0,01 g/m^2 or less [2].

Accordingly, two major processes influenced the proportion of the particular components in the Bazhenov rocks composition, they are: relative sea level fluctuations, and repeated nutrient delivery to the sea water. The considerable sea level fluctuations are the large-scale events poorly differentiated within the areas of current licensing activities of subsoil users, while the sources of nutrient supply (macro-fractures and faults) are the objects of much smaller scale, and they are able to form the mosaic of zones enriched and depleted in radiolarite assemblies even within the license areas.

The continued hydrothermal fluid afflux in diagenesis and catagenesis stages promoted the secondary transformations of siliceous rocks into carbonate rocks; at the same time, zones of radiolarite reworked into dolomite are considerably narrower than the zones of radiolarite development. This is indicative of hydrothermal activity dying out and small fissures healing. Only the largest faults and fracture zones remained active. Accordingly, distance from the faults open in the stage of catagenesis and from the fractured zones associated with them has affects directly the features of dolomitic radiolarite distribution.

Dolomitic radiolarite properties studies in the work [1] showed that they are the traditional reservoirs having matrix porosity up to 16% and permeability up to 50 mD. Thickness of individual partings may reach 3 meters; their number can range from 0 to 5 in the same area.

In one of the sites of PJSC LUKOIL activities, one kilometre long horizontal hole of the development well was drilled in the dolomitic radiolarite interval three meters thick. It should be noted that high quality of structural imaging carried out in the course of the work [3], and the use of the state-of-the-art Litho-Density logging while drilling allowed the accurate well targeting along the entire length of the horizontal segment within the target formation, despite its complex trajectory (Fig. 2). The obtained data made it possible to study lateral variations within the target formation.

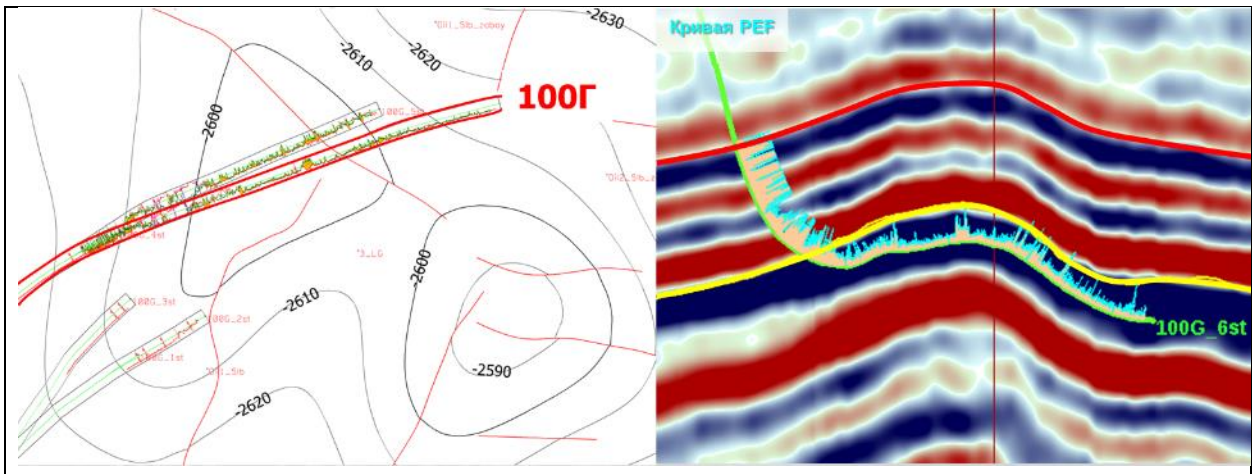


Figure 2. Left: planimetric position of the horizontal wellbore on the depth map of B Horizon. Red frame marks the borehole brought to the hole target. Well logs shown along the hole are: GR (red) and density (green). Right: time section along the horizontal borehole in the interval of Bazhenov Fm. Photoelectric Factor curve is shown along the borehole. Red colour in the section is a horizon at the top of the Bazhenov Fm (B Horizon); yellow is a position of one of the isochrone surfaces traced close to the reservoir top within the Bazhen.

Since the wellbore was drilled in carbonate rocks, the Gamma-Ray (GR) level is low in general. At the same time, the background level is disturbed by the segments having the extremely low GR values. High densities (up to 3 g/cm^3) are also typical for the very same intervals. High values of Photoelectric Factor (up to 9 units) is one more special feature of these intervals (Fig. 3).

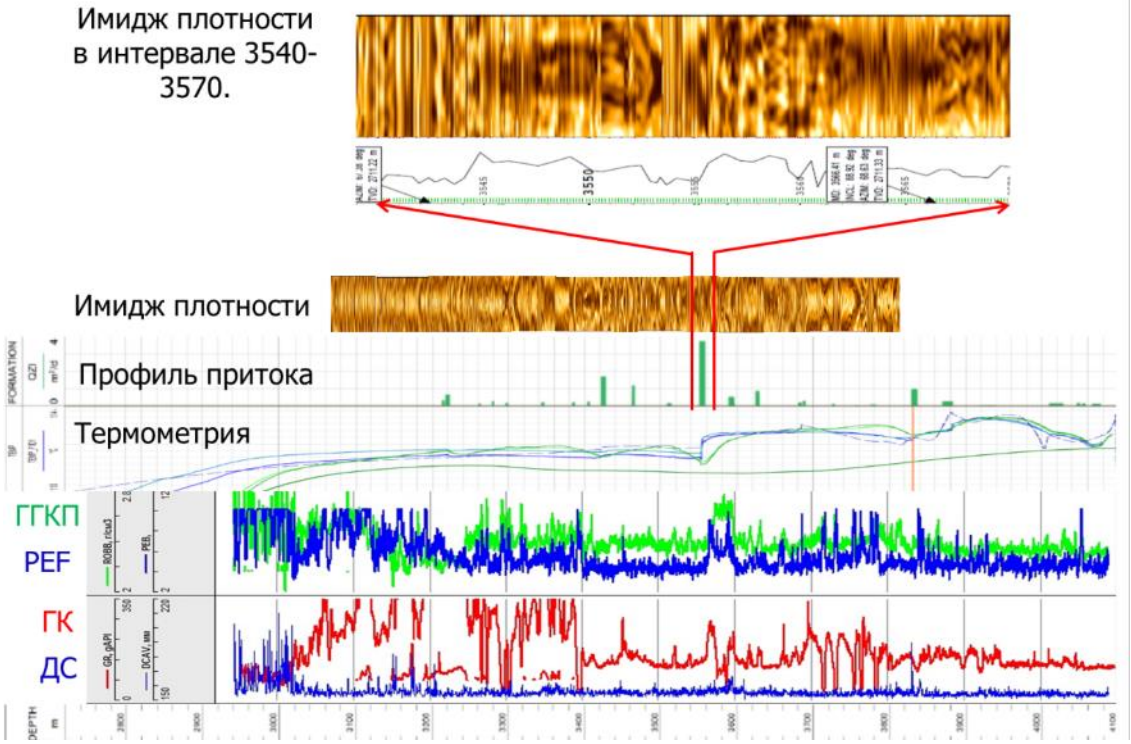


Figure 3. Well logs in horizontal wellbore.

Since there was no core sampling in the horizontal borehole, lithologic composition of these intervals having anomalous properties can be inferred only by the well log data. Low GR level - lower than in the dolomitic rocks - can be indicative of pure calcite content; high density values - of pyrite (siderite, aragonite?) content; and high Photoelectric Factor values - of high barite content (constituent of mud). Analysis of density images along the wellbore shows that in addition to the "smiles" (typical oval elements related to crossing of bedding interfaces), beds strictly perpendicular to the wellbore are observed, which even shift and distort the "smiles". Thickness of individual beds is not too large and makes centimetres. But associations of these beds may have a thickness of 1 to 2 meters reaching even 8 meters. Geometry of these zones (they are perpendicular to the wellbore unlike the bedding interfaces having oval shape - the so-called "smiles") and their composition can be indicative of only one hypothesis, namely: these intervals represent the intersection with fractures that are partially healed by calcite and siderite (aragonite, pyrite?) and mud-filled.

In the course of the well development, the 6-slot hydraulic fracturing was conducted. Frac operations were accompanied by microseismic monitoring from the surface. Figure 4 presents the acoustic events detected along the borehole in the course of proppant injection. Average amount of proppant was 227 m^3; absorption of 379 m^3 was observed only in one slot (#4). It is the slot that associated with the main fluid inflow registered during the temperature logging and spectral noise logging (Fig. 3).

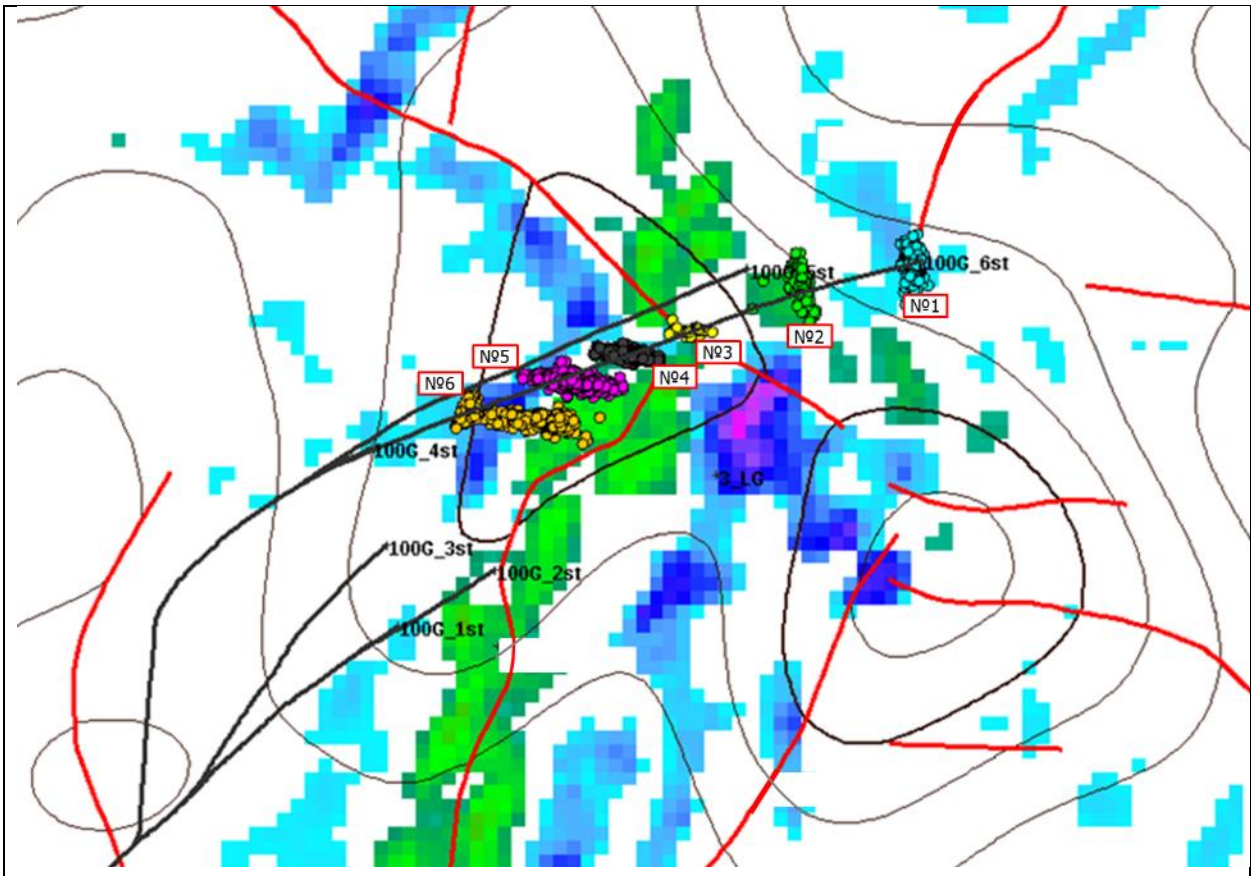


Figure 4. Fragment of duplex wave amplitude map in the vicinity of horizontal wellbore. The acoustic events detected using the passive seismic monitoring along the borehole in the course of hydraulic fracturing are presented.

The analysis shows that the predominant inflow (45%) in the well is definitely associated with the natural fracture. Each induced fracture gives at most 5 m^3 per day. Total production rate of the well was 175 m^3 per day.

The obtained results disprove the opinion currently emerging in the industry that reservoir beds associated with dolomitic radiolarite occur everywhere in the Bazhenov formations, and one needn't search for natural fracture, because the large-scale fracturing is enough to develop these reservoirs.

Our work demonstrates the huge role of natural fracture in formation of reservoirs having both increased thickness and higher permeability. Moreover, we believe that zones of fracture corridors have much larger volume of rocks being drained than can be attained using a hydraulic fracturing.

Literature

1. Report "Arrangement, analysis, and integration of all available information on the Bazhenov Fm obtained in the course of geological and geophysical studies of the Sredne-Nazymsky field", Lukoil Engineering LLC, Vol. 2, 2011 (coordinator Kalmykov G.A.).
2. Encyclopedic dictionary of biology. Chief Editor M.S. Gilyarov; Editorial Board: A.A. Babaev, G.G. Vinberg, G.A. Zavarzin, et al., 2nd ed., revised, M.: Soviet Encyclopedia, 1986.
3. Report "On the processing of the 3D CDP wide-azimuth seismic data in the Sredne-Nazymsky License Area". Schlumberger Logelco Inc. 2012 (Coordinator Kashcheev D.E.).

ANALOGUE MODELING OF WIDE SHEAR ZONES

G.A. Chernetsky[1], N.S. Frolova[2]

Geological faculty of Moscow State University ([1]-g.chernetskiy@gmail.com, [2]-n.s.frolova@mail.ru)

Key words: *analogue modelling, shear zones*

The shift zones in analog models were first obtained by G. Kloos and V. Riedel in 1928 and 1929 of the last century; experiments of this kind in different versions continue to this day. As a rule, zones with a non-uniform vertical and lateral stress state are modeled, which are formed in the case above the fault of the basement (the so-called "Riedel shift zones"). Their model is two plates (boards), imitating the foundation and a fault in the latter. On the plates is a sample - most often sand or clay - a simulated cover. When the plates are shifted relative to one another, an inhomogeneous stress field appears in the bag, and fracture systems of different rank (structural paragenesis) that are well studied by a number of researchers (J. Chalenko, R. Wilcox, S.S. Stoyanov, M. Neylor, S.A. Bornyakov and many others).

At present, analogue modeling of shear zones is complicated. For example, preliminary incisions are made or the "fault" is made curvilinear. It is known, however, that in nature the shear situation can take place not only over a single fault of the basement, but also in a rather wide zone. Experiments that reproduce such an atmosphere are few. The first experiment was carried out in 1955 by E. Cloos [1], laying a sample of moist clay on a wide movable metal mesh, one side of which was fixed, and the other was displaced along it. In this case, the stress field was uniform throughout the entire volume of the sample, and two equidistant and uniformly distributed cleavage systems R and R' were formed. Later, other researchers turned to the idea of modeling the shift in a wide zone. So, M. Nailor and co-authors [3] placed a rubber plate or a plate of porous material over a single vertical fault of the foundation. Above, the plate was covered with a layer of dry sand. In the sand, the R and R' chips were formed and their geometry resembled that in the Riedel shear zone, however, the cracks were distributed over the entire width of the deformable plate.

The original device for modeling was proposed by G. Schreurs [2]. His instrument consisted of two parallel planks, representing the basement plates, on which lay 50 closely plexiglass slats with a width of 5 mm. When one of the plates moves, the originally rectangular design turns into a parallelogram. On planks used silicone, and on it - dry quartz sand with a layer of glass powder. In the experiments on this installation, R-chips developed at the beginning of the shear, filling the entire surface of the model, and only when the amplitude of the shift between the R-chips is increased, does chips appear that are close in orientation to the R'-cleavages. In all the above experiments, the abstract mechanical situation of a simple homogeneous shear was reproduced, the discontinuities occurred during deformation and uniformly filled the space.

Another approach to analogue modeling is that experiments are performed with models of specific natural objects. At us such object became the Baim Ore-bearing Shear Zone (Western Chukotka). It has a width of about 20 km, stretches for 170 km and is represented by several subparallel sinuous intersecting faults. Examples of the experimental reproduction of such zones in the literature were not encountered by us. Using the idea of G. Shreurs, we created a special adaptation to the device for tectonophysical modeling, which makes it possible to carry out experiments in a wide shear zone. The device is a rectangular wooden frame, designed in such a way that it can be distorted to the shape of a parallelogram, preserving the original distance between the long sides. The latter is achieved due to the fact that the movable beam of the frame,

which forms one of the long sides of the original rectangle, moving in the grooves that are selected at the base of the device. The second long beam is fixed to the base of the device. The right and left bars of the frame are hinged to the fixed bar from one end, and from the other are conjugated by a rocker (the third wooden bar), which ensures their parallelism. The frame has the ability to tilt both to the right and to the left, as well as reverse movement from the extreme positions, and is characterized by an amplitude of 16 cm in each direction. Plexiglass bars (31 pieces, each 1 cm wide) are placed in the frame, which form the bottom of the device. Planks slide and covered with a layer of silicone. Above is placed any equivalent material. The speed of movement can vary over a wide range, and the direction of displacement can be changed at any time, depending on the need.

To model specific zones of shear with given faults, one of two options can be chosen: 1. There is no separation into the cover and the base; 2. A cover and a basement can be distinguished in the simulated zone. Since the Baim zone is not clearly divided into a foundation and a cover, we chose the first option for its reproduction. The sample is made of wet clay 3 cm thick (power can vary), after being placed in the device, leveled and cut so that it turned out to be divided into blocks. This operation was performed according to a template transferred on a scale from the scheme of the structure of the Baim zone, and thus the pattern was matched to its structure. Similarly, the block structure of any other shear zone could be specified. In addition, in some experiments, models imitating intrusives were also introduced into the samples, also performed on a scale based on the pattern of real intrusions of the studied zone and possessing deformation characteristics other than clay. The simulation of the Baim shift zone showed that a two-phase shift and the presence of "intrusives" with a viscosity greater than that of clay play a big role in the development of zones of increased fluid permeability. More on this is stated in the theses of N.S. Frolova and co-authors in this collection.

In the second variant, a sample of clay with a high viscosity is placed on the silicone, in which breaks are cut. Above is a homogeneous layer of low-viscous clay. In our experiments on areas where there were significant displacements along the faults of the "basement", zones of shifts of a higher order were formed in the case. Usually they consisted of chips R, rarely R'. When the sign of motion reversed, tearing cracks appeared.

As a result of our studies, we proposed a technique for modeling wide shear zones with a complex pattern of faults. The technique is tested using the example of the Baim shift zone. The results obtained make it possible to draw a number of conclusions on the location of ore minerals.

Literature

1. *Cloos E.* Experimental analysis of fracture patterns // Geological Society of America Bulletin. 1955. V. 66, P. 241-256.
2. *Dooley T. P., Schreurs G.* Analogue modelling of intraplate strike-slip tectonics: A review and new experimental results // Tectonophysics. 2012. V. 574-575. P. 1-71.
3. *Mandl G.* Mechanics of Tectonic Faulting. Elsevier. 1988. 287 p.

EXPERIMENTAL DATA FOR DISTRIBUTION OF RARE-EARTH ELEMENTS, SCANDIUM, YTTRIUM AND LITHIUM BETWEEN ALUMOSILICATE AND ALUMOFLUORIDIC MELTS AND FLUID AT 700 AND 800 ° C, 1 AND 2 KBARS AND DIFFERENT WATER CONTENTS IN A FLUORINE-CONTAINING GRANITE SYSTEM

T.I. Shchekina, A.A. Rusak, Ya.O.Alfer`eva, E.N.Gramenitsky, A.R. Kotelnikov, N.G. Zinovieva, A.Yu.Bychkov, G.M. Akhmedzhanova

Geological Faculty of Moscow State University;

IEM RAS (aleks7975@yandex.ru)

Keywords: *aluminosilicate and aluminofluoride melts, fluorine, separation coefficients, pressure dependence, granite system*

This work was supported by the Russian Foundation for Basic Research (Project No. 16-05-0089) Experimental data were obtained on the distribution of rare-earth elements (REE), scandium, yttrium and lithium between aluminum silicate (L) and salt-aluminum fluoride (LF) melts in the Si-Al-Na-K-Li-FHO system at 700 and 800 ° C, 1 and 2 kbar and a water content of from 0 to 50 wt. %. The experiments were carried out at a high-pressure gas installation at the Institute of Experimental Mineralogy of the Russian Academy of Sciences in Chernogolovka. The products of the experiments were examined on a Jeol JSM-6480LV scanning electron microscope (Japan) with an energy-dispersive INCA Energy-350 and crystal-diffractive INCA Wave-500 (Oxford Instrument Ltd., UK) spectrometer in the laboratory of local methods of MSU substance research. Rare earth elements, scandium, yttrium, fluorine, lithium were studied by the ICP MC method in the laboratory of the Department of Geochemistry of the Moscow State University. It is shown that all rare-earth elements, yttrium (Y), scandium (Sc) and lithium (Li) are distributed in favor of an aluminum fluoride salt melt with large separation coefficients regardless of the experimental conditions specified. For the first time in a fluorine-containing granite system, it is shown that the separation coefficients of rare-earth elements depend on the pressure. With an increase in pressure from 1 to 2 kbar, both at 700 ° C and at 800 ° C, there is a significant decrease in the separation coefficients between the aluminum fluoride and aluminosilicate melts. The coefficients of separation between melts decrease monotonically from light to heavy rare-earth elements, both at 1 kbar and at 2 kbar. According to ICP MS data, lithium behaves like rare-earth elements and is concentrated in an aluminum fluoride melt. Lithium with large separation coefficients is redistributed in favor of the aluminofluoride phase. Yttrium behaves like light rare earth elements and predominantly enters the salt melt, while in scandium the separation coefficients between LF and L are much lower, although they remain much greater than unity. This shows a greater affinity for scandium to an aluminosilicate melt compared with rare earth elements and yttrium. It is shown that all REEs are better redistributed in favor of the aluminofluoride melt than in the fluid, regardless of the experimental conditions. The tendency to an increase in the separation coefficients between salt and aluminosilicate melts is shown experimentally with increasing water concentration in the system. The reasons for the dependence of the behavior of REE, lithium, scandium and yttrium on the pressure and water content in the system are probably related to a change in the structure of the mineral phases and the solubility of water in the aluminosilicate and salt melts under various experimental conditions.

TECHNOLOGICAL FEATURES OF MONITORING AND RESULTS OF INVESTIGATIONS OF COASTAL CURRENTS DYNAMICS OFF THE SOUTHERN COAST OF CRIMEA

S.V. Shcherbachenko[1], V.A. Ivanov, A.S. Kuznecov[2]

[1]- *Federal State Budget Scientific Institution "Marine Hydrophysical Institute of RAS" (vicyla@mail.ru);*

[2]- *Moscow State University Sevastopol Branch, Sevastopol (edmhi@ukr.net)*

Keywords: *currents, monitoring, water dynamics, wave-vortex movements, coastal ecoton*

The coastal zones of seas and oceans are key landscape structures, where intense dissipation and phase transitions of energy flowing into the hydrosphere from the atmosphere occur. The mechanical energy transferred by global hydrodynamic factors to the offshore zone is expended on internal friction passing into thermal energy, on generation of coastal currents and local waves, vortices, turbulent and other hydrodynamic formations. Part of this energy in the contact zone and in the bottom boundary layer directly affects the coastal zone on land, causing their mechanical destruction and transfer of clastic products of this destruction. An investigation of the main factors affecting the coastal areas and an analysis of the energy losses of various types of water movements for solving the problem of sediment dynamics in the coastal zone is an urgent task. This task is directly related to studies of the structure, regime and variability of coastal currents. Geoenvironmental monitoring of the coastal zone of the Azov-Black Sea basin is a basic link in development of the methodology of rational nature management in the system of state management of coastal territories. Intensive development of biological, mineral, energy and recreational marine natural resources and active use of transport and communication potential of the coastal zone of the Black Sea ensures a continuous increase in the level of anthropogenic pressures on coastal zones and ecotones of the Black Sea coast of the Crimea. The processes of economic and recreational activities in the region are accompanied by abundant and intensive discharges of industrial-waste water from land directly into the coastal zones, causing additional damage to the ecosystem. An urgent task to establish the degree of damage to the coastal ecosystem, apart from estimates of the level of anthropogenic load, is getting information on regional dynamics of water masses and real transport routes for the transport of pollutants. At the same time, the task of minimizing the most probable risks for the water areas caused by active development of marine resources and discharge of industrial-waste waters with the purpose of preventing possible natural and man-made disasters and zones in critical ecological situations becomes urgent. Marine Hydrophysical Institute (MHI) of the Russian Academy of Sciences has developed a program of complex interdisciplinary studies of oceanological processes that determine the functioning and evolution of coastal zone ecosystems in the Black and Azov Seas. The aim of the research is to obtain new scientific knowledge on the relationship of dynamic processes in the coastal zone, to develop an approach to the rational use of the resource potential of marine areas off the coast of the Crimea and Sevastopol. The main tasks in the research are: development of observational systems of the coastal zone of the Azov-Black Sea basin, development and improvement of approaches, technologies and algorithms for monitoring the marine environment; complex interdisciplinary studies of the coastal zone of the sea and monitoring of the coastal zone condition in order to obtain morphodynamic forecasts of changes

in the bottom relief and the position of the coastline in order to solve the problems of conservation and rehabilitation of the coastal ecotone territories on land. MHI RAS has a fundamental scientific background in these research areas and many years of practical experience. The concept of development of instrumental monitoring in dynamically active coastal zones is implemented by forming a class of integrated measuring hydrophysical complexes that integrate within the given limits, allowing detailed characterization of various scale intensive natural processes with a high resolution and accuracy of measurements. Such unique equipment complexes include a cluster of vector-averaging Euler meters of horizontal currents developed in the MHI. Within the framework of the established information technology from 2008 to 2018, monitoring of the dynamics of coastal waters near the Southern coast of the Crimea has been made. Regional features of geomorphology of the coastal zone form a stable trend of atmospheric continental and sea flows and the development of intense anisotropic fluctuations of coastal currents in a wide range of spatio-temporal scales of variability. The analysis of the accumulated array of full-scale data revealed the average annual regime, the features of the intra-annual and seasonal variability of coastal currents near the Southern coast of the Crimea; spectral estimates of the contribution of intensive synoptic vortex-wave motions of water, mesoscale oscillations and internal waves in the inertial-gravitational range of variability were made. The proposed technology for monitoring the water dynamics and the practical results obtained can be used to develop the methodology of rational nature management in the system of state management of coastal areas.

The work was done in Marine Hydrophysical Institute of the Russian Academy of Sciences within the framework of the state task on the topic No. 0827-2018-0004 "Coastal Research".

ELECTRIC RESISVIVITY TOMOGRAPHY THE EXAMINATION KARST AREA IN THE WESTERN PART OF SEVASTOPOL

T.V.Yalov[1], A.A. Pelevin[2]

[1]- *Geological Faculty of Moscow State University (timofey.yalov@gmail.com);*

[2]- *Scientific-Production Center Geoscan (Pelevin.msu@gmail.com)*

Keywords: *electrical resistivity tomography, EM geophysics, geophysical investigations, karst*

Introduction The territory of the Heraclea Peninsula is composed of terrigenous-carbonate complex of rocks of Miocene age N1. A significant part of the investigated section is represented by carbonate rocks. These are limestones of various degree of weathering and clay, ranging from dense marble-like differences, to soft clay limestones, which are destroyed with little impact on them by the tool. The total capacity of these soils is about 60 m. It is known that to a certain extent these limestones are subject to karst, and this territory belongs to areas with a high degree of karst danger. At the same time, quite often there are emergency situations such as opening of cavities during drilling, failure phenomena on the surface of the earth, significant water leaks, etc., which occur during the construction of artificial reservoirs, tunnels, in the construction of ground structures [3]. According to the classification of B. A. Vakhrushev (2009), this territory belongs to the karst province of the Mountainous Crimea, Sevastopol region of the pre-Crimean karst region. In Sevastopol karst area is represented by monoclinal of hillside, often in the form relief with denudation and outlier bodies on limestones and marls of the Neogene-Paleogene age. Karst forms of relief are represented by grottos, small inclined and subhorizontal caves of karst and karst - gravitational origin. Due to the average and weak dissolution and destruction of limestones, the presence of a large amount of clay residue, filling cracks and other features of the geological and geomorphological structure, modern karst on the surface of the earth in the Sevastopol region developed limited [4]. However, when the construction of a high degree of responsibility required thorough investigation for the presence of karst. Electrical resistivity tomography(ERT): field research and data processing 21 ERT profiles were carried out on karst plot on the Western outskirts of Sevastopol [2]. The total length of the profiles was 6 km. the step along the profile corresponded to 5 m, the maximum spacing of AO was 187.5 m, which provided a real depth investigation of about 50 m. The calculation of the apparent resistivity values was performed and, and the sections of the apparent resistivity sections were constructed according to the results of field observations. Then a two-dimensional inversion was performed using the program Res2DInv 3.59 [1] (GeoTomo, Malaysia). Results As a result of the subsequent processing, the analysis of the obtained materials was performed, the interpretation and comparison of the geoelectric sections with the drilling results was carried out. The range of values of specific electrical resistances of the geoelectric section is from 16 to 700 Ohm.m. in most sections are represented as low-resistivity and high-resistivity deposits. In the vast majority of cases, conductors are present only in the upper parts of the section; the bases of the sections are more resistant to specific resistances and are represented by high-resistance soils. On the profiles located in the North-Western part of the site, the geoelectric section is calm, the upper part of the section here has a pronounced horizontally layered structure of the HK type. There are no karst forms here, and this cut can be defined as a

background one. Profiles located in the Central and southern parts of the study area differ in their structure from the Northern sections. There are sections such as KHK, HQ, Q. these sections are more variable horizontally, and most of the deposits are contrasting in specific resistances. On the site of the study pinch out the top few (3-4) layers in the South-West to North-East. In the southern part of the site is fixed zone with abnormal structure of sediments, which occupies about a third of the area of the site. This zone corresponds to a large karst failure, which resulted in a erosion of the upper part of the cut. As a result of the analysis of geoelectric sections, we have formulated the signs of abnormal karst cavities at a depth of 5 to 20 m: 1. the absence of a high-resistance layer in the upper part of the section, and the upper part of the section to depths of about 15-20 m is represented by relatively conductive rocks – their resistivity can reach 100 Ohm.m; 2. the presence of conductive deposits located in the middle (third) layer; 3. lowering the roof of limestone by 5-10 m and reducing their resistivity at depths of about 30-40 m. According to the results of ERT, 7 wells were drilled. In three wells there was a failure of the tool and thus voids were revealed. On geophysical profiles, these locations correspond to areas selected by geophysical characteristics.

This κesearch was financially supported by RFBR grant №18-45-920073 (headed by O.V. Krylov)

Literature

1. *Loke, M.H. and Barker, R.D.*,1995. Least-squares deconvolution of apparent resistivity pseudosections. Geophysics, 60, 1682-1690.

2. *Bobachev A. A., Gorbunov A.A., Modin I.N., Shevnin V.A.*,2006. Ehlektrotomografiya metodom soprotivlenij i vyzvannoj polyarizacii. Pribory i sistemy razvedochnoj geofiziki. 2006, N02, 14-17.

3. *Vahrushev B.A., Dublyanskij V.N., Gorbatyuk N.V., Dublyanskaya G.N*.,2004. Geoehkologiya karstovyh oblastej Kryma. Kul'tura narodov Prichernomor'ya, №50, t.1, p.11-15.

4. *Vahrushev B.A.*,2009. Rajonirovanie karsta Krymskogo poluostrova. Speleologiya i karstologiya, 3, p.39-46.

AUTHOR'S INDICATOR

Издательство «Перо»

109052, Москва, Нижегородская ул., д. 29-33, стр. 27, ком. 105

Тел.: (495) 973-72-28, 665-34-36

Подписано к использованию 03.07.2018.

Объем 4.5 Мбайт. Электрон. текстовые данные. Заказ 424.