Section 18

GEOLOGY AND PETROLEUM ENGINEERING (ENGLISH, GERMAN)

A CONCEPT FOR MARINE SHALLOW DRILLING

R.S. Akhmetzyanov, A.I. Kamaleeva, A.M Ibragimov
Scientific advisor associate professor N.G. Nurgalieva
Kazan state university, Kazan, Russia

BACKGROUND

There is a quantum leap between the costs of marine operations using conventional sediment coring devices with or without piston for 10–15 m of core recovery and drilling from a dedicated drill ship to increase penetration and recover more core material. A drill ship is far beyond funds available for the average research project and require large coordinated international efforts. However, in special cases such as in ice covered waters or sheltered fjords where the need for heave compensation is greatly reduced, it should be possible to carry out shallow drilling from a research vessel with a simple drill rig. Institute of Solid Earth Physics (Y. Kristoffersen), University of Bergen contracted Terra Bor A/S, Namsos in the spring of 1994 to carry out drilling tests with research vessel “Hakon Mosby” in water depths of 130 m and 197 m in Trondheimsfjorden. This experience was the background for proposals to drill on the continental shelf in the Weddell Sea, Antarctica during the 1995/96 season and later the Lomonosov Ridge, Arctic Ocean.

The key issue was reduced equipment weight. This was achieved by using a small mining exploration drill rig and thin-walled BX drill rods. The riser was a plastic tube clamped to a tight wire anchored by a bottom template. Based on the experience accumulated by the end of 1996, a scale model (1:10) of a conceptual drill rig to be housed in a single 20 foot container was handed over to Geo Drilling A/S (former Terra Bor) of Namsos. The idea was to build a rig that could be accomodated by even small.

Research vessels (150 foot) and serve as a useful tool for science. The concept formed the basis for Geo Drilling A/S to attract Nok. 28 mill. in venture capital to build a shallow drilling unit for commercial operations. A rig was built in Holland and the drill rig now encompassed seven 20 foot containers with a total weight of about 90 tons. The new rig was successfully tested from the vessel «Geograf». Unfortunately, the new rig was far beyond the carrying capacity of R/V Hakon Mosby and left out the possibility of obtaining a crucial initial track record of shallow drilling from scientific projects in a cooperation between industry and the university. With no track record, commercial jobs did not materialize as expected and the company eventually went bankrupt.

SCIENTIFIC FIELD PROJECTS

Antarctica

A glacially eroded shelf often exposes truncated sediment sequences at the sea floor, and provides access to a geological record that ranges from younger sediments at the shelf edge to successively older strata towards land or an ice shelf. Increased penetration beyond the conventional gravity- and piston-core sampling is a pre-requisite to new advances in our knowledge of ice sheet history from continental shelf sediments. This requires shallow drilling (< 100 m sub-bottom).

Shallow drilling in Antarctica began with the Dry Valley Drilling Project (1970–75), and progressed offshore to drilling from a sea-ice platform during the MSSTS and CIROS projects. More recently, drilling off Cape Roberts reached a record 939 mbsf. in a water depth of 295 m. Marine shallow drilling from over the stern of a research vessel using a light mining rig with riser was first attempted by University of Bergen from the Finnish research vessel "Aranda" on the Weddell shelf during the 1995/96 season. The string had reached 15 mbsf with 18 % recovery when the site had to be abandoned due to a change in the ice situation. The greatest operational flexibility is provided by a remotely operated rock drill deployed from a research vessel. In early 1998, a unit, capable of taking up to 5-m-long cores, was used in shelf areas of the northern Antarctic Peninsula. There, 77 rock drills were attempted, and 26 of these were successful in recovering rock cores (mostly less than 1 m., but one at 1,4-m-long and one at 2,5-m-long). Most of the rest are recovered «mixed pebbles», i.e. loose icerafted debris. Two were empty. Although, the results obtained to date by mobile systems deployed from research vessels are modest when compared to the achievements of drilling from fast ice, it should be pointed out that the resource requirements for these two different approaches are widely different.

Use of mobile light mining rigs used over the side or the stern of Antarctic research vessels have been shown to be feasible, but we still need to refine equipment and operating procedures. Also, experience suggests that for drilling within drifting sea ice fields on the Antarctic shelf, a moon pool is not necessarily required to provide protection. A drill string over the side may be adequately protected by a simple guard below the water line, thereby reducing the technical challenge to one of determining how best to secure the guard.

Arctic Ocean

An important driving force for development of an inexpensive shallow drilling capability was the potential scientific reward of obtaining pre-Quaternary sediment samples from the Arctic Ocean. Bear in mind that this was years before a proposal was submitted to ODP for Lomonosov Ridge drilling and almost a decade before ACEX became a reality.

Building on the results from a station keeping test of icebreaker «Oden» in 1991 and successful shallow drilling on the Antarctic continental margin in early 1996, a proposal was submitted jointly with Dr. Jan Backman, Stockholm University to attempt shallow drilling on the Lomonosov Ridge from «Oden». The Swedish Polar Secretariat was positive to the idea and the Swedish National Maritime Administration contributed to installation of a 0,6 m diam. moon pool on the starboard side behind the reamer of the icebreaker. On the Lomonosov Ridge, we were able to set the riser in 962 m water depth, and were underway with about 250 m drill string out when the attempt had to be aborted due to ice.

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HYDROGEOLOGICAL CHARACTERISTICS OF THE ABAKAN RIVER

K.J. Baranova, M.J. Nikalina
Scientific advisors associate professor J.G. Kopylova,
associate professor I.A. Matveenko
Tomsk polytechnic university, Tomsk, Russia

On the modern stage of social, economic and technical development of our country society consumes a plenty of water resources. Development of economic activity in the river basins leads to exhaustion of water resources and undesirable changing of its quality. It causes violation of the normal functioning of ecosystems and presenting a danger for the life of a man.

The purpose of the work is study of quantitative descriptions of the Abakan river.

Tasks:

- collection of necessary information on the charges of the Abakan river, estimation of water resources in this river;
- construction and dismembering of hydrographs;
- study of chemical bearing-out, estimation scales in chemical elements flow in river basin.

For solving these problems the following things were done: information on charges of the Abakan river during two hydrological decades (1960–1980) in river station of settlement. Abaza was collected and studied. Using this information hydrographs were drawn and dismembered, underground constituent feeds of the river was distinguished, chemical composition of water was studied, scales of chemical bearing-out of mountain breeds by the river were investigated.

Information for the article is represented by rows of observations within 20 years with the average charges of water in river station of the Abakan river – settlement Abaza and concentrations of some chemical elements, measured on the area of the Abakan river to this river station in 1997.

The Abakan river is the largest tributary of the Yenisei, formed by confluence of the Bolshoy and Maly Abakan rivers. Control river station on this river is settlement Abaza. It operates from 14.07.1908. Distance from the mouth of the river to the river station is about 2,4 km. The area of water intake pool is 32000 км^2. It disposes within the limits of republic. The general stretch of the river is 514 km. The river has mountain character.

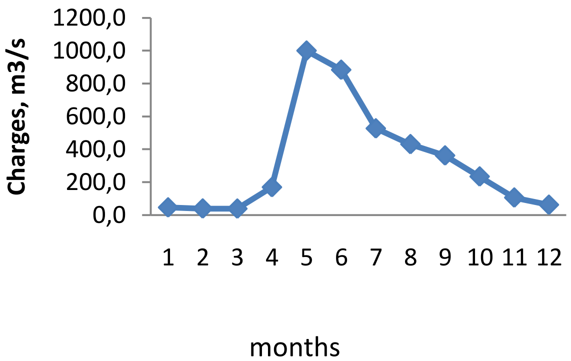

Fig. Hydrographer of the Abakan river – in control river station of settlement Abaza (1960–1980)

Riverheads of the Bolshoy and Maly Abakan rivers are in the range of area of joining of the Western Sayan with the structures of the Altai mountains (the least distance from watershed to the Teletskoe lake is 5 km). Sources are often located on the swamped ancient surfaces in tundra. The longitudinal slope is 0,04–0,05.

After confluence of the Bolshoy and Maly Abakan rivers receives such tributaries as the Ona, Dzhebash, Tashtyp, Askiz, Tes', Uybat. Left tributaries are more waterfull. In river station of hydrometric station in settlement Abaza a longitudinal slope is about 0,002, and width of river-bed amounts about 230 m with depth of 2 m.

After flowing on a plain the width of its river-bed part with islands ranges from 2 to 4 km.

For determination of the water mode in rivers of the Abakan region the changing of water charges during a year by the concrete example of the Abakan river – in control river station of settlement Abaza was researched. Also superficial making feeds (rain, snow) and feed underground waters in the river were analysed. As we can see on hydrograph (fig.), plotted on average facts of 2 hydrological decades, water mode of the river Abakan can be characterized by spring - summer high water level with maximum in the second half of May – beginning of June. The floods of rain begin from summer and autumn. In some years the rain maximum can be higher than spring tide. Therefore, summer – autumn low water is characterized by high level of water. Winter low water is water–abounded.

The feed of the river consists of 3 basic constituents: snow feed (the whole-year melting of snow occurs in mountains, where the river begins), rain feed and feed from underground waters. For their determination it is necessary to draw and dismember hydrograph. For today there are lots of methods of dismemberment of hydrographs and selection of the underground constituent of feed in the river. But the single method of calculation does not exist. In this work were used 3 calculation methods for underground waters in the general water volume of the Abakan river: with the use of linear interpolation, calculation of average expenses for every year, determination of the least expense in all periods. As a result we got the following.

Table 1

Calculation of constituents of feed of the river вy using three methods

Parts of the river feeds, km^3/g	1 method (linear interpolation)	2 method (calculation of average expenses for every year)	3 method (determination of the least expense in all periods)	average
Feed from underground waters, km^3/g	101	37,95	30,1	56,4
Snow feed, km^3/g	181,15	244,2	252,1	225,8
Rain feed, km^3/g	90,5	90,5	90,5	90,5
Summing up:	372,65	372,65	372,65	372,65

Thus, snow feed of the river is predominating and changes from 49 to 68 %, feed from rains takes place everywhere and its value in all methods of calculation remains constant – 24 %. Underground waters play an important role, especially in a winter period, when an underground feed disappears completely. The part of underground water feed is about 15 % of annual flow.

Mode of middle undergound flow on the Abakan river is 1,76 l/(s·кm^2). According to GWC average value of mode flow in general is 20,9 l/(s·кm^2). Most of its values belongs to alpine districts. Modes of minimum summer and autumn flow in the period of the opened river-bed are comparatively high, but not higher than 7 l/(s·km2). Modes of winter minimum flow are 5–6 times less than summer and autumn ones. The part of winter flow makes 7–10 % of annual flow.

Also the estimation of flow scales of chemical elements on all territory of water intake of the Abakan river from a source to the river station in settlement Abaza was made. 16 points were taken into consideration, such as the Bolshoy On river, Ona, Dzhebash etc. To estimate the flow scales of chemical elements standards of annual charges values of water in river station in settlement Abaza were used. Characteristic of middle- watered years were used for the calculation of flow volumes in August. And by multiplication it on the concentration of elements the sizes of complete flow (in kg) was obtained. As August is involved in period of summer low water, feed of flow river in this period substantially increases by underground waters. Consequently, chemical composition of underground waters is the same with river waters.

Analysing table 1, it is possible to say the following: according to the temperature water in all points is cold. Changing of pH goes equally through all territory. Its average value ranges about 7,3. Therefore, waters are mostly poorly alkaline, though we can meet the neutral ones. There is an exception in value of pH of spring before the river Maly Anzas - water is alkaline here. It can be caused by unloading of underground water in this point. It can be proved by the adjoining objects- water of the Maly Anzas and Kanzhul' rivers. They also have the increased value of index. That's why it shows that this locality is the hearth of unloading of underground waters. Tendency in changing general hardness is similar to changing of pH in the hearth of unloading of underground waters. Although water is very soft on the whole. Changing mineralization within the limits of territory ranges from 19,42 to 289,97 mg/l, not having large influence, because waters on the whole ultra-fresh. The only exception is a spring and adjoining objects of water. In this connection the same tendency of changes is observed in 7 basic ions. Waters are hydrocarbon calcium.

Using information of chemical elements in August, 1997 the size of chemical bearing-out of some elements was calculated. Because of absence of materials, characterizing composition of water during a year and because of disproportion on changing of maintenance of separate elements and general mineralization with the flow of river waters, a chemical bearing-out for a year was estimated in general for whole district on the average long-term mode of flow (1,76 l/s·km2) and average parameters of waters chemical composition. A chemical bearing-out for a year was about 40,84 t/y·кm^2. Lithogenic, biogenic and atmogenic parts of bearing-out are 24,2 %, 73 %, 1,14 %. A biogenic constituent was calculated within the limits of hydrocarbon rocks.

Summing up, by quantitative characteristics of flow and chemical composition we can see that anthropogenic loading on the superficial resources of water is not high. These and other factors may help to develop the district's to establishment of parameters for backgrounds' composition in natural superficial and underground waters.

Table 2

Chemical composition of superficial waters of the Abakan river basin

Parameters	**t H2O** **°C**	**pH**	**Miner.** **mg/l**	**HCO_3^-** **mg/l**	**SO_4^{2-}** **mg/l**	**Cl^-** **mg/l**	**General h.** **mg-ecv/l**	**Ca^{2+}** **mg/l**	**Mg^{2+}** **mg/l**	**Na^+** **mg/l**	**K^+** **mg/l**
river Dzhebash	8	7,8	84,74	61	0	0,4	1	20	0	1,5	0,5
the Abakan river,after settl.Abaza	9	7,3	35,49	24	0	0,4	0,4	8	0	1	0,7
precipitation,settl.Abaza	13	6,8	15,88	12	0	1,2	0,1	1	0,61	0,1	0,3
the Abakan river,before settl.Abaza	12	6,8	81,46	57	0	0,4	1	20	0	1,7	0,5
the Kangyl river	9,5	7,5	106,11	73	0	1,75	1,2	24	0	3,7	0,5
the Maly Anzas river	10	7,3	100,06	73,2	0	0,4	1,15	23	0	1,1	0,5
spring before the Maly Anzas river	4,5	8,7	289,97	220	0	0,5	3,1	62	0	4	0,7
the Unsug river	7	7,1	71,21	49	0	0,4	0,85	17	0	1,5	1
the Ona river	8,5	7,2	48,42	37	0	0,5	0,39	7	0,49	1	0,7
the Ona river, before the Karasuma river	11	7,4	48,02	37	0	0,4	0,4	8	0	1	0,3
the Maly On river	10	7,3	68,49	49	0	0,5	0,85	14	1,83	0,7	0,3
the Bolshoy On river	10	7	48,39	37	0	0,5	0,4	8	0	1	0,7
the Bolshoy On river, upper reaches	7	7,3	50,31	36,6	0	0,5	0,6	10	1,22	0,5	0,3
spring falling into the Bolshoy On river	8	7,2	19,42	12	0	0,4	0,25	5	0	0,5	0,7
the Stoctish river	7,5	7,6	82,22	61	0	0,6	0,9	18	0	1	0,5
the salbakiaz river	11	7,2	40,81	31	0	0,4	0,35	7	0	0,8	0,6
river without name	7,5	6,8	18,06	12,2	0	0,4	0,1	2	0	1,3	0,7

Determination of degree of connection of underground and superficial waters, research of the hydrochemical mode of this water, estimation of scales of underground flow, increase in exactness of calculations of the proper materials, are directions of further research of the examined district.

ANALYSIS OF DIFFERENT FACTORS ON ELECTRIC CURRENT IMPLUSES DURING DRILLING

A.V. Epikhin, K.V. Karneev
Scientific advisor associate professor M.A. Samokhvalov
Tomsk polytechnic university, Tomsk, Russia

The analysis of different factors on electric current impulses during drilling is an actual issue nowadays. This fact is due to high expenses and valuable time spent in determining the exact calculations of the drilling bit penetration into the pay zone. Different errors in drilling bit penetration determination affect the drilling and further results. There are two factors which should be considered in this case: exact pay zone depth and penetration time. In both cases, not only is money saved, but also drilling speed is increased.

The stated research is the further development in electric current impulse control of rock failure during drilling at Tomsk Polytechnic University. In 1970 Professor A.A. Vorobyev conducted the first theoretical and experimental research – electrization of solid bodies and their mechanical influence. It was proved that rock mineral composition and rock fluid saturation significantly affect the measured electromagnetic field. This research opened a new era in the practical application of the above-mentioned phenomenon. Another trend was to control rock failure during drilling by diamond bits. However, in this case, the electromagnetic field was recorded only during dry drilling (not in the samples). Drilling fluid (in this case, water) completely screened the electromagnetic fields by increasing fractures (fissures). To solve the above-mentioned problem, Drilling Department, TPU suggested the following method - convert non-contact electromagnetic current measurement within bits on the external contour which included the drill string, drilling units and rocks. Based on these facts, experimental (in laboratory conditions) measurements of electric current occurring during drilling and rock cutting through different drilling fluids were conducted.

Initially the first research procedures were carried out in drilling rig SKB -5 through diamond bits. Further, to speed up research results, electric current impulse recording and special diamond discs for cutting rock samples was applied. Electric current impulse recording of drill samples is conducted in special units, detecting acoustic signals (fig. 1). This installation includes a loading system and computerized measurement device system.

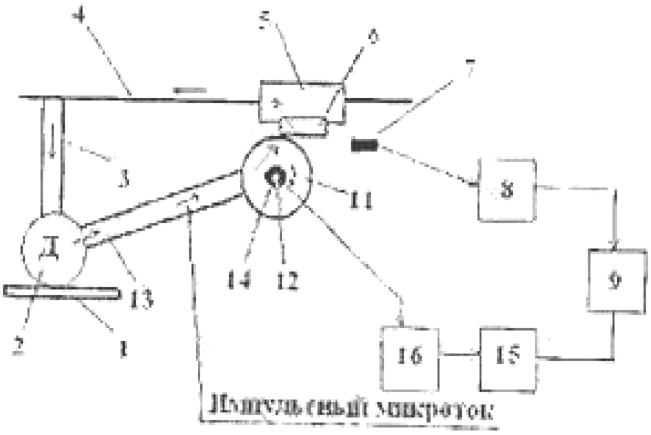

Fig. 1. Schematic installation illustration of acoustic signal and electric current impulse recording during drilling by diamond discs

The loading system includes the following units: 1 – foundation; 2 – electric motor; 4 – conductor; 5 – track-mounted traveling slide with special clamps to fasten rock samples; 12 – spindle; 11 – diamond disc; 13 – spindle transmission gear; 3 – slide transmission gear. The drilling fluid has the following function: 1) to cool the diamond disc and 2) to remove cuttings.

Measurement device system includes the following units: 9 – personal computer; 8 – intensifier and sensors. Microphones (7) receive acoustic signals, intensify these signals and then send them to digital acoustic converter card, installed in the PC. To register electric current impulses on the non-magnetic spindle (12), induction sensor transformer (14) on ferrite ring is installed. The voltage (as electric current impulses) is transferred to the intensifier (16) through the induction sensor exit. The intensifier includes rejecter filter to truncate mechanical frequency interferences. Further, electric current impulses pass to oscillograph «Tektronix» and computer (9), where the following procedure is completed –spectral-frequency signal processing.

RESEARCH:

Influence of different factors on electric current impulse dimensions.

- 3 rock samples to determine impulse dimension.
- Sample height – 35 mm from cores with 30 mmD.
- Samples as parallelepid with the following sizes from 35×30 × 20 mm to 35×40×35 mm.
- Samples are cut by diamond disc, d = 100 mm, depth = 5 mm (to record electric current impulses).

Influence of rock type and composition on electric current impulse dimensions. The following research material was used:

- medium-grained sandstone with high coarse-grained material content – clay-hydromica cement;
- coarse/medium – grained sandstone with calcite cement;
- coarse/medium-grained sandstone with calcite –quartz cement;
- fine-grained sandstone with calcite cement.

Research results are depicted in fig. 2. According to this histogram, granular composition significantly affects the electric current impulse dimensions. The smaller the sandstone particles, the more intensive the electric current impulses. This can be explained by the following fact-significant contact area between bit and rocks due to small grain composition size. The cement type also affects the electric current impulse dimension. For example, in samples with quartz cement, the current dimension is more significant than in samples with calcite cement because quartz is harder than calcite (Mohs Hardness Scale). Therefore, rock failure during drilling intensifies the electric current impulses.

Influence of mud type on electric current impulse dimensions. The following rock samples were examined:

- fine-grained sandstones with calcite cement;
- medium-grained sandstones with calcite cement;
- coarse-grained sandstones.

Research results are depicted in fig. 3 and Table. The following dependences were found:

- rock failure in drilling mud with salt solution results in maximum electric current impulse dimensions; next-water solution, SAS and then drilling fluid with clay solution (slurry) which show the least electric current impulse dimensions.
- reverse proportional dependence of electric current impulse dimensions to rock granular composition and its strength. The smaller the particle, the more intensive the electric current impulse during drilling, as well as, high sample strength.

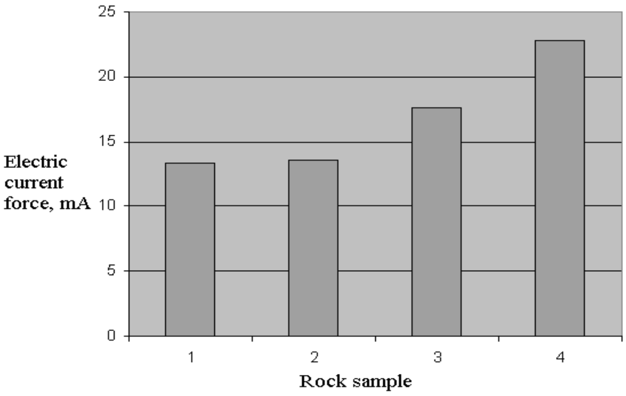

Fig. 2. Research results- influence of rock type and composition on electric current impulse dimensions

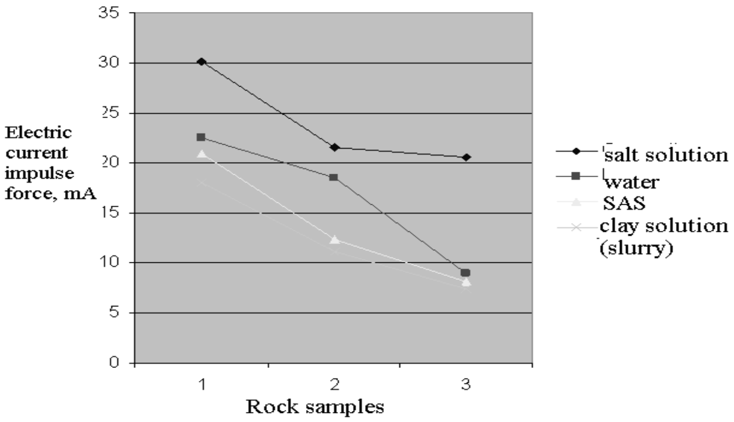

Fig. 3. Research results- influence of mud type on electric current impulse dimensions

Influence of oil saturation on electric current impulse dimensions. The influence of oil saturation on rock failure was also examined. During drilling electric current impulse significantly decreases in oil-saturated samples rather than in non oil- saturated samples (the results were based on the comparative analysis method). This can be an important factor in controlling and recording electric current impulses.

Table

Electric current impulse value ratio to drilling fluid type

Drilling Mud	Resistivity, Ohm·m	Electric current impulse force, mA		
		Rock sample 1	Rock sample 2	Rock sample 3
salt solution	0,0126	30,2	21,6	20,6
water	7,.07	22,5	18,5	9
water solution of surface-active substance (SAS)	5,21	21	12,3	8,1
clay solution (slurry)	1,57	18	11,2	7,4

All research information and results showed the dependence of electric current impulse to rock type, rock mechanical characteristics, drilling fluids and saturation fluids. Based on above-mentioned results, it is possible to design electric current impulse control and recording systems during drilling. This leads to less expenses and time during drilling into pay zone (by different bits).

DER EINFLUß DER BECKENENTWICKLUNG AUF KOHLENWASSERSTOFFPOTENZIAL AM BEISPIEL DES THÜRINGER BECKENS

S.S. Frolow
Wissenschaftliche Leiter Dr. T.A. Gaidukowa, Dozentin L.S. Ratner
Polytechnische universität Tomsk, Russland

Ein Hauptziel der Exploration auf Kohlenwasserstoffe im östlichen Deutschland ist der basale Zechstein. Die ersten Öl- und Gasfunde des Thüringer Beckens wurden in den dreißiger Jahren gemacht, im südlichen Brandenburg konnten seit den sechziger Jahren Explorationserfolge erzielt werden. Die vorliegenden Ergebnisse haben aber gezeigt, daß das Ca2-Play komplex aufgebaut ist und eine Reihe von Risiken wie die strukturelle Komplexität und Entwicklung, die unzureichende Füllung von Lagerstätten, die wechselnde Öl-Gas-Verteilung und das Auftreten nicht brennbarer Gase beinhaltet.

Um diese Risiken einzugrenzen, wurde eine dreidimensionale Beckenmodellierung im Untersuchungsgebiet durchgeführt. Das Ausgangsdatenmaterial entstammt seismischen, geologischen und geochemischen Untersuchungen und ermöglicht Aussagen zum Ablauf der Beckenentwicklung, zur Muttergesteinsqualität, -Reife und -Verbreitung, der Herkunft der Kohlenwasserstoffe und der Dichtigkeit potentieller Fangstrukturen. Für die Modellierung wurde ein Software-Paket der Firma Shell verwendet.

Das Liegende des basalen Zechsteins wird im südlichen Brandenburg und im Thüringer Becken im allgemeinen von klastischen Sedimenten unterschiedlichen Alters gebildet. Der Brandenburger Raum repräsentiert einen Ausschnitt des Südrandes des variskischen Vorlandbeckens. Feinklastisch ausgebildetes Unterkarbon wird von sandigtonigen Ablagerungen des Oberrotliegenden diskordant überlagert. Die gesamte Abfolge ist maximal wenige hundert Meter mächtig und kann im östlichen Bereich des Untersuchungsgebietes fehlen.

Eine Analyse der bisher erbohrten Lagerstätten im Untersuchungsgebiet zeigt, dass die Vorhersage des Lagerstätteninhaltes (Auftreten von Öl, Gas oder kombinierten Vorkommen) einen wesentlichen Unsicherheitsfaktor für Explorationsvorhaben darstellt. Die Anteile an nichtbrennbaren Gasen (in erster Linie Stickstoff) variieren stark. Zudem sind die Strukturen im allgemeinen nicht vollständig mit Kohlenwasserstoff gefüllt.

Um zu einer realistischen Vorhersage des Lagerstätteninhaltes zu kommen, ist daher notwendig, Aussagen über den Beginn und Zeitraum der Kohlenwasserstoffgenerierung sowie die dabei freigesetzten Mengen in Relation zu strukturbildenden und strukturzerstörenden Prozessen machen zu können.

AIs Lösungsansatz für die genannten Fragestellungen wurde eine dreidimensionale Beckenmodellierung gewählt, die auf geophysikalischen, geologischen und geochemischen Daten basiert. Es wurde ein Software-Paket der Firma Shell zur Rekonstruktion der Absenkungsgeschichte des Beckens sowie der damit verbundenei zeitlichen Einstufung und Quantifizierung der Bildung und Migration von Kohlenwasserstoffen benutzt. Die Modellierung wurde für das Zeitintervall Zechstein rezent durchgeführt, um das Potential der Ca2-Muttergesteinsfazies bewerten zu können. Zusätzlich wurde das KW-Potential der Muttergesteine des Prä-Zechsteins betrachtet.

Für den Ablauf der Kohlenwasserstoffgenese und -Migration ist das Paläo-Temperaturfeld von entscheidender Bedeutung. Aufgrund des Fehlens einer zeitlich differenzierten Wärmeflußgeschichte wurde für die Modellierung ein konstanter Wärmefluß von 70 mW/m^2 für Südbrandenburg und 80 mW/m^2 für das Thüringer Becken angenommen. Die modellierten Reifedaten zeigen eine gute Übereinstimmung mit in Bohrungen gemessenen Werten.

Ein Vergleich der geochemischen Daten mit der heutigen Beckengeometrie und Teufenlage des basalen Zechsteins zeigt, daß das Untersuchungsgebiet eine komplexe geologische Entwicklung erfahren hat. Die gemessenen Reifewerte des Ca2-Muttergesteins stimmen nicht mit der rezenten Teufe überein, die zwischen wenigen hundert Metern in den Randbereichen des Thüringer Beckens und der Lausitzer Triasplatte sowie maximal dreitausend Meter in anderen Teilen Südbrandenburgs variiert.

Für die aus diesen Daten abzuleitende signifikante Beckeninversion gibt es eine Reihe von Belegen. Eine Rekonstruktion der geologischen Schichtenfolge aus Bohrungen und Seismik zeigt, daß bis zu 1500 m Trias, Jura- und Kreideablagerungen im Untersuchungsgebiet erodiert bzw. teilweise nicht abgelagert wurden. Wie in anderen Bereichen (z.B. Niedersächsisches Becken, Subherzyn) ist davon auszugehen, daß erste Inversionsbewegungen ab dem Tura zu verzeichnen sind, die Hauptinversion aber während der Oberkreide stattgefunden hat.

Für eine Beckeninversion gibt es noch weitere Belege. Eine Reihe von Kohlenwasserstoffvorkommen im Ca2 in Brandenburg zeigen gegenüber den heutigen hydrostatischen Verhältnissen stark überhöhte Lagerstättendrücke. Überhydrostatische Drücke in Lagerstätten können durch eine Reihe von Vorgängen erzeugt werden, zum Beispiel Beckeninversion, Kompaktionsanomalien, Anhydrit-Gips-Umwandlung, Kohlenwasserstoffgenerierung und Temperaturzunahme (Martinsen 1994). Bei der Inversion von Lagerstätten kann es schon bei geringen Gasgehalten (> 3 %) zum Aufbau erheblicher überhydrostatischer Drücke kommen (Barker 1979). Als weiterer Mechanismus wird eine Übertragung des auflagernden lithostatischen Drucks auf die Lagerstätte diskutiert.

Im Untersuchungsgebiet gibt es deutliche Hinweise, daß ein Zusammenhang zwischen den überhydrostatischen Lagerstättendrücken und der Beckeninversion zu sehen ist. Darauf deutet unter anderem auch die Koinzidenz der Überdrücke mit erhöhten Schallgeschwindigkeiten in Tonsteinen des Mittleren Buntsandstein hin. Ein Maß für die Kompaktion von Tonsteinen ist ihre «Schallhärte», d.h. die aus akustischen Bohrlochmessungen ermittelte Schallaufzeit. Da die Kompaktion irreversibel ist, kann sie als Maß fiir die maximale Versenkungstiefe des entsprechenden Tonsteinpakets genommen werden. Der Vergleich dieser Schallaufzeiten mit einer Reihe von Meßwerten aus den gleichen Horizonten in nicht oder wenig invertierten Gebieten in Nordwestdeutschland zeigt, daß die Laufzeiten in Teilen von Brandenburg deutlich erhöht sind.

Daraus läßt sich schließen, daß diese Beckenbereiche in der geologischen Vergangenheit deutlich tiefer versenkt waren als heute.

Das Hauptmuttergestein für Kohlenwasserstoffakkumulationen im Zechstein des Untersuchungsgebietes ist die Hang- und Beckenfazies des Ca2. Es handelt sich im allgemeinen um ein öldominiertes Muttergestein vom Kerogentyp II, das im Thüringer Becken im Bereich des Ölfensters und im Raum Brandenburg im Übergangsbereich Ölfenster-Gasfenster liegt. Damit unterscheidet sich das Untersuchungsgebiet fundamental vom nordwestdeutschen Raum, in dem die Kohlen des Oberkarbons der Haupt-Gaslieferant sind. Die Rekonstruktion der Beckenentwicklung zeigt, daß die nachgewiesenen Lagerstätten spätestens in der Oberkreide gebildet wurden. Eine teilweise oder vollständige Lagerstättenzerstömng durch Tektonisierung während der Inversionsvorgänge stellt ebenfalls einen Unsicherheitsfaktor dar und muß für jedes Explorationsprojekt separat bewertet werden. Es konnte jedoch nachgewiesen werden, daß die Faziesfallen im Ca2 auch heute noch intakte, druckmäßig separate Kompartments darstellen.

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STRUCTURE AND GEOLOGY OF THE LAPTEV SEA CONTINENTAL SHELF

E.I. Grokhotov

Tomsk polytechnic university, Tomsk, Russia

Among Arctic seas of Russia, water areas of the eastern sector are most poorly investigated in geologic-geophysical respect. Therefore, ideas about oil and gas potential of this segment of Arctic water area are to a large extent based on evaluating hydrocarbon potential of sedimentary cover deposits framing land and islands as well as seismic activity results in water areas. The Laptev Sea is a very shallow epicontinental sea in the Russian Arctic and is bounded by the Taimyr Peninsula on the west and the New Siberian Islands on the east. About 70 % (475 000 km^2) of the shelf has a water depth of less than 20 m. The present-day understanding of the Laptev Shelf geology is based on Russian multichannel seismic reflection (MCS) data obtained by the Marine Arctic Geologic Expedition (MAGE) of Murmansk during 1986–1990 and by the Moscow Laboratory of Regional Geodynamics (LARGE) in 1989. These data allowed delineation of the structure of the rift system and the seismic stratigraphic features of its sedimentary fill. In addition to these surveys, about 7000 km of seismic profiles were acquired by joint Russian-German investigations during 1993 and 1994 in the northwestern part of the East Siberian Sea and the eastern part of the Laptev Sea. These data are mostly still under interpretation. The Laptev Shelf is a part of the broad continental margin of northeastern Asia in the Arctic. A Late Mesozoic folding and Tertiary rifting have played the most important roles in shaping the structure and present-day physiography of this region. Vinogradov describes the shelf as consisting of three main sedimentary complexes overlying an Archaean to Lower Proterozoic crystalline basement: Riphean to Middle Paleozoic, Upper Paleozoic to Lower Cretaceous, and Upper Cretaceous to Quaternary. The total thickness of the sedimentary cover of the shelf was postulated to vary from about 14 km within the most subsided, southwestern, part (South Laptev Basin), to 1–2 km on the uplifted blocks. The main graben in the central part of the shelf was named the Ust' Lena. Analysis of available material allowed to outline and consider the potential oil and gas complexes within shelf in sedimentary cover section.

Seismic stratigraphy and structure of eastern part of the Laptev Shelf. The absence of offshore drilling data necessarily results in considerable uncertainly about the age and nature of the seismic boundaries and units. However, based on the apparent regional extent of the unconformities in the offshore and Beaufort Sea sections, we correlate the boundaries between the seismic units with these regional unconformities. The internal structure of eastern part is very complicated due to numerous normal faults of different amplitudes, directions of block rotation and ages.

Western part of the shelf: preliminary description. The author reports data about oil and gas potential of the Laptev Sea shelf where Upper Riphean-Cambrian, Middle Paleozoic, Permian, Triassic, Jurassic-Neocomian potentially oil-and-gas-bearing complexes are outlined. A new geological zoning of the Laptev Sea is presented. It is based on the results of the basement zoning, the determination of stratigraphic range of sedimentary cover, oil and gas source formation within the section and on the range of their HC potential realization.

Conclusions. New offshore multichannel seismic reflection results combined with potential field observations and geological data from the adjacent parts of the land and islands have significantly improved our understanding of the Laptev Shelf geology. They allow the main structural elements of this rifted continental margin to be established as it is described in this paper. At the same time several important questions still remain. The most controversial point is the dating of the seismic stratigraphic units. The eastward decrease of the total thickness of the sedimentary sections from more than 10 km in the South Laptev Basin to about 4–5 km in Bel'kov-Svyatoi Nos Rift and the simplicity of the entire rift structure suggests an activation of the rifts from west to east.

ECOLOGICAL CONDITION OF GROUNDWATERS IN JIANGHAN PLAIN, PROVINCE HUBEI, CHINA

L.L. Kamaletdinova
Scientific advisors professor S.L. Shvartsev, associate professor I.A. Matveenko, associate professor J.G. Kopylova
Tomsk polytechnic university, Tomsk, Russia

In order to understand the concept of an ecological condition of underground waters more deeply it is not enough to know chemical compound only, excess in maximum permissible concentration and other indicators. First of all, it is necessary to find out character is the behavior of chemical elements in water, their ability to collect or dissipate, to determine factors that can support these processes. It is not always that a source of elements in natural waters is technogenic pollution. So, by the example of underground waters of Jianghan Plain (a province Hubei, China), characterized by elevated concentration of As and F, the geochemical research has been carried out for the purpose of definition possible sources of pollution.

Jianghan Plain occupies central and eastern parts of the province. The site of research take is between Yangtze and Hanshui rivers which define all water system of this area. The internal part of the formed basin represents the graben with rather rough surface of the base, filled with Cainozoic deposits, the top part of which is presented by Quaternary system. Generally clay sandstones, sandy soils and gravel are extended on this territory.

The selected 60 water samples have been analyzed. Data of cations and anions are obtained. The mineralization is calculated (table). It was found out that in the given territory various waters in composition and salinity, basically fresh, from neutral to alkalescent, mainly hydrocarbonate sodic are developed. HCO_3 prevails in anions, Na, Ca, Mg in cations respectively. Waters of this region are basically pure the concentration of SO_4, NO_3, NO_2, CL exceeds admissible limits only in individual cases. A possible source of this pollution is technogenic influence, because the plain is actively used by local people in agriculture already for many years. Therefore it is not excluded that the elevated concentrations of SO_4, NO_3, NO_2, CL in particular samples occurs due to using fertilizers and other agricultural means.

Table

Results of composition for typical underground waters in Jianghan Plain

№	Depth, m	pH	T°C	Mineralization	Cl	NO2	NO3	SO4	F	As
				mg\L						
12	20	7,3	17,5	580	5,42	<0,01	2,98	2,12	0,27	0,008
14	5	7,6	13,8	980	8,78	—	3,67	22,89	4,92	—
16	24	7,2	15,4	540	2,78	—	3,03	—	0,13	25,36
27	23	7,3	18,3	790	3,06	0,25	2,96	0,09	0,13	70,14
39	80	7,4	19,1	580	3,23	<0,01	2,96	12,81	0,05	45,90
41	10	7,9	16,8	530	11,31	3,53	78,83	35,02	0,3	3,83
42	11	8,1	17,3	305	25,58	0,01	8,85	24,18	0,27	1,28
43	5	7,5	16,4	1116	16,35	0,01	4,36	76,88	0,1	0,21
44	28	7,7	16,9	1000	19,03	0,01	51,53	102,4	0,18	0,006
51	5	7,0	18,7	840	31,06	0,23	20,1	67,01	0,11	—
58	6	7,0	25	580	21,05	0,49	10,32	32,3	0,16	0,003
60	11	7,0	18,1	485	41,11	0,34	15,13	29,56	0,36	—
61	4	7,4	25,3	615	11,31	0,44	5,68	50,58	0,28	—

Dependence of the general mineralization and pH is observed very poorly, however, this regularity is kept for waters within all type silica-alumina rocks (fig. 1) [3]. Dependence of change in underground waters mineralization in space characterizes intensity of water cycle on the given site. So, salinity of waters grows with depth increase, consequently intensity of water cycle weakens with depth.

Results of arsenic and fluorine concentration analyses are abnormal in underground waters of investigated region. In separate points, for example, № 16, 39, 27 concentration reaches 25,3 mg/l, 45,9 mg/l, 70,1 mg/l respectively. The fluorine concentration often amounts 0,07 – 0,36 mg/l, an exception is point № 14 where value reaches 4,92 mg/l. It is necessary to notice the important fact that points with raised concentration of SO_4, NO_3, NO_2, CL, do not coincide with points of abnormal fluorine and arsenic values. This indicates that other factors have served as source of these elements in underground waters.///

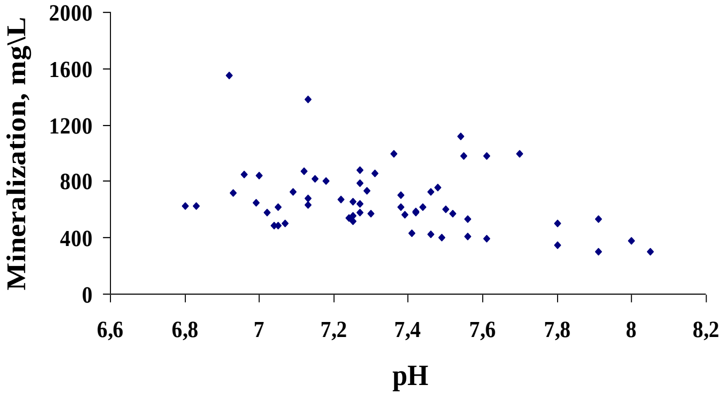

Fig. 1 Dependence of the general mineralization on size pH

To consider formation mechanisms of underground waters we carried out research of interaction character between waters and carbonates. Results have shown that practically all types of waters are equilibrium to calcium and only one point is close to balance. That indicates the supersaturation with respect to calcium carbonate and its possible sedimentation from waters.

According to the results of research, waters are far from saturation with respect to primary silica-alumina rocks (muscovite, feldspar, anorthite) and without an exception all underground waters of this region are equilibrium with products of weathering primary silica-alumina – clays (kaolin, illite, montmorillonite) (fig. 2). Ca reacts and precipitates as a calcite, Mg and K – as a clay, and Na concentrates in a water solution that leads to formation of sodic hydrocarbonate waters [1].

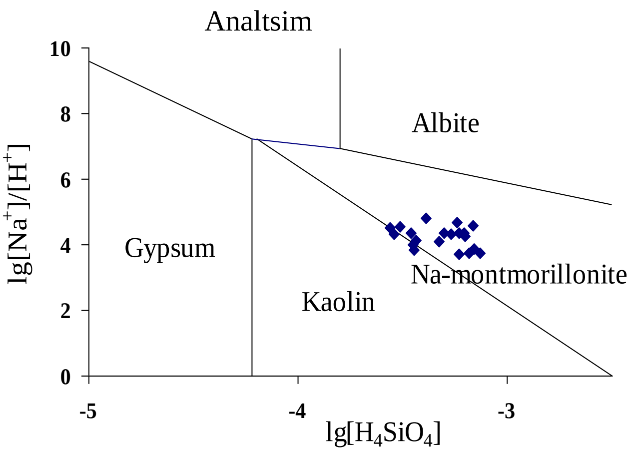

Fig. 2. The equilibrium diagram of Analtsim - Albite - Gypsym - Kaolin - montmorillonite with drawing of compound data of underground waters in Jianghan Plain, a province Hubei, China

From the above-stated it follows that geochemical type of the given waters is alkaline carbonate calcium. Waters of this type are characterized by the raised values of sulphates and chlorides. In process of underground waters saturation with calcium their interaction with rocks does not stop and many other elements, such as sodium, sulphate - and chlorine - ions continue to concentrate in the solution. Therefore, samples of water with supposed technogenic pollution can be a natural product, formed in the course of interaction between water and rocks.

As to the raised concentration of arsenic and fluorine the nature of these elements` behavior in water is not easy to understand. So, for example, for hydrocarbonate sodic waters with less mineralization the elevated concentration of fluorine in water is a characteristic feature. It is explained by horizontal zonality of fluorine waters. In this case rocks can serve as a powerful source of fluorine. Natural compound of arsenic possess the good solubility, the presence of sodic waters is a favorable conditions for its migration and accumulation because sodic compounds is a good solvent for anions of arsenic acids that is just typical for our case [2].

As a conclusion of the research one can introduce the fact that underground waters with high concentration of some elements, which exceeds the maximum permissible concentration, are not polluted. The given concentration can be natural, the geochemical background formed by the nature during geological evolution of interaction between water and rocks.

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LITHOLOGICAL ANISOTROPISM OF SAND ROCKS OF IGOLSKAYA OIL AREA (TOMSKAYA OBLAST)

M.S. Kholkina, Ya.D. Kuchinskaya, S.S. Frolov
Scientific advisor associate professor L.A. Krasnoshchyokova
Tomsk polytechnic university, Tomsk, Russia

Theoretical analysis. The formation and development of facial-palaeogeographical analysis methods allowed studying correlations between particle orientation and transporting medium direction. While considering this question, first only conglomerates were examined. Later on, the orientation of sand particles, mainly prolate ones, depending on the presence of regular directivity of medium motion was submitted for consideration. In scientific works by L.N. Kulyamin (1970), T.Ye. Gryaznova (1947), V.K. Golovenok (1955) and others', it was stated that long axes of clastic grains in streams with fast current are mainly directed along the current, and their pointed ends are orientated downstream. Lately, many researchers have started to apply the method that consists in measuring long axis of grain and its tilting about the horizon to study the orientation of sand grains. The orientation lies in the order of system components in space. If most of components have the same orientation in one of the planes of the sample, then we are talking about preferable orientation, that determines a primary structure of sediments.

During the deposition of sediments there always observes the effect of gravitational field, but more often the effect of forces, connected with the stream of transporting material medium, such as water, air or ice. The orientation of sand grains changes as a result of vital activity of organisms, consedimentional deformation of deposits and their postsedimentional changes; this should be considered at the recreation of sediment accumulation environment.

Experimental part. Distinction problems in a grain packing because of different sediment types represent an open field for research works.

Thus, Dupples and Romingher (1945) found out that quartz grains in transporting medium gain a definite orientation, according to which it is possible to recreate the direction and nature of the transporting medium. Unfortunately, the study of sand grains orientation in Russia in comparison to foreign countries takes place very seldom. Scientific works by I.S.Delitsyn (1967, 1979, 1985) should be marked as ones that give the fullest view on studying the internal structure of quartz stones in conditions of sediment formation and metamorphism.

The aim of this work is to set the preferable orientation of sand grains of J_1^2 bed of Igolskaya area of Igolsko-Talovoye hydrocarbon deposit (Tomskaya oblast), that allows to determine the conditions of sediment accumulation. The object of this research is the sandstones of J_1^2 bed of a given area.

The J_1^2 bed is represented by litofacies of grey, light-grey, mid-finegrained, semi-consolidated, and partly calciferous sandstones. One may notice oblique, convolute, interrupted, horizontal bedding due to occlusion of argillaceous-carbonaceous material; layer by layer jointing, moderate bioturbation and occlusions of fauna remains.

A morphological analysis includes measuring of grain elongation orientation in orientated slides. The gist of the measuring comes to the measurements of trend azimuths of elongated grains of the chosen direction.

We studied spacely orientated slides for each of four J_1^2 bed sandstone samples from Igolskaya area (we took a pair of mutually orthogonal slides in both vertical and horizontal planes). Determination of sand grains position was made with the help of petrographic microscope. The analysis of the nature of quartz grains elongation was held in plains close to stratum and at right angles to stratification and ripple marks.

A minimal quantity of measurements, necessary for getting a certain picture of grain orientation in rocks, was about 200–220 grains per a slide. After statistical processing by «Stereo SN» programme, the results were put onto rose diagrams.

Results and discussion of the results. The diagrams of mid-grained quartz grains elongation of wellsite 1087 are characterized by occurrence of 3 maximums, one of which is strongly marked. The maximum lies within the interval of 230°–240°. Two other ones are less marked, thereat the angle between them varies from 50° to 60°. The intensity of statistical maximum lies within 16–19 %.

According to the data of obtained diagrams of fine-grained quartz grains elongation of investigated samples there appeared a less certain picture. All presented maximums are poorly marked with the intensity of 14% and have a spindle-shaped fusiform structure. At the moment it is very problematic to make up the whole grain depositional mechanism and to single out the factor that affects the orientation of elongated grains. The presence of three poorly marked maximums can be explained by the influence of stream water, transporting fragmentary materials by dragging and rolling, under low speed conditions.

A bihump distribution of long axes of quartz can be seen in the diagrams of quartz grains elongation that were obtained for two grain fractions (mid-grained and fine-grained ones). In such a case one strongly marked maximum (with the intensity of 13,1–16,7 %) is recorded in the direction of North-East – South-West, that coincides with the defined direction of the coastline at the moment of sedimentation. Subordinate maximums with the intensity of 5–8 % lie subnormally to the principle one. An interpretation of bihump orientation, that more often occurs at refining the sediment by two streams flowing in different directions, is given in the work by R.Gradzinsky and others (1980). Waves, running on the coast at an angle, transport the material towards the coastline, and a motion goes at right angle to the coastline at reverse washout. Flat and elongated grains easily gain a linear orientation, whereas tube-shaped and spindle-shaped ones thanks to their ease of transposing by rolling hold a lateral position in the stream. We can see this as a submaximum in the diagrams. The details are given in the works by D. Leming (1966), V. Schwarzacher (1951)

Thus, we found out that the principal mechanisms, which significantly influenced the formation of well-disposed pattern of sandstones of J_1^2 bed of Igolskaya area, were alongshore currents and swashways. Summing up what has been said and taking into consideration materials by Danenberg, Belozerov, Brylina (2006) and Krasnoshchyokova (2006), with the help of investigation results we may define the conditions of sedimentation as coastal marine ones.

One should notice that various stream heterogeneities significantly affect the dispersion of orientations. The interference of these factors may stipulate a more complicated picture of orientation, though there is a common mechanism in the position of clastic grains. The orientation of north-east direction is a preferred orientation of clastic grain elongation.

Hence, every type of sediment transporting medium corresponds to well-defined types of sand grains orientation. Combined with another features of sediments (e.g. textural, structural, granulometric and other ones), a sedimentary grains orientation can be used to find out facial nature of deposition.

Rose diagrams of quartz grains elongation of bed J_1^2 bed in well-site 1087 of Igolskaya area. A – mid-grained rocks, B – fine-grained rocks, C – a collective diagram.

ADVANCED TECHNOLOGIES IN DIRECTIONAL DRILLING

M.S. Kostikov
Scientific advisor associate professor L.M. Bolsunovskaya
Tomsk polytechnic university, Tomsk, Russia

Technologies in directional drilling are always developing. These improvements allow drilling difficult wells with maximum accuracy in minimum time and with minimum break down risks.

In this work 3 advanced directional drilling systems of company Halliburton(Sperry Drilling Services department) are showed:

- Geo-Pilot system.
- EZ-Pilot system.

They are both Rotary steerable systems.

- And V-Pilot system - self-correcting vertical drilling device.

Geo-Pilot® Rotary Steerable System

The Geo-Pilot GXT rotary steerable system establishes a new benchmark for performance drilling. Delivering increased horsepower and revolutions per minute directly to the bit, the Geo-Pilot GXT system overcomes challenging formations while reducing the occurrence of stick-slip. The system gives you the ability to achieve higher penetration rates while minimizing casing wear by decoupling the bit speed from the drill string speed.

The Geo-Pilot GXT system delivers this new level of drilling performance by integrating a GeoForce® motor power section between the rotary steerable system and the LWD system. This next-generation positive displacement motor technology produces more than twice the horsepower of conventional power sections. By machining the helical lobe profile directly into the metal stator tube and then molding a uniform thickness of elastomer over the profile, the amount of flexible elastomer is significantly reduced, yielding higher efficiency and improved durability. This intense delivery of power directly to the bit dramatically reduces the occurrence of stick-slip and other types of undesirable bit dynamics. This results in the entire downhole assembly running smoother, with improved ROP, while providing seamless high-speed bidirectional communication between the at-bit sensors in the Geo-Pilot system and the LWD system.

Combining this new level of power with the high precision steering and on-the-fly control of the proven Geo-Pilot point-the-bit system creates a new standard in the industry for performance drilling systems. The Geo-Span® downlinking system can communicate from surface any of the more than 12,000 possible steering settings in only 90 seconds, while on bottom drilling ahead. This makes the Geo-Pilot GXT system virtually invisible to your drilling operation and allows you to precisely place your well exactly where you want it with no penalty for frequent tool setting changes. Less time talking and more time drilling results in significant savings on high-cost drilling operations.

The Geo-Pilot GXT system continues to deliver the proven benefits of FullDrift® bit technology. Using the state of the art in PDC cutter technology from Security DBS Drill Bits, in the FullDrift bits extended gauge configuration, ensures consistent build rates in extremely soft formations as well as the ability to punch through hard stringers and stay on course. All while producing excellent hole quality over the entire drilling interval for more efficient hole cleaning, lower torque and drag, better log quality, and easier casing runs. The Geo-Pilot GXT system is well suited to extended reach drilling, where completing entire intervals faster while avoiding excessive casing wear can be critical to the success of the project.

Geo-Pilot GXT System Applications

- Performance drilling.
- Extreme extended reach drilling.
- Harsh environment drilling.
- High cost drilling.
- Bit speed-sensitive formations.

Benefits

- More energy is directly applied to the bit improving cutting efficiency and rate of penetration while also overcoming stick-slip.

- Decoupling of the bit from the drill string reduces transmission of vibrations to LWD and other BHA components, improving life.
- Drill string rotary speed can be reduced to minimize casing wear while bit speed is optimized for best drilling performance.

EZ-Pilot® System

Reliable, cost-effective rotary steering

Sperry Drilling Services' new EZ-Pilot system delivers cost-effective rotary steering services to the greater drilling market. Rotary steering is no longer the domain of highcost operations, such as deepwater offshore drilling. With the EZ-Pilot system, land and shallow water operators can take advantage of all the benefits of rotary steering at an affordable price.

The EZ-Pilot system provides accurate directional drilling control while allowing continuous rotation of the drillstring. The tool employs the natural forces of gravity combined with simple infrequent geometric changes, forcing the bit off-center, thus changing the trajectory of the well.

EZ-Pilot System Operation

The EZ-Pilot system is an instrumented, near-bit stabilizer with three main components, including a rotating mandrel, an eccentric inner sleeve and a weighted, non-rotating outer housing. The tool works by controlling the orientation of the eccentric cam system which offsets the mandrel and the bit in the desired direction. Rotation of the cam system to change toolface orientation is accomplished by controlling an ultra-high torque DC motor powered by lithium batteries. The position of the outer housing is constantly monitored, and the tool automatically corrects the eccentric cam system setting as required to maintain proper toolface orientation.

The target toolface is set through simple rotary speed commands, or «on the fly» downlinking commands, sent from the surface when coupled with either Geo-Span® software/PWD or EM telemetry.

EZ-Pilot System Capabilities and Features

- Suitable for drilling vertical, directional and horizontal applications.
- Capable of kicking off from vertical.
- Simple and cost effective – with fewer than 130 components.
- Flow rate, rotary speed, weight-on-bit or LCM (lost circulation material) restrictions are consistent with MWD limitations.
- Easily reconfigurable for different hole sizes.

EZ-Pilot System Benefits

- Zero «sliding» time for more effective ROP.
- Helps reduce drillstring buckling in long horizontals, greatly extending reach.
- Continuous rotation helps improve hole cleaning and reduces risk of getting stuck.
- Low pressure drop design helps reduce hydraulics requirements, critical on smaller rigs.
- Helps increase ability to drill with more aggressive bits.
- Smoother wellbore curvature helps reduce torque and drag.
- Helps lower operating and lost-in-hole costs.

V-Pilot® Vertical Drilling Service

The Sperry Drilling Services' V-Pilot service uses a self-correcting vertical drilling device with an integrated high output mud motor power section designed to automatically maintain a vertical well path at less than 0.5° inclination.

The V-Pilot service can improve drilling efficiency in areas with strong natural deviation tendencies such as highly inclined beds and massive salt formations. Drilling time can be significantly reduced by eliminating the slow penetration rates associated with trying to maintain verticality with a conventional motor. The V-Pilot system is a purely hydro-mechanical solution with no electronics, making it more reliable and well suited to hard rock drilling and the high vibration levels that typically accompany these formations. The system has a GeoForce® enhanced performance motor power section that delivers maximum power to the bit, allowing the V-Pilot system to break through the toughest formations and increase rate of penetration (ROP).

The V-Pilot system automatically retracts all pistons at higher rotary speeds, for example, while backreaming. The mechanical design can tolerate very high levels of weight-on-bit without inducing ledging, while further improving ROP and consistently delivering excellent hole quality.

V-Pilot System Benefits

- Helps improve ROP compared to steering vertically with conventional motors.
- Helps reduce time for bit trips and remedial hole conditioning (backreaming, short trips).
- Helps improve success with running casing due to consistently high borehole quality.
- Perfect for «lean» casing design wells.

V-Pilot System Features

- Robust – no electronics.
- Automatically seeks vertical when inclination exceeds 0,2° with no user intervention.
- Suitable for high temperature applications.
- Tolerates wide range of drilling parameters, including high weight-on-bit without causing ledging.
- No particular bit pressure drop required.

INDICATIVE PROPERTIES OF ELEMENT COMPOSITION OF PLANT TOP BY THE EXAMPLE OF ALFREDIA CERNUA (L.) CLASS

E.A. Litusova
Scientific advisors associate professor N.V. Baranovskaya, associate professor I.A. Matveenko
Tomsk polytechnic university, Tomsk, Russia

Alfredia cernua (L.) Class of Asteraceae family is a perennial herbal plant growing in tall grass fields and lighted fir-spruce forests. In folk medicine the top of plants is used as a sedative, anticonvulsant and analgesic remedies in fees - with enuresis, neurasthenia, schizophrenia.

We have studied the elemental composition of plant top as it is a unique indicator of environmental pollution. It is just this plant where both harmful chemical substances from soil solutions and atmosphere and vital elements are accumulated.

Using instrumental neutron - activation analysis we studied 24 elements of the plant top - Alfred drooped gathered in the Republic of Gorny Altai, the Republic of Khakassia, Altai Krai and Tomsk Oblast, in 2001, 2005 and 2006. The changes in the content of elements depending on the location and year of sampling were analyzed. The plant tops were taken at different stages of development: budding, flowering and fruiting. The samples were selected by the workers of the Research Institute of Pharmacology, Russian Academy of Sciences. The plant was dried to air-dry state and grinded up to the size of particles 2–5 mm. Combustion (ashing) of the samples was carried out in a muffle furnace at temperature 450–500 ^{o}C according to the GF XI (1990). Then the ash was weighed and sent to the nuclear-geochemical laboratory of TPU training reactor for analysis.

To compare the elements accumulation levels in plants of different habitats the diagrams characterizing the dependence of elemental composition of the different sampling locations on the average content of elements in the ash of S.M. Tkalich (1969) were constructed (fig.).

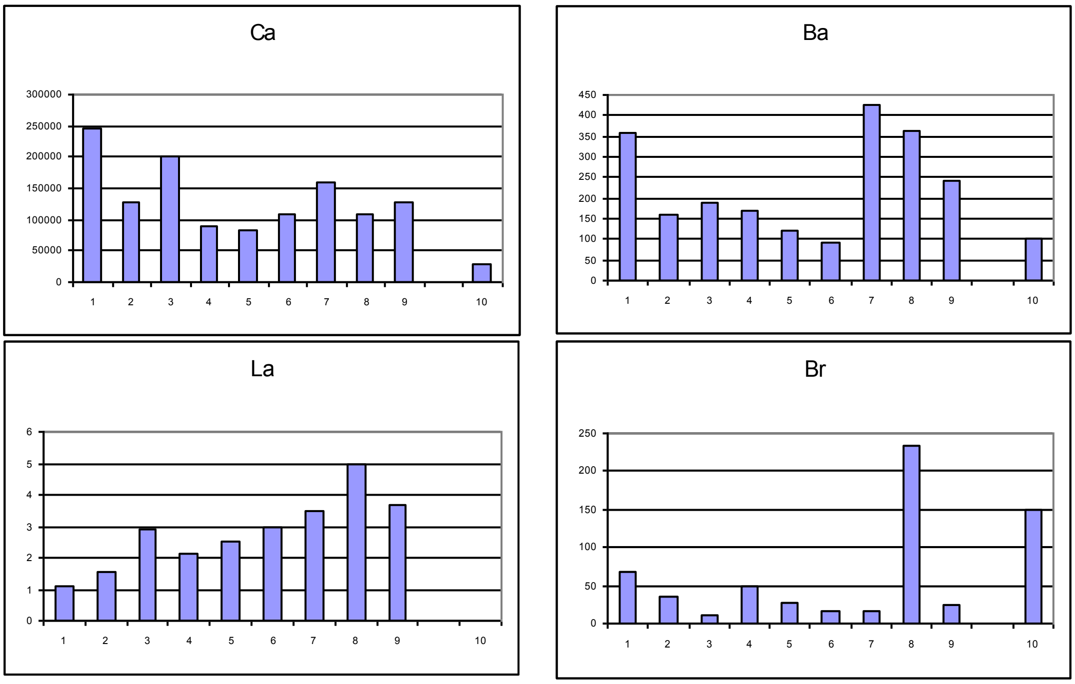

Fig. Diagrams of element distribution in the ash Alfredia cernua (L.) Cass. depending on the sampling locations. On abscissa axis - the sampling points 10 - the average content in the ash of S.M. Tkalich (1969). On Y-axis - content of elements in the ash (mg / kg)

It should be noted that equally high concentrations in all samples is typical for calcium, this is due to the fact that the element is necessary for plant activity and growth, so it is stored in large quantities. The similar situation is for bromine which is specific for medical plants. Mechanism of its accumulation was found as early as in the 1930–40's (Selivanov, 1939). Thus, the sampling points 7 and 8 (a botanical garden Tomsk, 2005 and 2006.) indicate multiple difference in element concentration in years that may be explained by a possible emissions by near-by industrial plants.

Thus, the diagrams demonstrate biogeochemical peculiarities of medicinal plants Alfredia cernua (L.) Cass clearly. They prove the appropriateness of its use to characterize the element composition compared to the average content of S.M. Tkalich (1969). On the whole, it can be concluded that there are some differences in the plant ash according to chemical elements in years and sampling places. Besides, this plant can be used as an indicator of environmental pollution. Accumulation of bromine indicates the necessity in taking into account the place of plant gathering because plants with greater concentrations of this element may have a more pronounced depressant effect on the nervous system of a man.

PETROGRAPHICAL CHARACTERISTIC OF COUNTRY ROCKS OF CHASCHKAT AREA

O.V. Logvinenko
Scientific advisor associate professor L.A. Krasnoshchyokova
Tomsk polytechnic university, Tomsk, Russia

In the context of this work there was made a research of material constitution and the role of the superposed processes of country rocks of Chaschkat area. The aim of this work is to study the role of dynamometamorphism and metasomatism processes as searching criteria for gold mineralization.

The Chaschkat field is situated in the east of Western Siberia on the south-east flank of Kuznetskiy Alatay.

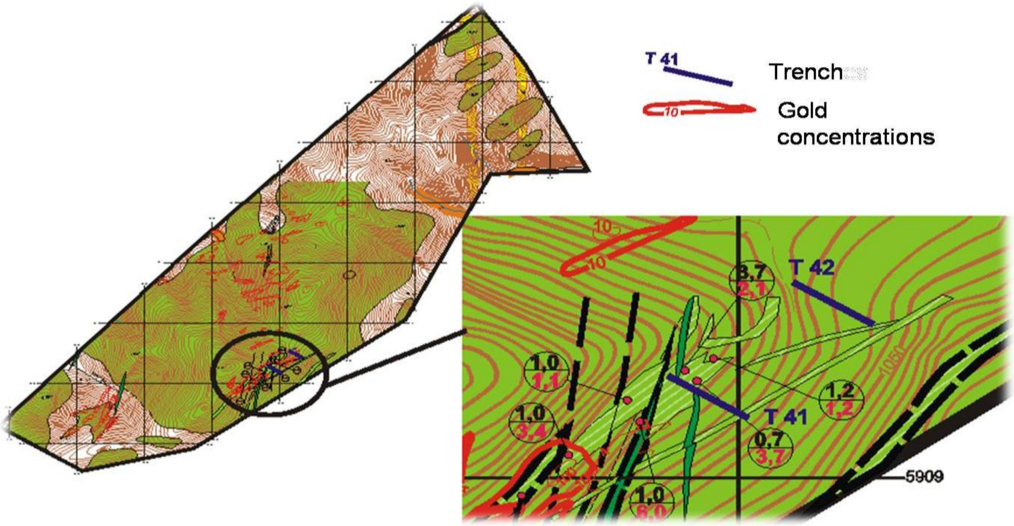

Fig. 1. Geological map of Chaschkat area (1:10 000)

Strata section of area is introduced by lower Cambrian deposits. At the basis [1] sediments are represented by andesites, basalts, theirs tuffs, siltstones and chlorite shales of the Atdaban layer of lower Cambrian. Deposits are located in the south and south-east part of the field. Upper layers are introduced by ore-bearing subgreywackes with slate, siltstone and tuff bands. The ensemble of this rocks show flysch formation formed on the slopes and terraces of andesite-basaltic isle structure. Rocks stretch to the north-east along the Chaschkat ridge and dip prior to the north-west at an angle of 50-80 degrees.

Igneous rocks within the field are represented by porphyritic gabbro and gabbro-diorytes of Kyndystyulsskiy complex of low-middle Cambrian age. Mentioned igneous rocks caused hornification and marble of sediments.

Zones of linear dislocations in Chaschkat area are linear stretched tectonic structures. These zones contain gold mineralization; dynamometamorphism of zones displayed with mylonitization and metasomatism processes like silicification, chloritization, amphibolization, epidotization and so on.

Detailed petrographical and mineralogical researches of ore containing deposits allowed to study the role of processes and make some deductions.

Analyzed samples were taken from trenches T–41 and T–42 crossing the zones of dislocations, containing gold mineralization (fig. 1).

Fig. 2. Mylonite with mottled structure. T–41. Cataclastic, friction texture

Dynamometamorphism and metasomatism processes appeared locally and with different rate and expressed in texture and structure changes, formation of new minerals and mineral associations. Analysis of typical rock altered features was shown below.

Mylonite is a fine-grained metamorphic rock showing banding and micaceous fracture, formed by the crushing, grinding, or rolling of the original structure (fig. 2). It can be characterized by cataclastic friction texture that indicates high stress circumstance [2].

Amphibolization, epidotization and albitization [4] are widely prograded in gabbro, spilite and other igneous rocks. They often accompany each other and can develop in the same rocks. Process of amphibolization occurs in replacing of pyroxene to amphibole (fig. 3); in many cases it is possible to trace all stages of this process – starting with light replacing of pyroxene grains from the borders to the full replacing. In metasomatically altered rocks epidote, actinolite and chlorite form nematogranoblastic aggregates (fig. 4).

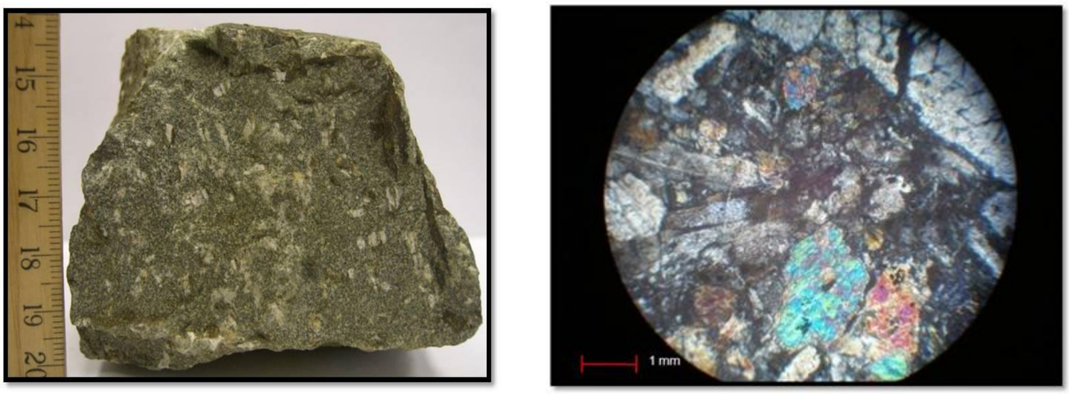

Fig. 3. Gabbro. T-41. Porphyraceous texture. Stress cracks and their systems are observed in plagioclase grains. Newly forming minerals form borders around pyroxenes. + nicols, zoom 72

All quartz containing rocks show quartz recrystallization what is typical for contact metamorphism. Mosaic texture [3] is also an indicator of contact metamorphism (fig. 4).

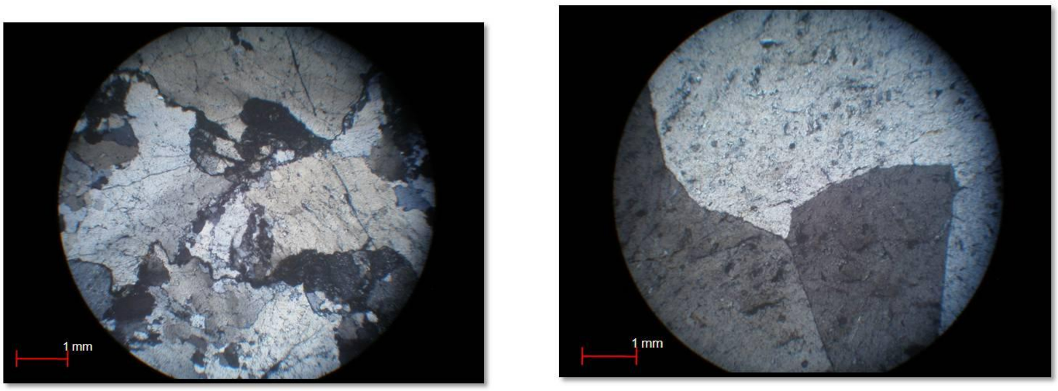

Fig. 4. Effusive rock with schistoise-porphyraceous texture. Quartz recrystallization. + nicols, zoom 72

The structure of metamorphic rocks is of importance because it shows the nature of pre-existing rocks and the mechanism of metamorphic deformation. It gives an opportunity of analyzing the mineralization forming processes and can be adapted as searching criteria.

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ASSESSMENT OF ENVIRONMENTAL GEOCHEMICAL CONDITION OF THE SMALL RIVER USHAYKA (TOMSK REGION)

O.S. Naimushina
Scientific advisors professor S.L. Shvartsev, associate professor I.A. Matveenko
Tomsk polytechnic university, Tomsk, Russia

The river Ushayka is the right inflow of the river Tom, flowing into it on the site of the bottom current (fig.1). This river is referred to small waterways with the catchment basin area up to 5000 km^2. Thawed snow waters, liquid precipitations, and underground waters contribute to the river input. Besides, the considerable role is played by the sewage making approximately 7–8 % of annual flow. By quantity of atmospheric precipitation the given territory belongs to a zone of moderate humidifying. Waters of the river Ushayka are fresh, mainly with average mineralization, neutral or alkalescent, hydrocarbonate calcium. Average annual charge of Ushayka during the observation period amounts 4,3 m^3/s.

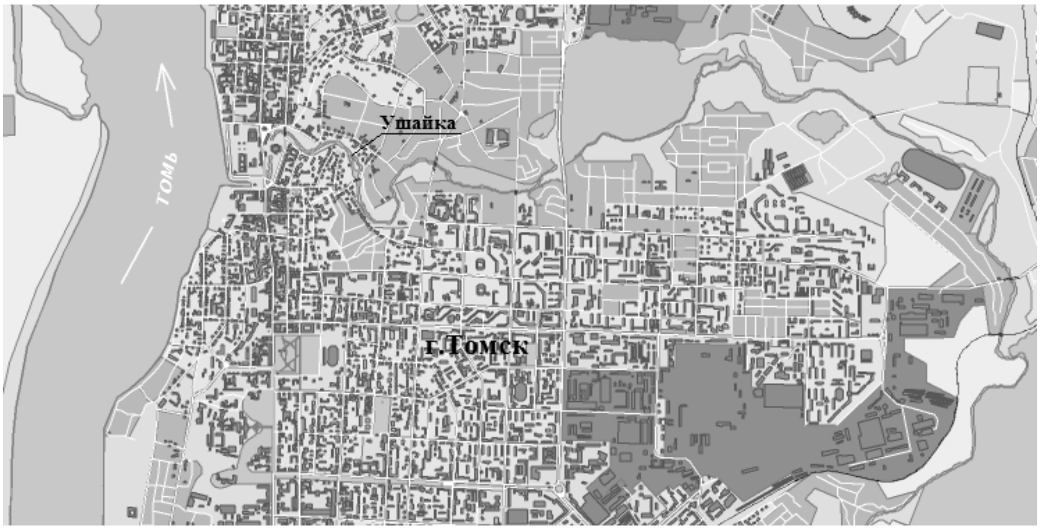

Fig. 1. Arrangement of the river Ushayka

Average concentration of the suspended substances in Ushayka waters makes 22–44 mg/l at maxima to 120 mg/l and more according to Russian Hydrometeorological Service. In this case it should be noted that statistically reliable relationship between charges of water and concentration of the suspended substances typical for river waters of the region [3] is absent. Presumably, it could be explained by the impact of anthropogenic factors, the exposure time of which does not necessarily coincides with the typical dates of natural fluctuations in the river water content.

Tomsk area covers 25210 hectares about 12 % of which makes the site of catchment basin of the river Ushayka flowing into the river Tom' in the central part of the city. Just on the territory of this site there are numerous residential buildings and large industrial enterprises such as Power station-2, «Emalprovod» plant, Radio engineering and Large-panel Construction plants, railway station, and a number of less considerable objects. Besides, sewage canalization comes into river Ushayka. Thus, it is necessary to notice that the main sources of polluting substances are the release of the rainwater disposal sewage and domestic drainage in the near-mouth of the river Ushayka.

The withdrawal of water from the investigated river in volume is much less than dumps of sewage and makes about 0,2–0,3 % of water yield in the river Ushayka. As a whole, this kind of water use makes insignificant influence on the hydrological regime of the investigated river, including geochemical regime.

According to the data obtained during the spring-summer period of 1999, water of the river Ushayka and its inflows is fresh with increased mineralization (500–700 mg/l), hydrocarbonate calcium, alkaline (table).

Table

Macrocomponental structure of Ushayka river waters of 1999, mg/l

№	pH	M	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	CO_3^{2-}	SO_4^{2-}	Cl^-
average	8,50	571	95	19	16	3	401	12	14	10
max	8,77	683	112	30	50	19	488	30	60	31
min	7,95	499	82	12	9	1	329	<1	3	1

Analyzing the spatial transformation of macrocomponent structure of the Ushayka waters the tendencies of certain reduction in concentration of ions HCO_3^- and Ca^{2+} from the sources to the mouth have been revealed.

This is likely to be connected with gradual dynamic balance in the process of river water flowing between the atmospheric carbonic gas and that dissolved in water as the result of which it is possible for calcium carbonates to precipitate, for pH and calcium and hydrocarbonates to reduce in comparison with the underground waters of sources forming the river drain [4].

The obtained data show the supersaturation of waters with carbonate minerals, calcite in particular.

At the same time the increase in concentration of SO_4^{2-} and Cl^- (fig. 2) is observed, that indicates their intake with sewage. Studying the data on spatial transformation of chemical compound in water (below Power station-2 the content of sulphates and chlorides decrease) and the analysis of materials on discharges allow us to make a conclusion that there is solution of industrial and domestic waste by ground and surface waters on the given site.

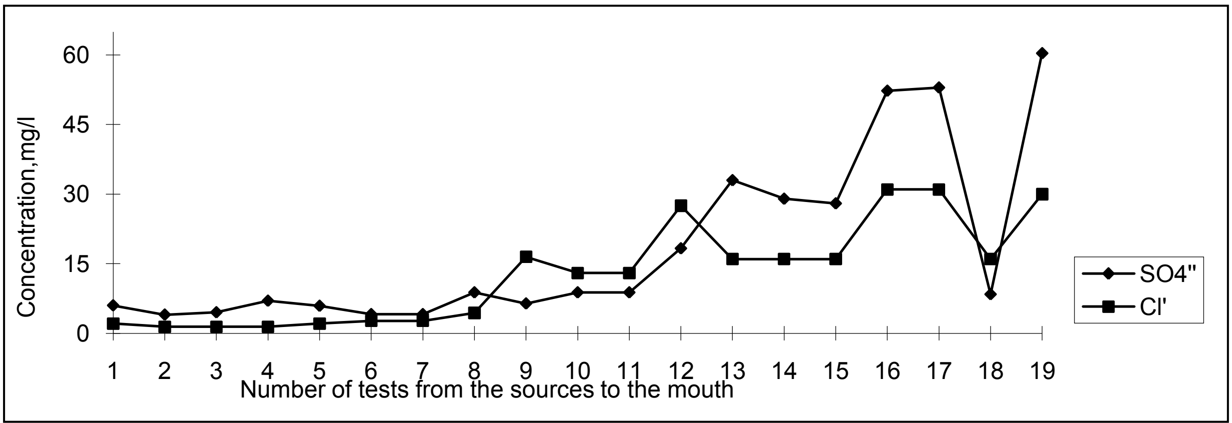

Fig. 2. Transformation of concentration of SO42 and Cl - along the Ushayka river

It should be noted that waters in the river Ushayka are disbalanced not only in carbonate minerals but also primary aluminosilicates. However, in contrast to carbonates only their dissolution is possible in this case. Thus, the steadiest minerals are kaolin and Na-montmorillonit (Fig.3). It is remarkable that formation of the latter is possible at the strongest pollution of river waters. Considering an arrangement of points on the diagram presented in Figure 3, it is possible to assume that formation of clay minerals along with sorption processes and an ionic exchange plays a significant role in self-regulation of water chemical compound after the system has been disbalanced owing to sewage discharge.

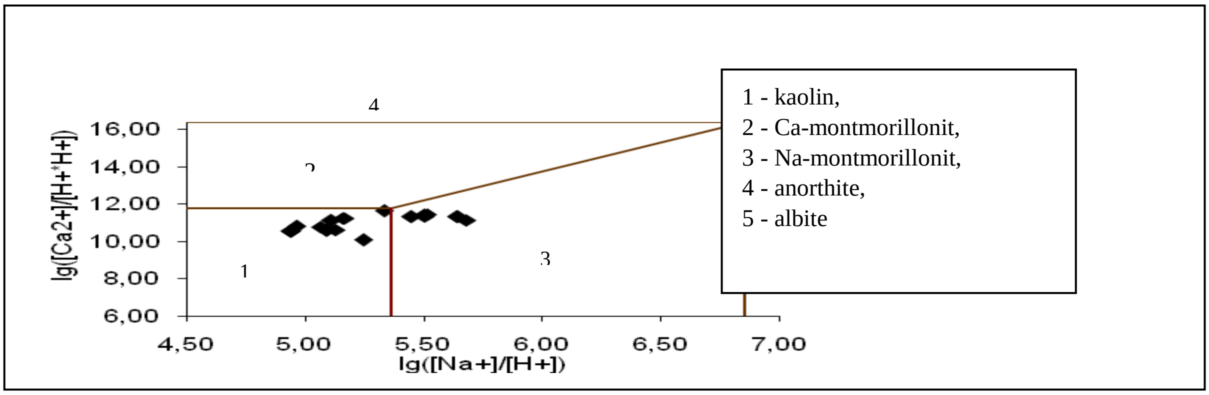

Fig. 3. System HCl-H_2O-Al_2O_3-CO_2-CaO-SiO_2-Na_2O at 25 °C,
lg [H_4SiO_4] = –3,5 with drawing of data on water structure of the river Ushayka

Content of microelements in waters of the river Ushayka and its inflows is insignificant in general. Thus, even the highest concentration of the considered microelements does not exceed the specification of economic-drinking water use.

The analysis of long-term observation of Federal Hydrometereology and Environmental Monitoring Service with application of the pollution Index of waters has shown that waters of the river Ushayka within Tomsk city belong stably to the group of «polluted» and «highly polluted» waters. The obtained results indicate that quality of water in the river Ushayka deteriorates considerably during the spring-summer period from the sources to the mouth changing from «pure water» degree to «exclusively dirty» one. The most considerable pollution of river waters is naturally observed within the territory of Tomsk, and its maxima are dated to the locations of sewage discharge from «Tomskvodokanal» and the rainwater disposal.

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FEATURES OF THE BOBRIKOVSKY HORIZON ROCKS MATERIAL CONSTITUTION AND CONDITIONS OF THEIR FORMATION ILLUSTRATED BY THE HOLES № 40101, № 16186, № 40052 OF THE ROMASHKINSKOYE OILFIELD DEPOSIT № 33

M.A. Naumova
Scientific advisor associate professor N.G. Nurgalieva
Kazan state university, Kazan, Russia

The Bobrikovsky horizon structure according to the correlation diagram analysis and geologic profile

The oil deposit under consideration is confined to the Bobrikovsky horizon of the Vizeisky storey's Yasnopolyansky subhorizon of the Lower Carboniferous. An average occurrence depth is 1098, 8 metres.

A terrigenous stratum is formed with sandstone, siltstone and argillite. An impermeable band of the Tulsky horizon rocks serves as a pool cap. It is about 8–10 metres thick and represented by dark grey, clayey, silicificated, sometimes biogenic limestone. Within the bottom boundary of the Bobrikovsky horizon an excellent bench mark are the Elhovsky horizon argillites (2–6 metres thick), as well as the Tournaisian storey carbonate reservoirs in erosion zones of the Elhovsky clays within the upper boundary.

This thickness represents a unified hydrodynamic system that is proved with common oil-water contact. Oil-water contact is found at a depth of 890 metres.

Total thickness of the Bobrikovsky horizon is 26,7 metres at an average with variation interval from 20,0 to 37,6 metres. Total oil-saturated thickness is 18,6 metres at an average; thickness of water-saturated formation comes to 10,3 metres. Effective thicknesses are considerably smaller – about 6,0 metres in total; oil-saturated and water-saturated portions are 4,4 and 5,3 metres respectively.

Material constitution of rocks

In order to determine material constitution of the Bobrikovsky horizon oil-bearing deposits the following laboratory examinations have been carried out:

1. An optical- microscopic core analysis – examination of core thin sections from the holes № 40101, № 16816, № 40052 with polarizing microscope for the purpose to detect material constitution of rocks and structural features of reservoir's cavity space. The thin sections have been studied with the microscope MIN-8.

2. A battery of methods for definition of rocks reservoir properties on scientific-training basis of the department: open porosity ratio (kerosene saturation method), oil saturation ratio (extraction method with Soxlet's apparatus), absolute permeability, carbonate content (10 % hydrochloric acid treatment of rocks), grain-size distribution (Sabanin method - sieve analysis + clay fraction soaking in water).

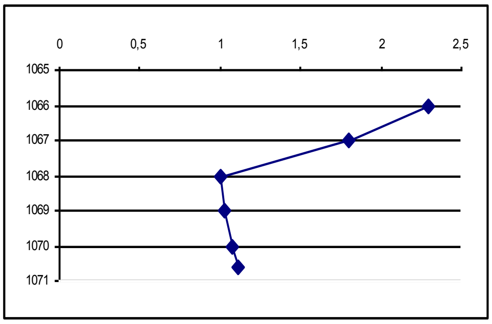

Fig. 1. Carbonate content ratio

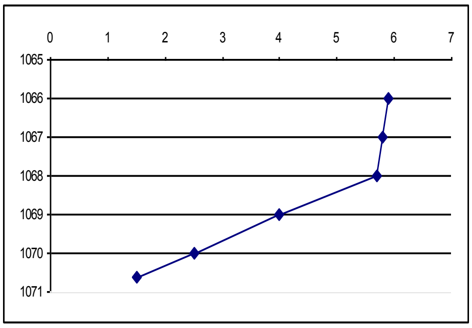

Fig. 2. Oil saturation ratio

10 samples have been studied. According to schedules, planned by the core examination, it's obviously that carbonate content ratio decreases with depth increasing, that also can be traced by results of the optical-microscopic core analysis. Oil saturation ratio decreases with depth increasing too (fig. 1, 2).

Results of the grain-size analysis of the Bobrikovsky horizon sandstone show that reservoir, represented in the hole № 40101cross-section, is nonuniform.

Thin sections examination has permitted to detect basic minerals, composing the rocks, and their percentage, type and specificity of rocks cementation, cavity-pore space structure of reservoirs. Subsequently 2 interstices types have been detected.

The first type has polygonal or irregular shape, and intergrain air space is often complicated with corrosion of quartz particles.

The second interstices type is characterized by big tortuosity and increased cohesion of pore channels. The channels delineate parts of reservoir matrix, in which particles have interlocked tightly through catagenesis. Generally quartz particles undergo coalescence.

Sediment grading is of defining value at generation of reservoir frame. Grading level rise causes porosity and permeability increase accompanied by good sediment sorting. However, this phenomenon is considerably more complex. So, clay is of maximum porosity, although it can't be a reservoir for lack of permeability. Theoretically, porosity must remain steady in spite of grain size increasing. If sand is a mixture of several fractions, under significant differences in grain sizes some of them locate in pore space and reduce porosity. This process takes place even through the lack of clay particles, purely at the expense of grain-size distribution. Naturally that maximum porosity is obtained with maximum sand sizing, i.e. if the vast majority of grains is of the same diameter. This indicates that grain-size distribution is defined by depositional environment dynamics, i.e. by paleogeographical conditions. These conditions influence on generation of raw sediment's primary reservoir properties.

Secondary processes may substantially change a rock structure. Grain size decreases through leaching and corrosion of grains, while regeneration processes lead to increasing of grain size. Therethrough sediment structure may change a lot. Reconstruction of primary grain-size distribution is of considerable difficulties. In granulometry interpretation it's necessary to allow for a probable distortion of sediment structure. For this purpose it is necessary to establish facts of corrosion and regeneration by thin sections examination and estimate their influence on dimensional change.

Grain shape and rounding are of a great importance for reservoir properties formation. In the study of granular reservoirs it has been determined that quartz grain shape is variable. (Quartz is the most common mineral of granulated reservoirs). Grains tend to obtain spherical or ellipsoidal shape. Degree of grains rounding depends on their size, physical properties, carrying duration. Coarse grain is of better rounding degree than a fine one. Sand grains become more rounded if decay and abrasion processes are intensive (fig. 3).

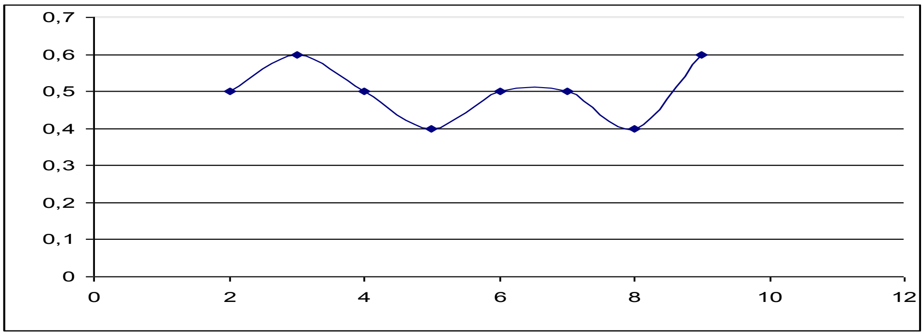

Fig. 3. Degree of quartz grains rounding

Lithofacies characteristic

A lithofacies map of the Bobrikovsky horizon reflects an early stage of the Vizeisky transgression which spread from the south-east to the west and northwest. This fact follows from horizontal lithofacies zonality.

Alternation of several limestone strata with terrigenous rocks marks oscillation phases of the Bobrikovsky basin and evidently activation phases of source area. This helps to explain complex cycling structure of the western cross-sections, where the Bobrikovsky horizon is entirely represented by terrigenous deposits. According to the GIS data, deposit composition shows that a new sedimentation cycle started at the Bobrikovsky time. In the south-east and south-west this cycle was accompanied by transgression.

Only coastal facies has substantial difference between clayey complexes of clays and sandstones. This is indicative of deltaic dump existence, taking place from time to time in conditions of uncompensated seabed downwarping. Detritus bad cull and profile stratification can be accounted for the same reason.

In terrestrial facies clay minerals complexes reproportioning occurs in the same range, though clayey complexes of clays and sandstones undoubtedly differ. Evidently, they have been formed in the same region conditions, and changes have been local, tidal, or seasonal. These changes have been accompanied by variations of sea basin salinity and source area that have caused a certain revising in clayey complex compound.

According to the lithofacies map it's obviously that the area of the Romashkinskoe oil-field has been occupied with the sea. Optical- microscopic analysis proves such a kind of terrigenous sediments generation conditions. Mineral composition of the samples, represented by quartz and feldspar, indicates the same. Small cement content and medium rounding confirm that the rocks have been formed at the seaside.

The examination of the samples from 3 Bobrikovsky holes shows that island occurred periodically within the sea basin area. Sedimentary material carried away from these islands to the sea basin. This fact proves that the hole №40052 was situated closely to the source area, this can be traced by bad-sorted quartz grains.

The hole № 16186 was situated in periodically swamped area. Its grains are medium- and bad-rounded. The finding shows that sediment accumulation occurred later than in the hole №16186 and the area was swamped.

Gradually shallowing and desalination of the sea basin area have been taking place, and so chiefly clay alternated with sandstone and siltstone has accumulated.

IMPROVEMENT OF CARBONATE RESERVOIR DEVELOPMENT EFFICIENCY CONTAINING HIGH-VISCOUS OIL (BASHKIR STAGE, AKANSKOE OILFIELD, TATARSTAN)

M.A. Petrov, I.A. Filippova, M.I. Manapov
Scientific advisor assistant R.F. Vafin
Kazan state university, Kazan, Russia

One of the reasons for low production during development of carbonate reservoirs with high viscous oil is low porosity and permeability of bottom-hole formation zone. For recovery and improvement of carbonate rock reservoir properties, at present is widely used technology of hydrochloric acid treatment of bottom-hole formation zone.[1]

Akanskoe oilfield was discovered in 1957 and developed from 2000. Reservoir of Bashkir deck consists of different genetic types of limestone with few interlayers of dolomite, micro and macro cavities (the main fluid conductive system) of chaotic and subvertical direction. Porous, fissured varieties of limestone are oil productive on all area of Akanskoe oilfield. Total oil thickness changes from 2,2 to 17,2 m. Layer temperature of Bashkir is +23 ºC, oil density on bedded conditions is 0,921 g/cm^3 , viscosity is 274,5mPa·sec. Level of reserve depletion of Bashkir is 0,9 % from initial recoverable reserves; current water cut is 9,3 %; average discharge of oil is 5,01 tones per day, of fluid is 5,53 tones per day.[2]

We worked in the laboratory of «Modeling of physico-chemical processes in the bed». «NIINeftepromkhim» corporation researched different technology decisions during hydrochloric treatment of bottom-hole zone. Experiments were made with real carbonate core samples, which were selected from Bashkir sediments of Akanskoe oilfield (fig. 1, 2).

Fig. 1. Carbonate samples from Bashkir sediments

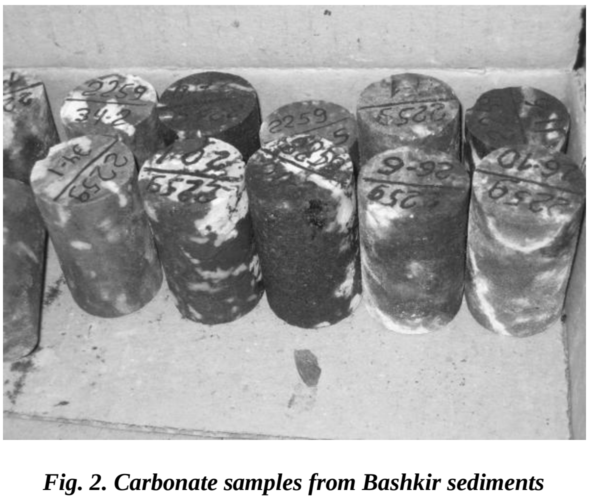

Fig. 2. Carbonate samples from Bashkir sediments

After series of experiments we selected the most appropriate technology for acid treatment of bottom-hole formation zone on Bashkir sediments of Akanskoe oil field. The following conclusions were made:

- It is necessary to use 22–24 % HCl solution for acid system to come to bed with high concentration;
- For improvement of effectiveness of realized hydrochloric treatments, it is necessary to add reagents in solution of HCl, which will give inhibitory and stabilizing properties. Especially for Akanskoe oil field was selected multifunctional СНПХ-8903А addition, which was created in «NIINeftepromkhim» corporation (fig. 3).

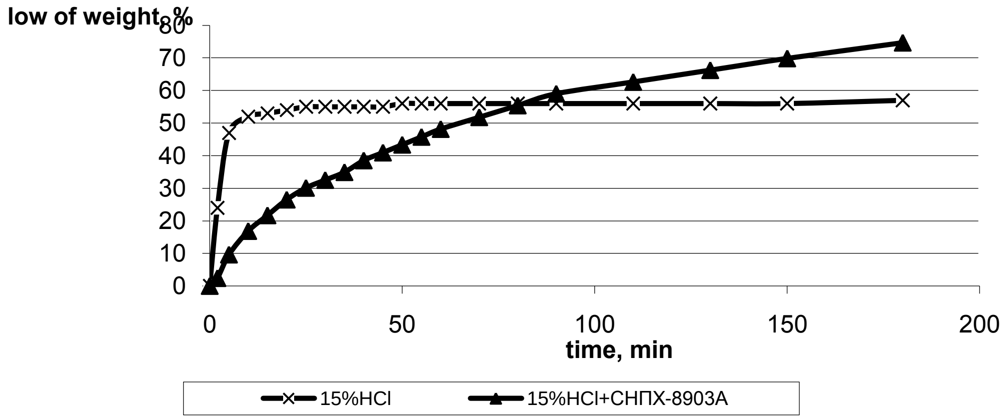

Fig. 3. Solvent ability of 15 % HCl and 15% HCl + СНПХ-8903А in reaction with $CaCO_3$

- For proportional and full reaction in high viscous oil conditions we recommend to inject edging of organic resolvent before the injection of acid system. It is necessary for the removal of the solvate coating of pitch and paraffin substance from the porosity wall. We analized next organic resolvents: mean fraction of butanol, nefras, distillate. Nefras showed the best results (table) [3].

Field tests of this technology on high seamy intervals showed that it is necessary to inject high viscous composition before treatment (for example: water-oil emulsion or polymer solution). It is needed for lower well injection capacity, as acid system can get away by the cavity from bottom-hole formation zone without reaction to far zone of bed (fig. 4)

Table

Results of experiments with organic resolvents

Amount of $CaCO_3$ enter into reaction with HCl (middle level), gr			
		Composition	
		15 % HCl + СНПХ – 8903А	15 % HCl
With solvent bank	nefras	1,002	0,89
	butanol	0,902	0,77
	distillat	0,87	0,7
Without solvent		0,842	0,63

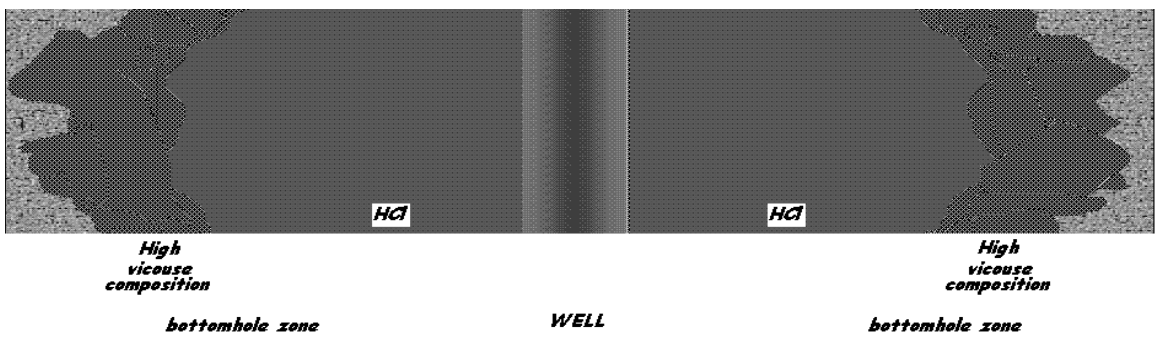

Fig. 4. Inject high viscous composition before acid treatment

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ESTIMATION OF EFFECTIVENESS IN THE APPLICATION OF TECHNOLOGIES FOR INCREASING OIL RECOVERY DURING THE DEVELOPMENT OF DEPOSITS WITH THE HIGH-VISCOSITY OIL EXPLOSIVE

V.V. Poplygin
Scientific advisor professor V.A. Mordvinov
Perm state technical university, Perm, Russia

Expediency and effectiveness of the application of different methods and technologies, directed to increase the current oil selections and oil recovery, depend on the quantity of the residual extracted reserves in the productive layers, on the composition and on the properties of rocks and stratified fluids, and also on the expenditures, connected with performing work on the project realization, and market oil prices.

The significant decline of the oil recovery rates besides the dynamics of water cutting in the well production is one of the arguments in favor to the application of a number of actions to the layer, which increase the oil recovery factor.

The heterogeneity of productive layers, the high viscosity of stratified oil and other factors, which complicate the development of deposits, determine the set of requirements that must be considered for the technical and economic substantiation of the technology selection. Solution of the problem requires the application of contemporary programs, utilized for the creation of the geological-hydrodynamic models for the deposits that help to evaluate and optimize the technological indices of the project.

At present we have executed the estimation of effectiveness in the application of technologies for increasing oil recovery for the carbonate deposits in the Bugrovskoe oilfield (CJSC «LUKOIL-PERM'»).

The oilfield is characterized by high viscosity and low gas saturation of oil (table 1) as well as by the weak activity of water-pressure system. Technological indices of the oilfield development for 01.01.09 are given in table 2.

The design coefficients for oil recovery of the layers of Bsh and T constitute, correspondingly, 0,35 and 0,40. The current actual indices of Bsh layer deposit development are exceeding the design, in case of the T layer deposit they correspond to design (table 2). With the existing field development system the delay will occur of the indices of development from the design (fig.). Their improvement is possible thanks to the application of the methods for increasing oil recovery factor.

In conditions of the Bugrovskoe oilfield deposits, in accordance with [1] and [2], to increase the oil recovery it is necessary to examine, in the first place, the thermal methods and method of polymeric water-flood. During the calculation of technical and economic indices alongside with these technologies the method of water-gas action is examined (cyclic rocking of water and gas).

Table 1

Geological- physical characteristic of the oil deposits of the Bugrovskoe oilfield

Parameters	Bsh	T
The average depth of the bedding, m	1302,5	1637,4
Type of collector	carbonate	
The average oil-saturated thickness, m	4,3	6,4
Porosity, %	16	16
Permeability, mkm^2	0,097	0,189
Initial reservoir temperature, °C	27	31
Initial reservoir pressure, MPa	13,0	16,6
Viscosity of oil in reservoir conditions, mPa·s	7,91	87,08
Oil density under the reservoir conditions, t/m^3	0,856	0,914
Oil density under the surface conditions, t/m^3	0,871	0,926
Volumetric coefficient of oil, portion of ones	1,032	1,021
Pressure of oil and gaz saturation, MPa	5,05	8,90
Gas content, m^3/t	10,3	6,6

The working hydrodynamic model of the oil deposits of the Bugrovskoe oilfield is executed in the program packet of Tempest More (model of black oil) and is isothermal two-phase. The thermal function of the model is activated to simulate the development with rocking of heat-transfer agent. The physical and chemical properties of species and fluids, depending on temperature, are determined using the procedure, presented in [2]. During the polymer injection on the basis of the model the functions of injection and of reversible adsorption of polymer are activated [3]; the dependence of changing of the viscosity of water due to the polymer concentration is accepted for the aqueous solution of polyacrylamide [1]. For the realization of water-gas action in model the gas phase is included and its properties are calculated with the assigned composition of gas using the procedures, presented in [4], the re-calculation of phase permeability is produced. Water-gas action is considered as the immiscible filtration of gas, oil and water in the layer.

Table 2

The basic indices that characterize the state of the development of the oil deposits of the Bugrovskoe oilfield

Layer	Acting fund of oil productive wells	Degree of exhausting oil recivery, %	Water cutting, %	Oil recovery for 01.01.2009		
				Current	Design	Model
Bsh	6	34,1	41,8	0,092	0,08	0,092
T	8	38,2	27	0,088	0,088	0,085

With help of the hydrodynamic model the variants are calculated and they differ in volumes and temperature of heat-transfer agent, concentration of polymer in the inject rocking water, parameters of injection period under the water-gas influence. Also the base version is calculated (with the present parameters of development). A quantity of versions with injection of heat-transfer agent has composed – 16, with rocking of polymer – 11, with the water-gas action – 2.

All calculations are executed for the period of 15 years, beginning from 01.01.2009.

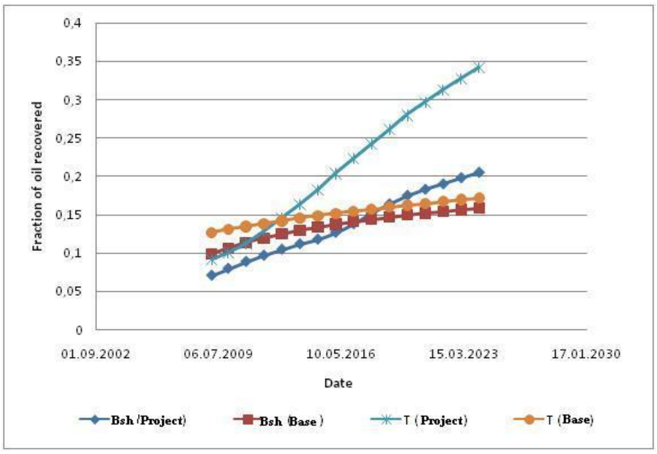

Fig. The dependence of design and calculated oil recovery on the time

The best results for the technology of heat-transfer agent injection are obtained with the forcing of water vapor with the water temperature of 85 °C on the face of the bore hole. In the implementation polymeric water-flood the best indices of development are obtained during the rocking into the layer of the edgings 2 % solution of polyacrylamide.

Increase of oil recovery coefficients due to the application of the best versions of each technology for the layer by the end of the calculated period is represented in table 3.

Table 3

Results of the hydrodynamic simulation

Layer	Oil recovery for the end of the calculated period				
	Design	Base variant	with the application PNP		
			Heat-transfer agent	Polymer	VGV
Bsh	0,223	0,161	0,173	0,200	0,169
T	0,342	0,172	0,197	0,182	0,179

To achieve the temperature of water of 85 °C on the face of the injection wells the required temperature of the forced fluid on the mouths of bore holes must be not less than 250 °C. The estimation of economic effectiveness of the measures is represented in table 4.

The heat-transfer injection agent can be conducted with the stationary and nonstationary systems. Injecting in the nonstationary system is possible with the help of the mobile units, however, short-term action on the layer does not give the essential effect. The introduction of steady states requires the use of steam-generator installations of the type UPG [1]. The return on project for the deposits during the stationary rocking of heat-transfer agent is 14,5 years.

In general for the carbonate deposits the method of rocking the polymer is the most effective to increase the oil recovery. The payback period of the polymeric water-flood for the layers does not exceed 3,5 years.

Table 4

<table>
<tr><td rowspan="2">Layer</td><td colspan="3">Net present value, mln.rub.</td></tr>
<tr><td>Inject heat-transfer agent</td><td>Injection of the polymer</td><td>VGV</td></tr>
<tr><td>Bsh</td><td rowspan="2">2,2</td><td>74,9</td><td rowspan="2">10,7</td></tr>
<tr><td>T</td><td>26,7</td></tr>
<tr><td>Sum</td><td>2,2</td><td>101,6</td><td>10,7</td></tr>
</table>

With increasing the viscosity of stratified oil the technological effect during the injecting of polymer decreases, during the rocking of heat-transfer agent it grows.

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HYDROCARBON GENERATION AND EMIGRATION MODEL

S.A. Popov
Scientific advisors professor V.I. Isaev, associate professor D.A. Terre
Tomsk polytechnic university, Tomsk, Russia

Estimation of climate factor influence on thermal conditions of sedimentary profile, localization and intensity of oil-gas generation sections within Verchnelaminsky swell were discovered on the basis of a number of investigation results. Accumulation scales have been estimated by means of integral index calculations and ranking of areas to oil-and-gas content prospects has been conducted.

The next stage of the research is concerned with elaboration of numerical model of hydrocarbon generation and primary migration (emigration) (HGE-model) from oil source rock and, consequently, quantitative assessment of oil-and-gas-source layer (OSL) potential on the basis of this model. The algorithm of oil-and-gas production based on a set of methods, that are most often used for this type of modeling - pyrolytic method Rock-Eval and chemical reaction kinetics method (Ar'ye method) has been examined in this article.

The model can be applied for estimation of HGE intensity in time taking into account thermal history, geodynamic parameters and dispersed organic material (DOM) type. The main characteristics that should be estimated are dependences of OGSL oil-production and gas-production from temperature and depth.

Physico-geological conditions and limits include:

- Sedimentary profile from under-OGSL.
- Time is limited by the interval from the beginning of OGSL diagenesis to present days.
- The generation process begins when the current active energy (heat flow) exceeds the value of activation energy.
- Emigration occurs when the concentration of generated hydrocarbons exceeds dissolubility limit value. When C ‹C_0 there is dissolved hydrocarbon release. When C› C_0 the products are carried on as a free phase. C_0 stands for hydrocarbon limit concentration (dissolubility) in formation waters.

The reference quantity of reactive DOM can be calculated by a number of ways:

1. By using Rock-Eval method which suggests the following:

$\Gamma o_{н} = mn(S_1 + 0,5S_2)$;
$\Gamma o_{г} = mn(S_0 + 0,5S_2)$;
$\Gamma_{ост} = mnS_2$.

2. By using scaler coefficients of Neruchev.

The maximum response rate can be calculated by any of the equations listed below.

$\ln\Gamma_{ост} = \ln\Gamma_0 - \varepsilon_1 t$ (n = 1); $1/\Gamma_{ост} = 1/\Gamma_0 + \varepsilon_2 t$ (n = 2); $1/\Gamma_{ост}^2 = 1/\Gamma_0^2 + 2\varepsilon_3 t$ (n = 3),

n – reaction order (oil or gas n = 1; oil + gas or gas + condensate n = 2; oil + gas + condensate n = 3),

Γ и Γ_0 – DOM concentration at the current stage (for reversed problem solution – for a present day profile, for direct problem solution – for a given time period) and initial stage respectively.

Current response rate is determined on the basis of Arrenius equation, where preexponential factor is maximum response rate. Activation energy is set in the form of spectrum (for gas 50 – 200 kJ/mol, for petroleum 46 – 210 kJ/mol).

By using one of equations which characterize hydrocarbon concentration change we can determine total reactive DOM (rock volume) concentration value by formation of that or another stratum. The change in concentration over the period of the previous layer accumulation specifies DOM mass that was used for generation process (generation potential) by the formation period of the next suite. Pressing flow, formation water, residual fluid total rate are defined in the following way:

$$w_ф = m \cdot n \cdot \beta_п /1000;\ w_0 = mn + m\Gamma/\tilde{\rho};\ w = w_ф + w_0.$$

Current concentration of component of DOM decomposition product: $C = m\Gamma(1\text{-}e^{-\varepsilon\tau})/W$.

Integral value of OGSL generation production:

$$G := m \cdot \Gamma \cdot \left|1 - e^{-\varepsilon \cdot t}\right| \cdot \left[\frac{m \cdot \Gamma}{2 \cdot W \cdot C_0} \cdot \left|1 - e^{-\varepsilon \cdot t}\right|\right]$$

Oil-and-gas generation and emigration potentials have been calculated without taking into account repeated product transformations, i.e. for the first order reactions.

Modeling results

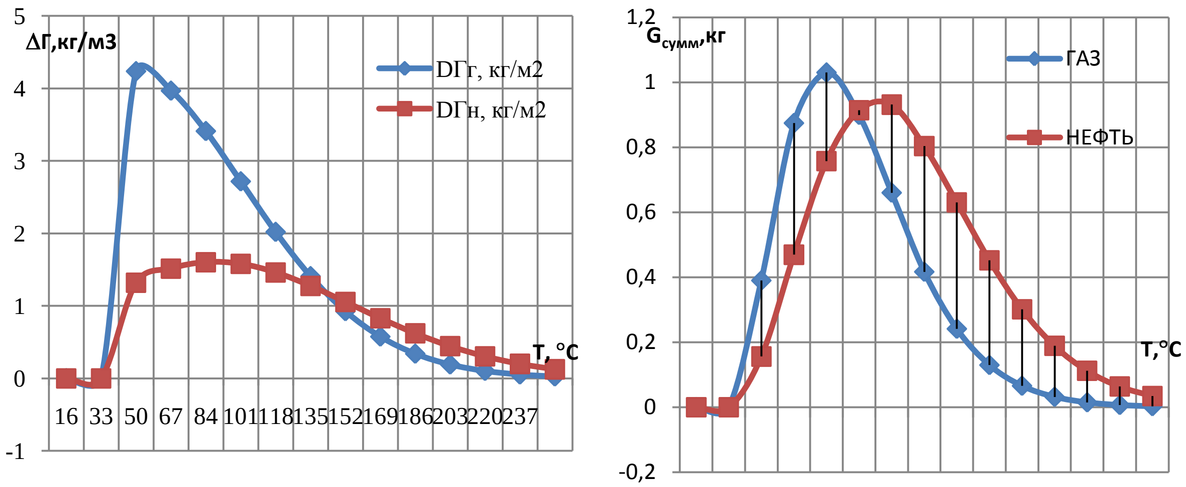
The given model modification is replication of the experiment conducted by A.E. Kontorovich. The qualitative interpretation and comparison of these method results are shown below.

There are dependencies of oil-and-gas generation and emigration potentials from temperature given in fig. 1. Dependency curves have been created with the value of resting permanent potential $S_2 = 0$ (kg /t).

Maximum generation intensity for these dependences conforms to 50 °C for gas and 84 °C for petroleum.

Maximum emigration intensity conforms to 67 °C for gas and 101 °C for petroleum.

On the base of these facts we can assert that emigration intensity maximum will be shifted to temperature increment. This means that more and more intensive influence of external factors (temperature and pressure) is required for outlet of generated products, as formation water amount is not capable to provide hydrocarbon outlet from oil-and-gas-source layer.



a b

Fig. 1. Thermal dependences of generation and emigration potentials:
a – generation ($S_2 = 0$); b – emigration ($S_2 = 0$)

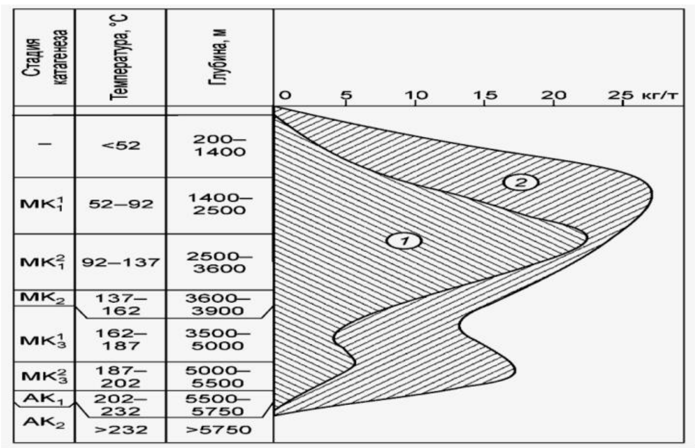


Fig. 2. Scale of catagenesis and zoning of oil-and-gas formation processes (A.E. Kontorovich)
Generation intensity: 1 - bituminoides, 2 – hydrocarbon gases

Generation potential curves conform to the data obtained by A.E. Kontorovich, but at the same time periods generation and emigration intensity maximum disposition differs remarkably, that, in its turn, influences oil and gas potential resource volume.

The existing differences in generation and emigration potential estimates are fully acceptable and possible as a consequence of statistic divergences of experimental data (chiefly from value of resting potential) and the factor of emigration delay.

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WALLROCK METASOMATITES OF DUCAT TYPE ARGENTAL ORE OCCURENCE

F.S. Prokopyev, Ya.D. Kuchinskaya

Scientific advisors professor V.G. Voroshilov, senior teacher N.S. Kemerova

Tomsk polytechnic university, Tomsk, Russia

In the course of this work the study of physical and chemical composition of metasomatically altered wallrocks of Krayny area and tracing their horizontal zonality was accomplished. The aim of this work is to reveal the searching criteria for tin-silver mineralization of Ducat type.

The object is situated in the northeast of Russia in Magadan region. The main tectonic structure of this area is Balygychano-Sugoysky deflection, which lies in the south-eastern part of Yano-Kolymskaya folded system and abuts on Okhotsko-Chukotsky volcanogenic belt. Mineralization Krayny is situated in the western part of Pestrinsky ore unit on the left bank of Columb stream. In the structural plan the ore field is arranged in volcano-tectonic construction that represents a deeply eroded volcanic apparatus of a central type, with a diorite pin revealing in the middle.

Only the sediments of Mesozoic age can be observed precipitated among and volcanic deposits in this area. The deposits of higher Triassic (T_3) are located in the central and north-western parts, and the deposits of lower Jurassic (J_1) are situated in the southern and south-eastern parts. These deposits are represented by sandstones, siltstones and by layers of tufa-sandstones. They form the basis of volcanic structure. The rocks lie monoclinally with a dip to the South-West at a 20–35 degree angle. Higher-cretaceous deposits of andesites and tuffs can be found in the southern and western part of this area.

Table

Results of RFA Analysis

№	K g/т	Ti g/т	Mn g/т	Zn g/т	As g/т	Rb g/т	Ag g/т	Sn g/т	Sb g/т	Ba g/т	Hg g/т	Pb g/т
140	33257	6033	576	1229	0	124	29	0	0	550	0	0
120	28858	6353	637	778	0	118	0	0	113	485	0	92
100	34100	6254	662	423	0	139	276	0	225	593	0	24
80	47388	6291	83	1326	3615	232	14	287	5934	798	252	12993
60	51539	5041	111	663	5590	301	24	353	1014	723	166	20641
40	53383	7428	114	353	2176	318	10	290	208	631	86	6974
20	46420	5083	110	238	1159	337	11	300	391	467	69	4394
Q Vein	-	-	-	10234	100935	-	5065	740	5467	-	-	160836
-20	47980	7276	105	495	3714	229	43	255	1219	488	92	852
-40	41818	6147	701	609	371	128	13	0	99	748	0	33
-60	37067	5796	514	691	219	108	138	0	0	802	0	30
-80	27456	6068	657	2372	327	68	6	0	51	447	0	0
-80	20565	6621	577	2110	137	56	0	0	0	461	0	0
-100	32335	6015	698	2209	0	71	0	0	0	690	0	0
Siltstone	39491	5713	1212	1086	0	57	0	0	0	1456	0	0

All intrusive formations of Krayny area are of Cretaceous age. The youngest abyssal formations of this area are diorites situated in the southern part of this mineralization. Magmatic activity was finished at the end of late Cretaceous with the intrusion of rhyolite dykes. Diorites are situated in the southern part of this area and controlled by two infractions. The pin occupies approximately 5000 m^2. The intrusion breaks through precipitation and volcanic deposits. Andesibasalt dykes come out in the north-western part of Krayny area. Docite pin and docite dykes lie in its central and northern parts. Two subparallel rhyolite dykes of meridian course are situated in the northwestern part of the area. The principal quartz-sulphide vein is located in the central part. The depth of the vein at a traced distance is changeable. An average depth of the vein is 0,7 m. The ore body falls at a 20-degree angle to South-East. It stretches from South-West to North-East and is marked by ditches over 1700 m. Halenit, which is the main mineral in vein, makes up its central part, forming lenses, hollows and streaks. The mineralization is highly unsteady; the content of silver varies from the first grams per ton to 21 kg/t. An average content of silver is 1672,3 g/t. The content of tin varies from 0,05 to 0,75 %. Apart from silver and tin, there was also found a high content of gold – up to 1,2 g/t.

This research is based on the rock material collected during the internship. The samples were chosen across the course of the ore body at intervals of every 20 cm. The general depth of the tested zone is approximately 3 m. This material was analyzed by means of roentgen fluorescent analyzer X-50 Mobile in the laboratory of TPU. This device can determine the concentration of elements in a sample from 1 g/t and higher. The ore body is surrounded by the area of active metasomatic alterations. Metasomatically altered rocks of the investigated area are introduced by argillisites. Minerals of hydromica groups and argillic minerals were found in sections.

As for geochemical zonality of agrillisites, it should be mentioned, that alterations major concentration are observed on the following elements: As, K, Ti, Mn, Zn, Rb, Ag, Sn, Sb, Hg, Pb. The rocks in the hanging wall of the vein are most heavily altered. Besides that the introduction and the removal of definite elements in the hanging wall are more intensive than in the footwall. Most elements were introduced during metasomatism. A clear removal can be traced by Mn and Sr. We should also pay attention to the fact, that lead, zinc, arsenic, antimony and some other elements have a very specific disposition in metasomatic column and their concentration in the inner zone is always lower than in the outer one (fig.). We believe, that this is caused by migration of these elements from the inner zone. It can be explained by equalization of chemical potentials of the elements during intensive mineralization [2].

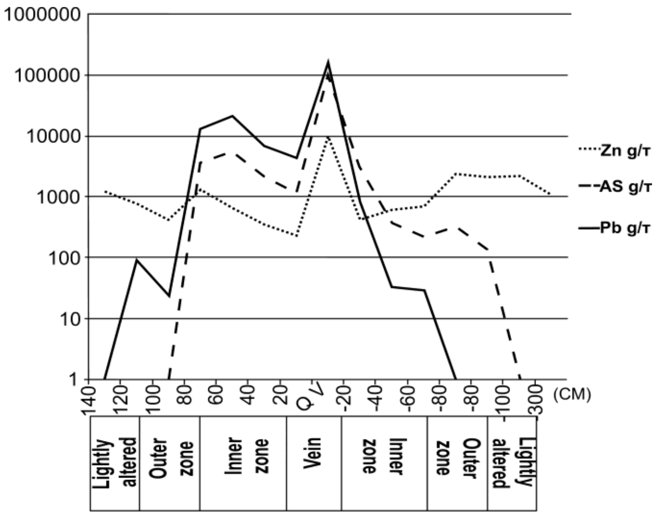

Fig. Zonality of ore elements (Zn, As, Pb)

Thus, during the processes of intensive mineralization the balance is upset. The system tries to restore the balance, a migration occurs from the inner zone of metasomatites into the vein of missing elements. The migrating elements should not be viewed as the main ore source. To our opinion, it explains the specific zonality of the metasomatic column.

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MODERN METHOD ANALYSIS OF PYROPHORIC SLUDGE AND TANK BOTTOMS CONTROL

R.V. Savitskiy
Scientific advisor associate professor L.M. Bolsunovskaya
Tomsk polytechnic university, Tomsk, Russia

One of the important problems of tanks operation is their cleaning.

During long-term operation, tank sludge forms, reducing efficient operating tank volume. The sludge obstructs oil flow and its movement through the tank, which, in its turn, localizes the concentration of aggressive salt solutions and further corrosion in tank bottom, welded seams and first tank belt.

It is necessary to note, that the sludge is distributed non-uniformly throughout the tank area, where its greatest thickness is created the remote distribution-connections pipeline that does not allow to measure precisely the actual quantity of oil in the tank. This, in its turn, reduces operation characteristics.

For reliable tank operation it is necessary to clean periodically the sludge. Periodicity of tanks clearing with mineral oil is established in accordance with GOST 1510-84. Tanks are cleaned out if necessary: from ground and pyrophoric sludge, high-viscosity deposits, and during tank diagnostics. To develop measurement requirements and methods, it is necessary to investigate structure of ground sludge as a starting point.

Bottom (underflow) sludge can have diverse enough structure, i.e.:

- mechanical inclusions;
- chemical compound – heavy hydrocarbons (paraffin, asphaltenes, oils);
- water;
- salts, sulphurous compounds.

Ways of tanks clearing and capacities are subdivided into three types: manual, mechanical and mechanochemical by applying washing-up liquids.

At a manual way of clearing capacity after removal of the firm rests are steamed, wash out with a hot water from a fire trunk at pressure (0,2 – 0,3) MPa. Bottling waste water with remained oil-slime pump out. Surface-active substances and other soluble substances in water could be added in water. Washout by water is the cheapest and rather fast way of sludge preparation to withdrawal from the tank.

Mechanised method of clearing surface pollution is washed by the hot or cold water submitted under pressure through special washing machines – hydromonitors. The mechanised clearing method considerably reduces clearing time, reduces tank idle time, reduces volume of heavy operations, which are injurious for health, and reduces tank clearing cost.

Hydromechanical water jet parametres influence the efficiency of clearing process established stream force with ground sludge, has optimum value, and is not in direct dependence of nozzle diameter and pressure of washing liquid stream.

The mechanised sludge removal of manual water washout has been applied in tank clearing technology «SUPERMAX».

Mechanochemical method of tank clearing by applying of washing-up liquid solutions improves quality clearing, intensity clearing process, characterises insignificant degree of manual application. The main disadvantage is its limited practical application, including specific agents and further clearing by washing-up liquid solutions.

Application of oil as a washing-up liquid excludes special chemical reagents and the problem regeneration of washing-up solution and recycling.

One of the most difficult labour-consuming and dangerous processes during tank cleaning is the removal of pyrophoric sludge, as it is flammable at -20 – -22 ^{o}C, which, in its turn, causes such damages as oil inflammation, tank break-downs and even human injuries. Pyrophoric sludge usually represents a mix of hydrosulphuric corrosion products, resinous substances, organic products and mechanical impurities.

Internal surfaces of tanks, pipelines and other equipment capable of formation pyrophoric sludge, cover with special sheetings – lacquer, cement, aluminium and other materials which do not cause formation pyrophoric sludge.

The clearing procedure is as following:

- internal tank walls should be watered;
- in damp conditions still complete removal of pyrophoric sludge;
- damp dirt and pyrophoric sludge is taken off the territory;
- it is buried at a safe distance flam tank location, due to the fact that dried-out pyrophoric sludge retains its properties.

In conclusion it should be stated that there are various highly-effective and technological methods to prevent tank bottom pyrophoric sludge formation.

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THE PROBLEM OF PIPELINE TECHNOLOGICAL MODEL CONSTRUCTION. WATER ACCUMULATION

R.E. Tereschenko
Scientific advisors associate professor A.L. Saruev, associate professor L.M. Bolsunovskaya
Tomsk polytechnic university, Tomsk, Russia

The necessity of conformity Russian major pipeline transport enterprises of petroleum to the international ecological standards ISO 14001 [1], sanctions toughening for environmental pollution and also increasing of illegal tapping of pipeline demands to increase sensitivity, reliability and leakage detection systems speed (LDS). All known monitoring methods of LDS are based on comparison of swapping and settlement controllable parameters, which are received by process modeling in real time. The conclusions reliability about presence of outflow substantially depends on used pipeline models. In spite of the numerous efforts of domestic and foreign scientists, we haven't yet mathematical models which can describe pipeline operational unit performance lowered in a lay of land. One of the reasons for lack of correct mathematical model is accumulation of any intratubal formation (there are water and gas congestions, adjournment of pitches, paraffin, silt, etc.). This formation distorts the dynamic characteristics of the flow.

This work is devoted to studying of water accumulation hydrodynamic conditions in the lowered unit of oil-and products pipe line with big diameter by classical hydromechanics methods.

In general for a phases condition determination (in a multiphase streams) the structural forms diagrams of two- and three-phase streams «gas - oil - water» are used[4]. These diagrams have narrow limits of application in the conditions close to experimental. Any changes of an inclination corner of the pipeline for horizon change the diagram that doesn't allow using such approach to the decision of problems in the generalized statement.

«Model of water accumulation»

To get analytical expression for the generalized criterion of the water accumulation existence which will be useful in practice we should consider the force balance equation system for each of the phases (fig. 1).

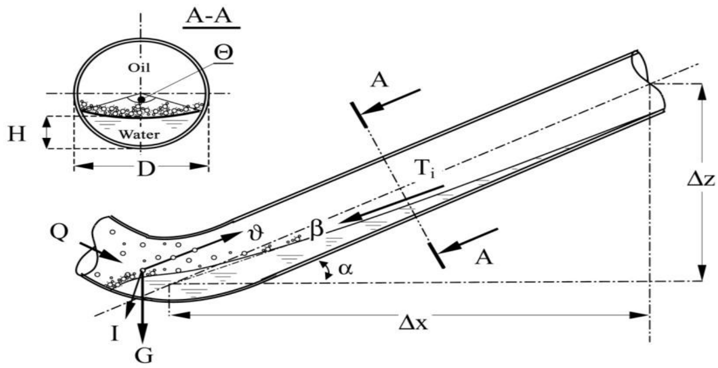

Fig. 1. The loading diagram of a stream above «motionless» water accumulation

$$\begin{cases} \overline{\omega}_w \cdot \frac{dP}{dl} + \tau_i \cdot a \cdot cos\beta \mp \tau_w \cdot \chi_w - \overline{\omega}_w \cdot \rho_w \cdot g \cdot sin\alpha = 0 \\ \overline{\omega}_{oil} \cdot \frac{dP}{dl} + \tau_i \cdot a \cdot cos\beta \mp \tau_0 \cdot \chi_{oil} - \overline{\omega}_{oil} \cdot \rho_{oil} \cdot g \cdot sin\alpha = 0 \end{cases} \quad (1)$$

w, oil – parameters indexes of a water and oil stream.

The joint decision of the equations (1), relative to a pressure gradient gives us a dependence of water section sediment area from boundary parameters of a product stream and water congestion interaction:

$$\tau_i \cdot a \cdot \left(\frac{1}{\overline{\omega}_{oil}} + \frac{1}{\overline{\omega}_w}\right) \cdot cos\beta + \tau_0 \cdot \frac{\chi_{oil}}{\overline{\omega}_{oil}} - (\rho_w - \rho_{oil}) \cdot g \cdot sin\alpha = 0. \quad (2)$$

To define of conditions of water existence congestion with constant characteristics (on length) we consider a special case of the equation (2) –$cos\beta = 1$, that means that the inclination of phases interface and axes of the pipeline is the same. Tangents shift pressure on a pipeline wall can be expressed through Darcy's factors. In the assumption, that circulation occurs concerning a level which is taking place through the centers of gravity of congestion sections, we express average thickness on section of a shift layer through the central corner. Assuming that a structure of speeds in a stream is logarithmic in turbulent movement, and expressing all geometrical section characteristics of the stratified stream through the central corner, we receive a required condition:

$$\psi = \frac{(2\cdot\pi - \Theta + sin\Theta)^3}{64\cdot(\pi - \frac{\Theta}{2})} - \frac{Q\cdot\nu}{D^4\cdot g\cdot sin\alpha} \frac{\rho_w}{\Delta\rho} \frac{2\cdot\pi\cdot sin\frac{\Theta}{2}\cdot(2\cdot\pi - \Theta + sin\Theta)\cdot\frac{u}{v}(\Theta)}{\left(\pi - \frac{\Theta}{2}\right)\left(\frac{2}{3}\cdot sin^3\frac{\Theta}{2} - \frac{1}{2}\cdot cos\frac{\Theta}{2}\cdot(\Theta - sin\Theta)\right)} \quad (3)$$

The physical meaning of the received equation is the parity of the gravitational forces which holds a congestion on the ascending site of the pipeline and - forces of friction; the first part of the equation - liquid friction forces near the pipe walls; the second member – on the border of the phases unit, which is aspiring to take out water by the stream of transporting product.

«The condition of a water accumulation existence»

The analysis of the relation of these measures gives a necessary condition of a water accumulation existence in an ascending part of the pipeline (under the set hydrodynamic conditions).

The points on the diagram in equality to parameter ψ means the parity of gravitational and frictional forces, that means a constancy of water accumulation geometry on a length. The position of the point to the left of the diagram means dominating influence of gravitational forces, on the right – frictional forces.

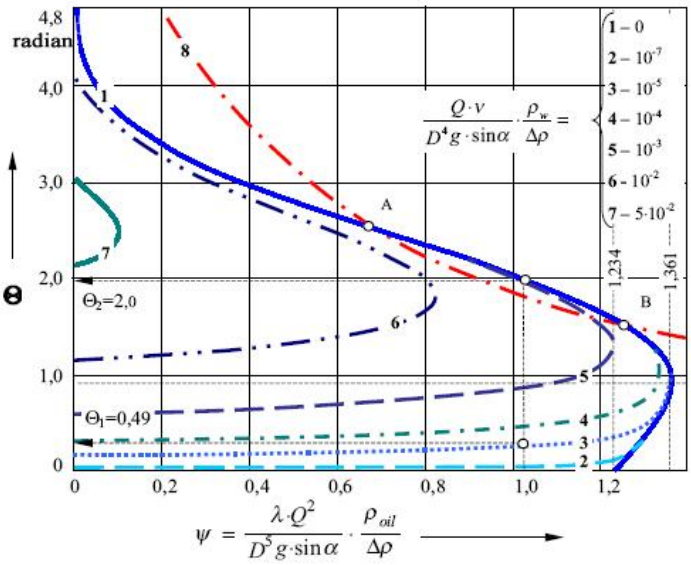

Fig. 2. The condition of a water accumulation existence

The presence of two branches of the diagram is caused by hydraulic sudden changes in a stream of transporting product.

If:

$$\psi = \frac{\lambda \cdot Q^2}{D^5 \cdot g \cdot sin\alpha} \cdot \frac{\rho_{oil}}{\Delta p} < 1{,}234,$$

than water accumulation is absolutely steady.

If:

$$1{,}234 < \psi = \frac{\lambda \cdot Q^2}{D^5 \cdot g \cdot sin\alpha} \cdot \frac{\rho_{oil}}{\Delta p} < 1{,}361,$$

than accumulation is unstable.

If:

$$\psi = \frac{\lambda \cdot Q^2}{D^5 \cdot g \cdot sin\alpha} \cdot \frac{\rho_{oil}}{\Delta p} > 1{,}361,$$

than the existence of an accumulation is impossible.

The reliability of the accumulation ability estimation made by the offered technique indirectly proved by independent researches of the pollution structure which are taken out by scrapers from the oil-and products pipeline sites in the station of transceiving of a scraper.

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MODELING OF GASFLUID FLOWS IN PIPELINES

D.E. Yartsev
Scientific advisor professor S.N. Kharlamov
Tomsk polytechnic university, Tomsk, Russia

The prediction of two-phase flow pressure drop in the gas-condensate pipelines is a challenge for optimal design of such pipelines. In [2] shows the applicability of Taitel and Dukler work with combination of appropriate friction factor correlations for the modeling of gas-condensate flow transmission systems.

In [Adewumi and Bukacek, 1985], appropriate constitutive equations are written for the particular flow regime. Note that the amount of liquid in the system is assumed to be small, and the gas flow rate gives a sufficiently high Reynolds number that the fluid flow regime can be assumed to be stratified flow and/or annular-mist flow regime [Danesh and Noghrehkar, 1976; Boriyantoro and Adewumi, 1994; Mokhatab, 2002 c]. The proposed procedure for the flow regime determination is based on the Taitel and Dukler (1976) mechanistic model. For stratified flow, momentum balance for the each phase (gas and liquid) is given by Taitel and Dukler (1976):

$$-\tau_L S_L + \tau_i S_i - H_L A \rho_L g \sin\theta - H_L A(dP/dx) = 0, \tag{1}$$

$$-\tau_G S_G - \tau_i S_i - H_G A \rho_S g \sin\theta - H_G A(dP/dx) = 0. \tag{2}$$

As it can be seen from these equations, the stratified flow model is a one-dimensional two-fluid model. It assumes steady-state, isothermal flow with no mass transfer between the gas and liquid phases. The shear stresses in the above equations are expressed as:

$$\tau_K = 1/2\, f_K \rho_K U_K^2 \quad (K = G, L), \tag{3}$$

$$\tau_i = 1/2\, f_i \rho_G (U_G - U_i)^2. \tag{4}$$

In the above model, the interfacial shear stress is calculated by Oliemans (1987) who makes the assumption that $U_i = U_L$ to calculate the interfacial shear from (3). Although based on the same momentum balance equations (1) and (2), the two-phase flow models differ significantly in the expression of friction factors and wetted perimeters. In [2], the gas friction factor is evaluated using an approach similar to that used in single-phase flow calculations, by using Colebrook (1939) correlation with the actual pipe roughness and the following definition of Reynolds number:

$$\mathrm{Re}_G = \rho_G D_G U_G / \mu_G, \tag{5}$$

where the gas hydraulic diameter is defined as:

$$D_G = 4A_G/(S_G - S_L). \tag{6}$$

In the present model, for different interface geometries, Kowalski (1987) empirical relations were used, where the transitional from a wavy interface to a flat interface occurs at holdup of 0.06.

$$f_i = 0{,}96\,\mathrm{Re}_G^{-0.52}: \text{flat interface}, \tag{7}$$

$$f_i = 0{,}000075 \cdot \left[\mathrm{Re}_L^{0.83} H_L^{-0.25} \mathrm{Re}_G^{-0.3}\right]: \text{wavy interface}. \tag{8}$$

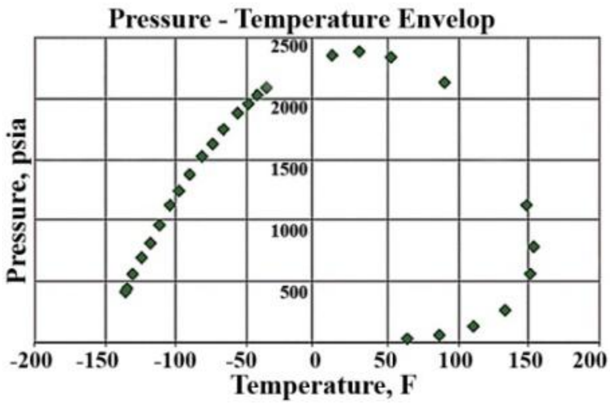

Fig. 1. Pressure-temperature diagram for Kangan gas-condensate system

Note that determining the stability of the stratified flow regime requires the calculation of the liquid level, which can be obtained by simultaneously solving (1) and (2). Assuming that the pressure gradient is the same in each phase, these equations then can be combined, eliminating the pressure gradient terms, and expressed in terms of the dimensionless liquid level, using the geometrical relationships outlined by Taitel and Dukler (1976). It was found that the equation yielded multiple solutions for the dimensionless liquid level for values of the Taitel and Dukler inclination parameters less than − 3,8 [Baker and Gravestock, 1987; Baker et al., 1988]. To avoid the problem of multiple solutions, the model was adjusted by the

Landman (1991) technique to limit the minimum value of inclination parameter to − 3,8. The phase behavior model is required for determining the phase condition at any point in the pipe, the mass transfer between the phases, and the fluid properties from Peng and Robinson (1976) equation of state. This equation is used to calculate the compressibility factors, the fugacity coefficients and the enthalpy departure functions. The compressibility factor is required for the liquid or gas density calculations. The fugacity coefficient is important in the vapor-liquid equilibria calculations. The enthalpy departure function is used for the temperature change calculation due to pressure drop [Brill and Beggs, 1991]. The proposed model was tested by performing a prediction on flow pressure drop of Iran's Kangan gas-condensate transmission line. As it can be seen in (fig. 1), depending on the pressure and temperature variations, the hydrocarbon mixture can exist as a single-phase, or as a two-phase mixture along the pipeline route. Examined case results demonstrate the ability of the introduced model to predict reasonably accurate pressure drop under operating conditions. The model, however, needs modifications to be suitable for simulating steady-state two-phase flow in gas-condensate transmission lines. For example, the liquid and gas continuity equations need to be modified to account for the mass transfer between phases.

Also, in [1] theoretical analyses have been performed to determine the feasibility of transporting gas-to-liquid (GTL) products through the Trans-Alaska Pipeline System (TAPS) using a non-Newtonian fluid flow approach. Due to heat loss, the fluid temperature decreases in the direction of flow, and this affects the fluid properties, which in turn influence the convection coefficient. The Trans-Alaska Pipeline was constructed using steel pipes with an outer diameter of 1,2192 m (48 in) and a thickness of 11,73 mm (0,462 in). Some pipeline sections are buried below ground at varying depths. The buried pipeline is surrounded by gravels whose thermal conductivity has been taken as 2 W/mK [Nerella 2002]. Sections of above-ground pipeline are insulated with fiberglass insulation of 8,89 cm (3,5 in), having a thermal conductivity of 0,0462 W/mK.

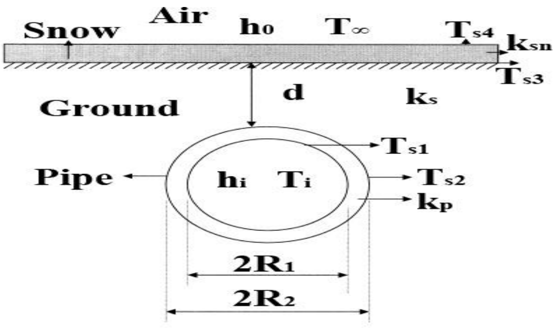

Fig. 2. Below - ground pipeline

The heat transfer rate from the fluid to the ambient air (fig. 2):

$$q = T_{iav} - T_{\infty} \Big/ [1/(h_i 2\pi R_1 L)] + [\ln(R_2/R_1)/(2\pi k_p L)] + [1/(k_s/S)] + [d_2/(k_{sn} LH)] + [1/(h_0 LH)]. \qquad (9)$$

This formula includes thermal resistance due to inside convective heat transfer coefficient of liquid, resistances due to pipe wall, soil, and snow, and, finally, the resistance due to outside convective heat transfer coefficient of air. Detailed explanation of each term in (9) appears in [Nerella 2002, Nerella et al. 2003]. In (9) the internal convection heat transfer coefficient between the liquid and the pipe inner surface can be determined by:

$$h_i = Nu_d k_f \Big/ 2R_1 . \qquad (10)$$

The overall heat transfer coefficient U_i is obtained from (9):

$$U_i = q \Big/ 2\pi R_1 L (T_{iav} - T_{\infty}) . \qquad (11)$$

For a non-Newtonian fluid, the Nusselt number Nu_d is dependent on fluid properties such as fluid density, flow behavior index *n*, consistency index *K*, and fluid thermal conductivity k_f. Clapp (as described in [Skelland 1967]) gives two important empirical correlations for the heat transfer coefficient of power law fluids for turbulent flow through pipe the first with maximum deviations of +1 % and -4,5 % from the experimental data and the second correlation with maximum deviations of +2 % and -4,5 %. For heat transfer from snow (in winter) or bare surface (summer) to the outside air, the convective heat transfer is given by:

$$h_0 = Nu_H k_a \Big/ H . \qquad (12)$$

The Nusselt number is based on the linear dimension *H* of a rectangular surface; h_o is the outside convective heat transfer coefficient, and k_a is the thermal conductivity of air. From parametric analysis, [Nerella 2002] determined that the heat flowed over a region *H* = 15 (pipe diameter); beyond that, the magnitude of heat flow was minimal. Due to this heat loss, the fluid temperature must diminish in the direction of flow. The exit temperature of the fluid from the pipeline can be determined by equation presented by Suryanarayana (1995):

$$(T_{\infty} - T_e) \Big/ (T_{\infty} - T_i) = \exp(-U_i A_i \big/ \dot{m} c_p) . \qquad (13)$$

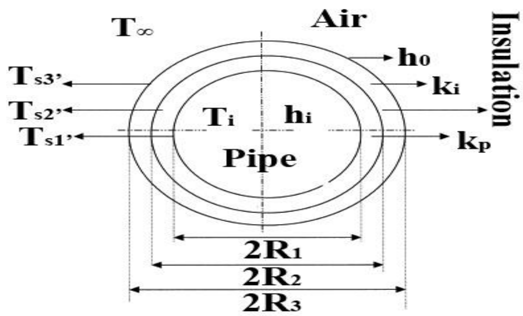

Fig. 3. Above-ground pipeline

Some sections of the TAPS are constructed above ground (Fig. 3) to protect the pipeline from failure due to melting of permafrost. To minimize heat transfer from the hot fluid to the cold ambient air, the steel pipe is adequately insulated with fiber glass insulation. The overall heat transfer coefficient U_i for this configuration is given by Nerella et al. (2003):

$$U_i = 1\Big/\left[1/h_i\right]+\left[\ln(R_2/R_1)(R_1/k_p)\right]+\left[\ln(R_3/R_2)(R_1/k_s)\right]+\left[(1/h_0)(R_1/R_3)\right] . \qquad (14)$$

The inner heat transfer coefficient can be found from [Skelland 1967]. For the external flows over the circular pipes, the Nusselt number is given in [Suryanarayana 1995]. The Reynolds number is based on the wind velocity across the pipeline and can be obtained from the relation:

$$\mathrm{Re}_D = 2V_\infty R_3 \rho_a \Big/ \mu . \qquad (15)$$

For all the above equations, the product $\{\mathrm{Re}\}_D$ Pr > 0,2 must be satisfied. Pressure drop due to frictional head loss can be determined using [White 1986]:

$$\Delta p = \rho g h_f , \qquad (15)$$

where h_f is the head loss due to friction. When compared in accuracy to the well-known implicit Colebrook equation the errors were within ±1 %.The recommended value of roughness for steel pipe is taken as ε = 0,00004572 m (0,00005 ft). The heat loss for winds of 20 mph is higher due to the increased convective heat transfer coefficient it is shown in (fig. 4). It is important to notice that the convection effects cause minor changes in the cumulative heat loss between 10 and 20 mph. The heat loss is at maximum when there is no snow on the ground, because snow acts as an insulator it is shown in (fig. 5). This shows that the presence of snow is an advantage, minimizing heat loss from TAPS. The same heat loss trends are obtained for different wind velocities.

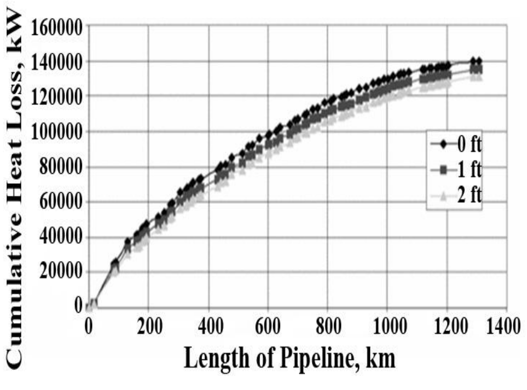

Fig. 4. Effect of snow depth on cumulative heat loss from GTL along TAPS, for a wind velocity of 10 mph

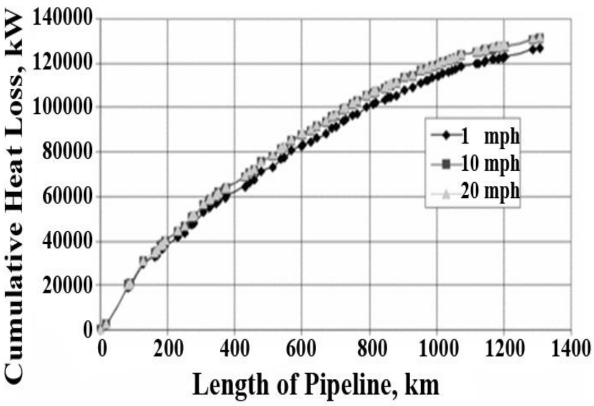

Fig. 5. Effect of wind velocity on cumulative heat loss from GTL along TAPS, with a snow depth of 0,61 m (2 ft). depth of 0,61 m (2 ft).

This analysis confirms the intuitive conclusion that the heat loss from the pipe decreases with the increase of snow depth on the ground surface for GTL. This reduction is due to the increased resistance offered by the snow layer. Also, the heat loss from the pipe increases with the increase in the wind velocity due to a higher convective heat transfer coefficient. However, the increase in heat loss due to an increase in the wind velocity from 10–20 mph is merely a small amount.

The investigation shows, that there is no way for describing one-phase flow by using criterion dependencies in examined hydrodynamic flow per se and demands an essential adaptation on multi-phase flow with following-up to empirical information about process features of each phase. The advantage is empirical information about complex criteria interdependencies of heat-transfer in the real ambient for work at Alaska, which is useful information for generalization the data on hydrocarbons flow regimes in Siberia region and testing the mathematical model for the purpose of prediction the wider process conditions and flow regimes.

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