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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ
«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится

работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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ZELTMAN Reymar, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) **H = 37**

PANFILOV Mikhail Borisovich, doctor of technical sciences, professor at the Nancy University (Nancy, France) **H=15**

SHEN Ping, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) **H = 25**

FISCHER Axel, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) **H = 6**

KONTOROVICH Aleksey Emilievich, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) **H = 19**

AGABEKOV Vladimir Enokovich, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) **H = 13**

KATALIN Stephan, Ph.D, associate professor, Technical university (Dresden, Berlin) **H = 20**

SEITMURATOVA Eleonora Yusupovna, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) **H=11**

SAGINTAYEV Zhanay, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) **H = 11**

FRATTINI Paolo, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) **H = 28**

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© A.G. Fremd[1*], A.J. Bibosinov[2], B.A. Iskakov[2], 2023
[1]Institute of Seismology, Almaty, Republic of Kazakhstan;
[2]Institute of Ionosphere, Almaty, Republic of Kazakhstan.
E-mail: afremd@list.ru

DISTRIBUTION OF ZONES OF DECOMPRESSION OF THE EARTH'S CRUST AS AN INDICATOR OF THE OIL PROSPECTS OF THE TERRITORY OF THE CASPIAN REGION

Fremd A.G. — Institute of Seismology, leading researcher, candidate of physical and mathematical sciences
E-mail: *afremd@list.ru*, https://orcid.org/0000-0002-4323-454X;
Bibosynov A.Zh. — Institute of Ionosphere, senior researcher**,** PhD
E-mail: *bibossinov@gmail.com*, https://orcid.org/0000-0002-5219-4279;
Iskakov B.A. —Institute of Ionosphere, deputy director
E-mail: *berikiskakov@gmail.com*, https://orcid.org/*0000-0002-8968-9531*.

Abstract. The issues of the structure of the earth's crust of the Caspian basin and the associated deep origin of hydrocarbons are considered. The main mobilist ideas about the role of tectonic forces in the formation of the modern appearance of the Caspian region, which were developed in theoretical conclusions arising from the "concept of the fluid regime in the upper crust", based on the crustal waveguide hypothesis (Karakin, 2001), are reviewed. It is shown that waveguides can be considered as elements of the section structure in which accumulation of fluids migrating from deeper horizons is possible. Based on regional seismic observation data presented by velocity levels, a non-trivial method for constructing 3D models of the distribution of decompression zones in the upper part of the earth's crust is proposed. The calculation results made it possible to develop a 3D model of the distribution of density heterogeneities, in which the leading role is given to zones of low velocity (density). It is shown that the decompaction zones are not randomly located. Their distribution is in good qualitative agreement with the known scheme of oil and gas potential prospects for the Caspian Sea. The preliminary results obtained give reason to assume that the decompression zones identified from experimental data objectively reflect the pattern of fluid flow direction and hydrocarbon accumulation. The revealed patterns in the distribution of decompression zones, in combination with other geophysical data, can serve as an additional criterion when assessing the oil potential of the territory and carrying out exploration work in the

Caspian region. And the method of identifying them can be applied when studying other oil-promising regions

Keywords: density inhomogeneities, hydrocarbons, fluid dynamics

© А.Г. Фремд[1*], А.Ж. Бибосинов[2], Б.А. Искаков[2], 2023
[1]Сейсмология институты, Қазақстан, Алматы;
[2]Ионосферы институты, Қазақстан, Алматы.
E-mail: afremd@list.ru

МҰНАЙ ПЕРСПЕКТИВТІЛІГІНІҢ КӨРСЕТКІШІ РЕТІНДЕ ЖЕР ҚЫРТЫСЫНЫҢ ТЫҒЫЗДЫҒЫ АЗАЙҒАН АУДАНДАРЫНЫҢ КАСПИЙ МАҢЫ АЙМАҒЫНДА ТАРАЛУЫ

Фремд А.Г. — Сейсмология институтының жетекші ғылыми қызметкері, физика-математика ғылымдарының кандидаты
E-mail: *afremd@list.ru*, https://orcid.org/0000-0002-4323-454X;
Бибосинов А.Ж. — Ионосфера институты, аға ғылыми қызметкер, PhD
E-mail: *bibossinov@gmail.com*, https://orcid.org/0000-0002-5219-4279;
Искаков Б.А. **—** Ионосфера институты, директордың орынбасары
E-mail: *berikiskakov@gmail.com*, https://orcid.org/0000-0002-8968-9531.

Аннотация. Каспий маңы ойпатының жер қыртысының құрылымы және онымен байланысты көмірсутектердің терең шығуы мәселелері қарастырылады. Каспий маңы аймағының қазіргі келбетін қалыптастырудағы тектоникалық күштердің рөлі туралы негізгі мобилистік идеялар жер қыртысының толқын өткізгіштік гипотезасына негізделген «жоғарғы жер қыртысындағы сұйық режимінің концепциясынан» туындайтын теориялық қорытындыларда әзірленген (Karakin, 2001), қаралады. Толқын өткізгіштерді тереңірек горизонттардан ауысатын сұйықтықтардың жиналуы мүмкін болатын секция құрылымының элементтері ретінде қарастыруға болатыны көрсетілген. Жылдамдық деңгейлері бойынша ұсынылған аймақтық сейсмикалық бақылау деректерінің негізінде жер қыртысының жоғарғы бөлігіндегі декомпрессиялық аймақтардың таралуының 3D модельдерін құрудың тривиальды емес әдісі ұсынылған. Есептеу нәтижелері жылдамдықтың (тығыздықтың) аймақтарына жетекші рөл берілген тығыздық гетерогенділігінің таралуының 3D моделін жасауға мүмкіндік берді. Декомпакация аймақтары кездейсоқ орналаспағаны көрсетілген. Олардың таралуы Каспий теңізінің мұнай-газ әлеуетінің келешегі белгілі схемасымен жақсы сапалы сәйкес келеді. Алынған алдын ала нәтижелер эксперименттік мәліметтер бойынша анықталған декомпрессиялық аймақтар сұйықтық ағынының бағыты мен көмірсутектердің жинақталуының заңдылығын объективті түрде көрсетеді деп болжауға негіз береді. Декомпрессиялық аймақтарды бөлудің анықталған заңдылықтары басқа геофизикалық мәліметтермен үйлесімде аумақтың мұнай әлеуетін бағалау және Каспий аймағындағы барлау жұмыстарын жүргізу кезінде қосымша критерий бола алады. Ал оларды анықтау әдісін басқа мұнайлы аймақтарды зерттеу кезінде қолдануға болады.

Түйін сөздер: тығыздықтың біркелкі еместігі, көмірсутектер, сұйықтық динамикасы

© А.Г. Фремд[1*], А.Ж. Бибосинов[2], Б.А. Искаков[2], 2023
[1]Институт сейсмологии, Алматы, Казахстан;
[2]Институт ионосферы, Алматы, Казахстан.
E-mail: afremd@list.ru

РАСПРЕДЕЛЕНИЕ ЗОН РАЗУПЛОТНЕНИЯ ЗЕМНОЙ КОРЫ КАК ИНДИКАТОРА НЕФТЕПЕРСПЕКТИВНОСТИ ТЕРРИТОРИИ ПРИКАСПИЙСКОГО РЕГИОНА

Фремд А.Г. — кандидат физико-математических наук, ведущий научный сотрудник, Институт сейсмологии, Алматы, Казахстан
E-mail: *afremd@list.ru*, https://orcid.org/0000-0002-4323-454X;
Бибосинов А.Ж. — PhD, старший научный сотрудник. Институт ионосферы, Алматы, Казахстан
E-mail: *bibossinov@gmail.com*, https://orcid.org/0000-0002-5219-4279;
Искаков Б.А. **—** заместитель директора Институт ионосферы, Алматы, Казахстан
E-mail: *berikiskakov@gmail.com*, https://orcid.org/*0000-0002-8968-9531*.

Аннотация. В статье рассмотрены вопросы структуры земной коры Прикаспийской впадины и связанного с ней глубинного происхождения углеводородов. Обзорно рассмотрены основные мобилистские представления о роли тектонических сил в формировании современного облика Прикаспийского региона, которые получили своё развитие в теоретических выводах, вытекающих из «концепции флюидного режима в верхней коре», основанной на гипотезе корового волновода (Каракин, 2001). Показано, что волноводы могут рассматриваться, как элементы структуры разреза, в которых возможно скопление флюидов, мигрирующих из более глубоких горизонтов. На основе данных региональных сейсмических наблюдений, представленных скоростными уровнями, предложен нетривиальный способ построения 3D моделей распределения зон разуплотнения в верхней части земной коры. Результаты расчётов позволили разработать 3D модель распределения плотностных неоднородностей, в которой ведущая роль отводится зонам пониженной скорости (плотности). Показано, что зоны разуплотнения расположены не хаотично. Их распределение находится в хорошем качественном соответствии с известной схемой перспектив нефтегазоностности Каспийского моря. Полученные предварительные результаты дают основание предполагать, что зоны разуплотнения, выделенные по экспериментальным данным, объективно отражают картину направленности флюидных потоков и аккумуляции углеводородов. Выявленные закономерности в распределении зон разуплотнения в комплексе с другими геофизическими данными могут служить дополнительным критерием при оценке нефтеперспективности территории и проведении поисковых геологоразведочных работ в Каспийском регионе. А сам метод их выявления может быть применён при изучении других нефтеперспективных регионов

Ключевые слова: плотностные неоднородности, углеводороды, флюидодинамика

Introduction

From the standpoint of abiogenic ideas about the origin of hydrocarbons, priority belongs to the geodynamic component of the research area and, in particular, to the geotectonic position, features of the geodynamic regime, the deep structure and distribution of waveguides in the Earth's crust, which are assigned the role of regional reservoirs of fluids of endogenous origin. Fluids are understood as natural rock solutions and melts (NRSM) formed at great depths due to the continuous transformation of matter (Sokolov, Starostin, 1997). Under the influence of high temperatures and pressure, fluids migrate from the lower layers of the earth's crust to the upper ones along the way, being enriched by leaching with useful components. The fluids thus enriched form, under certain conditions of the transition of useful components from a dispersed state to concentrated accumulations, deposits of various minerals, including hydrocarbons. From these positions, mineral deposits can be called products of the Earth's vital activity, and the direction itself is called fluid dynamics. One of the main problems of fluid dynamics is the solution of a priority applied problem – effective forecasting of oil and gas fields hidden at depth (Zhantaev et al., 2020).

Mobilization and oil and gas potential of the Caspian region.

The Caspian region is considered today as the most complex geodynamic polygon in which one can observe actively occurring natural seismotectonic processes manifested in relatively high seismic activity, mud volcanism and known fluctuations in the level of the Caspian Sea due to the geodynamic position of the region and its complex geological structure. The latter is expressed in extremely developed fault-block and salt tectonics, the presence of a platform cover unique in power, as well as in relatively fast-flowing geodynamic processes associated with the boundaries of blocks and the plasticity of salt structures.

Mobilist ideas about the role of tectonic forces in the formation of the modern appearance of the Caspian region were "unexpectedly" developed in theoretical conclusions arising from the "concept of fluid regime in the upper crust" (Dmitrievsky et al., 2004), based on the hypothesis of a crustal waveguide (Karakin, 2001). One of the most important conclusions "concerns the problem of the formation of mineral deposits in general, as well as ecology and hydrogeology" (Dmitrievsky et al., 2004). Without going into details, it should be shown that one of the consequences of the subduction process in the collision zone of lithospheric plates is the feat of the ocean floor (plate) under island arcs and active margins of continents. This process, which lasts for millions of years, is accompanied by the tightening of sediments under the island arcs, which are oil and gas mother material and other mineral resources. A gigantic mass of precipitation under favorable thermodynamic conditions occurring in subduction zones can serve as the basis for the emergence of oil and gas fields, including large ones. At the same time, the driving force of the final stage of the formation of deposits is the autowave process, justified in the crustal waveguide model (Karakin, 2001).

Paleogeodynamic reconstruction of the Caspian region, performed by Bankovsky S.Yu. and others (1990) (Kambarov, 2000), as well as the existence of a modern subduction zone in the zone of the Cheleken-Apsheron threshold, give grounds to assert that in the territory of the modern oil and gas basin (OGB) in the past there were conditions for abundant and prolonged sedimentation, which can be illustrated by the diagrams given on figure 1.

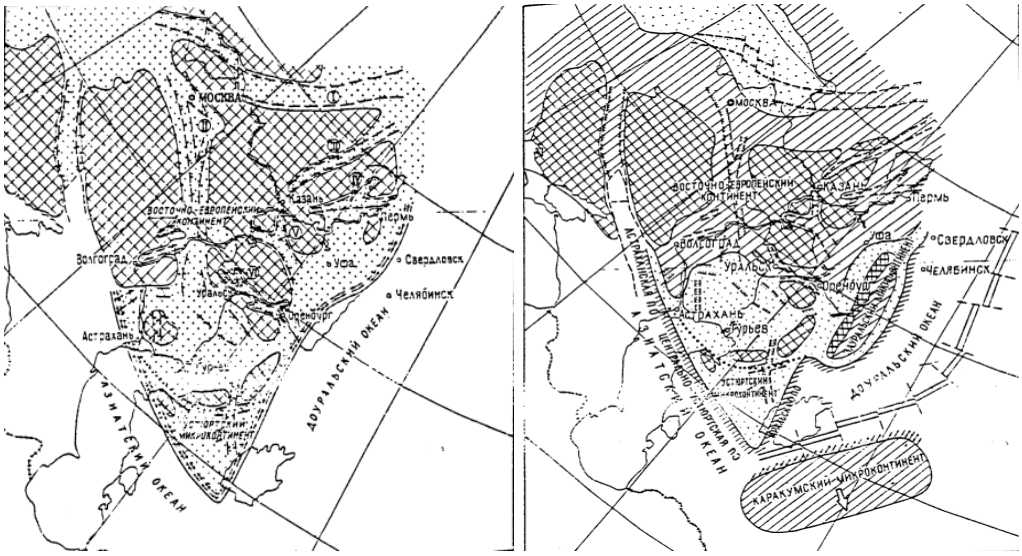


Figure 1. Schemes of paleogeodynamic reconstruction of the Caspian region of adjacent regions in the Middle-Late: A –Riphean; B – Cambrian (Bankov et al., 1990).

Crustal waveguides arising at depths from 10 to 20 km from the Earth's surface play an important role in the fluid regime of geodynamic evolution of sedimentary basins. It is the external reciprocating effects on the core waveguide that lead to the squeezing of fluids outwards (compaction) and sucking them inwards (dilatancy). Thereby, ensuring the transition of fluids from a dispersed state in the sedimentary column to concentrated accumulations in limited places. On the other hand, crustal waveguides having total propagation are not self-contained elements of the structure. They have a connection with both the above and the underlying layers of the earth's crust. And in the subduction zones, they act as a "lubricant" for the impending plate, which cannot but affect both fluid and seismic regimes occurring at the level of deep processes. In particular, the migration of fluids from deep strata, as well as the results of "dilatation embrittlement" (Dmitrievsky et al., 2004), which can occur as a result of seismic shocks, leading to a redistribution of pore pressure and, as a consequence, to an intensive flow of fluids, including their upward rise.

Thus, the existence of a subduction zone (Cheleken-Absheron threshold) and an adjacent sedimentary basin (Caspian Depression) suggests that a crustal waveguide located at depths of 10–15 km can serve as a channel for the transport of hydrocarbons

over long distances laterally and, with the existence of vertical migration channels, be their source in the formation of deposits. An example of such a deposit is Romashkinskoye. According to the authors of the concept, if a circle is drawn from the center of the Caspian Depression, the radius of which will be equal to the distance from this center to the Romashkinskoye field, then accumulations of oil and gas can be predicted throughout this region, although not as large as the mentioned deposits within the Caspian OGB" (Dmitrievsky et al., 2004). And, therefore, it can be assumed that the entire region under consideration is rich in hydrocarbon reserves. But unlike the marginal productive structure, where deposits have already been discovered, they are quite deep in the central part of the depression. But their location can be predicted by the distribution of decompression zones at appropriate depths.

Features of the geological structure and oil and gas potential of the Caspian basin

The Caspian region, where the largest hydrocarbon reserves are concentrated, is today an extremely attractive investment object for the economies of all countries of this region, as well as other states. The central place in this region is occupied by the Caspian Basin, located on the southeastern edge of the East European Platform (Figure 2).

Figure 2. Map of oil and gas provinces and deposits of Kazakhstan

A number of large hydrocarbon deposits have been discovered and are being developed on its territory. However, according to N.Sh. Kambarov, the undiscovered resources of the Caspian Basin account for 95% of their potential (Kambarov, 2000). The future prospects of oil and gas exploration in the Caspian sedimentary basin today are largely associated with studies of geo- and fluid dynamics of the Caspian region as a whole.

The peculiarity of the Caspian depression is expressed in the thickness and structure

of the sedimentary cover, which consists of three floors of sedimentary deposits — subsalt, salt and suprasalt. In the central part of the depression, their total capacity ranges from 16 to 24 km, in the instrument zones about 6–7 km.

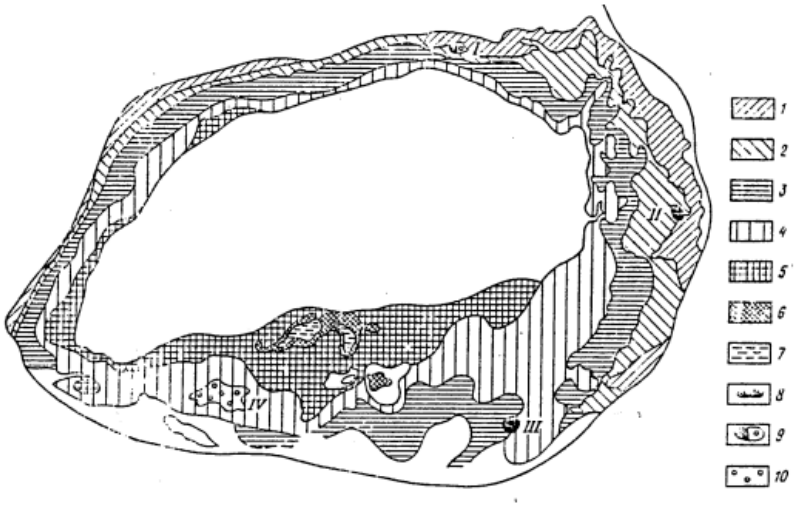


Figure 3. Map of the distribution of modern temperatures of subsalt deposits
The Caspian Basin (Perepelichenko, Rovenskaya,1991)
Boundaries of modern temperature zones (°C): 1 – less 60, 2–60-80, 3–80–100, 4–100–120, 5–120–140, 6–140–160, 7 – more than 160. Deposits: 8 – oil, 9 – oil and gas condensate, 10 – gas condensate; I – Karachaganak, II – Kenkiyak, III – Tengiz, IV – Astrakhan

The subsalt complex of the Riphean age lies inconsistently on the rocks of the crystalline basement. Its characteristic feature is the presence in it of an extensive carbonate massif containing organogenic limestones with good reservoir properties. In the subsalt deposits, oil and gas deposits are controlled by domed and brachianticlinal uplifts with an amplitude of about hundreds of meters, as well as riphogenic protrusions. The leading type of deposits of subsalt deposits are massive, rarely formation-massive and formation-arch deposits located in the depth range from 2700–3600 (Zhanazhol) to 3800–5500 and more (Tengiz, Karashyganak). Harsh thermobaric conditions were found at these depths. In particular, it was found that at a depth of 5.5 km, the reservoir pressure in the deposits can exceed the hydrostatic pressure by 1.95 times and range from 65 to 105 MPa, and temperatures on average reach 110–120 °C (Figure 3).

The salt and above-salt floors are a rock salt thickness with layers of anhedrites, terrigenous and carbonate rocks. Salt deposits have formed more than 1,200 domes, diapirs, salt ridges and salt pillows (Gabrielants et al., 1991). All of them are a salt regional fluid barrier for hydrocarbons of the subsalt complex and can be considered as potential traps.

Actually, the suprasalt complex of rocks is represented by terrigenous sandy-clay deposits with the subordinate presence of carbonate rocks of the Jurassic and Cretaceous periods. Its power varies from 2–4 km in the instrument zone of the depression to 5-6

km in its center. There are several dozen mainly oil and, in a smaller number, gas-oil and gas fields discovered here. The main type of deposits of the above-salt floor are the deposits of salt dome uplifts, which are complexly constructed and broken up by numerous discontinuities, the distribution of oil and gas content in which is also uncertain.

The foundation, according to seismic data, has an asymmetric step-block structure with numerous faults of a fault nature. The depths of its occurrence are consistent with the thickness of the sedimentary cover and range from 7-9 km at the periphery with an increase towards the center to 16–19 and 24–26 km (Kambarov, 2000).

The thickness of the consolidated crust here, on the contrary, has a convex shape. Its thickness increases from the center (15–20 km) to the sides (30–35 km). Similarly, the depth to the base of the earth's crust varies from 30–32 km in the center of the depression to 40–43 km to its sides (Seismic models,1980).

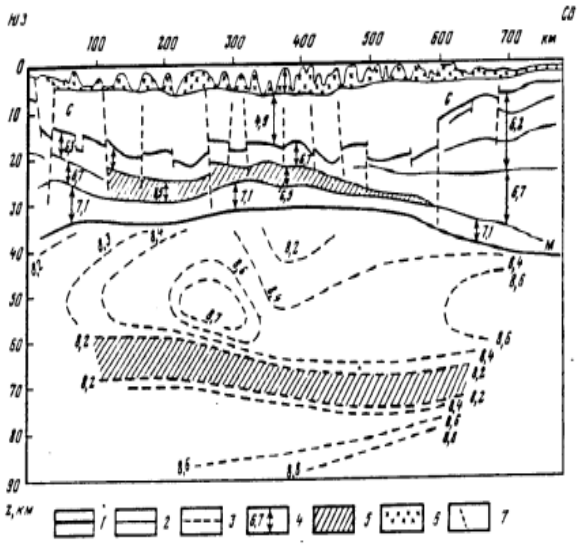


Figure 4. Seismic section of the Earth's crust and upper mantle of the Caspian depression according to the profile of Elista-Buzuluk (Seismic models …,1980)
1 – foundation and Moho surfaces constructed by refracted and exchanged seismic waves; 2 – boundaries in the crust; 3 – velocity isolines, km/s; 4 – reservoir velocities, km/s; 5 – areas of reduced velocities (waveguides); 6 – saline deposits; 7 – discontinuous disturbances.

An important feature of the section of the Caspian basin is the discovered crustal (at a depth of 25 km) and upper mantle (at a depth of 65 km) waveguides (Figure 4). The capacity of the first is about 5 km, and the second is 10 km. And the speed difference is from 0.2 to 0.9 km/s. Waveguides are also isolated at depths of 5-7 km .

The porosity of waveguides can reach 10%. From the standpoint of fluid dynamics, waveguides can play the role of "giant collectors for various kinds of fluids" (Kambarov, 2000), which in the pulsating mode (Karakin et al., 1996) are squeezed into the layers above and accumulated in the collectors.

The established zones of oil and gas accumulation associated with the subsalt complex are concentrated in the form of two concentric bands encircling the sedimentary basin along the periphery (Golov et al., 1987). The outer strip unites the well-known large operating deposits of Astrakhan, Orenburg, Karachaganak, Tengiz, etc. Oil-promising zones have been found in the inner strip. All of them are associated with massifs of carbonate rocks with good reservoir properties.

Methodology of identification and formation of a three-dimensional image of a decompressed section of the upper part of the earth's crust of the Caspian region.

In modern ideas about the structure of the earth's crust, an important place is given to zones of decompression (waveguides). The reason for this, as already noted, may be the established connection of oil-prospective structures, as well as seismogenerating zones with the position of decompression zones. Therefore, the identification of the latter today seems to be the most urgent task, the solution of which will allow for targeted prospecting and exploration work aimed at expanding the mineral resource base and, in particular, to identify places of possible localization of hydrocarbon deposits. On the Earth's surface, many elements of fault tectonics are associated with decompression zones, which can serve as channels for fluid migration from intracore waveguides to near-surface reservoirs bounded from above by fluid barriers. The presence of the latter is a necessary condition for the accumulation of hydrocarbons on an industrial scale. As an example, we can cite a number of works in which these provisions are developed and justified (Karakin, 2001; Dmitrievsky et al., 2004; Sokolov et al., 1997; Bagdasarova, 2011; Kissin, 1985) and others . That is why, the allocation of zones of decompression for today seems to be the most urgent task, the solution of which will help to narrow the area of searches for hydrocarbon deposits and expand the understanding of their location.

To solve this problem, the simplest and most expedient is the use of experimental data on the distribution of the velocity values of longitudinal seismic waves in the Earth's crust. Since velocity is an integral characteristic of the physical properties of the geological environment, it is quite appropriate to assume that the maps of the distribution of its values carry direct information about the objects of study that interest us, which should manifest themselves in the form of areas of relatively reduced velocity distributed in the volume of the Earth's crust under study. Therefore, the task in general is reduced to identifying these areas and establishing the physical meaning of the discovered patterns by analyzing and comparing with actual geological and geophysical data and performed model calculations on the distribution of stress-strain state parameters for individual local territories, including established hydrocarbon deposits.

The object of this study was selected a layer of the Earth's crust with a thickness of 7 km, which includes the known hydrocarbon-producing horizons of the Caspian region. The methodology for identifying velocity inhomogeneities was based on well-known methods of statistical analysis of data presented on the plane in order to identify trend and random patterns (Crambane et al., 1969). It is an established fact that residual value maps can play a significant role in the exploration of deposits and the study of local impacts on the factors controlling the deposits. The Grant also showed that the residual

map, based on non-anomalous gravity values, carries geological information about ore bodies (Grant, 1957). In contrast to the data of potential fields having a two-dimensional representation and the results obtained at the initial stage of research (Zhantaev et al., 2009), this problem was solved in a three-dimensional version.

If we denote the results of a single determination of the velocity V_p at a point with coordinates (X_i, Y_j, Z_k) as $V_P(X_i, Y_j, Z_k)$, then the model of the observed velocity field can be represented as

$V_P(X_i, Y_j, Z_k) = v_p(x_i, y_j z_k) + \Delta v_{i,j\,k}$, where

$v_p(x_i, y_j z_k)$ – systematic component (trend);

$\Delta v_{i,j\,k}$ is a random component.

A necessary condition for the successful solution of this type of tasks is the exclusion of abnormal upstarts from the created array of source data. The latter allows us to assume that the calculated residual values of $\Delta v_{i,j\,k}$ are carriers of some information about the relative variability of the density characteristics of the geological environment.

For the practical implementation of the task by software, it took:

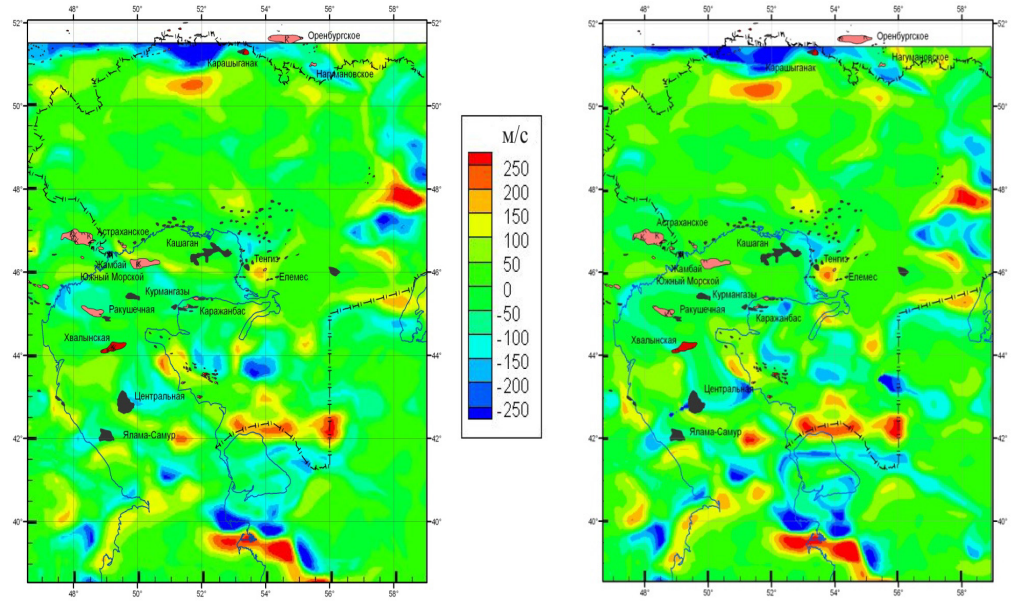
1. Form an array of initial data corresponding to the studied volume of the geological environment;
2. To separate the initial field with the allocation of normal and abnormal components;
3. To analyze and interpret the results obtained in order to identify the physical meaning of the discovered patterns of distribution of velocity inhomogeneities.

As practice has shown, the optimal filter can be a volume-sliding "averaging cube", the dimensions of which are selected based on considerations of minimizing deviations of the observed values and obtained as a result of filtration, as well as taking into account the estimated sizes of the inhomogeneities allocated.

The construction of three-dimensional images of decompression zones was carried out by subtracting the trend values of the velocity field from those observed for each point of the volume of the medium under consideration. It should be noted that decisions of this type cannot be considered formal, since they are based on the results of field observations.

The discussion of the results

The result of the calculations was a 3D distribution of velocity inhomogeneities in a layer of the Earth's crust with a thickness of 7 km (from the Earth's surface to a depth of 7 km), in which the main hydrocarbon-producing horizons corresponding to the subsalt deposits of the Caspian depression are concentrated.



A B

Figure 5. Maps of the residual values of the P-wave velocity for different levels of the section: 5 km (A) and 6 km (B). The well-known hydrocarbon deposits are shown.

By direct comparison of the locations of hydrocarbon deposits, both known and less significant, with the position of the decompression zones, their good qualitative correspondence was revealed (Figure 5). Practically, the contours of all large deposits are located within zones of relatively reduced velocity with some gravitation to the boundaries of areas of decompressed and relatively denser geological formations, possibly being fluid-resistant. The intensity of the selected decompression zones is mainly within the range of – (0,1–0.2) km/s and more, which is an objectively significant value.

Moreover, it was found that the zones of relatively reduced velocity (decompression zones) are not located randomly. They form an outer ring productive structure within the boundaries of the Caspian Basin, identified by the authors of earlier studies. All the largest deposits – Tengiz, Karachaganak, as well as Astrakhan and Orenburg – are connected with this structure. The authors of the concept explain their formation by the existence of conducting channels connecting the crustal waveguide located at depths of 10-15 km and being a receptacle of hydrocarbon-containing fluids squeezed into the upper part of the section and accumulating in the locations of reefs, which are good collectors.

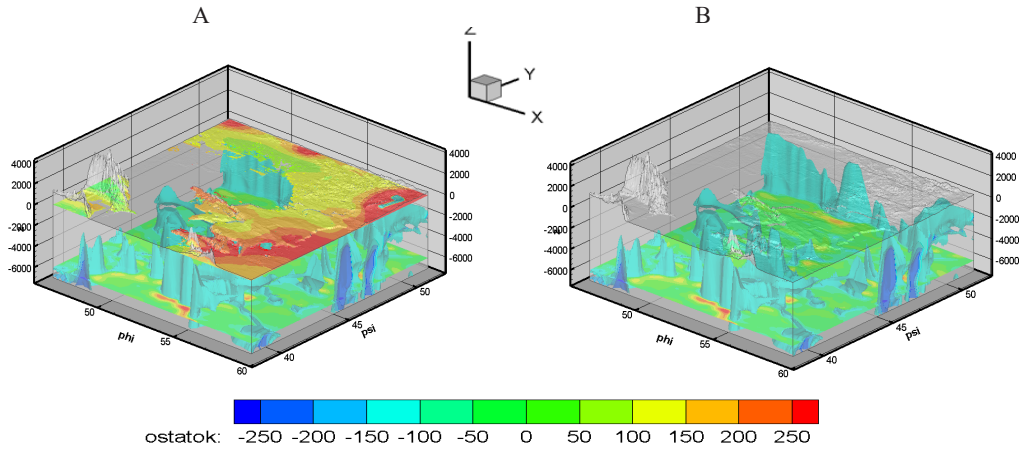


Figure 6. Distribution of velocity inhomogeneities in the Earth's crust of the Caspian Sea region: A – taking into account the relief of the Earth's surface and the level h = 6 km; B – only with level h=6 km.

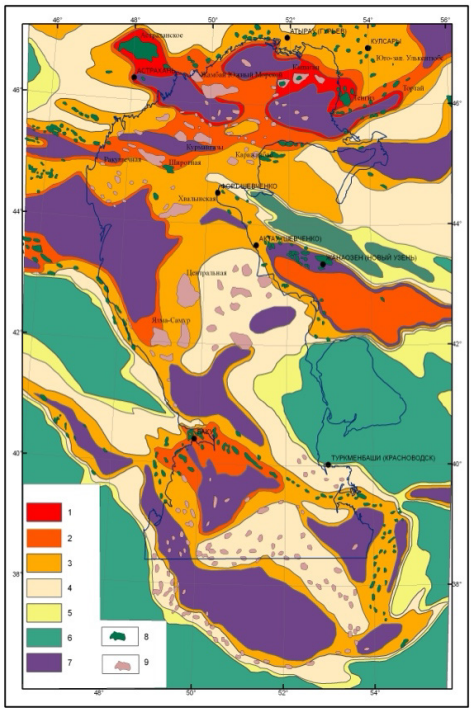
The obtained 3D distribution confirms the idea of fluid permeability of the selected layer, both in vertical and horizontal directions. The morphological features of the resulting mapping include two fundamental points:

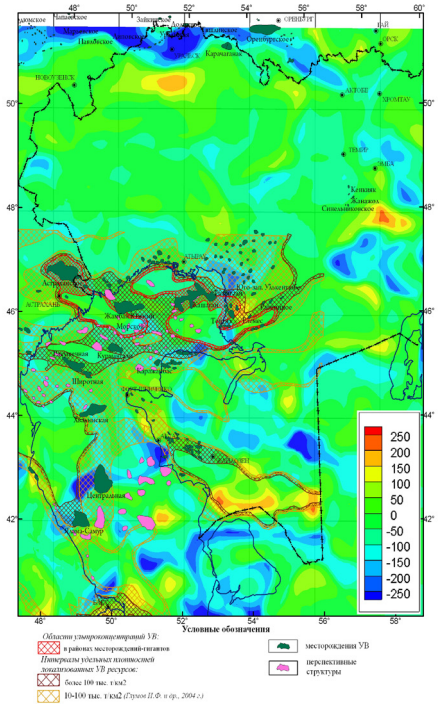
1. Flattening (degeneration) of decompression zones in the direction of the Earth's surface.
2. There are obvious signs of the connection of the revealed fragments of the structure of the decompressed substance with waveguides, the presence of which in the earth's crust of the Caspian region has been established by geophysical, in particular, seismic data.

On this basis, it can be assumed that the latter can be collectors and have a connection with the overlying near-surface horizons through migration channels, fragments of which are shown in Figure 6. And, as you know, industrial concentrations of hydrocarbons or other types of mineral raw materials can be formed only if there are conditions conducive to their accumulation.

The obtained results of experimental data processing confirm the main provisions of the fluid regime concept proposed in (Dmitrievsky et al., 2004), including the main regularities of the location of already identified hydrocarbon deposits.

Finally, the comparison of the constructed maps with the scheme of the prospects of the oil and gas potential of the Caspian Sea (Glumov et al., 2004) showed a good qualitative correspondence in the distribution of oil-promising areas, concentrations of oil occurrences of varying degrees of density, known deposits and velocity inhomogeneities (Figure 7).





A B

Figure 7 Diagram of the prospects of oil and gas potential of the Caspian Sea (Glumov et al., 2004) (A) and map of distributions of velocity inhomogeneities (In), where:
1 – areas of ultra–concentration of hydrocarbons in the areas of giant deposits; Intervals of specific densities of localized hydrocarbon resources: 2 – more than 100 thousand tons/km ^{2}; 3 – 10-100 thousand tons/km ^{2}; 4 – 1-10 thousand tons/km ^{2}; 5 – 0,1-1 thousand tons/km ^{2}; 6 – unpromising areas of orogens and shallow (less than 0.5 km) basement occurrence; 7 – focal areas enriched with dispersed organic matter with partial or complete absence of hydrocarbon traps; 8 – hydrocarbon deposits; 9 – promising structures.

Conclusion

The obtained preliminary results suggest that the decompression zones identified according to experimental data objectively reflect the picture of the direction of fluid flows and the accumulation of hydrocarbons.

The revealed patterns in the distribution of decompression zones in combination with other geophysical data can serve as an additional criterion for assessing the oil potential of the territory and conducting exploratory geological exploration in the Caspian region.

It can be assumed that the spatial solution of the problem with the coverage of deep zones will allow us to get new ideas about the horizontal stratification and vertical permeability of the Earth's crust and to establish the main migration routes of hydrocarbon fluids.

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