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FACTORS OF DRILLING HAZARDS CAUSED BY GEODYNAMIC STRESS

The paper studies factors triggering hazards while drilling processes under the influence of time-spatial variations of geodynamic stress in areas nearby to active and buried mud volcanoes in oil fields and perspective structures discovered on the basis of seismic survey. In case of Umid structure located in Caspian sea it has been displayed that due to variation of lithological composition dynamic and kinematic parameters of seismic wave also change and this is related to abnormal time-spatial variations of geodynamic stress.

In case of Neft Dashlary — Guneshli — Oghuz — D30 area of East Absheron oil-gas bearing area we have studied geodynamic-stress properties in relation to earthquakes occurred in drilling work sites and it was identified that most of the earthquakes happened at 10—15 km depth interval, in the sedimentary cover. In areas reflected in seismic sections by complex seismic records featured by properties characteristic for layered media due to probability of complications and drilling hazards it was recommended to strengthen the control over drilling process along with appropriate preventive measures.

Keywords: *Geodynamic processes, geophysical fields, seismic record, seismic horizon, dynamic depth cube, fault zone, mud volcano signs, accident risk.*

Exploration for hydrocarbon accumulations by using geophysical tools on land of Azerbaijan and Azerbaijani section of Caspian sea started since 1940—1950-ies. At present these works cover structures perspective for oil and gas accumulations and acquired data are processed and interpreted by latest software packages. More data are acquired on geologic setting of perspective structures followed by drilling of wells.

In Azerbaijan until now 52655 km area was covered by 2D seismic survey by Common Depth Point (CDP) technique and 710 km^2 area by 3D seismic survey. Across 48300 km ^{2} perspective area the survey density was Kp = 1.07 km/km^2. Maps drawn in 1:50 000 scale on the basis of acquired seismic data make it possible to infer 50—60 % knowledge on perspectice structures.

86525 km^2 area of Azerbaijan section of Caspian sea was covered by 158990 km of 2D and 1423 km^2 of 3D seismic survey. However, there are structures with geological and tectonic setting required to be studied in detail.

Data acuired by seismic survey make the basis for drilling works in discovered oil fields and perspective areas. In this respect, one of the pivotal problems consists in minimizing drilling hazards and undertaking of preventive measures.

This paper aims to research identification of factors which may lead to emergency situations while the drilling process in areas nearby to buried mud volcanoes under abnormal geodynamic stress.

In this paper we attempt to scientifically substantiate the role of two factors in increased drilling hazard and the importance to study them thoroughly.

1. Accurate outlining of active and buried mud volcanoes on the basis of seismic data.

2. Consideration of geodynamic-stress variations related to earthquakes in drilling areas.

The first problem was studied in case of dome-shaped Umid structure developed on the basis of underwater mud volcano and located at 40—45 km distance from Byandovan ledge in Caspian sea. Based on 3D seismic data acquired across 417.99 km^2 area including this structure the velocity model, seismic time and dynamic depth cubes were modeled.

Only in one well out of 12 wells drilled in Umid area, namely in well N 7 with depth below 5000 m the seismic survey by VSP has been done in interval down to 2400 m depths. Due to this, stratigraphic tie of time cube has been done according to VSP and well logging data acquired in Shah Deniz, Nakhchivan, Alyat-deniz, Zafar-Mashal and Bulla-deniz areas. Gas outburst while drilling in the study area and vicinity of Bulla-deniz, Shah Deniz and Bahar gas, gascondensate fields makes it possible to suppose high hydrocarbon bearing perspective of Umid structure.

Analysis of seismic data from Umid area evidencing the presence of faults with complicated geometry in the area of mud volcano in South-East of the area, variation of lithology of rocks, etc. display dynamic and kinematic parameters variation of seismic wave field. Geodynamic stress [8] developed in focal area of mud volcano disrupts initial burial of layers while shaly mud penetrated the layer and created an area with complex tectonics in South-West of the area (Fig.1). This complex deep morphostructure of mud volcano is caused by time-spatial abnormal alterations of geodynamic

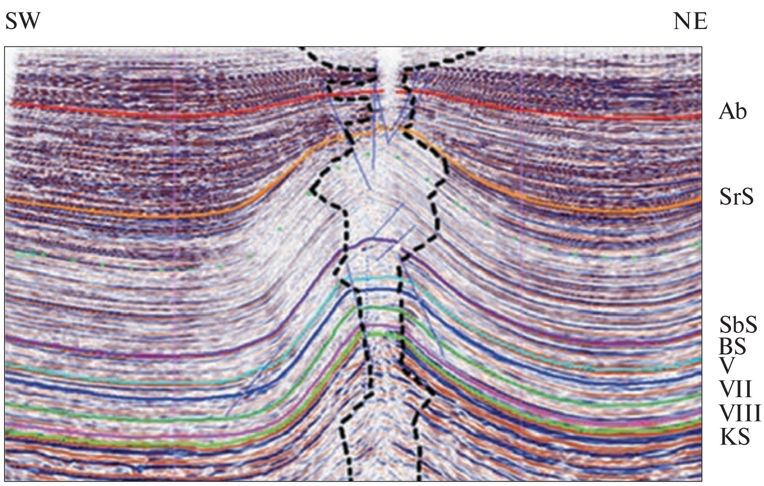

Fig. 1. Mud volcano interference image in vertical slice of dynamic depth cube in Umid area

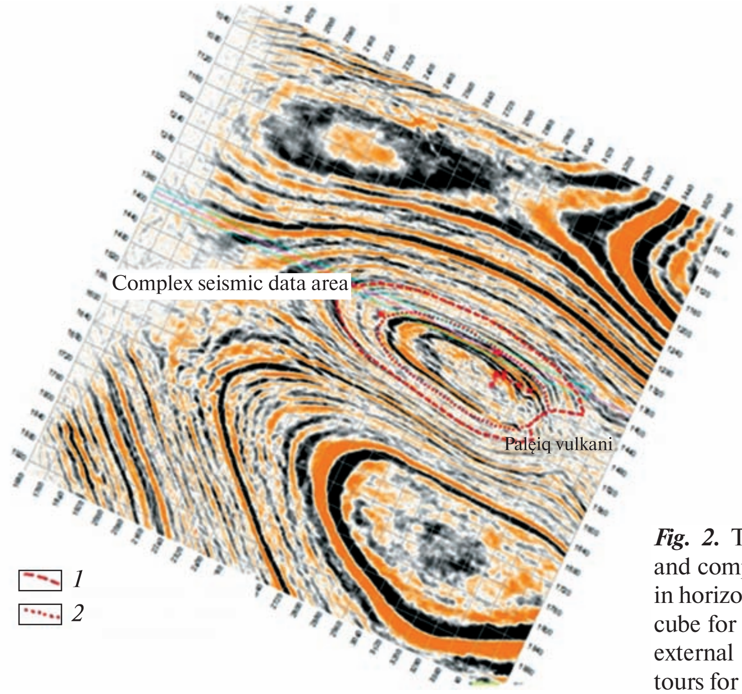

Fig. 2. The image of mud volcano and complex seismic record features in horizontal slice at 7000 m of depth cube for Umid area. Prognoses field external (*1*) and internal (*2*) contours for the horizon VII

stress. When drilling process is conducted through such area in sections with presence of rocks consisting of mud mixed with gas and oil the abnormal formation pressure increases leading to drilling hazards. Indicated peculiarities are characterized by chaotic reflection of time cube and depth cube in seismic data. While drilling, complications of seismic wave field observed in deep layers must be taken into consideration, in other case hazards while drilling will be inevitable.

It can be clearly seen that at 7000 m cross-section of cube with high accuracy approximation of geological section model in the study area the shaly mud with liquid gas content penetrates through the faults (in general, vertical and near-vertical) into the layer and surrounding area creating amorphous mass of geometrical shape (Fig. 2).

Under the impact of horizontal forces shaly mud with mixture of gas penetrates the surrounding area through channels created by faults. As a result, areas of conjugation of layers are featured by acoustic impedance and complicate the seismic image of the area. The mass made of mud is accumulated within shale-gas-water mixture area created by mud volcano [8]. If extra-ordinary, abnormal image of seismic section will not be taken into account complications will be inevitable. For example, in Azerbaijan in well N 42 drilled in Dashgyl area the outburst of mud threw out 2500 meter drilling pipe [2, 4]. In Caspian Sea in well N 90 drilled down to 5868 meters in Bulla-Deniz field the gas show resulted by fire. Other example is absorption of shale mud, gas show and gas bubbles, abnormal water flow (mud spring) were observed in Guneshli field on May 11, 2017 in well N 319, platform N 7.

As seismic data were not taken into account in Indonesia while drilling of gas well the outburst of mud covered a whole village leading to death cases [5]. If distinctive features are not properly studied [6, 7] and geodynamic stress is not taken into consideration while analysis of seismic data in such areas, this may result in drilling hazards leading to environmental issues and enourmous amount of financial losses.

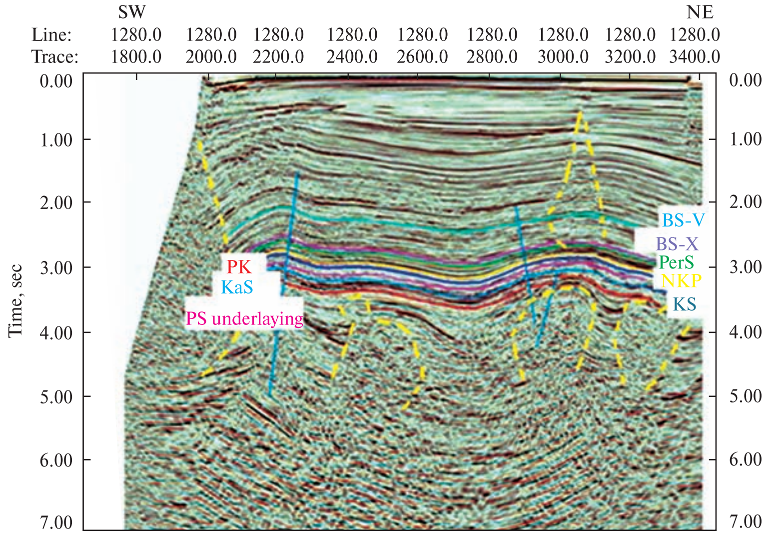

Fig. 3. Complex seismic record outlined by yellow line in time section of Neft Dashlary — Guneshli — Oghuz — D30 area

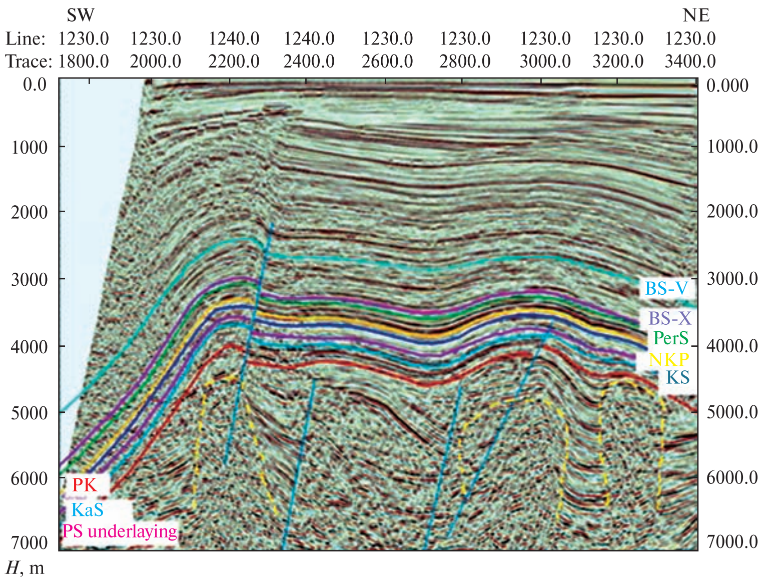

Fig. 4. Complex seismic image outlined by yellow in time section of Neft Dashlary — Guneshli — Oghuz — D30 area in SW-NE direction

Since VSP has not been applied in wells across Umid area, the average velocity model has been chosen on the basis of data acquired in Shahdeniz, Zafar-Mashal, Nakhchivan, Bulla-deniz and Alyat-deniz areas. This approach may result in ±60 m depth variations while trasformation from time cube to depth cube. Such unconformity increases drilling risks. Despite that for the last years the latest technologies have been applied in newly drilled wells VSP is not applied in full or not applied at all. As the exam-

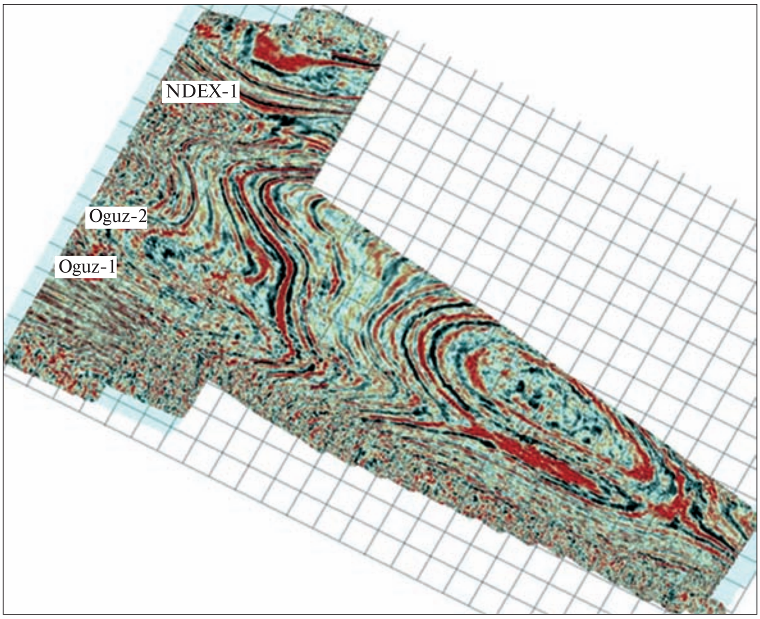

Fig. 5. Horizontal section of 4300 m depth in Neft Dashlary — Guneshli — Oghuz — D30 area

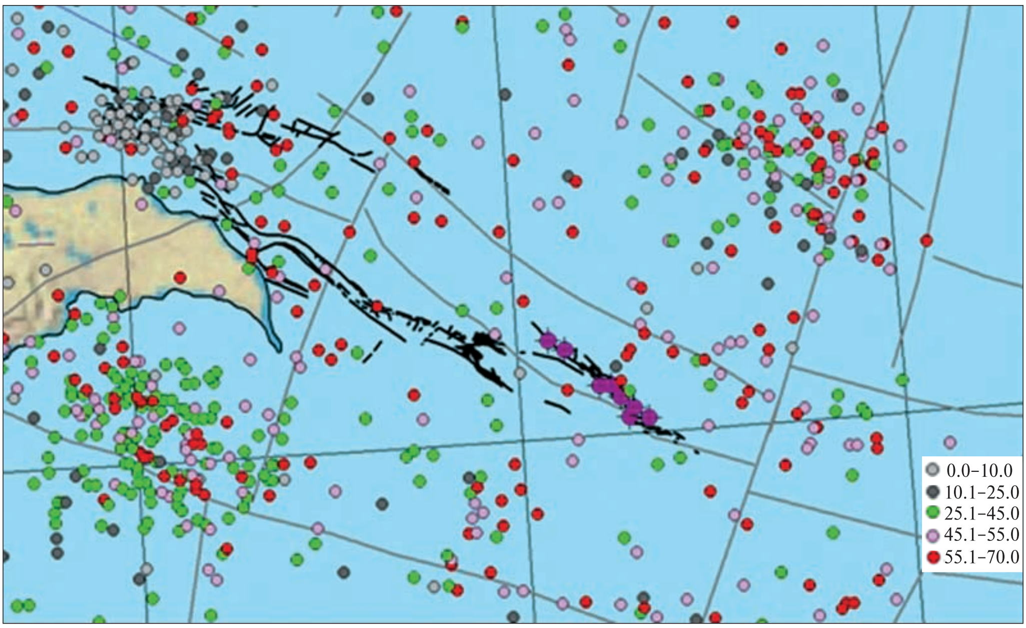

Fig. 6. Map of epicenters of earthquakes occurred through 2000—2016 in Neft Dashlary — Guneshli — Oghuz — D30 and nearby area

ple we may indicate Bulla-deniz area covered by SS-VSP in a small amount leading to ±50—80 m depth difference in seismic ties. Despite that drilling process was successfully completed in well N 78 drilled down to 5910 m depth from platform 6 the absence of SS-VSP may lead to risky complications while future drilling processes.

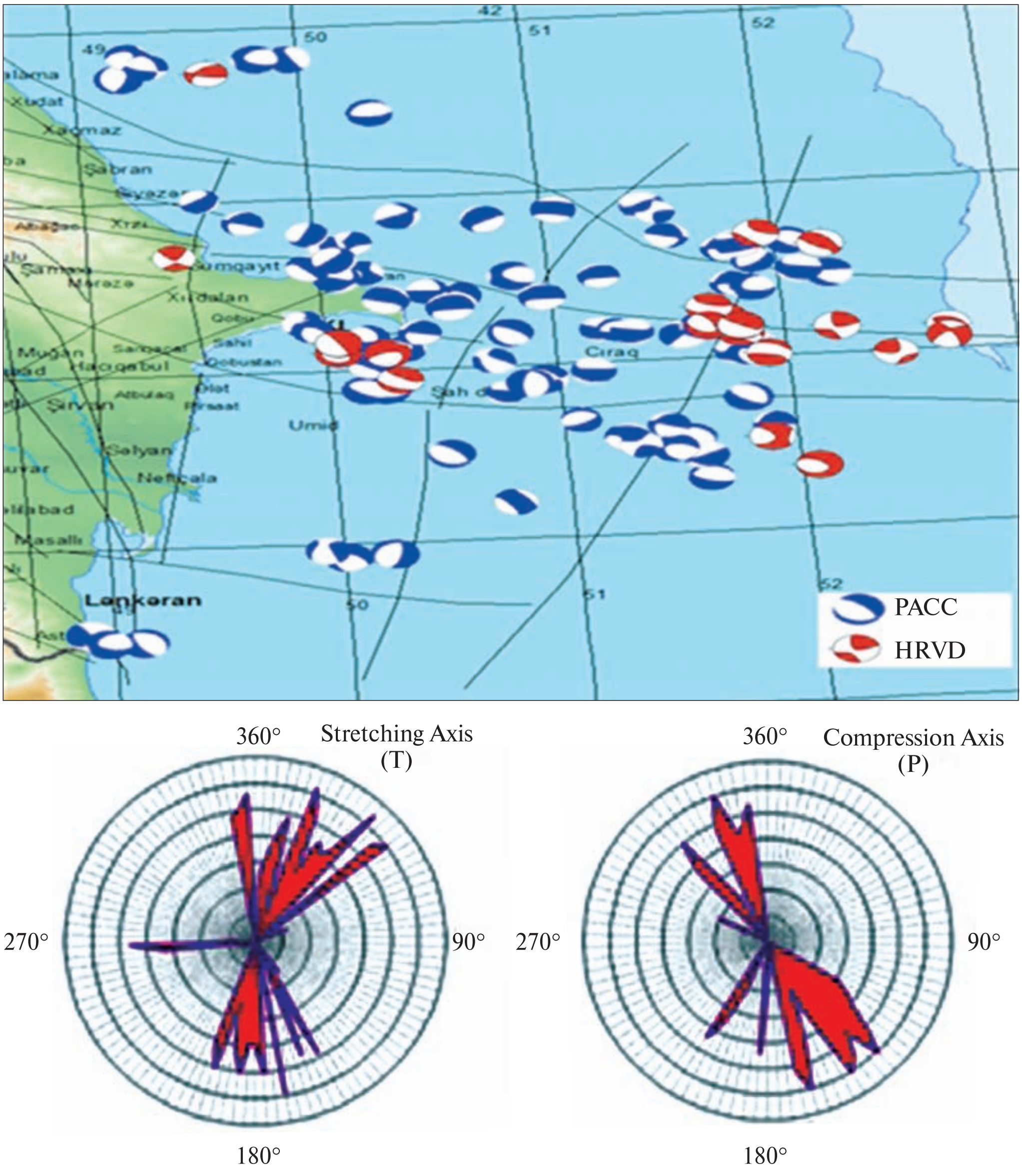

Fig. 7. Map of ml ⩾3.0 earthquakes occurred through 1975—2016 in Neft Dashlary — Guneshli — Oghuz — D30 and nearby area and histogram of tension-compression directions [8]

Geodynamic-stress variations related to earthquakes in areas covered by drilling has been studied in case of Neft Dashlary – Guneshli – Oghuz – D30 area of Eastern Absheron oil-gas bearing zone. Neft Dashlary, Guneshli uplift and Oghuz D-30 (Jabbar Garyaghdi) structures in its South-Eastern pericline are complicated by a large number of latitudinal, longitudinal and radial faults. Stratigraphic tie of 3D seismic data was done based on SS-VSP data acquired in wells Janub-2-6, GCA-1 and well log data acquired from Oghuz-1, NDEX-1 wells. In these structures large oil fields as Neft Dashlary, Guneshli, Chirag and Azeri are related to Kala suite, Pre Kirmaky, Kirmaky, Post Kirmaky sand, Fasile and X horizon of Balakhany series of Productive Series (PS).

Similarity of geological evolution history of Oghuz area with fields indicated above makes it possible to suppose perspectivity of Oghuz and D-30 structures. Presence of sandy horizons with good reservoir properties in Productive Series deposits identified in wells drilled in Oghuz area also support the idea of high hydrocarbon perspectivity of the area. Presence of sandy horizons in Miocene deposits underlaying PS also makes it possible to infer perspectivity of these deposits.

Comparison of cube derived by 3D seismic data acquired in Neft Dashlary-Guneshli-Oghuz-D30 area with cube calculated on the basis of well log data and layer velocity model displays that if average value of random errors for kinematic approximation models and inaccuracy of iteration in near-borehole areas does not exceed ±10 m, the value reaches ±150 m when distancing from well location. These errors may lead to unconformities while evaluation of drilling parameters for wells to be spud. This is also due to the reason of not considering characteristic time-spatial variations of geodynamic stress [3].

A large number of earthquakes occurred through evolution stages of Neft Dashlary — Guneshli — Oghuz — D30 area and development of tension-compression stress influenced formation properties leading to generation of small fractions and faults (Fig. 3 and Fig. 4). Deformation zone is clearly observed at 4300 hypsography section of Neft Dashlary — Guneshli — Oghuz — D30 area (Fig. 5).

Map of epicenters of earthquakes occurrred through 2000—2016 (ml > 4.0) (Fig. 6) reflects that the area constantly underwent stress deformation in various directions (Fig. 7). Most of these earthquakes were related to 10—15 km depth interval, in sedimentary cover. As a result, the area observed in seismic sections can be seen as the area of complex recording (Fig. 3 and 4) with features for layered environment. Drilling hazards and complications are possible in these areas.

Conclusions

1. Analysis of geophysical data acquired for the last years displays complicated deep morphology of mud volcanoes and increasing drilling risks if seismic data are not considered.

2. Well drilling project must include 3D data, deep section, etc. acquired across the well location and should be taken into account by drilling operator. The control over drilling process must be higher in areas featured by complex seismic records.

3. In intervals with presence of active or buried mud volcanoes planned for directional drilling the drilling risks are present.

4. Drilling process in areas of abnormal geodynamic-stress must be performed taking into account direction of stress arrows and stress condition in the area.

5. It is recommended to perfom SS-VSP survey in drilling wells and more accurately define seismic borders.

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The article was received 08.11.2018.

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ФАКТОРИ НЕБЕЗПЕКИ ПРИ БУРІННІ, ЩО ВИКЛИКАНІ ГЕОДИНАМІЧНИМ СТРЕСОМ

В роботі вивчаються фактори, що викликають небезпеку при бурових процесах під впливом просторово-часових змін геодинамічної напруги в районах поблизу активних і похованих грязьових вулканів на нафтових родовищах та перспективних структурах, виявлених на основі сейсморозвідки.

На прикладі структури Умід, розташованої в Каспійському морі, було показано, що через зміни літологічного складу також змінюються динамічні і кінематичні параметри сейсмічної хвилі, що пов'язано з аномальними часово-просторовими змінами геодинамічної напруги.

У районі Нафта Дашлари — Гюнешлі — Огуз — D30 Східноабшеронського нафтогазоносного району вивчались властивості геодинамічних напруг відносно землетрусів, що сталися на місцях буріння, і було встановлено, що більшість землетрусів сталося в інтервалі глибин 10—15 км, в осадовому чохлі. В областях, відображених в сейсмічних розрізах складними сейсмічними записами, що характеризується властивостями, характерними для шаруватих середовищ, через імовірність ускладнень і небезпек буріння було рекомендовано посилити контроль над процесом буріння разом з відповідними превентивними заходами.

Ключові слова: *геодинамічні процеси, геофізичні поля, сейсморозвідка, сейсмічний горизонт, глибинний динамічний куб, зона розломів, ознаки грязьових вулканів, ризик аварії.*

Г.О. Велиев, Р.В. Велиев

ПРИЧИНЫ ОПАСНОСТИ ПРИ БУРЕНИИ, СВЯЗАННЫЕ С ГЕОДИНАМИЧЕСКИМИ СТРЕССАМИ

В работе изучаются факторы, вызывающие опасности при буровых процессах под влиянием пространственно-временных изменений геодинамического напряжения в районах вблизи активных и погребенных грязевых вулканов на нефтяных месторождениях и перспективных структурах, обнаруженных на основе сейсморазведки.

На примере структуры Умид, расположенной в Каспийском море, было показано, что из-за изменения литологического состава также меняются динамические и кинематические параметры сейсмической волны, что связано с аномальными временно-пространственными изменениями геодинамического напряжения.

В районе Нефть Дашлары — Гюнешли — Огуз — D30 Восточноабшеронского нефтегазоносного района мы изучали свойства геодинамических напряжений в отношении землетрясений, произошедших на местах бурения, и было установлено, что большинство землетрясений произошло в интервале глубин 10-15 км, в осадочном чехле. В областях, отраженных в сейсмических разрезах сложными сейсмическими записями, характеризуемыми свойствами, характерными для слоистых сред, из-за вероятности осложнений и опасностей бурения, было рекомендовано усилить контроль над процессом бурения наряду с соответствующими превентивными мерами.

Ключевые слова: *геодинамические процессы, геофизические поля, сейсморазведка, сейсмический горизонт, глубинный динамический куб, зона разломов, признаки грязевых вулканов, риск аварии.*