NEWS
OF THENATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
PHYSICO-MATHEMATICAL SERIES
ISSN 1991-346X **https://doi.org/10.32014/2020.2518-1726.72**
Volume 4, Number 332 (2020), 114 – 118

УДК 550.383

B.T. Zhumabayev[1], I.V. Vassilyev[2], I.D.Kozin[2], I.N.Fedulina[2]

[1] Institute of Ionosphere, National Center for Space Research and Technology, Almaty, Kazakhstan;
[2] JSC Special Design and Technology Bureau "Granite", Almaty, Kazakhstan.
E-mail: beibit.zhu@mail.ru, iv@granit.kz

THE INFLUENCE OF WATER ON THE FORMATION OF EARTHQUAKE SOURCE

Abstract. A hypothesis is proposed to explain the relationship between the number of earthquakes and geographical latitude. Analysis of ultra-deep well drilling results showed that the boundaries of seismic wave reflection that were taken beyond the boundary between the granite and basalt layers were actually related to the rock decompression zone due to increased porosity and microcracking in the main granite layer. These cracks allow water to penetrate the rocks while being compressed and heated at the same time. Calculations show that at a depth of 30 km the temperature should be 460 degrees, and at 42 kilometers (at the base of the Earth 's crust) - already 580 degrees. The pressure at these depths is 3000 and 4200 atmospheres, respectively. When the temperature reaches 374.3 degrees Celsius and 221 atmospheres, the water changes to a supercritical state. In this state, water has special properties, in particular, increased solubility of various substances and high oxidative capacity. It mixes freely with oxygen, hydrogen, and hydrocarbons. Even with a small change in pressure and temperature, complete dissolution or, conversely, precipitation of oxides and salts can occur. The pressure required to achieve the supercritical state is already reached at a depth of 2.2 kilometers. The required temperature is reached at depths of 20-25 kilometers. However, in areas of magmatic hearths, this temperature can be reached at significantly lesser depths. The dissolution of rocks can lead to the formation of cavities like karst, the collapse of the arches of which leads to the collapse of large arrays of rocks with the formation of new cavities over the filled-in cavity, leading to the formation of sub-vertical clusters of earthquake hypocenters, called seismic "nails". At the same time, a Coriolis force proportional to the cosine of latitude must act on the water moving underground. The distribution of the centers of strong earthquakes shows a more sharp decrease in their latitude, proportional to the third degree of the cosine of latitude. These calculations show that the number of earthquakes correlates fairly well with the cubic root of latitude. An additional factor, which also depends on latitude, may be the increase in rock treadiness, which increases towards the equator in proportion to the square of latitude, reducing rock resistance to fluid movement and resulting in an increase in the speed of movement of the rocks.

Keywords: earthquake, seismic sources, fluids.

In 1927, as a result of the analysis of the locations of the epicenters of 1551 major earthquakes from 1903 to 1920, Moran established a relationship between the number of earthquakes and geographical latitude, these data were subsequently summarized by Polycarpov [1]. However, to date, there are no sufficiently convincing hypotheses explaining the nature of this relationship. Statistical analysis of a wider range of observational data (205311) from 1973 to 2014, added to the NEIC global seismological catalogue for earthquakes with magnitude greater than 4.5, showed a structural correspondence between the geographical location of seismically active zones and the geometry of the main geomagnetic field [2]. The reason for this dependency was not identified. The emergence in 2014 of work [3], which justified the connection of the main geomagnetic field of the Earth with the rotation of polarized silicon dioxide molecules, which form the basis of the Earth 's crust and mantle substance, allowed to put forward a hypothesis on the influence of water on the formation of earthquake sources.

The inner structure of Earth has now been studied very little. Analysis of the results of drilling of ultra-deep wells [4] showed that no ultra-deep well confirmed the geological cut that was expected before drilling began. And that the boundary of seismic wave reflection that was taken beyond the boundary

between the granite and basalt layers is actually related to the rock decompression zone. Decompression has been associated with increased porosity and microcracking in the base granite layer. These cracks allow water to penetrate the rocks.

Starting from depths of about 6-7 kilometers the strength of rocks is violated very much and it is not possible to keep the vertical of wells in practice. The deepest well in the world Kola (12261 meters) deviated from the vertical by 840 meters. The KTB-Oberpfalz well (Bavaria, Germany) remained the most vertical in the world to a depth of 7500 m, but then deviated 300 meters, reaching a depth of 9901 m. Due to high temperatures and high pressure, drill strings were repeatedly destroyed. At a depth of 12 km, the Kola well recorded a temperature of 212 degrees Celsius. Calculations show that at a depth of 30 km the temperature should be 460 degrees, and at 42 kilometers (at the base of the Earth 's crust) - already 580 degrees. The pressure at these depths is 1200, 3000 and 4200 atmospheres, respectively.

At depths of more than 4.5 km, even plastic clays are transformed into brittle argyllites prone to cracking and permeable to liquids and gases. Crack systems form subvertical fluid migration channels [5].

Thus, water penetrating through the fractured channels into the Earth 's interior under the influence of gravity is heated. It can be seen from the water phase diagram (Fig.1) that when the temperature of the 647.3 0K and the pressure of 22.1 MPa (374.3 degrees Celsius, 221 atmosphere) are reached, the water must become supercritical. In this state, water has special properties, in particular, increased solubility of various substances and high oxidative capacity.

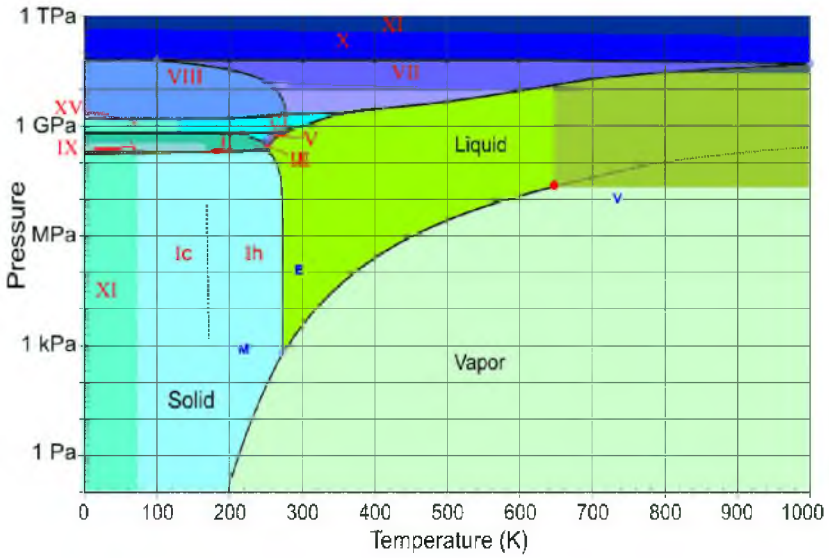

Figure 1

The pressure required to achieve the state of supercriticality is already reached at a depth of 2.2 kilometers. The necessary temperature - on average reached only at depths of 20-25 kilometers. In areas of magmatic hearths, such temperatures can be reached at substantially lesser depths. Thus, a temperature of 223 ^{0}C was recorded on the Tyrnyauz well (North Caucasus, Russia) at a depth of only 4001 meters. This well was drilled to build a geothermal station [4]. And the solubility of various substances in supercritical liquids is primarily influenced by temperature. It has been shown in [6], that even at pressures 4 times higher than supercritical, the best solubility of the substances is observed near the supercritical temperature. The results of the experiments published in [7] show that supercritical water is indefinitely mixed with oxygen, hydrogen and hydrocarbons. Even with a slight change in pressure and temperature, complete dissolution or, conversely, precipitation of oxides and salts may occur. Of the 30 ceramics studied, only pure alumina and alumina with zirconium oxide were not corrosive by supercritical water. At the same time, despite the high concentration of dissolved substances, the electrical conductivity of water in the supercritical state remains quite low and can vary significantly even with small variations in temperature and pressure.

If we accept the presence of water in a sub-and supercritical state in the depth of the earth and its circulation, the dissolution of rocks can lead to the formation of cavities like karst, which are well known

for their ability to collapse with the formation of karst craters. The collapse of the vaults of such cavities in the depth of the earth does not directly lead to the formation of craters, but only to the collapse of large masses of rocks with the formation of new cavities over the filled-in cavity. The sub-vertical clusters of earthquake hypocenters were described in detail in [8], in which they were called the seismic "nail". Such hypocentres are typical mainly for earthquakes with small magnitudes (2-3). The epicentral projection of such "nails" has a diameter of 5-10 kilometers. The time of their formation is from a few days to a month. The authors of this work assumed the connection between the formation of these "nails" with fluids.

In [8] it was shown (from the earthquake analysis for the period 1900-2004) that there are several depths at which severe earthquakes occur most frequently. The figures given in this work show that at a depth of 25 kilometers earthquakes occur most often, although there are several more depths where statistically they are more frequent (10, 33, 40 and further up to 250 km every 10 km). As depths increase, the vertical dimensions of the blocks increase. The data presented in [8] show that, within a century cycle, the accumulated energy is gradually transferred from the deeper layers of the Earth 's substance to the upper layers.

But if there is a circulation of water under the ground, then the Coriolis force must act on this water. Under the influence of this force on the surface of the earth, rivers shift their channels, washing away one of the banks. When water (fluids) moves from the earth's surface to its center, the maximum value of the Coriolis force will be at the equator, but it will be absent at the poles. The Coriolis force for vertically directed fluids decreases from the equator to the poles in proportion to the cosine of latitude. And the distribution of centers of strong earthquakes shows a sharp decrease in their latitude. We will use the data of Moran 's statistics [1] from the work of Polycarpov mentioned at the beginning of the article. It analyzed 542 earthquakes from 1914 to 1920 and 1009 earthquakes from 1903 to 1910.

Table 1 - Distribution of the number of earthquakes by latitude

Latitudes, degrees	Number of earthquakes	Average latitude, degrees	Cosine of average latitude	Cosine cube	Estimated number of earthquakes	Deviation, %
0-10	450	5	0,996	0,988	450	0
10-20	329	15	0,966	0,901	410	20
20-30	244	25	0,906	0,744	339	29
30-40	258	35	0,819	0,549	250	3
40-50	152	45	0,707	0,353	161	6
50-60	87	55	0,574	0,189	86	1
60-70	21	65	0,423	0,076	35	40
70-80	9	75	0,259	0,017	8	12
80-90	1	85	0,087	0,001	0	-

The table shows that the number of earthquakes correlates fairly well with the cosine of the third degree of latitude. So, in addition to the Coriolis force, there must be some other factors that also depend on latitude.

In 2016, a paper [9] was published to explain the causes of vertical cracking of rocks at great depths, which contributes to the penetration of fluids into the earth's interior. It has been calculated tangential mass forces (TMS) and shows that the power of stress horizontal stretching and shear depend on the square of latitude and decrease from the equator to the poles. If we accept this hypothesis and assume that the fracturing of rocks increases to the equator in proportion to the square of latitude, then, accordingly, the resistance of rocks to the movement of fluids should decrease, leading to an increase in the speed of their movement. This may be the additional factor leading to an increase in the Coriolis force, and thus the pressure of fluids on the rocks in the horizontal direction.

The work was carried out on the RBP-008 "Development of space technologies for monitoring and forecasting natural resources, man-made changes in the environment, creation of space technology and ground space infrastructure, research of objects of far and near space" within the framework of the topic "Development of statistical models of spatial and time variations of seismicity characteristics in connection with variations of the structure and dynamics of the radiation belt of the Earth (2018-2020), registration number (RN). 0118RK00797

Б.Т. Жумабаев[1], И.В. Васильев[2], И.Д. Козин [2], И.Н. Федулина[2]

[1]Ионосфера институты, «ҰҒЗТО» АҚ, Алматы, Қазақстан;
[2] «Гранит» АКТБ, Алматы, Қазақстан

ЖЕР СІЛКІНІСІ ОШАҚТАРЫНЫҢ ҚАЛЫПТАСУЫНА СУДЫҢ ӘСЕРІ

Аннотация. Мақалада жер сілкініс санының географиялық кеңдікпен байланысын түсіндіретін гипотеза ұсынылады. Терең ұңғымаларды бұрғылау нәтижесін талдау гранит және базальт қабаттарының шекарасында қабылданған сейсмикалық толқындардың көрініс шекаралары негізінен гранит қабатының кеуектігі мен микрожарығының ұлғаюына байланысты жыныстың тығыздалу аймағымен байланыстығын көрсетті. Жарық суға тау жыныстарының ішіне еніп, қысылады әрі қызады. Есептеу барысында көрсетілгендей, 30 км тереңдікте температура 460 градус, ал 42 километрде (жер қыртысының түбінде) 580 градус болуы тиіс. Осы тереңдіктегі қысым тиісінше 3000 және 4200 атмосфераны құрайды. Температура 374,3 градус Цельсийге және 221 атмосферага жеткенде су сынақ күйге ауысады. Бұл жағдайда су ерекше қасиетке, атап айтқанда, түрлі заттардың жогары еруі мен тотығу қабілетіне ие. Ол оттегімен, сутегімен және көмірсутектермен араласады. Тіпті, қысым мен температураның болмашы өзгерісі кезінде де толық еріп немесе керісінше, оксидтер мен тұздардың шөгуі мүмкін. Аса сыни жағдайга жету үшін қажетті қысым 2,2 километр тереңдікте, қажетті температура 20-25 километр тереңдікте жетеді. Алайда, магмалық ошақ аудандарында мұндай температурага айтарлықтай аз тереңдікте қол жеткізуге болады. Тау жыныстарының еруі себебінен карстралық сынды қуыстар пайда болуы мүмкін, олардың күмбездерінің құлауы сейсмикалық «шегелер» деп аталатын жер сілкінісі гипоорталықтарының субвертикальды топтануына әкеледі. Сонымен бірге жер астында қозгалатын суга Кориолис күші әсер етуі тиіс, ендік косинусына пропорционалды. Қатты жер сілкініс ошақтарының таралуы олардың кеңдік шегінің үшінші дәрежесіне пропорционалды кеңдігі арқылы күрт азайганын көрсетеді. Келтірілген есептеу жұмыстары көрсеткендей, жер сілкіністерінің саны кеңдікте текше тамырымен жақсы корреляцияланады. Әрекет ендікке тәуелді болатын қосымша фактор флюидтер қозгалысына тау жыныстарының кедергісін азайтып және олардың қозгалыс жылдамдыгын арттыратын кеңдік квадратына пропорционал экваторга ұлғаятын жынысындагы кеуек өсуі мүмкін.

Түйін сөздер. Жер сілкінісі, жер сілкінісі ошағы, флюидтер

Б.Т. Жумабаев[1], И.В.Васильев[2], И.Д.Козин[2], И.Н.Федулина[2]

[1] Институт ионосферы АО «НЦКИТ», Алматы, Казахстан;
[2] СКТБ «Гранит», Алматы, Казахстан

ВЛИЯНИЕ ВОДЫ НА ФОРМИРОВАНИЕ ОЧАГОВ ЗЕМЛЕТРЯСЕНИЙ

Аннотация. Предлагается гипотеза, объясняющая связь количества землетрясений с географической широтой. Анализ результатов бурения сверхглубоких скважин показал, что границы отражения сейсмических волн, которые принималась за границу между гранитным и базальтовым слоями, на самом деле связана с зоной разуплотнения пород из-за увеличения пористости и микротрещиноватости в основном гранитном слое. Эти трещины позволяют воде проникать внутрь горных пород, при этом подвергаясь сжатию и нагреву одновременно. Расчёты показывают, что на глубине 30 км температура должна быть 460 градусов, а на 42 километрах (у основания земной коры) – уже 580 градусов. Давление же на этих глубинах составляет 3000 и 4200 атмосфер соответственно. При достижении температуры 374,3 градуса Цельсия и 221 атмосфер вода переходит в сверхкритическое состояние. В этом состоянии вода обладает особыми свойствами, в частности, повышенной растворяемостью различных веществ и высокой окислительной способностью. Она неограниченно смешивается с кислородом, водородом и углеводородами. Даже при небольшом изменении давления и температуры может происходить полное растворение или, наоборот, осаждение оксидов и солей. Необходимое для достижения состояния сверхкритичности давление достигается уже на глубине 2,2 километра. Необходимая температура достигается на глубинах 20-25 километров. Однако в районах магматических очагов, такая температура может быть достигнута на существенно меньших глубинах. Растворение горных пород может приводить к образованию полостей наподобие карстровых, обрушение сводов которых приводит к обрушению больших массивов горных пород

с образованием новых полостей над засыпанной полостью, приводя к формированию субвертикальных скоплений гипоцентров землетрясений, называемых сейсмическими «гвоздями». В то же время на движущуюся под землёй воду должна действовать сила Кориолиса, пропорциональная косинусу широты. Распределение очагов сильных землетрясений показывает более резкое уменьшение их с широтой, пропорциональное третьей степени косинуса широты. Приведённые расчёты показывают, что количество землетрясений достаточно хорошо коррелируется с корнем кубическим от широты. Дополнительным фактором, действие которого также зависит от широты, может служить рост трещиноватости пород, которая увеличивается к экватору пропорционально квадрату широты, уменьшая сопротивление горных пород движению флюидов и приводя к увеличению скорости их движения.

Ключевые слова: землетрясение, очаг землетрясения, флюиды.

Information about authors:

Zhumabayev Beibit Tenelovich, candidate of physical and math. sciences, head of laboratory, Almaty, Kamenskoe plato, Institute of Ionosphere, National Center for Space Research and Technology,beibit.zhu@mail.ru, https://orcid.org/0000-0001-7882-0277;

Vassilyev Ivan Veniaminivich, candidate of physical and math. sciences, deputy general director for science, Almaty, JSC Special Design and Technology Bureau “Granite”, iv@granit.kz, https://orcid.org/0000-0002-6216-0443;

Kozin Igor Dmitrievich, doctor of physical and math. science, consultant, Almaty, Special Design and Technology Bureau “Granite”, IDKozin@yandex.kz

Fedulina Inna Nikolaevna, candidate of physical and math. sciences, consultant, Almaty, Special Design and Technology Bureau “Granite”, innafedulina@yandex.kz

REFERENCES

[1] Polycarpov M. On earthquake distribution along latitude// UFN 8, 1928. Page 417-419.

[2] Khachikyan G.J., Zhumabayev B.T., Toishiyev N.S., Kaldybayev A.A., Nurakynov S.M. Variations of solar activity and spatial-temporal distribution of strong earthquakes (M 7.0 1973-2014) on the territory of Eurasia in 2016.// News of the National Academy of Sciences. Page 40-45.

[3] Vasilyev I.V. Influence of Gravity on Formation of Earth Magnetic Field// PEOS Journal, para. 16, vol. 1. 2014. Page 48-55.

[4] Popov V.S., Krenetskiy A.A. Deep and Super Deep Drilling on Continents// Sorosovsky Educational Journal. № 11. 1999. Page 61-68.

[5] Korotkov B.S., Korotkov S.B. Gas potential of deep horizons// Scientific and technical collection "News of gas science," № 3 (8). 2011. Page 26-31.

[6] Humpback Y.E., Bondarenko G.V. Supercritical state of water// Supercritical fluids: Theory and practice. 2007. № 2. Page 5.

[7]. Galkin A.A., Lunin V.V. Water in sub- and supercritical states is a universal medium for carrying out chemical reactions// Success of chemistry, No. 1 (74). 2005. Page 24-40.

[8] Vadkovsky V.N. Subvertical clusters of earthquake hypocenters - seismic "nails"//Journal of ONZ RAS, № 4. 2012. Page 1-8.

[9] Rebetsky Y.L. Assessment of the impact of daily rotation of the earth on the stressed state of the continental crust // Reports of the Russian Academy of Sciences. 2016. T. 469, No. 2. Page 230-234.