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S. M. Kan, E. Zh. Murtazin, V. D. Vyalov

LLP "Institute of Hydrogeology and Geoecology named after U. M. Akhmedsafin", Almaty, Kazakhstan

GEOTHERMAL WATER ZHARKENT ARTESIAN BASIN AND PROSPECTS CREATION ON THEIR BASED COMPLEX OF THERMAL AND POWER PRODUCTION

Abstract. Presented results of research capacities of industrial development and exploitation of geothermal resources Zharkent artesian basin. Zharkent artesian basin of fresh thermal water with a temperature of 40 to 100°C or more is located in the south-eastern part of Kazakhstan, in the East – Ili depression. The territory of Zharkent basin relates to Panfilov district of Almaty region with the main administrative center of the city of Zharkent located in 330 km east from the city Almaty. Given a brief description the hydrographical network, relief, climate of the region research, geological and structural conditions of the territory. According to data hydrogeological studies in the section Zharkent artesian basin are five aquifers containing thermal waters: Neogene, Paleogene, Cretaceous, Jurassic and Triassic. Shown the most prospects for using geothermal waters of Cretaceous aquifer complex, which has fairly widespread. By results of researches defines the main directions and sphere of use geothermal resources indicated region – this is combined heat and power, water and wellness.
Keywords: geothermal waters, Zharkent artesian basin, complex of production heat and electricity.

Introduction. The modern demand geothermal energy as one of renewable energy sources due to: exhaustion of stocks of organic fuel and dependence the majority developed countries from its imports (mainly oil and gas imports), as well as with significant negative impact the fuel and nuclear power engineering on the human environment and wildlife nature [1].

The main advantage geothermal energy is possibility its use at the form of geothermal water or mixture water and vapor (depending on their temperature) for hot water and heating power generation or simultaneously for all three objectives, its practical inexhaustibility, complete independence from the conditions environment, time of day and year. Thereby use of geothermal energy (along with use of other environmentally friendly renewable energy) can make a substantial contribution to solving following pressing issues: ensuring sustainable heat and electricity supply of population in those regions of our planet where centralized power supply is absent or costs too much; ensuring guaranteed minimum power supply population in areas of unstable centralized power supply due to a deficiency of electric power in the energy systems, prevention of damage from emergency and restrictive outages, etc.; reduction of harmful emissions from energy installations in particular regions by environmental problems.

Thus the study geothermal waters of Kazakhstan becomes an important issue in sphere of development power engineering in generally and particularly in the area than traditional and renewable energy sources. One of the most perspective regions in the Republic of Kazakhstan is the Zharkent artesian basin.

In the East – Ili basin, located in the south-eastern part of Kazakhstan, there is a large Zharkent artesian basin of fresh thermal waters with a temperature of 40 to 100ºC and more. Performed earlier studies [2-4] have shown that in the sedimentary cover has powerful layers of rocks having good collector properties. The territory of Zharkent basin relates to Panfilov district of Almaty region with the main administrative center of the city of Zharkent located in 330 km east from the city Almaty.

Geographically – is a central part Ili intermountain depressions, bounded on the north – Jungar Alatau ridge in the south – Ketmen ridge from the west of mountains Kalkan and Katutau the east studied region is limited to the state border with China.

Hydrographic network well developed and presented Ili River and its ducts, as well as a branched network of irrigation canals. Ili River presented in operation area of its middle part the largest in magnitude and water content in the region. The rivers Usek, Borohudzir, Korgas and others often do not convey its flow to the main water artery – the river Ili. The rivers are fed caused by spring melting of snow and summer melting of glaciers, atmospheric precipitation as well as spring runoff.

The relief of the studied region differs by great diversity. Most of the territory a typical foothill plain, bounded by the southern spurs of Zhongarsky (Jetysu) Alatau and Ketmen ridge. Slopes of the mountains steep and precipitous. Absolute level of separate peaks over 4000 m, mainly 2500–3000 m with relative exceedances up to 3000 m. The foothill plain has level from 1400 m, at the foothills and up to 500 m in the region Ili River valley. By the nature relief foothill flatlands can be subdivided into foothill plume debris cones of mountain rivers, peripheral lacustrine-alluvial plains and river valleys.

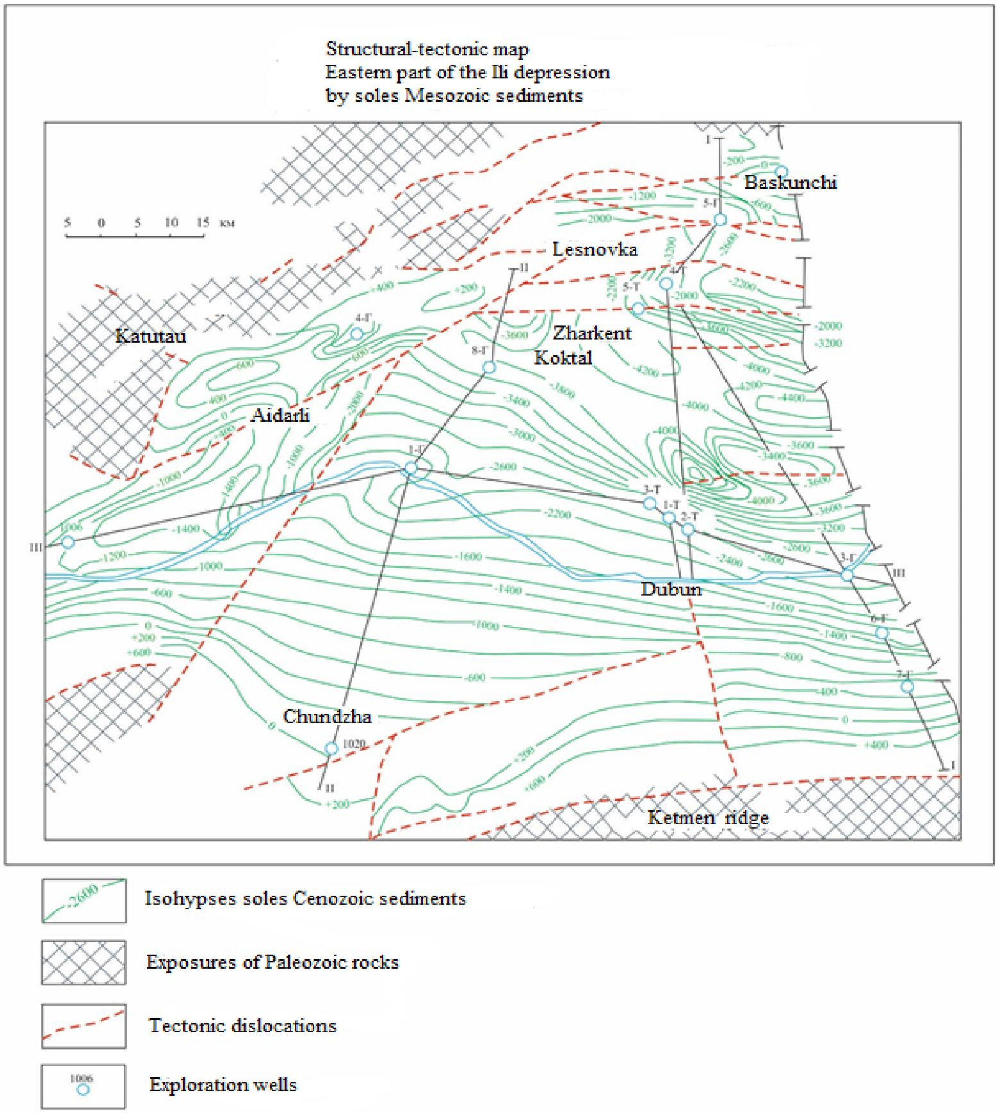
Climate of the region dry, sharply continental, with increasing specific gravity of summer rainfall. The mountain spurs, closing the depression, play a decisive role in moistening climate valleys, causing a small amount rainfall not only on the flat its parts, but also on the slopes of closing ridges. The annual amount of precipitation within the cavity to be about 125-150 mm. The steady snow cover lasts 1.0–2.5 months and does not exceed 10cm. In the summer intense heat in combination with the constantly blowing wind dehumidifies the lower layers atmosphere and creates a large deficits moisture.

According to the scheme hydrogeological zoning of Kazakhstan, developed by academician U. M. Akhmedsafin [5], Zharkent artesian basin is second order basin in relation to the Copa-Ili. Deflection represents multilevel artesian basin, areas nutrition which are surrounding mountain structures. Geological and structural conditions of the territory (picture 1) allow to consider it as an independent hydrogeological unit and allocate in it within the two regions with very specific conditions formation of hydrogeological conditions. The conditional border between them is carried out on modern river channel Ili. Left-bank part (Karadala) - district development of Ketmensky monocline, although complicated by faults, but with little amplitudes. Mesozoic deposits are here or rise to the surface or lie not deep under layer of low-power Jurassic deposits and common not in the whole territory.

The right bank region – central and northern part depression, is characterized more complicated geostructural conditions. It is characterized by sharp division of Paleozoic basement on the blocks, thick network tectonic fractures, deep occurrence Mesozoic sediments and in general Mesozoic and Cenozoic cover. The power Cenozoic sediments are here reaching their maximum and often dislocated into the folds.

Mesozoic – Cenozoic deposits Zharkent artesian basin contain a range water-bearing of thicknesses, various lithological composition, capacities, conditions of distribution and formation of groundwater, character hydraulic connection with overlapping and underlying water-bearing sediments.

According to data hydrogeological studies in the section Zharkent artesian basin distinguish five water carrying complexes containing thermal waters: Neogene, Paleogene, Cretaceous, Jurassic and Triassic. The most promising for use of geothermal waters is Cretaceous aquifer complex, which has enough wide circulation. It is not only in the extreme south-west, where it runs along the border Shelek-Kemin fault. Outputs of the Cretaceous deposits exposed at the surface are known in foothills of Ketmen ridge at the mouth river Budutysay. With removal northward rainfall submerges under of younger age sediments, increases depth stratification and power sediments. Within the limits foothill plain by wells at depths Cretaceous sediments are revealed to 150 m, their power does not exceed 3–26 m. In region Useksky area roofing of Cretaceous deposits is revealed at depths 1680-2264 m (wells 1T, 2T, 3T) in the Ili area – 2580–2710 m (wells 1RT, 1TP, 2TP) and Kirov area – 2688 m (4T well). The total capacity of Cretaceous deposits varies from 171–260 m on the Useksky areas to 174 m on the Kirov area.



Picture 1 – Structural-tectonic map

According to data geophysical research roofing Cretaceous sediments submerged under rainfall of a younger age. The greatest depth occurrence roofing of the Cretaceous sediments is marked in area of Zharkent city (about 5 km).

Thermal waters of Cretaceous sediments were studied on wells 3G and 6G Korgas profile, supporting well 1G situated in the west central part of the basin, as well as its central part and on Useksky and Iliysky areas. Is allocated two water-bearing complex: Lower Cretaceous and Upper Cretaceous. The power aquitard on the studied wells varies from 3-10 m Useksky area to 22–25 m in wells 1G, 6G, 7G.

The lower Cretaceous aquifer complex had been tested in wells 1T, 3G and 6G. It should be noted that tested intervals were allocated conditional to Lower Cretaceous sediments. Aquifer are small pebbles conglomerates and gritstones and Rollovers higher along the section in coarse-grained sandstones and even higher in the fine-grained sandstone and marly clays. The power sediments is an average 170 m, decreasing to the south up 33 m and rising to 250 m to the north. Thermal waters described aquifer system were tested in wells 3G and 6G Korgas profile, as well as in the well 1T Useksky areas at a depth of 782 m (6G well) to 2290 m (1T well). In this case in the well 1T Lower Cretaceous sediments were tested jointly with Middle Jurassic, Lower Jurassic and Upper Triassic horizons. The total production rate amounted to 2450 m^3/day production rate Cretaceous aquifer amounted to 727 m^3/day, mineralization 2.3 g/dm^3, temperature of 720ºC.

Upper Cretaceous aquifer complex on the territory Zharkent artesian basin received widespread development. In the lower part of the aquifer are deposited matured on the area brick-red clays, passing into aleurolites with interbedded light brown clayey sandstone. Above the cut are deposited large and medium sandstones. For the northeast of the basin is characteristic conglomerate composition of sediments upper section. The power of water-containing rocks here increases with distance from the ridge to the north Ketmen. If in the foothills ridge, it is within the of 3–10 m, then in area the asphalted trails Shonzhy-Kalzhat it reaches 81–175 m and more. Revealed by are here thermal water wells possess high pressure. Piezometric levels of their are established from 31-162 m below surface of the earth (foothills Ketmen) to 13,7–114,2 m above it in the area water intake profile.

Filtrational properties water-bearing rocks over the area distinguished by relatively small. coefficient of filtration varies from 5 to 12.3 m/day, water conductivity – from 454 to 877 m^2/day, and piezoconductivity $3.4{\cdot}10^5$, $3.4{\cdot}10^6$ m^2/day. With advancement on the north from exploration profile, these parameters are reduced. Decreases they also from the west to the east.

Mineralization horizon water is not high usually does not exceed 1,1 g/dm^3. Chemical composition of the groundwater also not uniform that associated block structure territory. In gas composition at all areas prevails nitrogen 75,0–98,4% vol.

Evaluation regional and operational stocks of thermal waters Zharkent artesian basin is given based on the available factual material on geology, hydrogeology and geothermics.

The regional operational resources of thermal waters are defined taking into account the area of distribution, power of water-bearing strata and water rendering properties.

Specific water loss basic collectors of Triassic and Jurassic aquifers consisting of loose conglomerates, sandstones and sands on average adopted as 0,14. Cretaceous sediments represented of coarse sand with inclusion gravel and pebbles and unconsolidated sandstones have water loss about of 0,15–0,20. Paleogene by sandy sediments, often with admixture silt and clay particles, are characterized small magnitude water loss – about 0,05, and Neogene by sandy sediments – to 0,07.

Proceeding from aforementioned parameters of water-bearing sediments, assessed regional resources of thermal waters for specific water-bearing complexes (table 1).

Table 1 – Estimated parameters and regional operational resources of thermal waters Zharkent artesian basin

Age water-bearing rocks	Area dissemination, 10^6, m^2	The average power of water-bearing rocks, m	Specific water loss	Regional stocks bln, m^3
Neogene	5170,0	240	0,07	86,9
Paleogene	6285,0	85	0,05	26,7
Cretaceous	4037,5	67	0,20	54,1
Jurassic	4275,0	63	0,14	37,7
Triassic	3527,5	85	0,14	42,0

As shown in Table 1, regional operational resources of thermal waters by Zharkent basin is 343 billion m^3. The regional operational reserves of thermal waters are estimated for waters with temperatures above 35°C.

The results of the operational stocks are shown in тable 2.

Table 2 – Operational reserves of thermal waters

Age water-bearing rocks	Area dissemination, 10^5, м^2	The average power of water-bearing rocks, m	The average coefficient filtering, m/day	Radius "big well", m	Hydraulic resistance layer	Regional operational stocks, m^3/day
Neogene	5170	240	0,8	40 625	1,309	368 452,3
Paleogene	6285	85	1,1	44 792	1,114	210 836,6
Cretaceous	4037,5	67	1,0	35 901	1,556	108 164,5
Jurassic	4275	63	0,6	36 942	1,499	63 344,6
Triassic	3527,5	85	0,53	34 030	1,663	68 049,1
Total						1 397 911,5

Water-bearing complex Cretaceous sediments on the territory of Zharkent artesian basin is the most perspective for obtaining fresh groundwater with temperature to 100°C and in the deepest their parts and above.

Structural position Zharkent depression among folded structures of Northern Tien Shan and Dzungaria, geomorphological and climatic features of the area, presence of in the context thick strata of different heat conductivity and permeability caused existence here of a large of artesian basin with thermal water, having a closed hydrodynamic regime. Temperature of groundwater dependent on exogenous (climate) and endogenous (geothermal) factors, combination of which causes geothermal zonality terrestrial bowels.

Seasonal and multitude of years temperature variations cover only upper part of the section without penetrating deeper neutral layer and depend on lay of land, climate and hydrodynamic factors. As shown in works [4, 6, 7] depth stratification of neutral layer increases from the central to peripheral parts from 20–25 to 40–50 m and temperatures is correspondingly reduced from 13 to 11ºC.

Geothermal characteristic of the section deeper neutral layer is provided according to data thermometer measurements, both in the drilled deep wells of hydrocarbons and in wells drilled with the purpose searching of thermal waters at the Kirov, Useksky, at the Iliysky and Molodezhnaya areas. Analysis of thermograms taken by wells Useksky area (Picture 2–5) shows that: temperature curves have practically straight line, indicating on the direct dependence temperature from the depth. However, geothermal gradient is not constant both in area that in the section. It is visually shown in table 3.

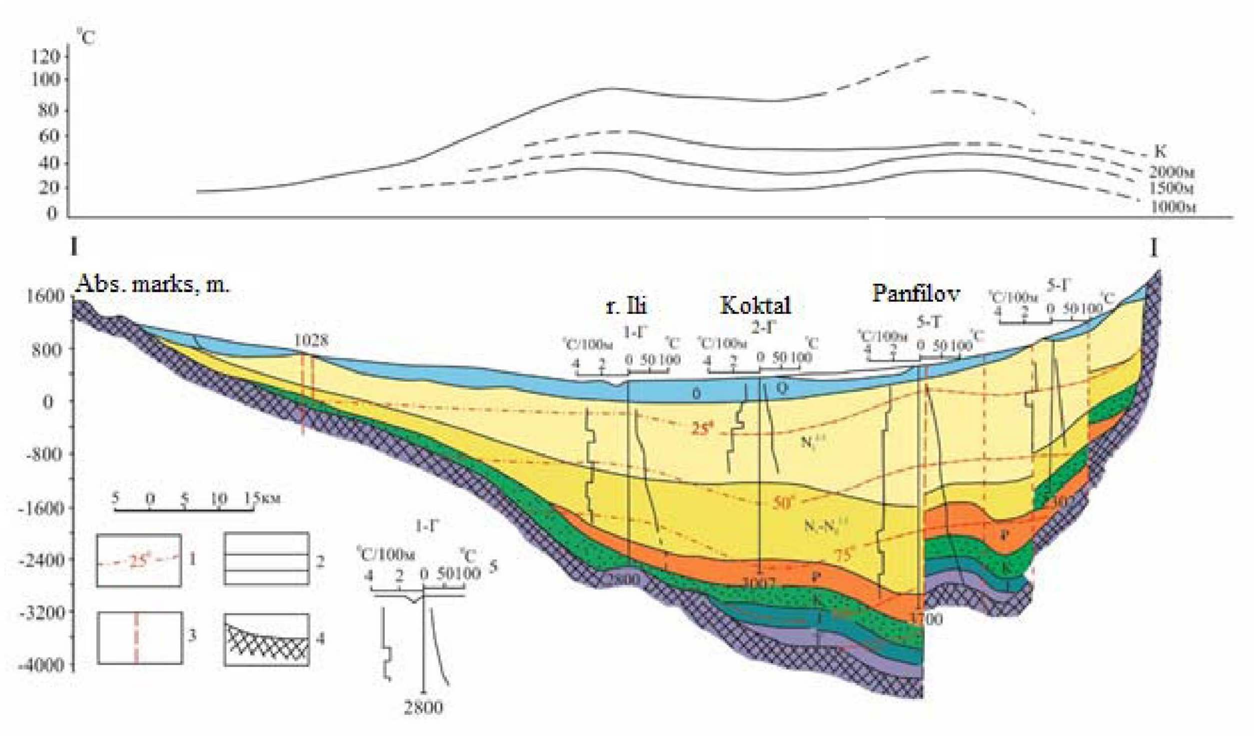
Table 3 – Change of temperature and geothermal gradient from the depth on wells Useksky areas

Depth, m	Temperature, °C			Geothermic gradient, °C/100 m			Geothermic level, m/°C		
	well 1T	well 2T	well 3T	well 1T	well 2T	well 3T	well 1T	well 2T	well 3T
250	22,5	16,0	13,5						
500	26,0	20,5	18,5	1,4	1,8	2,0	71,4	2,0	50,0
750	30,0	26,5	25,5	1,6	2,4	2,8	62,5	2,8	35,9
1000	36,0	33,5	31,5	2,4	2,8	2,4	41,6	2,4	41,6
1250	42,0	40,4	37,5	2,4	2,8	2,4	41,6	2,4	41,6
1500	48,0	46,5	43,5	2,4	2,4	2,4	41,6	2,4	41,6
1750	55,0	52,5	50,5	2,8	2,4	2,8	35,7	2,8	35,9
2000	61,0	58,0	56,5	2,4	2,2	2,4	41,6	2,4	41,6
2250	66,0	66,5	61,0	2,0	3,4	1,8	50,0	1,8	55,5
2500	71,0	74,0	63,2	2,0	3,0		60,0		
2750	77,0	81,0		2,4	2,8		41,6		
3000	84,5 (2888 m)	90,0 92,7 (3073 m)			3,6				

When comparing materials geothermic with data on the stratigraphy and lithology by wells located on Useksky area are observed definite regularities on the values geothermal gradient for different ages thicknesses.

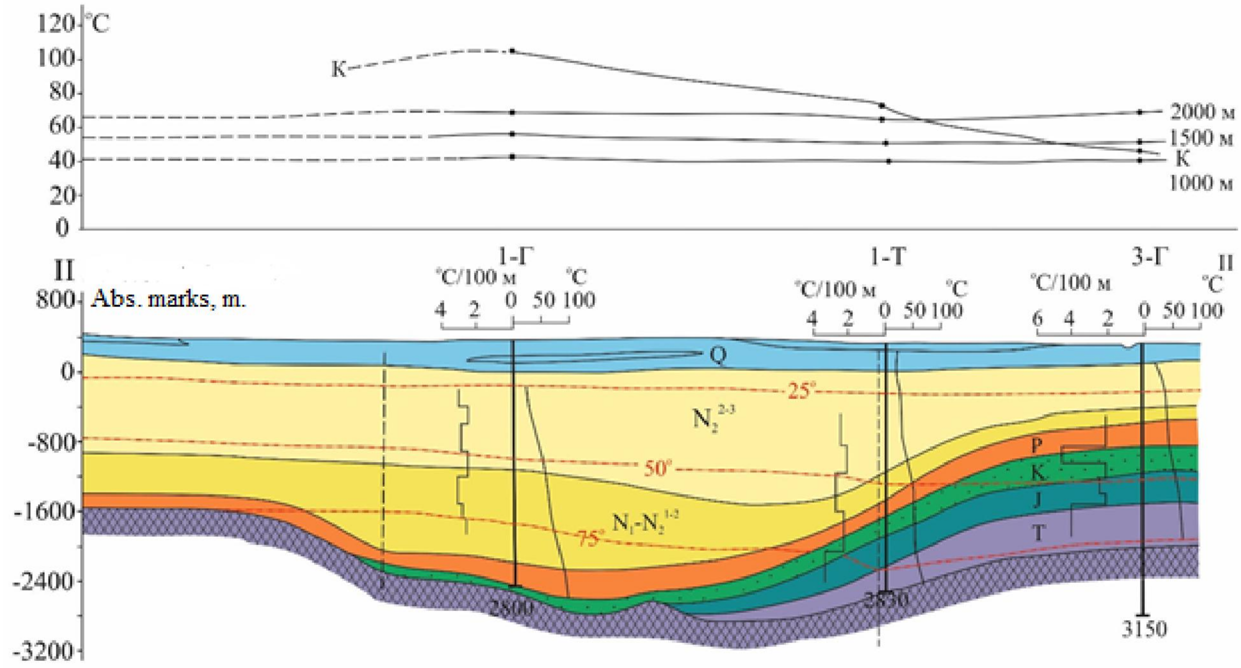
Comparison materials of geothermal research data shows on the geology and hydrogeology area that a basic role in the distribution of temperatures are playing block structure of depression, lithologic-facies composition water surrounding rocks and character of water exchange. In connection with this, values of geothermal gradients separates stratigraphic thicknesses vary within wide limits. Performed geothermal research allowed within the basin in section Mesozoic-Kaynazoy cover allocate five of geothermal zones.

Geothermal zone (to 25°C) circulated on all territory of depression. Its lower boundary is traced to the depths of 200–1000 m and dated for onboard part of the depression. This zone mainly covers Quaternary rocks and Upper Miocene sediments, for which characterized active water exchange.

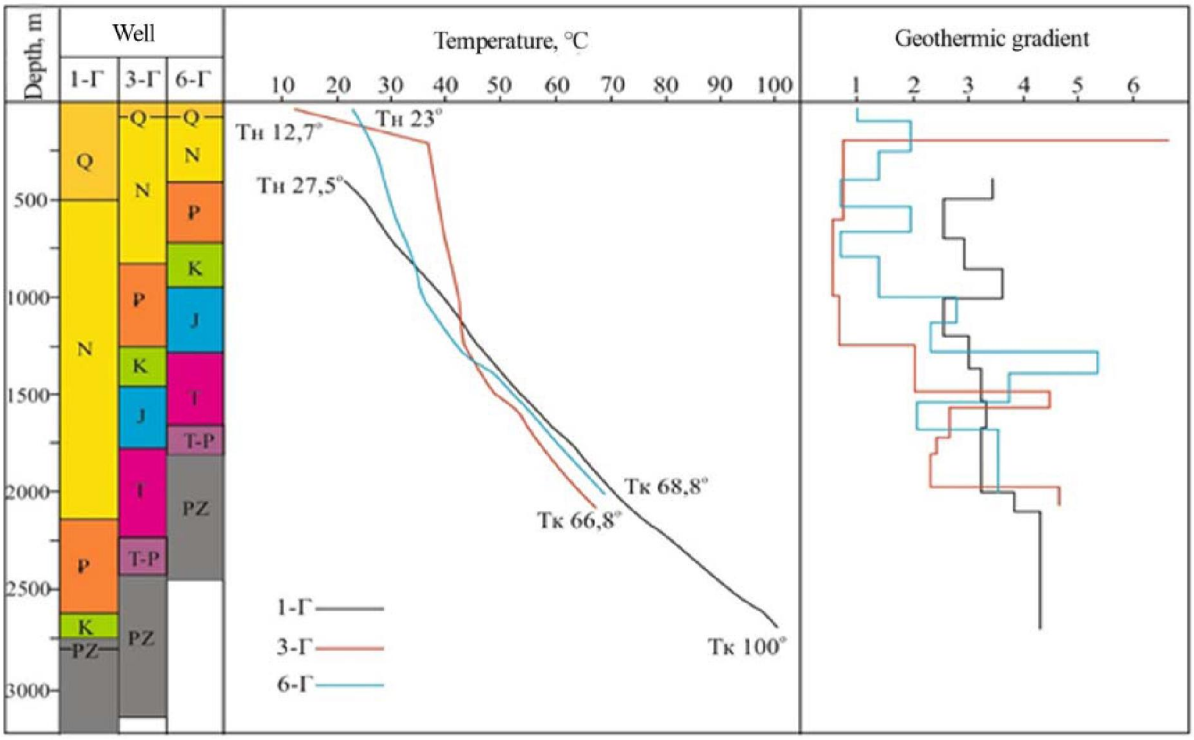


Picture 2 – Hydrogeothermal slit by lines I–I.

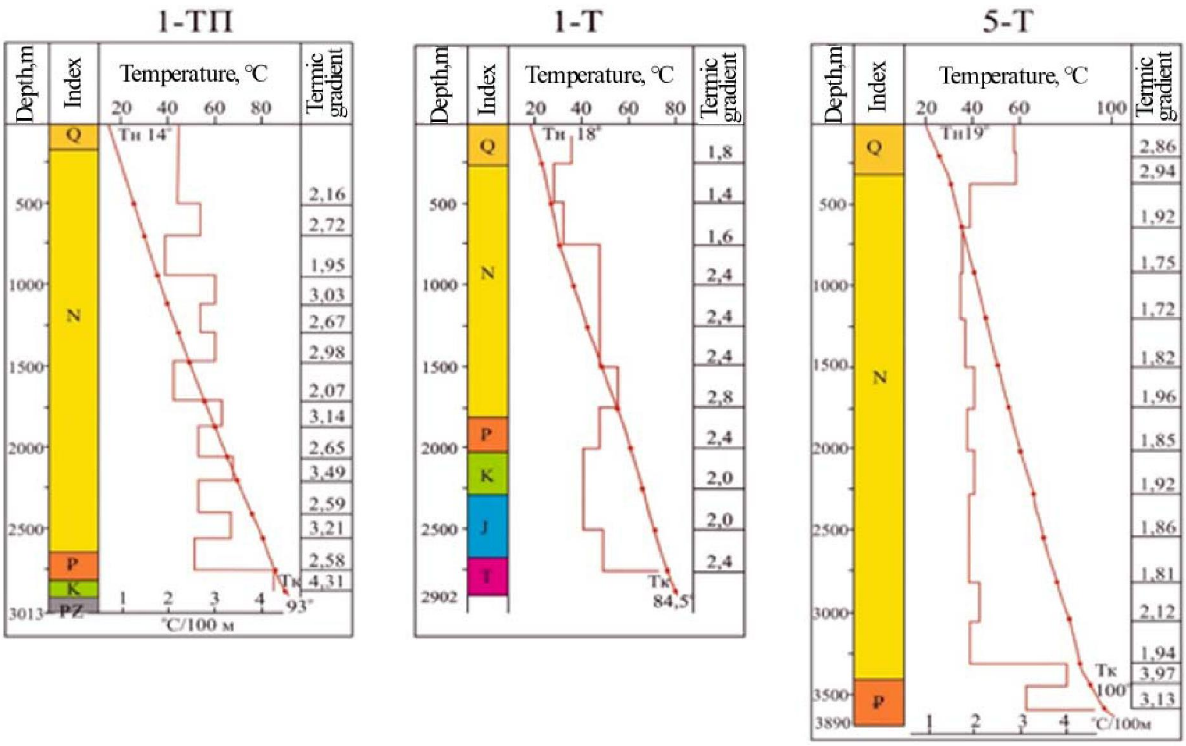
1 – isolines of temperature; 2 – Cretaceous aquifer; 3 – line tectonic disturbances; 4 – Paleozoic basement; 5 – well, from the top – number, at the bottom – depth, m; left – diagram values geothermal gradient; right – thermogram.



Picture 3 – Hydrogeothermal slit by lines II–II



Picture 4 – Thermograms and diagrams value of geothermal gradient by wells 1G, 3G, 6G



Picture 5 – Thermograms and values of geothermal gradients by wells 1 TP, 1T, 5T

Geothermal zone (25–50°C) occupies smaller area and captures, mainly Miocene sediments, in the southern and south-eastern part of the depression dated for the water enclosing rocks Cretaceous, Jurassic and Triassic. The greatest depth of the lower boundary of this zone (1900–2000 m) are traced in the south-eastern part of the depression, where affects cooling effect on subsurface infiltration of surface water, atmospheric precipitation and introduction cold water along the meridional fissures.

Geothermal zone (50–75°C) occupies the whole central part of the basin. The lower boundary its overlies mainly at depths of 2400–2600 m, capturing sediments of Neogene, Paleogene, and on the periphery of depression – the Cretaceous, Jurassic and Triassic.

Geothermal zone (75–100°C) is traced to the depths of 3000–4000 m and dated for chiefly to the Mesozoic sediments.

Geothermal zone with temperatures above 100°C dated for the central part of the basin depth, is located at depths of over 4000 m and covers Cretaceous, Jurassic, Triassic aquifer complexes.

By the direction center part of basin as a whole there is a trend to the decrease area spread each succeeding geothermal zone.

Conducted research allow the conclusion that commercial development and operation geothermal resources Zharkent field gives opportunity to replace traditional methods of heat and power, ensuring achievement of effective economic and social results.

Based on estimated reserves of thermal resources were conducted calculations by the definition possible extent use thermal heat on the territory of Zharkent depression at various modes operation fields. Thus in the reserves of thermal waters takes into account water with temperatures above 50°C. Productivity typical water abstraction out of 5 wells located in the area of 25 km^2, provided drawdown levels at 250 m over all horizons are defined [8] in the following volumes:

Neogene 44952 m^3/day,

Paleogene 29086 m^3/day,

Cretaceous 29220 m^3/day,

Jurassic 12494 m^3/day,

Triassic 14895 m^3/day.

The values of forecasted reserves and productivity water abstraction are characterized a high level prospect area and separate horizons.

Difficult to forecast, in conditions of lithological inhomogeneities rocks depression, value of the coefficient filtration and capacity of aquifers. Credibility their for southern part of the basin, where wells in some measure determined character consistency of these parameters at this stage enough. In the area deep plunge horizons, in the central part of the basin, capacity and filtration properties of rocks did not determine by direct methods, intended section through does not open any one well. Therefore adopted values of these parameters are conditional. Should also be note that the filtration properties of rocks were determined by short-term experiments.

Proceeding from above considerations, for design studies the calculations water intakes of three wells with a distance between them of 3,5 km and single wells dispersed throughout the area. Location of wells defined in area the maximum excess pressures, allocated by hypsometry areas. The costs are calculated on joint exploitation horizons and operation nearest to the surface horizon. In the calculations take into account the interaction of water intake and boundary conditions artesian basin. In the basis of calculation put averaged parameters from the work of Institute Hydrogeology and Hydrophysics AS KazSSR [4, 8].

On territory of the region, taking into account the location of existing settlements, their thermal load, possible location of the thermal wells, proposed to use thermal waters in the period 2015–2025 yy. for heat supply settlements: v. Koktal, v. Altiuy, v. Uch-Aral, c. Zharkent.

Comparison of data for growth heat loads and heat capacity wells reveals possibility of organizing geothermal heat supply mentioned settlements (each from nearby wells) at the level till 2025 without the construction of peak heat sources. An exception is c. Zharkent heat supply it for the period 2015–2020 yy. can be arranged with using heat from 1 wells with heat in the peak boiler. During the period after 2020 till 2025 covering heating load of the city would require warmth from the water intake of the 2 wells and a peak boiler.

Temperature reservoir in Zharkent field too low for providing work geothermal power plant of conventional type. The only practically implemented option for the production of electricity from geothermal steam with temperature 70–96°C is binary technology. Binary technology usually divided into two categories: Organic Rankine Cycle (ORC) and Kalin cycle. However, Kalin cycle is more preferable for geothermal liquid at temperature 100–140°C and further did not considered. ORC technology is the most prevalent form of electricity production from reservoirs with low enthalpy.

Analysis of information about previously prospected geothermal resources Zharkent artesian basin, as well as its current status allow to make following conclusion.

Basic directions and sphere of use geothermal resource indicated region, by which at the moment has enough reliable information, that satisfy needs of different calculations of technical and technological parameters of their application combined heat and power water supply and wellness.

A more limited possibility choose from the above data on fund wells objects to recommend their use for electricity generation, even taking into account use of binary technologies. It is true that definite prospect such using of geothermal resources exist in Zharkent district, where temperatures the main water intake amounts 93°C and ensuring appropriate of extraction conditions in estuary of can be not lower 90–91°C.

Industrial development and exploitation of geothermal resources Zharkent artesian basin in fuel and energy complex allows to replace traditional methods of energy supply, ensuring achievement of effective economic and social results.

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С. М. Кан, Е. Ж. Мұртазин, В. Д. Вялов

«У. М. Ахмедсафин атындағы гидрогеология және геоэкология институты» ЖШС, Алматы, Қазақстан

ЖАРКЕНТ АРТЕЗИАН БАССЕЙНІНІҢ ГЕОТЕРМАЛДЫ СУЛАРЫ ЖӘНЕ ОЛАРДЫҢ НЕГІЗІНДЕ ЖЫЛУ МЕН ЭЛЕКТР ЭНЕРГИЯСЫ ӨНДІРІСІНІҢ КЕШЕНІН ЖАСАУ БОЛАШАҒЫ

Аннотация. Жаркент артезиан бассейнінің геотермалды суларды пайдалану және өнеркәсіптік игеру мүмкіндігінің зерттеу нәтижелері келтірілген.

Жаркент артезиан бассейнінің тұщы термалды сулары температурасы 40-тан 100 °С-қа дейін немесе одан жоғары Қазақстанның оңтүстік-шығыс бөлігінде, шығыс Іле ойысында орналасқан. Жаркент бассейнінің аумағы Алматы қ. шығысқа қарай 330 км орналасқан, Жаркент қаласы негізгі әкімшілік орталығы болып табылатын Алматы облысының Панфилов ауданы жатады. Аумақтың геологиялық-құрылымдық жағдайына, зерттеу аумағының климатына, жер бедеріне, гидрографиялық тармақтарына қысқаша сипаттама берілген. Жаркент артезиан бассейнінің гидрогеологиялық зерттеу мәліметтері бойынша құрамында термалды сулары бар бес сулы деңгейжиек кешендері анықталған: Неогенді, палеогенді, борлы, юралық, триастық. Көп жерде таралған борлы су кешенінің геотермалды суларын қолдану үшін мейлінше жоғары болашағы көрсетілген.

Зерттеу нәтижелері бойынша аталған аумақтың геотермалды қорларын пайдалану саласы және негізгі бағыттары анықталған, олар жылу энергетикасы, сумен қамтамасыз ету және бальнеология болып табылады.

Түйін сөздер: геотермалды сулар, Жаркент артезиан бассейні, өндіріс кешені, жылу және электр энергиясы.

С. М. Кан, Е. Ж. Муртазин, В. Д. Вялов

ТОО «Институт гидрогеологии и геоэкологии им. У. М. Ахмедсафина», Алматы, Казахстан

ГЕОТЕРМАЛЬНЫЕ ВОДЫ ЖАРКЕНТСКОГО АРТЕЗИАНСКОГО БАССЕЙНА И ПЕРСПЕКТИВЫ СОЗДАНИЯ НА ИХ ОСНОВЕ КОМПЛЕКСА ПРОИЗВОДСТВА ТЕПЛОВОЙ И ЭЛЕКТРОЭНЕРГИИ

Аннотация. Приведены результаты исследования возможностей промышленного освоения и эксплуатации геотермальных ресурсов Жаркентского артезианского бассейна.

Жаркентский артезианский бассейн пресных термальных вод с температурой от 40 до 100 °С и более расположен в юго-восточной части Казахстана, в Восточно-Илийской впадине. Территория Жаркентского бассейна относится к Панфиловскому району Алматинской области с главным административным центром г. Жаркент, расположенным в 330 км на восток от г. Алматы. Дана краткая характеристика гидрографической сети, рельефа, климата региона исследований, геолого-структурных условий территории. По данным гидрогеологических исследований в разрезе Жаркентского артезианского бассейна выделено пять водоносных комплексов, содержащих термальные воды: неогеновый, палеогеновый, меловой, юрский и триасовый. Показана наибольшая перспективность для использования геотермальных вод мелового водоносного комплекса, который имеет довольно широкое распространение.

По результатам исследований определены основные направления и сферы использования геотермальных ресурсов указанного региона – это теплоэнергетика, водоснабжение и бальнеология.

Ключевые слова: геотермальные воды, Жаркентский артезианский бассейн, комплекс производства, тепловая и электроэнергия.