POSSIBILITY TO BUILD POWER PLANT IN SHARGALJUUT, MONGOLIA

Jigjidsuren BATBAATAR[1], Naidan BATSUKH[1] and Mustafa ALEY[1]
[1]Mongolian University of Science and Technology, Ulaanbaatar, Mongolia
E-mail: batbaatar@must.edu.mn

ABSTRACT

There are numerous hot springs in Mongolia, and many are mainly utilized for heating and medicinal purposes, but there is presently no geothermal electric power utilization. Feasibility studies for small-scale energy development projects, however, have been conducted by domestic and foreign developers as Mongolia presently depends on nonrenewable sources of energy for almost all of its electrical power requirements. In this paper, authors intend to show possibility of building geothermal power utilization in Shargaljuut hot spring area by taking below mentioned two main reasons. 1. Shargaljuut is one of the famous hot spring areas and it has highest temperature of surface and relatively shallow (300 m) drillings wells. 2. Shargaljuut is located in north-western part of Mongolia. Electric supply of the western Mongolia is dependent from local small scale power generations and power from Russian Federation. If we able to build geothermal power plant in this area, the way to solve the electricity related problems would be taken carry out.

Keywords: geothermal energy, power utilization, Shargaljuut, Mongolia

1. GEOTHERMAL STRUCTURES OF MONGOLIA

Ample and comprehensive studies on geothermal resources and their potential uses have not been carried out in Mongolia. Some general studies on regional geology, tectonics, geophysics, geology, hydrogeology, study of hot springs and chemical analysis carried out. The Ministry of Agriculture and Industry of Mongolia investigated a research programme "Geothermal Energy" in 1999 and as a result of it, scientists reached some conclusions, compiling existing research results (Lkhagvadorj and Tseesuren, 2005).

A geophysical survey on the crustal structure affirmed that accumulative thermal sources (magma lumps) are located near the surface under the Khangai and Khentii mountainous region. Heat flow in Mongolia was studied from 32 heat flow stations (gradient wells) (See Figure 1). However, the heat flow map does not cover the South Mongolia and the Mongolian Altai province, where information is scarce. The average heat flow in different tectonic regions is approximately estimated as follows: Mongolian Altai mountainous region: 54±24 mW/m^2, Khangai mountainous region: 52±6 mW/m^2, Khuvsgul lake region: 80±10 mW/m^2, East Mongolian steppes: 44±6 mW/m^2. (Dorofeeva et al, 1986-1987 and Dorjderem, 1992-1994).

Besides the local anomaly, there is a large regional anomaly with a maximum heat flow in two regions, the North East and South West of Kherlen-Argun regions (Khangai and Khentii mountainous regions).

The Mongolian-Siberian mountainous province includes the Sayan-Baikal, the Altai-Sayan regions and West Mongolian high ranges, and those of Mongolian Altai, Gobi Altai and Khangai. In the Late Cenozoic all this provinces were involved in an intensive orogeny, the latter occurring both in the area under extension and in that under compression (the Sayan-Baikal domain uplift and the Altai uplift system, respectively) (Zorin et al, 1990).

Geothermal energy resources in Mongolia are mainly distributed in Khangai, Khentii mountainous regions, Khuvsgul lake regions, Mongolian Altai platforms, where intensive orogeny took place in Late Cenozoi. The Mongolian geothermal structural map was made based on regional research materials (Batsukh et al, 1999).

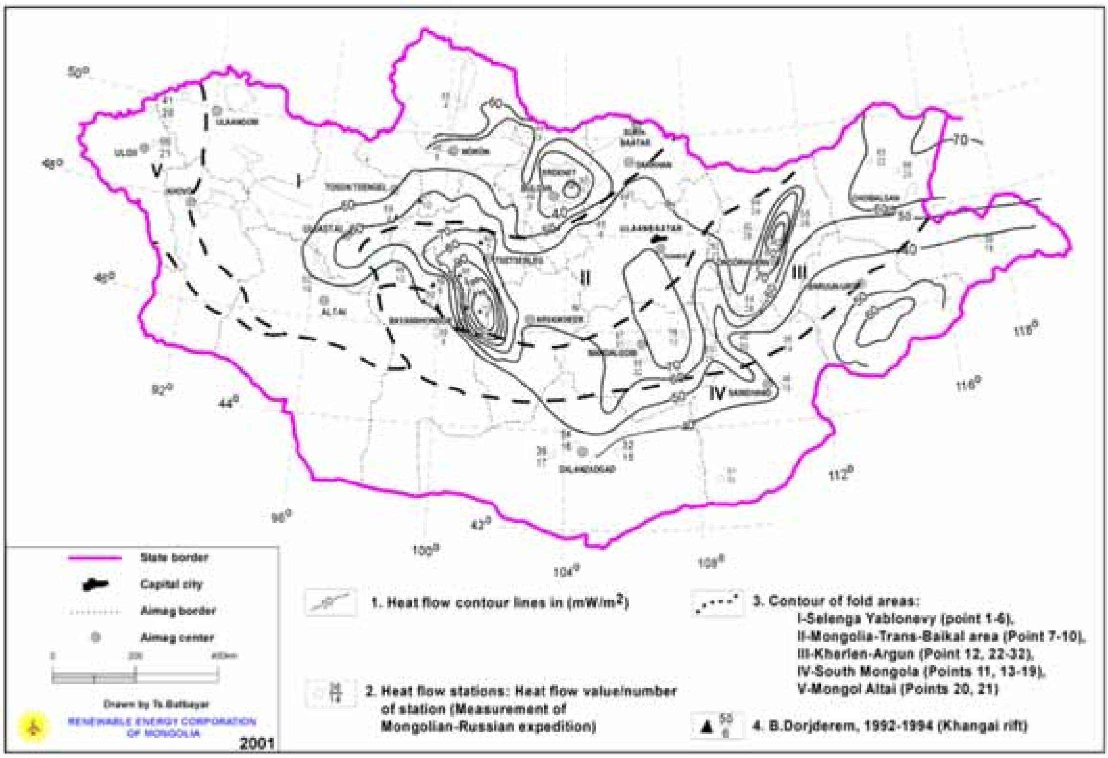

Figure 1. Heat flow map of Mongolia
(Dorofeeva, Sintsov, Bat-Erdene, 1986-1987 and Dorjderem, 1992-1994)

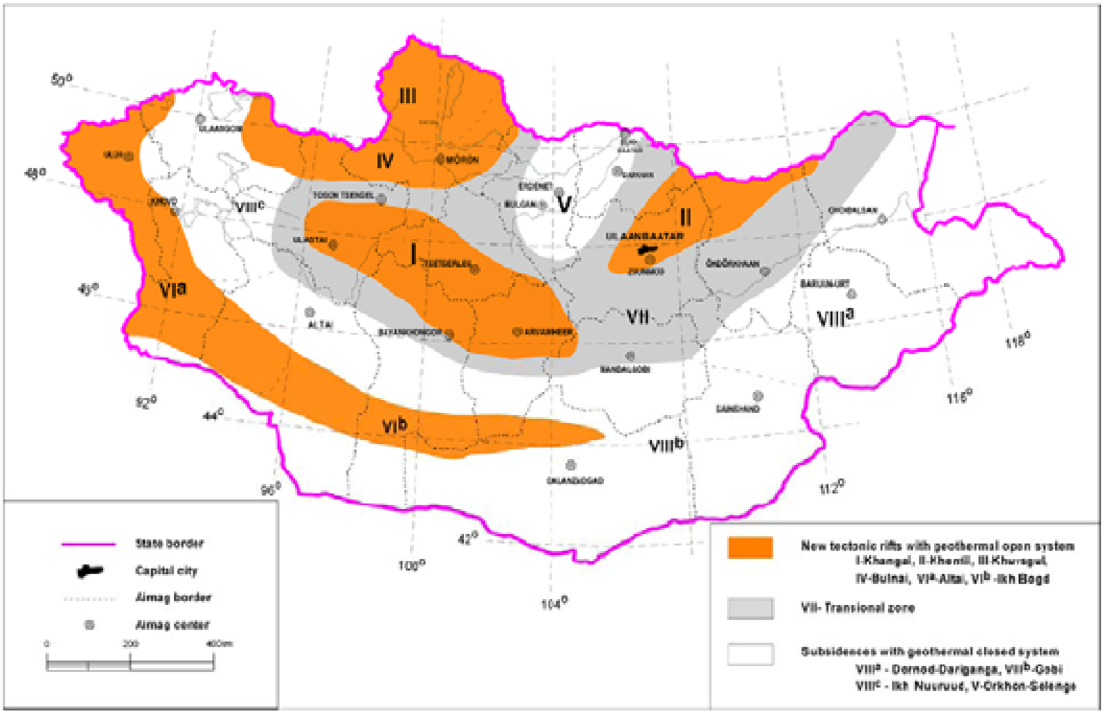

Figure 2. The main geothermal structures of Mongolia
(Batsukh, Aley, Dorjderem, Borchuluun, 1999)

2. KHANGAI GEOTHERMAL SYSTEM

Khangai geothermal system consists of Orkhon-Taats, Baidrag-Tamir and Tarvagatai-Uliastai subsystems. Hot springs distributed in the Khangai geothermal system are distinguished with their physical and chemical characteristics due to geotectonic structures of the subsystems, faults, hydrogeological conditions and thermal activities etc (Lkhagvadorj and Tseesuren, 2005).

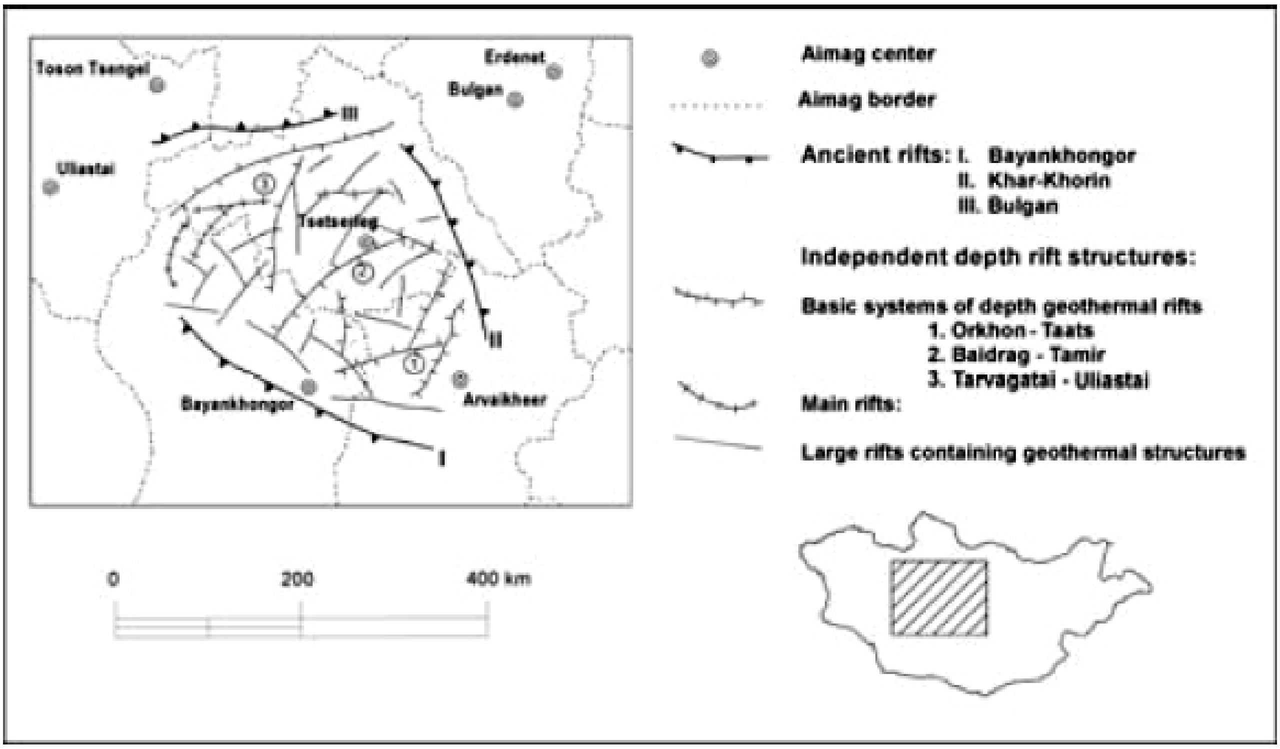

Figure 3. Tectonic rifts of Khangai geothermal system

Hot springs in Tarvagatai-Uliastai subsystem are characterized by water composition of sulphate-bicarbonate and sodium-sulphate-chloride, comparatively low flow rate of 0.1-6 l/s and medium surface temperature of 35-62°C. Hot springs in Baidrag-Tamir and Orkhon-Taats subsystems are characterized by water composition of sodiumbicarbonate, higher surface temperature of 53 – 92°C, higher flow rate of 4-50 l/s, low mineralization of 0.1-0.2 g/l and high in fluoride and silica. (Batsukh et al, 1999)

Table 1. Characteristics of some hot springs in Khangai geothermal system
(Batsukh et al, 1999)

	On the surface		In the depth of 150 – 300 m	
	T (°C)	Flow (l/s)	T (°C)	Flow (l/s)
Mogoi	66-70	3.5	90	10-15
Tsenkher	69	15	100	20-25
Bor tal	40	18	80	15-20
Ukhug	40	5	90	20
Urguut	50	6	80	10-20
Shargaljuut	**90**	**51**	**160**	**30**
Tsagaan sum	58	18	90-120	10-15

3. SHARGALJUUT THERMAL AREA

There are numerous hot springs in Mongolia, and many are utilized for cooking, heating and medicinal purposes. One thermal area, known for more than 300 years and developed in 1962 as a year-round National Sanatorium, is the Shargaljuut Hot Springs, although little has been published on the nature and chemistry of its thermal waters.

Shargaljuut (Long: 101°13’20 – 36”E; Lat: 46°19’50” – 20’03”N) - is located 42 km away from Erdenetsogt sum in the Bayankhongor Prefecture, ~680 km by paved (mostly) road west of Ulaanbaatar.

The Shargaljuut hot springs occur in the NNE – SSW oriented Shargaljuut Valley, within the Khangai Mountain Range (the highest point is Ugalz Gol, at 2803 mRSL). The Shargaljuut hot springs, adjacent to the 10-30m wide/0.6m deep Shargaljuut River, occur at -2120 mRSL (Bignall et al., 2003).

The climate in the Shargaljuut area is harsh, with winter temperatures of -23 to 27^0C and deep snowfall (up to several metres) that begins at the end of August and remains on the ground to May. Summers are mild, with temperatures reaching 17 to 22°C in July and August, which coincides with most of the annual rainfall (average precipitation is 250 – 300 mm/yr) (Bignall et al., 2003).

Each year, the Shargaljuut Sanatorium receives >3000 visitors from Mongolia and central Asia, due the "invigorating qualities" of the thermal waters, which are effective for those with "contagious skin diseases, high blood pressure, rheumatic fever, liver or stomach complaints, or problems with the nervous system". The complex, utilizes thermal waters for bathing and traditional cooking, and now boasts its own cinema, post office, library, restaurants and hotel. Hot and cold spring waters flow from several locations at Shargaljuut and these have reportedly "changed over the years", almost certainly due to wasteful extraction of an undetermined volume of thermal fluid for use in the sanatorium, as well as natural discharge to the nearby Shargaljuut River (Bignall et al., 2003) .

4. REGIONAL GEOLOGY OF THE SHARGALJUUT AREA

The geology of the Shargaljuut area comprises Devonian sedimentary units, Upper Carboniferous granite and quartz-diorite, which are covered by unconsolidated Quaternary sediments (Uflyand et al., 1966; in Lhagva 1975).

The Devonian Erdenetsogt Formation consists of alternating siltstone-sandstone units. The 1500 – 2000 m thick Erdenetsogt Formation crops out SW of Shargaljuut, and to the NE of the hot spring area, where its occurrence is fault controlled.

Upper carboniferous granitoid rocks are common, and intrude the older sedimentary unit. Intrusive rocks include leucocratic biotite-hornblende granite, quartz-diorite and granodiorite. Near the Shargaljuut River, granite is hydrothermally altered, with conspicuous epidote alteration. Quartz veining also occurs, associated with weak malachite, hematite and sphalerite mineralization.

The Quaternary deposits comprise 0.5-2m thick deluvial sequences, 4-5m thick alluvial deposits (well rounded gravel and clay) and proluvial material (<10 m thick; sandstone, coarse-grained clay and poorly sorted / subround gravel).

The Shargaljuut area is situated within the Ineerbakal-Mongolian fold belt (Hasin, 1971; in Lhagva 1975) which is characterized by NE-SW trending faults (subparallel to the Shargaljuut valley) and cross-cutting NW faults. Hot spring locations at Shargaljuut are coincident with the intersection of the two fault sets (Bignall et al., 2003).

5. THERMAL FEATURES AT SHARGALJUUT

Thermal features at Shargaljuut cover a wide area, with hot and cold spring waters discharging from several locations, whilst the stony hillside facing the Shargaljuut Sanatorium steams effusively. The cold springs are used as a source of domestic drinking water and for watering farm animals, whilst the Baga Shargaljuut and Taats Sharga hot springs are also located nearby.

Odourless, near boiling hot waters discharge at Shargaljuut over an area of about 0.5 km^2 mainly from small cracks in discoloured, lichen-covered metamorphosed sandstone and intrusive rocks (with flow rates up to 5 l/min although most discharge at 0.2 -2 l/min and from loose alluvial sand and gravel in the Shargaljuut River.

Most spring waters at Shargaljuut range in temperature from 45^{o}C close to the Shargaljuut River (at about 2150 mRSL, where they are mixed with rain and river water), and 98°C further away from the river (at higher elevation).

Thin, translucent to white opaque silica sinter coat rock surfaces around most springs on the hillside above the Shargaljuut Sanatorium, but is not evident where warm (near-neutral pH, colourless, and odourless) waters seep out of the loose sedimentary units (Bignall et al., 2003).

6. SHARGALJUUT HOT SPRING SYSTEM

The Shargaljuut hot spring area is located in rugged, mountainous terrain, with a large area of steaming ground and numerous hot springs. The manner, however, that local people utilise hot waters discharging at Shargaljuut is quite different to traditional bathing, cooking and energy utilisation in Japan, New Zealand and elsewhere.

Unlike active geothermal systems in New Zealand, Japan, and elsewhere, there is no obvious heat source for thermal manifestations at Shargaljuut, or for the nearby Baga Shargaljuut, Taats Sharga, Ugalz gol hot springs – i.e. there are no active or recently active volcanoes in the area and large scale active faulting is not a convincing means of generating sufficient heat for the large number of thermal areas (many with near-boiling hot springs).

Researchers at the Mongolian University of Science and Technology have proposed the presence of the "Mongolian Hot Spot" in the Khangai area (pers.com) and it is possible that the source of geothermal energy is conductive heat from magma associated with the "Hot Spot" which is transferred through overlying Palaeozoic metamorphosed sediments and igneous rocks, to heat rainwater and melted snow in the near surface (Bignall et al., submitted). Dorjderem (unpubl. report, 1995) has suggested a "deep", 150–180°C water reservoir at ~300 m depth (although solute geothermometry in this study indicates a fluid source of no more than 130 - 140^{0}C) (Bignall et al., 2003).

The upwelling waters react with Palaeozoic rocks in the Shargaljuut area, and are channelled to the surface via NE-SW and cross-cutting NW faults. The weakly mineralised waters finally discharge from cracks in the metamorphosed rocks, with low flow-rate from the Shargaljuut springs (about 50–60 Vsec over the entire thermal area; Dorjderem, 1995) attributed to the amount of past rain and snow fall in the Khangai area (Bignall et al., 2003).

7. POWER GENERATION

Mongolia has vast land area and a large number of small, isolated settlements. In the future, it is likely that an off-grid solution will prove the most economic means of solving the country's problem of providing electricity to the rural areas.

At present, there are three electricity markets in Mongolia. The largest is the urban market (comprising, for the most part, three independent transmission grids; the Central (CES), Eastern (EES) and Western (WES) Energy Systems, which supply a total load of about 560MW). The second market is non-connected regional centers, comprising standalone diesel generator systems, which account for ~3% of the overall electricity supply to the country, but is the primary supply for most small towns. The biggest problem with the existing diesel system, however, is the pressure of ongoing costs for operation and maintenance, which often causes interruptions to power supply. The third market consists of individual electrification solutions for rural areas (~82% of the non-electrified population live in rural areas) (Bignall et al., 2005). Also there is one resource of electricity from Russian Federation. Electric supply from Russia is relatively high cost and sometimes government has problems in payment for this source of electricity.

Table 2. Present and planned production of electricity (Bignall et al., 2005)

	Geothermal		Fossil Fuels		Hydro Electric		Renewables		Total	
	Capacity MWe	Prod. GWh/y	Capacity MWe	Prod. GWh/y	Capacity MWe	Prod. GWh/y	Capacity MWe	Prod. GWh/y	Capacity MWe	Prod. GWh/y
In Operation	0	0	>1000*	2.355	3.28	X	0.5	X	>1000	>2.350
Under Consruction	0	0	X	X	0.57	X	X	X	X	X
Funds Commited	0	0	X	X	18	X	X	X	X	X

(*from Rentsen and Enebish, 2003). No information = x

Note: There is no nuclear power generation and also there is no intention to build it.

Resource assessments conducted at Shargaljuut reveal that the area has potential for small scale geothermal power generation, possibly by installation of a binary-cycle geothermal power plant (Dorj, 2001). It was estimated 2-3 wells would be required to produce 60 t/h fluid (with power plant inlet temperature of 120^{0}C) to generate 300 kW of electricity (Tseesuren, 2001). The electricity generating cost for the project was estimated to be 10-15 c/kWh. Worley International

(1995) estimate a 300kW binary cycle plant would be sufficient for the existing demands of the 2,500 (est) people who live in the Shargaljuut area (Bignall et al., 2005).

8. CONCLUSION

1. There are real states to build geothermal power plant at Shargaljuut thermal area according to below mentioned two main reasons. Here are:
    a. Temperature of its surface and shallow drilling water. Both surface and drilling waters at Shargaljuut area have highest temperature among the other hot springs in Mongolia.
    b. The location of Shargaljuut area. People settled in western part of Mongolia have poorly supplied by electricity. They (such as civilians in Bayan-Ulgii province) also have to buy electric power from Russia due poor electric supply.

2. There is also one reason to locate future geothermal power plant in Shargaljuut. It is chemical composition of the water. According to chemical analyses on hot spring water of Shargaljuut, it's suitable for power plant requirement which mineralization is low. But this point of view should be carried out and researched more slightly. Because, geothermal water has to be pumped out from more than 1000 m of deep, and for sure, chemical composition should differ from hot spring water.

3. Mongolia, or Mongolian government have no access to build power plant by itself, due to financial situation and problems. Therefore, in order to build geothermal power utilization, we have to find financial support from foreign country investors. In the mean time, government has to develop our "law of electricity" with good condition for development of renewable energy use and make guarantee for foreign investors.

4. Scientists and researchers have to cooperate in order to make project for researching and exploiting geothermal energy of Shargaljuut area. Currently, government of Mongolia is searching for new "renewable" resources of energy. Unlike wind or water generated power utilization, geothermal energy is ecologically clean, relatively constant generator of energy.

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