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# Geothermal Energy Resources of Pakistan

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## ABSTRACT

Most of the high enthalpy geothermal resources of the world are within the seismic belts associated with zones of crustal weakness such as plate margins and centers of volcanic activity. A global seismic belt passes through Pakistan and the country has a long geological history of geotectonic events: Permo-carboniferous volcanism (Panjal traps in Kashmir) as a result of rifting of Iran-Afghanistan microplates, Late Jurassic to Early Cretaceous rifting of the Indo-Pakistan Plate, widespread volcanism during Late Cretaceous (Deccan traps) attributed to the appearance of a "hot spot" in the region, emergence of a chain of volcanic islands along the margins of the Indo-Pakistan Plate, collision of India and Asia (Late Cretaceous-Paleocene) and the consequent Himalayan upheaval, and Neogene-Quaternary-volcanism in the Chagai District. This geotectonic framework suggests that Pakistan should not be lacking in commercially exploitable sources of geothermal energy. This view is further strengthened by the fairly extensive development of alteration zones and fumeroles in many regions of Pakistan, presence of a fairly large number of hot springs in different parts of the country, and indications of Quaternary volcanism. These manifestations of geothermal energy are found within three geotectonic or geothermal environments, i.e., (i) geo-pressurised systems related to basin subsidence, (ii) seismotectonic or suture-related systems, and (iii) systems related to Neogene-Quaternary volcanism. Pakistan, despite the enormous potential of its energy resources, remains energy deficient and has to rely heavily on imports of hydrocarbon products to satisfy hardly its needs. Moreover, a very large part of the rural areas does not have the electrification facilities because they are either too remote and/or too expensive to connect to the national grid. Pakistan has wide spectrum of high potential renewable energy sources, conventional and as well non-conventional, which have not been adequately explored, exploited and developed. Geothermal energy is one of them. Pakistan can be benefited by harnessing the geothermal option of energy generation as substitute energy in areas where sources exist. As Pakistan is the agricultural country and also has tremendous mineral potential where the major part of population lives in the rural areas, the electricity generated by renewable sources will also improve rural life, thereby reducing the urban migration that is taxing the ability of cities to cope with their own environmental problems.

## 1. INTRODUCTION

As the availability of adequate supplies of energy is a pre-requisite to generate economic activities, the energy sector plays a vital role in ensuring all-round development and growth of economy of a nation. Energy is considered as one of the four major drivers of growth in strategic planning of Pakistan Government (FD, 2001). The other three drivers are agriculture, small & medium enterprises, and information technology. Since the inception of Pakistan, the primary power supplies from the conventional energy sources were (and are still today) not enough to meet the country's demand. Pakistan, despite the enormous potential of its indigenous energy resources, remains energy deficient and has to rely heavily on the imports of the petroleum products to satisfy its present day need.

The conventional energy sources, i.e. fossil fuels, mega-hydels, and nuclear plants have remained the energy sources of choice in Pakistan for the decades (Fig.1). Now, there has been a growing recognition, for more than one reason, of the dangers inherent in continuing with the model of economic development based on these sources, particularly the excessive consumption of fossil fuels. One reason is that the reserves of fossil fuels are not unlimited and at the present rate of consumption they would not last very long. Moreover, it has been conclusively proved that climate change, which has been resulting in global warming, is mainly caused by greenhouse gas emissions from energy generating systems based on fossil fuels. Yet another aspect that has come into sharp focus is that the developing countries can ill afford to depend excessively upon petroleum imports marked as they are by volatile price fluctuations. Moreover, indiscriminate use of fuel wood leads to deforestation with consequent environmental hazards and inefficient burning of fuel wood leads to an increase in indoor air pollution.

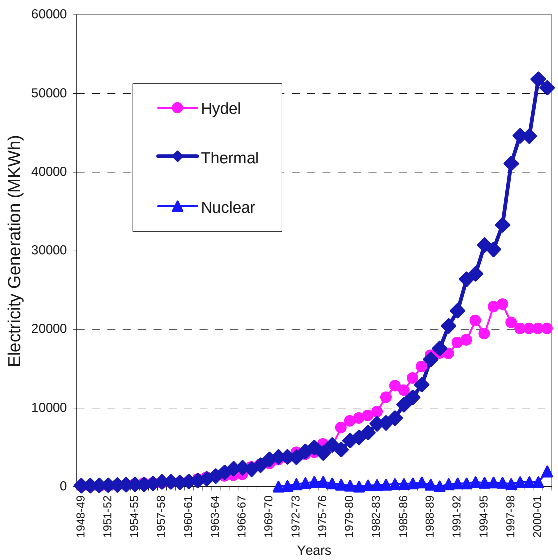


**Figure 1: Generation of electricity from 1948 to 2001 by hydel, thermal (oil, natural gas, & coal) and nuclear in million kwh. Data source: Federal Bureau of Statistics, 1998 and Energy Year Book (HDIP), 2001.**

Considering the geological setup, geographical position, climatological cycles and the agricultural activities, Pakistan has wide spectrum of high potential of renewable energy sources, conventional and non-conventional as well, which have not been adequately explored, exploited or developed. Geothermal energy source is one of them. Geothermal energy is the energy derived from the heat of the earth’s core. It is clean, abundant, and reliable. If properly developed, it can offer a renewable and sustainable energy source. People have used geothermal resources in many ways, including healing and physical therapy, cooking, space heating, and other applications. One of the first known human uses of geothermal resources was more than 10,000 years ago with the settlement of Paleo-Indians at hot springs (GEP, 2002). Geothermal resources have since been developed for many applications such as production of electricity, direct use of heat and geothermal heat pumps. This paper describes the prospects for the geothermal energy sources of Pakistan with the view of the geological set up of the country.

## 2. TECTONIC FRAMEWORK OF PAKISTAN

Pakistan stretches from 24°N to 37°N latitudes and from 61°E to 76°E longitudes. The total land area of Pakistan is about 800,000 km². The northeast to southwest extent of the country is about 1,700 km, and its east-west width is approximately 1,000 km. The geomorphology of Pakistan varies from lofty mountains of Himalayas, Karakorum, Hindukush and Pamirs in the north to the fascinating coastline of the Arabian Sea in the south. In between the northern and southern extreme ends of the country, notable and unique bended north-south oriented mountain ranges exist centrally bounded by the fertile plains of 3000-long River Indus and western part of famous Thar Desert on eastern side, and by the Chagai volcanic arc, vast tectonic depression of Kharan, and the westward swinging mountain ranges of Makran flysch basin.

The tectonics of Pakistan is dominantly the result of various phases of the collision, convergent and rift events (Fig.2). It reflects the complicated pattern of competent and incompetent tectonic blocks as a whole, and of competent and incompetent rock sequences in particular. In the southwestern part of Pakistan, the dominant structural features trend east in the Makran region and turn north in parallel with the Pakistan Fold-Thrust Belt. Further to the north in approaching the Himalayas, they swing to the northeast before curving into the general ESE-direction of the Himalayas. The course of the tectonic elements is here marked by the Main Boundary Thrust (MBT), the Main Mantle Thrust (MMT), and the Main Karakorum Thrust (MKT).

Tectonically, Pakistan is situated on the western-rifted margin of the Indo-Pakistan subcontinental plate. In the present plate tectonic setting, Pakistan lies partly on (i) the northwestern corner of the Indian lithospheric plate, (ii) the southern part of the Afghan craton, and (iii) the northern part of the Arabian oceanic subducting plate. The eastern part of Pakistan represents (a) the Tertiary convergence with intense collision between the Indian and Eurasian plates in the north creating Karakorum Thrust Zone and (b) the translation between Indian continental plate and the Afghan craton in the north-west developing Chaman Transcurrent Fault System that connects the Makran convergence zone (where oceanic lithosphere is being subducted beneath the Lut and Afghan micro-plates) with the Himalayan convergence zone (where the Indo-Pakistan lithosphere is underthrusting the Eurasian continental plate).


**Figure 2: Salient tectonic features of Pakistan (after Zaigham, 2000).**

The western part of the country also represents the Tertiary convergence between (i) the Arabian oceanic plate and the Afghan craton resulting Chagai Arc and the Makran Flysch Basin and (ii) a segment of the Arabian oceanic plate and the western rifted margin of the Indo-Pakistan subcontinent obducting Bela Ophiolite Complex. All the major tectonic boundaries or the suture zones are distinctly traceable by the presence of numerous ophiolite occurrences.

## 3. POTENTIAL OF GEOTHERMAL SOURCES

Most of the high enthalpy geothermal resources of the world are within seismic belts associated with zones of crustal weakness such as plate margins and centers or volcanic activity. A global seismic belt passes through Pakistan and the country has a long geological history of geotectonic events: Permo-carboniferous volcanism (Panjal traps in Kashmir) as a result of rifting of Iran-Afghanistan microplates, Late Jurassic to Early Cretaceous rifting of the Indo-Pakistan Plate, widespread volcanism during Late Cretaceous (Deccan traps) attributed to the appearance of a "hot spot" in the region, emergence of a chain of volcanic islands along the margins of the Indo-Pakistan Plate, collision of India and Asia (Cretaceous-Paleocene) and the consequent Himalayan upheaval, and Neogene-Quaternary volcanism in the Chagai District (Kazmi & Jan, 1999; Raza & Bander, 1995).

In Tibet, which occupies more or less the same geological position in Himalayan mountain ranges as Pakistan, more than 600 surface indications of geothermal energy resources have been discovered with an estimated potential of 800,000 kilowatts (Fig.3). The Yangbajain Geothermal Power Station started operation in 1988 sending annually about 50 million kwhs of electricity to Lhasa fully meeting the need of the local people.

**Figure 3: Geothermal manifestation, Ningzhong, Tibet (Zhao Ping , 2000; Source: IGA website).**

The geotectonic framework suggests that Pakistan should not be lacking in commercially exploitable sources of geothermal energy. This view is further strengthened by the fairly extensive development of alteration zones and fumeroles, presence of a fairly large number of hot springs in different parts of the country, and indications of Quaternary volcanism.

In general, the geothermal exploration addresses at least nine phases of integrated study, i.e., i) identification of geothermal phenomena, ii) classification of the geothermal field production field exists, iii) location of productive zones, iv) ascertaining that a useful geothermal, v) estimation of the size of the resource, vi) determination of heat content of fluids that will be discharged by wells in the geothermal field, vii) compilation of a body of data against which the results of future monitoring can be viewed, viii) assessment of pre-exploitation values of environmentally sensitive parameters, ix) determination of any characteristics that might cause problems during field development . In Pakistan, first three phases have so far been undertaken on limited scale to study the geological characteristics of the geothermal energy sources. Nearly half of the developing countries have rich geothermal resources, which could prove to be an important source of power and revenue. Geothermal projects can reduce the economic pressure of developing country fuel imports and can offer local infrastructure development and employment. For example, the Philippines have exploited local geothermal resources to reduce dependence on imported oil, with installed geothermal capacity and power generation second in the world after the United States. In the late 1970s, the Philippine government instituted a comprehensive energy plan, under which hydropower, geothermal energy, coal, and other indigenous resources were developed and substituted for fuel oil, reducing their petroleum dependence from 95% in the early 1970s to 50% by mid-1980s (IAEE, 2003).

In Pakistan, these manifestations of geothermal energy are found within three geotectonic or geothermal environments, i.e. the geo-pressurised systems related to basin subsidence, the seismo-tectonic or suture-related systems, and the systems related to Neogene-Quaternary volcanism (Fig.4).

### 2.1 Geopressurised Geothermal Sources

In geopressurised systems, the normal heat flow is trapped by insulating impermeable beds in a rapidly subsiding sedimentary basin. It is an account of their great depth (as much as 6,000 m) that temperatures ranging from less than 93ºC to more than l50ºC are encountered. They commonly contain pressurised hot connate water at pressures ranging from 40 % to 90 % in excess of the hydrostatic pressure corresponding to the depth. Gradual subsidence has led to the ultimate isolation of trapped pockets of water contained in alternating pervious and impervious sequences.

In Pakistan such geopressure zones are present within the Indus River basin in southern Sindh province along the western margin of the Indus Plain and in the Potwar Basin of Punjab province (Fig.4). The available information indicate the association of the geothermal zones with south-Sulaiman, south-Kirthar, and Lower Indus geological structures.

The southeastern part of the Sulaiman Foredeep shows the existence of the geothermal energy conditions (Fig.5). The Sulaiman foredeep geothermal zone has the deepest burial of over 15 km sedimentary pile (Raza et al., 1990), which is seismically active and a number of earthquakes with magnitudes 3 to 7 on the Richter scale have been recorded associated with deep seated faults. Many lineaments have

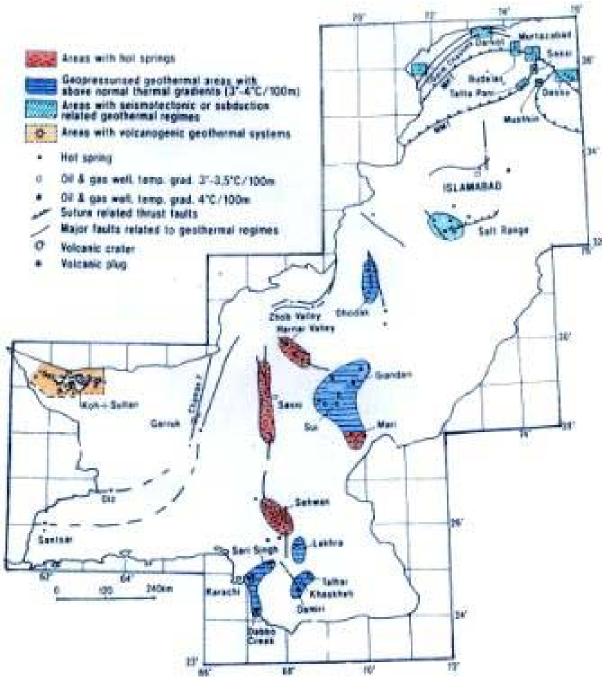


**Figure 4: Map shows the occurrences of geothermal sources in Pakistan (Source: Geological Survey of Pakistan).**

been traced on the surface, which probably are the reflections of basement faults (Kazmi, 1979). The great thickness of sediments and depth of burial has generated exceptionally high geothermal temperatures in depth. It appears likely that thermal water is leaking through the faults, fractures or fissures at Giandari, giving the impression of the presence of a "warm spot" beneath Giandari (Fig.4). In the southernmost region of the foredeep, an abnormally high thermal gradient of 4.1°C/100m is encountered in the Giandari oil & gas well (Khan and Raza, 1986). Likewise, the neighbouring oil & gas wells at Sui and at Mart have also recorded higher than normal geothermal gradients of about 3.0 to 3.49ºC/l00m. Farther northward the well at Dhodak has similar thermal gradient. In this region, thermal springs have been recorded at Uch, Garm Ab at the foot of Mari Hills, Zinda Pir, Taunsa and Bakkur (Oldham, 1882; Bakr, 1965).

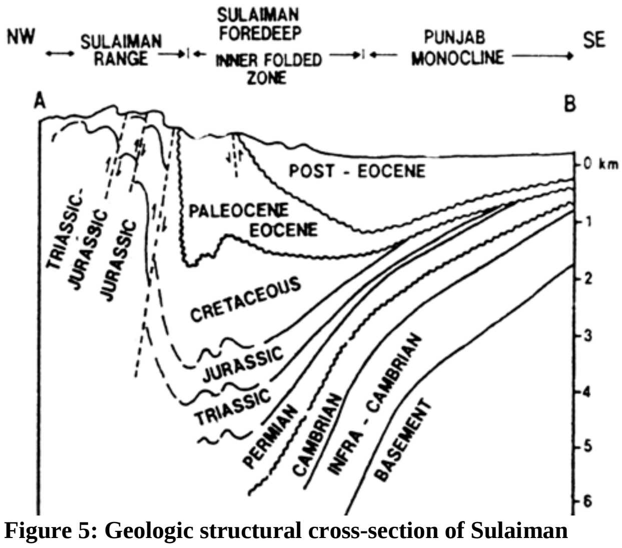


**Figure 5: Geologic structural cross-section of Sulaiman Foredeep.**

In the south-Kirthar geothermal zone, the oil & gas wells drilled at Lakhra show thermal gradients above normal (3.3°C/100m). Farther southward the oil & gas wells at Sari and Karachi revealed a geothermal gradient of about 3ºC/l00m. In Karachi, two hot springs exist one at Mangho Pir and one at Karsaz. The geological setting of the south-Kirthar geothermal zone is similar to that of the south-Sulaiman geothermal zone. The Kirthar zone also includes, a depression containing a pile of sediments 6km-10km thick. The basement beneath the depression shows prevalence of higher compression causing by the anticlockwise rotational component of the Indo-Pakistan continental plate (Zaigham & Mallick, 2000). The region is seismically active and epicenters of shallow earthquakes ranging in magnitude from 3 to 5 on Richtcr scale have been recorded.

The Lower Indus trough and the offshore geothermal zone are characterized by geothermal gradients above normal, which were encountered in borehole drilled for the oil & gas exploration. The well Damiri-1 had a geothermal gradient of 4ºC/100m (Khan and Raza, 1986), whereas the wells at Talhar and Khaskheli have encountered geothermal gradients in the range of 30 to 3.5°C/100m. The offshore well at Dabbo Creek revealed a geothermal gradient of 3.7ºC/100m. The southern part of the Lower Indus trough forms a rifted monocline (Fig.6) containing a prism of sediments ranging in age from Triassic to the Neogene (Zaigham et al., 2000).

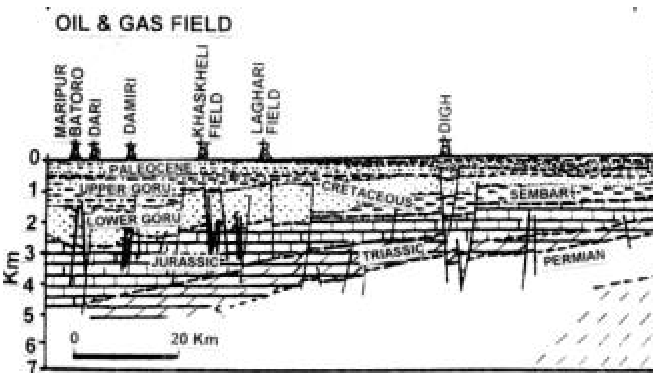


**Figure 6: Geologic structural cross-section of rifted monocline in southern part of lower Indus trough.**

### 2.2 Seismo-Tectonic & Suture Related Systems

Geothermal regimes in the northern part of Pakistan, as manifested by many thermal springs, are associated with sutures and related structures. This part of the country is comprised of Karakorum, Hindukush and Himalyan thrust mountainous belts, which show very strong seismicity activities. The hot spring sites of Chitral region are associated with the Hindukush fault system. In Gilgit-Hunza region the hot springs of Murtazabad, Budelas, Sassi and Dassu are associated with Main Karakorum Thrust (MKT), whereas the hot springs of Tatta Pani, Sassi, and Mushkin are associated with the Main Mantle Thrust (MMT). As to the heat sources, the obvious evidence such as the existence of a young volcano is not found in this part of the country. However, the heat generated due to friction along the MKT, MMT or the Hindukush fault system and the that due to radioactive decay of the Karakorum granodiorites are likely the source of heat giving rise to the thermal springs. Figure-7 shows a schematic model for the hot springs associated with the MKT, which could be applied to other fault-associated hot spring of the area.

In Garm Chashma valley about 50km northwest of Chitral, thermal springs are located within the Reshun and Ayun fault domain. These springs are near the contact of granites intruded in metasediments (Calkins et al., 1981), in a region of extremely high seismicity. Another hot spring is reported near the snout of Pechus glacier, about 105 km northeast of Mastuj (Bakr, 1965), which is located near the contact of granite intruded in Cretaceous metasediments. In Yasin District, a hot sulphurous spring is located 3 km north of Rawat Village oozing from the metasediments of the Darkot Group.

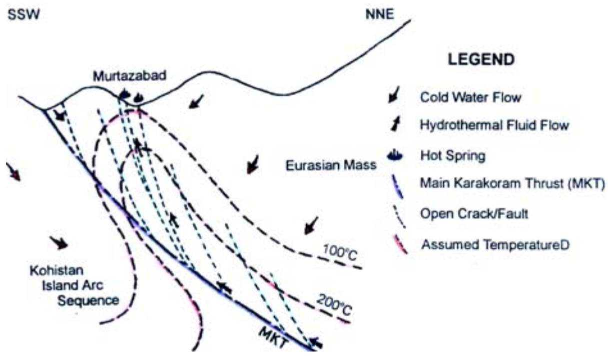


**Figure 7: Schematic model for hot spring occurrences on Karakorum-Himalayan thrust zone (after Todaka et al., 1999)**

In the western part of the Hunza Valley, the thermal springs are associated with the geothermal system of the Main Karakorum Thrust (MKT). One cluster of five springs is near Murtazabad village, which is situated within 7km of the MKT. The water temperature of these springs ranges from about 26° to 91°C (Shuja and Sheikh, 1983). The reservoir temperature at this site has been estimated to range from 198° to 212 °C. Farther to the southeast, in the Skardu District, two sulphur springs and three hot springs have been reported in the Dassu area. The maximum water temperature of these springs is 71ºC. They are also located in the vicinity of the MKT, close to granitic rock. The geological conditions in the Dassu are similar to those of Murtazabad and Budelas.

The geothermal system related to the Nanga Parbat–Haramosh Massif forms hot springs along the faulted margins of the massif. On the eastern side, there is a hot spring near Mushkin associated with the Main Mantle Thrust (MMT). The water temperature is about 57ºC. The estimated reservoir temperature (silica geothermometer) range from 86º to 90ºC (Todaka et al., 1999).

There are a number of hot water springs in the Tatta Pani area, arranged in a row on either side of the Rakhiot bridge and spread over a distance of about 8 km. They emanate from Quaternary terraces and colluvial deposits. Amphibolites fractured by the MMT constitute the hard rocks exposed around these geothermal manifestations. Hot springs also emanate from the Raikot fault zone along the western margin of the Nanga Parbat – Haramosh Massif at Sassi and at Tatta Pani, along the Indus. The Sassi spring has a field temperature of 54C, whereas the reservoir temperatures range from 40º to 48ºC to 152ºC (TODAKA *et al.*, 1999). The physical and chemical characteristics of the hot springs oozing in the northern part of the country have been summarized the Table-2.

In other parts of the Indus and Balochistan sedimentary basins, geothermal manifestations in the form of hot springs are scattered, associated mainly with seismotectonic and suture zones. Three hot springs are located in the foothill region of the Kirthar Range west of Dhadar, near Sanni, and south of Thal (Fig.4). They appear along the Mach and Kirthar faults (Kazmi, 1979) at the northwestern edge of the Kirthar Range which has a pile of sediments more than 10 km thick, which is a region of high seismicity also (Quittmeyer et al., 1979). Hot springs are present in many parts of Balochistan, associated with faults, which show significant seismic activity. In the Harnai valley, prominent thermal springs are located associated with the Harnai and Tatra faults, where earthquakes of magnitudes 6 to over 7 on Richter scale have been recorded (Bakr, 1965; Kazmi, 1979; Quittmeyer, 1979). Similarly, two hot springs are located north of the Zhob valley that occur amidst a series of imbricated faults in a region of relatively high seismicity.

### 2.3 Geothermal Systems related to Neogene-Quaternary volcanism

Geothermal systems associated with the Chagai Magmatic Arc are manifested by mineralized thermal springs, which are largely confined to the Koh-e-Sultan volcano and appear in the vicinity of the Miri crater (Fig.8). The water temperatures of the springs, which range from 25.6º to 32ºC, are lower than the ambient temperature in summer season.

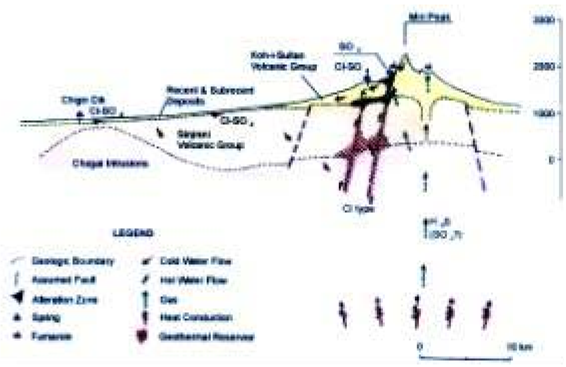

**Figure 8: Schematic model for the geothermal springs associated with Koh-e-Sultan Volcano.**

An acidic alteration zone has formed southwest of the Miri peak (Fig. 9). A part of this zone is strongly silicified. Hydrogen Sulphide was observed in places as there are scattered sulphur deposits in the alteration zone. In the Koh-e-Sultan geothermal system, the reservoir temperatures estimated on the basis of the silica geothermometer range from 150ºC to 175ºC (Shuja *et al.*, 1984). This region apparently has the highest geothermal potential in Pakistan and an economically exploitable geothermal reservoir may be expected in the southwestern part of Koh-e-Sultan. Preliminary physical and chemical characteristics of these geothermal springs have been summarized in Table-3.

The aeromagnetic investigations, done in a large area of Chagai Volcanic Arc and the Kharan Trough, have revealed a number of buried volcanic plugs, necks and stocks all over the Chagai region, which could be very important targets for the exploitation of geothermal energy.

Similarly, high magnetic zone has also been observed in Kharan area striking in east-west direction almost parallel to the Chagai Volcanic Arc. The most important subsurface crustal feature revealed by the aeromagnetic anomalies is the distinct presence of a large semi-circular embayment of reduced magnetization within the zone of high magnetic anomalies, known as South Mashkhel Magnetic Belt (Fig.10).

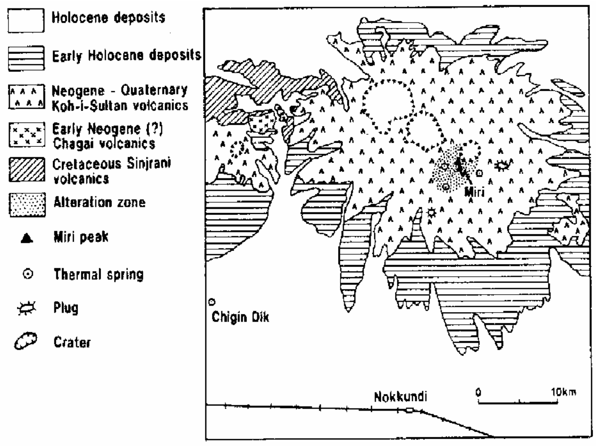


**Figure-9: Geological sketch map of the Koh-e-Sultan volcanogenic geothermal zone**

The estimated depth to the reduced magnetic embayment is about 2000m. The shape of the crustal feature is suggestive of a plug-like intrusive. The reduction in magnetite content, compared to adjacent rocks in the hosting magnetic belt, is suggestive of rocks that are felsic in composition, i.e. high in quartz content. The tensor analyses of seismicity events of the areas also show rifting conditions beneath the Kharan trough (Noushaba, 2004, Personal communication). Such rifting process may cause consequent upwelling of hot mantle creating excessive heat regime within the trough. This intrusive-like body appears to be a very good source of geothermal heat, if, additionally to tectonic process, these rocks have a high content of radioactive minerals.

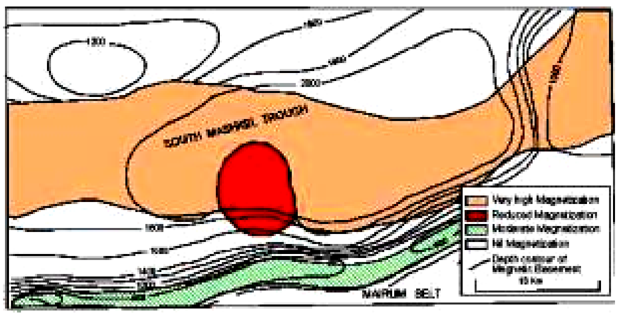


**Figure-10: Map shows viable geothermal energy source inferred from characteristics of the magnetization and the depth configuration of the basement in the Kharan Trough.**

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**Table-1: Physical and chemical characteristics of Karachi hot springs (Source: Todaka et al., 1999).**

| Hot spring locality | | Temperature °C | pH | Electirc Cond. in μ/cm | Feature of hot water | Remark |
|---|---|---|---|---|---|---|
| KARACHI | Mangopir | 50.3 (Ambient temp.36.0) | 7.45 | 2380 | Colourless; ordorless | Surface soil ; $CO_2$ gas bubbling |
| | Karsaz | 39.0 (Ambient temp. 5.4) | 7.87 | 7910 | Colourless; H2S small | $CO_2$ gas bubbling |

**Table-2: Physical and chemical characteristics of hot springs in northern part of Pakistan (Source: Todaka et al., 1999).**

| Hot spring Locality | | | Temperature °C | Flow Rate in l/min | pH | Electirc Cond. in μ/cm | Feature of hot water | Geology | Remark |
|---|---|---|---|---|---|---|---|---|---|
| NORTHERN PART OF PAKISTAN | Murtazabad | N1 | 42.3 (Ambient temp. 35.0) | 33 | 7.5 | 1720 | Colourless, odorless & taste less | Terrace deposit Garnet shist | Bathing & cloths washing |
| | | N2 | 36.9°C (Ambient temp. 33.5) | 6.7 | 7.8 | - | Colourless, $H_2S$ smell & sour taste | Surface Soil Terrace depost Garnet staurolite schist | Washing for prayer |
| | | N3 | 30.0 (Ambient temp. 28.0) | 500 | 9.21 | 2470 | Colourless, H2S smell | Surface soil Terrace deposit Garnet staurolite schist | Boiling temp92°; $CaCO_3$ deposition |
| | BUDELAS | N8 | 46.0 (Ambient temp. 32.0) | 100 | 7.85 | 1540 | Colourless $H_2S$ smell, salty taste | Talus/Garnet mica schist (Baltit Group) | Bathing |
| | | N9 | 36.0 (Ambient temp. 17.0) | 100 | 7.49 | 77.6 | Colourless, $H_2S$ smell | Talus/Garnet mica schist (Baltit Group) | |
| | | N10 | Near boiling temperature (91°C) | - | 7.64 | 1160 | Colourless, $H_2S$ smell | Talus/Garnet mica schist (Baltit Group | |
| | TATA PANI | N4 | 83.0 (Ambient temp. 17.0) | > 621 | 8.83 | 1060 | Colourless $H_2S$ smell, salty taste | Terrace deposite or Fractured mphibolite | - |
| | | N5 | 65.5 (Ambient temp. 36.5) | 800 | 8.57 | 1540 | Colourless, $H_2$ S smell salty teste | Terrace deposite/Fractured amphibolite | - |
| | | N6 | 78.0 (Ambient temp.36.5) | More than 100 | 718 | - | Colourless, $H_2S$ smell salty taste | Terrace deposite Fractured amphibolite | - |
| | | N7 | 80.0 | 34 | 8 | - | Colourless, $H_2S$ smell salty taste | Talus/Fractured amphibolites | - |
| | Mashkin | | 57 (Ambient temp. 34.4) | 1 | 7.87 | 1070 | Colour less, $H_2S$ smell | Surface soil/Gneiss (Nanga Parbat Gneisses) | Cloth washing |
| | Sassi | | 54.0 (Ambient temp. 33.0) | - | 7.87 | 1310 | Colour less, Odorless | Talus/Gneiss (Kohistan Island Are sequerice) | $CaCO_3$ deposition |
| | Chu Tran | | 43.9 | 200 | 7.74 | 5090 | Colour less, Odorless | Talus/ Limestone (Eurasian Mass) | $CaCO_3$ deposition |

**Table-3: Physical and chemical characteristics of hot springs in Chagai Volcanic Arc (Source: Todaka et al., 1999).**

| Hot spring Locality | | | Temperature °C | Flow Rate in L/min | pH | Electirc Cond. in μ/cm | Feature of hot water | Geology | Remark |
|---|---|---|---|---|---|---|---|---|---|
| CHAGAI VOLCANIC ARC | Chicke n Dik | | 29.9 (Ambient temp: 40.9) | - | 6.58 | > 10,000 | Colour less, odorless salty taste | Recent Deposits | $CaCO_3$ Deposition |
| | Koh-e-Sultan Voleanies | C2 | 29.5 (Ambient temp. 34.7) | < 1 | 7.44 | 1060 | Colourless, ordorless salty taste | Basal agglomerate | Discharge from never bed |
| | | C3 | 32.2 (Ambient temp. 38.6) | < 1 | 6.89 | > 10,000 | Colourless, odorless salty taste | Basal agglomerate | $CO_2$ gas bubbling $CaCO_3$ deposition Discharge from river |
| | | C4 | 32.0 (Ambient temp. 36.9) | < 1 | 6-7 | - | Colourless, odorless salty taste | Basal agglomerate | $CO_2$ gas bubbling $CaCO_3$ deposition Discharge from river |
| | | C5 | 26.9 (Ambient temp. 31.1) | < 1 | 2.77 | >10,000 | Colourless, $H_2S$ smell | Altered andesite | Sulphur & Salt deposition Discharge from river bed |
| | | C6 | 25.5 (Ambient temp. 31.9) | - | 2 | - | Colourless $H_2S$ small | Altered andesite | Sulphur & Salt deposition Discharge from river bed |
| | | C7 | 27.5 (Ambient temp. 35.9) | 10 | 7.13 | > 10,000 | Pale brown odorless salty taste | Basal agglomerate | Water contains Fe discharge from river bed |