PLANNING, MANAGEMENT AND CASE STUDIES OF GEOTHERMAL ACTIVITY IN AZERBAIJAN (ARDEBIL AREA)

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Description of geothermal systems is one of the important issues for better analysis of renewable energy and management affairs of sustainable energy programmers. It is designed specifically to evaluate, develop and encourage the commercialization of renewable energy Technologies and other novel energy sources. One of the principal aims of the programmed is to assist Iran industry to identify and evaluate business opportunities in international markets.
Many hydrothermal convection systems are situated at or near Plio-Quaternary volcanoes in Azerbaijan Especially in Ardebil area. The zone of springs extends from Sahand to Savalan volcanic zone towards Kamchy and Kantal-Harzand in the border Aras River. For detecting topographic features related to geothermal activities and by detecting thermal anomalies by the use of thermal infrared imagery. The difference in temperature between butter zones and shallow colder zones generate in Azerbaijan a conductive flow of heat the former towards the latter, with a tendency to create uniform conditions, although, as often happens with natural phenomena, this situation will have actually be attained. The reservoir flied of the Ardebil geothermal system is high in chloride and berry rich ingest. The highest measured temperature in the reservoir reaches (80-100)^{o}C. Geothermal energy is used now for electricity generation and for space heating in many areas of the world.

INTRODUCTION
(RENEWABLE AND SUSTAINABLE ENERGY SOURCES)

Iran enjoys considerable potential to take advantage of renewable energies such as Wind, Solar and Geothermal.

It is hoped that electricity of about 32 MW would be generated from these sources by the end of 2001. Solar, Iran has a very high solar radiation factor (19.23 MJ per square meter). Most of the country enjoys considerable hours of sunshine per day. Recently an agreement has been signed with a German delegation to act as advisor to the Ministry of energy (MOE) to build Iran's first Thermal Solar Plant in the Yazd (central of Iran) province.

The plant will be constructed in an area of 9 square kilometer, and will operate as combined cycle, having Gas and Steam units in addition to solar farms.
Another solar project underway is to equip the Iranian islands of the Persian Gulf with Solar energy. These islands enjoy 10 months of sunshine throughout the year.
The plan calls for an initial Solar Energy Generation of 10MW, and promotion of solar energy consumption by the inhabitants.

The wind velocity in the provinces of Kerman, Sistan and Baluchestan, East Azerbaijan and Guilan provide ample opportunity to harness this natural energy. The Manjil area of Guilan provides constant high wind velocity due to its mountainous topography. Already a pilot project with 20 windmills are underway is this area. It is expected that by 2004, 60MW electricity be generated by wind energy turbines.

The MOE has been undertaking various studies for development of geothermal power since 1992. Recently it has bees decided that a 100MW geothermal power plant is to be established in Savalan (Meshkinshahr-Khiav).

Most geothermal resources in Iran are in region of volcanism and active faults. Hot springs, pools boiling mud and fumaroles are the most easily exploited sources. Geothermal energy's greatest potential lies in the generation of electricity.
It was first used to produce electric power in Italy in 1904. Today geothermal power plants are in operation in Argentina, Bolivia, Canada, China, Costa Rica, Elsalvador, Ethiopia, Fiji, India, Indonesia, Iran, Italy, Japan, Mexico, New Zealand, Philippines, Russia, Turkey, Vietnam, Yemen, US and other countries.

Geothermal Studies in Iran

Geothermal energy is one of the alternative energy sources that are being used in various ways, including for electric power generation and local heating systems.

The geothermal studies in Iran started by (MOE) of Iran in 1975. Lineaments interpreted from remotely sensed imagery provide important information on subsurface fractures that may control the convective movement of geothermal fluids. Many hydrothermal convection systems are situated at or near Plio-Quaternary volcanoes in Iran (Savalan, Sahand, Damavand and other regions) and photogeologic interpretation is quite helpful in volcano-stratigraphic studies of these areas. Molten or solidified magma beneath such areas generally is accepted as the heat source for the volcano – related geothermal systems.

Large-scale circular features are observed in volcanic terranes from synoptic Landsat imagery. These features are known sometimes to be Quaternary calderas (Fig.)

Other features are concealed partly by sediments or are obscured by dissected geomorphology. The Savalan area in the northern most part of Iran (Azerbaijan) was studied in order to (1) clarify the geologic meaning of its large circular feature and (2) assess the geothermal potential of the area. The researchers concluded that the area was the center of early Pleistocene, large-scale volcanism and that the circular feature is a caldera which was formed by the eruption of voluminous acidic volcanic rocks (rhyolites to trachyandesites and tuffs) and was given the name of Savalan caldera. The Savalan area was selected as a geothermal exploration target. A combination of several new types of data obtained in drilling and in assessment of geothermal resources assisted in interpreting the caldera structure. The electric power research center (EPRC) and Renewable Energy Organization of Iran (SUNA) were established to justify priorities of the above-mentioned regions. As a result Khiav or Meshkinshar and Sarein area in Savalan region, were proposed for electric and direct use respectively. Savalan volcano is a point volcano and its coning is a strato-volcano type. This volcano from geology point of view is formed on the great Oligocene period. Its primal activity happened during Eocene time and the last activity in as during the end of Quaternary time.

There are several hot hydrothermal springs around the Savalan and other volcanoes in Iran especially in Azerbaijan areas.

In 1998 Kingston Morrison Ltd (KML) on behalf of SUNA completed a resistance survey consisting of D.C., TEM and MT measurements in Khiav (Meshkinshar). In this area location of three exploration wells were proposed the Dc Schlumberger and tem and MT survey also performed in Sarein area for direct uses in the summer of 1998.

Hydrothermal alteration and geothermal potential investigations in Meshkinshahr and Sarein areas

A hydro thermally altered area is a typical surface manifestation of geothermal activities and is, therefore, an important target for remote sensing techniques applied to geothermal areas. A 100 km2 area of hydrothermal alteration was interpreted from spot imagery with part of it within the Meshkinshahr prospect. At least in this area essentially all of the hydrothermal alteration is confined to the Pliocene formation. Within the Pliocene formation, the original volcanic lithology exerts a major control over the intensity of alteration (Ian Bogie and others 2000).

The andesite lavas are generally weakly altered or fresh and are only strongly altered close to some fractures. The tuffs and pyroclastic breccias are strongly to intensity altered. In general, the existence of the alteration assemblages described below is consistent with the development of a widespread, low temperature part of a hydrothermal system.

The stratigraphically higher lavas, however, are all unaltered and may have been above the piezometric surface of the hydrothermal system the secondary minerals found in the weakly alters trachyandesite lavas include smectite, kaolinite, cristobalite, opal, chalcedony, and opaques However, some samples contain smectite, cristobalite, opal and quartz, which indicates their alterntion maybe associated with current thermal activity evident in the near surface.

Geophysical exploration in Meshkinshahr area

Geophysical techniques are used in the northeast (Azerbaijan, Savalan area) of Iran for exploration the geothermal energy.

This course will examine the principal geophysical techniques which are used to image the subsurface at deep (>1km) medium (<1000 m to 500m) and shallow (<200m) depths of investigation.

These methods include seismic reflection, and refraction profiling, ground penetrating radar (GPR) electromagnetic and resistance survey and borehole geophysical logging.

Gravimetric survey in Savalan was carried out by Ente Nazionale per L'Energia Electtrica of Italy (ENEL) 1983. The negative anomaly of gravity method was interpreted by SUNA, thereafter detailed geological, geochemical, resistance survey using Mt, TEM and DC Schlumberger methods have been carried out by Kingston Morison Ltd (KML, 1998) these survey covered approximately an area of 500 km2. As result, a low resistance secured in an area of about 75 km2, that the apparent resistance of the area is less than 4 ohm (M. Fotohi and Y. Noorollahi 2000). Hence this area has been recognized as a promising section for geothermal exp location drilling and location of three exploration wells proposed in the area.

At the present time SUNA is in the position to drill for drilling the first geothermal exploration well in the Meshkinshahr area and drilling activities may start in near future.

Geophysical exploration in the Sarein area

The small city of Sarein is famous for geothermal hot spring resources. In this area gravity survey has been conducted by ENEL (M. Fotohi and Y. Noorollahi 2000), and result of Electric Power Research Center (EPRC) and SUNA Justification MT, TEM and DC. Measuirements has been carried out in an area of 100 km2. Results of the said investigation are under consideration.

In general, geophysical exploration methods are fundamental tools in the search for geothermal resources, in the Sarein and Meshkinshahr areas for exploitation renewable energy in the Azerbaijan.

Spring minerals and chemical components

Numerous hot springs occur in the Azerbaijan. The zone of the springs extends from Sahand to Savalan towards Kamchi and Kantal in the border Aras river.

The hot springs usually occur along faulted contacts of tertiary and pretertiary formations.

Large fracture systems in the Azerbaijan have facilitated the emergence of these hot springs.

The hot springs locate between the Lijan (Bostanabad) and Savalan region. Geochemical thermometry indicates high reservoir temperature (180°C to 250°C in depth). The total heat discharge at the surface has been estimated as 10000 k cal/sec.

Shallow thermal surveys have demarcated thermal anomalous areas where boreholes have been drilled which tapped steam/water under pressure 1.5 to 4 kg/cm2. The data indicate very high geothermal gradient (30-80)°C.

Resistance surveys indicate the presence of a narrow vapor dominated zone at shallow depth in the central part of the Savalan.

The springs in the Meshkinshahr prospect issue mainly from the gravels (Quaternary period).

There are no springs reported downstream at lower elevations. The Gheynarge, Khosraw-Su, Malek-Su and Ilando springs produce neutral Cl-so4 waters with up to 1500 ppm Cl and 442ppm So4 and have significant concentrations of Mg (up to 24 ppm). They have a simple dilution trend indicating mixing with varying amounts of shallow groundwater. They exhibit a strong seasonal variation in temperature or chemistry, which is indicative of strong behavior. Despite the elevated Cl concentration, isotopically the waters lie on the local meteoric water line.

Mg concentrations show little inverse correlation with chloride, suggesting that Mg is high in both the chloride aquifer and the shallow diluting groundwater. The hot spring waters at Sarein show a wide range of salinity, ph, and gas concentration, which indicates modification of the deep water by boiling and mixing processes. On the basis of surface sampling, the reservoir fluid is sodium chloride water that has a neutral ph, a high H2S concentration, and a temperature of (40-48)°C.

Oxygen and hydrogen isotopic data on the waters Sarein and Meshkinshahr show a significant shift in oxygen and hydrogen away from the local meteoric water. This shift is toward the end member for high-temperature volcanic steam from calc-alkali volcanoes of an arc environment, which gives at least a 70 percent contribution of magmatic fluid to the Sarein hydrothermal system.

The Moil, Moil 2, Aghsu and Ramy springs in Meshkinshahr area are acid (ph= 4.28, 3.20, 3.35 and 2.76 respectively). The Moil 2 Aghsu springs are typical acid-so4 waters and there fore have formed by condensation and oxidation of H2S, implying boiling at greater depths. The Moil spring have been slightly neutralized and are there fore further from the source of H2S than the Moil 2 springs. The Romy springs waters contain significant Cl (1/g ppm).

The storage behavior of the springs is indicative of them being fed by very large perched groundwater aquifers. To be heated and to obtain a high my neutral Cl-So4 composition requires that magmatic voltailes have condensed and been neutralized within these aquifers. The highest measured temperature in the reservoir reaches (180-250)°C. Measurements of tritium concentration indicates that the deep water in the hot aquifer has a very long residence time.

Conclusion

In summary we see a broad spectrum of styles and ages of hot springs and geothermal energy in Azerbaijan. This reflects the tectonic framework of the Azerbaijan in the late Cenozoic.

The diversity is due to local volcanic processes, the location of the hydrothermal system in relation to volcanic vent, and the subsequent uplift and erosion of the area.

Surface detailed geothermal explorations have been carried out in the Savalan regions. Groundwater aquifers containing neutralized magmatic volatiles and the pattern of low resistances at depth implies that a vapor cored geothermal system may be present.

Results of feasibility studies for two zones of high geothermal potential (32×1018 Jules) in the Savalan region indicate the following priority: Meshkinshamr and Sarein areas.

According to geothermometric evaluation the average temperature of deep reservoirs are (140-250)°C. Therefore, Meshkinshahr area has the highest geothermal potential for electric generation whereas Sarein area for direct Uses. There Fore, information about geothermal activity and hot springs provides an insight into the evolution of this volcanic region.

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AZƏRBAYCANDA GEOTERMAL AKTİVLİYİN TƏDQİQİ (ƏRDƏBİL BÖLGƏSİ)

QƏNBƏRİ İ.

Alternativ enerji mənbələri ehtiyatlarını müəyyənləşdirmək məqsədilə İranın Ərdəbil bölgəsində geotermal aktivlik tədqiq edilmişdir. Müəyyən edilmişdir ki, tədqiq edilən geotermal sistemlərdə maksimal qeydə alınmış temperaturun ədədi qiyməti (80-100)°C qədərdir. Geotermal enerjidən elektrik enerjisi və istilik təchizatı əldə etmək məqsədilə istifadə etmək təklif olunur.

ИЗУЧЕНИЕ ГЕОТЕРМАЛЬНОЙ АКТИВНОСТИ В АЗЕРБАЙДЖАНЕ (ЗОНА АРДЕБИЛЯ)

ГАНБАРИ И.

Исследуется геотермальная активность в Ардебильской зоне Ирана с целью выявления ресурсов возобновляемых источников энергии. Показано, что в исследуемых геотермальных системах максимальная измеренная температура достигает (80-100) °C. Предлагается использовать геотермальную энергию для выработки электричества и для теплоснабжения.