PROSPECTING GEOTHERMAL ENERGY FROM HOT WATER SPRINGS AT PADIYATHALAWA

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ABSTRACT

Being a country with an increasing population, the demand for power is also increased in Sri Lanka. As a result there will be a power crisis in the country near future. In this scenario we can not totally depend on the conventional power sources. It is timely to find out alternative cleaner energy sources. Geothermal is a prominent energy source which can produce uninterrupted power supply. Thermal springs of Sri Lanka are a manifestation of the earth's internal heat, and this tremendous potential of geothermal energy is not yet fully investigated for vast range of applications mainly for power generation. This research project mainly focused on assessing the feasibility of Padiyathalawa hot springs to produced geothermal energy. Mainly geophysical and geochemical explorations were carried out along the target area to locate the fracture pattern and the sources of hot springs. As a conclusion, feasibility study indicates that the all hot water springs are originates at a single source and zone having high fracture density has been identified which is suitable for further investigations. Also two locations have been identified for produce energy combining with another technology using the water having out flow temperature of 44 °C.

KEYWORDS

Geothermal energy, Hot spring, Magnetic survey, Resistivity profiling, Resistivity sounding.

INTRODUCTON

Being a developing country and also being a country with an increasing population, the demand for a continuous, steady power supply is a necessity for Sri Lanka. A significant proportion of Sri Lanka's power supply depends on hydro-power and the other power generation sources have not been fully developed. This high dependency on hydro-power was continued until it was challenged at the beginning of the new millennium. In 2002, there was a power crisis in the country, which considerably disabled the economy and almost all of the most important functional areas of the country. Its impact was also manifested in the political power shift that took place later in that year. Therefore it has to be accepted that we cannot depend on hydropower alone.

Alternative sources of power have to be identified and developed. As a poor developing country we have to look for cheaper means of producing power. Many of the existing technologically feasible renewable energy sources are already being exploited to its maximum capacity. Therefore it is essential that Sri Lanka explore means of improving efficiency of energy use, assess the feasibility of using alternative cleaner energy sources that do not exert undue pressure on foreign exchange, and examine new avenues for renewable energy sources within the country.

In recent years hot spring systems also known as geothermal systems, have become an important sources of alternative energy. In a few rare locations in the world, water in the ground is hot enough to exist as steam. In these instances, wells have been drilled into the heart of the steam zone and the steam is used to operate a steam turbine to generate electricity. The more common type of geothermal system is the hot water type. These geothermal systems are used to generate electricity in several countries including few Asian countries (India, Nepal etc.).

The thermal springs of Sri Lanka are a manifestation of the earth internal heat, and its potential for our consumption is yet to be fully investigated. Ten thermal springs have already been identified in Sri Lanka along the geological boundary between the Highland Complex (HC) and Vijayan Complex (VC). The Padiyathalawa hot water spring which was focused in this study is situated at Marangala Wahawa in Ampara district within Vijayan complex.

METHODOLOGY

There are many types of investigation methods; Geological, Geophysical, Geochemical and Borehole exploration.

Geological investigations such as field mapping and remote sensing interpretation are helpful to prepare subsurface geology and geological structure at both local and regional scale.

Hydro geochemical investigation of the hot water springs plays a major role in understanding the condition of a geothermal system as all geochemical and physical characteristics (properties) at hot water are totally controlled by the surrounding underground environment and the sources of origin of hot water.

Geothermal source are mainly investigated by geophysical exploration methods; Electric method, Magnetic method, Seismic method, Gravity method and Electromagnetic method.

Geophysical exploration methods will help to locate the geothermal body by estimating the depth, the extent and its temperature distribution.

Borehole investigation can be used to investigate the actual condition of aquifer like temperature of source, what the type is, and so on. Especially it can be used to find the temperature gradient of the site.

Detailed geological mapping

The Global Positioning System (GPS) coordinates of all hot water springs within the target area, the stations along the resistivity profiles, magnetic profiles and resistivity sounding points were taken by using Magellan Platinum Hand GPS. In this stage, surface fractures in the target area were also located by using this coordinate system and dip & strike of the outcrops were measured. All GPS coordinates were mapped using ARCVIEW software.

Geophysical investigations

The Resistivity Survey can be carried out to investigate the deep fractured areas. Resistivity profiling and Resistivity sounding are useful and effective geophysical methods to obtain information on direct variations of resistivity below the earth surface. Resistivity profiling is a method to investigate the fractures, joints, lineaments etc laterally below the earth surface according to the variations of resistivity. The resistivity sounding is used to investigate how many depth fractures extend to the earth core. The deep sounding is more effective and efficient for our purpose. Thus, the feasibility of these hot water springs can be found for diverse applications. Resisitivity survey which consists of a combination of depth sounding, profiling and mapping, was done to investigate the nature of the target area. For resistivity sounding and profiling, the schlumberger array was used and the results were processed by using RESIST software.

Magnetic profiles were carried out along the resistivity profiles in the target area using two magnetometers (proton precession magnetometers), one for the base station and other one for traversing. Throughout the day the strength of the field varies, and these variations have been removed from the survey data before they were accurately interpreted. The corrected magnetic survey data was interpreted and the magnetic variations in the area were modeled to identify the fracture patterns.

Geochemical investigation

In the field the temperatures and pH values of hot water springs were measured by using standard portable HANNA instrument HI 8314 model pH meter and the conductivity and turbidity of water samples were measured by using TSP WP-84 model conductivity meter and WTW Turb 350 IR model turbidity meter respectively. In the laboratory total

Hardness, concentrations of bicarbonates, carbonate and chloride ions of water samples of hot water springs were measured by titrimetric method. The concentrations of Sulphate of water samples of were measured by Nephelometric method. Na, K, Li, Mg, Fe and Ca concentrations were analyzed using Atomic Absorption Spectrometric method (AAS). The concentration of dissolved silica of water samples were measured by using UV Visible Spectrometer.

RESULTS

Geological mapping

The study area consists of quartzite and biotite gneiss having two joint systems. Also a zone having high fracture density has been identified.

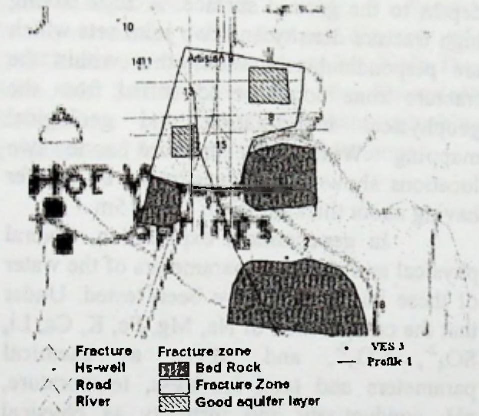

Fig 1: fracture map of the study area.

Resistivity Profile

Profile 01 was carried out along the NW-SE direction to have better lateral resolution of the subsurface geological structure. From the resistivity vs. distance graph of profile 01 it is clear that the south area shows very high resistivity values of about 600Ωm compared to other part of the section. The Vertical Electrical Sounding (VES) 03 was done at the point 200m away from the starting along this profile 01. Combining these two (Profile 01 and VES 03) we can say that overburden is shallow and it s thickness is 3m to5m. Bedrock is found within first 200m along the profile line. The graph shows high fluctuation of resistivity values. This may be mainly due to the fractured bedrock. Along the profile line resistivity is gradually decreased and subsurface resistivity is very low at North (less than 100 Ωm). This variation may be due to the conductive materials such as water, clay, mud etc... Area between 450m -550m profile distance, where resistivities of about 100 Ωm are apparent (which is the apparent resistivity of fresh water). Combining this with VES 04, can suggest that there may be an aquifer layer having 15m thickness and about 100m width along the profile line.

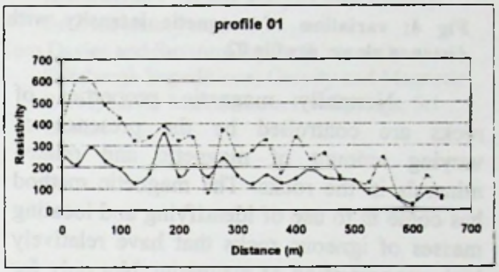

Fig 2: variation of resistivity with distance

Resistivity Sounding

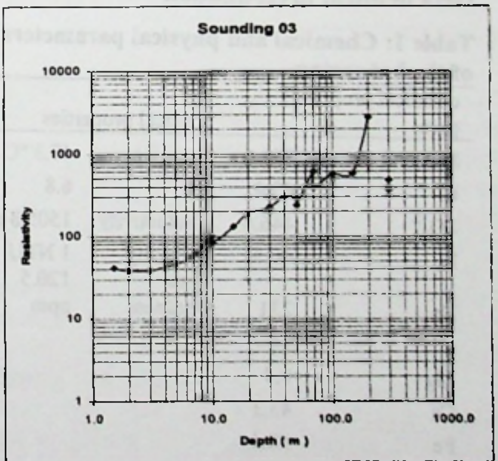

Fig 3: variation of resistivity with depth of sounding

Three different layers up to 300m depth can be identified in this point. There may be 4m thick overburden of porous soil (with sandy clay) or weak weathered material underneath up to 4m because resistivity is low up to 4m. This graph shows approximately 45^0 inclinations after 4m depth due to the bed rock at 4m depth.

Magnetic (along profile 02)

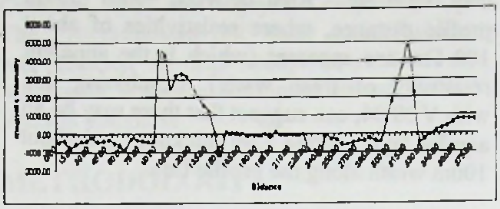

Fig 4: variation of magnetic intensity with distance along profile 02

Normally magnetic properties of rocks are controlled by the presence of varying amount of magnetic and related minerals in the rocks. The magnetic method has come in to use of identifying and locating masses of igneous rocks that have relatively high concentration of magnetite. Not only for detect the magnetic minerals, it can be also used to detect the non magnetic minerals and weak zones like faults and shearings.

Geochemical investigation

Table 1: Chemical and physical parameters of the hot spring

chemical properties ppm		physical properties	
HCO_3^-	142.6	Temp	47.3 °C
Cl^-	40.4	pH	6.8
SO_4^{2-}	446.4	conductivity	1505.8 µs
Li	<0.3	Turbidity	1 NTU
Na	231	Total Hardness	120.5 ppm
K	14		
Mg	0.4		
Ca	43.3		
Fe	<0.1		
SiO2(dissolve)	131.2		

Sri Lanka mainly consists of metamorphic rocks. There are some igneous bodies isolated in several places in the country. Our study area consists of quartzite and biotite gneiss having metamorphic origin. Although magnetic minerals show magnetic properties, weathered zones also show magnetic properties. This is because magnetite is formed in weathered zones in the earth. Therefore this formation helps to identify the fractured or weathered zones in the earth using magnetic method. From magnetic survey which has been done along the resistivity profiling 02 indicates two areas(90m-150m and 300m-330m) having high magnetic values. Resistivity profiling 02 shows low resistivity values in the same areas. Therefore this region can be identified as a fracture zone.

DISCUSSION

Resistivity profiles and soundings were carried out at the target area clearly indicate presence of a deeply extending fractures, faults or shear zone which provides the pathway for thermal water to flow from the depths to the ground surface. A zone having high fracture density and two joint sets which are perpendicular to each other within the fracture zone could be identified from the geophysical investigation and geological mapping .Within the fracture zone two locations shows characteristics of an aquifer having about thicknesses of 10m-15m.

In geochemical exploration, several physical and chemical parameters of the water of these hot springs have been tested. Under that the composition of Na, Mg, Fe, K, Ca, Li, SO_4^{2-}, CO_3^{2-}, and HCO_3^- as chemical parameters and total hardness, temperature, pH, conductivity and turbidity as physical parameters were determined. When comparing the results, it is clear that all hot springs exhibit almost same characteristics. It indicates that all of these hot springs have been fed from one aquifer or a source. Under this survey, the above parameters of normal wells in the area which we concern were also determined. When comparing the results of that wells with hot wells deviation of the results could be observed. From that we can say they are originated from two different sources and hot water is not contaminated with cold water while back their journey to the surface along discontinuities in the earth. Sub surface temperature of the springs were estimated using silica geothermometer and it indicated temperature of 124°C.

CONCLUSION

A zone having high fracture density has been identified which is suitable for further investigations. Based on similarities in the Chemical composition of water, it can be suggested that all hot water springs are originates at a single source through discharged at different outlets situated few meters apart from each other. Energy can be produced by combining with another technology (dendro power) using the water having out flow temperature of 44 °C. But the subsurface temperature of this water is considerably high. Therefore energy can be directly produced by using a binary cycle.

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