



Study of the Near-Surface Resistivity Structure in Kapurella Area Using Transient Electromagnetic Method

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1. Introduction

Sri Lanka has several hot water springs that are distributed around the Highland-Vijayan lithological boundary. The thermal spring belt along this boundary implies some heat source beneath. Two hypotheses have been proposed to explain the existence of thermal springs in Sri Lanka. Above normal geothermal gradient is proposed by Chandrajith et al. (2013) while some researchers proposed a deep penetrating fracture system. The temperature of the spring waters varies from place to place. The highest temperature (73.5°C) was recorded at Kapurella hot spring in Ampara District.

In 2010, a comprehensive geophysical survey was conducted around all the known thermal springs in Sri Lanka except the Jayanthiwewa in Ampara district. Magnetotelluric (MT) and Transient Electromagnetic (TEM) methods were used in combination, for the first time in Sri Lanka. These non-invasive electromagnetic methods can be used to determine physical parameters down to several kilometres and an overview is presented in Hobbs et al (2013).

Electromagnetic methods provide information on subsurface resistivity, which can be used to

understand subsurface structures and related properties such as salinity, porosity, alteration, temperature etc. We present preliminary TEM results from one of the geothermal sites investigated during the above survey.

2. Methodology and Study Area

Transient electromagnetic (TEM) method became very popular due its exploration

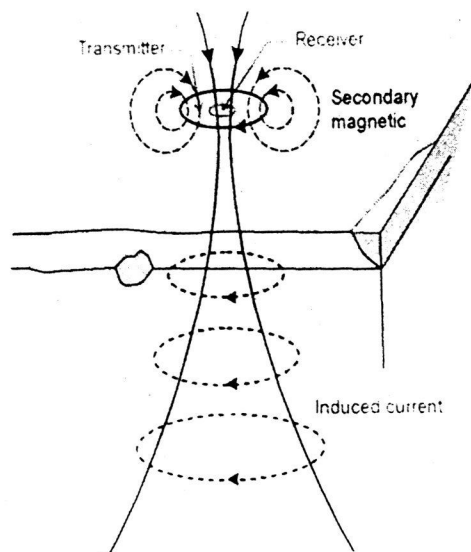


Figure 1 - The central loop TEM electric-magnetic field generation



potential in many areas (Figure 1). It is extensively used not only in geothermal energy exploration, but also in ground water exploration, mineral exploration, archaeological exploration and for many other purposes (Árnason, K., 1989).

TEM method gained its popularity since 1980s. This method can be used in many areas, where Schlumberger method practically can never make good results, for example in rough terrains and glaciers. According to resistivity profile, basic conceptual model is defined and final model is obtained through complex processing and calculations. A controlled electromagnetic source is used in TEM method. A time varying electromagnetic field is injected to the earth using a large conductor loop called transmitter loop. This magnetic field induces currents inside the earth. Induced current generates secondary magnetic fields, which are detected by a small centre loop called receiver loop. In this method, reliability factor is not affected by near surface low resistive structures such as very shallow saline water or conductive clay minerals. Its simple site layout requires small work force and it allows to make repeated readings effectively and reliably. The combination of several soundings along a profile may give 2D variations of the subsurface resistivity (Arnoson, K., 2006a, 2006b).

In Sri Lanka, number of hot springs exists around the Highland-Vijayan boundary. Among them, Kapurella thermal spring system reports the highest temperature (above 70 °C). Nine TEM soundings and nine MT soundings were done around this hot spring area (Figure 2).

In order to interpret shallow resistivity structure TEM data need to be processed. Different resistivity profiles and iso-resistivity maps were

prepared to identify major fluid flow patterns and fracture zones over the studied area.

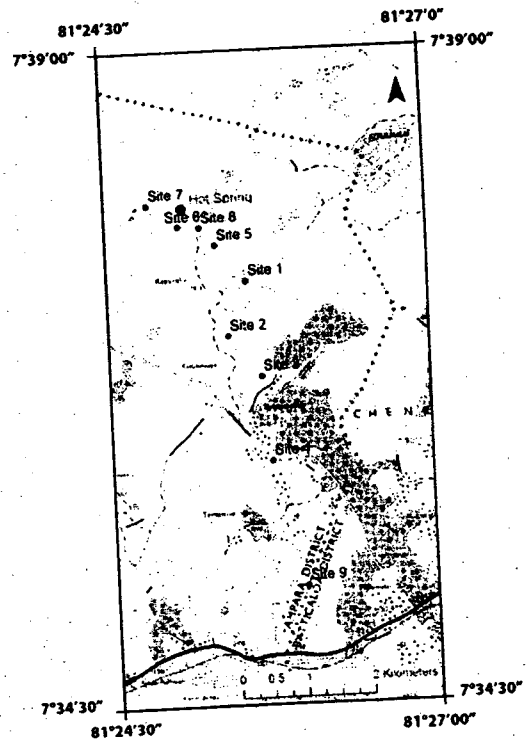


Figure 2. Area of investigation showing the sampling sites (site 1- site 9) and the location of the hot spring.

3. Results and Discussion

Figure 3 shows a cross section down to 200m depth below sea level (b.s.l.) with a horizontal profile spreads over the 7km. Relatively low resistive layer overlaying most of the area. The hot spring complex is situated close to the sites 5 and 8. The highly resistive layer spreads to about 150m deep. There are some interesting low resistive vertical and horizontal connections as shown in Figure 2. One of these channels directly connects to thermal spring area around site 06 and 08. Another one runs towards site 02 and spreads over 1km area creating low resistive chamber.

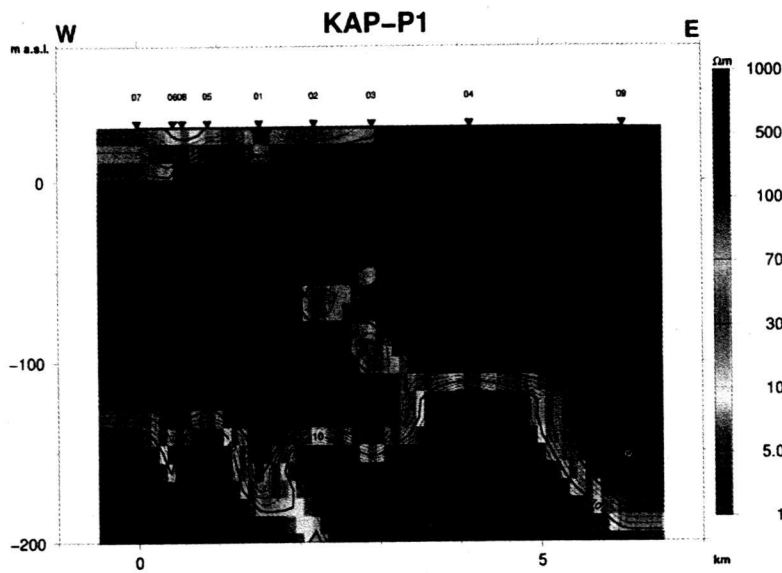


Figure 03- Resistivity profile of the study area derived from TEM data

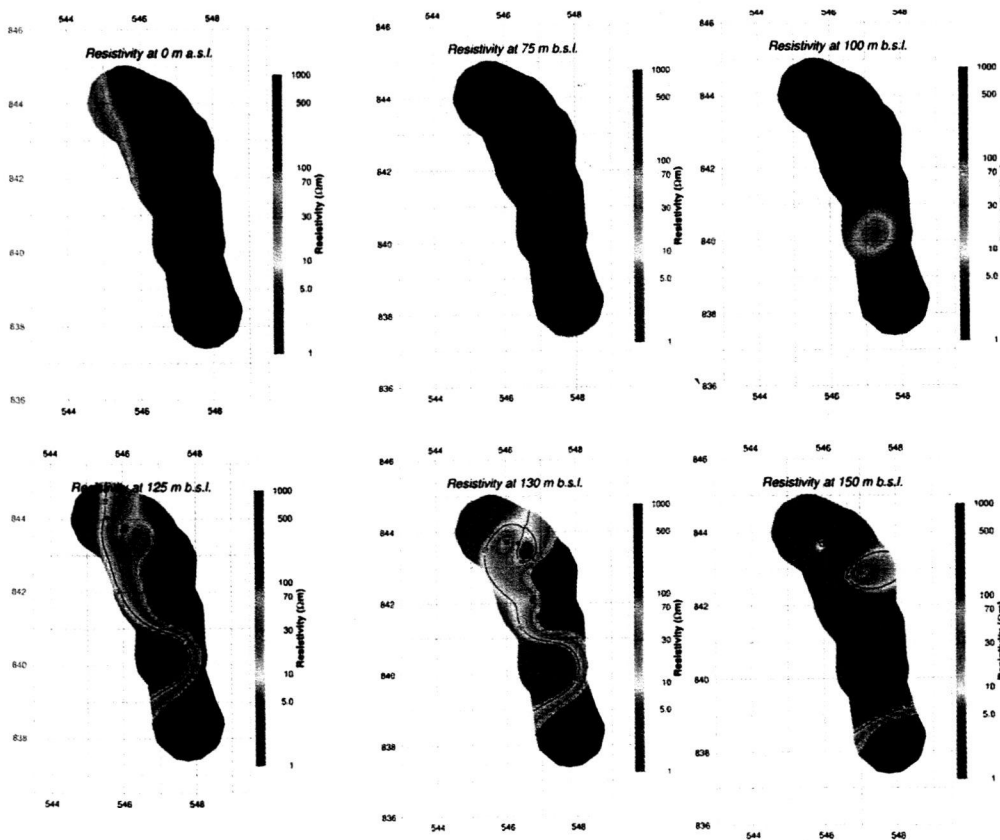


Figure 04 - Iso-resistivity maps for the study area for different depth levels



Figure 4 shows iso-resistivity maps at different depths, which can be compared with resistivity profile data in Figure 3. At the sea level, thick high resistive layer covers the whole area. But at the 75m b.s.l. relatively low resistive spots start to appear. At 125 b.s.l., these low resistive zones connect to very low resistive zone, indicating the possible channels of fluid flow. As shown in the right lower corner in Figure 4, very low resistive zone becomes dominant at the 150m b.s.l.

The low resistivity of the surface near the locations 07, 06, 08 and 05 is accounted by the water logged swampy conditions found around the hot spring. There are number of clearly seen low resistivity paths dipping eastwards to the hot spring, most probably indicating the path of the thermal water to the surface through fractures which are indicated by their high conductivity values of about $>2000\mu\text{s}$. The extremely low resistivity conditions found around 150m depth can be regarded as an indication of water accumulation or aquifer. However, the low signal strength at greater depths could be a major disadvantage in approximating the results to produce an accurate geological profile. In this case it is recommended to test the results by a secondary method like DC resistivity and confirm the validity of TEM data. Further, bore-hole logs can be utilised to aid the modelling of the subsurface.

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