IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

AN INTEGRATED 1D VES AND 2D AUDIO MAGNETO TELLURIC IMAGING FOR MAPPING VERY DEEP POTENTIAL CRYSTALLINE ROCK AQUIFERS IN A DROUGHT PRONE TERRAIN OF TAMILNADU, INDIA.

1 Badrinarayanan T.S *, 2 S. Sundara moorthy,

1 Geoscientist, 2 Research Scholar,
1 B Square Geotech Services, Kollidam, Tamil Nadu, India
2 Research Scholar, Department of Geology, National College, Bharathidasan University, Tiruchirappalli, Tamilnadu, India.

Abstract: Geoelectrical methods are most commonly considered to be the fundamental methods in groundwater research, but in case of deeper aquifers the electrical resistivity tomography [ERT] / 1D VES cannot achieve deeper targets and the electrical sounding cannot ensure a complete and dense space coverage. In such a case the use of the magneto telluric [MT] method can provide for great depths of research, as well as a good space sampling. As huge amount has to be incurred for very deep drilling, utmost care has to be taken. Considering this view it is planned to go for integrated aquifer mapping. This study pertains to an integrated geophysical investigations combining one dimensional vertical electrical sounding [1D VES], a geoelectric method and two dimensional audio magneto telluric imaging [2D AMT], an electromagnetic technique to prospect the very deep potential hard crystalline rock aquifers for an individual farmer with 25 acres of land at Pukkulam, Tiruppur district, Tamilnadu, India which being a acute drought prone area. Before going for selection of new potential point, a correlative and confirmative study has been taken by this integrated approach near the existing very deep bore well drilled to a depth of 394m with a high yield of 130 lpm. As both geoelectric and AMT studies revealed good correlation and good coincidence of potential targets, the method proved to be a good approach. By this integrated approach one deep bore well has been drilled in the study area to a depth of 207m with a good discharge of 130 lpm. With this same methodology one more very deep borewell point has been recommended to drill up to a depth of 400m. Since this integrated approach gives a good encouraging result it may be followed to minimize the failure rate so as to relieve the agriculturist from mental agony.

Keywords: ERT; 1D VES; MT; 2D AMT

1. Introduction

Since the research paper confines to integration of both geoelectric and electromagnetic- audio magneto telluric imaging techniques it is a prerequisite to know the concept and principle of both methods.

Geophysical methods aid in determining the subsurface structure. Under electrical prospecting method, electrical resistivity techniques [ERT] are very simple because of its response to the quantity and chemical quality of ground water. It is non-invasive, cost effective and widely and globally adopted technique and helps to delineate the regional hydrogeologic features or pinpoint location of drilling bore wells. Magneto telluric (MT) is an electromagnetic geophysical method for inferring the earth's subsurface electrical conductivity from measurements of natural geomagnetic and geoelectric field variation at the Earth's surface. Basis of the magneto telluric theory are Maxwell’s equation. The source of the magneto telluric fields is in the magnetosphere and ionosphere, separated by the non-conductive atmosphere [4].

2. Area of Investigation

The study area Pukkulam village in Gudimangalam Union of Udumalpet taluk of Tiruppur district, Tamil Nadu is about 5 km North West of Udumalpet on Udumalpet Senjeri hills highway. The areal extent of agricultural land is about 25 acres, lies on north latitudes 10º 37’ 50.5’’ to 10º 38’ 00.7’’ and east longitudes 77º 13’ 51.8’’ to 77º 14’ 08.0’’. The topography of the area is slightly undulating with a maximum altitude of 1179’ in the North West and minimum altitude of 1164’ in the south east. The total extent of agri land is 25 acres with coconut plantations. There are three bore wells, out of three, two are unyielding and one 163mm dia bore to a depth of 394m with a discharge of 270 lpm is the only source with drip irrigation system. During acute summer the static water level in borewell dips down to 180 mbgl.

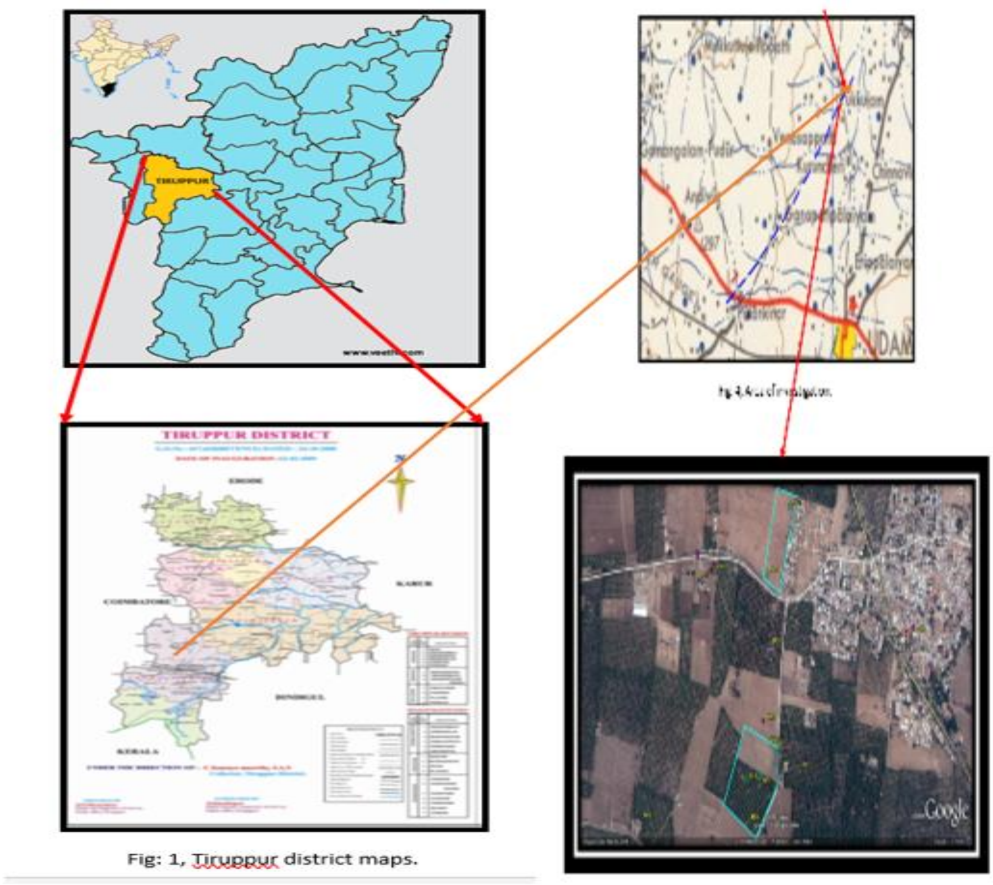


Figure 1. 1 to 4 Location Maps

3 Geology And Geomorphology of Tiruppur District

Tiruppur district is bounded by North latitudes 10°14’00 to 11°20’00’’, east longitudes 77°27’00 to 77°56’00’’. The areal extent is 2296 square kilometers. The southern part of the district is covered by hill ranges of Western Ghats mainly Anamalai hills. The district is underlain by wide range of metamorphic rocks of peninsular gneissic complex of Archean age. The major rock types comprising the area are charnockite, garnet biotite gneiss, fissile hornblende biotitte gneiss, pink migmatites, hornblende biotite gneiss, pyroxene granulite, garnetiferous quartzo felpathic gneiss, anorthosite, Nepheline syenites, corundum syenites & ultra-mafic complex. The gneissic rocks are intruded by granites & magnetite quartzite. Pegmatite and vein quartz are seen traversing the migmatites throughout the area. Most of the area is covered by brown and red brown soil. Brown soil is probably derived from the acidic rocks while the red brown soil is derived from the basic rocks.

The three major geomorphic zones are i] plains, ii] pediments iii] hills & plateaus. The district consists of varied landforms like shallow flood palin, pediplain, moderate, deep and buried Pedi plain, pediments, pediments-inselberg, linear ridge, residual, denudation & structural hills.

3.1 Hydrogeology

The normal rainfall of the district is 702.2mm. The major rivers under Cauvery basin draining are Noyyal & Amaravathi. The Chinnar and Thenar rivers are the main tributaries of Amaravathi River which is the main source of irrigation in the district. Nallar & Palar Rivers come under Parambikulam-Aliyar river basin. Both Amaravathy & Thirumoorthy dams are the main source for irrigation whereas Uppar dam which receives water from seasonal rainfalls. Weathered and fractured crystalline rocks constitute the important aquifer systems. The ground water occurs mainly under water table conditions in the weathered mantle, joints and fractures. Ground water is developed mostly by deep bore wells & by open wells. Due to periodic monsoon failures the district frequently reels under drought conditions. Owing to depletion of ground water resources and deep decline of water table, farmers resort to deep bore well drilling. Generally ground water is suitable for domestic and irrigation purposes.

3.2 Structure and Tectonics

The ground water occurrence, movement and potential in hard rock terrain is controlled by geological structures like fault, shear, folds which are commonly referred as lineaments. Udumalpet taluk forms a highly tectonized belt and hence structures are complex. Pukkulam area is a tectonically disturbed and highly sheared. The general regional strike is north east- south west with a south east dip. Lineament analysis for ground water exploration has considerable importance as the joints and fractures serve as conduits for movement and storage of ground water. A major lineament extending from east of Pukkulam, passing through Pottayampalayam, Venasapatti, Poolankinar and Sadayagoundenpudur in the west. The trend of lineament is north north east- south south west with an extension of about 6 to 7 kms. A minor plunging anticlinal structure is also observed in the central part of village. The drag folds and folded structures indicate a highly tectonized belt. Presence of deep seated fractures below 200 m confirms that the area is highly sheared and shattered again reflecting the tectonic activity. The area of extent influenced by the major structural deformation is very intensive the district is endowed with 3 sets of lineaments criss crossing North east-south west, North West- south east & north-south directions. Dykes and intrusive are also noticed. The regional strike of foliation of the rocks varies from east north east [ENE] to west south west [WSW] through EW to WNW-ESE with moderate to steep dips on both sides indicating a number of anti-forms and synforms.

3.3 Lineaments

A lineament is a large scale feature express itself in terms of topography and an expression of underlying geological structural features which include fault zone, fracture [joint] zone, fold axes and linear igneous intrusion. Lineaments are often located by means of detailed study of geomorphological maps, aerial photographs and satellite imageries. The ground water potential and movement are governed by the geological structures like fault, shear zones / lineaments which play a vital role in the tectonically disturbed zones.

4 Electrical Resistivity Techniques- 1d Vertical Electrical Soundings [Ves]

Resistivity is a physical property of a substance which can be defined as the resistance offered by a unit length of a substance of unit area, to the flow of electric current governed by the Ohm's Law, R = V/ I. Resistivity is the inverse of conductivity. A series of measurement of resistivity are made by increasing the electrode spacing [AB/2] in a fixed point along a tract and this method of vertical exploration in known as resistivity sounding or 1D VES.
Resistivity system used is GEOMATIVE, GD-20 2D resistivity & IP imaging system, employing Schlumberger configuration with AB/2 separation=500m. Numbers of 1D VES carried- 5. The geoelectric data acquired are volt [V], current [I], Apparent resistivity [pa], apparent chargeability. Software packages used for interpretation of VES data are Inverse slope, Rinvert, Surfer & Voxler.
The primary geoelectric parameters computed are true resistivity & thickness. The secondary geoelectric parameters [Dar Zarrouk-DZ] computed are longitudinal conductance[S] and tranverse resistance [T] [8].

4.1 Electro Magnetic Exploration Techniques

4.1.1 Two Dimensional Audio Magneto Telluric Imaging

Magneto telluric (MT) is an electromagnetic geophysical method for inferring the earth's subsurface electrical conductivity from measurements of natural geomagnetic and geoelectric field variation at the Earth's surface. Combining magnetic and telluric methods gives you the magneto telluric method of exploring. It measures and compares the fluctuations of both the telluric currents and magnetic fields [5]. Basis of the magneto telluric theory are Maxwell's equations, the source of the magneto telluric fields is in the magnetosphere and ionosphere, separated by the nonconductive atmosphere [9]. Controlled-source EM (CSEM) is a low-impact, ground geophysical survey method used extensively in minerals, geothermal, and groundwater exploration and CSEM / CSAMT is useful for mapping the 20 to 1,000 meter depth range. Depth of investigation depends on the transmitted frequency and resistivity of the subsurface [10] In general, the lower the frequency and the higher the ground resistivity, the greater the depth of the data. More [10].

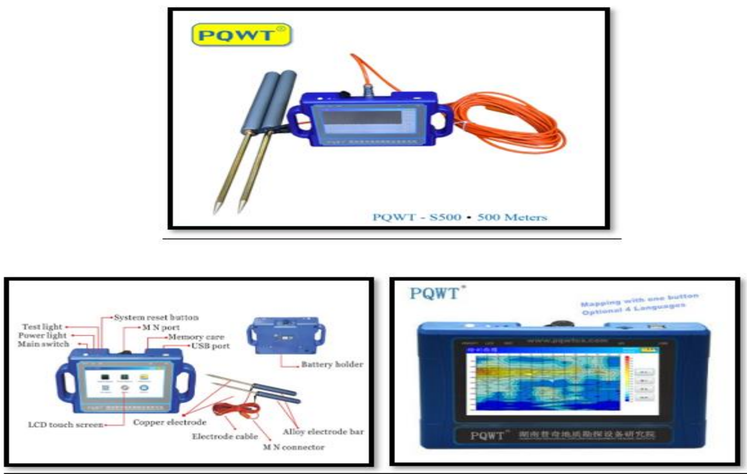
Vertical resolution of MT mainly depends on the frequency being measured, as lower frequencies have greater depths of penetration. Magnetic fields in the frequency range of 1 Hz to approximately 20 kHz are part of the audiomagnetotellurics (AMT) range. These are parallel to the Earth surface and move towards the Earth's centre. Depth of investigation depends on the transmitted frequency and resistivity of the subsurface. In general, the lower the frequency and the higher the ground resistivity, the greater the depth of the data. Because this method measures the electrical component of the electromagnetic field of the earth, so called natural electric field method. The Audio-magneto telluric (AMT) method uses natural electromagnetic (EM) fields to investigate the electrical conductivity structure of the earth. Energy for the natural source EM frequencies higher than about one hertz are generated by thunderstorms worldwide. The equipment uses earth"s natural current to measure different resistances of rock layers and transforms the parameters to voltage in milli volts (mV), producing anomaly [6].

4.1.2 Pqwt Geophysical Prospecting Instrument

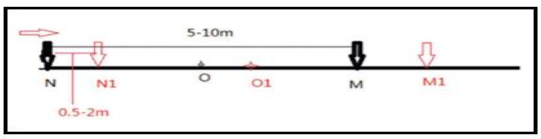
This equipment works on the principle of Audio Magneto Telluric [AMT} method. The prospecting technique is based on natural electrical field source which is influenced by resistivity contrast of underground rock, minerals and ground water. Without heavy power supply, it uses low frequency signals in earth natural electric field as signal source [7]. Equipment is automatically controlled by micro PC with a high resolution of measuring accuracy of 0.001 mili volt. Since it uses natural electric field source without any external source of heavy batteries, it is handy, tiny & portable [Figures-27-30]. Prospecting & profiling can be done more rapidly than conventional resistivity survey, which is time consuming & laborious. It has built in software to digitally process the data & 2D profile is directly displayed on the system. The data & 2D profiles are stored in the system and could be imported directly to computers. There are different models with different depth of investigation ranges.

4.1.3 Pqwt Tc-500 Model

This model [Figures-5, 6 & 7] is capable of investigating up to a depth of 500 meters below ground level [MBGL]. There are 3 main options of methods of frequency of profiling. 1. Single frequency, 2. Three frequency & 3.Multi frequency. In this research, multi frequency profiling is adopted where in data sets for 56 frequencies are recorded & stored as csv file format in Excel. For correlation purposes, profiling was carried out near existing bore wells i.e., both yielding and unyielding.



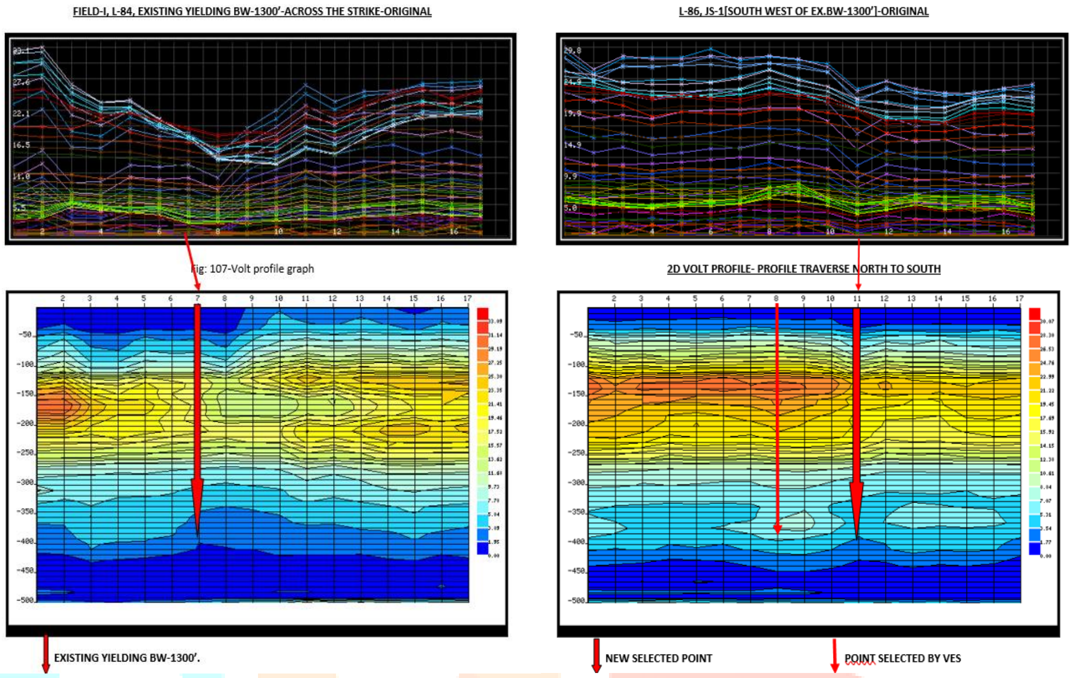
Figures-5,6 & 7.

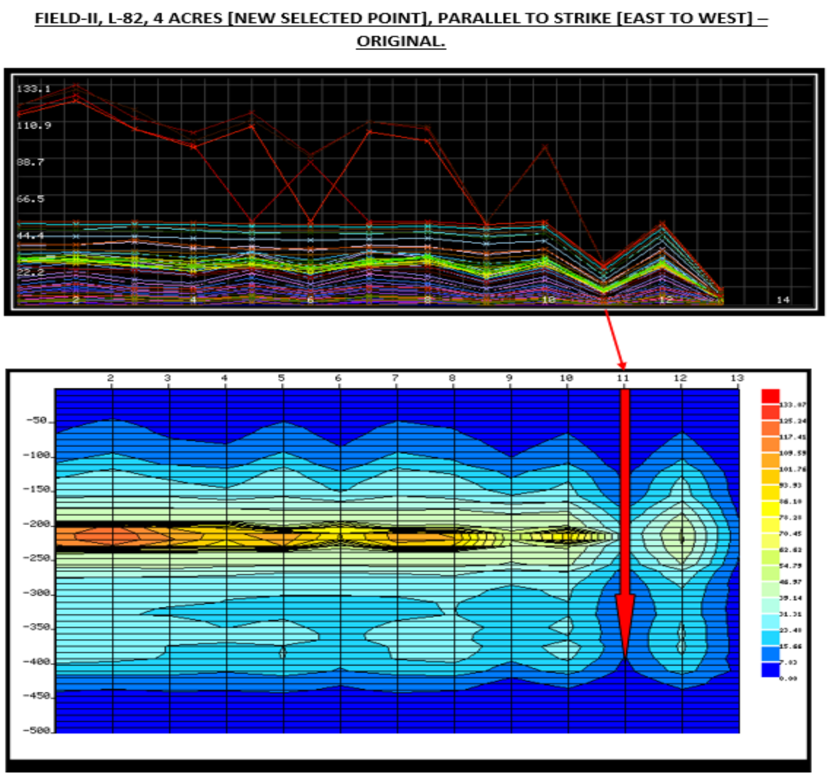


Figures 2. PQWT device and field set up

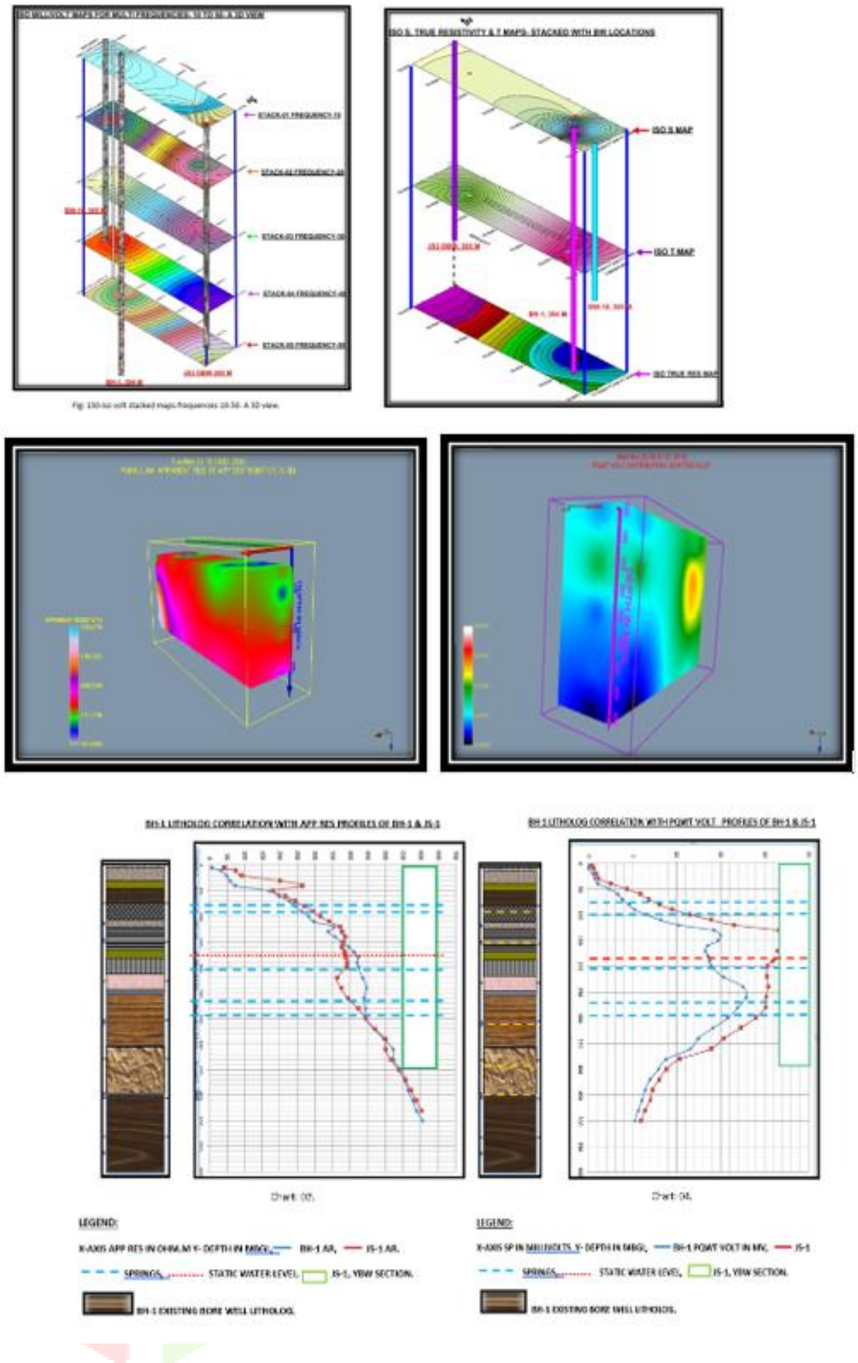
In the study area totally 07 multi frequency profiles have been conducted with standard 10m spacing of M-N electrodes and dot point spacing is 01 m interval.

4.1.4. Field-I, L-84, Existing Yielding Bw-1300’-Across the Strike-Original

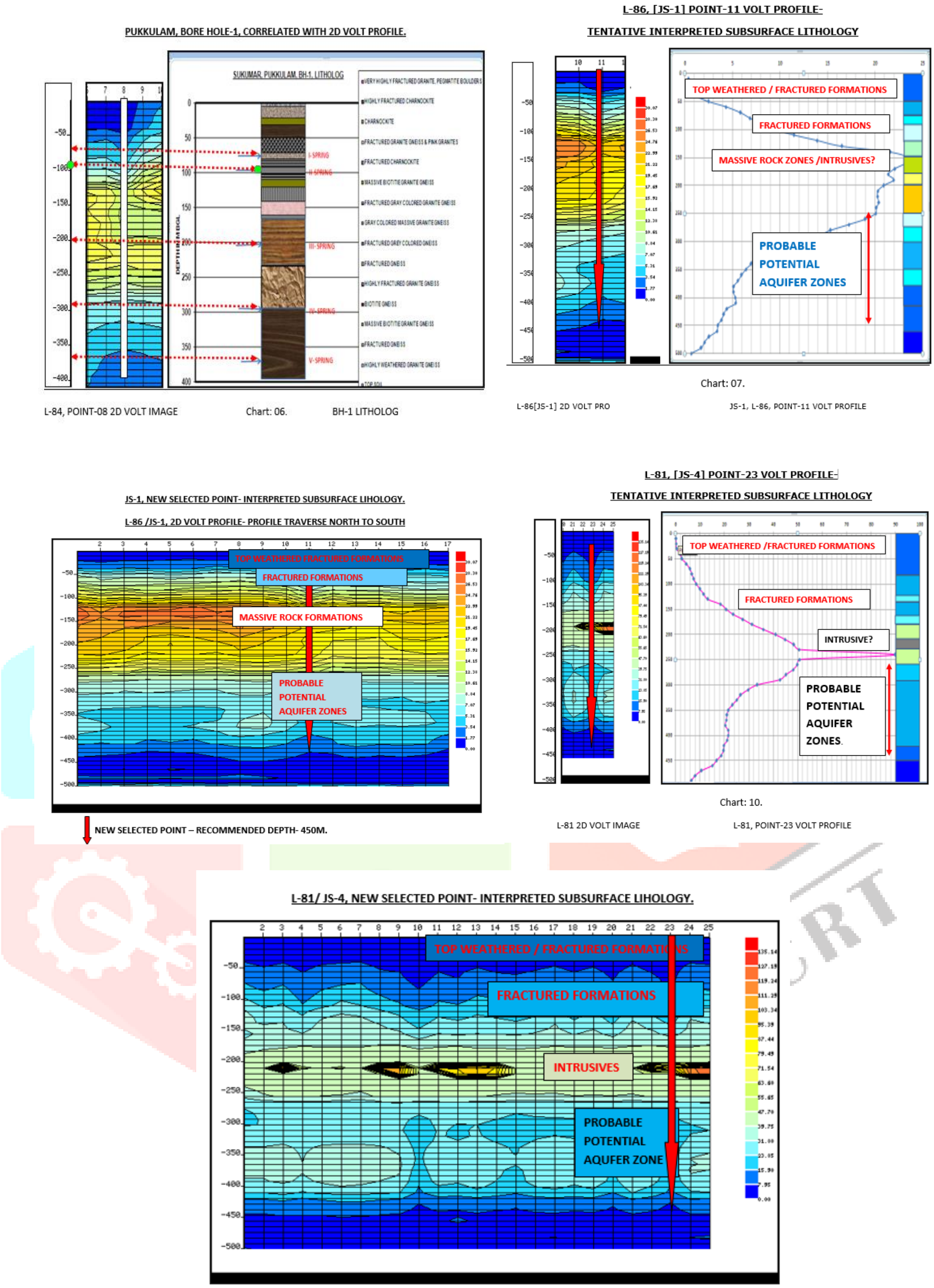




Figures 3. 2D image of subsurface



Figures 4. 12 to 17 2D and 3 D cross section



Figures 5. 18,19,20,21 & 22

5. Results and discussions

2D AMT Profiles: - The L-84 profile [Fig-9] near the existing borewell of 394m [1300'] is the 2D volt profile was run across the strike with 17 observation points with 1m dot spacing indicating a prominent low anomaly @ point 08. But the borewell located @ point 07 which almost coincides with the favorable feasible point. The fractured aquifer zone extends down to a depth of 400mbgl. The yield of the well is 270 lpm with maximum aquifer depth of 370m.

Profile L-86, JS-1 [Fig-10] was run south-west of this existing borewell is the 2D volt profile with 17 observation points with 1m dot spacing indicates a very prominent low volt anomaly @ point 11, but whereas the 1D VES results show a low resistivity anomaly zone @ point 8 which is 3m away from that of 11. As the point 11 reflected more prominent anomalies than 8, point 11 was selected to drill up to 450m.

Profile L-82 field-II [4acres field] [Fig-11] is the 2Dvolt profile with 13 points with 1m dot point spacing, exhibits a very dominant low volt anomaly @ point 11 with good aquifer zones of millivolts of 7 to 35mv, below 150m to 275mbgl. The mv values may be attributable to presence of deep seated pegmatite intrusions with good fractures.

Iso volt 3D stacked maps: [Fig-12]-is the volt contour maps for frequencies 10,20,30,40 & 50 stacked one over the other to get a 3D projection, all the contour maps reflecting a very prominent low millivolt anomaly in the extreme southern most parts of the area, where the potential well of 394m depth is located.

Iso volt 3D stacked map [fig-13] is the iso-S, iso-T and iso true resistivity maps stacked one over the other so as to give 3D projected view. The iso S & iso resistivity map exhibits very prominent low S & true resistivity zone at the southernmost ends reflecting encouraging potential aquifer zones. But whereas iso T map exhibits high transverse value which means high transmissivity value in the northern areas which may be attributable to deep seated pegmatite intrusive with potential yields.

3D resistivity image: [Fig-14]- This is the 3D apparent resistivity image-scatter plot projected by Voxler software. High resistivity anomaly is exhibited in the northern corner and low-moderate resistivity is dominant in the southern most sides indicating potential aquifer zones.

3D scatter plot: [Fig-15]- This is the 3D millivolt distribution by scatter plot projected by Voxler. Low mv anomalies are exhibited in the southernmost end at deeper depths indicating good fractured zones. Where as in northern sides moderate to high mv anomalies are dominant.

5.1 Correlating apparent resistivity & millivolts with lithology

[Fig-16]- This is the apparent resistivity profiles of existing borewell BH-1 394m with JS-1 correlated with lithology of BH-1. Both the profiles exhibit almost same trend and the spring encountered depths of BH-1 shown. Red dotted line is the static water level of BH-1. The JS-1 profile shows good resistivity breaks @ the depths of 50, 220 & 370mbgl indicating highly fractured formations. [Fig-17] is the correlation of millivolt profiles of existing borewell BH-1 with JS-1. Both the profiles follow the same trend but JS-1 mv values are slightly higher than BH-1. There is a good drop in mv values @ the depths of 150 & 210mbgl indicating good potential zone. The JS-1 profile shows a continuous declining trend below 350mbgl. Fig: 18 is the correlation of 2D volt profile with BH-1 liholog & spring details. Fig-19 is the tentative interpreted subsurface lithology. The probable potential aquifer zones fall below 250 mbgl up to 450m. [Figures: 20 & 21]- Fig-20 is the interpreted subsurface lithology of L-86/JS-1 which shows a good productive fractured zones below 270mbgl up to 450m. Fig-21, L-81, [JS-4] is the 2D volt profile of point-23 with interpreted subsurface lithology. 100 to 150 depth zone indicates fractured formations, 230-250m may be an intrusive zone with high mv values of 90-100 mv and below 250-430m indicating potential aquifer zones. Fig-22, L-81 is the 2D volt profile with 25 observation points with 1m dot point spacing. The selected point 23 is with good prominent low mv anomalies below 300-425mbgl which may be the potential aquifer zones.

6 Summary and conclusion

This Pukkulam zone is structurally disturbed with deep seated fractures. The occurrence & movement of ground water is controlled by geological structure- lineaments. Deep seated fracture systems, prominent pegmatite & pink granite intrusive, boulders & big cavities at very deeper depths of 200mbgl, indicate that the area might have been structurally disturbed, resulting in shattering & shearing of formations. Deep springs encountered and good yields of bore wells also confirm that this area is concealed with deep lineaments, which have been inferred by surface geophysical investigations. The south western area of field-I, i.e. JS-1-BH-1 zones are prospective with deep fractures. Since the bore well drilled @ JS-1 in field-I with a good yield of > 130lpm, based on the integrated 1D VES & 2D AMT geophysical investigations, point JS-4 [field-II] has been recommended to drill up to a depth of 450mbgl. Thus the integrated approach has paved way to do more such investigations and as the studies revealed satisfactory encouraging results this integrated techniques seems to be very much fruitful in the very deep aquifer mapping in drought prone crystalline rock terrains.

References

(1) Abdullah Abderahman- B.Sc. research Essay- magneto telluric deep into ground water exploration- Helwan University Faculty of Science Geology Department - 2019

(2) Badrinarayanan TS1, Mohd Abdul Kadhar Prabu2, and Inayathulla M3- An Integrated Geoelectrical Approach using 1D Technique to Explore the Deep Crystalline Rock Aquifers. Research and Reviews: Journal of Engineering and Technology.

(3) Badrinarayanan T.S-Integrating ancient Varahamihira's hydrological methods and geoelectric techniques for aquifer mapping in parts of Pollachi, Udumalpet taluks of Coimbatore & Tiruppur districts, Tamilnadu, India-An unpublished project report.Blog@ wordpress.com-http:// weatherbyenergy.com- Magnetic and Telluric application to locate fresh water dated 28-07-2017.

(4) Franjo Sumanowac, - Magnetotelluric Method in the Exploration of Deeper Aquifers-conference paper, Near surface Geoscience, 2012- 18th European Meeting of Environmental and Engineering Geophysics Paris, France, 3-5 September 2012- https://www.researchgate.net/publication/284182810.

(5) Okogbue, C.O.1, Ukpai.S.N, 1 University of Nigeria, Nsukka, 2 Ebonyi State University, Abakaliki- Exploration for Groundwater using integration of Aeromagnetic and Electromagnetic geophysical methods with Hydrogeologic Pumping Test in Uburu-Okposi Salt Lake Areas, Southeast Nigeria - IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 2 Ver. I (Mar. - Apr. 2016), PP 82-94 www.iosrjournals.org Operation manual TC-500-www.pqwtcs.com

(6) Ramanuja Chary K.R, Gangadhara Rao T- A Monograph on ground water exploration by resistivity, SP and well logging techniques- 2005, IGIS P Ltd, Hyderabad, India.

(7) Tran Trong Lap1, Chuandong Xue1, Aiying Wei1, Lv Liu1, Wenyao Li1, Qiquan Hu2, Jingjie Li2, Dafeng Luo2, Shaoyong Zhu2, Tiangui Zhang2- Application of Audio-Magnetotelluric Method for Exploration the Concealed Ore-Bodies in Yuele Lead-Zinc Ore Feild, Daguan County, NE Yunnan Province, China -Journal of Geoscience and Environment Protection, 2014, 2, 35-45 Published Online June 2014 in Scientific Research.

(8) V5 Geotech explorers, Chidambaram, unpublished Project report- Hydrogeological investigations & geophysical explorations in Mr.Sukumar’s Pukkulam farm, Udumalpet taluk, Tiruppur district. Zongae international- Controlled-source Electromagnetics (CSEM) and Audio-frequency Magnetotellurics (CSAMT).