Available Online at http://journalijcar.org

International Journal of Current Advanced Research
Vol 4, Issue 11, pp 465-468, November 2015

ISSN: 2319-6505

International Journal of Current Advanced Research

ISSN: 2319 - 6475

RESEARCH ARTICLE

ASSESSMENT OF GRANITE RESOURCES FROM BATHOLITHS AND DYKES USING 2D ERI TECHNIQUES - A CASE STUDY IN SALEM DISTRICT TAMILNADU

Venkateswaran S[1] Ifthikhar Ahmed M[2] and Balamadeswaran P[3]

[1,2]Department of Geology, Periyar University, Salem, Tamil Nadu
[3]Department of Mining Engineering, College of Engineering, Anna University, Guindy, Chennai-600 025, Tamil Nadu

A R T I C L E I N F O

Article History:

Received 9th September, 2015
Received in revised form 21st September, 2015
Accepted 10th October, 2015
Published online 16th November, 2015

Key words:

Granite Exploration, Electrical Resistivity Imaging of granite, demarcating granite in subsurface

A B S T R A C T

Electrical Resistivity Imaging technique is considered as one of the most important geophysical methods in mineral exploration to locate hidden mineral deposits or rock types that are conductive or resistive. Unlike conventional 1D, ERI not only takes vertical resistivity variation but also it takes into account horizontal variation in resistivity. ERI is an inexpensive method in comparison with the direct investigations such as exploratory drilling. In this research the ERI has been used to study the degree of weathering of granite and locate the fresh granite below the surface in order to know the depth of the fresh granite capable of producing blocks with desired size. The ERI investigation has been validated with the geological investigation in order to identify the suitable granite for commercial exploitation. The ERI investigation has revealed the factors such as the volume of the overburden, degree of occurrence of fractures with depth and the depth to fresh granite rock that affect the recovery of commercial granite. The information from ERI image provides a clear picture corresponding to the successful recovery of the granite blocks.

INTRODUCTION

Granite rock is characterized by the absence of all stratification of any indication of parallel joints; the rock is uniformly compact in all directions (Frederick Overman, 1863). It is of great hardness and strength, and of durability; it takes a fine polish. Being more resistant to wear and tear as well as weathering, granite is most sought-after stone to be used as construction aggregates as well as ornamental rock. The fascination for granite is due to its amenability for taking mirror-like polish, high compressive strength, longevity and aesthetics. Granite is formed of all shades and colours from a bright white to deep black. Granite's crushing strength varies between 160 and 240 MPA (F.G.Bell, 2007). It has exceptional weathering properties, and most granite is vitally indestructible under normal climatic conditions. Its use dates back to the dawn of civilization, and only buildings made of stone have survived from ancient times (L.Mead and G.S.Austin, 2006).There are examples of granite polished over 100 years ago on which the polish has not deteriorated to any significant extent. The maintenance cost of granite as compared with other rocks is very much less and in most cases, there is no maintenance cost at all for a considerable number of years. Commercial granites occur where masses of unweathered granite lie at or near the surface and are available within reasonable. Salem is one of the most important places that produce a wide variety of commercial granites, which are exported to foreign countries besides catering domestic markets. The granite industry plays a vital role in the economy of Tamilnadu state and India. There are more than ten varieties of granite which are internationally marketed from Salem district consistently for more than two decades. The typical commercial granite names include *Imperial white, Black of different generation (PTR Paithur Black), Tropical apricot, Coloneual Gold, Midnight Blue (YKD Blue), Samantha Pink, Rosa verda, Summer sky, Tropical Juparana, Incus Gold (Arasiramanipatti), Solar Juprana, etc.* Commercial names of granite are assigned after area, color, patterns or textures,etc (anandhi-MM2, 2009). The resistivity of the surface and sub surface layer varies from place to place depending upon the surface conditions of the area.(S .Venkateswaran, and P. Jayapal, 2006).They occur as stocks,batholiths,dikes,etc. There are two major types of granite in terms of colour/mineral composition. They are multi colored granite and black granite (Dolerite). Black granite is found in smaller amounts when compared with the Multi coloured granites. From a report published by IBM in Nagpur, the total resources of granite in Tamilnadu is 559435 thousand cubic meters as on 01.04.2010 and Exploration on Granite is still in progress.

Geological Setting

The study area, Salem district is located between latitudes from11^0 50' 0'' N to 11^0 20' 0''N and longitudes from 77^0 45' 0''E to 78^0 30' 0''E. It is bounded by Dharmapuri district in the north, Namakkal district in the east, and Erode district in the west. The railway junction lies at the heart of the study area.

Salem is well-known for its mineral resources, surrounded by hills. The rock formations of the district belong mainly to Archaean age along with rock formations of Proterozoic age. The rock formations include Granite of Proterozoic to Palaeozoic age, Charnockite of late Archaean age, Limestone of Archaean age, Carbonatite and alkaline rocks of Palaeo-Proterozoic age, Syenite, Quartz veins, Champion gneiss, Ultramafic intrusions and basic dykes. The crystalline rocks of the study area are believed to have derived from a complex evolutionary history during Archaean and Proterozoic times with multiple deformations, anatexis, intrusions and repeated metamorphic events (GSI, 2006).

METHODOLOGY

The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. From these measurements, the true resistivity of the subsurface can be estimated. The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock. Electrical resistivity surveys have been used for many decades in hydrogeological, mining and geotechnical investigations (V.S.Sharma, 2014). As structural defects such as joints, fractures influence the recovery of commercial granite in the subsurface, considering the economic importance of the granite, ERI investigation has been chosen to systematically study those joints and fractures. ERI can be efficient one to locate the occurrence of massive granite rock as the occurrence of fractures/joints produces considerable resistivity variations against the non-fissured fresh granite resistivity values and the ERI measures those variations in the resistivity distribution within the granite body.

Instrumentation

SSR-MP-ATS resistivity meter usually used for ID resistivity survey has been used for this 2D ERI data generated in the field. The ERI data obtanied by manually shifting electrodes in a straight line.

Fig 1 Resistivity Field survey in Arasiramani granite quarry

Resistivity Field Surveying

First of all, the profile area was selected in such a way that it should be across the trend of a granite exposure and it should have length greater than the width of the granite exposure. A constant electrode spacing was set up on the basis of the length of the profile area and width of the granite exposure in order to get ERI of maximum resolution. Mainly two electrode configurations such as Wenner and Wenner-Schlumberger were adapted in order to delineate multi-coloured granite batholith and dolerite dykes respectively.

ERI data collection was initiated and achieved by injecting direct current into the earth through one pair of electrodes (transmitting dipole or current electrodes) and measuring the resultant voltage potential (V) across another pair of electrodes (receiving dipole or potential electrodes). From the current (I) and Voltage (v) values, an apparent resistivity value (r_a) was calculated by the formula:

$$\rho_a = G\ V/I$$

Where

$\rho_a =$ apparent resistivity in ohm-m
G= geometric factor
v= volt
I=current

Here the geometric factor (G) depends on the electrode configuration. The resistivity meter used in this survey directly measured apparent resistivity values, which were the resistivities of a homogenous ground. True resistivities were obtained from inverting the apparent resistivity values through a program called RES2DINV (Loke M.H., 2004). The true resistivity values were used to make a 2D model through a least-squares inversion scheme for further interpretation. The ERI image was validated with the relevant surface investigation data and mine cuttings as the electrical resistivity values were not unique and different rock types would show the same resistivities.

ERI RESULT AND DISCUSSION

Six images were generated with help of resistivity field survey data and used to study the subsurface conditions of six quarries. The ERI profiles 1,2,3,4 are of 126m length and 3m electrode spacing. The remaining two ERI profile dimensions along with the electrode configurations have been given in the interpretation part itself. Locations and trends of ERI profiles have been compiled in the table.1

Table 1 Location and Trends of ERI Profiles

ERI reference no	Geographical co-ordinates		Profiling trends
1	N11^{0}30'03.87"	E77^{0}45'00.43"	N-S
2	N11^{0}33'45.44"	E77^{0}49'01.06"	N-S
3	11°25'58.9"N	78°30'18.9"E	N-S
4	N11^{0}32'38.26"	E77^{0}48'07.57"	N-S
5	N11^{0}49'29.15"	E78^{0}13'15.11"	N-S
6	N11^{0}33'43.35"	E77^{0}50'37.52"	NE-SW

Note ERI Ref.no 1– GEM Granite, Devannagoundanur, ERI Ref.no 2– GEM Granite, molamuniyapanpatty, ERI Ref.no 3– imperial Granite, Arasiramani, ERI Ref.no 4– GEM Granite, Devoor, ERI Ref.no 5 – Arunachalam Granite, Yercadu, ERI Ref.no 6– Tropical Granite, Thammampatty.

Profile 1 over granite batholith at Devannagoundanur quarry

The ERI survey of wenner configuration conducted over the granite terrain with soil cover identified the vertical variation of the granite rock body over the profile area. The profile length with the 3m electrode spacing was set up to 128m in order to reach 22.1m depth. The top soil, showing true resistivity values from 1 ohm-m to 150 0hm-m was demarcated at the upper portion of the ERI profile. The top soil with the thickness of 3m and 10m was identified at the extreme left and right side of the profile respectively. The electrodes positioned between 60m and 84m showed the fissured granite showing true resistivity values from 150 ohm-m to 2000ohm-m, extending downward up to 17m depth. The location of fresh granite was identified at shallow depth in the left side of the profile, starting at 5m depth and extending downwards up to the maximum depth of investigation, 22.1m. In this ERI profile it is seen that a thin layer of fissured granite separates fresh granite from the top soil cover.

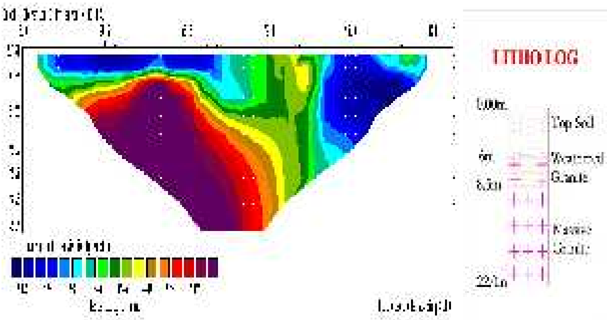

Fig 2 2D ERI showing the degree of weathering in a Batholith- active granite quarry at Devannogoundanur

Profile 2 over granite batholith at Molamuniappan pudhur quarry

The ERI survey conducted across the granite rock terrain indicated topsoil of resistivity values from 1ohm-m to 100 ohm-m covering the electrodes positioned between 44m to 112m, extending downward up to 6m depth. The variation in the resistivity values of top soil is due to the variation in moisture content. The ERI image shows fissured granite of nearly 2m to 2.5m thickness, starting at 6m just below these electrode positions (44m to 112m). Generally the weathered or fissured granite is shown at various depth ranges and the whole length of the profile is covered by the fissured granite rock. Its thickness varies from 3m to 8m throughout the profile. At the extreme right side of the profile, rigid soil with weathered granite is present with relatively high resistivity values. The fresh granite at relatively shallow depths, 8m to 10m is shown in most of the profile area.

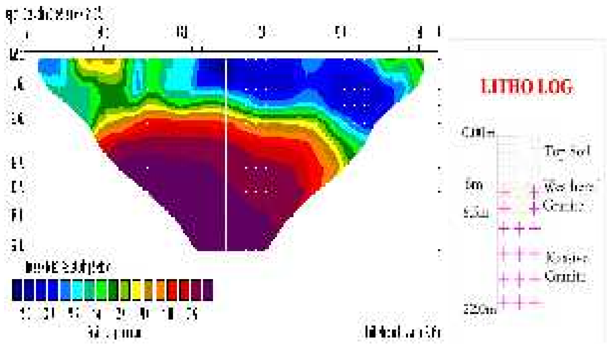

Fig 3 2D ERI showing the degree of weathering in a Batholith- active granite quarry at Molamuniappan pudhur

Profile 3 over granite batholith at Arasiramani quarry

The ERI survey of Wenner method of the total length of 128m with 3m electrode spacing conducted over the granite terrain reached 22.1m as the maximum depth of investigation. The ERI profile represents the weathered granite of resistivity values ranging from 100 ohm-m to 531ohm-m and of nearly 5m thickness at the extreme left side of the profile. The top soil cover is demarcated from 20m electrode mark to 96m mark, showing resistivity ranges from 1 to 100 ohm-m. There is a thin layer of weathered granite at 44m mark to 84m mark. There is a gradual increase in the thickness of fissured granite towards right side of the profile. The minimum and maximum thickness of the fissured granite is measured as 2.5m and 10m respectively. The minimum and maximum resistivity values of fissured granite through out the profile are 100 ohm-m to 2000 ohm-m respectively.

The ERI investigation reveals that the fresh granite is found at 10m depth just below the fissured granite and is present at relatively shallow depth at the right side of the profile. The fresh granite shows the greater resistivity ranges from 2000 ohm-m to greater than 15100 ohm-m.

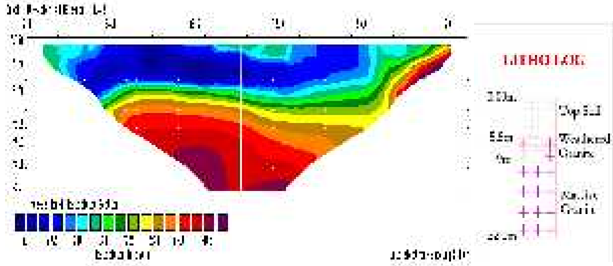

Fig 4 2D ERI showing the degree of weathering in a Batholith- active granite quarry at Arasiramani

Profile 4 over granite batholith at Devoor quarry

The ERI survey conducted over the granite rock terrain indicated highly fissured and slightly fissured granite, showing resistivity values ranging from 100 ohm-m to 10000 ohm-m covering the whole profile both horizontally and vertically. The considerable variation in resistivity values of the fissured granite is due to moisture content, degree of weathering, and mineralogical composition. The high degree of weathering is shown at the extreme left and right side of the profile and at the electrode positions between 48m and 64m. The average thickness of the highly weathered part is 2m. Massive granite is located at 5m depth. The upper part of the massive granite is covered by the electrodes positioned between 42m and 76m and it diagonally extends down towards left side of the profile. The massive granite of lenticular shape is immediately underlain by the fissured granite at the electrode position between 48m and 64m. But the lenticular shape is surrounded by relatively highly altered granite on all sides, extending up to the depth of 22.1m. From the ERI investigation it is apparent that the fresh granite is not found in most part of the profile but fissured granite is found in most of the profile area.

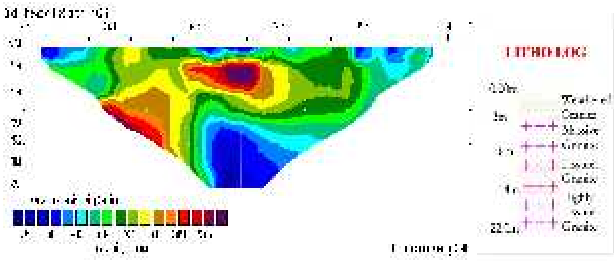

Fig 5 2D ERI showing high degree of weathering/fissuring in a Batholith- active aggregate granite quarry at Devoor.

Profile 5 over dolerite dyke at Yercaud quarry

The Wenner ERI survey of 105m length with 5m electrode spacing conducted over the dolerite rock body with a thin skin of soil layer reached 17.3m as the maximum depth of investigation. The ERI shows that the fissured dolerite is found at 1.25m depth, covering almost the whole length of the profile with the resistivity values ranging from 100 ohm-m to 2500 ohm-m. The thickness of the fissured dolerite is measured as 5.5m in the most part of the profile. Dolerite with the resistivity values range from 2500 ohm-m to greater than 4772 ohm-m is encountered at the extreme right side of the profile, extending up to the maximum depth of the investigation.

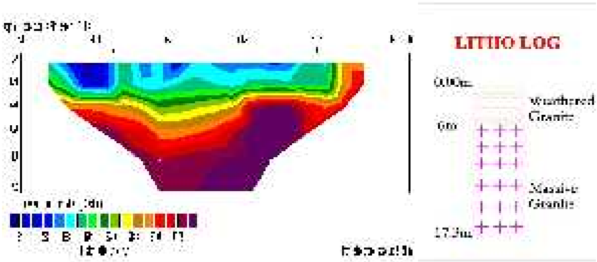

Fig.6 2D ERI showing the degree of weathering in a Dyke - active Dolerite quarry at Yercaud

Profile 6 over dolerite dyke at Thammampatty quarry

The Electrical Resistivity Imaging (ERI) survey of 168m length with 4m electrode spacing was conducted across the trend of dolerite exposure by the Wenner-Schlumberger configuration in order to demarcate dolerite dyke from the surrounding rock of different lithology as well as horizontal formations. The ERI investigation reached up to 34.5m depth. The ERI profile shows the top soil of nearly 4.5 m thickness with true resistivity ranges between 1 to 300 ohm-meters. Higher resistivity in soil layer may be due to compactness and/or the presence of air filled voids and the lower resistivity may be due to water saturation. At 96m mark, an intrusion is found at 5m depth just below the top soil cover. The near-surface intrusion is confirmed to be dolerite from the observation of surface exposures in the form of boulders. The outer part of the intrusion shows moderate weathering and the degree of weathering decreases with depth. Fresh dolerite with true resistivity values ranging from 1962 ohm-m to above is located at nearly 25m depth. The highest resistivity values represent the presence of relatively massive dolerite that is low in moisture. The 2D ERI was validated with the adjacent mine cuttings and the field observation data.

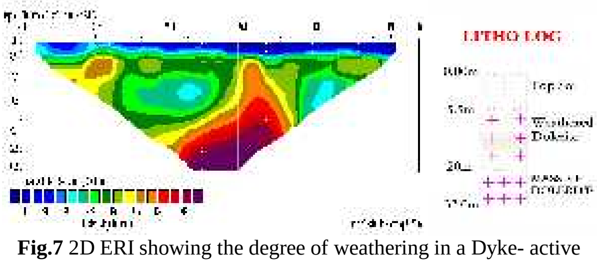

Fig.7 2D ERI showing the degree of weathering in a Dyke- active dolerite quarry at Thammampatty

CONCLUSION

Wenner's and Schlumberger's electrode configuration resistivity survey have been successfully employed over the granite batholith and dolerite dykes to understand the different litho-units. The depth information on the occurrence of fresh granite resulting from six ERI images is to be compiled and shows fresh granite rocks encountered at 5m, 8m, 10m, 5.5m, and 25m depths respectively below the surface. The profile 4 is showing fresh granite at 5 m depth as a small lenticular body. As massive granite rock portion is not found within the profile dimensions, this site is not suitable for producing dimensional blocks with preferred dimensions and can be used for extracting construction aggregates. All ERI profiles except for profile 4 show the fresh and massive granite at depths ranging from nearly 5m to 25m. Hence it is concluded that all the five ERI profile sites are considered as suitable for commercial exploitation of the granites and be commercially quarried up to 40m depth. The results are derived from the investigation is validated in the field as well as running quarirries. Eventually, the 2D ERI technique has proved as cost effective, fast, and reliable in support of new granite quarrying project by delineating massive granite in the subsurface.

References

1. Anandhi-MM2-(2009) -Policy (2009). displayed by the Government.
2. Bell, F.G. (2007). Engineering Geology. Elsevier Ltd, USA, P. 277.
3. Frederick Overman, (1963). Practical Mineralogy, assaying and mining with a description of the useful minerals and instructions for assaying and mining according to the simplest methods (sixth edition), Lindsay and Blackiston.
4. Geological Survey of India. (2006). Geology and Mineral Resources of the states of India: Part VI – Tamil Nadu and Pondicherry.
5. Indian Bureau of Mines, (2015). Indian Minerals Yearbook 2013, IBM, Nagpur.
6. Loke, M.H, (2004). Tutorial: 2-D and 3-D Electrical Imaging Surveys. Website:http://geoelectrical.com.
7. Mead, L. and Austin, G.S. (2006). Industrial minerals and rocks (Dimension Stone), p.907.
8. Sharma, V.S. (2014). Electrical Resistivity (ER), Self Potential (SP), Induced Polarisation (IP), Spectral Induced Polarisation (SIP) and Electrical Resistivity Tomography (ERT) prospection in NGRI for the past 50 years-A Brief Review.
9. Venkateswaran, S and Jayapal, P. (2013). Geoelectrical Schlumberger Investigation for Characterizing the Hydrogeological Conditions Using GIS (IJITEE) ISSN: 2278-3075, Volume-3

****