IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 6, Issue 5 Ver. I (Sep. – Oct. 2018), PP 01-04
www.iosrjournals.org

Demarcation of Faults and Fracture Zones from Very Low Frequency-EM Studies

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Abstract: *The Very Low Frequency-EM method is helpful to identify the different geological formations, faults and fractures depending upon their variable conductive properties. The study area Putluru and Yellanur mandals in Ananthapur district, AP mainly covered with Tadipatri shales and few sills and dyke intrusions are present in these shales. Real and Imaginary component plots and Real component pseudo sections up to depth of 60m clearly demarcated the tectonically disturbed zones from the undisturbed areas. Several faults and fractures are identified from these VLF studies which are highly conductive. The evidence of sill intrusions are inferred from high resistive zones in the medium resistive zones of Tadipatri shales.*

Keywords: *Tadipatri shales, Conductive zones, Sill intrusions, faults and fractures*

Date of Submission: 01-09-2018 Date of acceptance: 17-09-2018

I. Introduction

The present study area Yellanur and Putlur mandals are located in Ananthapur District of Andhra Pradesh, geologically comprised of Tadipatri Shales and few sills and dyke intrusions (King, 1872, Nagaraja Rao et al., 1987). In 2007 there was gas leakage from few irrigation borewells in Vengannapalle, Goparajupalle and Komatikuntla of these mandals (Sreedhar Murthy, 2007, 2012, Rajagopal, 2007). To know the causes for this incident few geophysical studies were carried out and present paper contains the VLF-EM studies. VLF-EM frequencies are high, so this method is useful for shallow depth investigations about 100 m (Fischer et al. 1983, Lazarus, 2013). In this present case this method is used to demarcate the fault and fracture zones, sill intrusions which might be the cause for gas leakage from the irrigation borewells.

II. VLF-EM Data Acquisition

To identify the tectonically disturbed zones in the study area there are four traverses (T1-T4) were carried out perpendicular to the major Fault which is in NW-SE direction in the study area (Figure 1). To cover all the borewells, four traverses are laid in NNE-SSW trending, with station interval of 25m, each length is about 4km and traverse interval is about 1km.

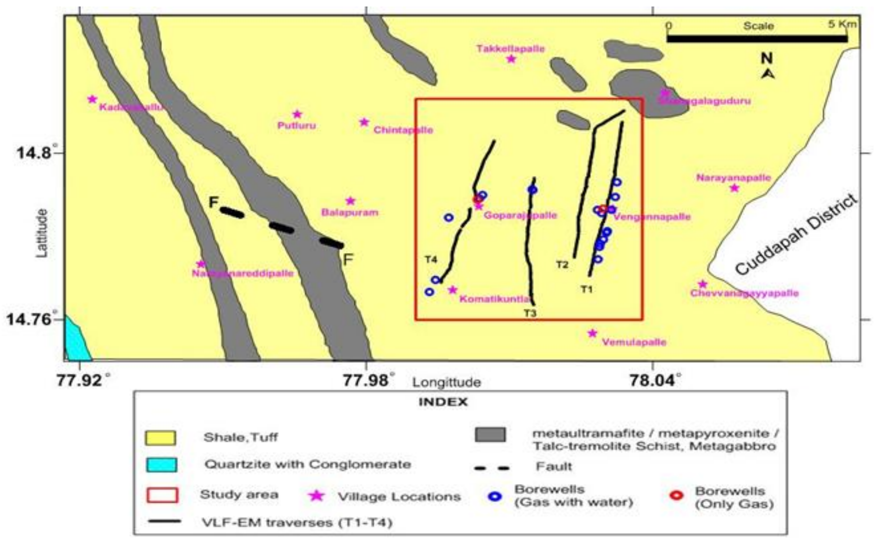

Figure 1 Geology map of the study area along with VLF-EM Layout and borewell locations. (GSI,2001)

III. Qualitative Analysis

The measured raw real and imaginary components were subjected to Fraser filter to suppress noise and enhance signal. Fraser filtered data again was subjected to Karous-Hjelt filter and modeled to obtain apparent current density pseudo section up to 60m depth along all the traverses T1-T4, using Ramag VLF modelling Software (Karous and Hjelt, 1977; Kaikkonen, 1979; Saydam, 1981).

3.1 Real and Imaginary Component plots and Psuedo Sections

i) Traverse - T1

This traverse passes from Vemulapalle to Shanagalaguduru and is 3960m long. The positive real and imaginary components cross over points, indicate the fault/fractures (F) which shows in this figure (Figure 2(a)). The maximum positive amplitudes of real components indicate the conductive zones and low negative values indicate resistive zones.

The Karous-Hjelt apparent current density real component Psuedo section (Figure 2 (b)) shows that this traverse is tectonically highly disturbed. This section is a measure of the conductivity of the subsurface as a function of depth. The high current density zone /high conductive zones are identified as fractures / faults, shown in red colour, medium conductive bodies as Tadipatri shales in green and low conductive/ high resistive bodies as sills in blue colour.

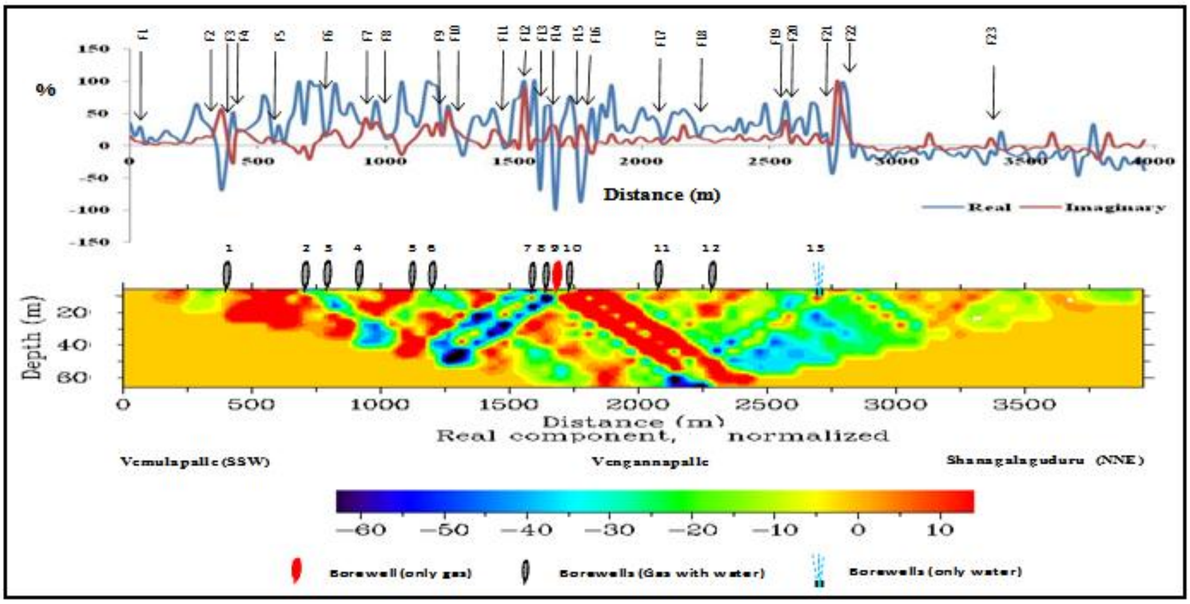

Figure 2(a) The Fraser filtered data of real and imaginary components plots and (b) the Karous-Hjelt apparent current density real component psuedo section along the Traverse - T1.

There are thirteen irrigation borewells are located along this traverse and among these the 11 borewells are emanating gas with water, one (Borewell-9) is leaking only gas are situated over/near high conductive faults/fracture zones which are near to high resistive sill segments. The borewell-13 is producing only water where there is no appreciable fault/fractures are noticed.

ii) Traverse-T2

This traverse passes west side of Traverse -T1, which is 4km long. Only few faults/ fractures are noticed in the real and imaginary components plots (Figure 3 (a)). The real component Psuedo section (Figure 3 (b)) shows that this traverse is less disturbed. The high conductive zones which are noticed in this section may be local fractures. Because of this reason there is no gas leakage from the two borewells present in this zone.

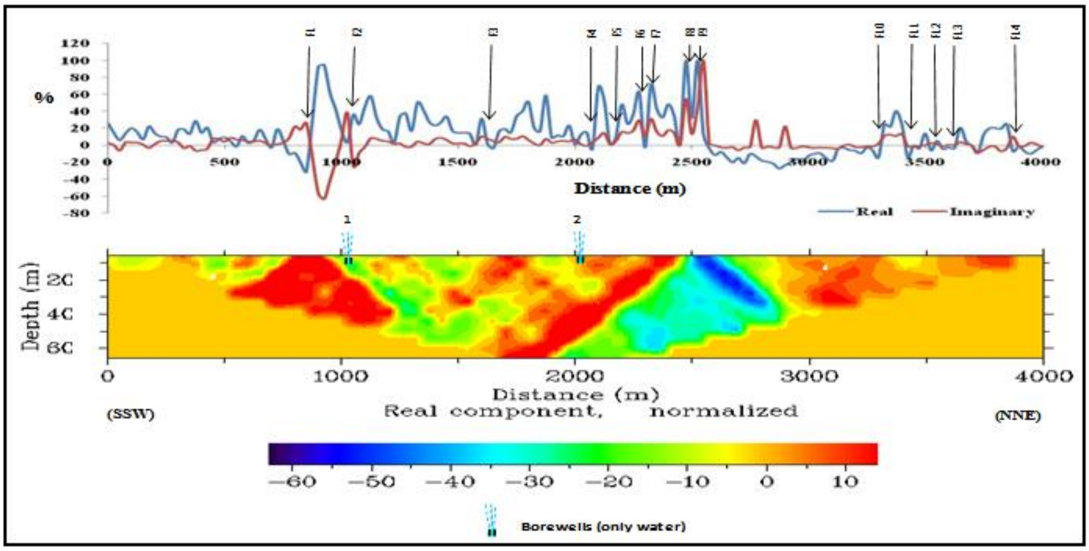

Figure 3 (a) The Fraser filtered data of real and imaginary components plots and (b) The Karous-Hjelt apparent current density psuedo section of the real component along the Traverse-T2.

iii) Traverse - T3

This traverse passes west side of Traverse -T2, which is 3.2km long. Both the real and imaginary components plots (Figure 4 (a)) and Pseudo section (Figure 4 (b)) showing that this traverse is also less disturbed as Traverse -T2. There are eight borewells present in this traverse producing only water except two borewells-7&8 which are emanating gas with water. There is no clear evidence of fault/fractures and sills in the Pseudo section (Figure 4 (b)) but in the real component plot (Figure 4 (a)) it is clearly shows positive and negative anomalies. These anomalies which it self indicate the presence of conductive fault/fractures and high resistive sill segments, may be cause for gas leakage.

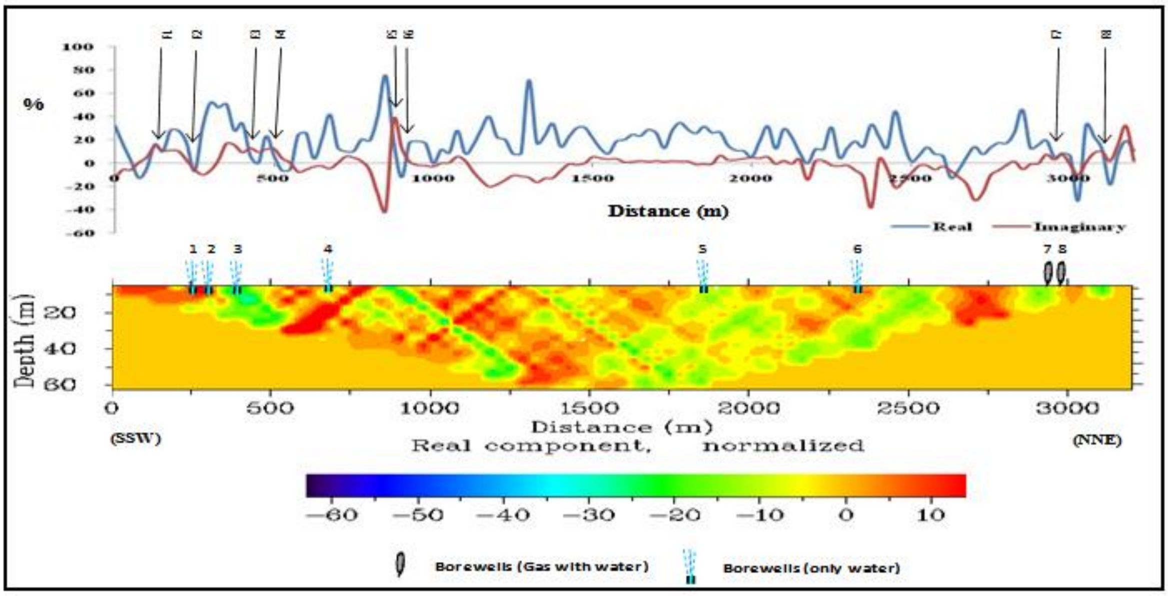

Figure 4 (a) The Fraser filtered data of real and imaginary components plots and (b) Karous-Hjelt apparent current density psuedo section of the real component along the Traverse -T3.

iv) Traverse-T4

This traverse passes from Komatikuntla through Goparajupalle and further and is 3800m long. Both the real and imaginary components plots (Figure 5 (a)) and Pseudo section (Figure 5 (b)) showing that this traverse is also highly disturbed as Traverse –T1.

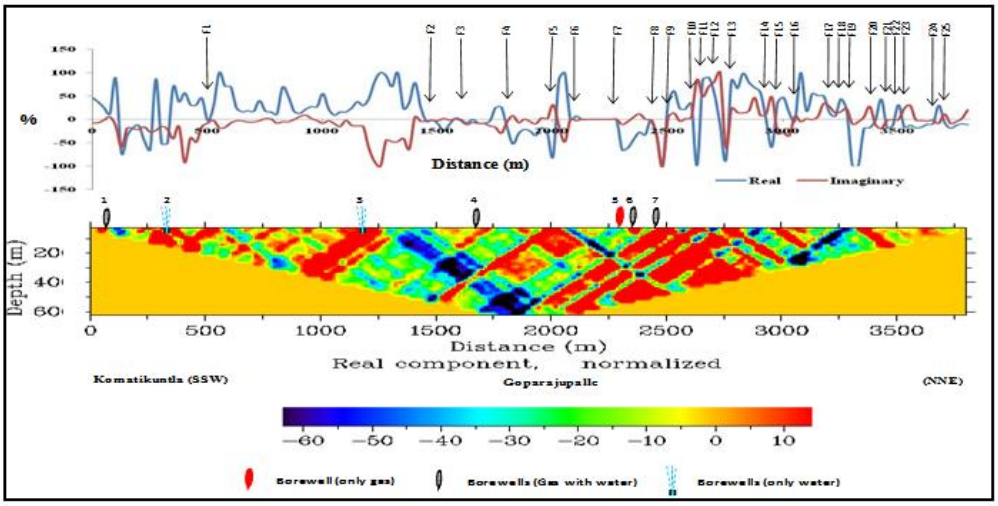

Figure 5 (a) The Fraser filtered data of real and imaginary components plots and (b) Karous-Hjelt apparent current density Psuedo section of the real component along the Traverse -T4.

There are seven irrigation borewells are located along this traverse and borewell-1 is located at the starting point of the traverse. The two borewells-2&3 are producing only water situated on the local fractures and the real component plot also show only one fault/fracture upto 1500m. From the 1500m there are multiple fractures are present at the locations of the borewells-4,6&7 which are emanating gas with water and borewell-5 which is leaking only gas.

IV. Conclusions

From the Figures 2 to 5, it is clear that the traverses- 1 and 4 are highly disturbed. Because of faults, the sills might be broken and resulted into few sill segments identified as high resistive bodies, shown in blue colour. Multiple fractures are also identified in these two sections (Fig.2 and 5) which are high conductive zones. The gas emanating borewells located over or near to these multiple fractures which are source for upward migrating of gas. Traverses-2 and 3 (Fig.3 and 4) are clearly shown that these zones are less disturbed and there is no appreciable sill segments and fractures are identified in these zones.

Acknowledgements

One of the author (First) is highly acknowledged to the UGC (New Delhi) for awarding UGC (RFSMS) fellowship and Prof and Head, Department of Geophysics, Osmania University, Hyderabad, India, for providing the facilities in the department.

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M. Preeti " Demarcation of Faults and Fracture Zones from Very Low Frequency-EM Studies.." IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) 6.5 (2018): 01-04.