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Geological, Geo-electrical resistivity and Geochemical studies on gem tracts inparts of Eastern Ghats, Visakhapatnam District, Andhra Pradesh, India

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ABSTRACT

The occurrence of gemminerals is a rare phenomenon and in the same way the geological information, geophysical and geochemical information are also very rare.

Visakhapatnam District of Andhra Pradesh state in India, located in parts of Eastern Ghats comprising valuable mineral resources especially gemminerals. The precious and semi-precious stones of Alexandrite, Chrysoberyl, Chrysoberylcat's eye, Garnets, Tourmaline, Sillimanite and a variety of quartz group are known to occur in this region. The gemstones are very much engulfed within the pegmatite both in primary and secondary stages.

The geological studies on exploration, mining and environmental planning have shown very promising results, where the gem mineral resources were estimated to a depth of 15 mts. from the surface. Geoelectrical resistivity surveys have been utilized and the results are favorable and correlated with the surface geological features.

The geo-chemical investigation carried out for the hostrocks and the associated gem-variety stones and analyzed for their major and minor elemental concentrations. Geochemical analysis of the petrological members of gem bearing tracts of the region was carried out by ICP-MS and elemental concentrations were determined. A few of the samples were processed for XRD analysis.

The following important points are noted in (i) Invaluable gem minerals are found in association with the Khondalite suite of rocks, as per their geochemical evaluation. (ii) The secondary pegmatitic body indicated all the mineralogical characteristics of the primary pegmaties in a deeply altered stage (iii) The colluvium forms as the target of explanation for the gem minerals in this region. (iv) The study shows that the element fluorine is endangerous to the local rural people, which may result fluorosis in parts of the this region.

Keywords: gem tracts, pegmatites, colluvium.

1. Introduction

Visakhapatnam District of Andhra Pradesh State, India [Fig.1] forms an important segment of Eastern Ghats Mobile Belt (EGMB) comprising valuable mineral resources of apatite, bauxite, graphite, clays, feldspars, silica minerals, decorative rock types, calcite, dolomite and placer minerals.

Invaluable gem minerals (gemstone) resources viz., alexandrite, chrysoberyl cat's eye and many semi-precious minerals have been found to occur in parts of Visakhapatnam District through pegmatitic intrusive bodies along the Khondalitic and Leptynitic gneissose bands.

Gemstones have been identified in parts of Eastern Ghats, Visakhapatnam District, Andhra Pradesh by using only geological parameters so far. But, by using both geological and geo-electrical resistivity surveys have comprehensive geo-scientific interpretation of lateral and subsurface nature of gemtracts. Geochemical evaluation of the gemstones and the associated host rocks is of utmost importance to investigate the gemstone deposit.

Pegmatite is the important lithological member of the Eastern ghat terrains has been studied in detail for the gemstone occurrences, where all the precious and semiprecious stones are being found from this rock and its colluvium. The pegmatite along with quartz veins have been found to be intervened with basic and ultra basic rocks and hosted along with the gneissose bands of Khondalite and Leptynite.

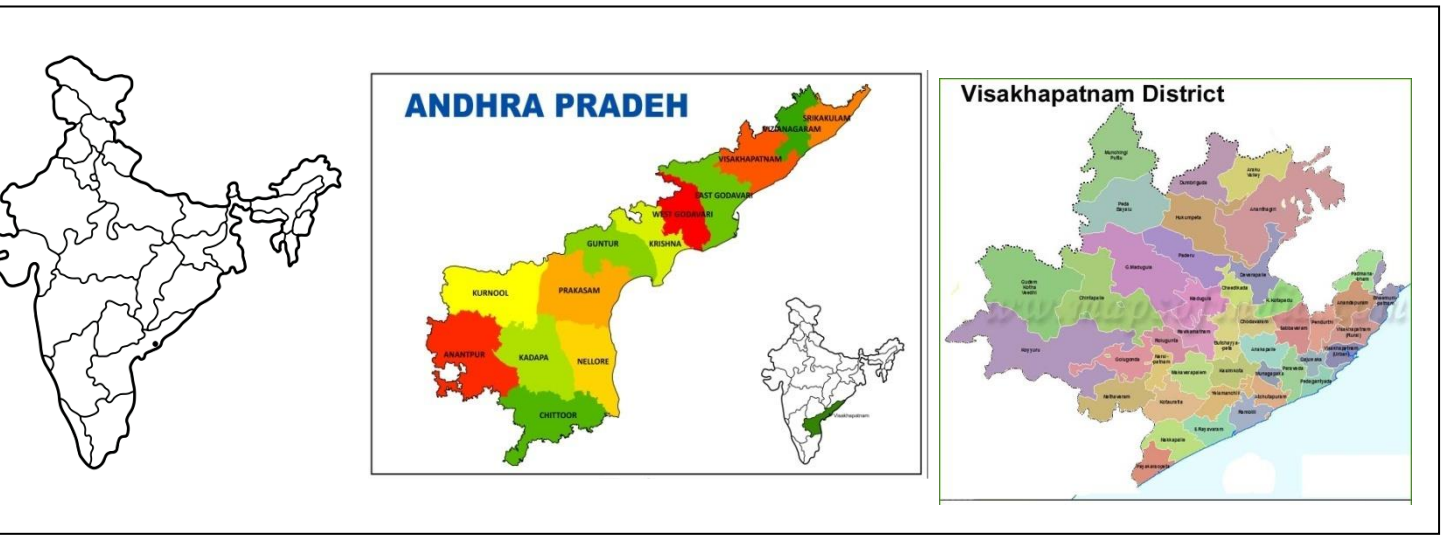


Fig .1 Visakhapatnam District, Andhra Pradesh State, India

2. The Study Area:

The study area Visakhapatnam is a fast developing industrial city of South India and it is well connected from many important parts of India. The study area lies between $82^0$00' to $83^0$30' E longitude and $17^0$30' to $18^0$30' N Latitude [Fig-2].

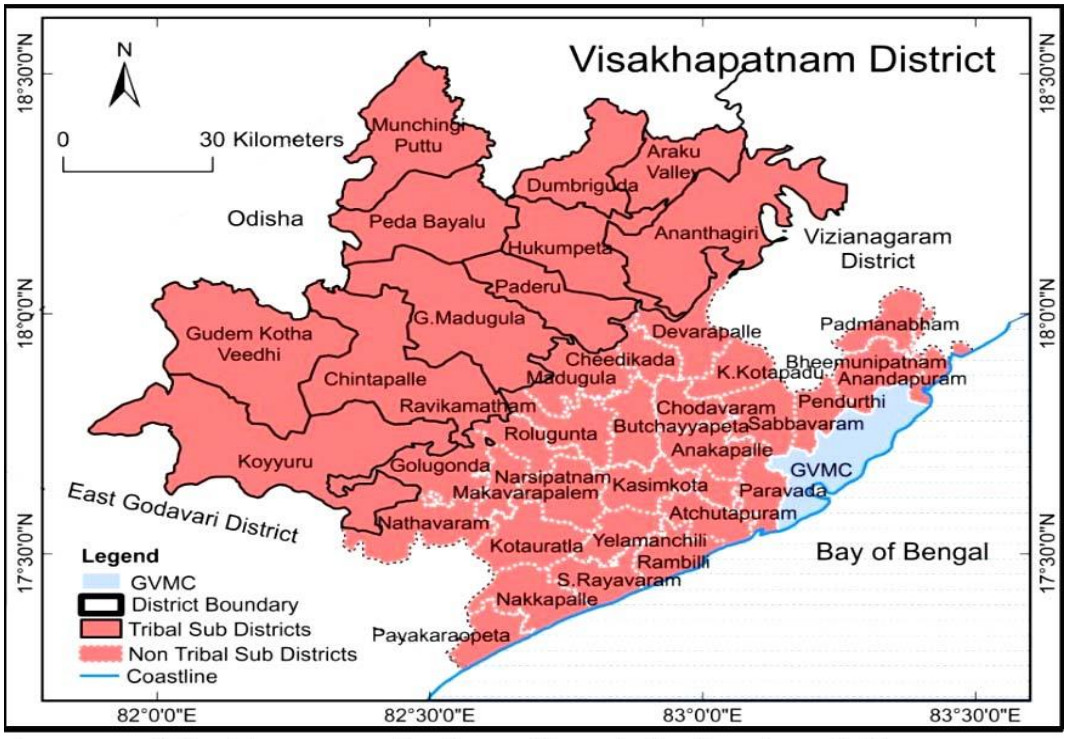


Fig.2 Location Map of Study Area

The study area is a part and parcel of Eastern Ghat Mobile Belt (EGMB) dominated by quartzo – feldspathic–garnet – micaceous – sillimanite $\pm$ graphite – gneiss and schist (Khondalite, as per Indian geological nomenclature), which generally results in reddish soils are found in this area. The area of study are located NW of Visakhapatnam city. The area has warm temperate climate with a temperature range from 18^0C to 48^0C representing winter and summer seasons. The average rainfall records at 1050-1120 mm per annum. The area generally receives cyclone resulted rains during June to October season and located close to the coastal line (Bay of Bengal).

3. Geology and Field Relations

Geology of Eastern Ghats is quite interesting and highly complex too; Pioneering work of this region was carried out by Oldham – Cf. Krishnan (1943), Blanford – Cf. Krishnan (1943), Ball (1889), King (1880), Holland (1900), Walker (1902), Fermor (1936), the recent work in this century include Perraju (1982), Venkatesh (1982) Sriramadas (1957), Krishna Rao et al (1982), Murthy (1994) and others. The contributions by Geological Survey of India, and some Indian Universities viz., Andhra, Osmania, Sri Venkateswara, Utkal, Calcutta, Jadavpur and Baroda are very significant.

Krishnan (1943) defined the Eastern Ghats as a series of rather detatched hill ranges of heterogeneous composition which stretch intermittently along the northern borders of Orissa through the coastal regions of Andhra Pradesh to join Nilgiris in the Western part of Chennai. He also envisaged that possibly a part of the Eastern Ghats in the Krishna District, Andhra Pradesh extended into the Bay of Bengal to continue further into Ceylon (Srilanka). The generalized sequence of the lithology of Eastern Ghats is as follows:

	Soil and alluvium	
	Pegmatite and quartz veins	
Post-Tectonic Intrusion	Alkaline plutons and carbonatites	
	Mafic/ultramafic intrusions-dunite, banded pyroxenite, anorthosite, spinel-meta gabbro enclosing chrome-ore bodies	
	---------- Intrusive contact ----------	
Eastern Ghats Super-Group	Migmatite group:	Migmatites, garnetiferous, granites, gneisses and leptynites
	Charnockite Group:	Acid, intermediate charnockites, pyroxene granulites, meta anorthosites (layered) and eclogites
	Khondalite Group:	Garnet-sillimanite-potash feldspar (graphite)gneisses, garnetiferous quartzites, cordierite-gneisses, magnetite-quartz-hypersthene-garnet rocks, calc-silicate rocks, marbles etc.
	Basement not recognisable	

(Modified after Murthy (1971), Narayana Swami (1975), Kasipathi (1980), Perraju (1982), Venkatesh, 1984)

The Eastern Ghat rock types host several economic minerals (Kasipathi et al 1990, Ramam and Murthy 1997) which are (i) Iron ore (Magnetite) deposits (ii) Manganese Ore deposits (iii) Graphite lenses (iv) Chromite (v) Bauxite deposits (vi) Beryl and beryl – Wolframite – Columbite – Tantalite association with Pegmatites etc. In addition to these resources, beach sands (comprising ilmenite, magnetite, rutile, monazite, garnet, zircon and sillimanite, gemstones, copper sulphides, molybdenite and wolframite are noticed (Venkatesh, 1984; Kasipathi et al 1990). Geology of Eastern Ghats shown in [Fig.3.1, 3.2, 3.3].

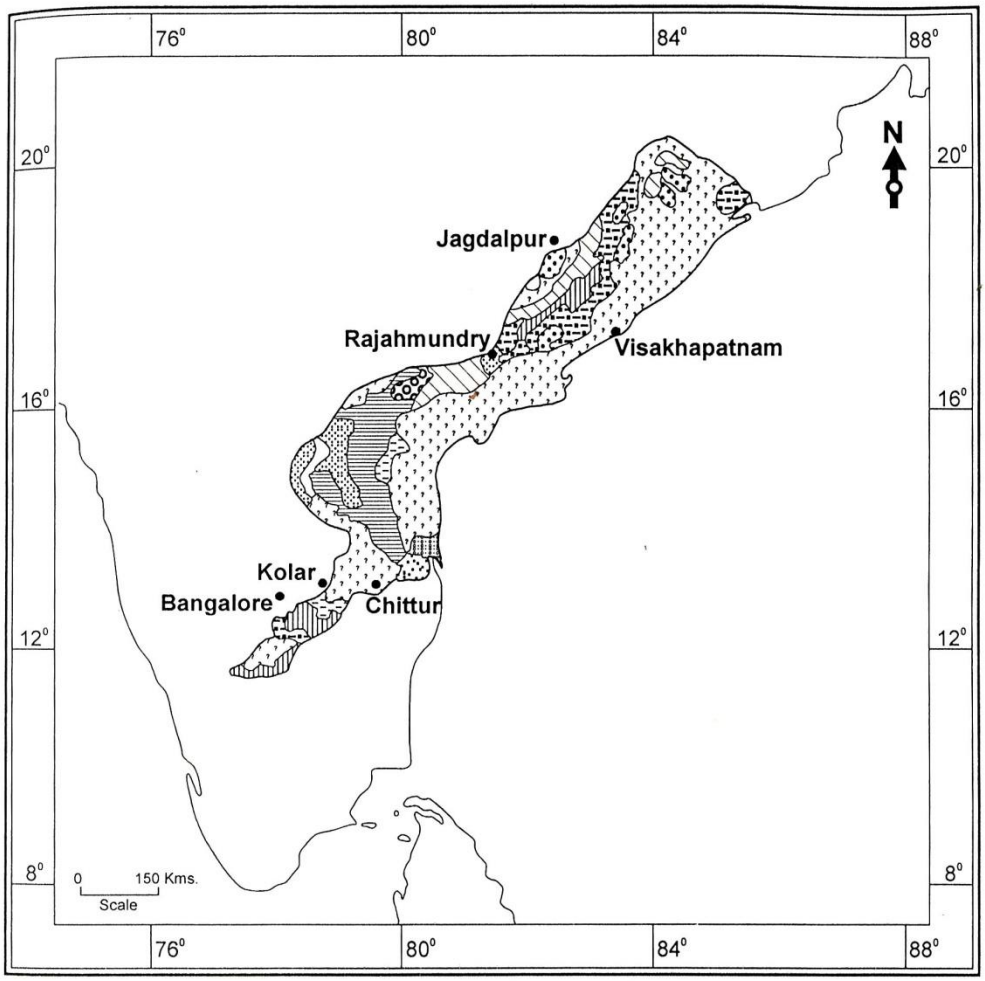
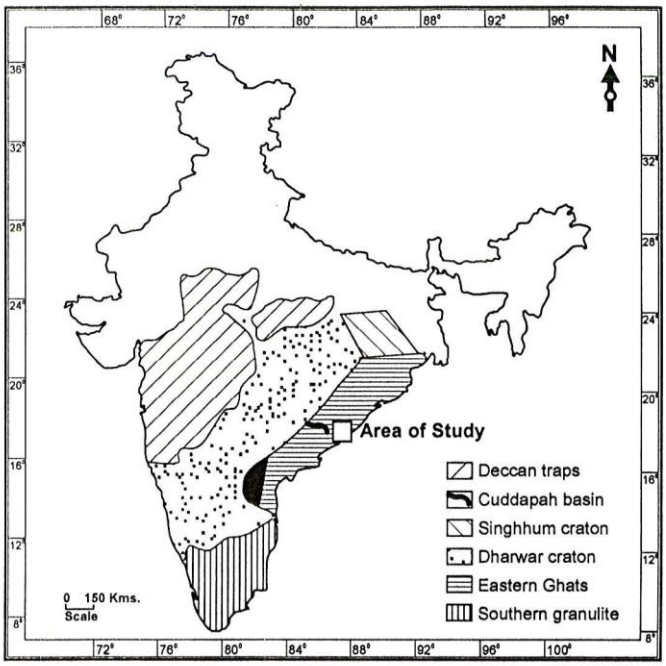


Fig.3.1 : Regional Geology of Eastern Ghats showing Petrological Units
(After Dr. C. Kasipathi, 1980)

Slate	Khondalites	Sand Stone
Lime Stone	Meta basic & Ultra basic Rocks	Recent Alluvium
Schists	Granite, Granodiorite & Pegmatite	Laterite Unclassified
Charnockites	Quartzite	Crystalline Rocks



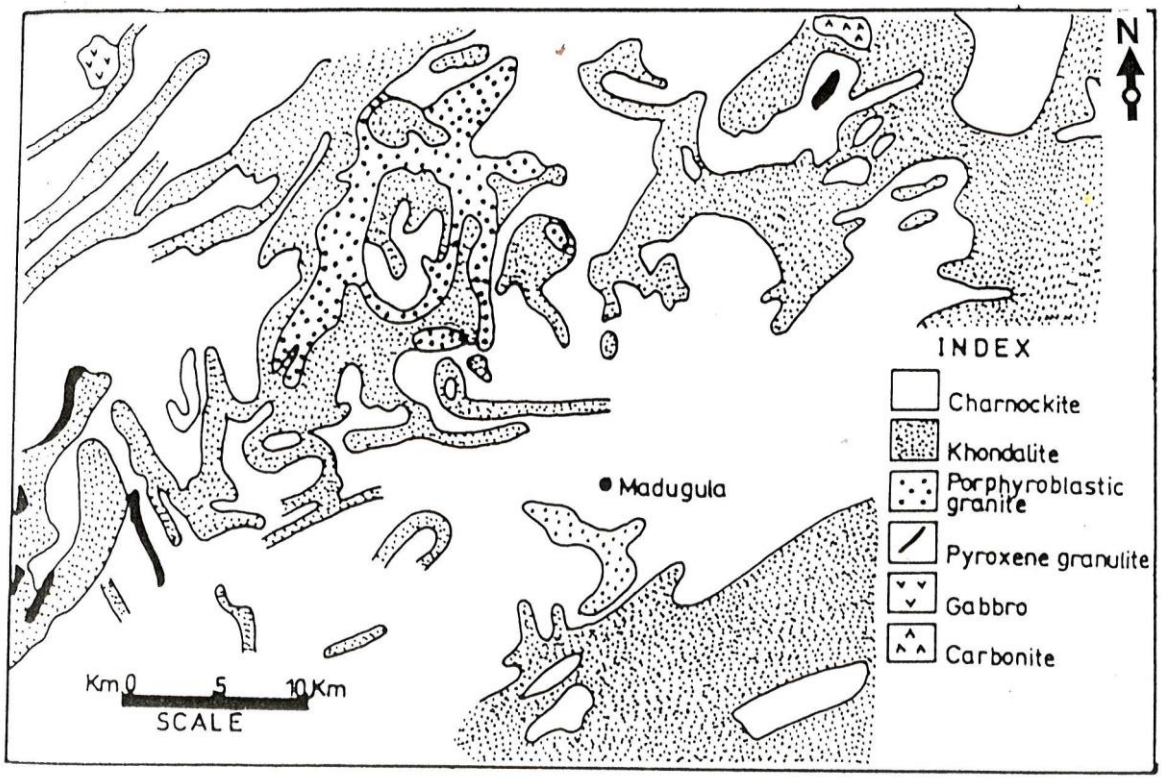


Fig. 3.2 . GEOLOGICAL SKETCH MAP OF PARTS OF THE EASTERN GHATS MOBILE BELT, VISAKHAPATNAM DISTRICT, ANDHRA PRADESH (After Ramam & Murty, 1997)

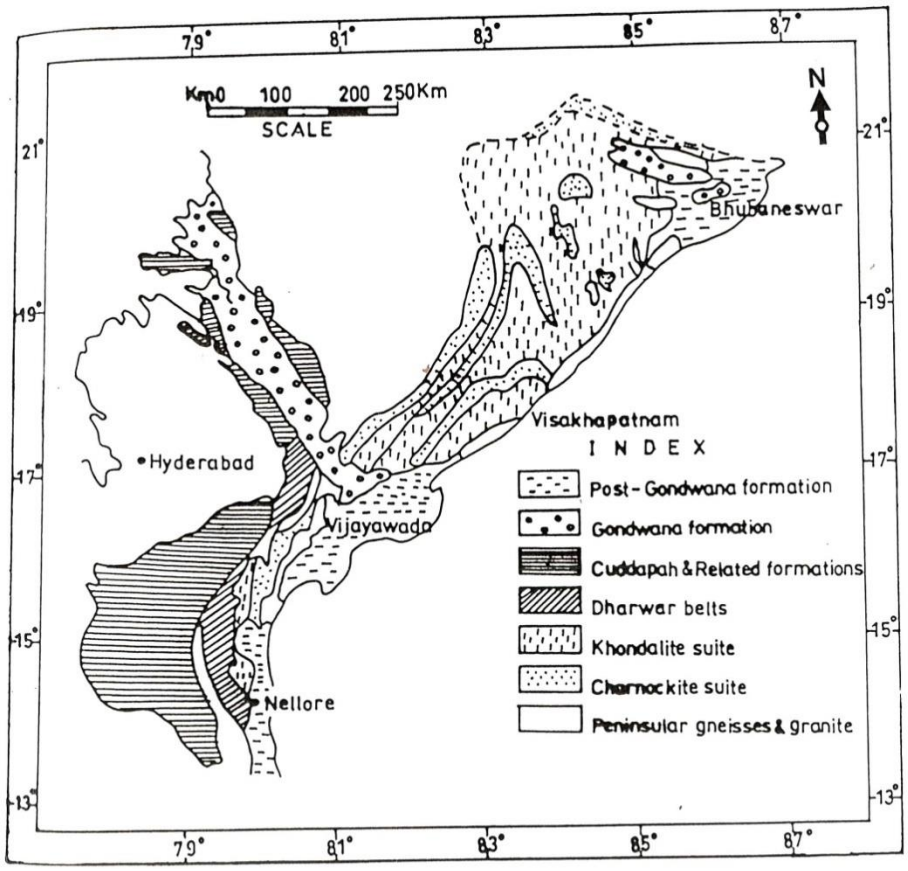


Fig.3.3 GEOLOGICAL MAP OF CHARNOCKITE – KHONDALITE SUITES OF EASTERN GHATS, ANDHRA PRADESH (After Narayana Swami 1975)

Based on the structure and field relations of the rock type in Visakhapatnam region, the following stratigraphy is established.

Pegmatites	:	Garnet-biotite-sillimanite-chrysoberyl-Moonstone bearing pegmatites
Granites	:	Pink granites
Younger charnockites	:	Garnet-biotite-hypersthene-granodioritic Gneiss
Younger basic intrusions	:	Pyroxene granulites, garnet pyroxene, pyroxene granulites
Old charnockites	:	Hypersthene bearing tonalites
Old basic intrusions and leptynites	:	Hornblende-pyroxene granulites and garnetiferous granites
Khondalites:		
Metasediments	:	Pelitic:
		Garnet-sillimanite gneiss Garnet-sillimanite-biotitegneiss Garnet-sillimanite-magnetite-spinel gneiss Garnet-sillimanite-magnetite-biotite gneiss
		Psammitic: Quartzite, garnet-sillimanite-quartzite
		Calcareous: Calc-granulites
---------- ? ---------- ? ---------- ? ----------		
Basement	:	Granite gneisses, garnetiferous granites, porphyritic grantie gneiss

The villages in Visakhapatnam District viz., Asakapalli, Gunnempudi, K.Vallapuram and Karaka of the study area have been identified as potential zones by the presence of number of gem bearing pegmatitic veins and by the presence of adjoining colluvial plains.

The geological field relations, the nature of pegmatites, various stages of exploration carried out including laboratory investigations and sampling undertaken confirmed the occurrence of worthy gem mineral resources from all these villages of the study area. (Fig.3.4)

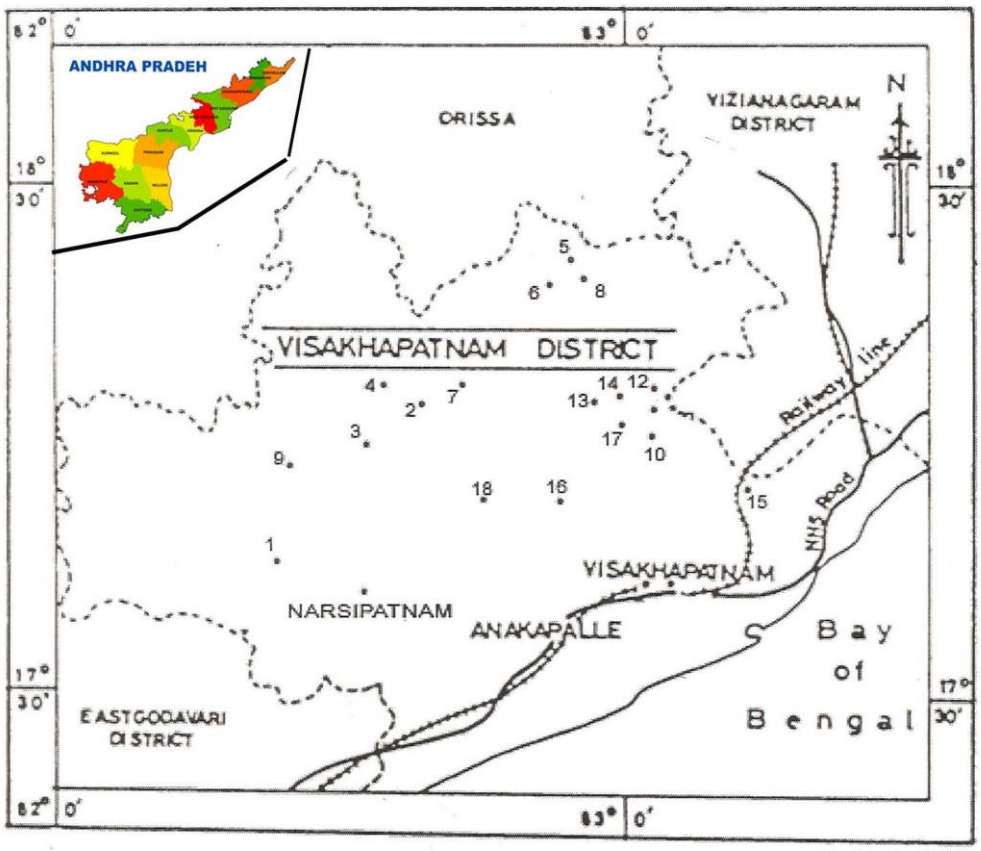


FIG. 3.4 Location of gem stone occurences in parts of Visakhapatnam District, Andhra Pradesh, India.

1. Karaka	2. Paderu	3. Busupalli	4. Andravara
5. Araku	6. Turaiguda	7. Chintalaveedhi	8. Ravvalaguda
9. Lothugedda	10. Chintapaka	11. Pedda Madina	12. Chinna Madina
13. K. Vallapuram	14. Turakalapudi	15. Asakapalli	16. Rolugunta
17. Gunnempudi	18. Pittagedda		

4. Geo – Electrical Resistivity Studies:

The geo electrical survey by geophysical exploration is an effective method in the location of quartz bearing reef / dyke like bodies, petroleum structures, ground water investigations and civil engineering projects. In geologically complicated areas and in areas where only a uniform soil cover exists without any outcrops or other indications, the geo electrical investigation is the only tool available to locate the areas of potential zones. In the study, Schlumberger configuration of electrodes has been adopted which is widely used for quantitative interpretation of layers in Vertical Electrical Soundings (VES).

Two electrode arrays of Wenner (1916) and Schlumberger (1920) have been widely used and both the arrays consist of four electrodes [Fig.4.1] The outer two electrodes (current electrodes) are used to energise the sub surface, and the inner two electrodes (potential electrodes) are used to measure the potential difference. In Wenner array, all the four electrodes are equally spaced while in Schlumberger array, the distance between the potential electrodes is always maintained to be less than one fifth of the current electrode separation.

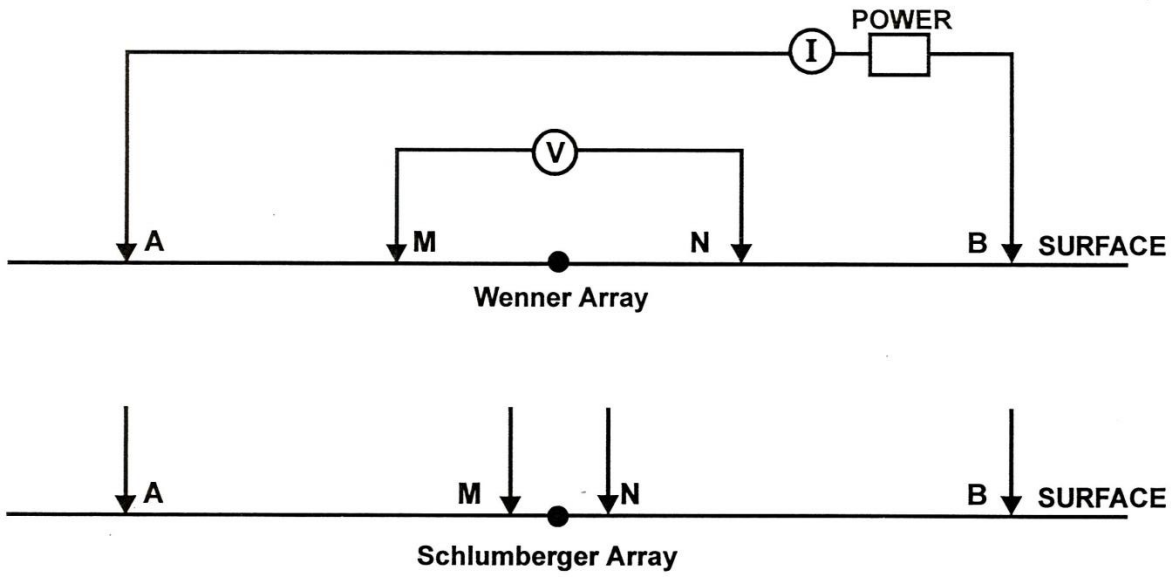


Fig. 4.1 : Diagram of Wenner and Schlumberger Arrays

Schlumberger (1920) defined the resistivity interms of the electric field E, rather than the potential differences ΔV (as in the Wenner). The apparent resistivity is calculated by using the equation $\rho_a = \pi \left(\frac{AB}{2}\right)^2 \frac{E}{I}$.

Where $E = \underset{MN \to 0}{Lt} \frac{\Delta V}{MN}$ = Electric field.

provided that AB $\geq$ 5MN (Deppermann, 1954)

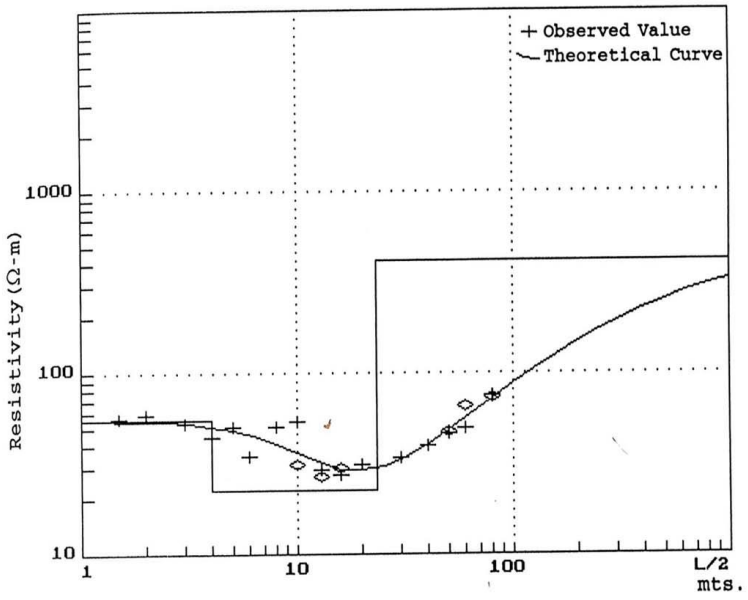
A series of measurements of resistivity are made by increasing the electrode spacing in successive steps about a fixed point. This method of vertical exploration is known as the expanding electrode method, resistivity sounding, depth probing or Vertical Electrical Sounding (VES).

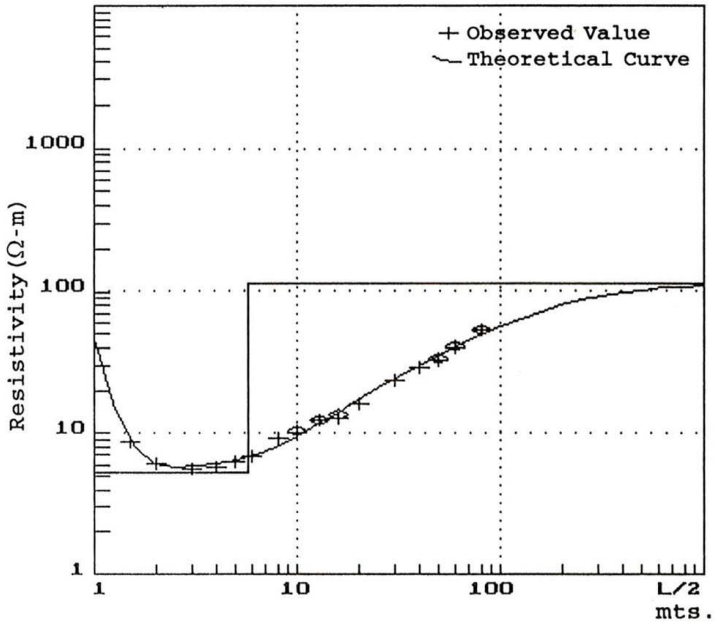
In Schlumberger arrangement of VES, the electrodes M and N are kept fixed, but the electrodes A and B are moved further away on either side i.e., increasing the internal 'a' i.e., (AB/2) in successive steps and

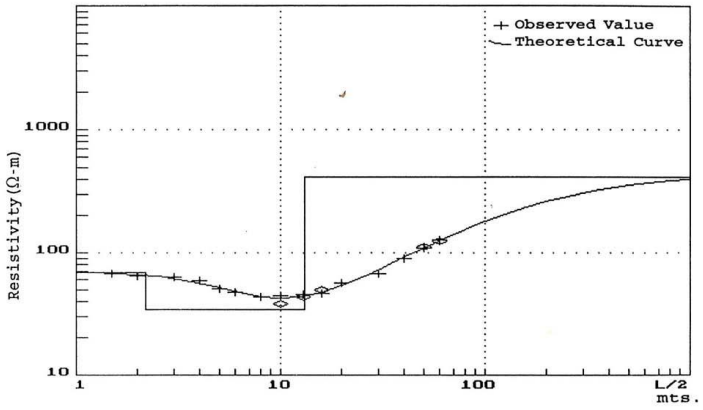
obtaining the resistivity values for a series of such increases for one setting of MN with interval of 'b'. The apparent resistivity values are plotted against AB/2.

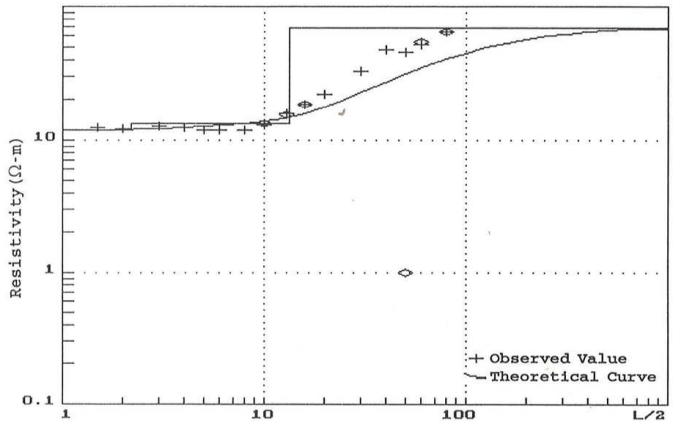
One hundred twelve (112) geo-electrical resistivity Vertical Electrical Soundings (VES) were made in the study area. A few model curves drawn from the VES date are also presented in [fig. 4.2(i), (ii)]. The model curves are processed using the software on Schlumberger and Wenner analysis. The software is the version 2 and serial No.1632 developed by Charistian J. Hemkar (1988) in Turbo Pascal Programming language after Van Dam (1965). Hemkar utilized the article of O.Koefoed (1979) on Geo-Sounding Principles in the development of software. The software is applicable to both Wenner and Schlumberger geo–electrical data analysis. This software is utilized to construct a best-fit model of the sub surface by giving suitable values of layers thickness and true resistivites obtained after manual curve matching technique.

Fig.4.2 (i) Resistivity Model Curves









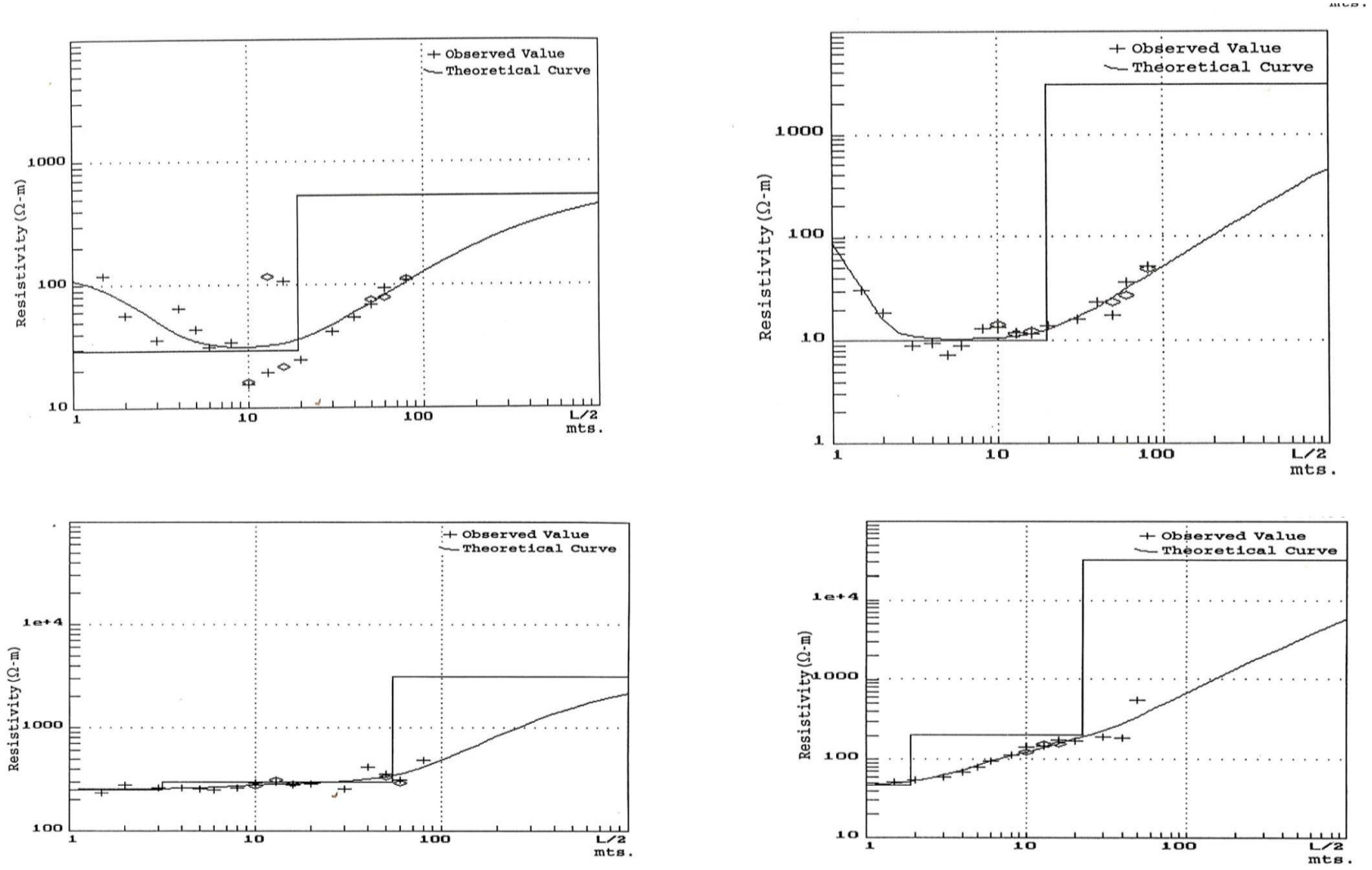


Fig.4.2 (ii) Resistivity Model Curves

5. Geochemical Studies:

The study area is a part and parcel of Eastern Ghat Mobile Belt comprising mainly two important groups of rocks known as Khondalite and Charnockite groups. Precious and semiprecious stones such as Alexandrite, Chrysoberyl, Chrysoberyl Cat's eye, Zircon, Tourmaline, Garnet and many varieties of silica group minerals have been reported from the pegmatitic lithological members of Eastern Ghats formations.

Geo chemical evaluation of the gemstones and the associated host rocks is of utmost importance to investigate the gemstone deposit. The rock samples collected from the area of study were studied under microscope and analysed under customary analytical system. The gem mineral samples were studied in gemological laboratories of Jaipur, Mumbai, Andhra University, Visakhapatnam. Some of the samples selected from the gem-bearing localities were analysed by X-Ray diffraction study (XRD analysis). XRD study is a versatile, non-destructive technique that reveals detailed information about the chemical composition and crystallographic structure of natural and manufactured materials. Some of the selected samples were tested in ICP-MS (Inductively Coupled Plasma Mass Spectrometry) which has the capability to scan for all elements simultaneously. This allows rapid sample processing.

6. Results and Discussions:

The study area is in parts of Eastern ghats, Visakhapatnam district comprises Kohndalite, Charnockite, Pyroxene Granulite, Leptynite, Granite, Carbonitite and Pegmatite. The Khondalite group comprises garnet – biotite – graphite–sillimanite–quartz–feldspar gneisses, quartzites and calc–granulites. The Charnockites are mostly confined to the axes of overturned isoclinal synclines exhibited by Khondalites. The Charnockites occasionally show stock like intrusive relationship with garnet – biotite granites (Vijaya Kumar, 1983). The Pyroxene granulites occur as sills and dykes. Leptynites occupy the plains as bands. Granite consists of acid pegmatitic and pink varieties – Migmatitic impress is common in both Khondalite and Charnockites. Khondalites represent pelitic, pegmatitic and calcareous varieties of metasedimentals (Perraju, 1982).

The Petrological members identified in the study area are

(1) Quartzo-feldspathic–garnetiferous–sillimanite–micaceous $\pm$ graphite greiss (Khondalite)

(2) Porphyritic quartz - feldspar – mica – tourmaline – phologopite hosting gem-mineral resources (Pegmatite)

(3) Gravel composed soil (Colluvium).

The geological field relations, the nature of pegmatites, various stages of exploration carried out including laboratory investigations and sampling undertaken confirmed the occurrence of worthy gem mineral resources from this area of study. The estimates of the gem mineral resources in the different areas are presented in [Table 6.1].

Table 6.1

Estimation of gem mineral resources in different gemtracts of Visakhapatnam district, Andhra Pradesh

In tonnes

Area	Chrysobryl And Chrysobryl cat's eye	Alexandrite	Garnet	Moonstone
*Asakapalli	2.95	-	4.53	8.69
Pappusettipalem	815.00	--	46.00	27.00
Chintapaka	8.58	51.26	72.10 (all other categories)	

*One of the areas of present study

Ref: Dr. C. Kasipathi and his research group

Personal Communication

One hundred twelve 112 geo electrical resistivity Vertical Electrical Soundings (VES) were made in the study area representing geologically feasible colluvial and pegmatitic gem-hosted bodies. The resistivity surveys are aimed to cover an area of about 200 sq.km of Sabbavaram, Buchhayyapeta, V. Madugula and Narsipatnam mandals. Different geological units viz., hard rock (Khondalites), soft rocks (Colluvium) and clayey soils are covered in general and special attention was paid in the targeted areas, which are Asakapalli, Gunnempudi, K.Vallapuram and Karaka villages in the respective mandals. The values are interpreted by using 3 layer master curves shown on [Table 6.2 (i), (ii)]**.** The interpreted data was confirmed with that of geological nature of the areas, and the uniformity of subsurface conditions are established. Significant soundings where high and low resistivity peaks occurred, indicating the presence of hard bodies, like pegmatite veins and quartz veins which is a common phenomenon of the area are emphasized. The resistivity ranges of each layer are compiled with the established geological scenario of the study area and also other parts of the district. The interpreted thickness obtained through various cross sections are correlated with the geological cross sections for confirmation.

MANDAL : SABBAVARAM

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
1	Asakapalli	S1	150	2	45	29	32	12	α		43	0.00 - 2.00 2.00 - 31.00 31.00 - 43.00
2	Asakapalli	S2	140	3	140	27	α				30	0.00 - 3.00 3.00 - 30.00
3	Asakapalli	S3	10	2	70	24	α				26	0.00 - 2.00 2.00 - 26.00
4	Asakapalli	S4	220	2	44	6	82	18	α		26	0.00 - 2.00 2.00 - 8.00 8.00 - 26.00
5	Asakapalli	S5	120	2	24	3	51	27	α		32	0.00 - 2.00 2.00 - 5.00 5.00 - 32.00
6	Asakapalli	S6	25	3	12	27	18	10	α		40	0.00 - 3.00 3.00 - 30.00 30.00 - 40.00
7	Asakapalli	S7	80	2	16	14	α				16	0.00 - 2.00 2.00 - 16.00
8	Asakapalli	S8	120	2	36	11	80	22	α		35	0.00 - 2.00 2.00 - 13.00 13.00 - 35.00
9	Asakapalli	S9	130	2	85	20	α				22	0.00 - 2.00 2.00 - 22.00
10	Asakapalli	S10	90	2	90	6	230	18	α		26	0.00 - 2.00 2.00 - 8.00 8.00 - 26.00
11	Asakapalli	S11	600	2	42	14	α				16	0.00 - 2.00 2.00 - 16.00

MANDAL : SABBAVARAM

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
12	Asakapalli	S12	55	2	27	12	80	30	α		44	0.00 - 2.00 2.00 - 14.00 14.00 - 44.00
13	Asakapalli	S13	55	2	44	16	140		α		18	0.00 - 2.00 2.00 - 18.00
14	Asakapalli	S14	35	2	23	6	24	14	α		22	0.00 - 2.00 2.00 - 8.00 8.00 - 22.00
15	Asakapalli	S15	28	2	28	12	46	22	α		36	0.00 - 2.00 2.00 - 14.00 14.00 - 36.00
16	Erukunaidupalem	S16	32	2	21	52	α				54	0.00 - 2.00 2.00 - 54.00
17	Erukunaidupalem	S17	18	2	24	4	16	54	α		60	0.00 - 2.00 2.00 - 6.00 6.00 - 60.00
18	Pydivada	S18	32	3	13	12	75	50	α		65	0.00 - 3.00 3.00 - 15.00 15.00 - 65.00
19	Pydivada	S19	40	3	8	18	α				21	0.00 - 3.00 3.00 - 21.00
20	Sureddipalem	S20	55	2	68	6	128	14	α		22	0.00 - 2.00 2.00 - 8.00 8.00 - 22.00
21	Sureddipalem	S21	30	2	30	2	150	12	α		16	0.00 - 2.00 2.00 - 4.00 4.00 - 16.00
22	Tavvavanipalem	S22	9	2	9	8	30	32	α		42	0.00 -2.00 2.00 - 10.00 10.00 - 42.00

MANDAL : SABBAVARAM

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
23	Pedanaidupalem	S23	25	2	25	14	70	35	α		51	0.00 - 2.00 2.00 - 16.00 16.00 - 51.00
24	Sabbavaram	S24	6	2	6	3	15	9	α		14	0.00 - 2.00 2.00 - 5.00 5.00 - 14.00
25	Sabbavaram	S25	210	2	60	16	α				18	0.00 - 2.00 2.00 - 18.00
26	Sabbavaram	S26	210	2	210	16	480	10	α		28	0.00 - 2.00 2.00 - 18.00 18.00 - 28.00
27	Gorlevanipalem	S27	70	2	45	22	α				24	0.00 - 2.00 2.00 - 24.00
28	Gorlevanipalem	S28	65	2	43	18	100	9	α		29	0.00 - 2.00 2.00 - 20.00 20.00 - 29.00
29	Antakapalli	S29	7	2	14	8	55	25	α		35	0.00 - 2.00 2.00 - 10.00 10.00 - 35.00
30	Lagisettipalem	S30	52	2	16	4	89	12	α		18	0.00 - 2.00 2.00 - 6.00 6.00 - 18.00
31	Lagisettipalem	S31	210	2	63	6	250	18	α		26	0.00 - 2.00 2.00 - 8.00
32	Galibheemavaram	S32	100	4	15	28	α				32	0.00 - 4.00 4.00 - 32.00
33	Galibheemavaram	S33	130	2	13	40	α				42	0.00 - 2.00 2.00 - 42.00

MANDAL BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
1	Kondapalem	B34	9	2	22	37	α				39.00	0.00 - 2.00 2.00 - 39.00
2	Gunnempudi	B35	180	4	18	16	77	40	α		60.00	0.00 - 4.00 4.00 - 20.00 20.00 - 60.00
3	Gunnempudi	B36	280	2	28	6	80	39	α		47.00	0.00 - 2.00 2.00 - 8.00 8.00 - 47.00
4	Gunnempudi	B37	180	2	18	8	60	39	α		49.00	0.00 - 2.00 2.00 - 20.00 20.00 - 40.00
5	Gunnempudi	B38	900	5	63	45	α				50.00	0.00 - 5.00 5.00 - 50.00
6	Gunnempudi	B39	280	5	28	15	30	22	α		42.00	0.00 - 5.00 5.00 - 20.00 20.00 - 42.00
7	Gunnempudi	B40	300	5	30	20	80	50	α		75.00	0.00 - 5.00 5.00 - 25.00 25.00 - 75.00
8	Gunnempudi	B41	480	5	34	15	150	30	α		50.00	0.00 - 5.00 5.00 - 20.00 20.00 - 50.00
9	Gunnempudi	B42	11	2	11	8	77	36	α		46.00	0.00 - 2.00 2.00 - 10.00 10.00 - 46.00
10	Gunnempudi	B43	14	2	9	8	33	33	α		43.00	0.00 - 2.00 2.00 - 10.00 10.00 - 43.00

MANDAL : BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
11	Gunnempudi	B44	11	3	22	12	α				15	0.00 - 3.00 3.00 - 15.00
12	Gunnempudi	B45	23	2	26	9	45	24	α		35	0.00 - 2.00 2.00 - 11.00 11.00 - 35.00
13	Gunnempudi	B46	80	2	16	5	70	21	α		28	0.00 - 2.00 2.00 - 7.00 7.00 - 28.00
14	Gunnempudi	B47	7	2	28	14	α				16	0.00 - 2.00 2.00 - 16.00
15	Gunnempudi	B48	3	3	15	9	α				12	0.00 - 3.00 3.00 - 12.00
16	Gunnempudi	B49	18	2	24	16	α				18	0.00 - 2.00 2.00 - 18.00
17	Gunnempudi	B50	11	2	11	5	33	16	α		23	0.00 - 2.00 2.00 - 7.00 7.00 - 23.00
18	Gunnempudi	B51	40	3	80	9	220	20	α		32	0.00 - 3.00 3.00 - 12.00 12.00- 32.00
19	Gunnempudi	B52	100	3	150	12	260	39	α		54	0.00 - 3.00 3.00 - 15.00 15.00 - 54.00
20	Gunnempudi	B53	22	2	14	3	100	25	α		30	0.00 - 2.00 2.00 - 5.00 5.00 - 30.00

MANDAL : BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
21	Gunnempudi	B54	50	2	15	6	60	18	α		26	0.00 - 2.00 2.00 - 8.00 8.00 - 26.00
22	Peddapudi	B55	38	3	11	12	65	20	α		35.00	0.00 - 3.00 3.00 - 15.00 15.00 - 35.00
23	Peddapudi	B56	15	2	19	8	63	18	α		28	0.00 - 2.00 2.00 - 10.00 10.00 - 28.00
24	Peddapudi	B57	25	2	5	2	39	6	α		10	0.00 - 2.00 2.00 -4.00 4.00 - 10.00
25	Peddapudi	B58	14	2	28	10	100	25	α		37	0.00 - 2.00 2.00 - 12.00 12.00 - 37.00
26	Karaka	B59	22	2	33	8	22	32	α		42	0.00 - 2.00 2.00 - 10.00 10.00 - 42.00
27	Karaka	B60	25	3	20	12	57	28	α		43	0.00 - 3.00 3.00 - 15.00 15.00 - 43.00
28	Turakalapudi	B61	3	4	15	13	α				17	0.00 - 4.00 4.00 - 17.00
29	Turakalapudi	B62	11	2	11	5	24	36	α		43	0.00 - 2.00 2.00 - 7.00 7.00 - 43.00

Table 6.2 (ii) VES Interpreted Results

MANDAL : BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
30	Turakalapudi	B63	12	2	30	48	α				50	0.00 - 2.00 2.00 - 50.00
31	Turakalapudi	B64	250	2	100	20	α				22	0.00 -2.00 2.00 - 22.00
32	Turakalapudi	B65	23	3	18	9	40	30	α		42	0.00 - 3.00 3.00 - 12.00 12.00 - 42.00
33	Turakalapudi	B66	25	2	20	10	45	29	α		41	0.00 - 2.00 2.00 - 12.00 12.00 - 41.00
34	Chittayyapalem	B67	100	2	65	14	140	24	α		40	0.00 -2.00 2.00 -16.00 16.00 - 40
35	Chittayyapalem	B68	110	3	22	9	62	32	α		44	0.00 -3.00 3.00 -12.00 12.00 -44.00
36	Chittayyapalem	B69	12	2	12	16	28	64	α		82	0.00 -2.00 2.00 -18.00 18.00 - 82.00
37	Chittayyapalem	B70	14	2	21	10	24	40	α		52	0.00 -2.00 2.00 -12.00 12.00 - 52.00
38	Chittayyapalem	B71	40	3	60	12	30	28	α		43	0.00 -3.00 3.00 -15.00 15.00 - 43.00
39	Chittayyapalem	B72	90	2	60	10	40	31	α		43	0.00 - 2.00 2.00 - 12.00 12.00 - 43.00

MANDAL : BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
40	Taipuaram	B73	24	2	12	12	28	14	α		28	0.00 - 2.00 2.00 - 14.00 14.00 - 28.00
41	Taipuaram	B74	15	3	10	18	50	27	α		48	0.00 - 3.00 3.00 - 21.00 21.00 - 48.00
42	Taipuaram	B75	10	2	15	26	α				28	0.00 - 2.00 2.00 - 28.00
43	Taipuaram	B76	15	2	10	18	α				20	0.00 - 2.00 2.00 - 20.00
44	Taipuaram	B77	3	2	3	3	15	8	α		13	0.00 - 2.00 2.00 - 5.00 5.00 - 13.00
45	Taipuaram	B78	33	2	10	8	39	36	α		46	0.00 - 2.00 2.00 - 10.00 10.00 - 46.00
46	Taipuaram	B79	120	2	120	24	α				26	0.00 - 2.00 2.00 - 26.00
47	Chinamadeena	B80	55	2	17	8	70	25	α		35	0.00 - 2.00 2.00 - 10.00 10.00 - 35.00
48	Chinamadeena	B81	90	2	18	8	70	22	α		32	0.00 - 2.00 2.00 - 10.00 10.00 - 32.00
49	Chinamadeena	B82	70	2	14	8	75	40	α		50	0.00 - 2.00 2.00 - 10.00 10.00 - 50.00

MANDAL : BUCHAYYAPETA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
50	Pedamadena	B83	600	2	180	18	250	36	α		56	0.00 - 2.00 2.00 - 20.00 20.00 - 56.00
51	Pedamadena	B84	9	1	14	21	α				22	0.00 - 1.00 1.00 - 22.00
52	Pedamadena	B85	46	1	30	23	230				24	0.00 - 1.00 1.00 - 24.00
53	Pedamadena	B86	39	1	25	25	α				26	0.00 - 1.00 1.00 - 26.00
54	Pedamadena	B87	29	3	12	32	α				35	0.00 - 3.00 3.00 - 35.00
55	Pedamadena	B88	300	2	60	20	α				22	0.00 - 2.00 2.00 - 22.00
56	Pedamadena	B89	230	2	46	6	97	20	α		28	0.00 - 2.00 2.00 - 8.00 8.00 - 28.00
57	Pedamadena	B90	10	1	7	10	68	27	α		38	0.00 - 1.00 1.00 - 11.00 11.00 - 38.00
58	Pedamadena	B91	240	3	58	22	60	25	α		50	0.00 - 3.00 3.00 - 25.00 25.00 - 50.00

MANDAL : V.MADUGULA

SL. No	VILLAGE	VES NO	P_1 Ohm.m	h_1 m.	P_2 Ohm.m	h_2 m.	P_3 Ohm.m	h_3 m.	P_4 Ohm.m	h_4 m.	H m.	LAYER THICKNESS
1	K.Vallapuram	M92	180	2	25	14	40	14	α		30	0.00 - 2.00 2.00 - 16.00 16.00 - 30.00
2	K.Vallapuram	M93	75	2	40	8	60	14	α		24	0.00 - 2.00 2.00 - 10.00 10.00 - 24.00
3	K.Vallapuram	M94	220	2	70	8	50	40	α		50	0.00 - 2.00 2.00 - 10.00 10.00 - 50.00
4	K.Vallapuram	M95	120	3	75	10	75	47	α		60	0.00 - 3.00 3.00 - 17.00 17.00 - 60.00
5	K.Vallapuram	M96	240	3	60	30	80	45	α		78	0.00 - 3.00 3.00 - 33.00 33.00 - 78.00
6	K.Vallapuram	M97	260	3	90	7	100	40	α		50	0.00 - 3.00 3.00 - 10.00 10.00 - 50.00
7	K.Vallapuram	M98	100	3	80	8	150	40	α		51	0.00 - 3.00 3.00 - 11.00 11.00 - 51.00
8	K.Vallapuram	M99	240	2	190	15	250	45	α		62	0.00 - 2.00 2.00 - 17.00 17.00 - 62.00
9	K.Vallapuram	M100	95	2	70	10	40	28	α		40	0.00 - 2.00 2.00 - 12.00 12.00 - 40.00
10	K.Vallapuram	M101	75	2	60	15	50	33	α		50	0.00 - 2.00 2.00 - 17.00 17.00 - 50.00
11	K.Vallapuram	M102	120	3	70	16	90	21	α		40	0.00 - 3.00 3.00 - 19.00 19.00 - 40.00

Mandal Narsipatnam

Sl. No.	Village	VES No	p_1	h_1	P_2	h_2	p_3	h_3	p_4	h_4	H	Layer thickness
1	Karaka	N103	120	3	170	40	α				43	0.00-3.00 3.00-43.00
2	Karaka	N104	240	2	80	16	250	30	α		48	0.00-2.00 2.00-16.00 18.00-30.00
3	Karaka	N105	600	6	100	12	200	20	α		38	0.00-6.00 6.00-12.00 18.00-38.00
4	Karaka	N106	400	3	110	20	220	25	α		48	0.00-3.00 3.00-20.00 23.00-48.00
5	Busupalli	N107	32	2	21	30	100	α	α		32	0.00-2.00 2.00-32.00
6	Andravara	N108	55	2	68	3	128	15	α		20	0.00-2.00 2.00-3.00 3.00-22.00
7	Turaiguda	N109	90	2	60	10	30	31	α		43	0.00-2.00 2.00-12.00 12.00-43.00
8	Turaiguda	N110	300	2	60	20	α	α	-		22	0.00-2.00 2.00-22.00
9	Turaiguda	N111	220	2	58	6	97	97	20	α	28	0.00-2.00 2.00-8.00 8.00-28.00
10	Ravvalaguda	N112	13	3	10	5	30	20	α		28	0.00-3.00 3.00-8.00 8.00-28.00

Table 6.2 (i) VES Interpreted Results

The resistivities and thicknesses of various layers at Asakapalli are as below:

Layer No.	Resistivity range	Thickness range
1	10-600 ohm.m,	2.0-3.0 m
2	12-140 ohm.m.	3.00-29.0 m
3	18-230 ohm.m.	10.0-30.0 m

The hard rock varies from 16.00 to 43.00m One exploratory bore hole was drilled at this village Asakapalli. This site is selected as its 3rd layer thickness is 30.00m and resistivity value of 80 ohm.m. The drilling results are in confirmity with resistivity data [Table 6.3].

Table 6.3

DTH (Depth to Hole) Drilling log made at Asakapalli Gem Mine

Depth of drilling from the Surface level (m)	Litho-unit encountered
0.0-6.0	Colluvial material, comprising specks of gem minerals
6.0-18.0	Semi-weathered khondalite
18.0-27.0	Highly weathered khondalite
27.0-45.0	Semi-weathered khondalite
45.0-48.0	Thin band of schistose rocks
48.0-58.5	Schistose rocks with pyrite and chalcopyrite
58.5-59.4	Khondalite
59.4-61.5	Schistose rocks

The resistivity data of the villages around Asakapalli have indicated clearly non-continuation of the gem-bearing zones which helped, thus in other terms in locating an ore body like gem-bearing pegmatite vein.

The resistivity survey carried out in the Buchhayyapeta mandal and special emphasis was given to Gunnempudi village, where previous excavations have proved the existence of gem–bearing zones, associated with pegmatite veins. About 20 VES were conducted in Gunnempudi village to locate gem-bearing pockets. The resistivities and thickness ranges are as follows:

Layer No.	Resistivity range	Thickness range
1	3 to 900 ohm.m.	2.0-5.0m
2	9 to 150 ohm.m.	3.0-45.0 m
3	30 to 260 ohm.m.	16.0-50.0 m

The thickness of second and third layers in this village are considerably good and have confirmed the presence and existence of gem-bearing pockets. These pockets are further confirmed with the previously mapped and proved zones.

The resistivity survey carried out in the V.Madugula Mandal and an isolated village K.Vallapuram, surrounded by unapproachable area due to bushes and other vegetation and so about eleven (11) VES points were taken up. The resistivity and thickness ranges are as shown below:

Layer No.	Resistivity range	Thickness range
1	75 to 260 ohm.m.	2.0 to3.0 m
2	25 to 190 ohm.m.	7.0 to 30.0 m
3	40 to 250 ohm.m.	14.0 to 47.0 m

The 1st layer is an indicative of unclassified top soil followed by weathered zone with intrusive nature at places. This is followed by third layer of semi weathered nature. The interpreted data in this village are in confirmation with the previously mapped and proved gem-bearing zones. Perhaps, this may be further continued and new areas can be identified, but for the topographical constraints, the investigations were confirmed to a limited extent i.e., in and around K.Vallapuram village only.

The resistivity survey carried out in the Narsipatnam mandal and special emphasis was given to Karaka Village which is a hill of reserve forest category occupying about 32 sq.kms by area. This hill is located about 15 km away from Narsipatnam Town. 10 (ten) VES points were conducted. The resistivity and thickness ranges are as follows: -

Layer No.	Resistivity range	Thickness range
1	13 to 600 ohm.m.	2.0 – 6.0 m
2	10 to 170 ohm.m	3.0 – 40.0 m
3	30 to 250 ohm.m	15.0 – 48.0 m

The top soil is generally indicated by unclassified soil nature and clayey nature at some places. The second layer is weathered zone, with a varied nature of weathering and the third layer is of semi-weathered nature. Geo electrical basement (Hard rock) occurred after third layer and at some places it encountered after second layer. The variations of Hard rock at places indicate deeper depths and confirms the presence of colluvial body extension. Good thickness of third layer, with moderate resistivities i.e. 30 to 250 ohm.m. and with considerable highs have confirmed the presence of pegmatite veins, and the continuity of which are established on surface by prior geological mapping.

From the vertical electrical sounding data Ten profiles were drawn, restricting to geologically and geo-physically prospective gem-bearing Pegmatitic – Colluviums zones (gem tracts) in the area of study. The following are the different VES profiles shown in [Table 6.4] and the geo-electrical subsurface sections are shown in [Fig.6.1 to 6.10].

TABLE 6.4

DETAILS OF VES PROFILES

S.No.	Mandal	Villages	VES Nos. considered	Remarks
1	Sabbavaram	Asakapalli	S1, S4, S5, S6, S8	Electrical basement at 3rd layer
2	Sabbavaam	Asakapalli	S2, S3, S7, S9 and S11	Electrical basement at 2nd layer
3	Sabbavaram	Asakapalli-Pydivada	S12, S14, S15 and S18	Electrical basement at 3rd layer
4	Buchhayyapeta	Karaka-Turakalapudi-Chittayyapalem-Taipuram	B59, B65, B67 and B74	Electrical basement at 3rd layer
5	Buchhayyapeta	Gunnempudi-Kondapalem	B34, B35, B39 and B40	Electrical basement at 3rd layer
6	Buchhayyapeta	Gunnempudi	B35, B40, B41, B46 and B52	Electrical basement at 3rd layer
7	Buchhayyapeta	Gunnempudi	B39, B43, B45, B46 and B50	Electrical basement at 3rd layer
8	Buchhayyepeta	Turakalapudi-Mittampalem, Chinamadena-Pedamadina	B66, B70, B80, B82, B83 and B91	Electrical basement at 3rd layer
9	V. Madugula	K.Vallapuram	M92, M93, M94, M95, M96 and M97	Electrical basement at 3rd layer
10	Narsipatnam	Karaka	N104, N105, N108 N110 and N112	Electrical basement at 3rd layer

f

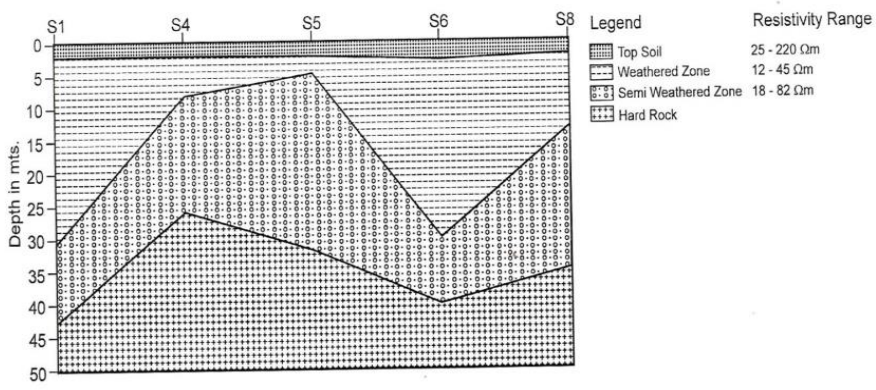


Fig. 6.1 : Geo-Electrical subsurface section from sounding data Profile - 1 Asakapalli

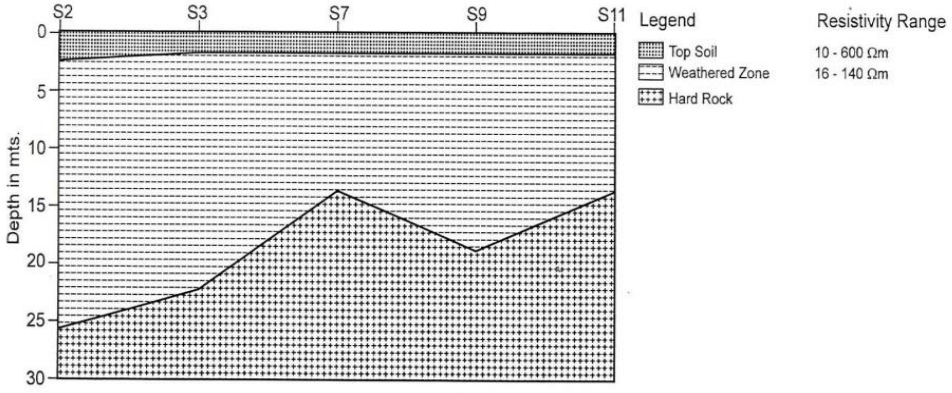


Fig. 6.2 : Geo-Electrical subsurface section from sounding data Profile - 2 Asakapalli

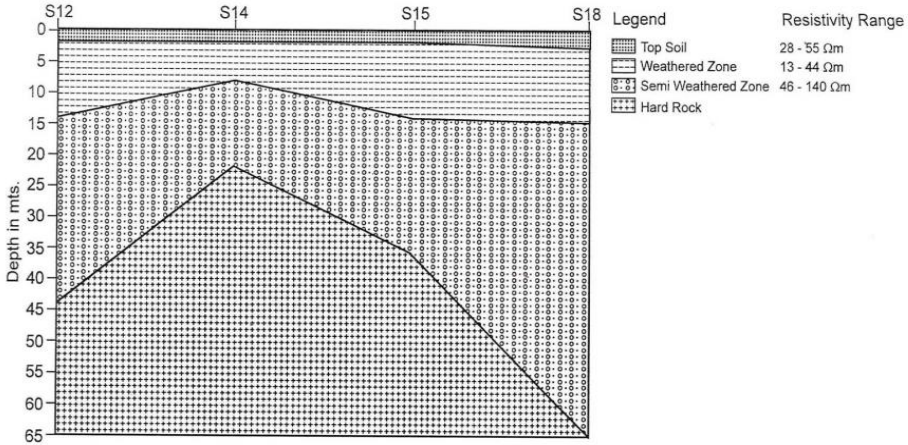


Fig. 6.3 : Geo-Electrical subsurface section from sounding data Profile - 3 Asakapalli - Pydivada

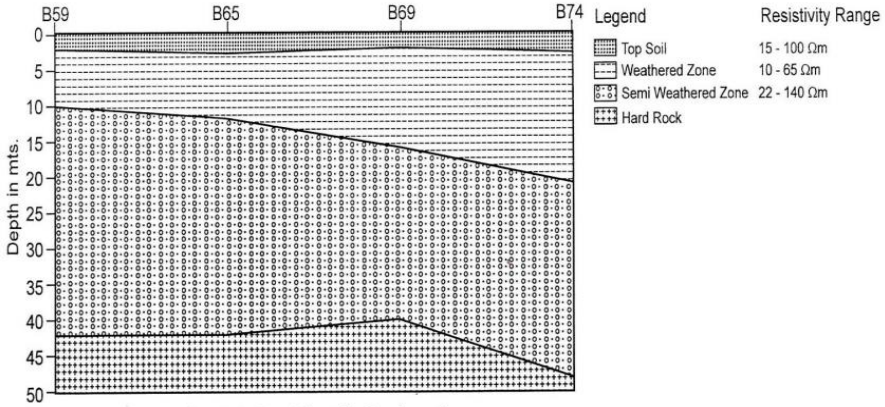


Fig. 6.4: Geo-Electrical subsurface section from sounding data Profile - 4 Karaka, Turakalapudi, Chittayyapalem, Taipuram

Fig. (6.1 to 6.4) Geo – Electrical Subsurface Sections

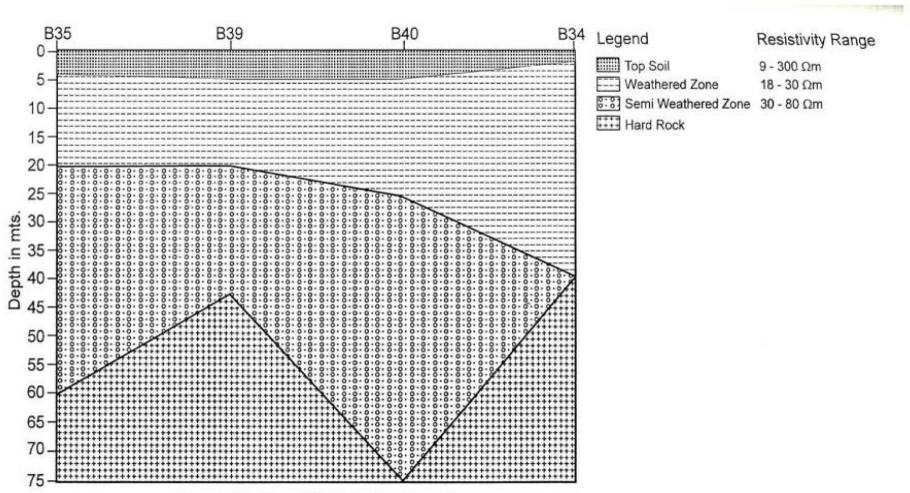


Fig. 6.5 : Geo-Electrical subsurface section from sounding data Profile - 5 Gunnempudi - Kondapalem

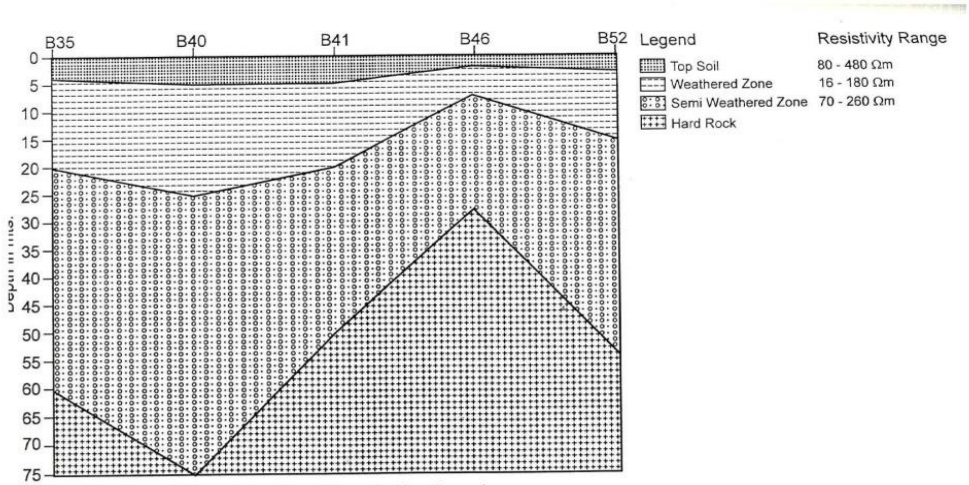


Fig. 6.6 : Geo-Electrical subsurface section from sounding data Profile - 6 Gunnempudi

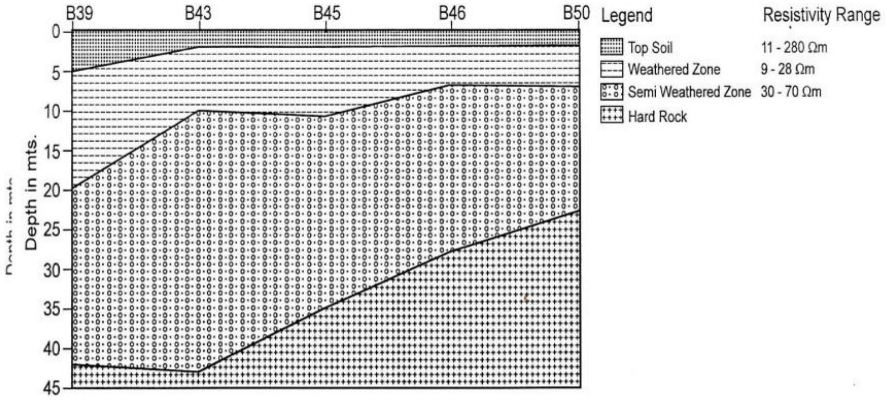


Fig. 6.7 : Geo-Electrical subsurface section from sounding data Profile - 7 Gunnempudi

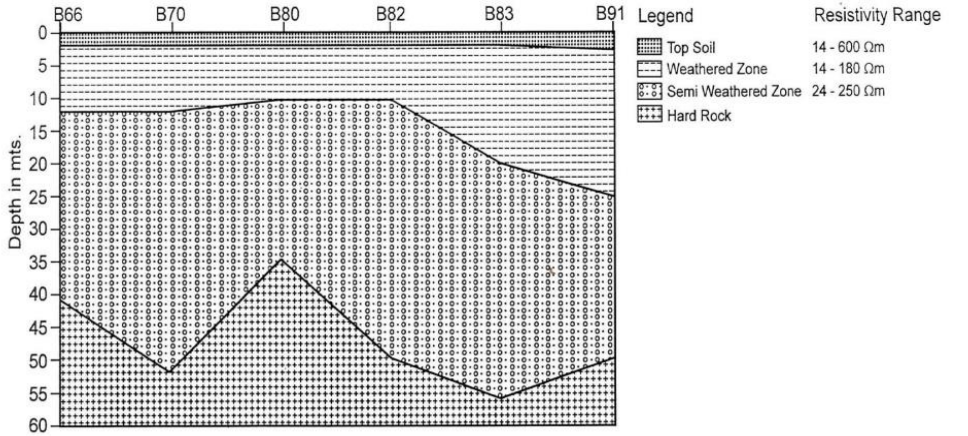


Fig. 6.8 : Geo-Electrical subsurface section from sounding data Profile - 8 Turakalapudi - Chittayyapalem - China Madeena - Peda Madeena

Fig. (6.5 to 6.8) Geo – Electrical Subsurface Sections

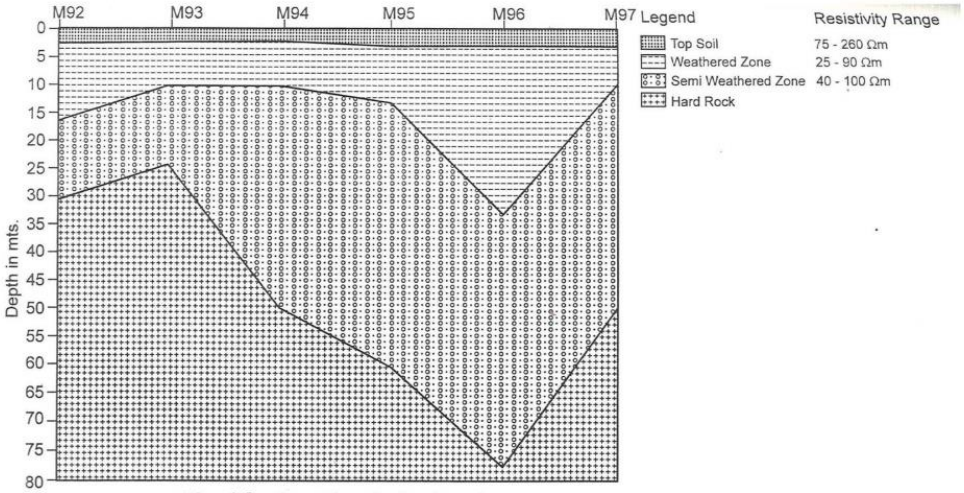


Fig. 6.9 : Geo-Electrical subsurface section from sounding data Profile - 9 K. Vallapuram

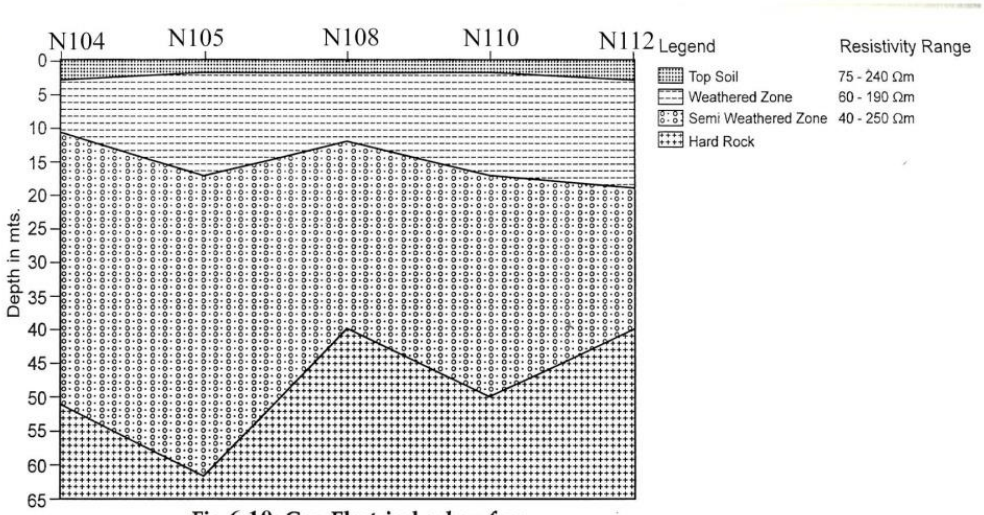


Fig.6.10: Geo-Electrical subsurface section from sounding data Profile - 10 Karaka

Fig. (6.9 to 6.10) Geo – Electrical Subsurface Sections

The discussion of the above geo electrical and lithological profiles shows the relevance of resistivity surveys. The extension of colluvium is defined by the way of deeper zones with uniform trend of curves. The presence of peaks in resistivity curves indicate hard bodies preferably pegmatite and quartz veins. The absence of either uniformity or peaks in the trend of the curves indicates with weathered and semi-weathered nature of sub surface formations.

The application of geo-electrical surveys in the delineation of colluvium i.e. gem-bearing colluvium is made possible for the first time in this area of study. The present study indicated a relevance with confidence to utilize these surveys for confirming the gem-bearing secondary colluvium bodies. This study paves a new line of utility of geo-electrical studies.

Rock samples collected in the selected field area of study are powdered and analysed chemically in the laboratory with usual procedure. Chemical analysis data in [Table 6.5].

Table 6.5
Chemical Analysis of Rock Samples

Name of the Village	Sample No.	% Silica	% Iron	% Mg.	% Ti	% Cr	% K	% Ca	% Al
Karaka	A2	60	3.1	0.0	0.0	1.9	√	0.8	7.12
Karaka	A3	57.7	3.7	.0.0	0.0	0.435	√	0.4726	1.6
Busupalli	A5	83.0	0.7	6.12	0.0	2.72	√	1.4	6.2
Andravara	A7	74.5	1.56	22.1	0.0	1.8	X	1.2	3.12
Turaiguda	A8	68	3.7	0.0	0.0	0.819	X	0.13	8.11
Turaiguda	A10	82	4.74	0.0	0.0	2.72	X	0.68	4.26
Turaiguda	A11	95	0.95	0.0	0.0	2.72	X	0.5	0.96
Turaiguda	A12	68.3	1.96	0.0	0.0	0.816	X	1.96	2.8
Turaiguda	A14	79	2.1	0.0	0.0	1.08	X	0.66	4.28
Turaiguda	A16	69.7	1.32	20.9	0.0	1.53	X	0.66	1
Turaiguda	B6	65	3.36	0.0	0.0	1.36	X	1.45	8.16
Turaiguda	B7	63	3.2	0.0	0.0	1.36	X	0.91	3.14
Ravvalaguda	B2	84	1.7	0.0	0.0	1.7	X	0.5	9

SiO_2 varies from 57.7% -84%. Fe content from 0.7% - 4.74%. Mg Percentge varies from traces to 22.1%. Chromium varies from 0.43% up to 2.72%. Calcium varies from 0.5% upto 1.96% and Aluminium varies from 0.96% upto 9%.

Some of the samples selected from the parts of the gem bearing localities of study area were analysed by X-Ray diffraction study. The XRD diagrams are shown in [Fig.6.11].

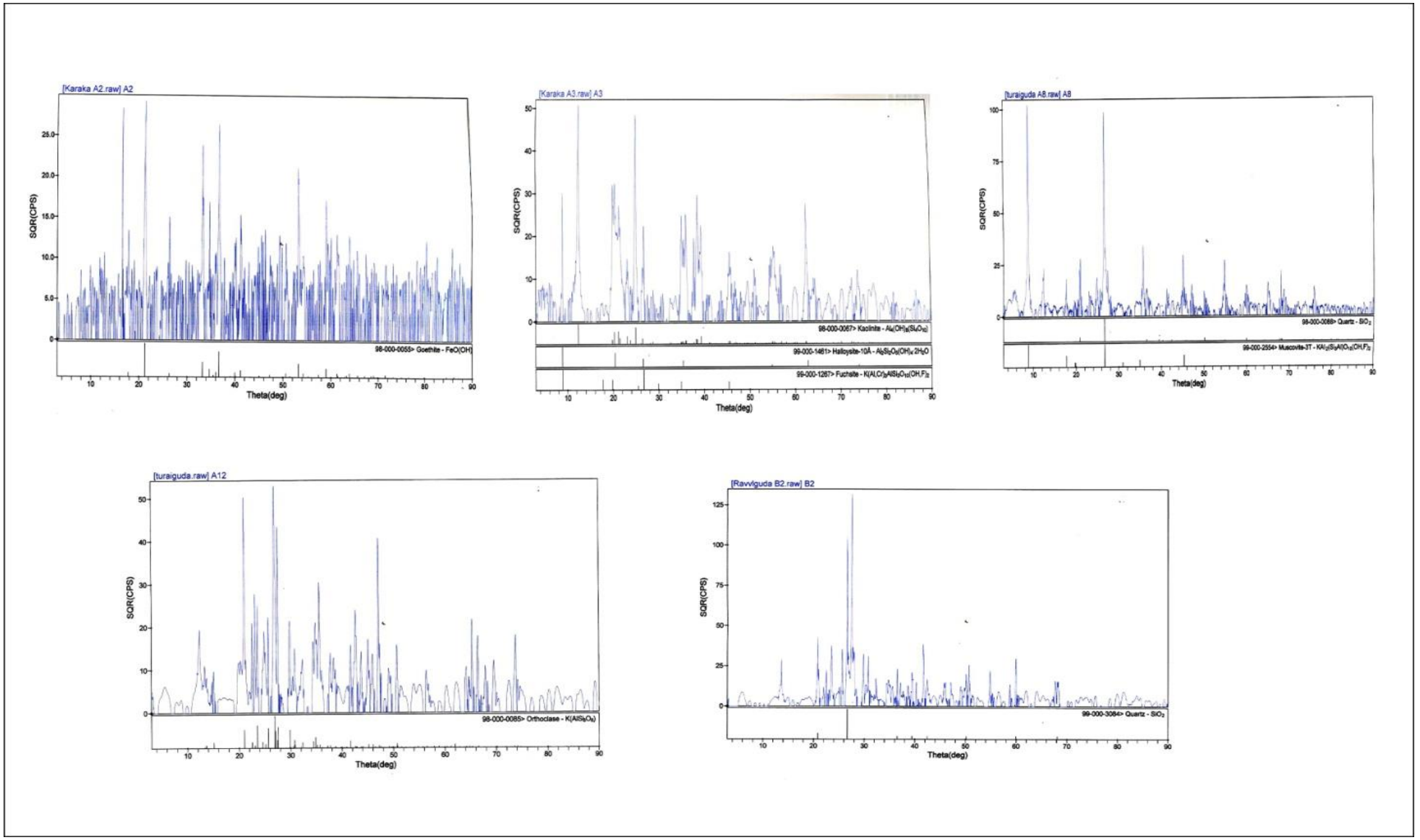


Fig.6.11 XRD Diagrams

The X-ray peaks indicate the presence of Kaolinite, halloysite, fuchsite, quartz, muscovite, orthoclase and geothite, which are all derivatives of the primary pegmatite formations. The presence of fuchsite is endangerous in association with the colluvium, which may create fluoride enrichment in the nearby areas preferably at Karaka Village of Narsipatnam Mandal.

Geochemical analysis of the petrological members of the gem-bearing terrains of the area of investigation was carried out using Inductively Coupled Plasma Mass Spectrometry (ICPMS). The elemental concentration of Be, Al, V, Cr, Mn, Fe, Ni, Co, Zn, Cu, Ga, As, Rb, Sr, Ag, Cd, Cs, Ba, Pb, U were determined and tabulated in the [Table 6.6 (a), (b)]

Table 6.6 (a) TRACE ELEMENTS

Name of the Village	Sample No.	9 Be PPM	27 Al PPM	51 V PPM	52 Cr PPM	55 Mn PPM	56 Fe PPM	58 Ni PPM	59 Co PPM
Karaka	A2	0.03138	9.75741	0.32323	0.22885	2.70428	2417.09424	14.60820	0.30212
Karaka	A3	0.00358	777.17108	0.08007	0.81639	0.36584	91.19965	0.43165	0.006
Busupalli	A5	0.01560	570.55276	1.14669	1.29021	3.515	1448.24242	7.72473	0.09838
Andravara	A7	0.06085	1110.61613	1.22753	0.45423	0.11321	34.62731	0.28031	0.00123
Turaiguda	A8	0.04033	354.79927	0.32559	0.12988	2.34533	512.96971	3.10791	0.17947
Turaiguda	A10	0.11923	417.13017	0.46771	0.28307	13.98211	1004.27483	5.59546	0.16517
Turaiguda	A12	0.00705	436.67787	0.00238	0.05232	0.12476	16.61121	0.14532	0.00693
Turaiguda	B6	0.05443	462.55016	0.45628	0.09372	1.58984	603.05260	3.46737	0.13892
Turaiguda	B7	0.02109	946.42719	0.32433	0.52612	0.40237	161.67160	0.79446	0.04980
Ravvalaguda	B2	0.01450	293.75480	0.03301	1.67148	0.58026	70.36259	1.59465	0.02222

Table 6.6 (b) TRACE ELEMENTS

Name of the Village	Sample No.	63 Cu PPM	64 Zn PPM	69 Ga PPM	75 As PPM	85 Rb PPM	88 Sr PPM	107 Ag PPM	114 Cd PPM	133 CS PPM	138 Ba PPM	208 Pb PPM	238 U PPM
Karaka	A2	0.35746	0.67792	0.04328	3.86212	0.02310	0.06743	0.01070	0.00319	0.00043 78	0.50202	0.02658	0.00206
Karaka	A3	0.07894	0.50971	0.05154	0.02644	0.15274	0.06941	0.02269	0.00122	0.00219	0.04859	0.01436	0.00208
Busupalli	A5	0.31658	0.71087	0.13527	1.10263	0.08471	0.04338	0.00765	0.00209	0.00085	0.38961	0.10534	0.01053
Andravara	A7	0.40658	0.24751	0.69418	0.09190	0.01976	0.03320	0.01605	0.00118	0.00015	0.03872	0.00201	0.00003
Turaiguda	A8	0.34680	0.59635	0.53270	0.05071	8.52224	0.08397	0.01957	0.00719	0.14444	2.39058	0.07722	0.17405
Turaiguda	A10	0.61755	1.63724	0.60179	0.05418	5.05029	0.26018	0.00101	0.00471	0.07830	2.32273	0.09293	0.09178
Turaiguda	A12	0.14928	0.12692	0.96234	0.01343	2.80440	0.46823	0.00209	0.0000	0.00582	5.63159	0.13977	0.00425
Turaiguda	B6	0.50032	0.70274	0.54292	0.04335	7.82724	0.46510	0.04024	0.00328	0.07795	1.94659	0.05062	0.01180
Turaiguda	B7	0.06568	0.20358	0.23105	0.01517	0.05955	0.04359	0.00155	0.00128	0.00011	0.08424	0.07323	0.00451
[illegible]	B2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The geochemical relations of Be vs. Al; V vs. Cr; Be vs. Fe; V vs. Ni; Be vs. Co; Al vs. Fe; Fe vs.Ni; Cu vs. As; and As vs. Rb; were drawn to identify their geo-chemical relationship. Graphs are shown in [fig 6.12 (i) to (x)].

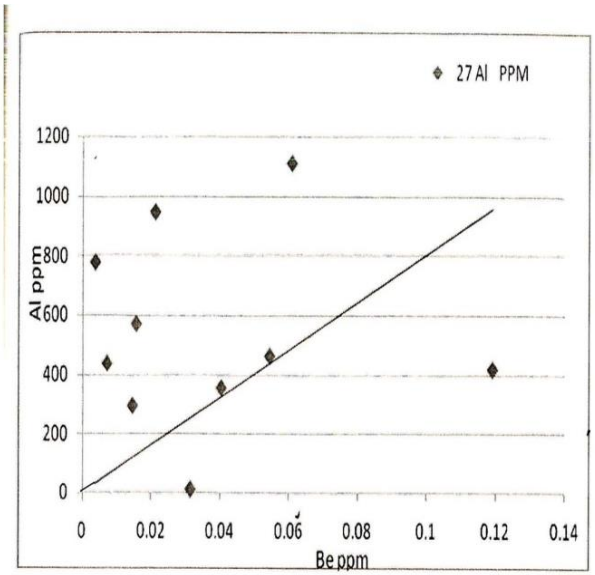


Fig.6.12 (i)

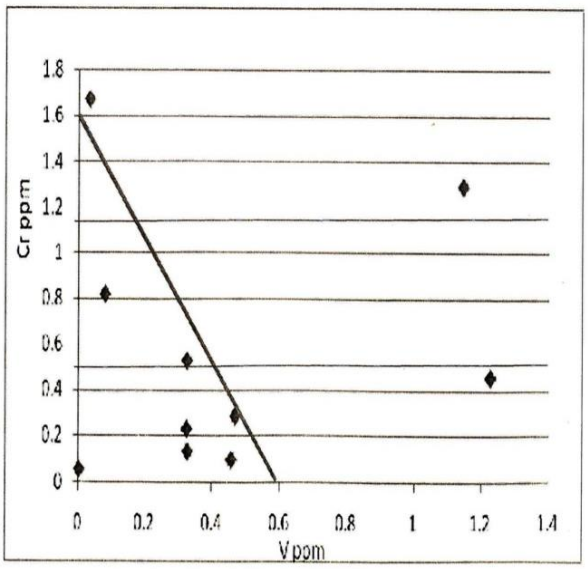


Fig.6.12 (ii)

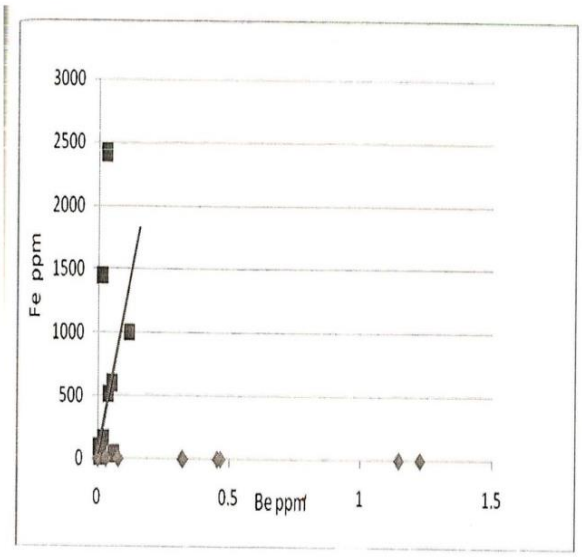


Fig.6.12 (iii)

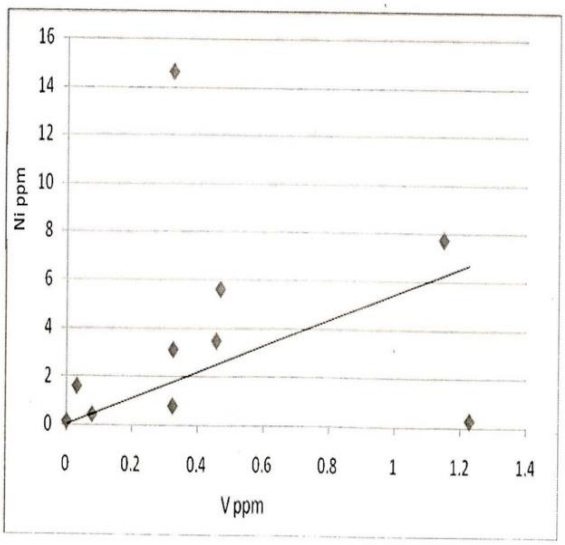


Fig.6.12 (iv)

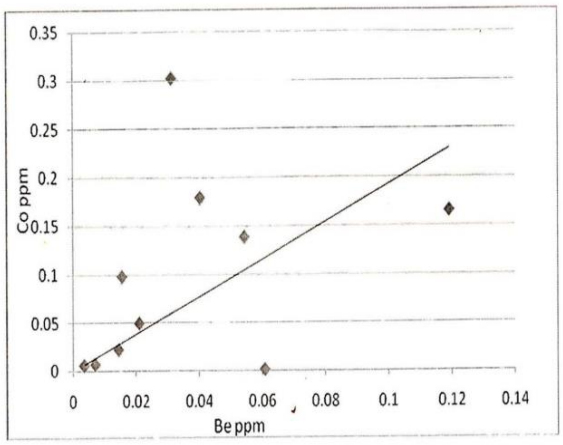


Fig.6.12 (v)

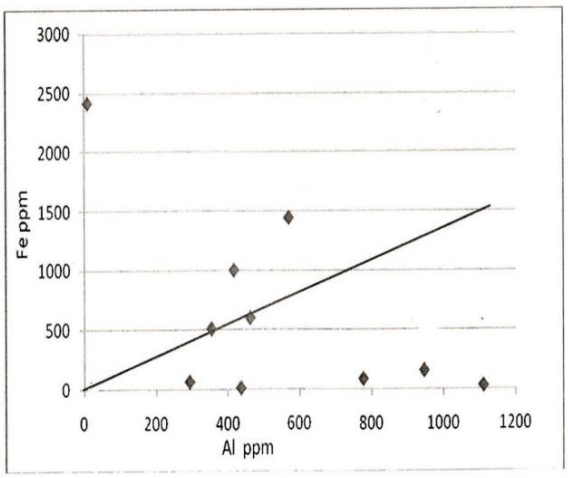


Fig.6.12 (vi)

Fig. 6.12 (i) to 6.12 (vi) Geo Chemical Relationship

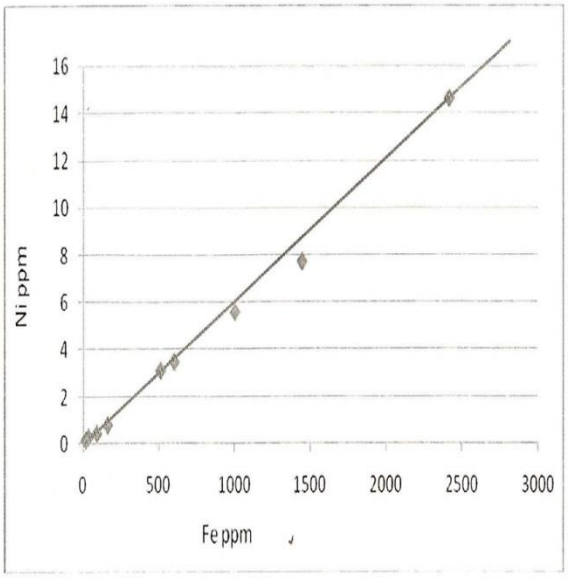


Fig.6.12 (vii)

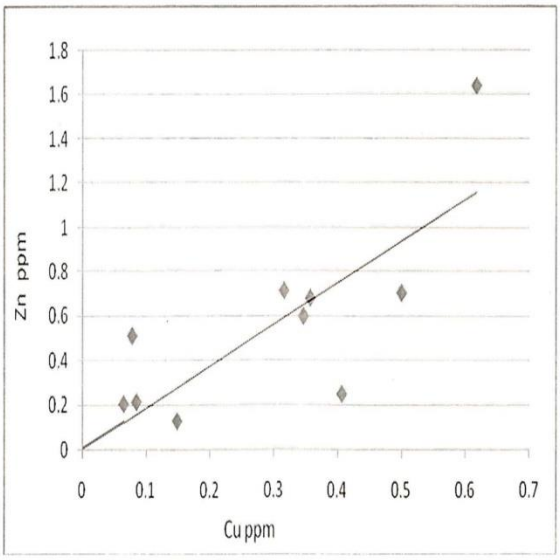


Fig.6.12 (viii)

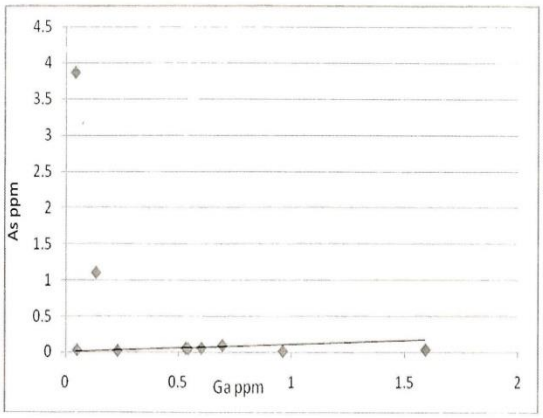


Fig.6.12 (ix)

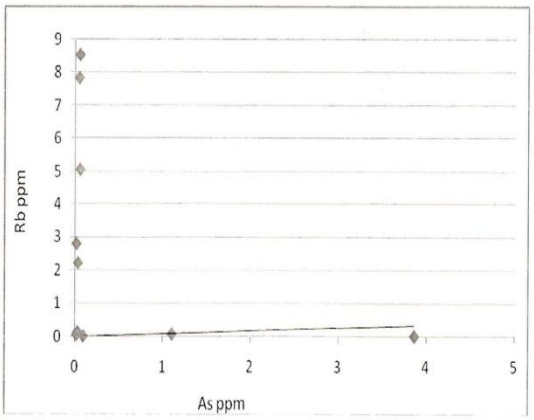


Fig.6.12 (x)

Fig. 6.12 (vii) to 6.12 (x) Geo Chemical Relationship

All the graphs shows sympathetic relationship except the graph V vs. Cr; shows antipathetic relation.

7. CONCLUSIONS:

The following are the significant conclusions of the present study.

(1) Invaluable gem mineral resources Viz., Alexandrite, Chrysoberyl, Chrysoberyl cat's eye (precious minerals) and Moon stone, Garnet, Zircon, Sillimanite, Tourmaline, Citrine, Amethyst and Rose quartz were identified through geological exploration in the study area i.e., in parts of Eastern Ghats Mobile Belt, Visakhapatnam District, Andhra Pradesh, India for the first time.

(2) The precious and semi-precious stones as enumerated earlier have been restricted in their occurrence along with coarse grained quartzo – feldspathic – micaceous – porphyritic rock type (Pegmatite) and its altered and weathered depositions (Colluvium i.e., conglomerated gravel with soil).

(3) The gem-hosted Pegmatites are found to be intruded through the EGMB rock units viz., quartzo - feldspathic – micaceous – garnetiferous – sillimanite $\pm$ graphite gneiss (Khondalite) and quartzo – feldspathic – garnetiferous – gneiss (Leptynite)

(4) Vertical Electrical Soundings (VES) were made in the study area to find out the sub surface nature of thick gem-hosted Colluvium and weathered Pegmatitic extensions.

(5) In the study area, the thickness of substratum was shown by variable resistivity ranges, where the first layer with thickness 2.0 – 5.0 m of resistivity range between 3 and 900 ohm.m; second layer with thickness of 2.0-48.0 m. of resistivity range between of 3 and 210 ohm.m; and the third layer has thickness 6.0 – 64.0 m with resistivity range between 15 and 480 ohm.m. This data reflects the general pattern of resistivity and thickness of the three layers investigated.

(6) But in specific, with reference to the gem-bearing areas (gem tracts) indicate the first layer with thickness of 2.0 – 5.0 m in the resistivity range of 3 to 900 ohm.m; second layer with thickness of 3.0 – 45.0 m in the resistivity range of 9 to 190 ohm.m and the third layer with the thickness of 10.0 – 50.0 m in the resistivity range of 18 to 260 ohm.m.

(7) VES profiles and lithologs were drawn and these profiles indicated clearly the extension of Pegmatitic bodies laterally, and depthwise behaviour of pegmatitic and quartzo intrusive bodies and thickness of gravel composed Colluvium in deeper levels.

(8) The geological and geo-electrical resistivity exploration carried out in gem-tracts in parts of Eastern Ghats, Visakhapatnam District, Andhra Pradesh, India, corroborated the sub-surface conditions and extension of gem-bearing colluvium and weathered intrusive Pegmatitic bodies.

(9) Invaluable gem-minerals are found in association with the Khondalite suite of rocks, as per their geo-chemical evaluation.

(10) The secondary Pegmatitic body indicated all the mineralogical characteristics of the primary Pegmatites in a deeply altered stage.

(11) The Colluvium forms as the target of explanation for the gem minerals in this region.

(12) The study shows that the element fluorine is endangerous to the local rural people, which may result fluorosis in some parts of the study area. This point has to be investigated in a very detailed manner in future.

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