GEOPHYSICAL SURVEY REPORTFOR GROUNDWATER EXPLORATION AT FALSHEWADI, KANKAVLI - SINDHUDURG, MAHARASHTRA

REPORT BY

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GEOPHYSICAL SURVEY REPORT FOR LOCATING POTENTIAL BOREWELL POINTS FOR GROUNDWATER EXPLORATION AT SALSHI, KANKAVLI, SINDHUDURG DISTRICT, MAHARASTRA.

CONTENTS

1.0 INTRODUCTION

The Geophysical survey was carried out on 22nd & 23rd April 2017, at Fadshawadi, Kankavli, Sindhudurg district, Maharashtra for locating favorable bore well sites for production purpose. The site is situated 7 km west of Kankavli city and is approachable by road.

Sindhudurg district is located in the Konkan region of Maharashtra State and covers a geographical area of 5087 sq.km. The district lies in the Survey of India degree sheets 47H, 48 E and 48 I. The district is located between north latitude 15°37' and 16° 40' and east longitude 73° 19' and 74° 13'. The district is bounded in the north by Sindhudurg district, west by Arabian Sea and in the east by Kolhapur district and in the south by Goa State and Belgaum district of Karnataka State.The district has a geographical area of 5087 sq. km. out of which about 390 sq.km. is covered by forest, whereas cultivable area is 2495 sq. km and net sown area is 1354 sq. km.

The district headquarters is located at Oras (Kudal). The district comprises of two revenue sub-divisions viz: Sawantwadi and Kankavli. The eight taluka ofthe district are Sawantwadi, Vengurla, Kudal, Kankavli, Malvan, Deogad, Dodamarg and Vaibhavwadi.A map of the district showing the taluka boundaries, taluka headquarters, physical features and location of Peizometers and monitoring wells is presented as **Figure 1**.

1.1 Climate and Rainfall

Climatic conditions in the district are strongly influenced by its geographical conditions. The district falls under the 'Assured and High Rainfall zone'. The climate is generally humid. The cold season is from December to February followed by summer from March to May. June to September is the southwest monsoon, while, October and November constitute the post-monsoon season. Being a coastal district, variation in the temperature during the day and throughout the season is not large. December is the coldest month with mean daily maximum temperature at 32.7°C and the mean daily minimum temperature at 18.7°C. April is the hottest month. The relative humidity during the southwest monsoon is very high (86 to 90%). The relative humidity during winter and summer months is also above 57%.

The normal annual rainfall over the district varies from 2300mm (Malvan) to about 3205mm (Kudal). It is minimum in the western part of the district along3the coast and gradually increases towards east and reaches maximum along Western

Ghats. The average annual rainfall for the period 1998-2007 ranges from 2541.70mm (Devgadh) to 3937.80mm (Savantwadi).

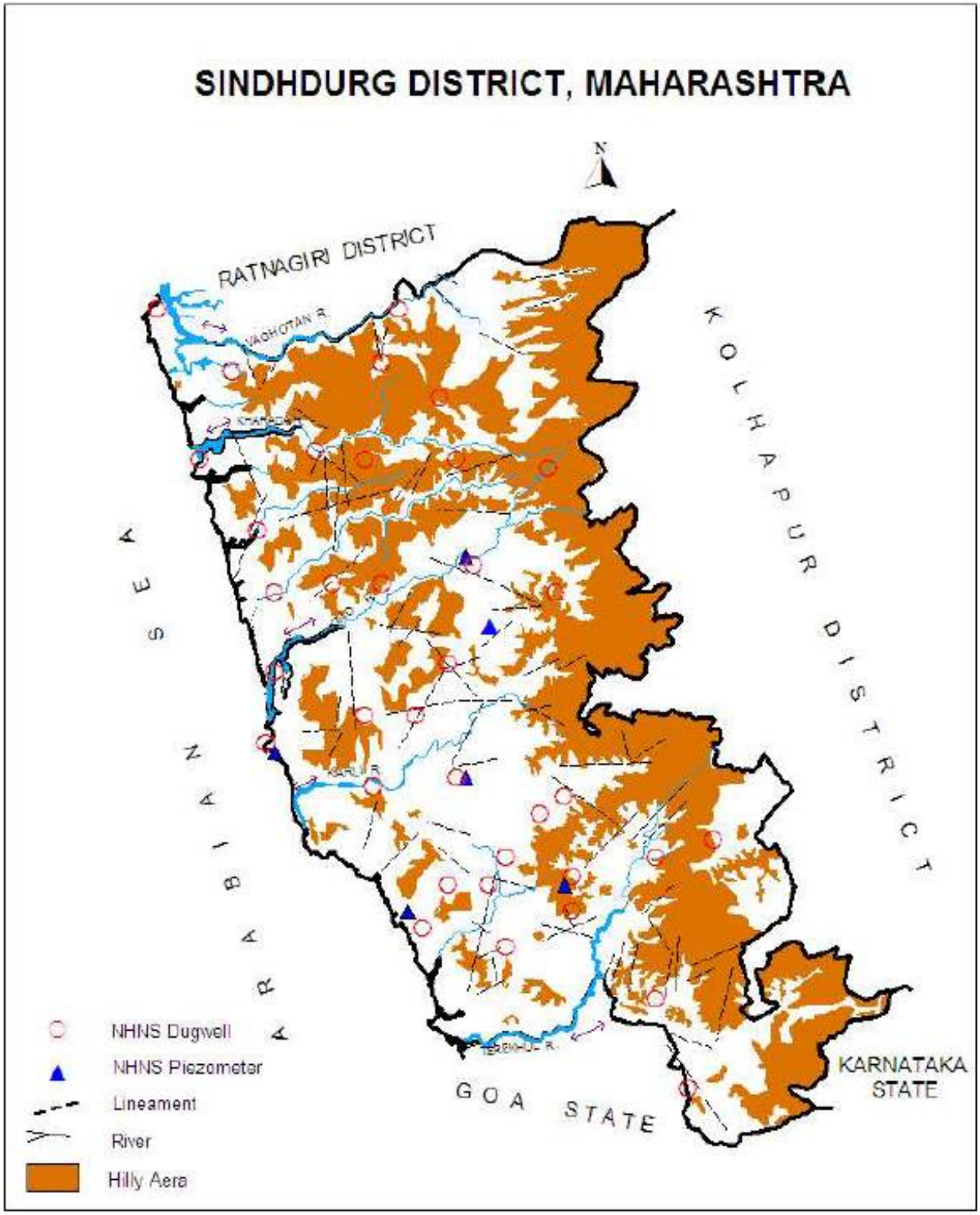

Figure 1: Location

1.2 Geomorphology and Soil Types

The outstanding feature in the relief of the district is its highly uneven nature and very narrow riverine plains that fringe the coastline. About 40 to 50% of the area in the district is hilly. The district has three major physiographic divisions from east to west. (i) The eastern part close to the Western Ghats, is highly dissected with deep valleys. (ii) The middle part of the district is occupied by flat-topped hills with undulating plateau with elevations up to 300 meter above mean sea level (amsl) covered by Laterite. (iii) The coastal plain in the western part with elevations of 100 to 150 m amsl. The physiograhic features have given rise to five characteristic landforms viz. (i) The coast line (ii) The estuarine alluvial plains (iii) The Lateritic plateau (iv) Highly eroded remnant hills (v) Scarp faces of Sahayadri hill ranges. The drainage system of the major rivers in the district is mostly of sub-parallel type and the tributaries drainage pattern tends to be sub rectangular type. Major joints in the Basalt control the drainage pattern. The river systems are young with a small drainage area and westerly seasonal regime. During monsoon the rivers carry heavy load of water having tremendous headward eroding capacity and ultimately drain in the Arabian Sea. All the major rivers originate in the Sahayadri Hill ranges. The five major rivers in the district are Gad (Length- 84km.), Karli (92km.), Terekhol (69km.), Tillari (53 km.), Deogad (48km.) and Wagothan (24km.). All these rivers form part of the westerly flowing river system originating from Sahayadri hill ranges and debouching in Arabian Sea.

The soil formation in the district in the district is controlled mainly by climate. Most of the soils are derived from Lateritic rocks. The soils are classified based on physical characteristics into four types viz., Rice soil, Garden soil, Varkas soil and Alluvial soil. The Rice soils are termed as ‘Mali soils’ when situated in higher levels, ‘Kuryat soils’ in lower levels and ‘Panthar or Vaigam’ when situated near water courses. Varkas soils are reddish brown to yellowish red in colour and are situated on hill slopes. These soils are poor in fertility, shallow in depth and coarse in texture. Garden soils are of mixed origin, yellow red to brown in color and are located in the valley portions. These soils are light, well drained and fairly fertile. Coastal Alluvial soils are recent deposits found along the coastal tracts and constitute deep loam. Due to inundation of sea, part 4 of the coastal soils has become salty. In the Devgad, Malwan and Vengurla talukas practically entire strip is salty.

1.3 General Geology

A major part of district is covered with basalt lava flows generally called as Deccan traps. This volcanic activity was confined mainly to the Upper Cretaceous to Lower Eocene age. Besides Deccan traps the formations like local alluvium, beach sand, coastal alluvium, laterites, trachytes & rhyolites cover a very small area of the district. The main topographic features of this lava flows are flat topped hills and step like terrace. A geological and mineral map of Maharashtra (GSI) is presented as **Figure 2**.

The stratigraphic sequence of the geological formation in the district is shown as below:-

Formation	Age	Lithology
Alluvium	Recent	clay, silt and sand
Beach sand	Recent	sand and silt
Laterite	Pleistocene	Laterite
Dykes	---------	Basic intrusion
Deccan traps basalt	Eocene to upper cretaceous	Amygdaloidal basalt
Rhyolite	Eocene to upper cretaceous	Rhyolite
Trachyte	Eocene to upper cretaceous	Trachyte

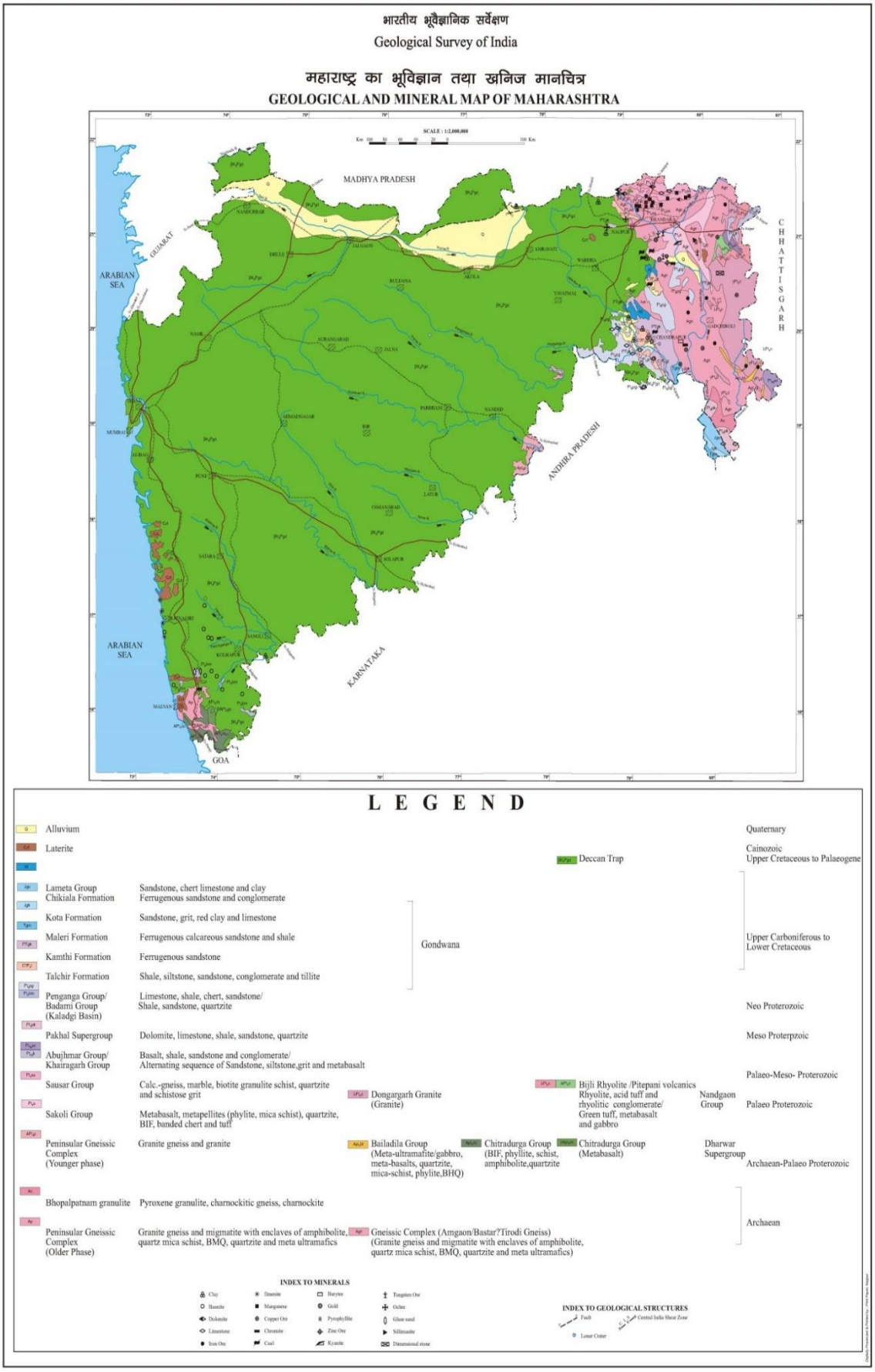

Figure 2: Geological map of Maharashtra

1.4 Ground Water Scenario

1.4.1 Hydrogeology

Hydrogeologically the basaltic terrain has aquifers in the form of jointed and fractured trap. The occurrence of ground water in Deccan trap is governed by its degree of weathering, concentration of joints & fractures planes, porosity & permeability of geological units. The movement & storage of ground water are mainly controlled by physical & geological set up of the terrain. The lava flows have no primary porosity. Only after weathering the cracks develop which allows to store ground water. However due to adverse morphological conditions, the availability of ground water is mainly restricted to plains & valley fill. The irrigation based on ground water is seen only in the parts of Dahanu, Talasari, Vasai, &Palghartahsils. The irrigation is mainly of horticultural crops. The coastal sandy aquifers are sufficiently good yielding, but even a marginal over exploitation causes intrusion of saline water.

For monitoring of ground water levels 92 nos. of observation wells have been set up in 34 nos. of elementary watersheds. The manual monitoring of static water levels is being carried out four times in a year. The water level data collected are useful for ground water assessment and planning for future groundwater development. The water table fluctuations in the observation wells vary from terrain to terrain. In coastal area water level fluctuations range between 1.0 to 4.0m whereas water level fluctuations range between 4.0 to 7.0m in hilly areas.

Dharwarianmetasediments (Archean), Kaladgi formation (Precambrian),Deccan Trap lava flows (Upper Cretaceous to Lower Eocene age), Laterite (Pleistocene) and Alluvial deposits (Recent to Sub-Recent) are the water bearing formations observed in Sindhudurg district. However Kaladgi formation occurs in very limited patches and does not form potential aquifer in the district. The Alluviums also has limited areal extent found mainly along the coast. A map depicting the hydrogeological features is shown in **Figure 3**.

1.4.2 Hard Rock Areas

1.4.2.1 Dharwarian Metasediments

The Dharwarian metasediments and intrusions are devoid of primary porosity and permeability. The major aquifer formations are Granitic Gneisses and Granites, which are banded or jointed, locally sheared and weathered that facilitates movement and storage of water. The secondary porosity and permeability thus developed gives rise to moderately yielding aquifers. Granulites are dense and compact and hence not suitable for storage or transmission of ground water.

The unconfined aquifer is developed down to depth of 15 metres below ground level (m bgl) and the yield of the wells tapping such aquifer varies form 2 to 3 m3/day. Borewells generally tap deeper aquifer down to the depth of 70 m bgl and their yield varies between 500 and 7770 litres/hr.

1.4.2.2 Kaladgi

The Kaladgi rocks are mainly represented by orthoquartzite, sandstone and shales. They are jointed in diverse directions and this along with weathered portion controls the water bearing properties. The unconfined aquifer is developed down to depth of 10-12 m bgl and the yield of the wells tapping such aquifer varies form 2 to 5 m3/day. Borewells generally tap deeper aquifer down to the depth of 60 m bgl and their yield varies between 500 and 9315 litres/hr.

1.4.2.3 Deccan Trap Basalt

The primary porosity is negligent in the Deccan trap basalts. The secondary porosity imparted due to jointing, fracturing plays an important role in ground water circulation. In the basaltic terrain ground water occurs under unconfined conditions in the phreatic zone up to a depth of 15 meters in the weathered zone, fractures and joints in the massive unit and weathered/fractured vesicular units. The basalts occupying higher elevations do not form good aquifers however the basalts occupying lower elevations give rise to good aquifers. The unconfined aquifer is developed due to the weathering and jointing of upper flow in Basalt down to depth of 15-20 m bgl and the yield of the wells tapping such aquifer varies form 0.50 to 4.00 m3/day. Borewells are not common in the district and they tap deeper aquifer in generally down to the depth of 90 m bgl their yield varies between 500 and 770 litres/hr.

1.4.2.4 Laterite

Laterite has better porosity due to intricate network of sinuous conduits making it porous formation. The ground water circulates through a network of voids and conduits, joints and fractures. The local water table aquifer develops in the topmost layer down to the depth of 20 m bgl under unconfined conditions. The wells in these areas show rapid decline in water levels during post monsoon season and go dry in peak summer due to lateral movement at lithomarge/ laterite contact and through spring discharge. Only dugwells are found in this formation.

1.4.3 Soft Rock Areas

1.4.3.1 Beach Sand/Alluvium

The Alluvial deposits are found along the coastal areas in few isolated patches having limited areal extent and limited thickness as Beach Sand.

The ground water occurs in inter-granular pore spaces of sands, gravels and silts. The ground water occurs under phreatic/unconfined aquifer at relatively shallow depths of 2-10 m bgl and their yield ranges from about 2 to 5 m3/day.

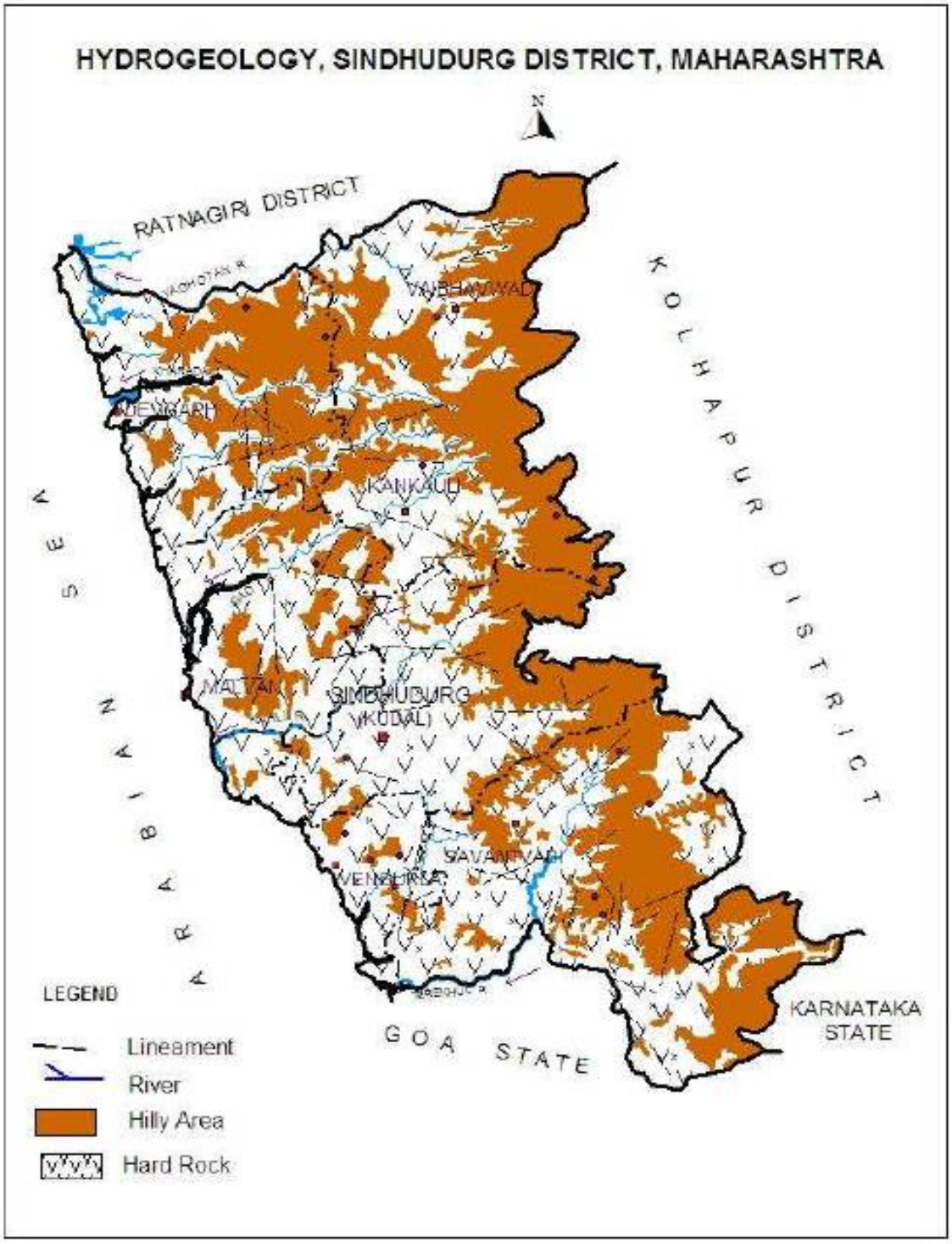

Figure 3: Hydrogeology

1.4.4 Aquifer Parameters

As mentioned earlier, CGWB has not carried out any deep exploratory drilling in Sindhudurg district and as such no data is available on aquifer parameters of deeper aquifer. The aquifer parameters are available from dug well pumping tests conducted during previous studies by CGWB. The summarized results of pumping test are given in Table-3. The specific capacity ranges from 3.38 to 424.57 lpm/m of drawdown, transmissivity ranges from 5.58 to 375.22m2/day, whereas permeability varies from 4.28 to 425.22 m/day.

Following table comprises of Aquifer Parameters:

Sr. No.	Aquifer	Specific Capacity (lpm/m of dd)	Transmissivity (m2ay)	Permeability (m/day)
1.	Laterite	79.10 to 424.57	46.59 to 375.22	7.40 to 425.22
2.	Fractured basalt	3.38 to 51.44	5.58 to 28.95	4.28 to 24.85

1.4.5 Yield of Wells

The yields of the wells are the functions of the permeability and transmissivity of aquifer encountered and vary with thickness of the aquifer zone encountered, location, diameter and depth etc. Ground water in the area is being developed by two type of abstraction structures i.e., borewells and dugwells.

However dugwells are the main ground water abstraction structures in the district. Majority of dugwells in the district are basically used for domestic purpose. Some of the dugwells with good yield are fitted with centrifugal pumps which are used for irrigation purpose and some with submersible pumps for piped water supply schemes. Generally dugwells with rope and pulley as well as Persian wheel are used for domestic purpose.

The yield of dugwells in Coastal Alluvium ranges from 2 to 5 m3/day, in Deccan Trap it varies from 0.50 to 4.00 m3/day, in Kaladgis it varies between 2 and 5 m3/day, whereas in Metamorphics it ranges between 2 and 3 m3/day. The depth of the dugwells in all the formations is shallow up to 13 m bgl. The wells located in topographic lows have better yield than located elsewhere. However, the yield of the dugwells is more during post-monsoon period and declines with the approach of summer.

The borewells are mainly constructed for rural water supply. The successful borewells are fitted with hand pumps and those with high yield are fitted with power

pumps. The yield of the borewells drilled by Groundwater Survey and Development Agency (GSDA) ranges between 500 to 9315 lph, whereas the depths of the borewells range between 45 and 70 m bgl. The formation-wise depth and yield of dugwells and borewells are given in the following Table.

Tablulated Yield of Dugwells and Borewells:

S. No.	Formation	Dugwells		Borewells	
		Depth (m bgl)	Yield (m^3/day)	Depth (m bgl)	Yield (lph)
1	Coastal Alluvium	2.00 to 11.80	2 to 5	---	--
2	Deccan Trap	8.00 to 13.50	0.5 to 4	45 to 65	500 - 770
3	Kaladgis	3.80 to 10.00	2 to 5	50 to 60	500 - 9315
4	Metamorphics	3.00 to 11.50	2 to 3	50 to 70	500 – 7770

2.0 AIMS AND OBJECTIVES

2.1 Aim

The aim of this project is to carry out groundwater exploration and locate potential bore well points within the premises of Falshewadi.

2.2 Objective

The main objective of the survey is to delineate the aquifer zones and suggest best locations suitable to construct groundwater extraction & recharge. The survey will form a basis for Water Master Planning, for Falshewadi.

2.3 Scope of Work

The work involves carrying out a geophysical investigation survey which comprises the following:

- Mobilization of machinery and manpower to carry out geophysical investigation.
- Running Multi Frequency - EM Profiling in the 10 Acres work area.
- Demarcation of the Anomalous points in the field area.
- Data Analysis.
- Preparation and Submission of Geophysical Survey Report.

3.0 METHODOLOGY

The Geophysical method adopted to survey the area was Multi Frequency Electromagnetic (MF-EM) profiling, which gives the lateral variation in the resistivity of the ground.

3.1 VLF –EM method

VLF – EM Geophysical instrument finds physical structures in the ground and bed rock. VLF – EM instrument operates on the VLF principle and it makes use of radio waves in the VLF band sent out from distant transmitters. VLF –EM instrument utilizes the magnetic components of the electromagnetic field generated by military radio transmitters that use the VLF frequency band (Very Low Frequency 15 – 30 KHz). They are used mostly for the long distance communication.

Electrically conductive structures on the surface or under-ground even when covered with thick over burden, affect locally the direction and strength of the field generated by the transmitted radio signal. A weak secondary field builds up around the geological structure. This field can be measured and analyzed. This VLF-EM instrument measures the field strength and Phase displacement around a fractured zone in the rock. When the electromagnetic field from a VLF transmitter passes through a conductive body, secondary currents will grow up in the body. This is the principle of induction. These secondary currents will in turn generate a magnetic field, a secondary field which will try to repel the primary field. Only a body with a low electrical resistivity can generate secondary fields.

3.1.1. Methodology of Survey:

Field:

1) Marking of the VLF profiles on the field in a grid pattern.
2) Carry out VLF EM survey in the area under investigation on a grid pattern.
3) Marking of the anomalous spots on the ground surface with proper labeling.
4) GPS marking of the anomalous points on the site.

Interpretation:

1) From detailed interpretation recommend preferential order for drilling of the demarcated points.
2) Preparation of the Geophysical report.
3) Plotting of the marked points with preferential order on the layout plan of the area.
4) Compilation and final submission of the report.

4.0 FIELD OBSERVATIONS AND DATA ANALYSIS

Multi Frequency Electromagnetic (MF- EM) profiles in the North-South, East-West directions were carried out in the area. A total of 13 electromagnetic profiles namely L179, L180, L181, L182, L183, L184, L185, L186, L187, L188, L189, L190 & L191 were carried out in the area.

The MF-EM profile details and 16 anomalous spots marked are mentioned in the table as follows:

Sr. No.	Site No. /Area	Profile No.	Total Profile Length (m)	Point Name	Distance (m) from zero of each profiles
1	I	L179	15	P1	120
2	I	L179	35	P2	120
3	I	L180	5	P3	80
4	I	L180	35	P4	80
5	I	L181	-	-	30
6	I	L182	15	P5	100
7	I	L182	35	P6	100
8	I	L182	55	P7	100
9		L183	15	P8	60
10	I	L183	35	P9	60
11	I	L184	25	P10	100
12	I	L184	35	P11	100
13	I	L184	85	P12	100
14	I	L185	5	P13	40
15	I	L185	25	P14	40
16	I	L186	-	-	40
17	I	L187	-	-	40
18	I	L188	-	-	30
19	I	L189	25	P15	70
20	I	L190	15	P16	50
21	I	L191	-	-	40

Also 4 Vertical electrical soundings were carried out. The details of the VES is as follows:

Sr. No.	VES NO.	TOTAL LENGTH	LOCATION
1	VES 1	80m	Chinchecha Dob (Tambal)
2	VES 2	100m	Along Nala Nr. Brahman dev Temple
3	VES 3	100m	Near Well outside Ashok Rane's House
4	VES 4	85m	On point P7

VES - 001

VERTICAL ELECTRICAL SOUNDING DATA

Dist AB/2 (m)	MN /2 (m)	App. Resistivity (Ω-m)
1.5	0.5	361.43
2	0.5	403.07
3	0.5	365.75
5	0.5	280.03
8	0.5	300.54
10	0.5	373.07
12	0.5	449.53
15	0.5	608.88
20	0.5	812.86
25	0.5	1024.95
30	0.5	1119.80
40	0.5	1402.75
50	0.5	1728.40
60	0.5	2217.45
70	0.5	2848.85
80	0.5	3439.41

VES - 002

VERTICAL ELECTRICAL SOUNDING DATA

Dist AB/2 (m)	MN /2 (m)	App. Resistivity (Ω-m)
1.5	0.5	106.86
2	0.5	98.29

3	0.5	83.60
5	0.5	86.73
8	0.5	97.77
10	0.5	123.52
12	0.5	140.51
15	0.5	201.31
20	0.5	290.22
25	0.5	375.03
30	0.5	463.76
40	0.5	643.56
50	0.5	763.64
60	0.5	846.25
70	0.5	883.91
80	0.5	939.30
100	0.5	1074.83

VES - 003

VERTICAL ELECTRICAL SOUNDING DATA

Dist AB/2 (m)	MN /2 (m)	App. Resistivity (Ω-m)
1.5	0.5	289.14
2	0.5	238.07
3	0.5	180.68
5	0.5	191.35
8	0.5	276.49
10	0.5	342.97
12	0.5	377.90
15	0.5	845.64
20	0.5	986.32
25	0.5	760.32
30	0.5	1030.79
40	0.5	1408.10
50	0.5	1726.34
60	0.5	1773.40
70	0.5	1708.65
80	0.5	1735.73
100	0.5	289.14

VES - 004

VERTICAL ELECTRICAL SOUNDING DATA

Dist AB/2 (m)	MN /2 (m)	App. Resistivity (Ω-m)
1.5	0.5	289.14
2	0.5	238.07
3	0.5	180.68
5	0.5	191.35
8	0.5	276.49
10	0.5	342.97
10	2	377.90
15	2	845.64
20	2	986.32
30	2	760.32
40	2	1030.79
50	2	1408.10
60	2	1726.34
70	2	1773.40
80	2	1708.65
100	2	1735.73

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions:

1. The recommended diameter of recharge well is 6 ½" inches. If enough space for setting up drilling rig is not available then 4 ½" inches diameter well is recommended.
2. The recommended depth for drilling is around 100 meters.
3. Few major fractures/joints detected. Many minor fractures/joints detected.
4. Based on the analysis of the obtained data the preferential locations in descending order are mentioned as follows:
5. If there is no proper access for the borewell vehicle to reach the drilling point than in-well drilling technology may be used.
6.

Based on the analysis of the obtained data the preferential locations in ascending order are mentioned as follows:

Sr. No.	Site No. /Area	Profile No.	Point Name	Preferences	Geo-reference
1	I	L182	P7	1	Lat: 16°15'38.4" Long: 73°39'26.3"
2	I	L182	P6	2	Lat: 16°15'37.7" Long: 73°39'26.5"
3	I	L182	P5	3	Lat: 16°15'37.3" Long: 73°39'26.6"
4	I	L183	P9	4	Lat: 16°15'38.2" Long: 73°39'274"
5	I	L184	P12	5	Lat: 16°15'37.0" Long: 73°39'28.4"
6	I	L179	P1	6	Lat: 16°15'34.7" Long: 73°39'26.0"
7	I	L179	P2	7	Lat: 16°15'35.3" Long: 73°39'25.9"
8	I	L183	P8	8	Lat: 16°15'37.9" Long: 73°39'26.8"
9	I	L180	P3	9	Lat: 16°15'37.7" Long: 73°39'24.7"
10	I	L180	P4	10	Lat: 16°15'38.1" Long: 73°39'25.6"
11	I	L185	P14	11	Lat: 16°15'37.3" Long: 73°39'29.0"
12	I	L184	P10	12	Lat: 16°15'38.4" Long: 73°39'27.5"

13	**I**	**L184**	**P11**	**13**	**Lat: 16°15'37.9" Long: 73°39'27.6"**
14	**I**	**L185**	**P13**	**14**	**Lat: 16°15'36.8" Long: 73°39'28.6"**
15	**I**	**L190**	**P16**	**15**	**Lat: 16°15'39.3" Long: 73°39'25.0"**
16	**I**	**L189**	**P15**	**16**	**Lat: 16°15'42.8" Long: 73°39'30"**

5.2 Recommendations:

Based on the data acquired by multi frequency electromagnetic profiling (MF-EM) it can be inferred that the area is consists of a few major fracture zones. Thus, few major fractures zones were encountered. The existing fractures recorded, are trending mainly in two directions, North West - South east and North east – South west.

The fracture is identified at 8-10 m depth bgl, 45 - 55 m depth bgl , 65 – 95m depth bgl. The area is covered with lateritic clayey soil. The Basement rock is identified as Basalt and is encountered at a depth of 3-6 m bgl. The expected yield of the bore well will be minimum 900 to 1200 liters/hr.

The basement rock in the study area is very compact and hard. It is very feebly fractured. Very few number of fractures were detected in the area. The bore wells are suggested only at points P7, P6 and P5. As all the three points are on same fracture any one point is suggested for drilling and in that case P7 is the best. All the other points are good for open well. There is a good shallow water zone. But there are possibilities of the open well going dry in summers.

Rainwater harvesting seems to be the best solution in this area in order to increase the groundwater reserves. In this case the existing fractures contain moderate quantities of groundwater which will be depleted with time if over-exploited, it is advised to implement artificial recharge of groundwater resource via rain water harvesting. Rain water can be made to flow by drilling borehole at point P5 after proper primary filtration of the rain water with the help of gravel & sand filter media. This will enhance the potential of yielding groundwater of the existing open well as well as help in recharging all the existing fracture zones within the boundary limits by increasing the storage of groundwater in the aquifers thus enhancing the performance of the well specially during the summer months i.e. April and May.

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6.0 ANNEXURE – I

VLF Profiles:

Fig 1.Profile L179

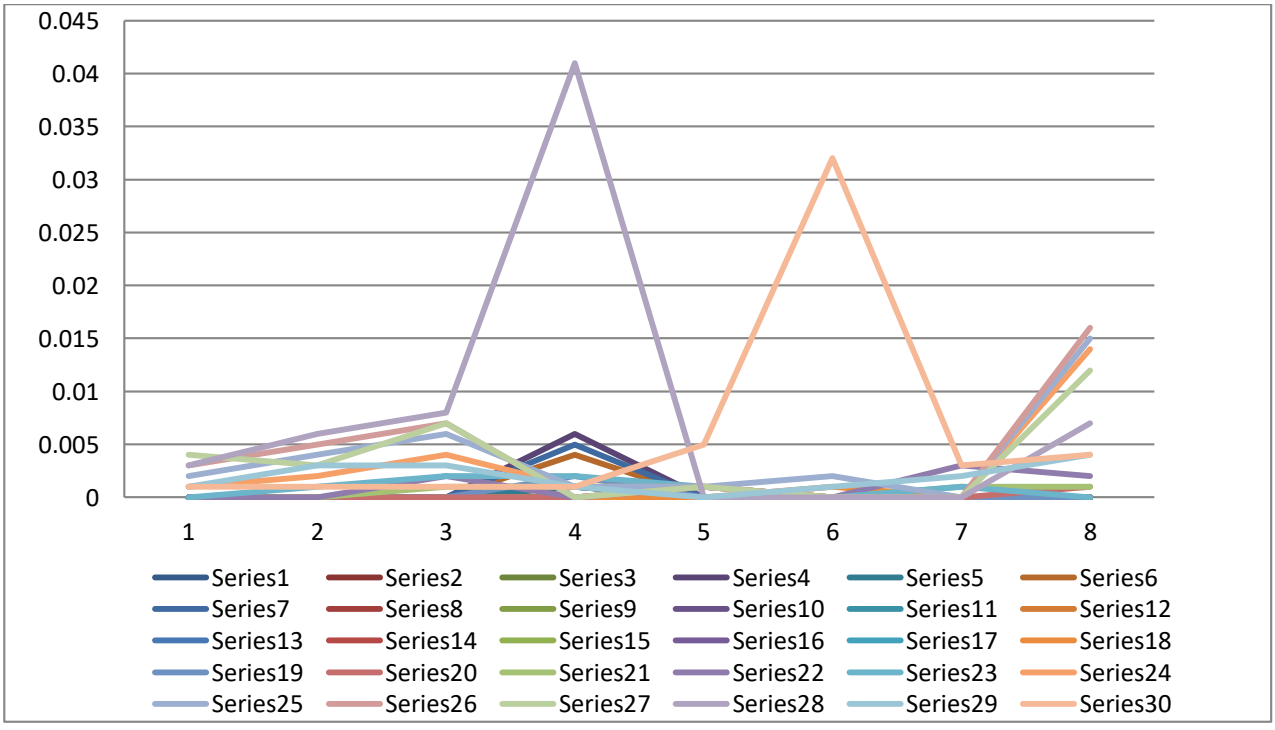


Fig 2. Profile L180

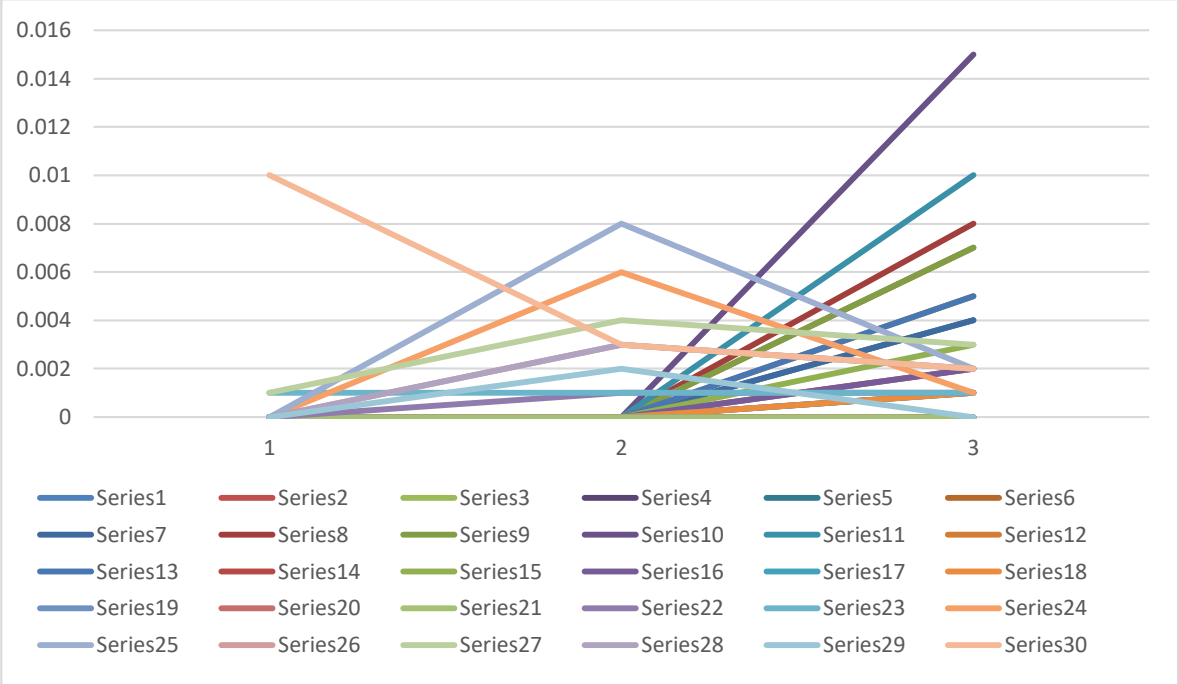


Fig 3. Profile L181

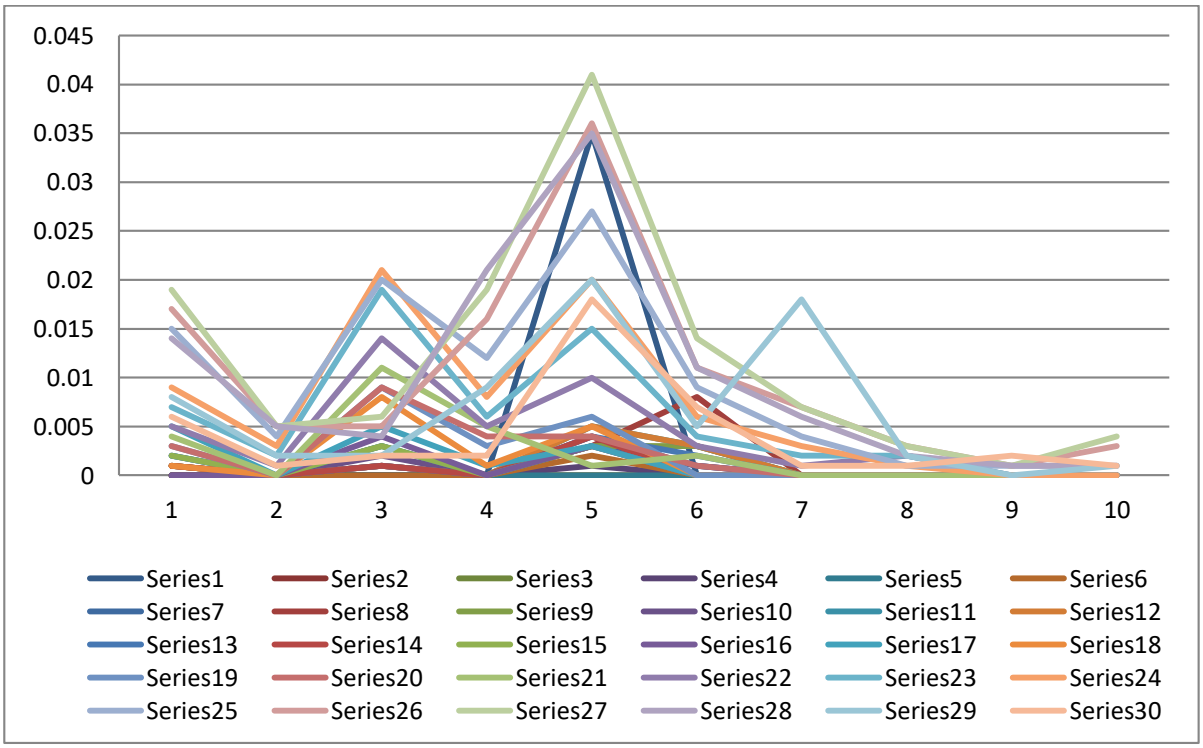


Fig 4. Profile L182

Fig 5. Profile L183

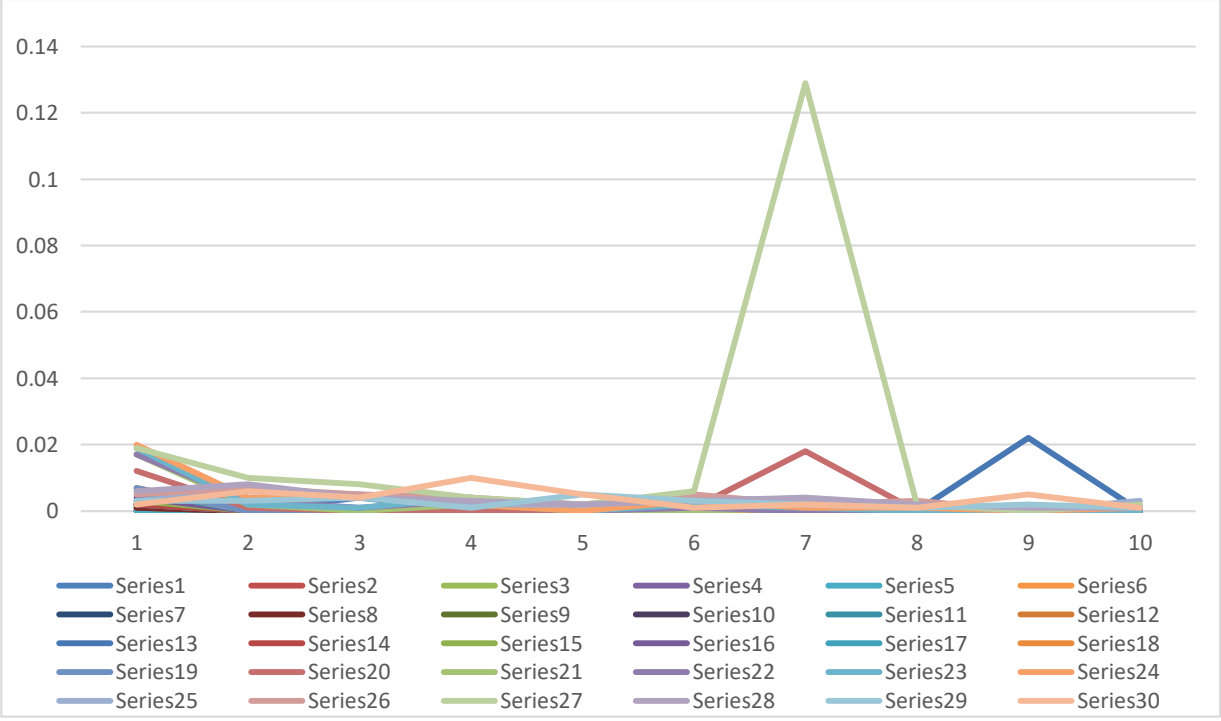


Fig 6. Profile L184

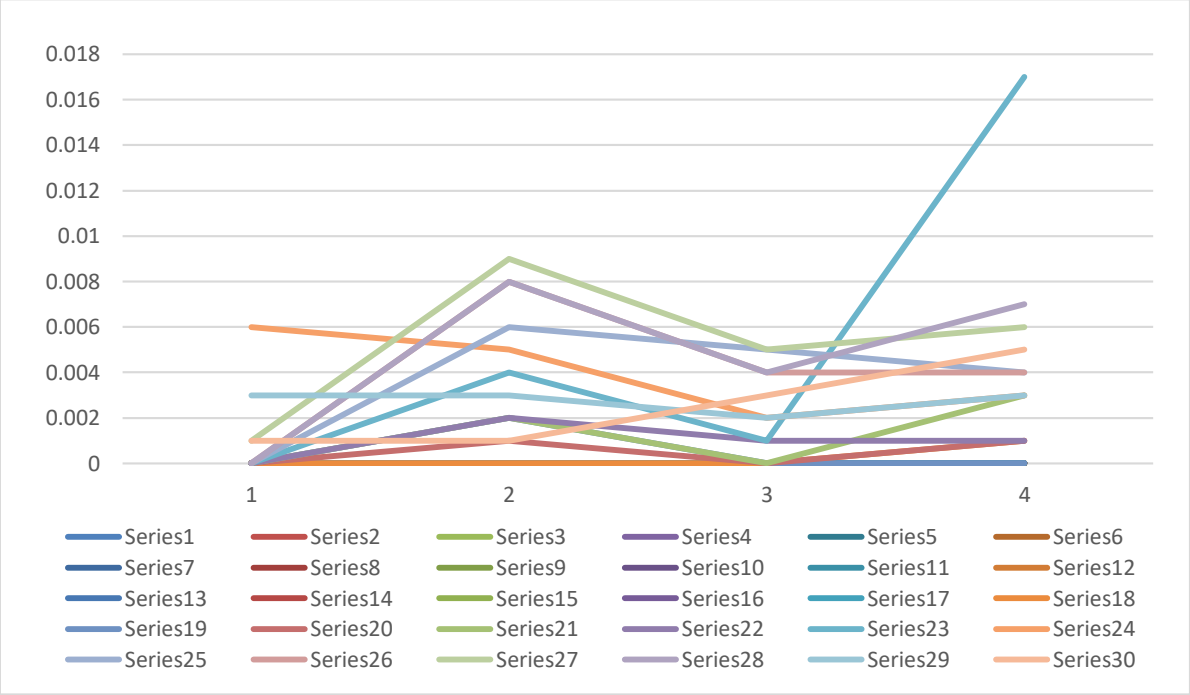


Fig 7. Profile L185

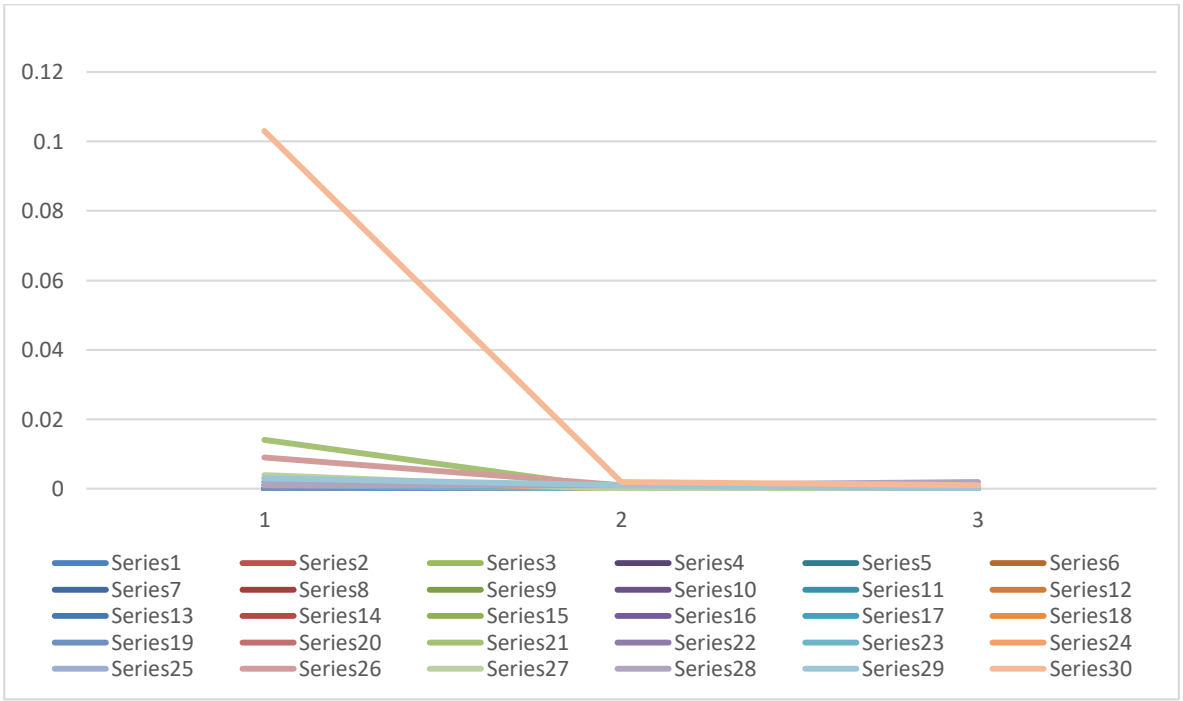


Fig 8. Profile L188

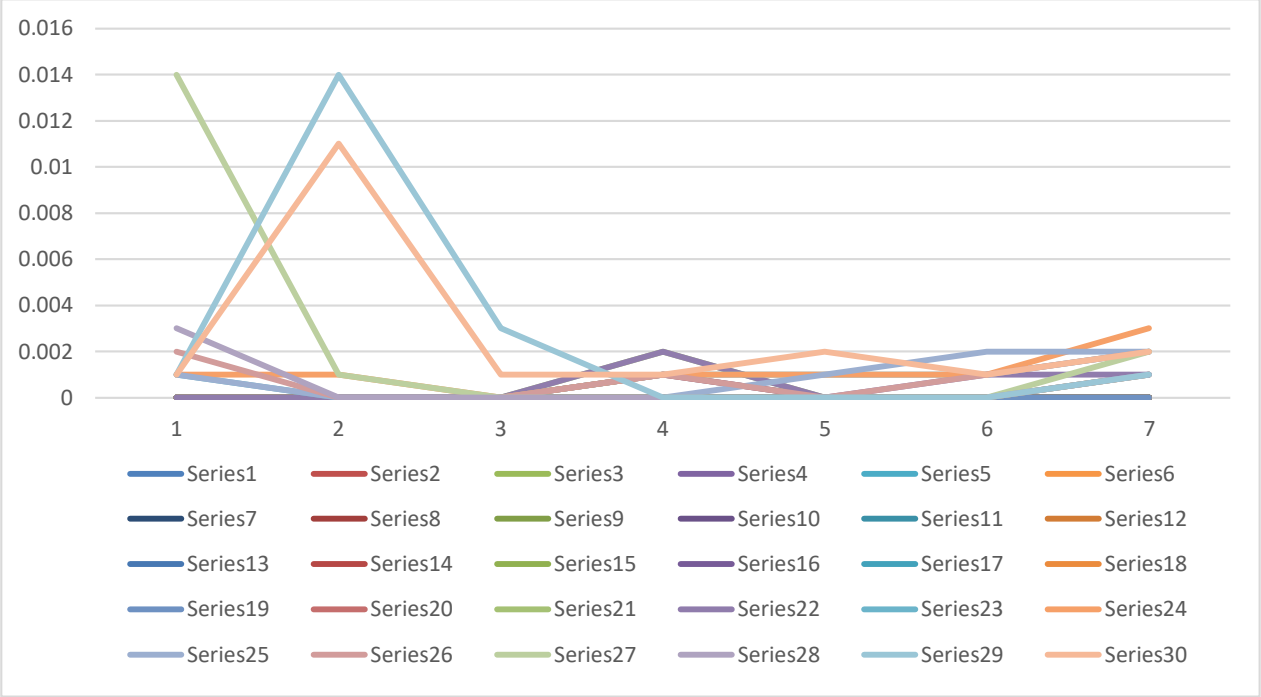


Fig 9. Profile L189

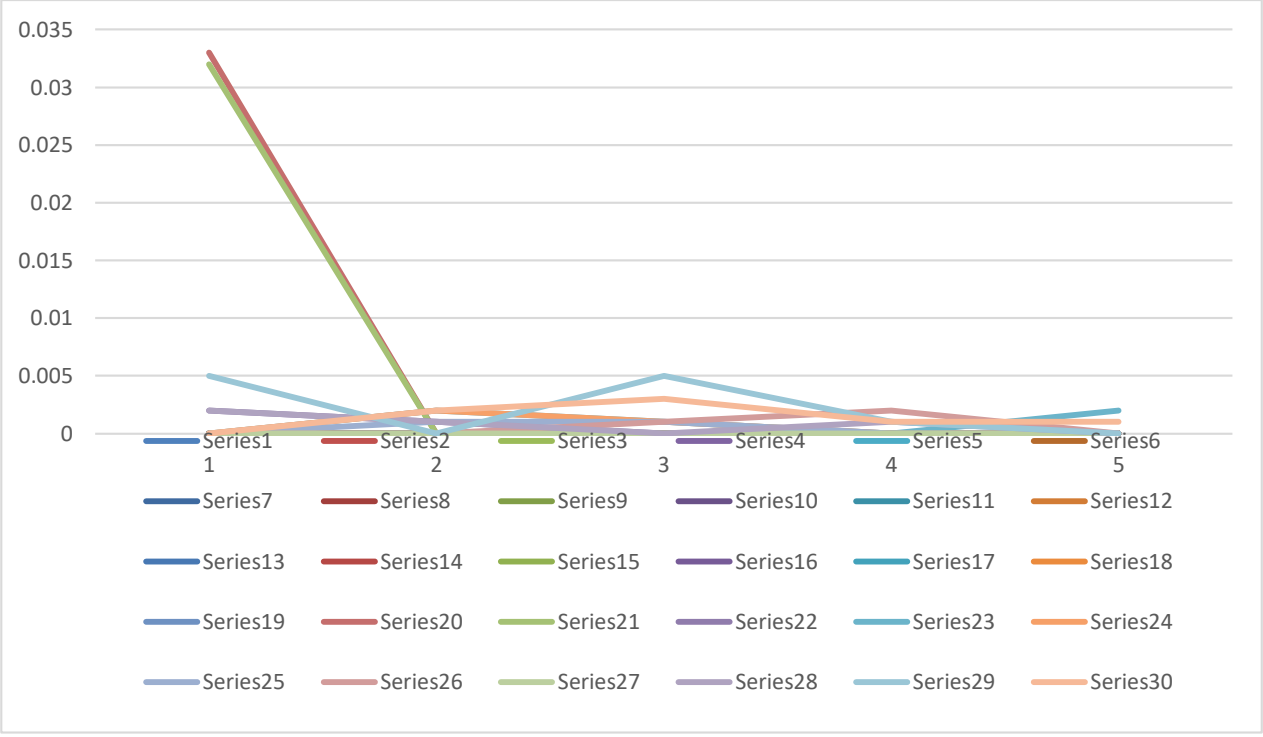


Fig 10. Profile L190

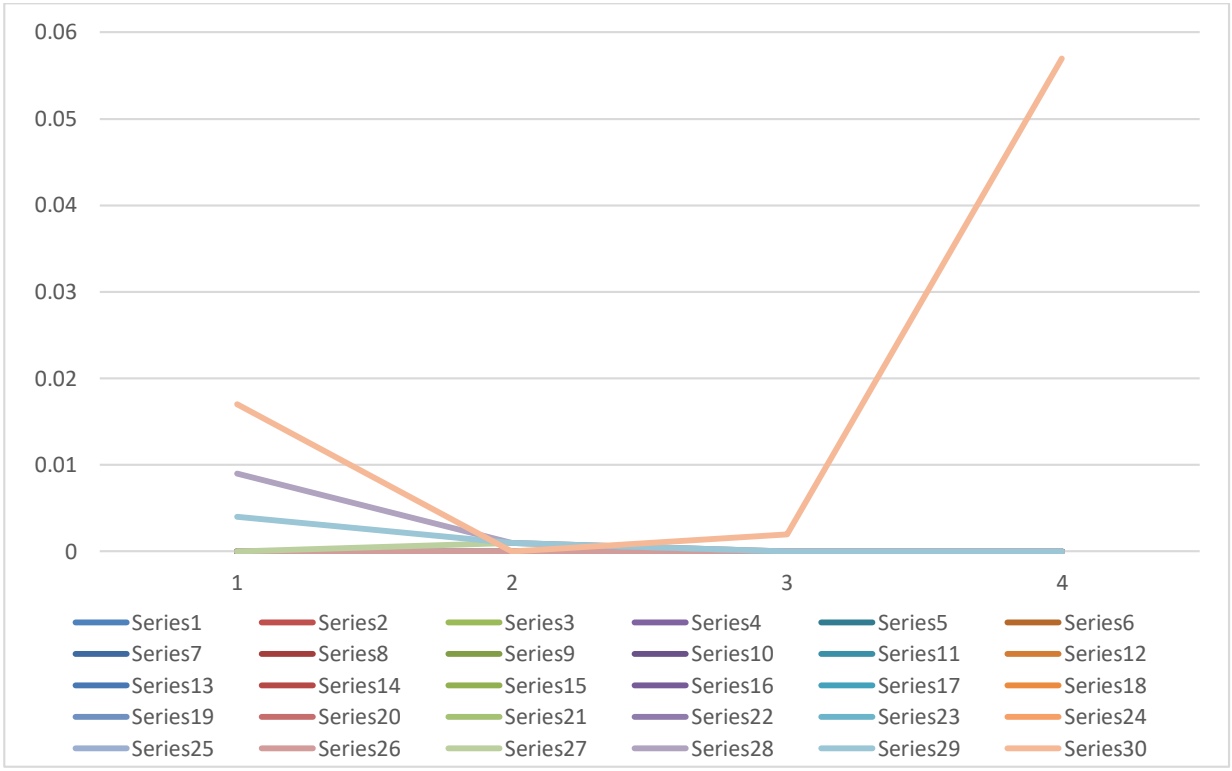


Fig 13. Profile L191

7.0 ANEXURE –II: Vertical Sections of VLF Profiles:

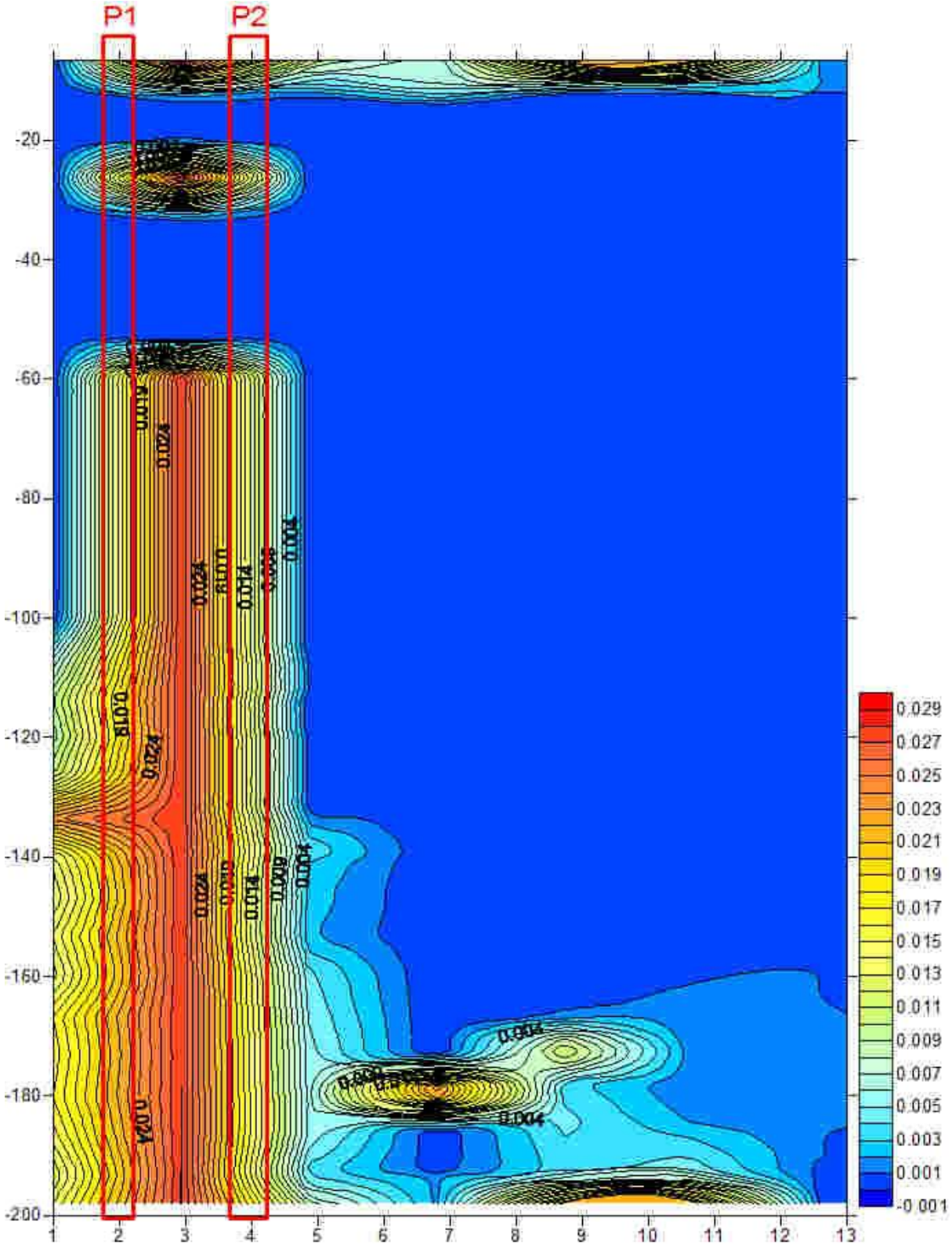


Fig. 18 Vertical Section of Profile E179

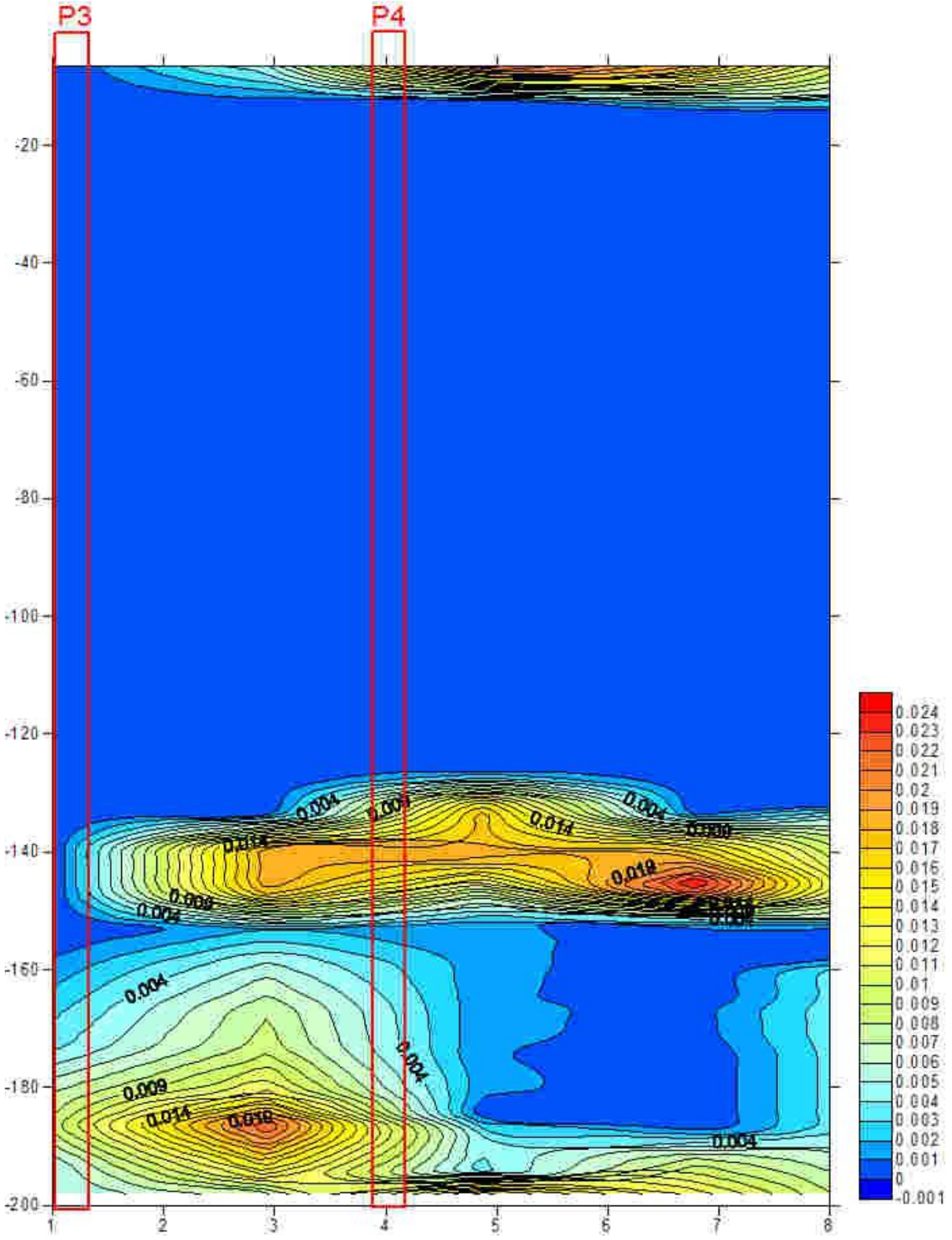


Fig. 19 Vertical Section of Profile L180

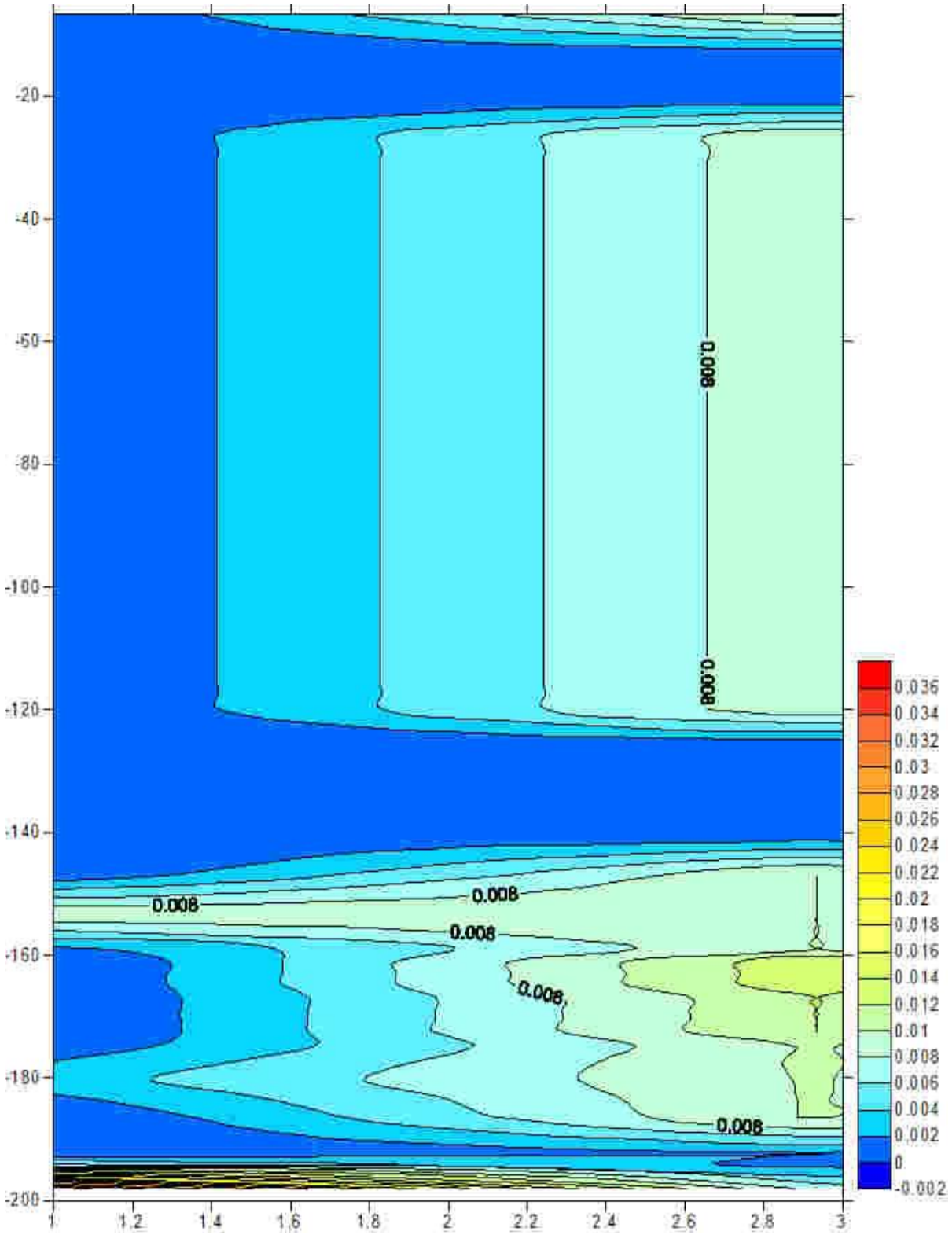


Fig. 20 Vertical Section of Profile L181

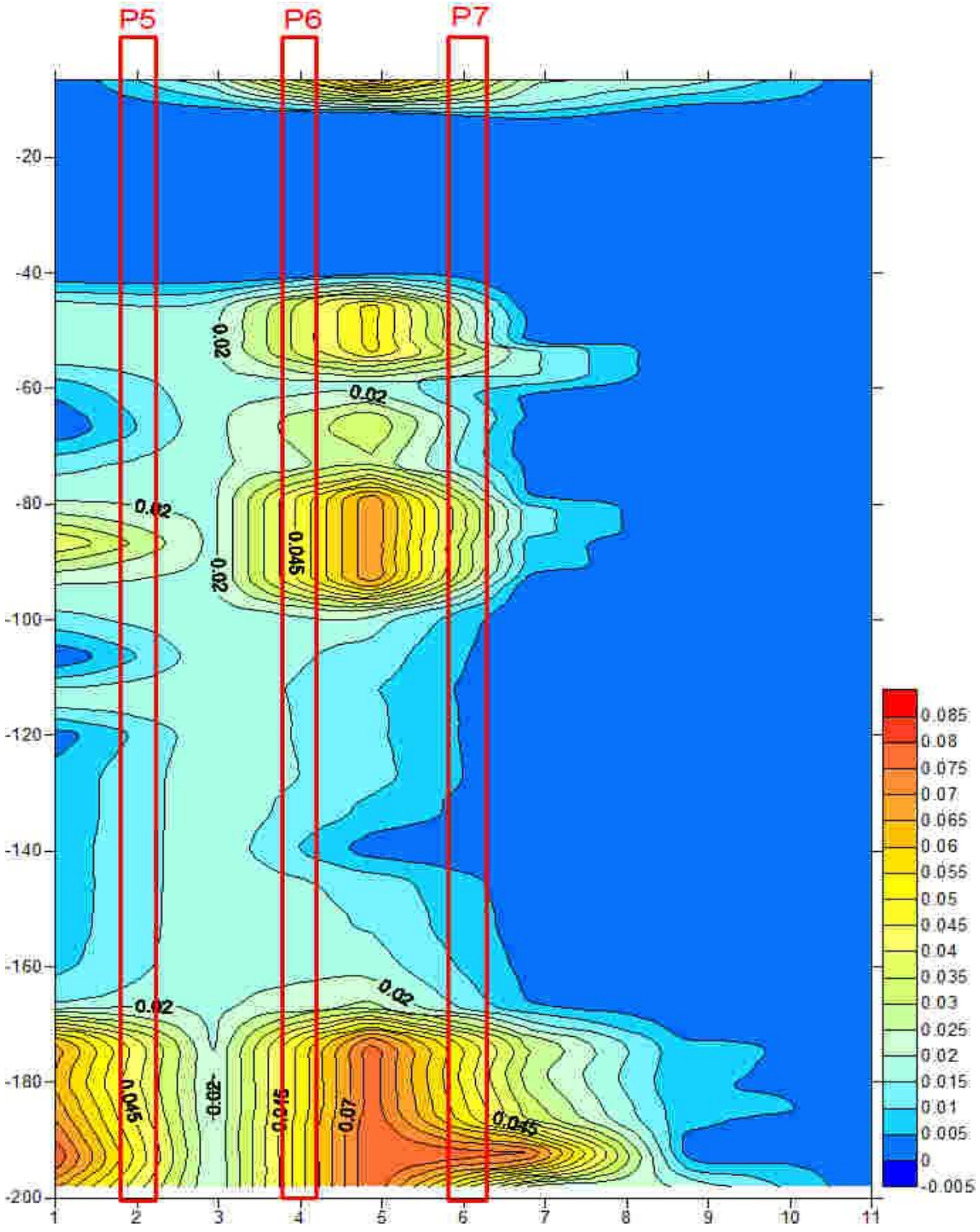


Fig. 21 Vertical Section of Profile L182

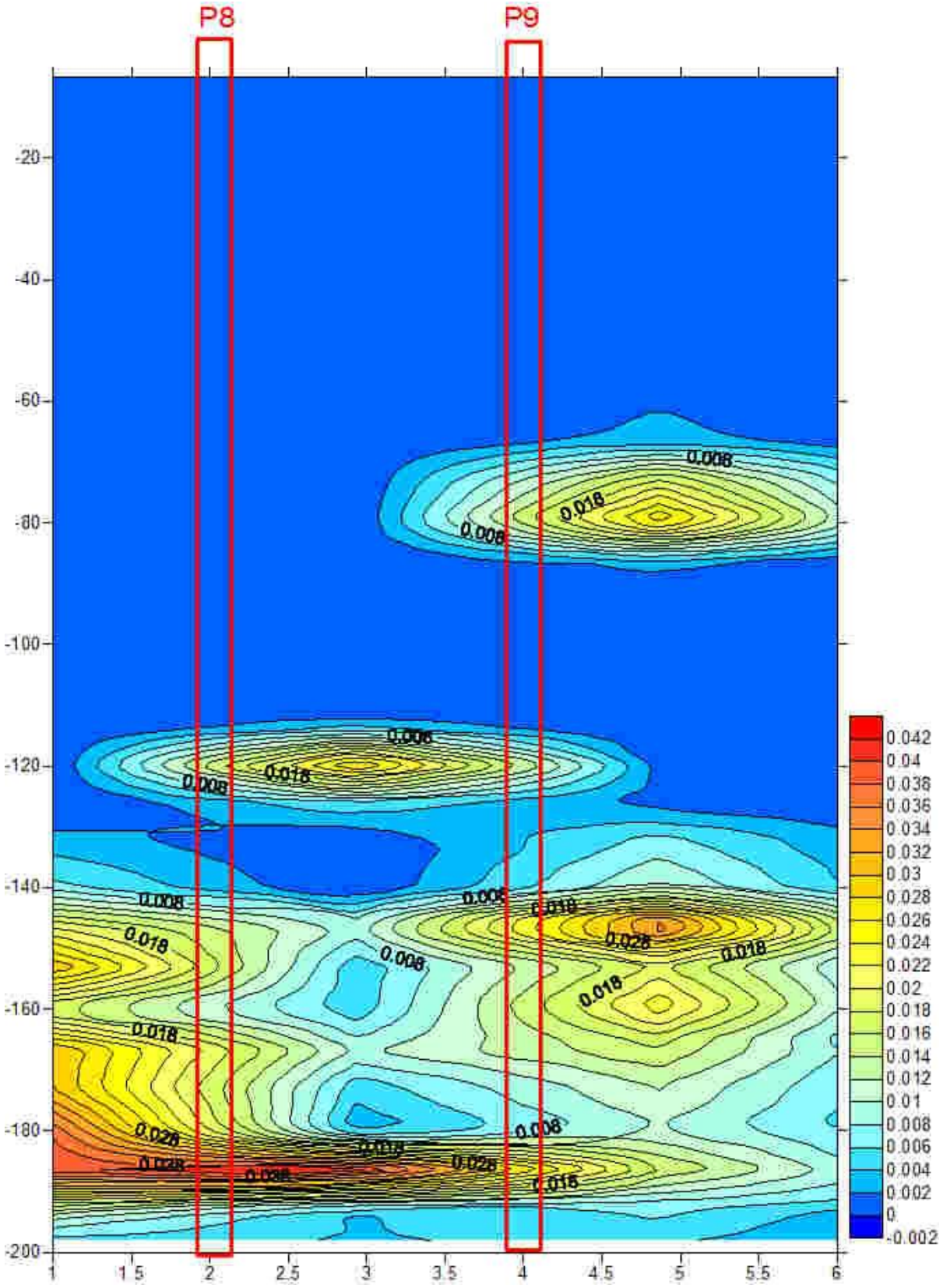


Fig. 22 Vertical Section of Profile L183

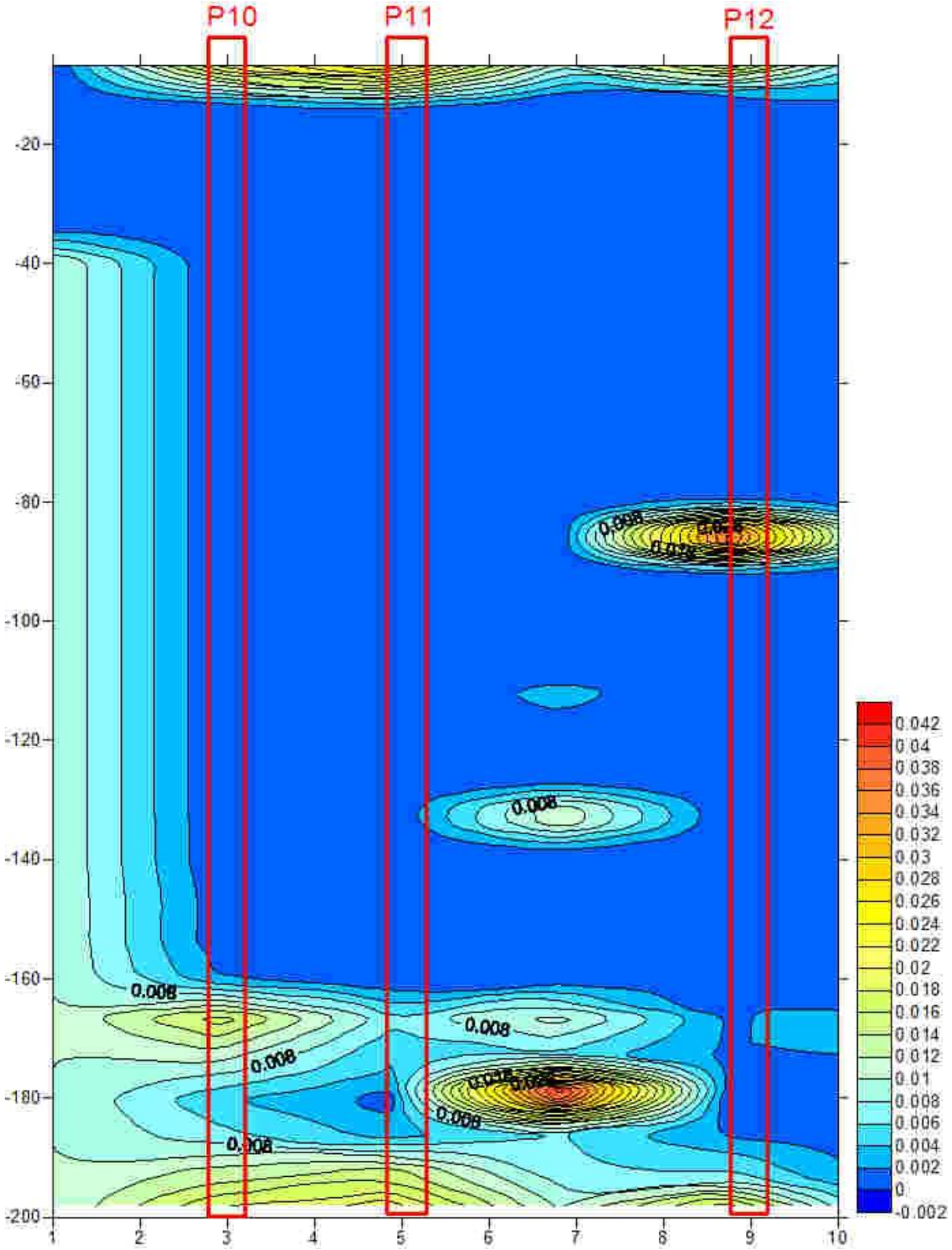


Fig. 23 Vertical Section of Profile L184

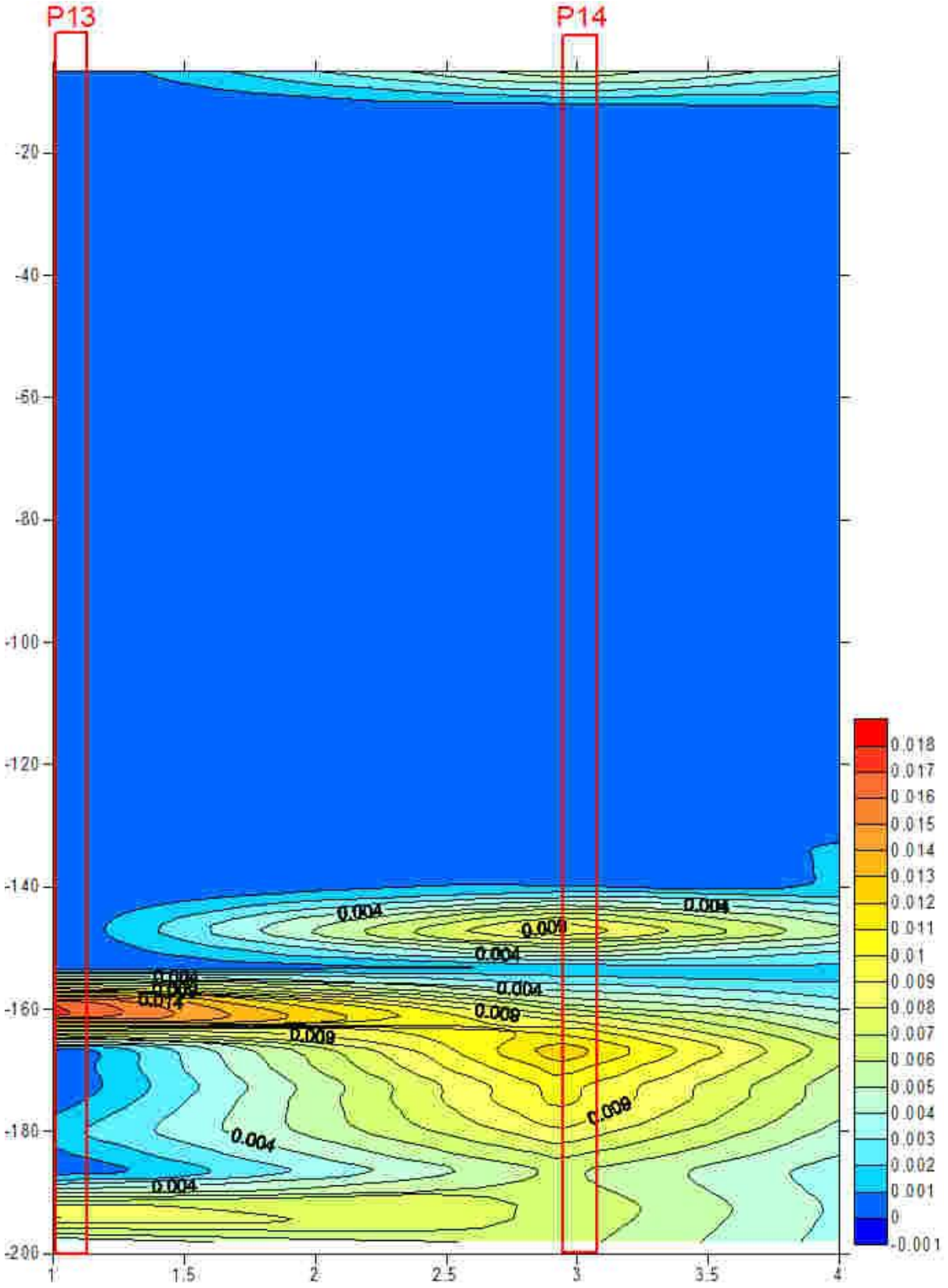


Fig. 24 Vertical Section of Profile L185

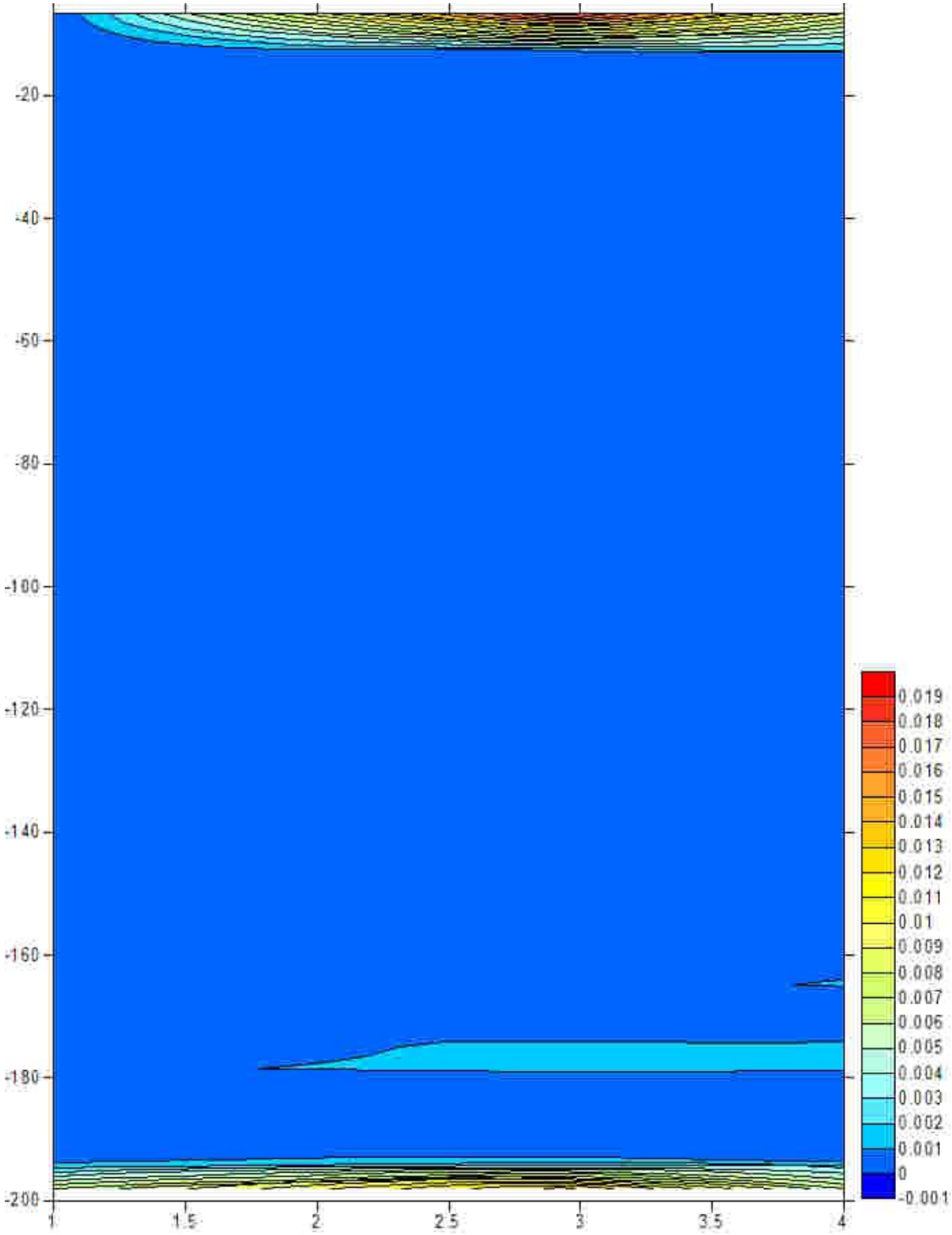


Fig. 25 Vertical Section of Profile L188

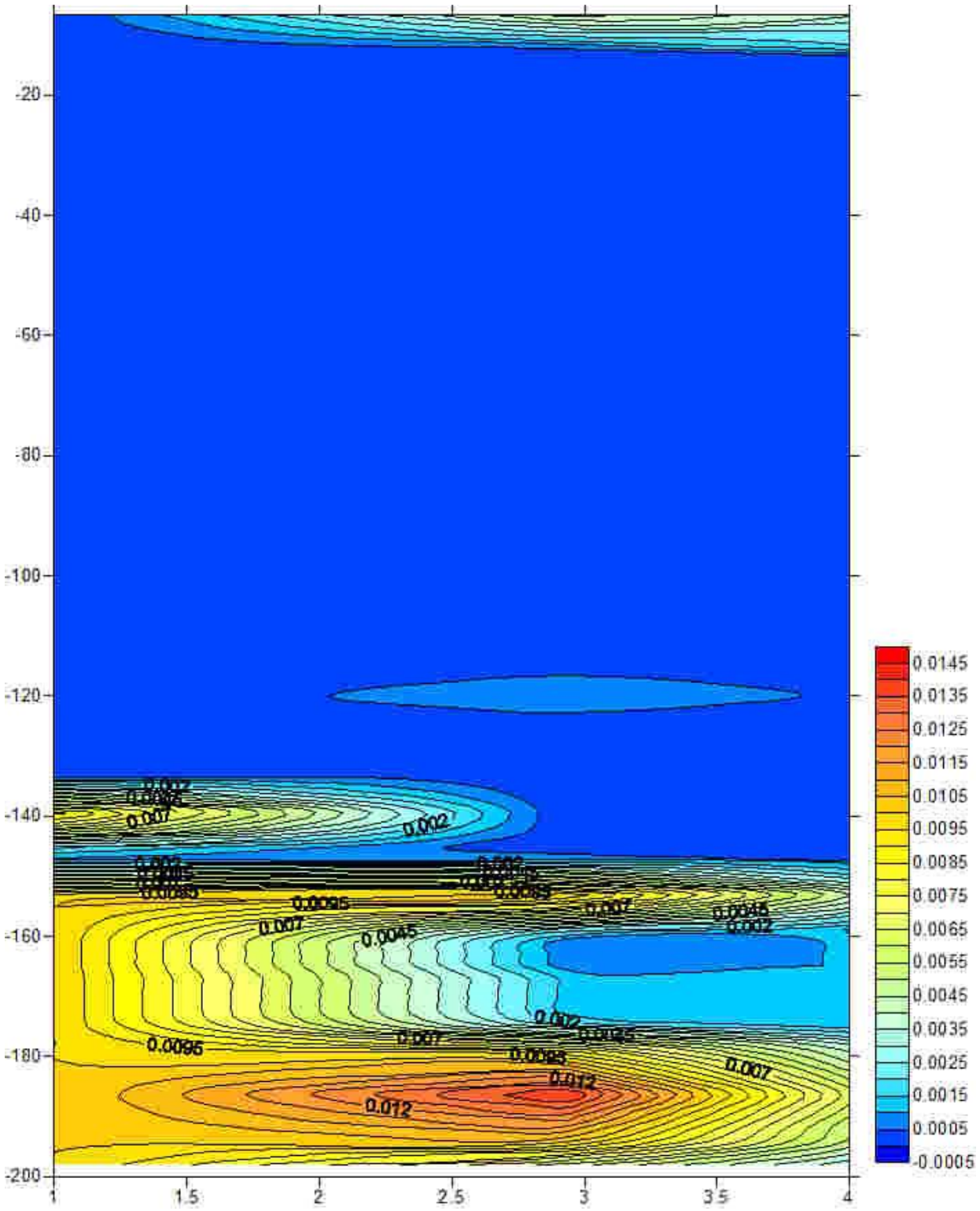


Fig. 26 Vertical Section of Profile L189

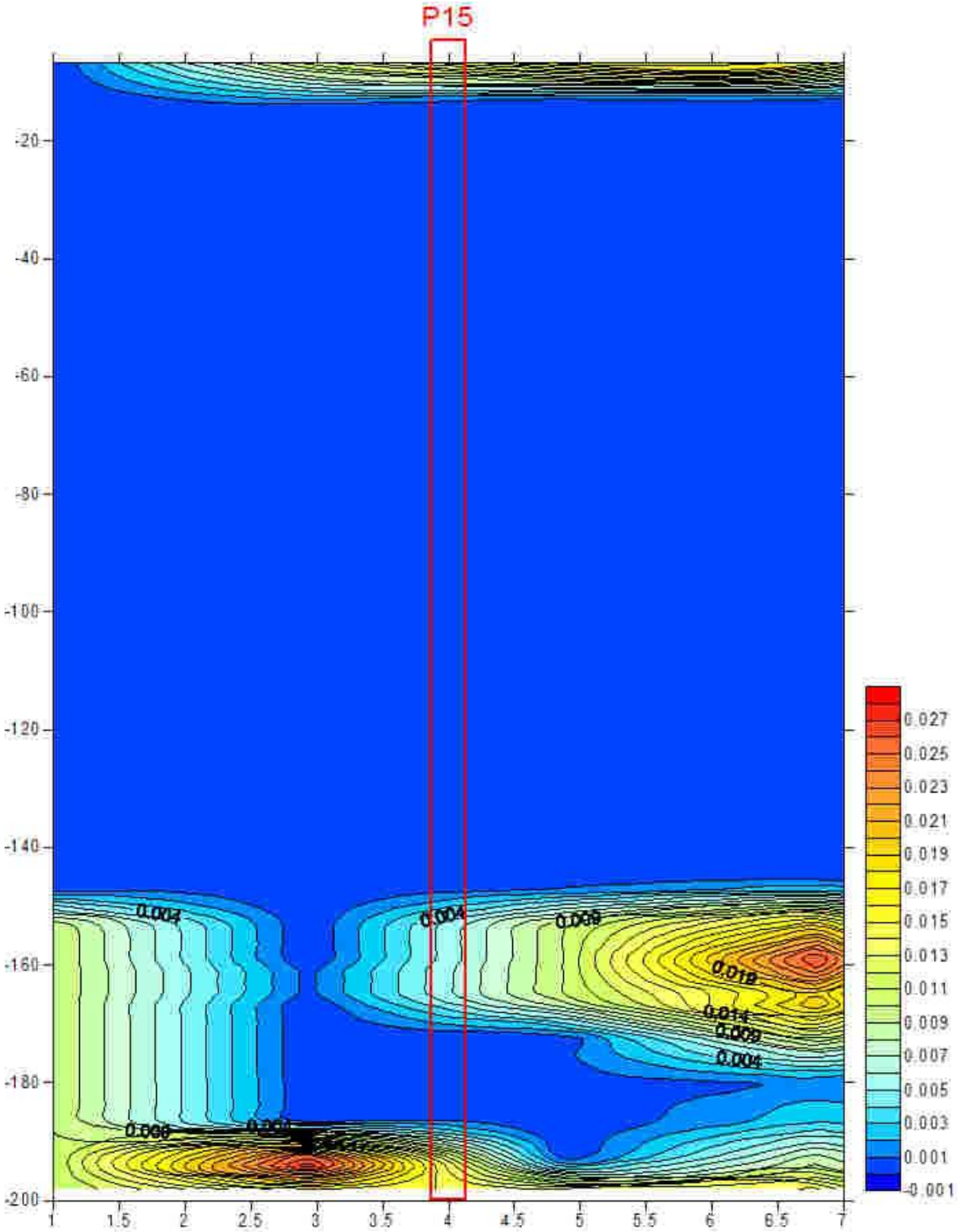

P15
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
0.027
0.025
0.023
0.021
0.019
0.017
0.015
0.013
0.011
0.009
0.007
0.005
0.003
0.001
-0.001

Fig. 28 Vertical Section of Profile L190

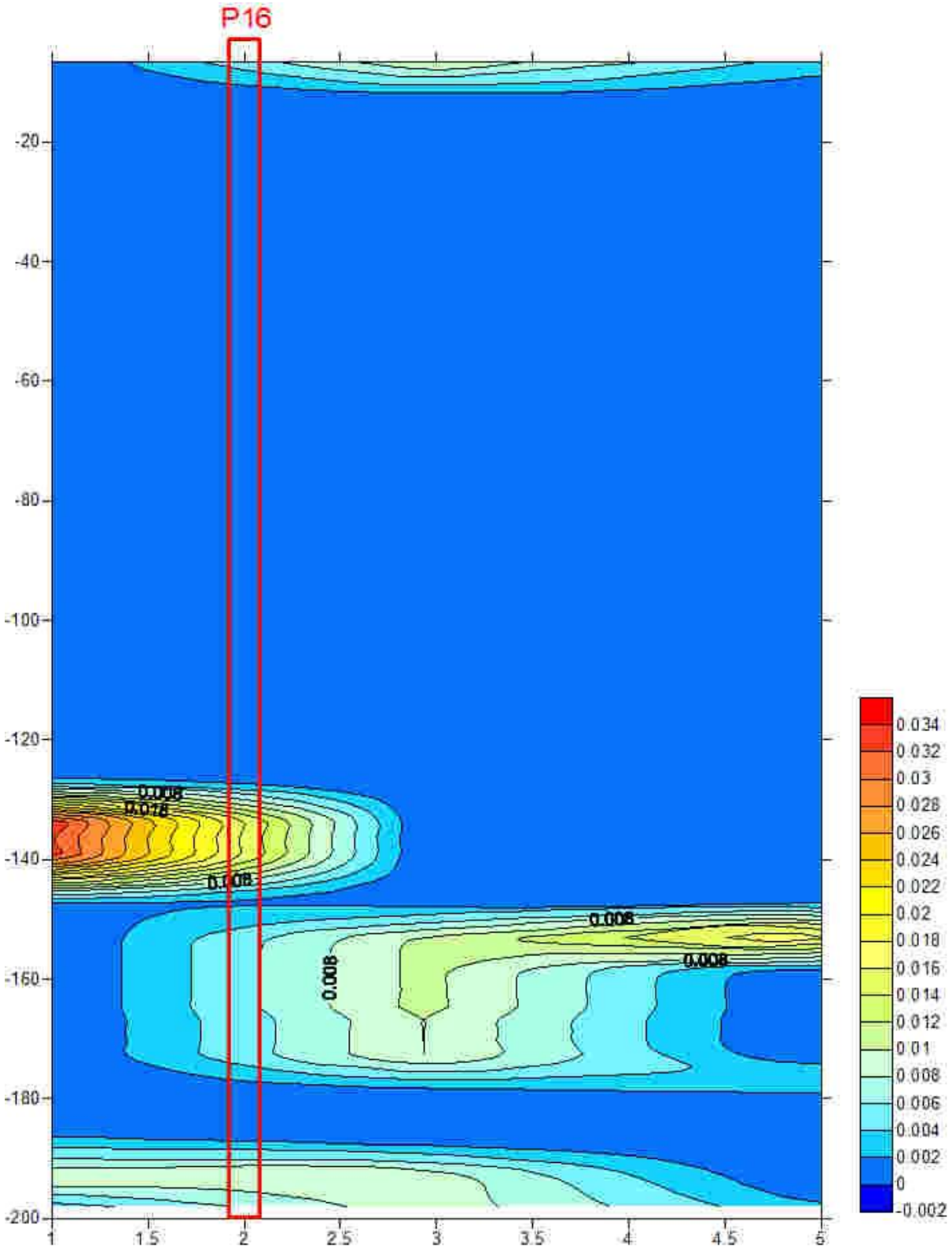
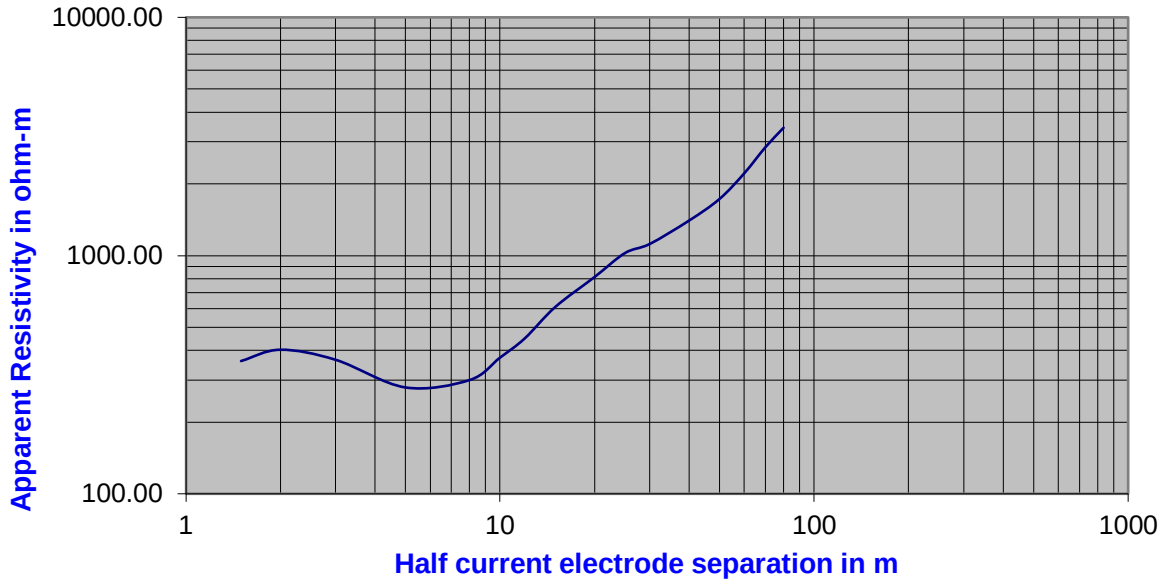


Fig. 29 Vertical Section of Profile L191

8.0 ANEXURE –III: VERTICAL ELECTRICAL SOUNDINGS

Vertical Electrical Sounding Curve V-1



N	True Resistivity (p) in Ohm-m	Thickness of Layer (H) in M	Depth to layer (z) in M
1	116.14	0.87	0/0
2	70.79	0.84	0.87
3	10715	1.34	1.71
4	12302.69		3.04

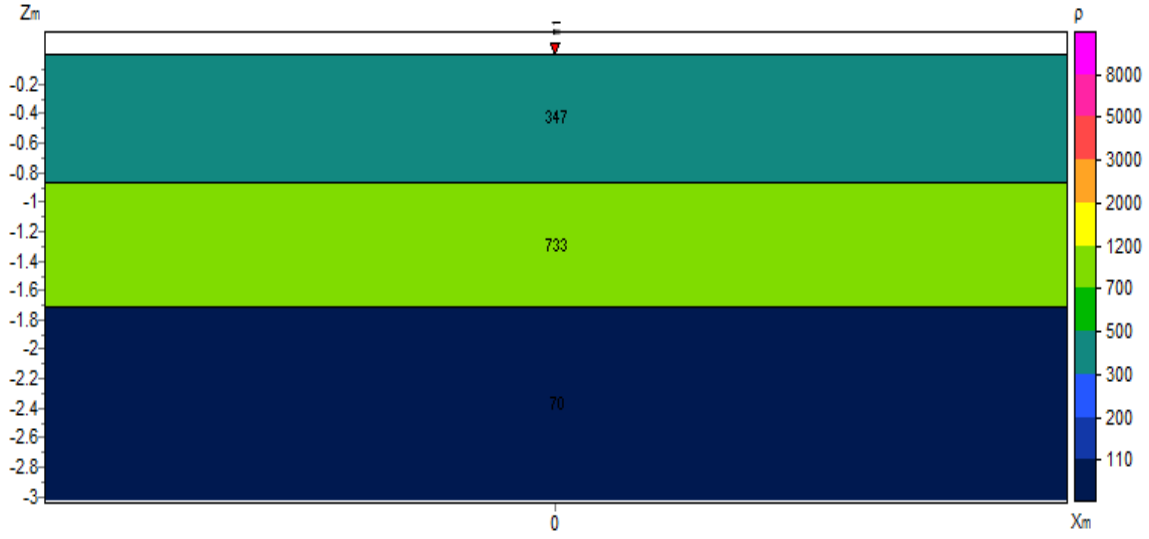
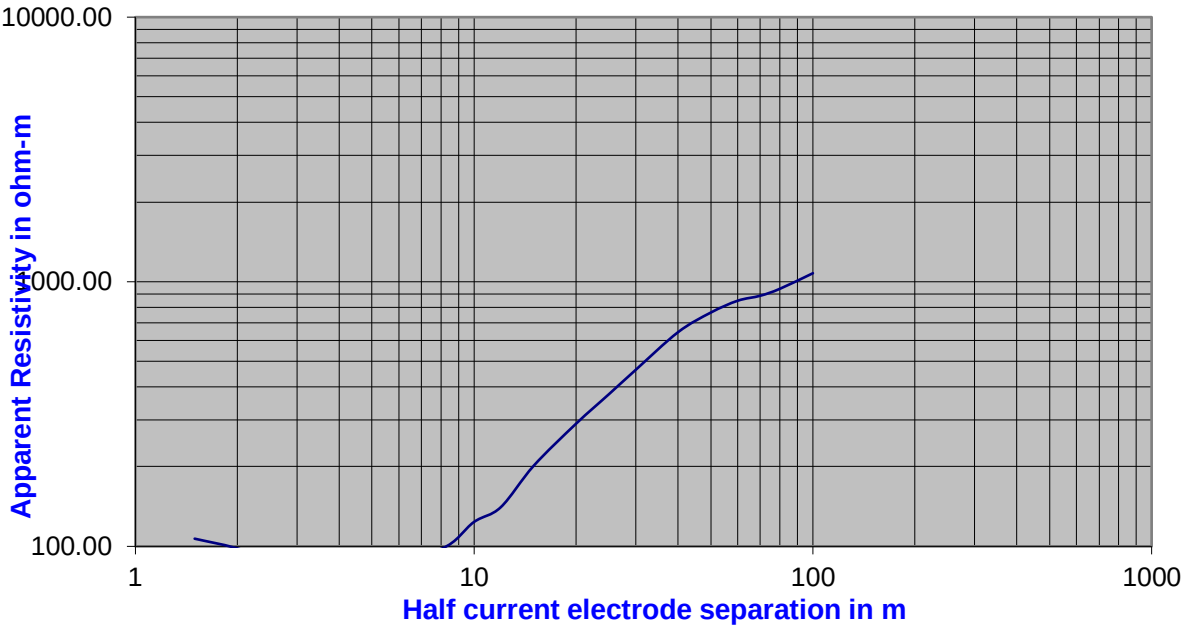


Fig. 30 VES 1 graph, interpretation table and Section

Vertical Electrical Sounding Curve V-2



N	True Resistivity (p) in Ohm-m	Thickness of Layer (H) in M	Depth to layer (z) in M
1	116.14	1.06	0/0
2	70.79	4.53	1.06
3	10715.19		5.59

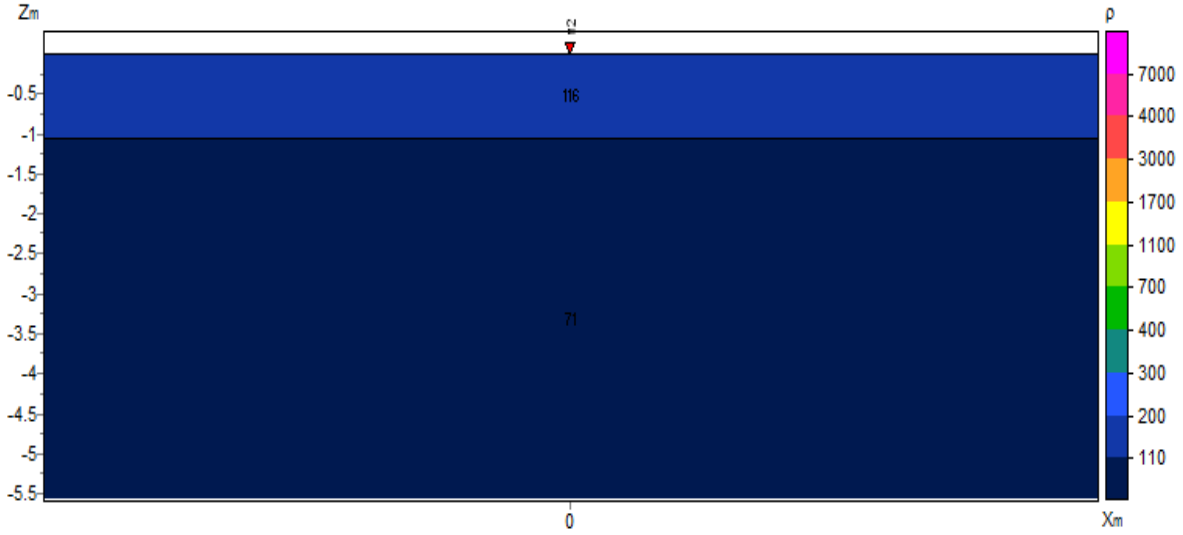
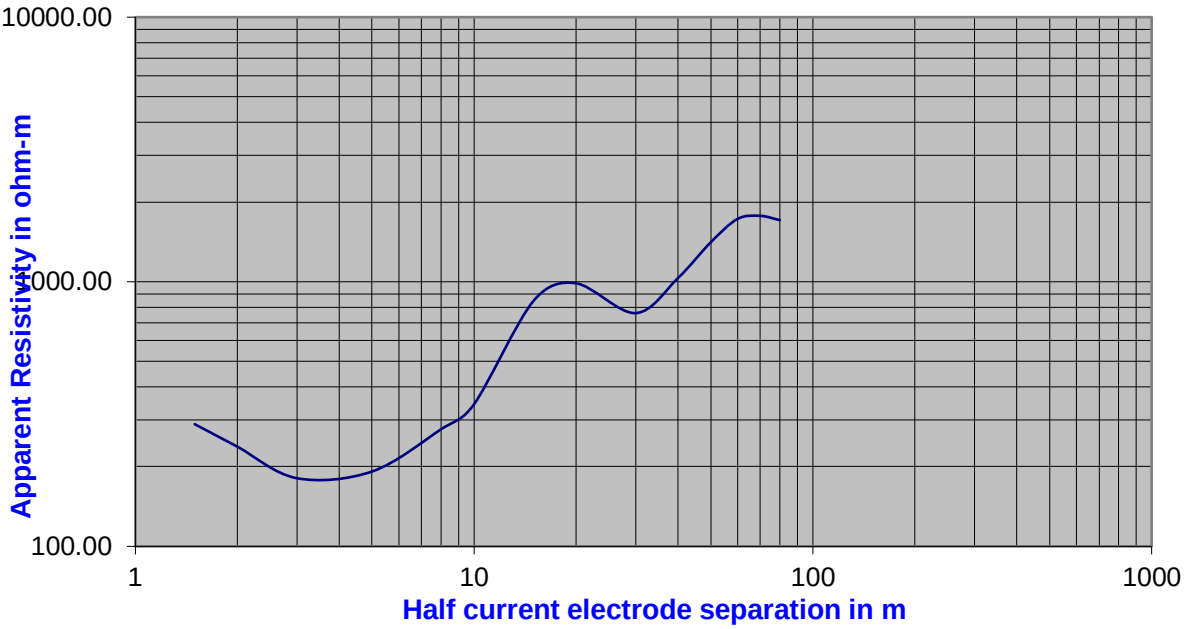


Fig. 31 VES 2 graph, interpretation table and Section

Vertical Electrical Sounding Curve V-3



N	True Resistivity (p) in Ohm-m	Thickness of Layer (H) in M	Depth to layer (z) in M
1	333.04	1.06	0/0
2	89.64	2.09	1.06
3	3254.62		3.15

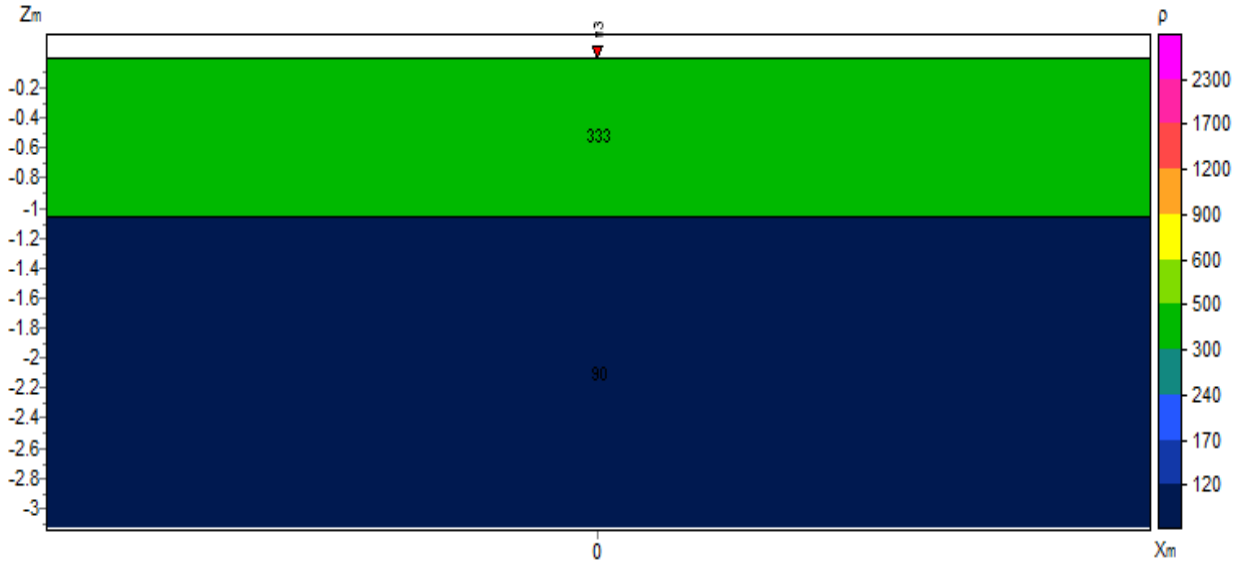
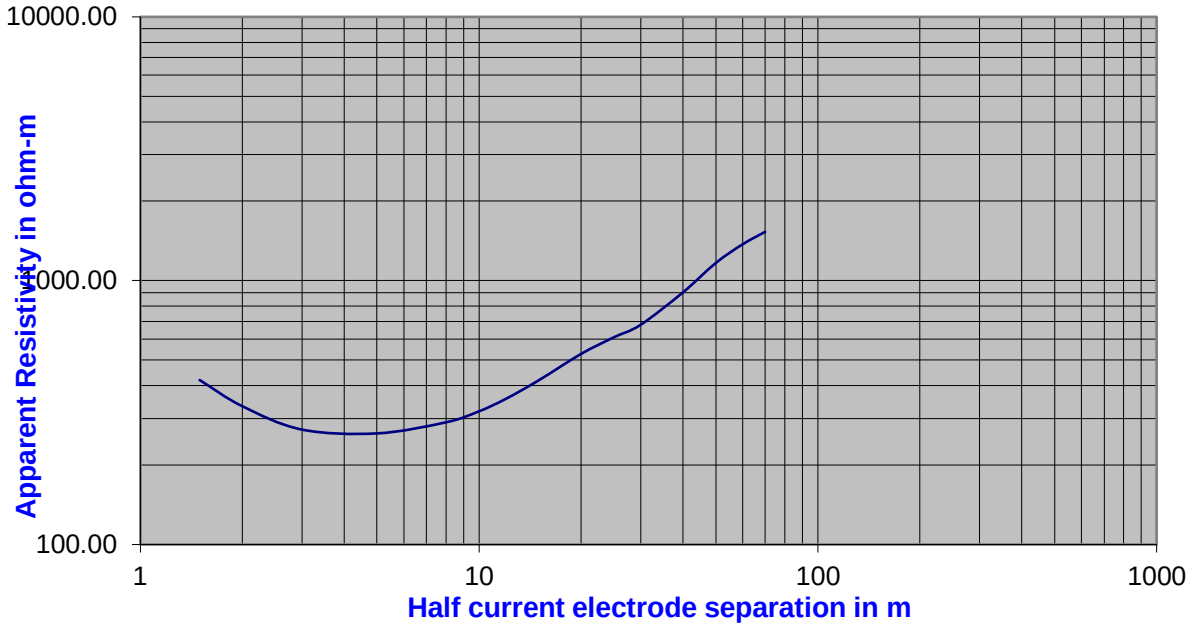


Fig. 32 VES 3 graph, interpretation table and Section

Vertical Electrical Sounding Curve V-4



N	True Resistivity (p) in Ohm-m	Thickness of Layer (H) in M	Depth to layer (z) in M
1	457.09	1.32	0/0
2	105.32	2.52	1.32
3	1983.91		3.83

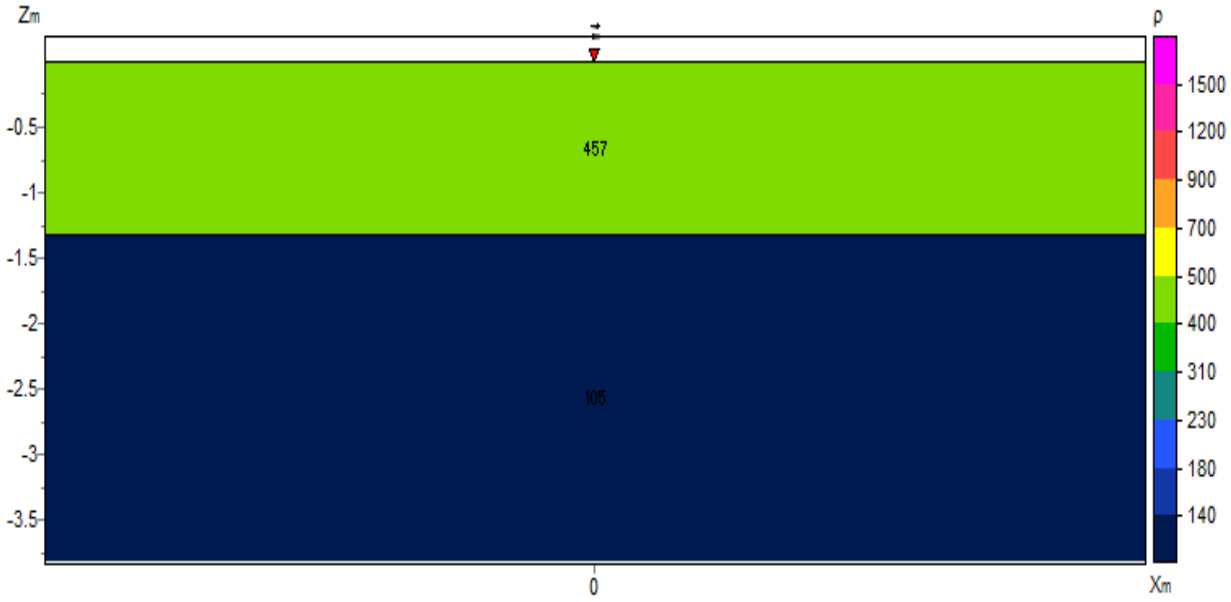


Fig. 33 VES 4 graph, interpretation table and Section