Qatar Univ, Sci, J. (1997), 17(1) : 173-181

SUBSURFACE EXPLORATION FOR CONSTRUCTION OF LIGHTNING PROTECTION SYSTEM USING THE GEOPHYSICAL METHODS, ALEXANDRIA, EGYPT (A CASE STUDY)

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استكشاف تحت سطحي لإنشاء نظام حماية من الصواعق باستخدام الطرق الجيوفيزيائية - الاسكندرية مصر (دراسة حالة)

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تم قياس كل من المقاومة الكهربية والشدة المغناطيسية الكلية في إطار تكاملي لإستكشاف الطبقة التحت سطحية وطبيعة المجال المغناطيسي الأرضي في منطقة خطط فيها لإنشاء نظام للحماية من الصواعق لمصنع بتروكيماويات ولقد أستخدم شكل ونر للنشر الحقلي من أجل إجراء مساحة المقاومة الكهربية ، وقد أستخدم جهاز قياس المغناطيسية البروتوني لقياس الشدة الكلية للمجال المغناطيسي . وقد أوضحت النتائج وجود طبقة تحت سطحية ذات توصيل كهربي مناسب ، كما حُدد مجال مغناطيسي ذو تدرج كبير عند بعض الأماكن بداخل منطقة الدراسة مما يسمح باستخدام هذه الطبقة لتفريغ الشحنات الكهربائية .

Key Words : Subsurface Lightning Protection, Exploration System, Alexandria.

ABSTRACT

Both electrical resistivity and total intensity magnetic measurements are combined together in an integrated manner to explore the subsurface layer and behavior of magnetic field in an area, where lightning protection system for a petrochemical factory is planned. Wenner configuration is used as a field layout for resistivity survey. The total intensity magnetic measurements are carried out using the proton magnetometer. The results revealed that, suitable base subsurface conductive layer is detected. A high gradient magnetic field is also detected at some places inside the study area.

INTRODUCTION

Actually, lightning strikes may give rise to harmful in and on the building and constructions. The major concern in the protection of a building is the occurrence of potential differences between the conductors of the lightning protection system and the grounded metal bodies and wires belonging to the buildings. These potential differences are caused by resistive and/or inductive effects and can be of such a magnitude that dangerous the building when sparking occurs. This could produce a potential of the order of few millions of volts. In order to reduce or prevent the possibility of sparking it is necessary to equalize potential by bounding ground metal bodies to the lightning protection system.

Determination of the ground resistivity is a vital step for construction of any lightning protection system. This requires measuring equipments working at low frequencies. Ground resistivity which used to calculate lightning conductor potential when a high frequency lightning discharge strikes a building must be for the grounds in the immediate area of the building. If the building is small and the lightning protection system can be disconnected totally from any other grounding network, then the resistivity of the ground can be determined using the electrical resistivity technique. Variations in soil resistivity either laterally or vertically are due to many factors such as lithologic composition, moisture content, temperature, etc... [1]. So, this method is being considered as one active reasonable one of exploration in many exploration fields [2,3]. The subsurface geologic concepts should be considered during the application of the electrical resistivity method[4].

When large current passes down lightning conductor a circular motion magnetic field is generated around the conductor. The higher the lightning current the higher the magnetic field gradient. Any conducting body lies near by and within the transient magnetic field zone would be intercepted by those lines of magnetic flux. The ra171!'Ùf charge of the flux passing through this body induces a voltage in it creating a potential difference between the gabs. Moreover, the worst case took place when the transient magnetic field is interacted with an ambient fluctuated earth. This will exaggerate the change of flux passing through the conducting bodies and in turn will magnify the potential difference.

Earth's magnetic field is in favor with lightning protection and is a trust to put hard on both zones of steady magnetic field (has minimum interactive effect on the transient field) and/or the nonsteady or highly fluctuating earth's magnetic field which must be taken into consideration during the construction of the lightning protection system. Cyclic variations in environmental and climatic conditions may lead to some risks on some industries. So, design of lightning protection system connected to a deep good conducting earth's basin is necessary to prevent the destruction effect of the lightning electrical shocks. Sensitive industries (such as petrochemical industries) to lightning shocks, specially those situated at the coastal areas must have special attention in this contex. Based on the above mentioned arguments both electrical resistivity and total intensity magnetic field measurements are used in the current study to identify the most suitable places from the subsurface point of view to be connected with the lightning protection system.

DATA ANAYLSIS AND INTERPRETATION :

In an area located Southwest of Alexandria city where a petrochemical factory is constructed comprehensive electrical resistivity and magnetic measurements are carried out in order to explore the relative shallow subsurface and determine the magnetic field gradient, Fig. (1) shows the distribution of the measured resistivity soundings and the direction of the magnetic profile (M-M'). The construction units of the factory are shown at the same figure.

Electrical resistivity investigation is carried out using Wenner configuration as an effective tool in such cases of study. The distances between the current electrodes is a function to the depth of penetration[5,6]. Thirty nine electrical resistivity sounding points are measured Fig.(1). The maximum current electrode separation reached at some sounding points to 180m indicating maximum depth of penetration of about 50m [6]. The measured sounding points have different curve types. The number of layers ranges between 3 and 5 layers Fig. (2) shows some of these curves. Each curve is exposed to detailed quantitative interpretation using a program based on the method described by Ghosh [7]. Table (1) shows the results obtained from the quantitative interpretation. Each model is

Table (1): The calculated resistivity models of the measured soundings.

VES No.	P (ohm-m)	h (m)	VES No.	P (ohm-m)	h (m)	VES No.	P (ohm-m)	h (m)
1	1.10	0.4	8	4.0	1.2	15	3.1	1.0
	21.4	0.8		11.4	14.7		3.3	6.4
	50.8	8.1		1.9			0.9	
	11.0							
2	4.1	0.8	9	11.4	1.0	16	11	0.9
	27.3	1.2		17.5	17.2		16	11.3
	12.1	7.4		4.5			1.9	
	24.3							
3	48.1	1.1	10	14.7	0.9	17	1.9	0.9
	31	1.0		30.7	11.4		23.6	4.6
	26	10		6.5			0.5	
	11							
4	12.7	1.1	11	11	1.0	18	1.9	1.0
	23.7	13.6		17	15.1		8.3	14.5
	3.1			8.0			0.9	
5	11	1.4	12	1.4	0.7	19	2.1	0.5
	29.3	12.7		9.0	10.7		7.2	14.1
	5.4			1.2			1.0	7.6
							2.3	
6	15.1	1	13	1.3	0.5	20	2.4	0.6
	14	11		1.9	0.5		7.7	4.2
	5			15	10		5.4	10.6
				1.1			2.2	
7	5.5	0.9	14	1.0	2.0	21	2.8	1.0
	11.9	10.7		4.8	7.9		3.8	15.1
	91.3	7.0		0.9			1.5	
	2.3							

Table (1) : Continue

VES No.	P (ohm-m)	h (m)	VES No.	P (ohm-m)	h (m)	VES No.	P (ohm-m)	h (m)
22	1.8	1.0	29	68	0.7	36	1.7	1.1
	8.5	11.5		5.8	7.8		6.1	10.2
	1.2			16.8	3.8		2.1	
				1.9				
23	68	0.7	30	7.0	0.5	37	2.4	1.0
	10	14.5		2.2	1.2		9.3	10.1
	3.2			6.1	13.6		1.5	
				0.9				
24	5.5	0.5	31	3.5	1.2	38	1.4	1.1
	2.0	2.4		8.5	1.8		7.7	4.3
	10.9	7.4		7.3	2.7		1.8	
	1.2			12.1	8.6			
				0.5				
25	1.7	0.7	32	4.7	1.0	39	1.5	1.0
	5.0	18		5.6	6.7		13.2	2.8
	0.8			1.2			10.7	3.6
							8.7	4.1
							5.0	
26	2.1	1.0	33	1.8	1.2			
	12.8	17		5.3	10.2			
	4.2			1.1				
27	1.6	0.8	34	8.6	0.9			
	7.4	22.5		17	2.7			
	1.0			7.3	14.3			
				2.3				
28	1.0	.8	35	7.0	0.9			
	20	1.4		16	2.0			
	3.3	6		7.0	13			
	28	7.1		3.0				
	0.6							

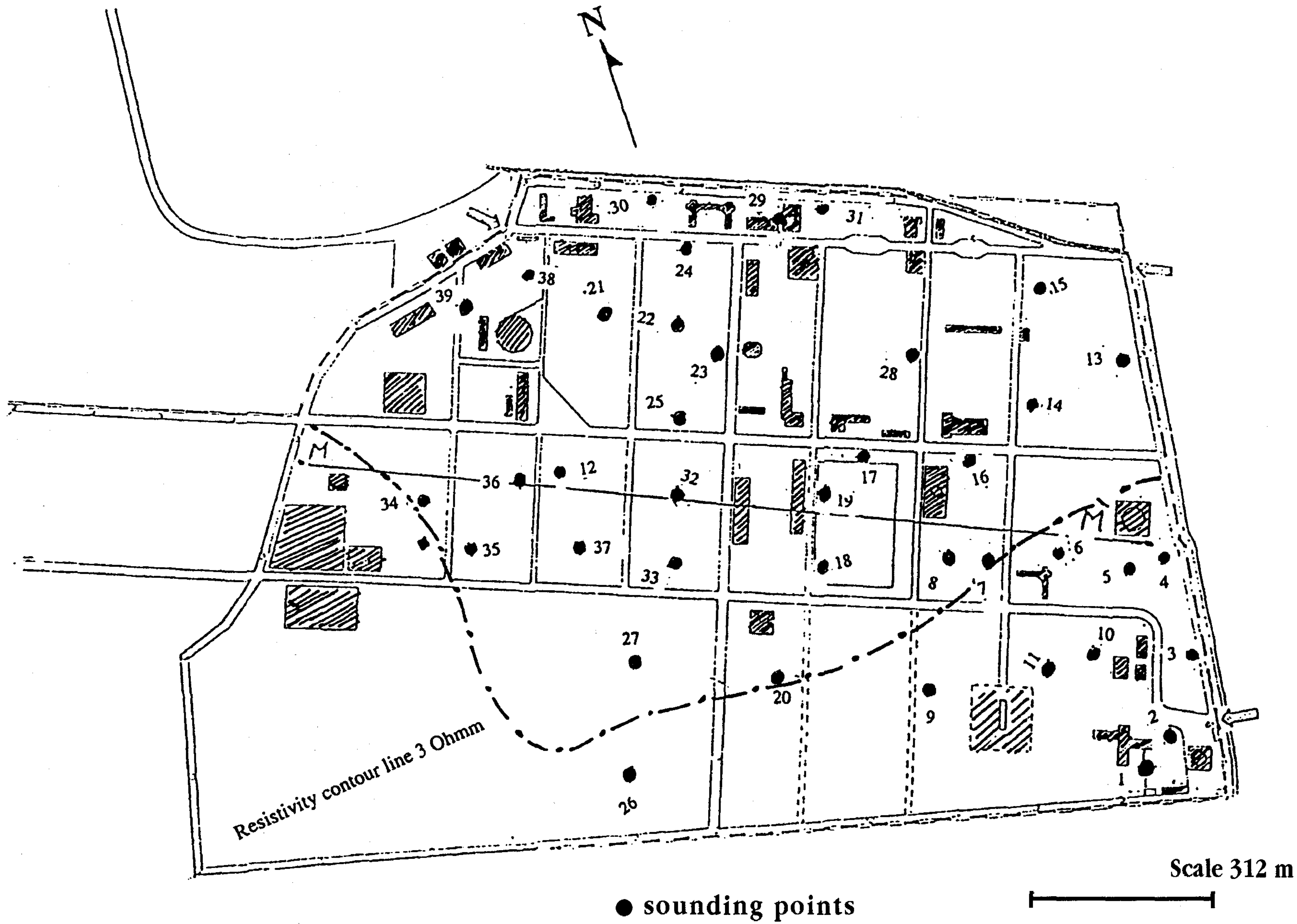

Fig. (1) Location of the factory units and the measured sounding points

studied according to the distribution and behaviour of each layer. The most important result is the presence of a distinctive low resistive layer at most models. Resistivity values of this base layer are projected on a sounding point location map and contoured. mention here that, the depth to this layer ranges from 6 to 23m. Fig.(4). The main construction units of the factory are concentrated in the zone of the low resistive values (see fig.1). Because of the relative high resistivity values of the

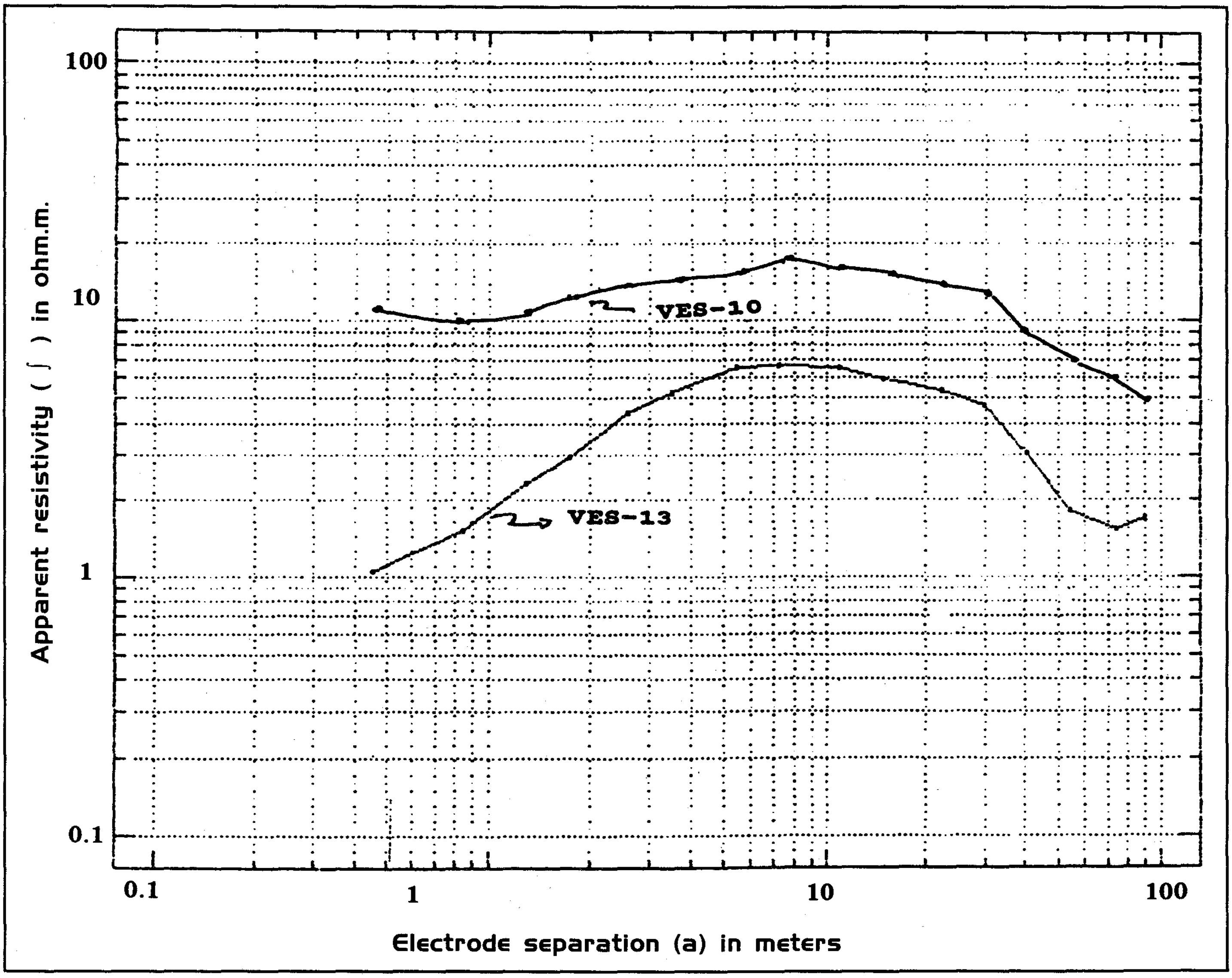

Fig. (2) examples of the measured sounding points

Analysis of the obtained isoresistivity map Fig. (3) shows that three resistivity zones are identified all over the study area. The first zone has resistivity values less than 1 ohm-m , the second with resistivity values range between 1 and 3 ohm-m and the third has resistivity values more than 3 ohm-m. Interepretation of these zones shows in general a vast low resistivity area (3 ohm-m and less) . The underground in this case is being considered as suitable from the conductivity point of view to be connected with the lightning protection system with this layer. It is worth to base layer at the southern and southeastern part of the study area, it is not suitable for connecting the lightning protection system with the underground in this part. The reason for the presence of the low resistivity values may be attributed to the presence of salt water bearing layers.

Using the Protone Magnetometer one NW-SE total intensity magnetic profile was measured Fig. (1). The aim of that is to detect any abnormal magnetic field variations. Fig. (5) shows the obtained profile after carrying out the

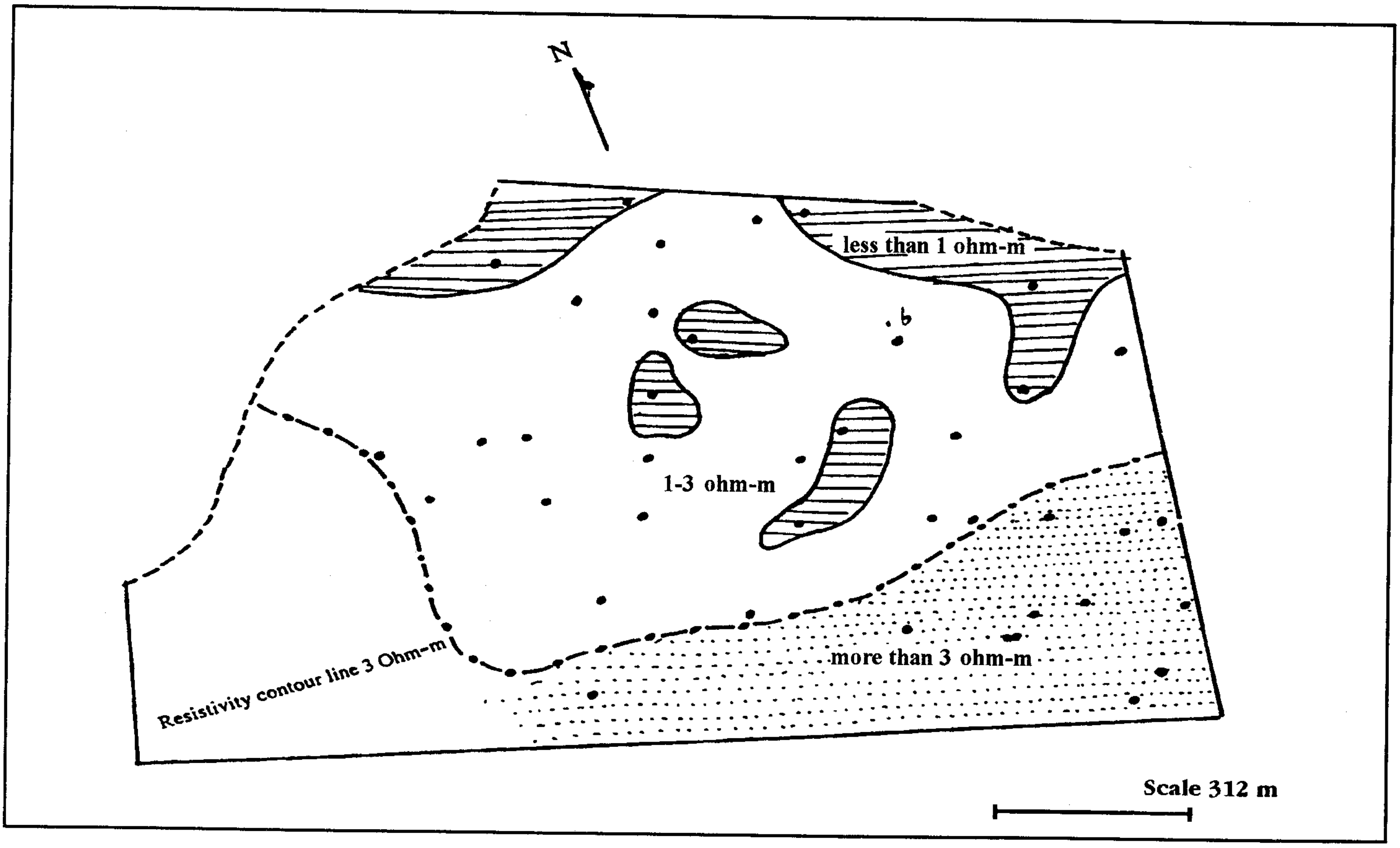

Fig. (3) Resistivity zonation map of the base layer

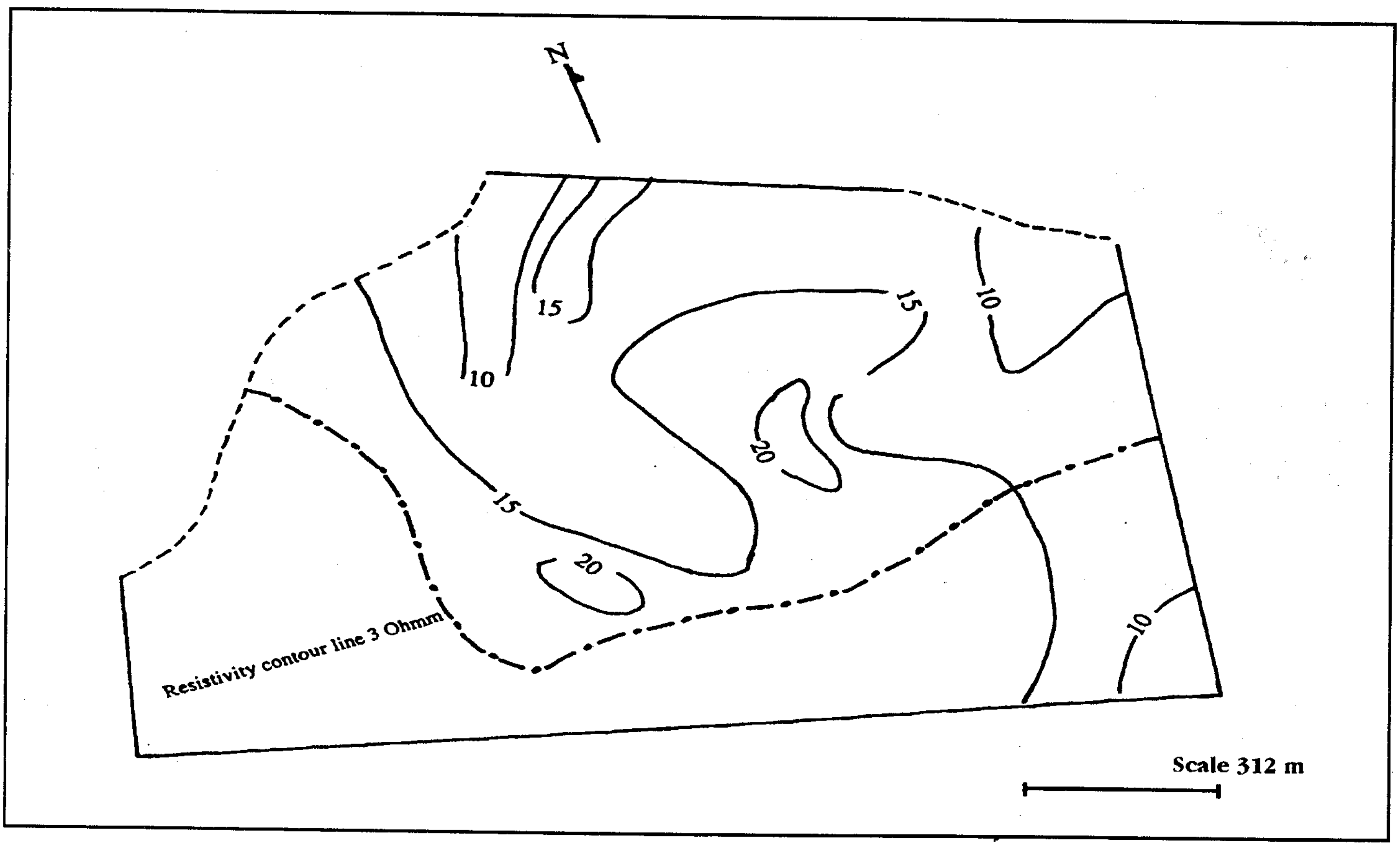

Fig. (4) Depth map of the base layer

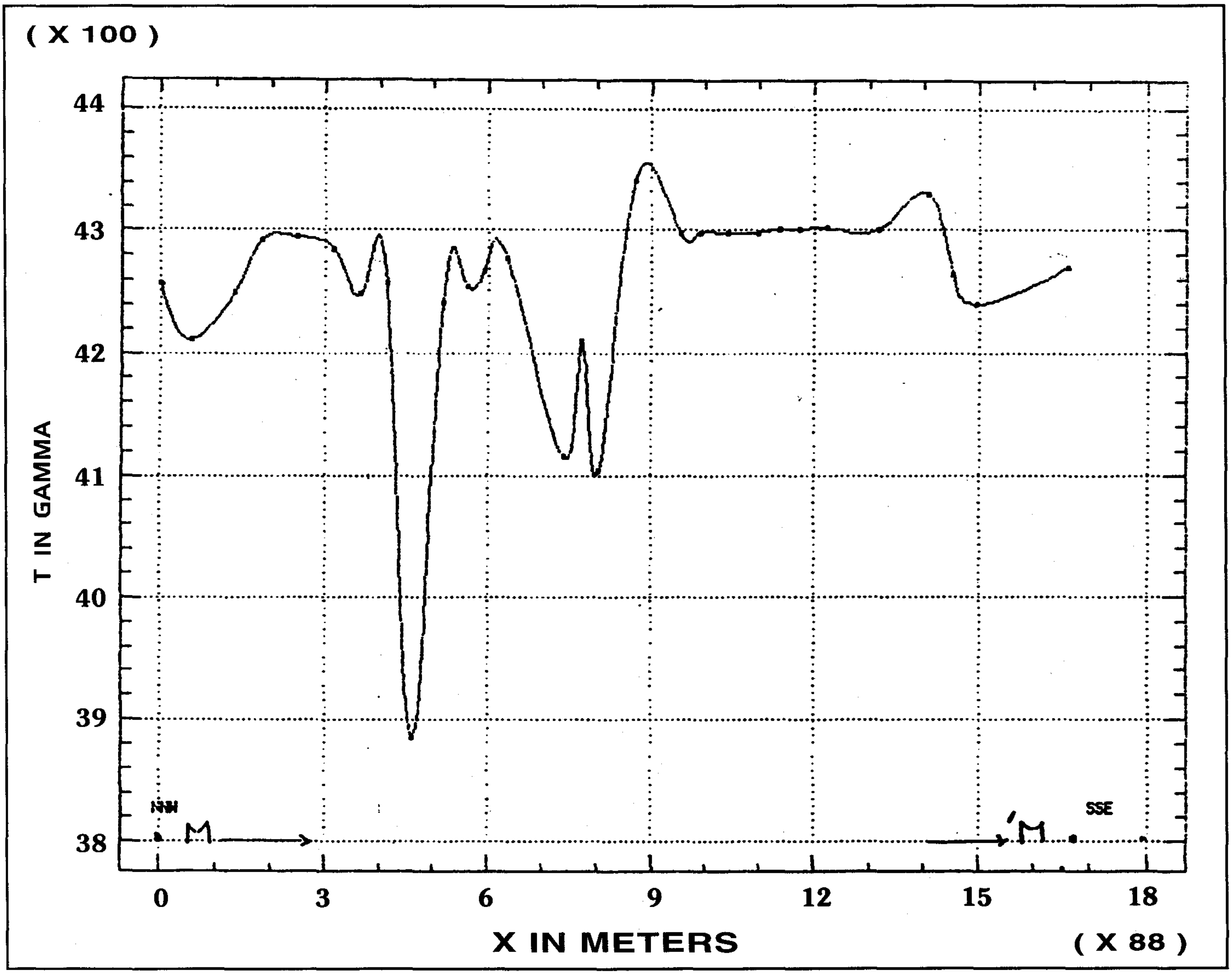

Fig. (5) Total intensity magnetic profile (MM̀)

necessary corrections. This profile passes by or near some of the measured electrical soundings. Analysis of this profile shows presence of relative high gradient magnetic field by the area including the sounding points 37, 33 and 18, from NW to SE, respectively. These sounding points are located inside the relative low resistivity zone.

CONCLUSIONS :

For the aim of construction of a lightning protection system at a petrochemical factory both electrical resistivity and total intensity magnetic investigation are carried out to study the subsurface layer and magnetic field gradient. The results of this investigation revealed that:

1) Most of the study area is characterized by the presence of a base subsurface conductive layer (berween 3 and 0.5 ohm-m). The area located to the South and Southeastern part of the study area is not characterized by this low resistivity values.

2) The gradient of the total intensity magnetic field shows that at some places inside the low resistive part the gradient is high and this in turn is suitable for connecting the lightning protection system with the underground at the area including the sounding points 37, 33 and 18 from NW to SE, respectively.

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