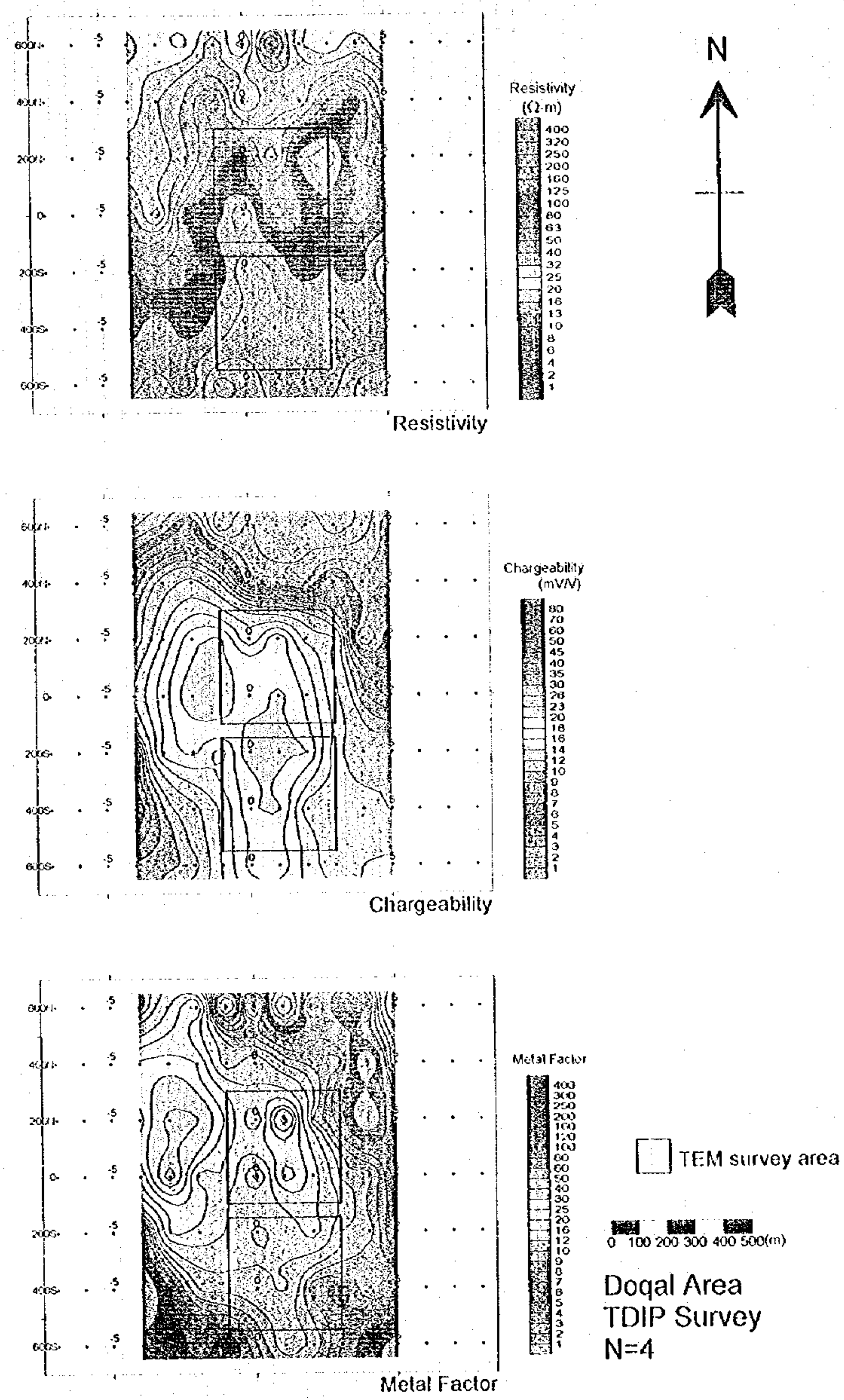
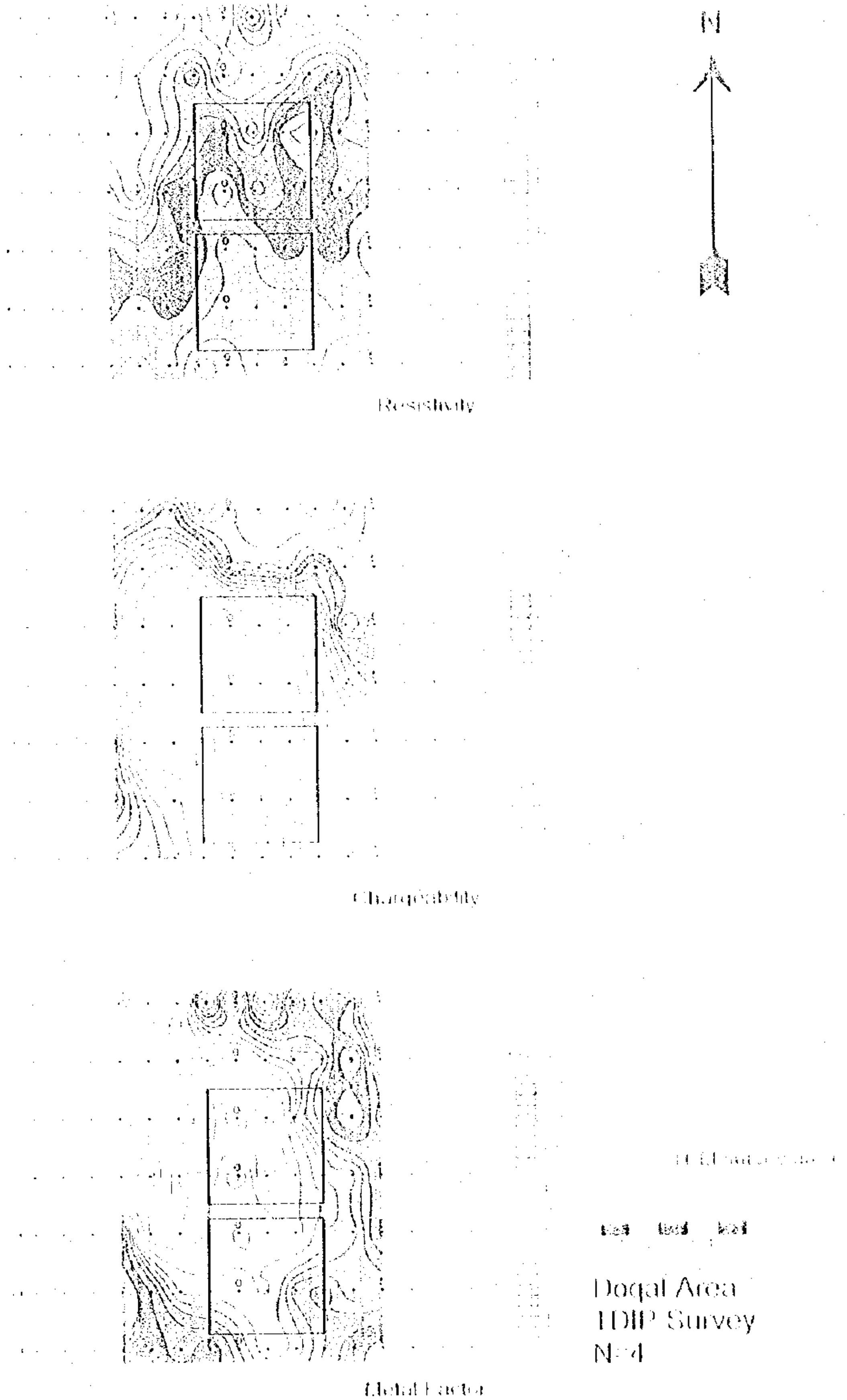


Fig.II-2-38 IP plane map of n=4 in Doqal area


N
Resistivity
Chargeability
Metal Factor
Doqal Area
TDIP Survey
N=4

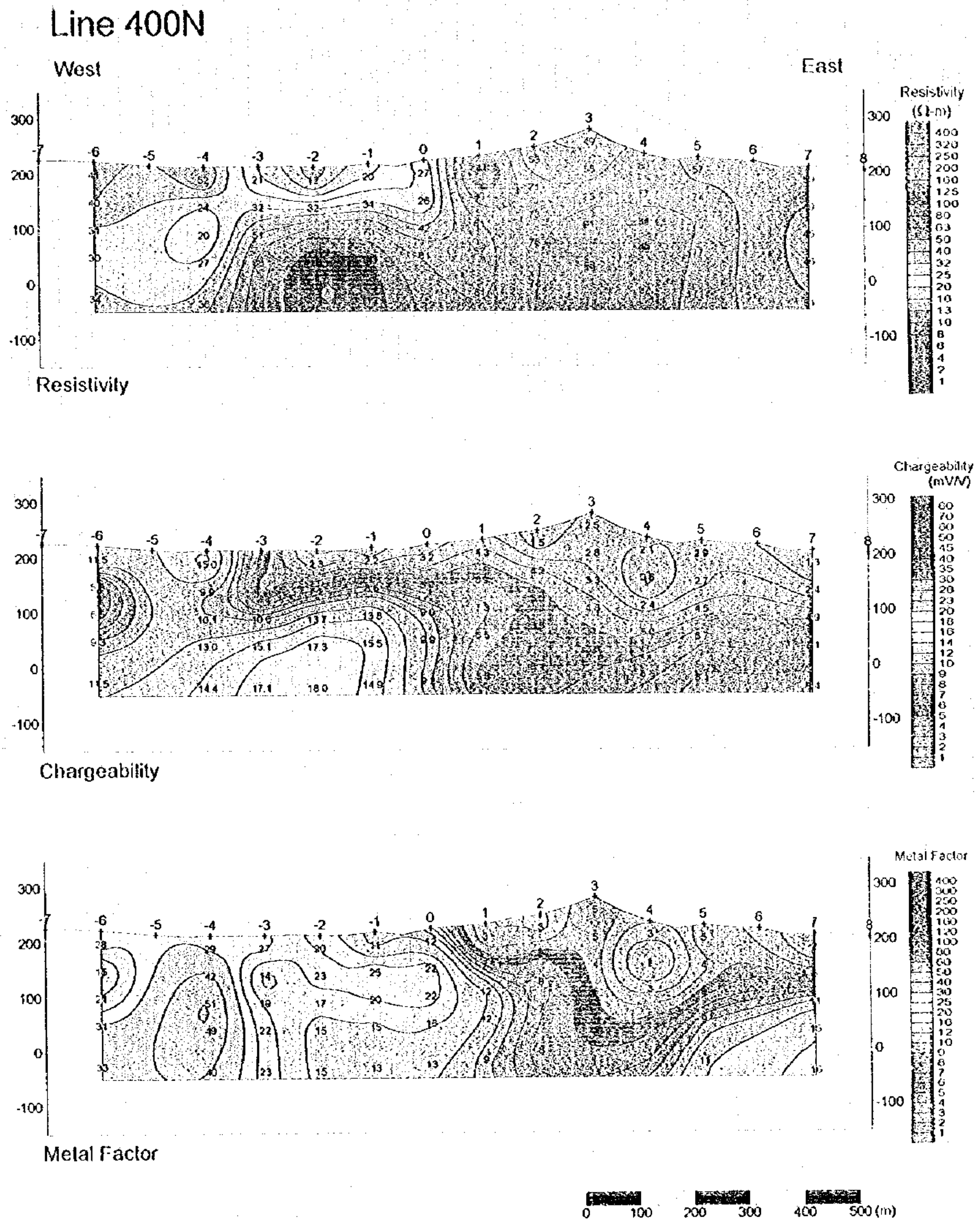
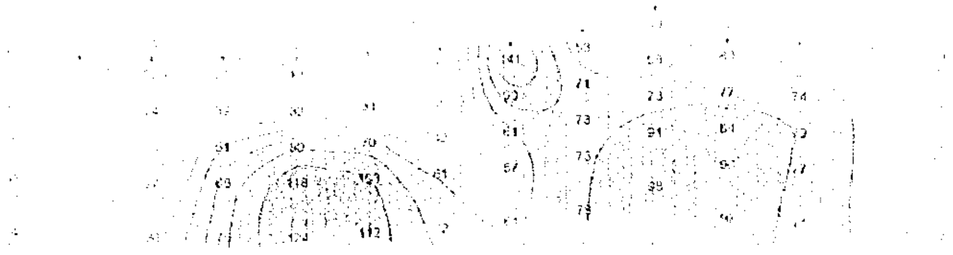
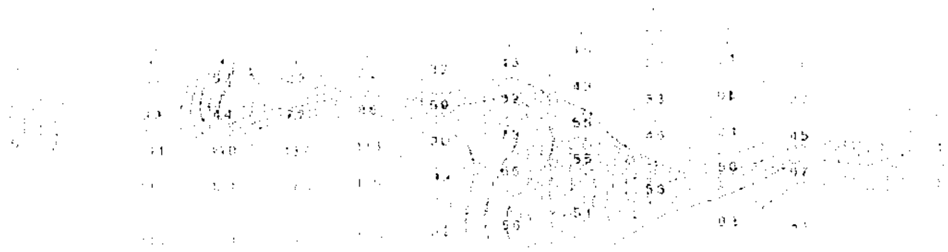
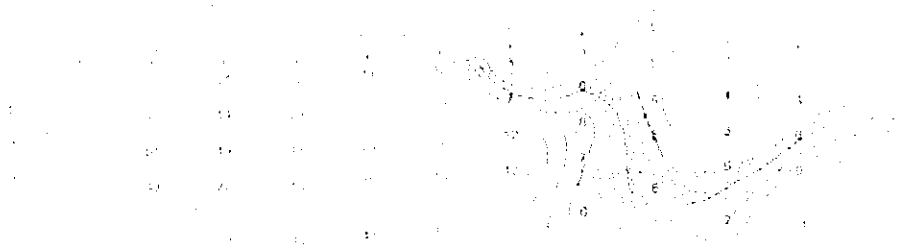


Fig.II-2-39 Results of model simulation on Line 400N in Doqal area

Line 400N







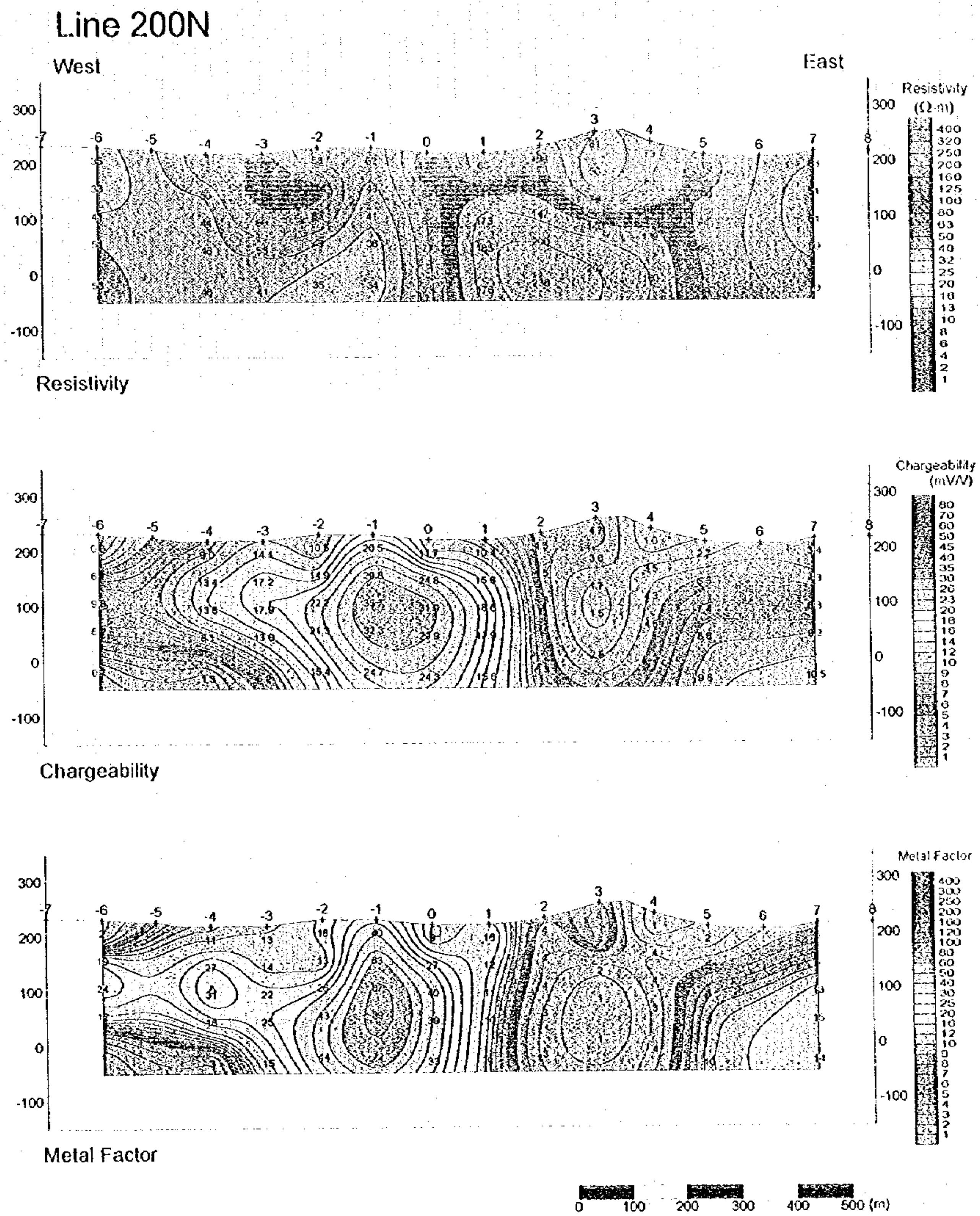
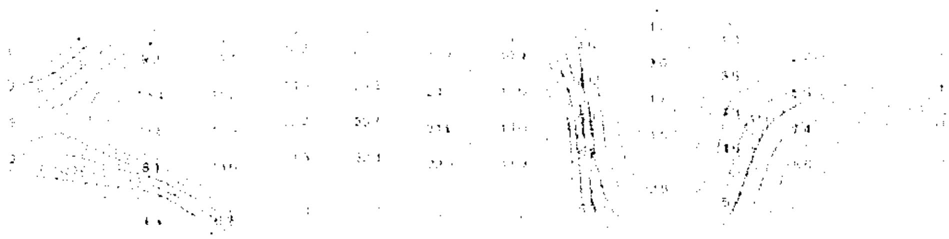
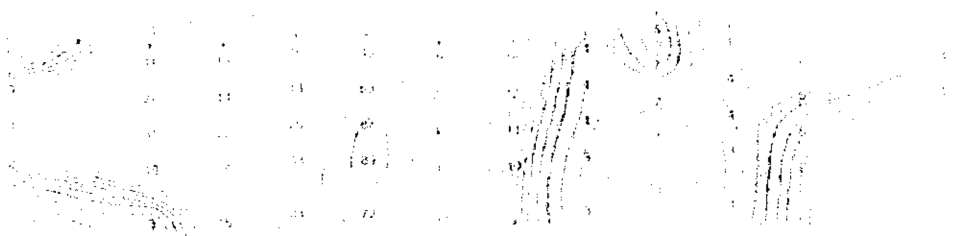


Fig.II-2-40 Results of model simulation on Line 200N in Doqal area

Line 200N





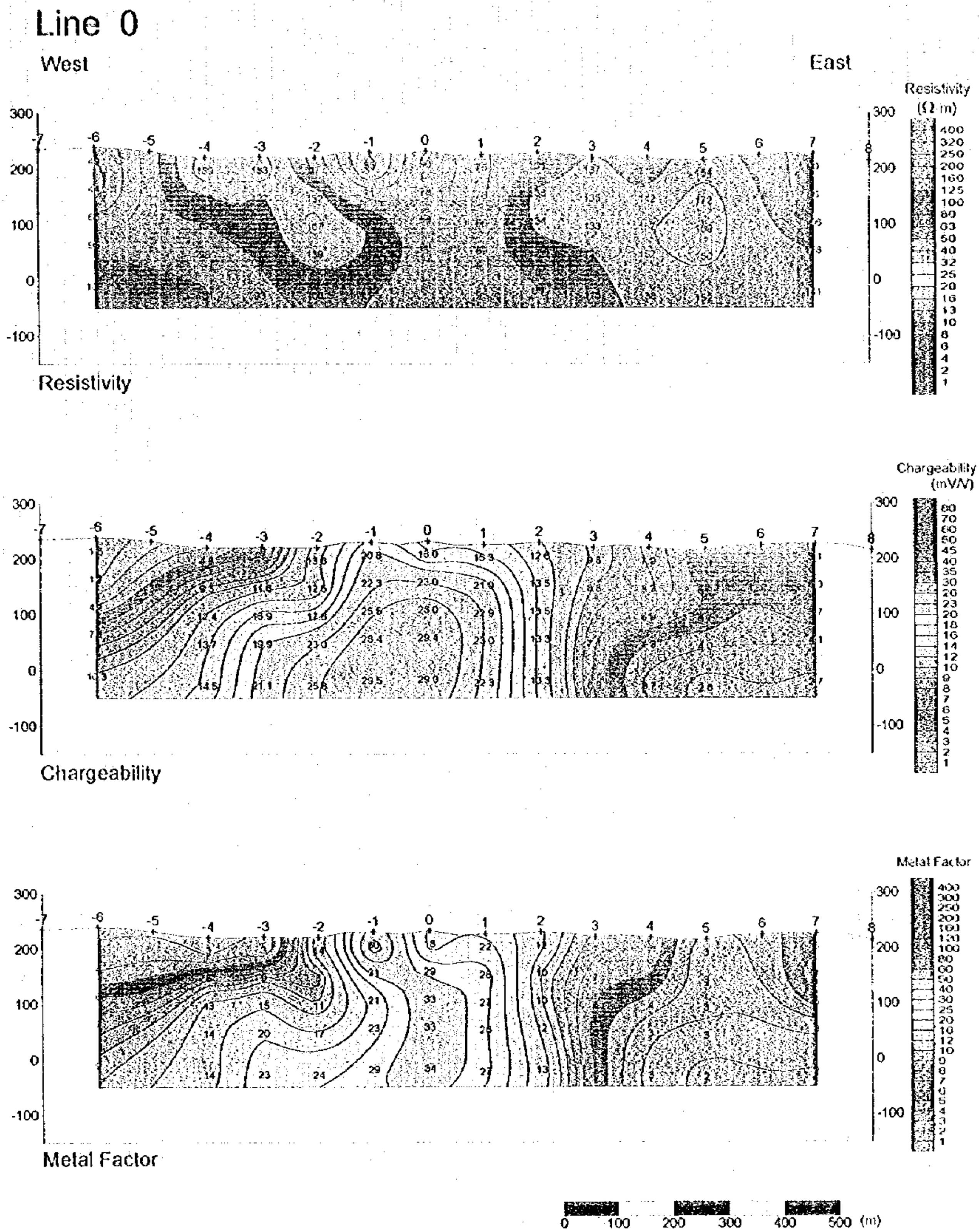
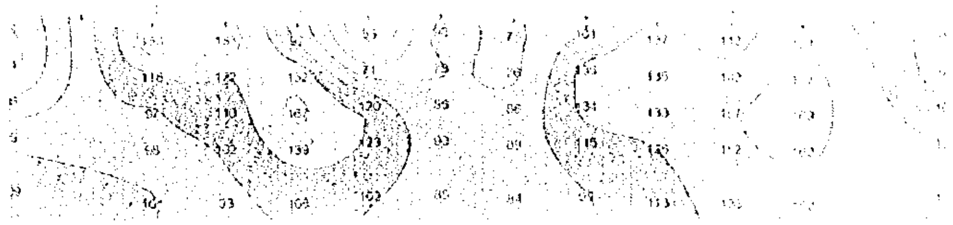


Fig.II-2-41 Results of model simulation on Line 000N in Doqal area

Line 0



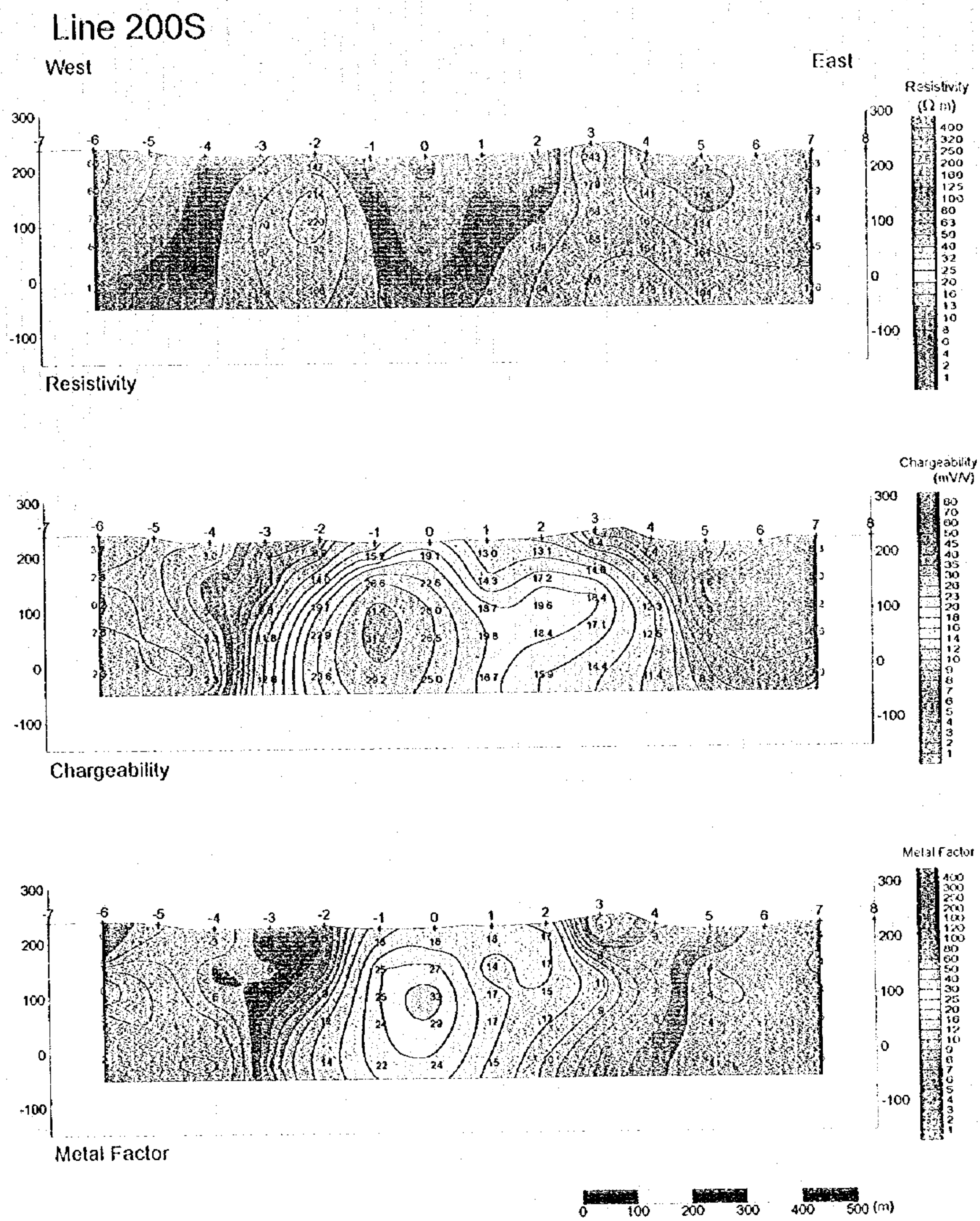
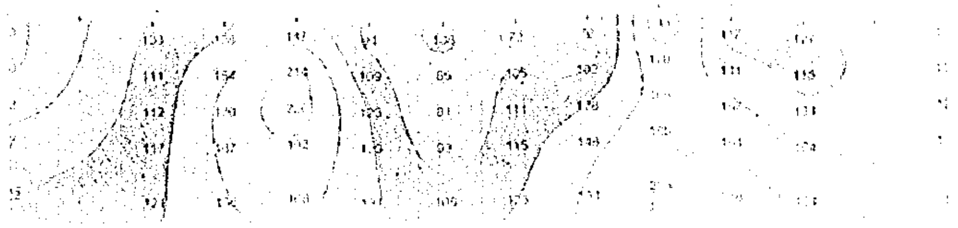
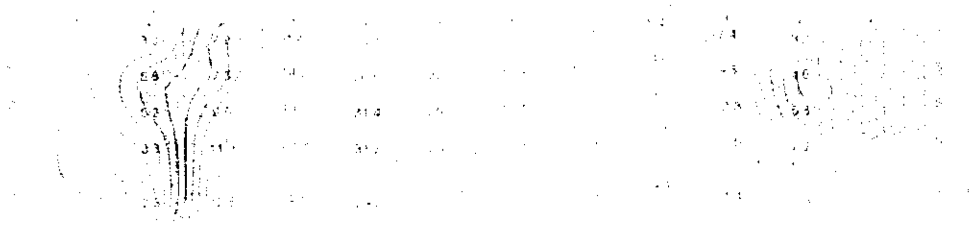
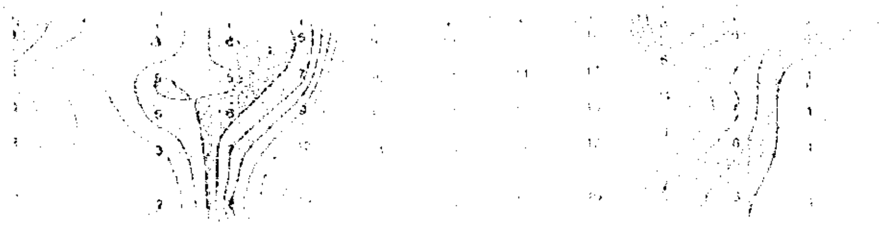


Fig.II-2-42 Results of model simulation on Line 200S in Doqal area

Line 200S







(1) Line 400N

Resistivity values of less than 20 Ωm are seen around the station -2 and extended at depth by dipping slightly towards west with less resistivity values.

Comparatively high chargeability values of above 10 mV/V are seen at station -2 at depths of more than 100 m and dipping westards at deeper levels.

Below station -4 and about 150 m depth as center, metal factor values of more than 30 are seen. This relatively high values of more than 20 are seen to the east of the above mentioned station up to the station 0 at depths between 50 and about 150 m.

(2) Line 200N

Resistivities of about 40 Ωm are seen at medium depths on station -1 and extending to the west part of the area.

Chargeabilities of more than 20 mV/V are also seen distributed below station -1 with its maximum value centered about 150m depth.

Metal factor distribution with values of more than 30 follows almost same pattern as the chargeability distribution mentioned above.

(3) Line 000N

The resistivity distribution presents in general values higher than 100 Ωm in this line, however, slightly low resistivity distribution is seen between stations No. -1 and 1.

Chargeabilty values of more 20 mV/V are seen at all depth levels between the stations -1 and 0, corresponding to the above mentioned slightly low resistivity pattern and becoming broader at depth

Metal factor values of more than 20 are seen all the way vertically down from stations -1 and 1.

(4) Line 200S

Although, this line also shows in general high resistivity values above 100 Ωm, slightly low resistivity distribution is seen present between 50 and 150m depth.

Chargeability values of more than 20 mV/V are seen distributed in station -1 with prominent values at medium depth levels.

Metal factor values above 20 are seen about 150m depth of the station 0 and extended about 100m around this depth.

CHAPTER 3 TEM SURVEY

3-1 Objectives

Since it is considered that the TEM method is sensitive to conductive bodies, such as massive sulphide deposits, the TEM survey was conducted to confirm the existence of these deposits within the area delineated from the results of the TDIP survey.

3-2 Survey Locations and Specifications

Among the selected survey areas for TDIP survey, promising anomalies were detected in 2 places in Ghuzayn and 3 in Daris. Among them, 3 zones were selected to pursue follow-up TEM geophysical surveys, i.e., 2 in Ghuzayn gossan and 1 in Daris. All of these activities were carried out during the first year survey (Phase I).

This year, taking into consideration the above results and the results of the TDIP survey carried out during this year in Fardah, Sanah and Doqal areas, follow-up TEM surveys were carried out in 13 locations, i.e., 3 locations in Daris North, 1 in Fardah, 2 in Sanah, 2 in Doqal and 5 in Ghuzayn.

TEM measurements were collected at 50m intervals and within a square loop of 400m X 400, making a total of 1018 measurement points covered on 13 locations in the five areas above mentioned.

The amounts of survey carried out in these areas are as indicated in the following Table II-3-1.

Table II-3-1 Survey Amounts

AREA	No. of LOOPS	No. of POINTS
DARIS NORTH	3	243
FARDAH	1	81
SANAH	2	162
DOQAL	2	162
GHUZAYN	5	370
Total	13	1018

3-3 TEM Survey Method

3-3-1 Basic Principles

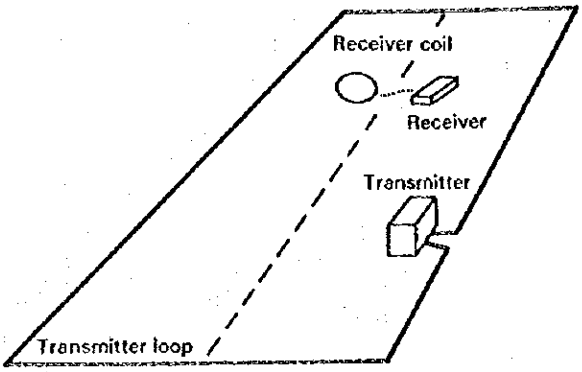
The principle of the TEM system used in this survey is to energize an ungrounded loop situated on the surface of the earth, as illustrated in Fig. II-31-1. When the currents flowing in the loop are switched off, free electron conduction currents are induced (called eddy currents) in the ground. The eddy currents are known to depend on the conductivity, size and shape of the conductive body, and position with respect to the sensing loop. These eddy currents set up a secondary magnetic field which can be detected by a receiver coil as a time-dependant decaying voltage (See Fig. II-3-2).

The measurement of the time dependant decaying voltage is a means of detecting conductors in the ground. This decay can be measured by a number of measurement channels recording the voltage at various delay times after the transmitted fields are switched off.

The quick decay of the primary magnetic field, caused by the current termination, induces a pulse of emf in the surrounding media, according to Faraday's law. The resulting eddy currents produced in nearby conductive material support a surrounding secondary magnetic field for the duration of the pulse. Thereafter, with no external emf to support it, this system of currents and magnetic field decays with time, and it is this transient magnetic field which the receiver measures. These measurements occur during fixed time "windows" which occupy most of the "off-time" of the transmitter. Since the receiver must know when the transmitter is off, synchronization was done by using crystal clocks.

3-3-2 Survey Procedure

There are several varieties of TEM systems and modes of operations. During this survey it was used the fixed-loop TEM system, in which a large, single-turn loop of wire is laid out on the ground. The loop used was a square loop of 600 m X 600 m carrying about 12 amps. A portable power generator of 2500 W fed a transmitter, which provides a series of alternating bipolar currents pulses with slow exponential turn-on and a rapid linear turn-off precise current waveform through the loop. After the transmitter loop has been set up, a small portable multi-coil receiver is moved to stations inside the loop. the receiver apparatus is moved along surface lines. Lines were surveyed within the loop to a distance of 100m away from the loop and the grid interval between the observed points was 50m. Previous to the data gathering, the crystals of the transmitter and receiver are warmed up before attempting to synchronize. Synchronization of the transmitter and receiver was carried out using the built-in high stability quartz crystal oscillators. Integration for each measurement was carried out over 2^8 cycles.



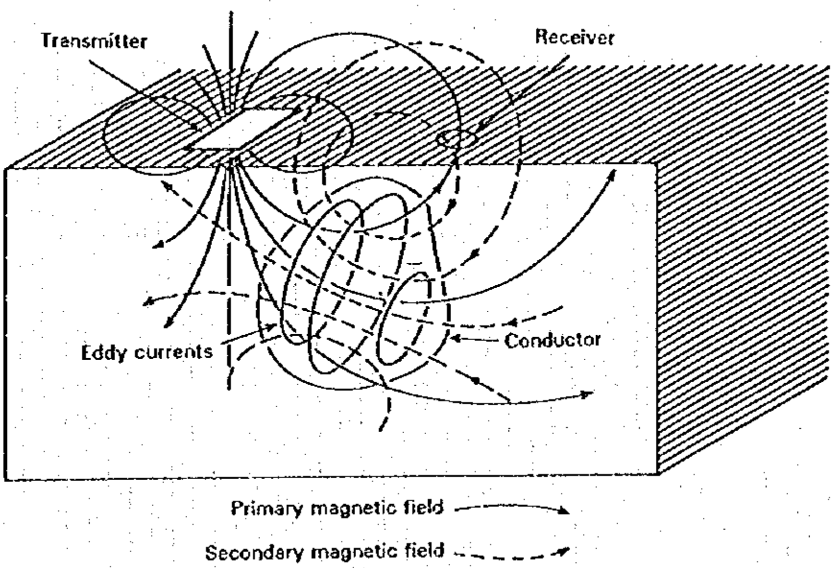


Fig.II-3-1 Schematic TEM survey configuration

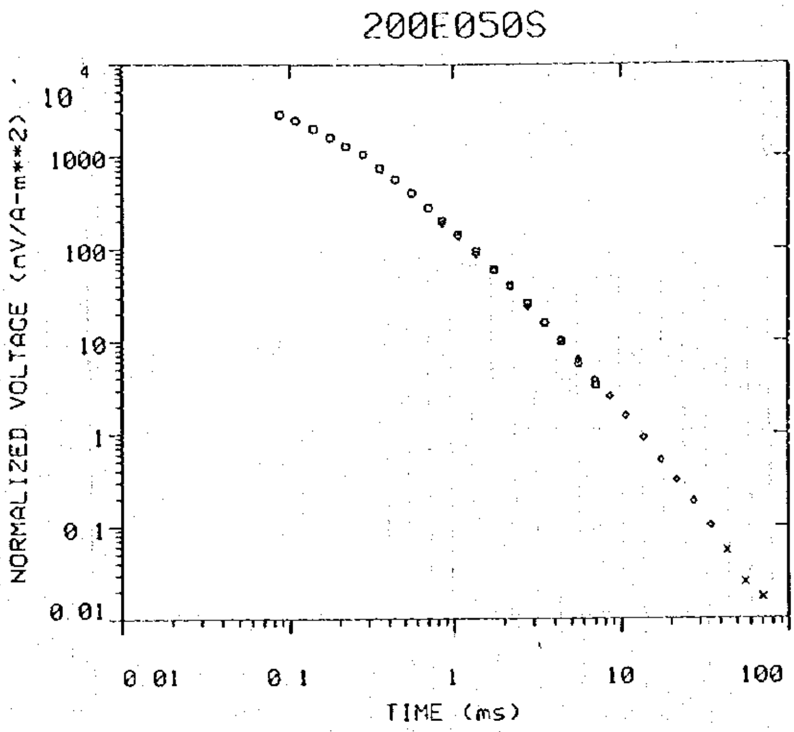


Fig.II-3-2 Example of TEM decay curve

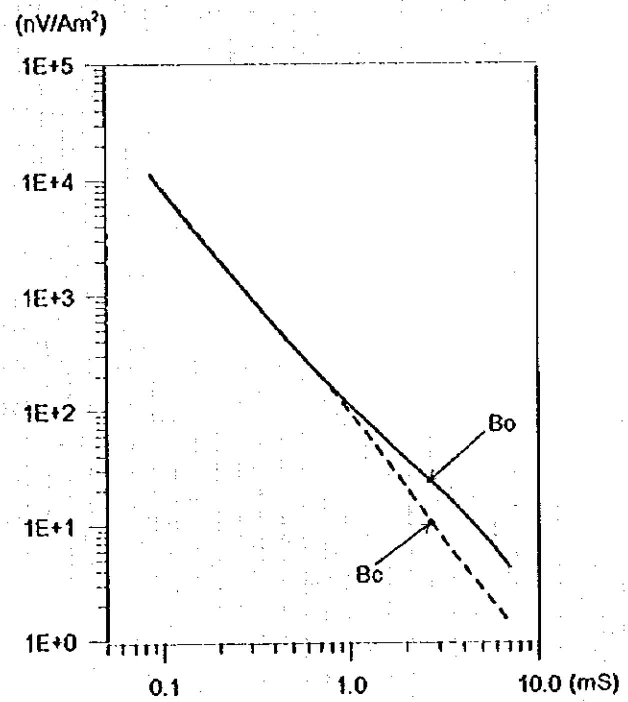


Fig.II-3-3 TEM decay difference

The current waveform driven through the transmitter loop, and the number of spacing of channels in the receiver are the main distinguishing features of this method. 20 time channels with locations and width are shown in Table II-3-2. Succesive operations at 25Hz, then 2.5Hz, effectively gives 30 channels covering range from 88 μsec. to 72 msec. A steady current is terminated rapidly by a 220 μsec ramp.

Table II-3-2 Channel times after switch-off

Channel	Gate Center (μsec)	Gate Width (μsec)	Channel	Gate Center (μsec)	Gate Width (μsec)
1	88	18	11	881	180
2	110	24	12	1096	250
3	140	37	13	1411	380
4	177	36	14	1795	390
5	220	50	15	2224	500
6	280	72	16	2850	720
7	355	76	17	3600	780
8	443	100	18	4490	1080
9	564	142	19	5700	1420
10	713	156	20	7190	1560

3-3-3 Equipment Specifications

The EM37 system is a ground transient EM system manufactured by Geonics Ltd. of Canada with the following specifications:

Table II-3-3 Specifications of TEM survey instruments

ITEMS	SPECIFICATION
Transmitter	Max. output 30A, 180V
Generator	5HP, 120V, 3phase, 400Hz
Receiver	25.0Hz: 0.088 - 7.17 msec 6.25Hz: 0.35 - 28.7 msec 2.5 Hz: 0.88 - 71.9 msec
Magnetic sensor	Induction coil Effective area: 100 m^2
Recorder	Model DAS54, 500kb

(1) EM37 Transmitter

Although the size of the EM37 transmitting loop can be varied, a single loop of 600 X 600 m was chosen for this survey.

For the loop size we used No. 6.5mm copper wire and a current amplitude of about 12 Amp.

The current waveform in the transmitter consists of alternating bipolar current pulses with a slow exponential turn-on and a rapid linear turn-off. The base frequency of operation can be set at 2.5, 6.25 or 25 Hz, with corresponding window times of 71.9, 28.7, or 7.17 ms respectively. In this survey we used a base frequency of 25 Hz.

Transmitter motor generator: 5 HP Honda gasoline engine coupled to 120 volt, 3 phase, 400Hz alternator.

(2) EM37 Receiver

Measured quantity: Time rate of decay of magnetic flux

Coil Sensor: Air-cored coil of bandwith 40 kHz; 100cm dia. by 7 X 5cm cross-section

Time Channels: 20 with locations and width as shown in Table II-3-2

Syncronization to Tx: Oven controlled quartz crystals

Receiver Battery: 12 volt rechargeable Gel-cell.

Station spacing : 50m

At the receiver the induced voltage in the coil ismeasured in millivolts. Using the effective area of the coil and the gain of the receiver, these measurements are converted to the time derivative of the magnetic field in nanovolts/meter sq.

3-4 Analysis Method

The fact that the primary field is abscent during measurement time, leads to "cleaner" data which is easier to interpret. The rate of decay of a conductor's magnetic field depends primarily on its size and conductance. Eddy currents decay rapidly in poor conductors, while those due to good conductors decay slowly, and the timing of the channels is such that only the effects of eddy currents due to the good conductors are seen in the later channels. In conductive environments, therefore, the response from overburden and uneconomic ore deposits should be minimal in the later channels where the target response predominates.

The TEM response detected in the receiver, depends not only on the electrical properties of the ground, but also on the location of receiving points and transmitter loop size, generally the highest response are observed at the center of the loop.

To correct the respose due to the receiving location, the following procedure was carried out:

From the TEM data obtained at the center of the transmitter loop, a layered resistivity structure was calculated by using an inversion analysis which assumes that this electrical structure represents an average resistivity in the loop.

By using the parameters of this resistivity structure, a synthetic response Bc(x,y) was calculated at all the points within the loop by taking also into account the relative position between the receiver and transmitter loop. If the resistivity structure at a point is nearly same as the average resistivity structure, the observed EM response should be almost the same as the calculated synthetic response, resulting in a mininal difference. On the contrary and if the average resistivity structure is not related to an anomaly but the point represents the location of the conductive body underlied, the response becomes extremely high as compared with the synthetic response, and therefore, the difference between the responses becomes high, i.e.,

$\Delta B(x,y) = \log (Bo(x,y)/ Bc(x,y))$

where:

$\Delta B(x,y)$: difference of response

$Bo(x,y)$: observed response

$Bc(x,y)$: synthetic response

log : logarithm base 10

Contour map of the difference in the TEM responses permit the clarification of anomalies (if any) by the contrast in the TEM response values.

To verify the above description, it was carried out a model calculation which consisted of a conductive plate of 100m width and 200m length at a depth of 150m and immersed horizontally in a 100 Ωm homogeneous half space earth.

Fig.II-3-4 shows the TEM response obtained from the model, while Fig.II-3-5 shows the difference of the response. The responses obtained from channels 1 to 7 show the highest values at the center of the loop due to the 100 Ωm homogeneous earth. A red colored frame illustrates the location of the above mentioned conductive plate.

After channel 8 the highest values gradually shift to the conductive plate, and from channel 13 to 6 the highest response is shown just above the conductive plate.

According to the results of Fig. II-3-5 no anomalies related to the plate are seen form channels 1 to 7, however, the difference in the responses becomes bigger as the channel number (window time) gets higher until the maximum respose is obtained at channel 14.

The TEM response as compared to the difference in the TEM response, clearly indicates that the distribution in the latter case represents the anomaly pattern due to the conductive plate.

For the depth estimation, the following formula is used:

$$d=\sqrt{500\times\rho_a\times t}$$

where:

ρa: Average resistivty(ohm-m)

t: Time(ms)

d: Depth(meter)

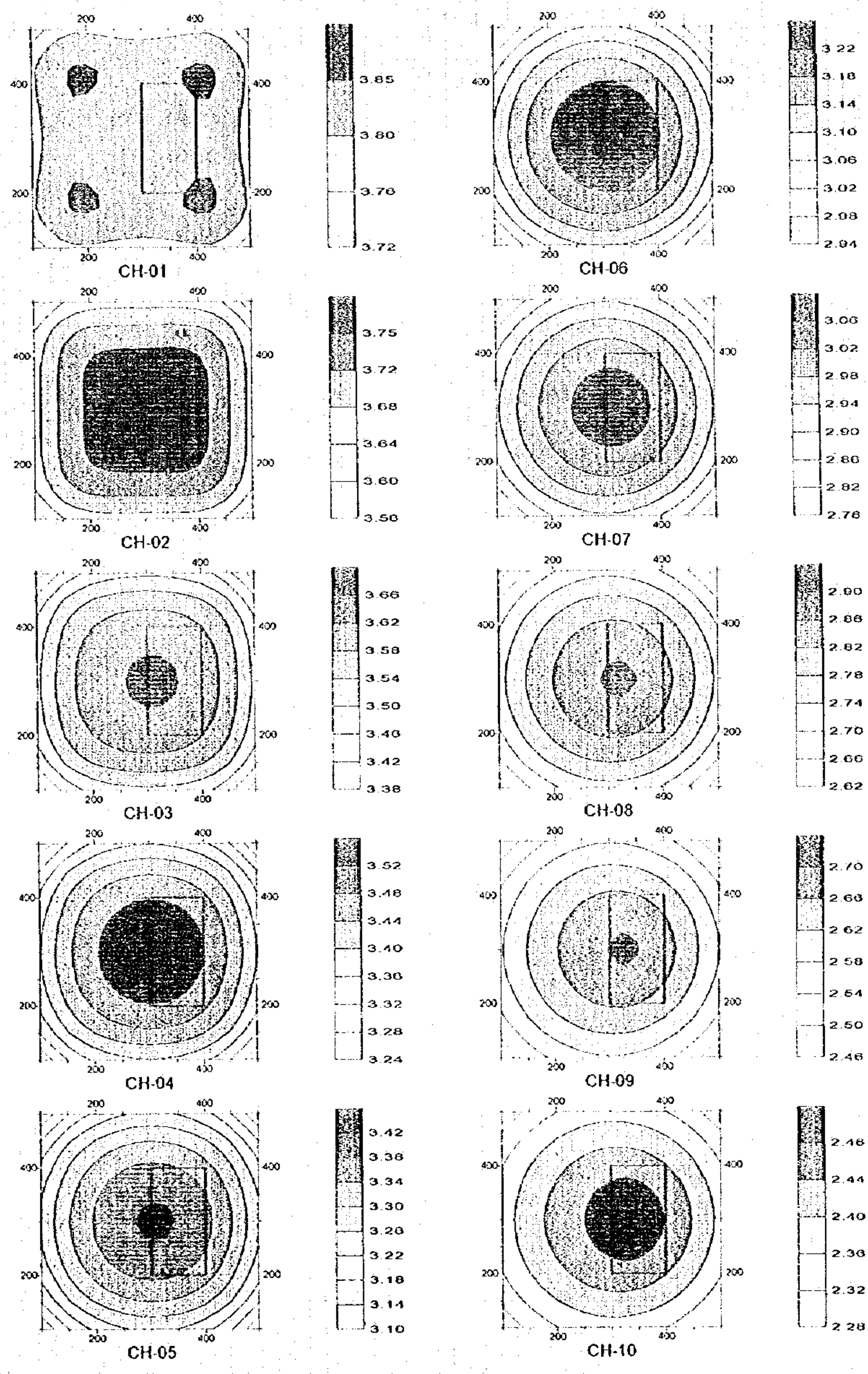


Fig.II-3-4 Contour plot of secondary magnetic response

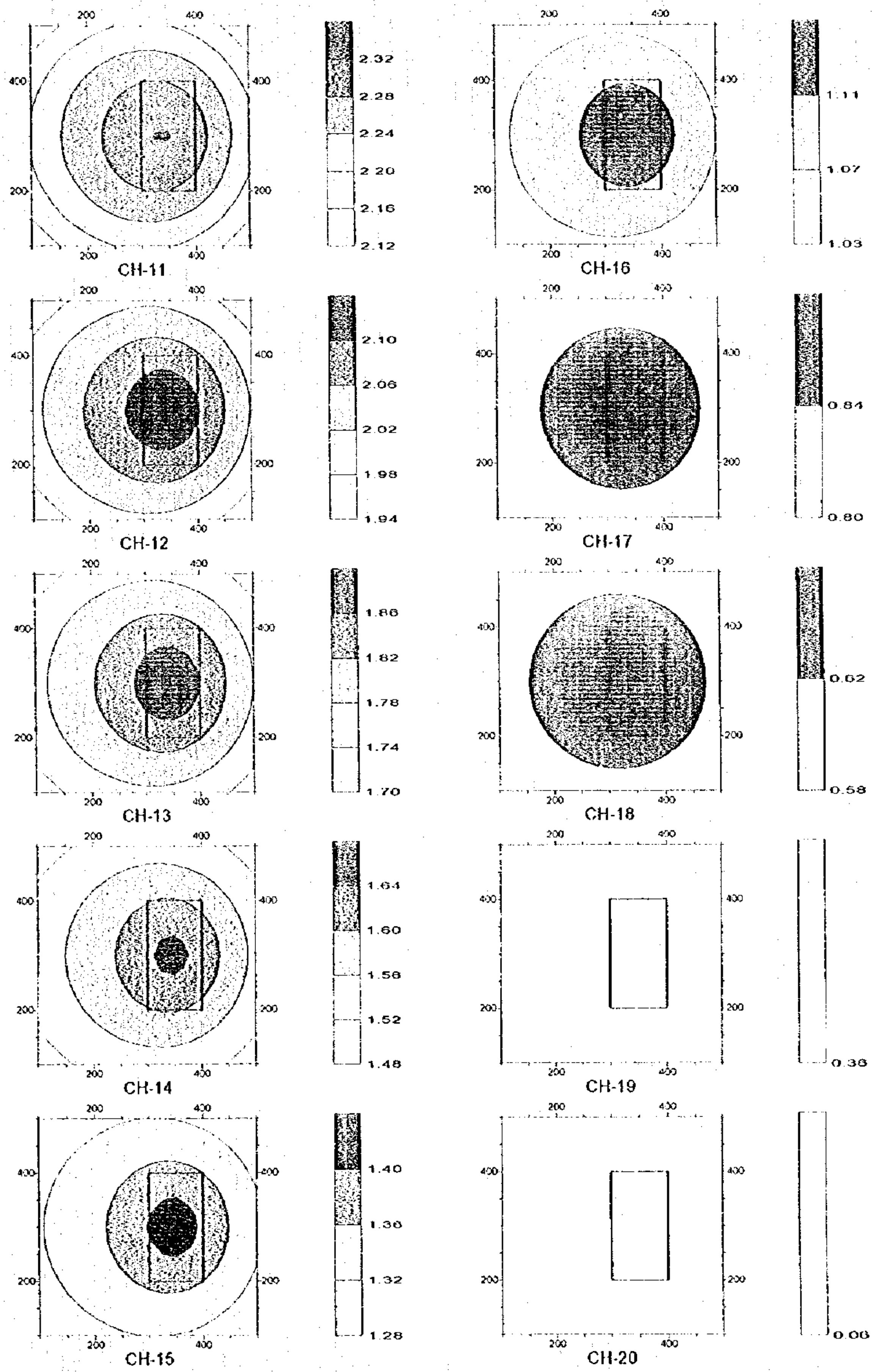


Fig.II-3-4 Contour plot of secondary magnetic response

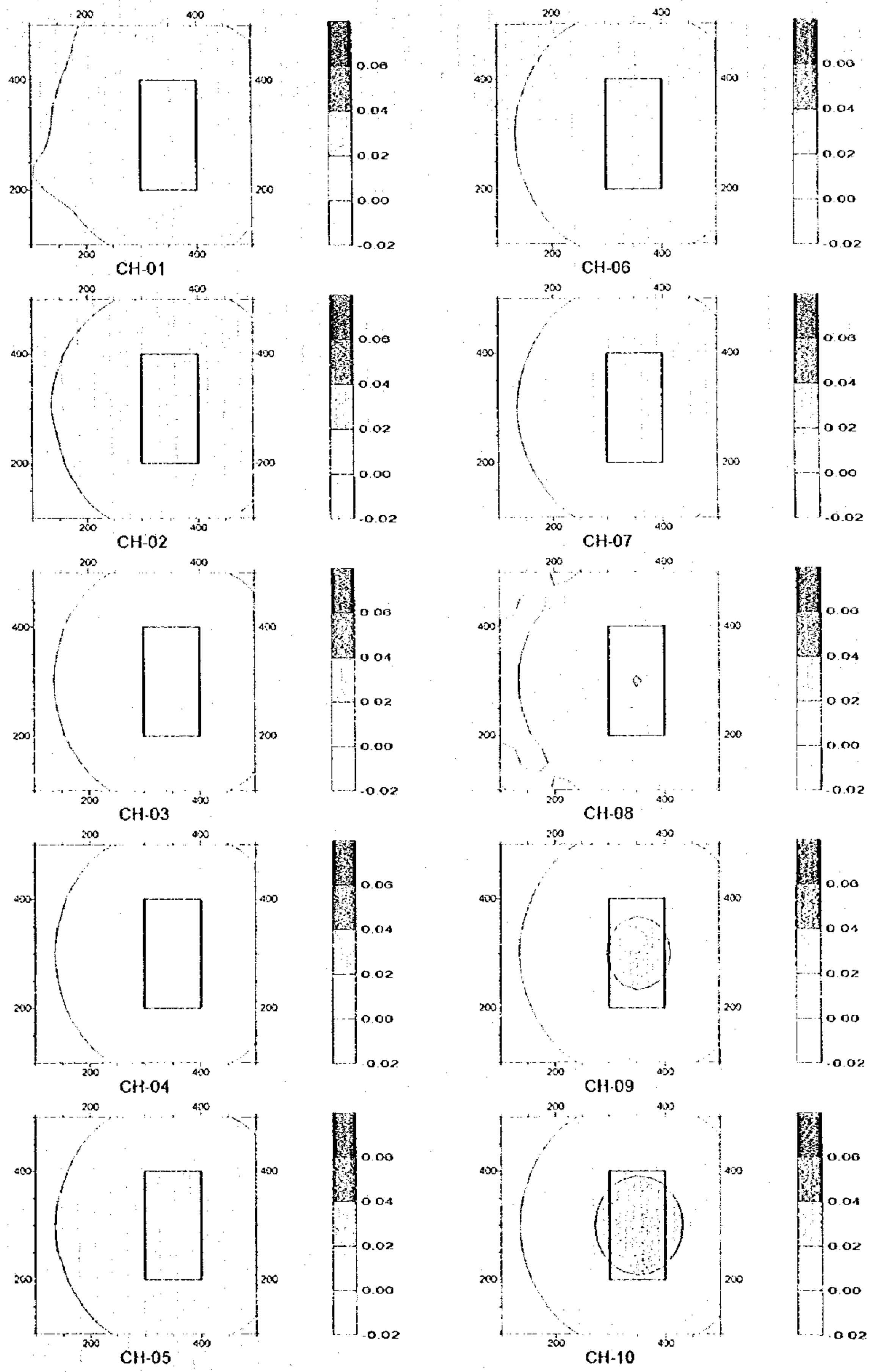


Fig.II-3-5 Contour plot of magnetic difference

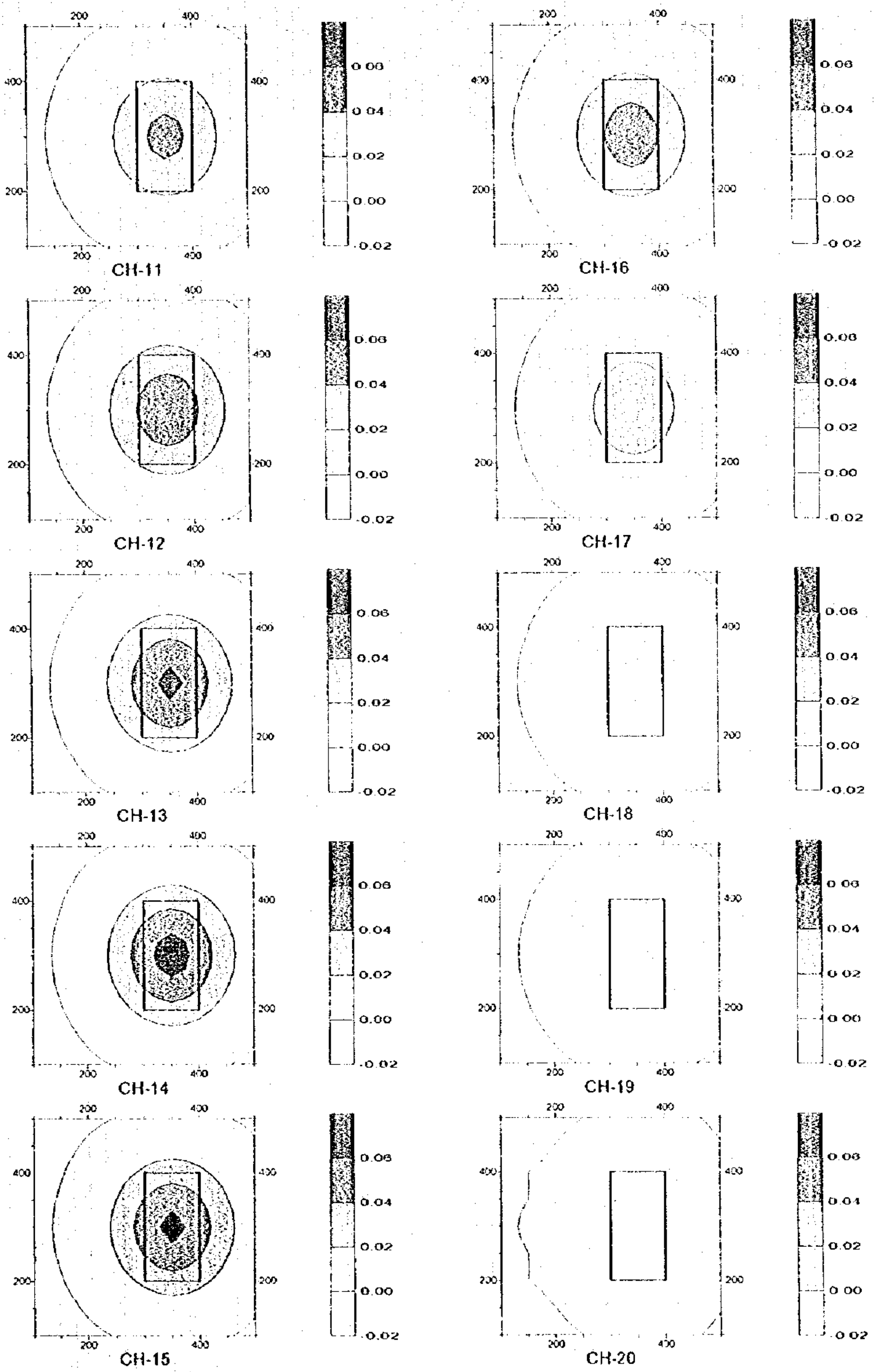


Fig.II-3-5 Contour plot of magnetic difference

3-5 Ghuzayn Area

3-5-1 Loop Locations

According to the results of the TDIP survey, IP anomalies were widely detected in the central part of the area. On this basis and to clarify in more detail the nature of these anomalies and to trace the massive sulphide deposits confirmed by drillings, a TEM survey was carried out over these anomalies by using six transmitter loops located as indicated in Fig.II-3-6.

The depth estimation calculated from the formula described in Section 3-4 is listed for each area in table II-3-4. Since these values are calculated from a layered resistivity structure at the center of the loop, the calculated depth does not always correspond to the real depth.

3-5-2 Results

(1) Loop 1

TEM response maps are shown in Figs.II-3-7(1) and (2).

Two high TEM anomalies are detected:

1) In the west side of the boreholes G15 and G17, a 100 meters wide anomaly zone is detected in the direction of NE-SW. This anomaly is considered to bear no relation with mineralization because its depth is relativelly shallow (less than 80 m depth) and distributed in a low chargeability zone. This anomaly is likely to be caused by a shallow conductor, such as, saline ground water.

2) A 150 m wide anomaly, which is clearly detected in channels 15 to 20, is seen distributed from borehole G5 northwards. This anomaly is considered to be caused by the massive sulphide deposit that was intersected in borehole G5 at depths from 137 to 170 meters. To confirm the extension of this orebody, the boreholes G14, G15, G16 and G17 were located within the range of this anomaly.

(2) Loop 2

TEM response maps are shown in Fig.II-3-8(1) and (2).

Two high TEM anomalies are detected:

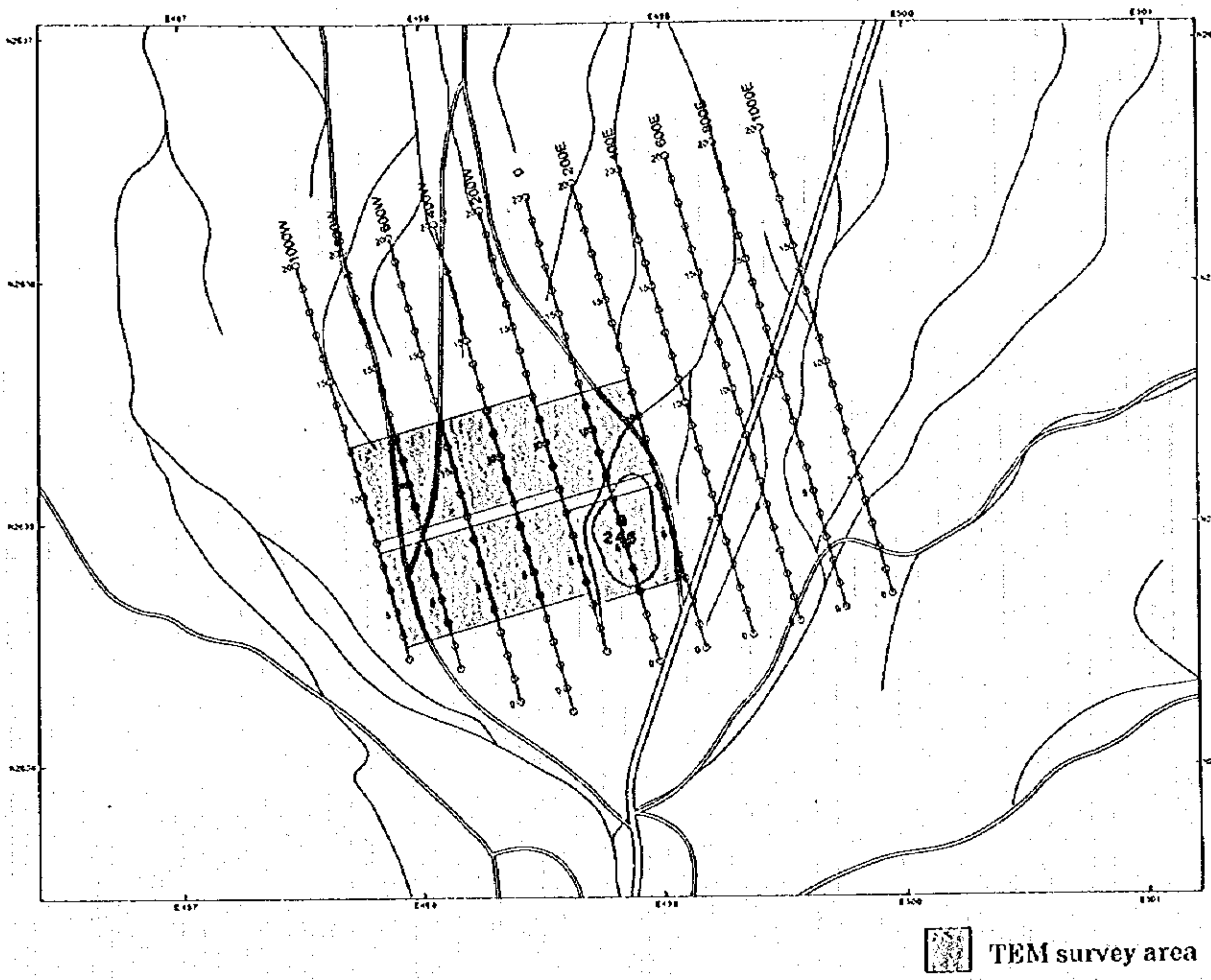
1) From station 900W200S toward NE it is seen an anomaly distributed along diagonal line of the loop in the SW-NE direction (Ch.1-Ch.10) and becoming wide toward NE. Since its maximum

Table II-3-4 Depth estimation in survey area

Unit:meter

	Ghuzayn						Daris north		
Channel	Loop1	Loop2	Loop3	Loop4	Loop5	Loop6	Loop1	Loop2	Loop3
Ch1	31	29	35	38	48	40	21	22	22
Ch2	35	32	39	43	53	45	24	25	24
Ch3	39	36	44	48	60	51	27	28	27
Ch4	44	41	50	54	68	57	30	32	31
Ch5	49	46	55	60	76	64	33	36	34
Ch6	55	52	63	68	85	72	37	40	39
Ch7	62	58	70	77	96	81	42	45	44
Ch8	70	65	79	85	107	91	47	50	49
Ch9	79	73	89	96	121	102	53	57	55
Ch10	89	82	100	108	136	115	60	64	62
Ch11	98	91	111	121	151	128	66	71	69
Ch12	110	102	124	134	169	142	74	79	77
Ch13	125	116	141	153	192	162	84	90	87
Ch14	141	131	159	172	316	182	95	102	98
Ch15	156	145	176	192	240	203	106	113	110
Ch16	177	165	200	217	272	230	119	128	124
Ch17	199	185	224	244	306	258	134	144	139
Ch18	222	207	251	272	342	288	150	161	156
Ch19	250	233	282	307	385	325	169	181	175
Ch20	281	261	317	344	432	364	190	203	197

	Fardah	Sanah		Doqal	
Channel	Loop1	Loop1	Loop2	Loop1	Loop2
Ch1	13	11	11	65	81
Ch2	15	12	12	72	91
Ch3	17	14	13	82	102
Ch4	19	15	15	92	115
Ch5	21	17	17	102	128
Ch6	24	19	19	115	145
Ch7	27	22	21	130	163
Ch8	30	25	24	145	182
Ch9	34	28	27	164	206
Ch10	38	31	30	184	231
Ch11	42	35	34	205	257
Ch12	47	39	38	228	287
Ch13	53	44	43	259	325
Ch14	60	49	48	292	367
Ch15	67	55	54	325	408
Ch16	75	62	61	368	462
Ch17	85	70	68	414	520
Ch18	95	78	76	462	580
Ch19	107	88	86	520	654
Ch20	120	99	97	584	734



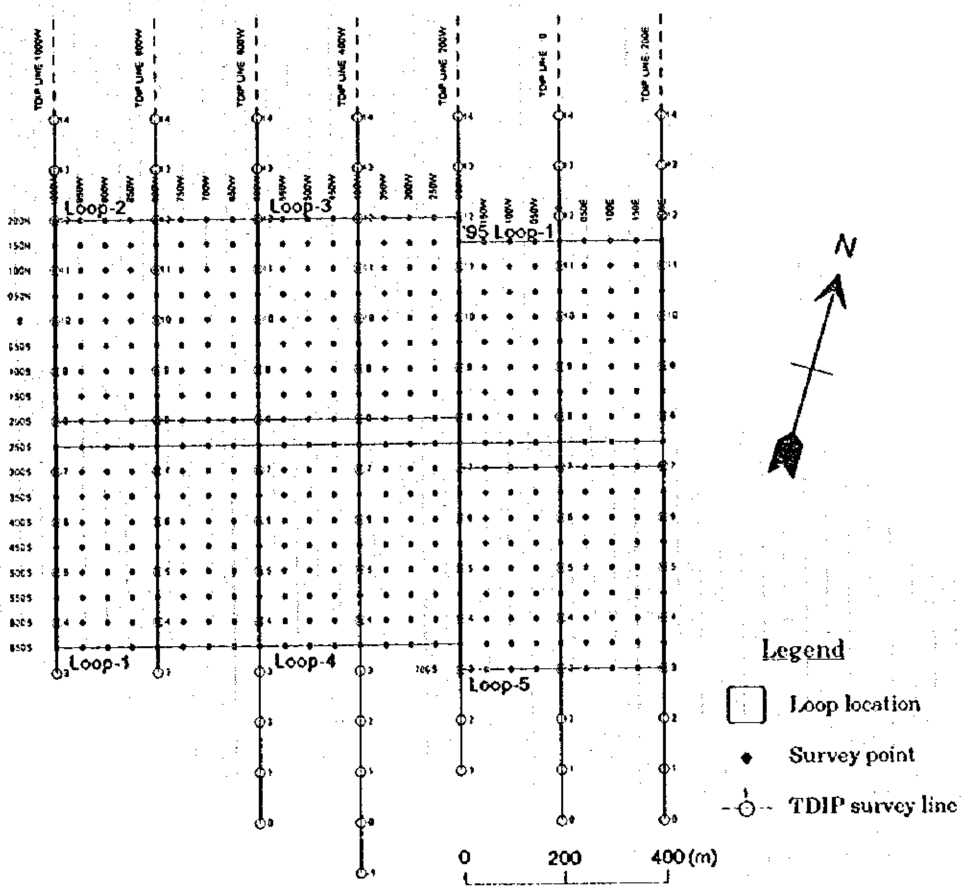


Fig.II-3-6 Ghuzayn survey site showing observation points

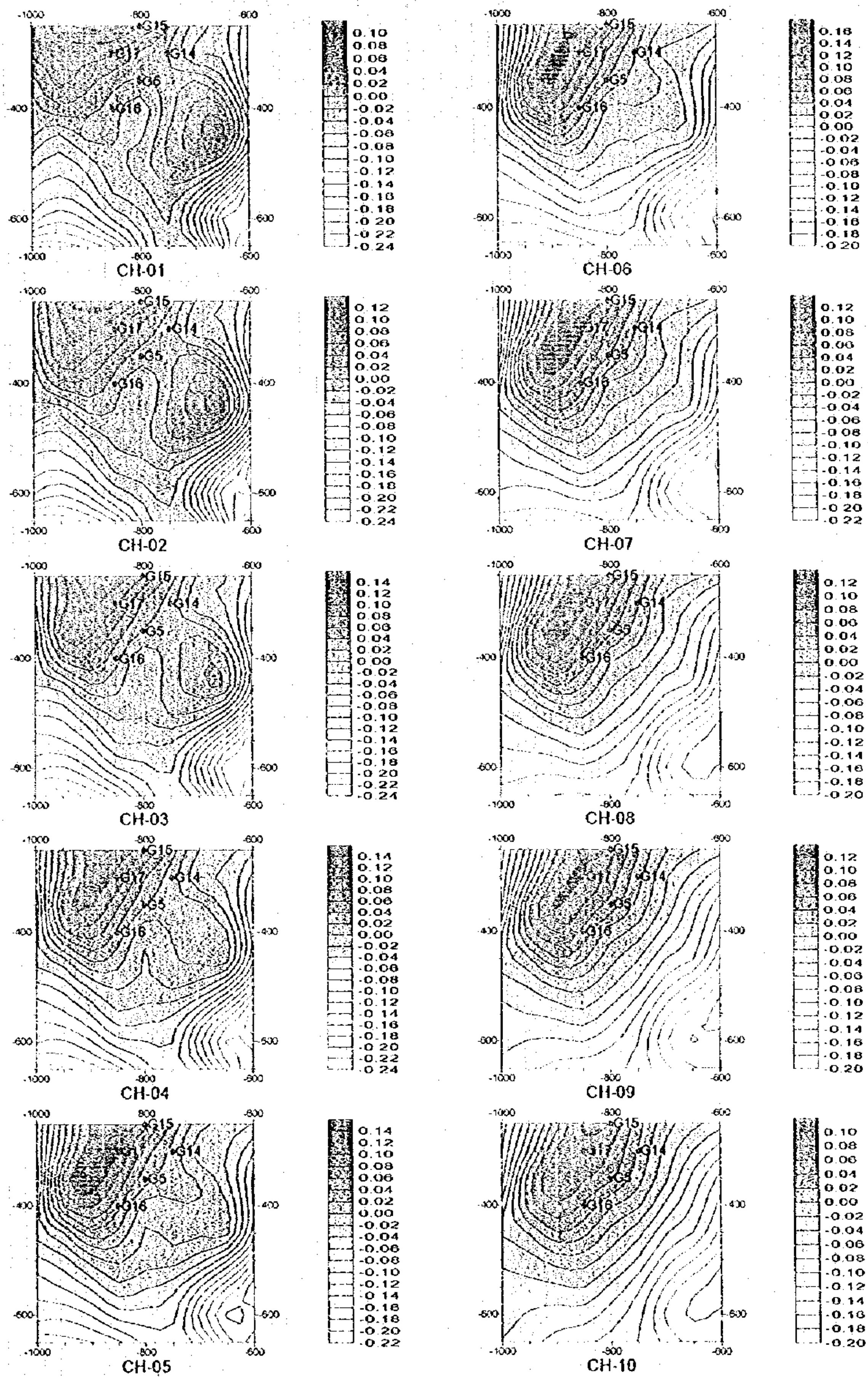


Fig.II-3-7(1) TEM response plane maps of Loop1 in Ghuzayn area

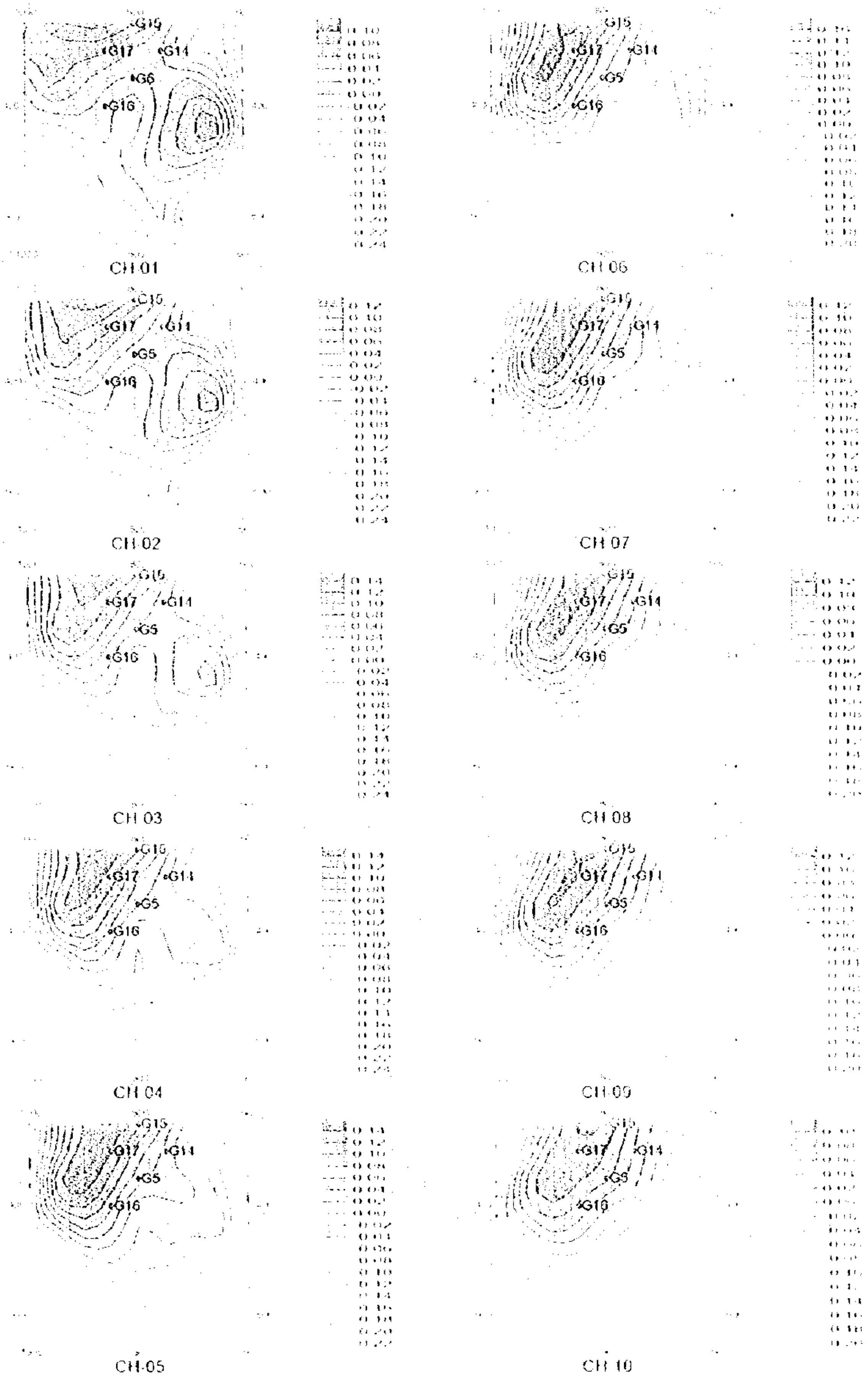


Fig II-3-7(1) TEM response plane maps of Loop1 in Ghazayn area

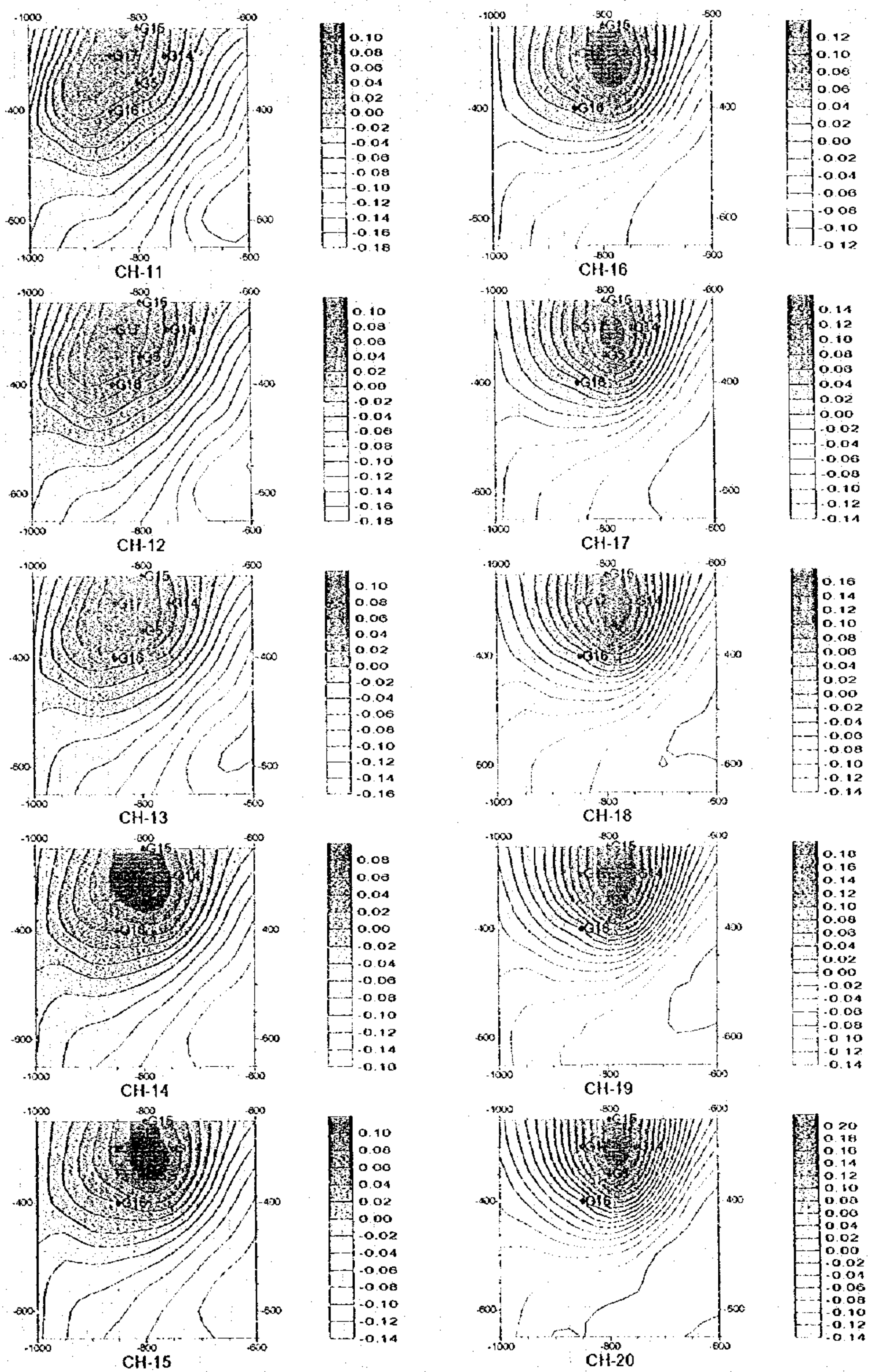


Fig.II-3-7(2) TEM response plane maps of Loop1 in Ghuzayn area

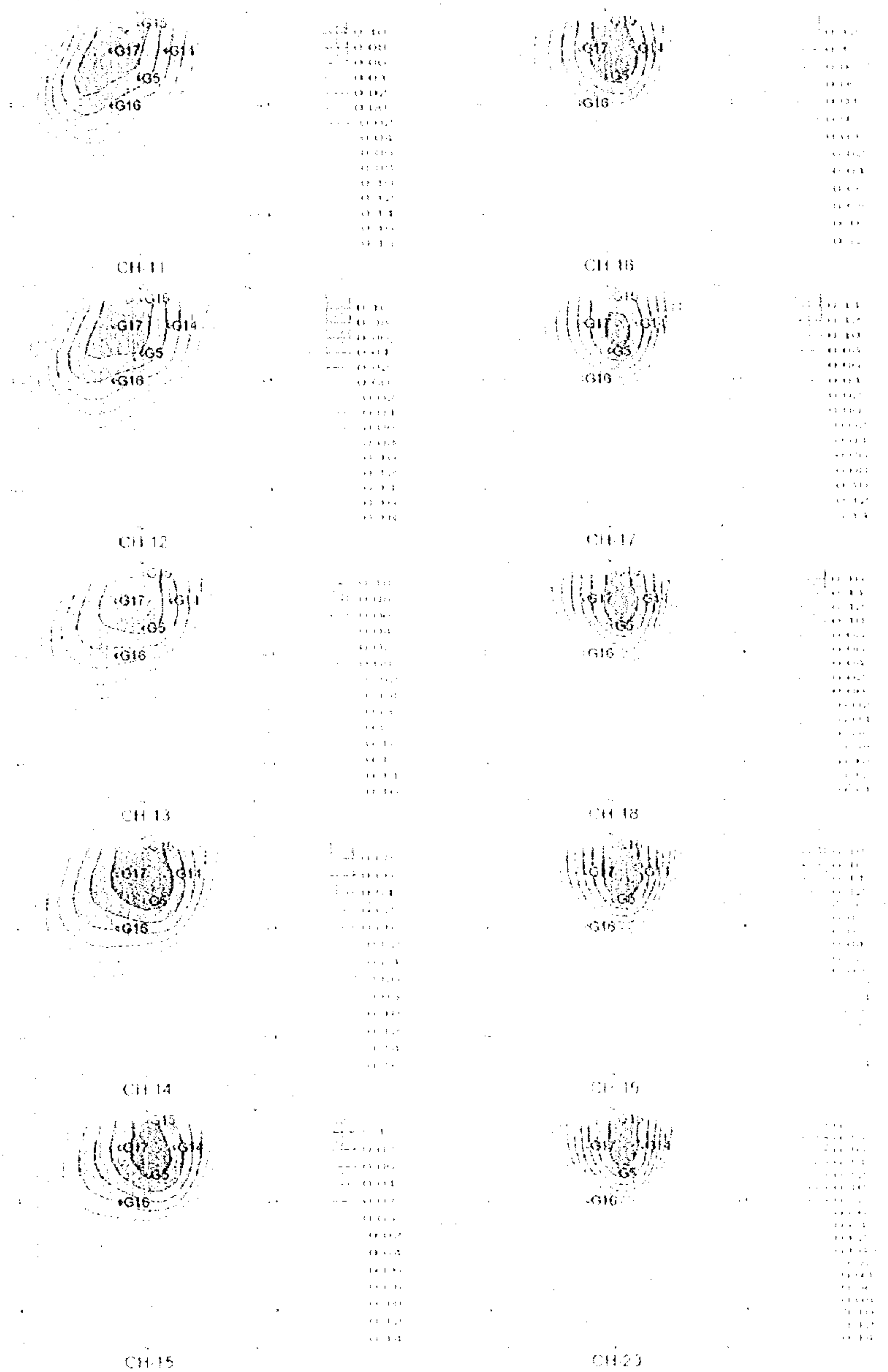


Fig II-3-5-2: TEM response plane maps of Loop I in Ghazaghi area

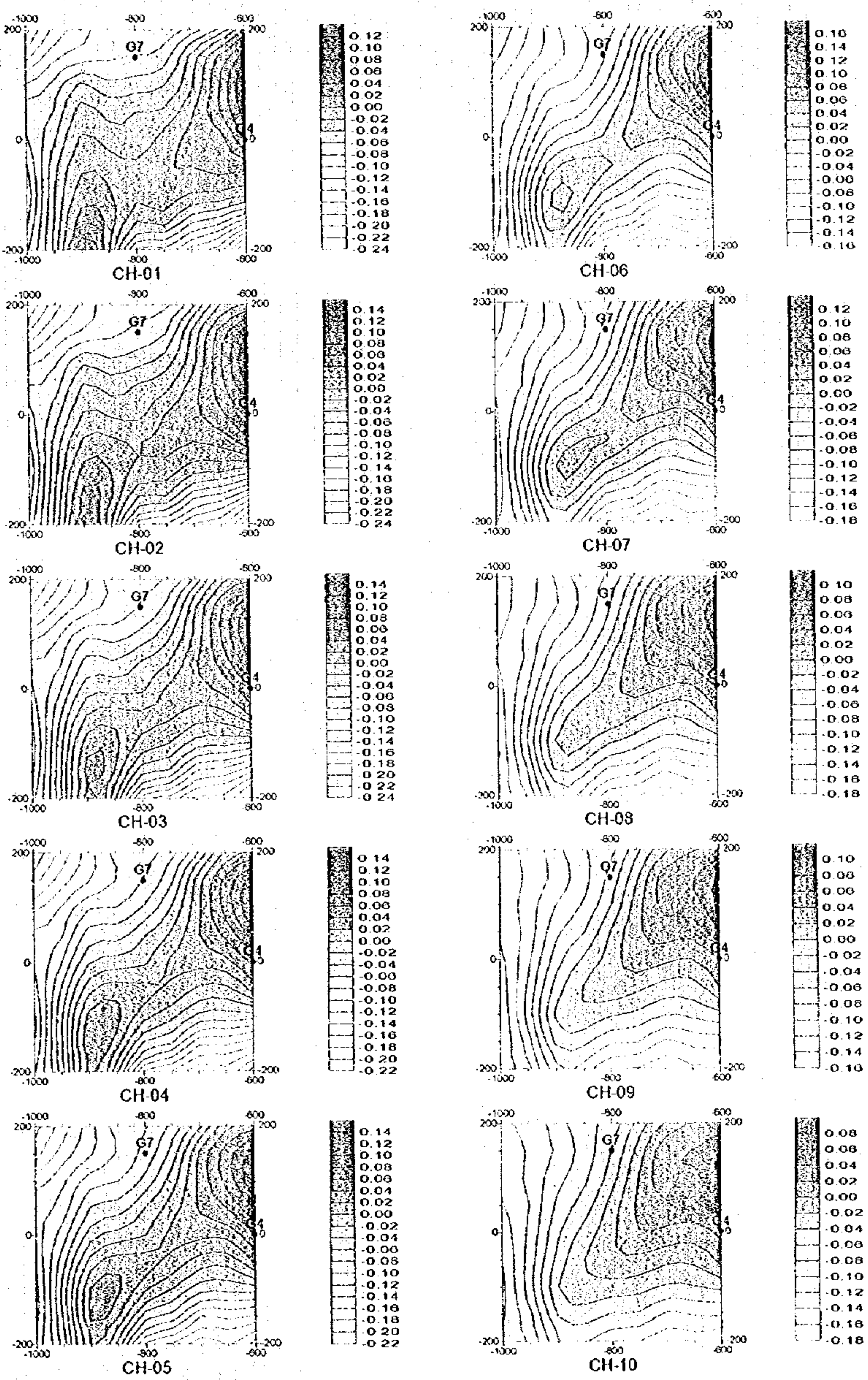


Fig.II-3-8(1) TEM response plane maps of Loop2 in Ghuzayn area

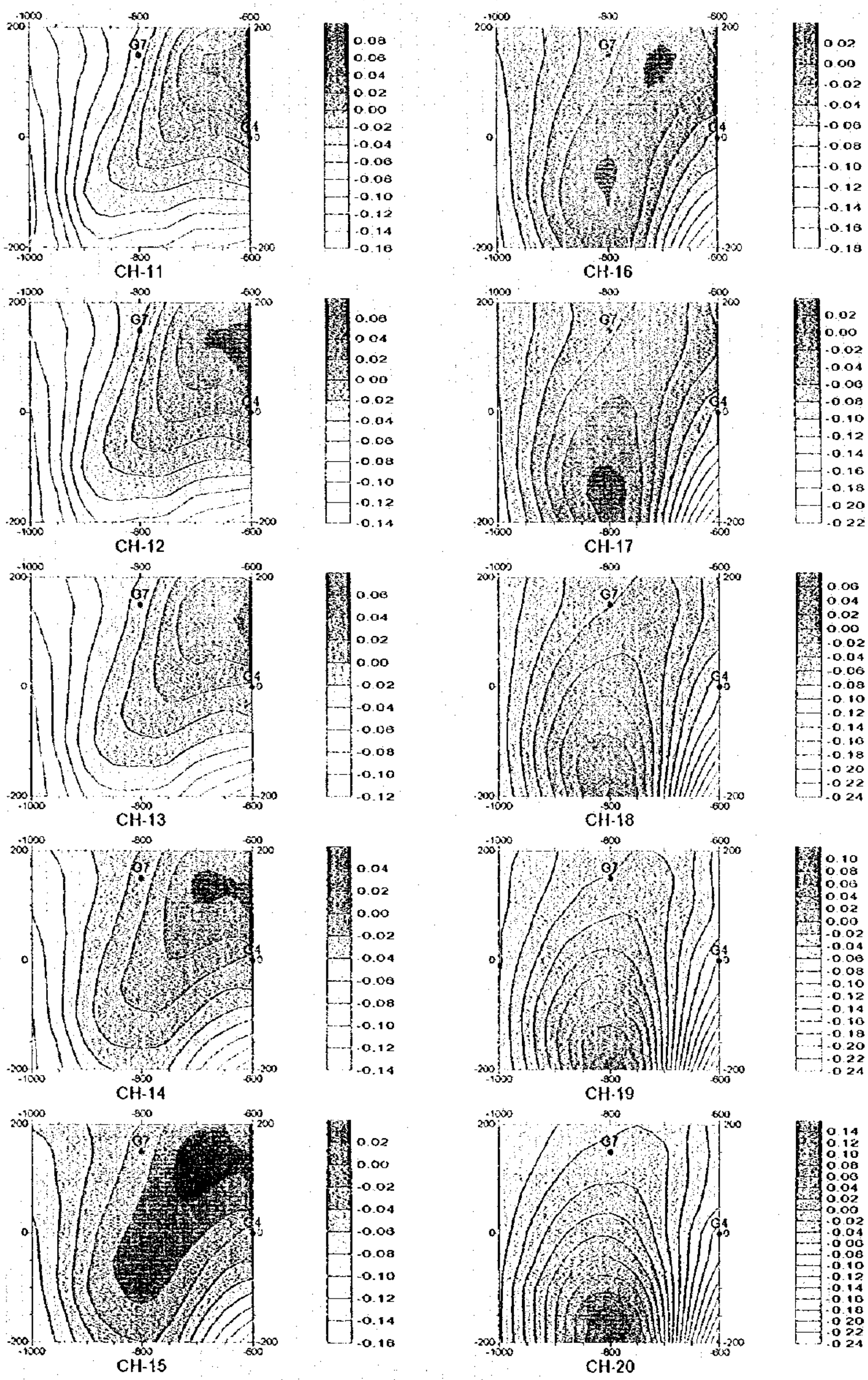


Fig.II-3-8(2) TEM response plane maps of Loop2 in Ghuzayn area

value is detected in Channel 6, the source of this anomaly can be estimated about 50 m depth.

2) From station 800W200S toward north it is seen an anomaly clearly detected in Channels 17 to 20 and considered to be caused by same massive sulphide ore body which discovered in borehole G5. This anomaly extends to near of the station 800W100S with a width of about 150 m. The depth of this anomaly source is estimated to be deeper than the one mentioned in Loop1.

(3) Loop 3

TEM response maps are shown in Fig.II-3-9(1) and (2).

A high TEM anomaly is clearly detected in the north-western part of the loop (Channel 6 to 20). This anomaly is seen as of concentric circles of about 100 m radius in the earlier channels, however at later channels the concentric circles become ellipse with major axis in NS direction. Because its maximum value is detected in Channels 6 to 11, the depth of its source seems to be between 60 to 110 m. There exists the possibility of a conductor in deeper parts, because TEM anomalies do not decrease immediately at later channels.

(4) Loop 4

TEM response maps are shown in Fig.II-3-10(1) and (2).

A high TEM anomaly is detected in the eastern edge of the loop (Channels 1 to 12).

(5) Loop 5

TEM response maps are shown in Fig.II-3-11(1) and (2).

A high TEM anomaly corresponding to the gossan is detected at the center of the loop from Channels 6 to 20. But, there is no anomaly in the south of the loop. The area of this anomaly becomes narrower, as channel number becomes larger. At the station 100E550S, the anomaly is continued to Channel 20.

(6) Loop 6 (PhaseI, Loop 1)

TEM response maps are shown in Figs. II-3-12(1) and (2).

The TEM survey for this loop was carried out last year during Phase I.

Two high TEM anomalies were detected as follows:

1) Around station 000E250S. This anomaly is detected from channels 1 to 13 and extending northwards. Due to the fact that its maximum value is detected in the channels 3 to 5, its source can be located around 60 to 80 m.

2) To the south of borehole G3. This anomaly is detected mainly from channels 14 to 20. Massive sulphide was found in G3 located on the center of this anomaly. Boreholes G9, G10, G11, G12

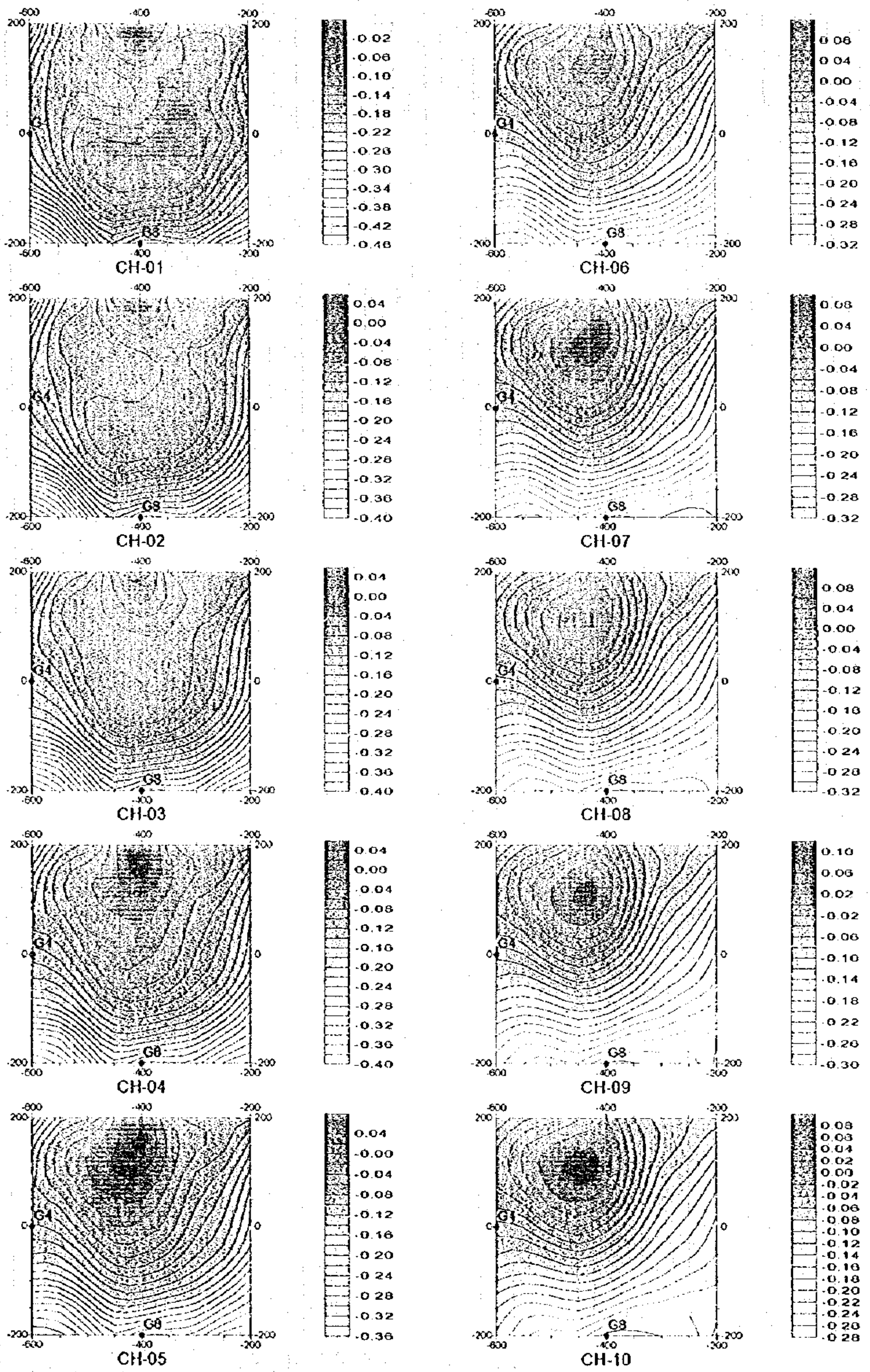


Fig.II-3-9(1) TEM response plane maps of Loop3 in Ghuzayn area

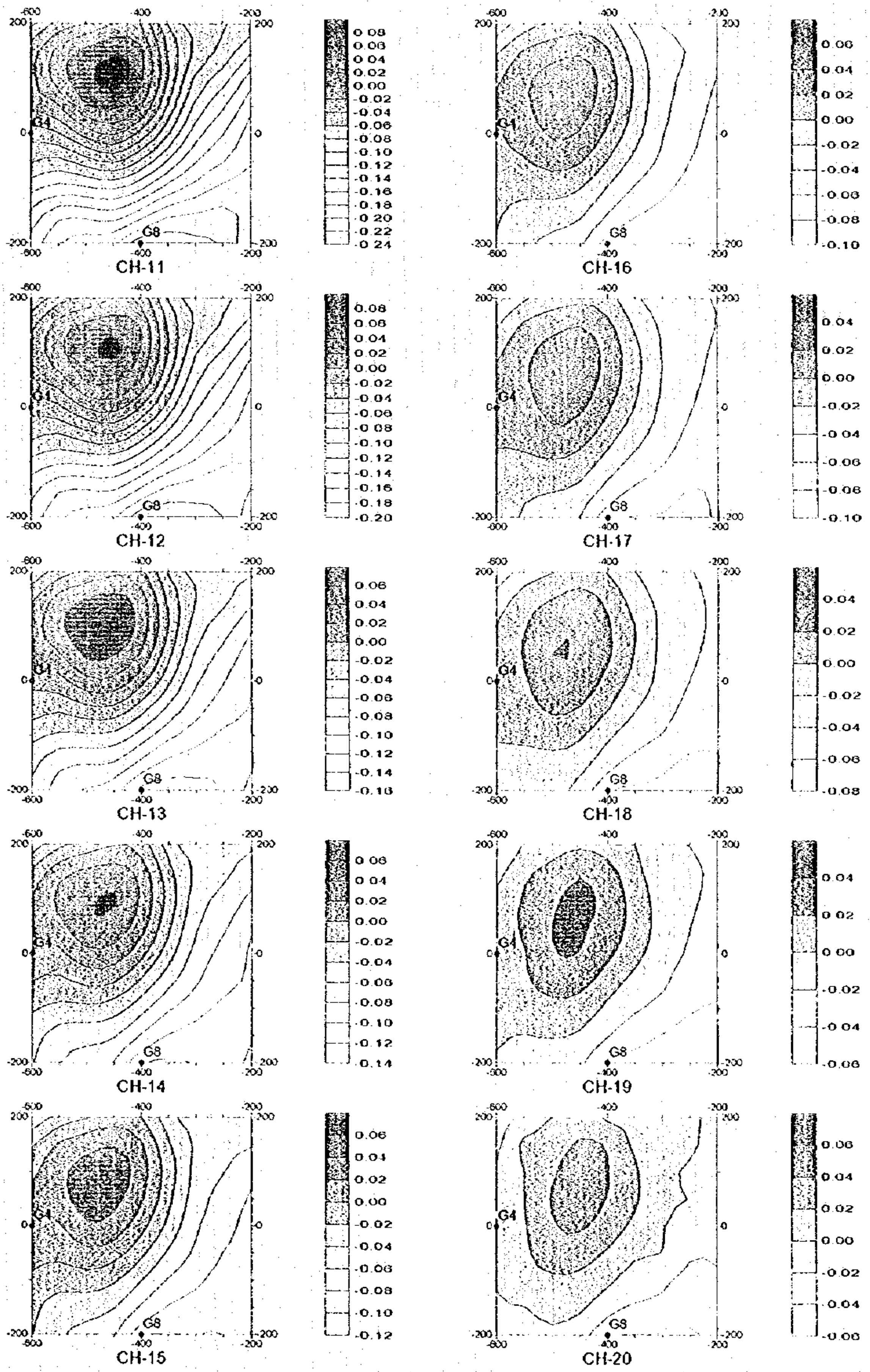


Fig.II-3-9(2) TEM response plane maps of Loop3 in Ghuzayn area

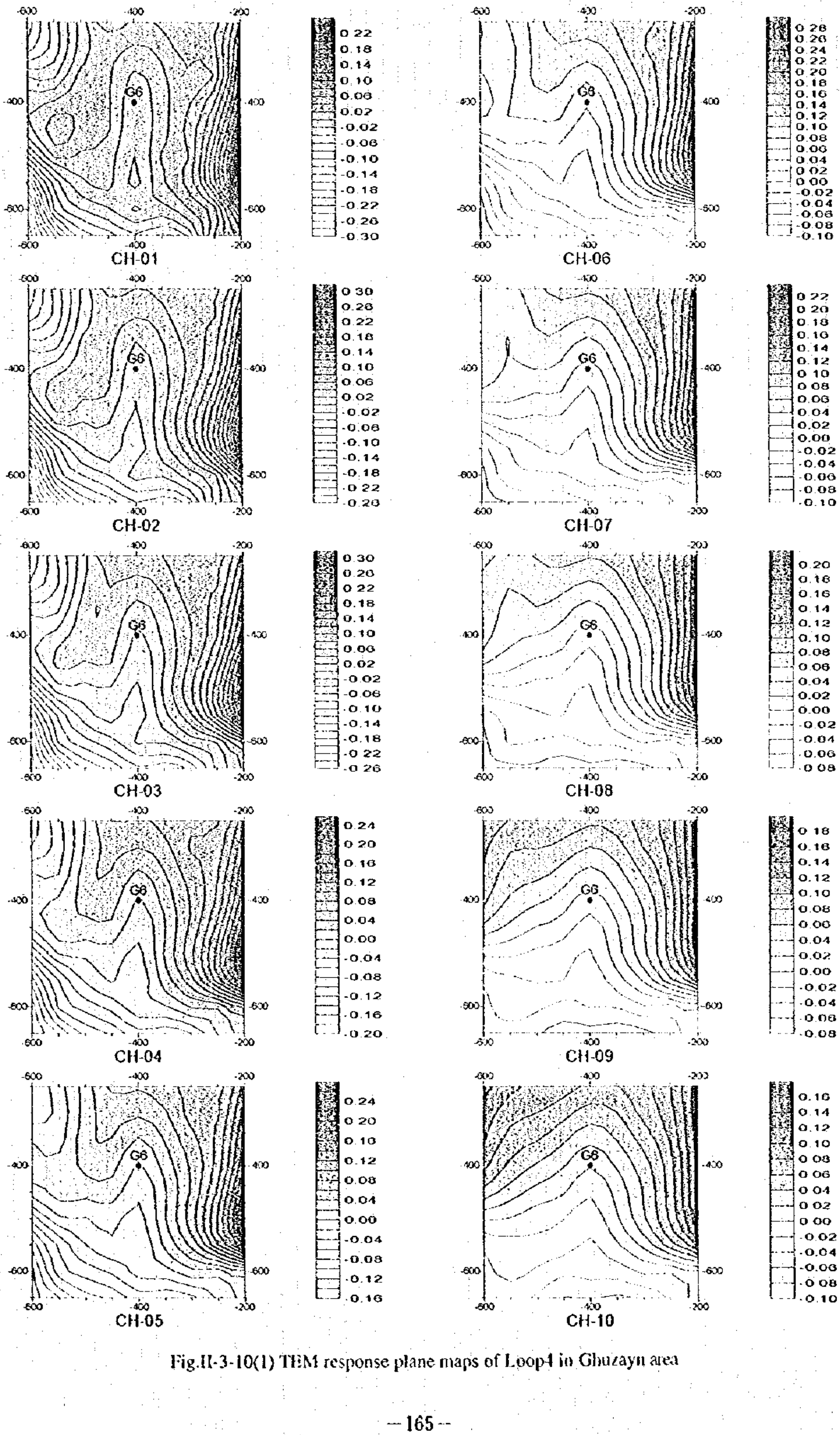


Fig.II-3-10(1) TEM response plane maps of Loop4 in Ghuzayn area

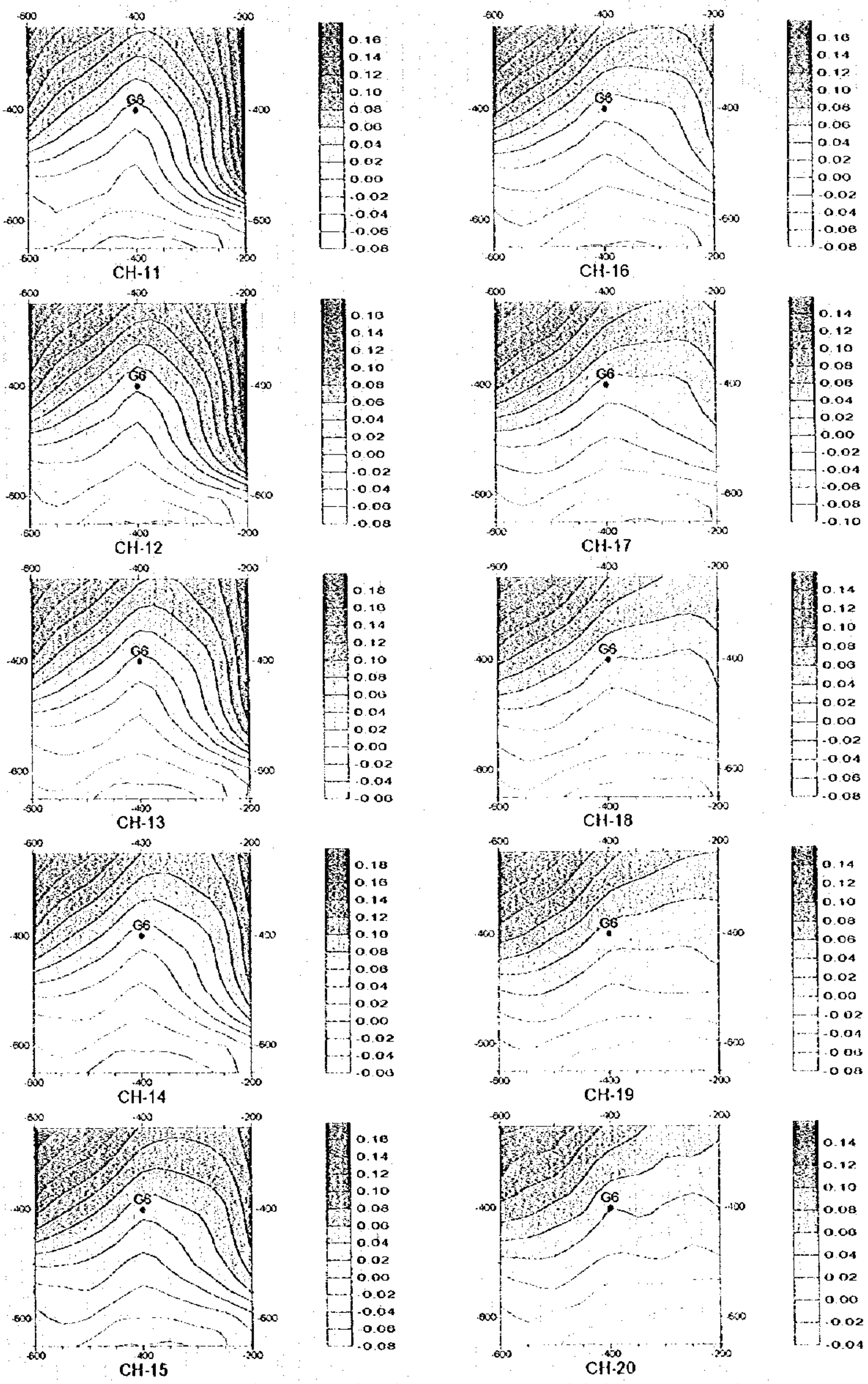


Fig.II-3-10(2) TEM response plane maps of Loop4 in Ghuzayn area

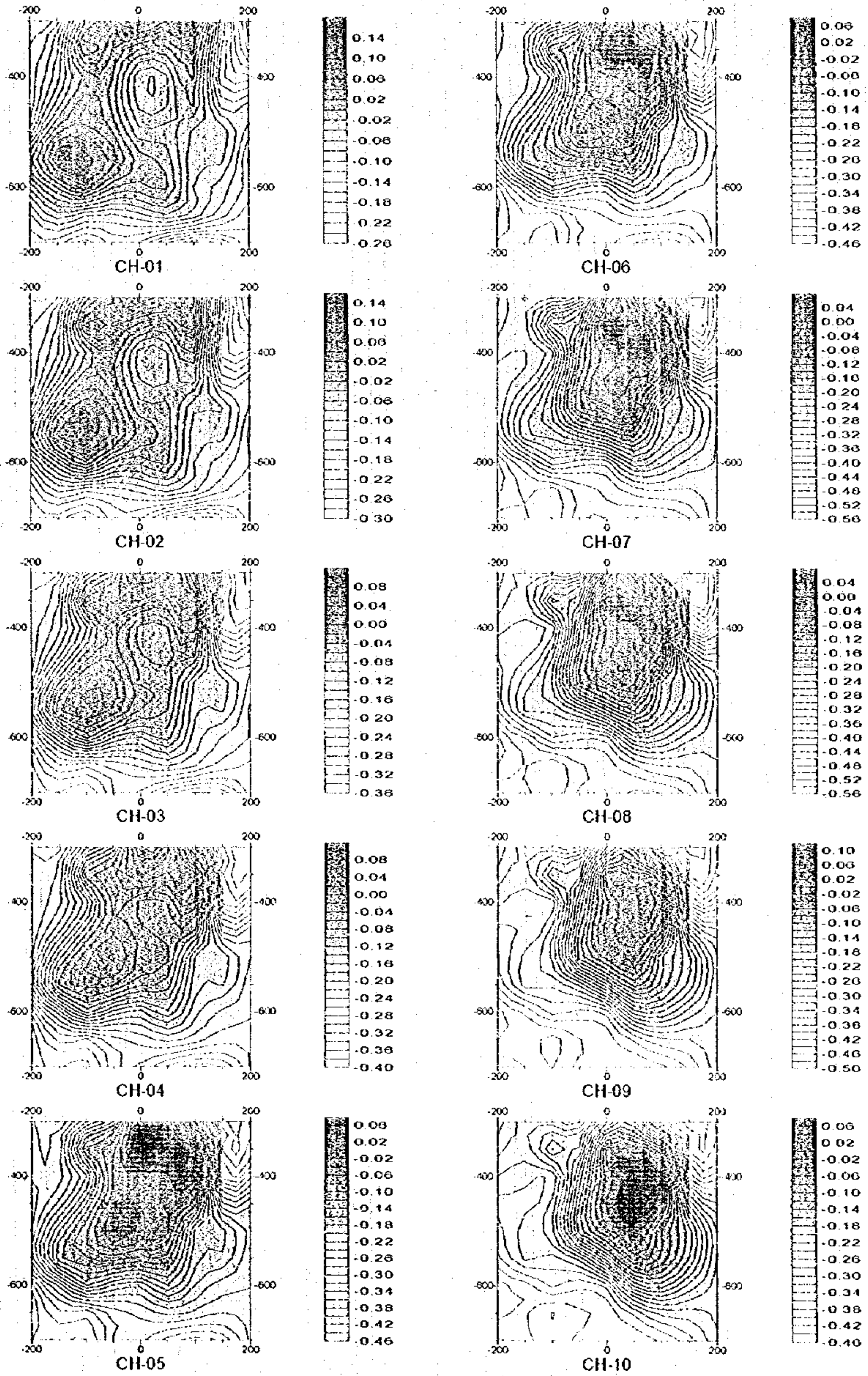


Fig.II-3-11(1) TEM response plane maps of Loop5 in Ghuzayn area

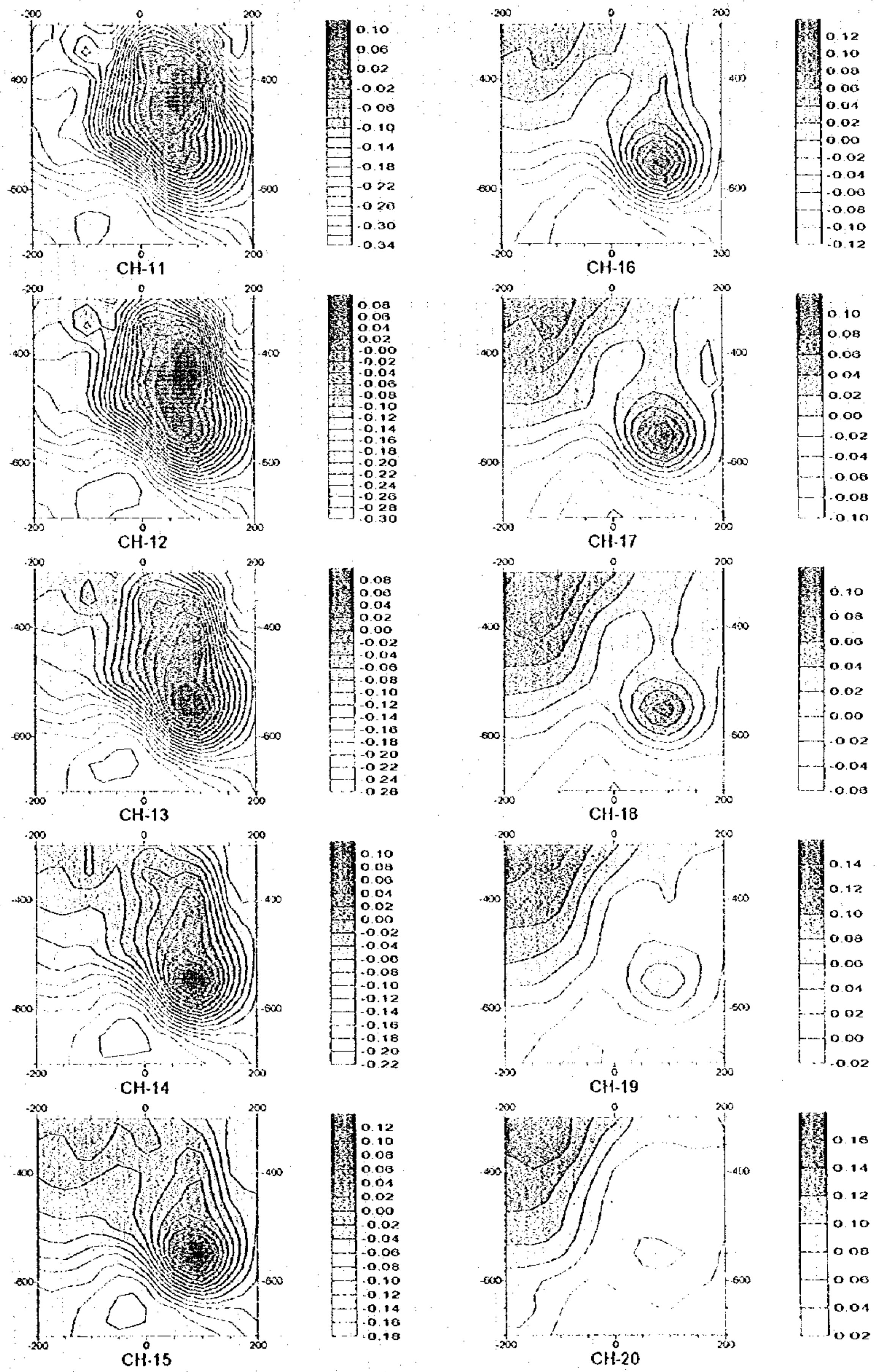


Fig.II-3-11(2) TEM response plane maps of Loop5 in Ghuzayn area

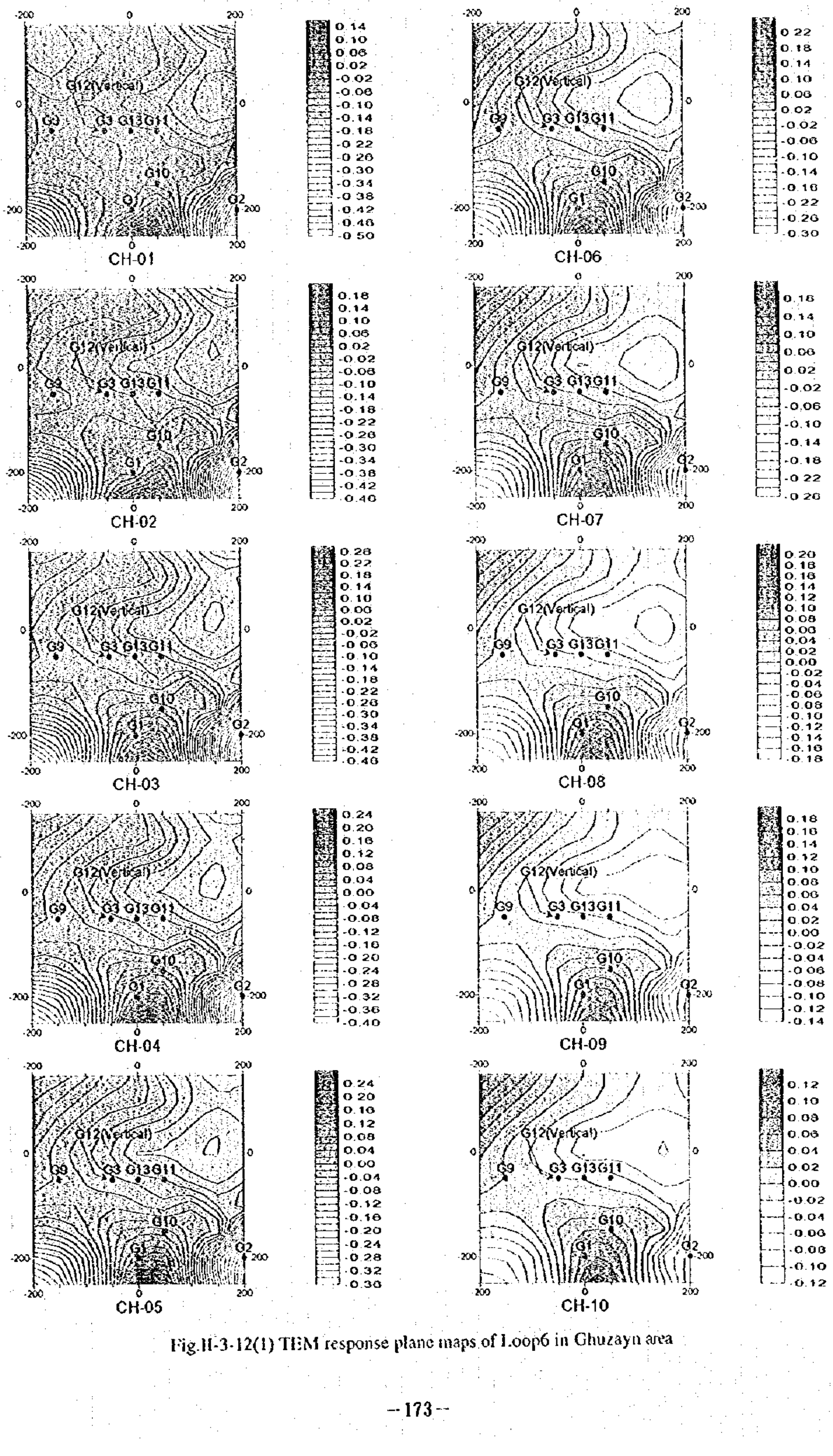


Fig.II-3-12(1) TEM response plane maps of Loop6 in Ghuzayn area

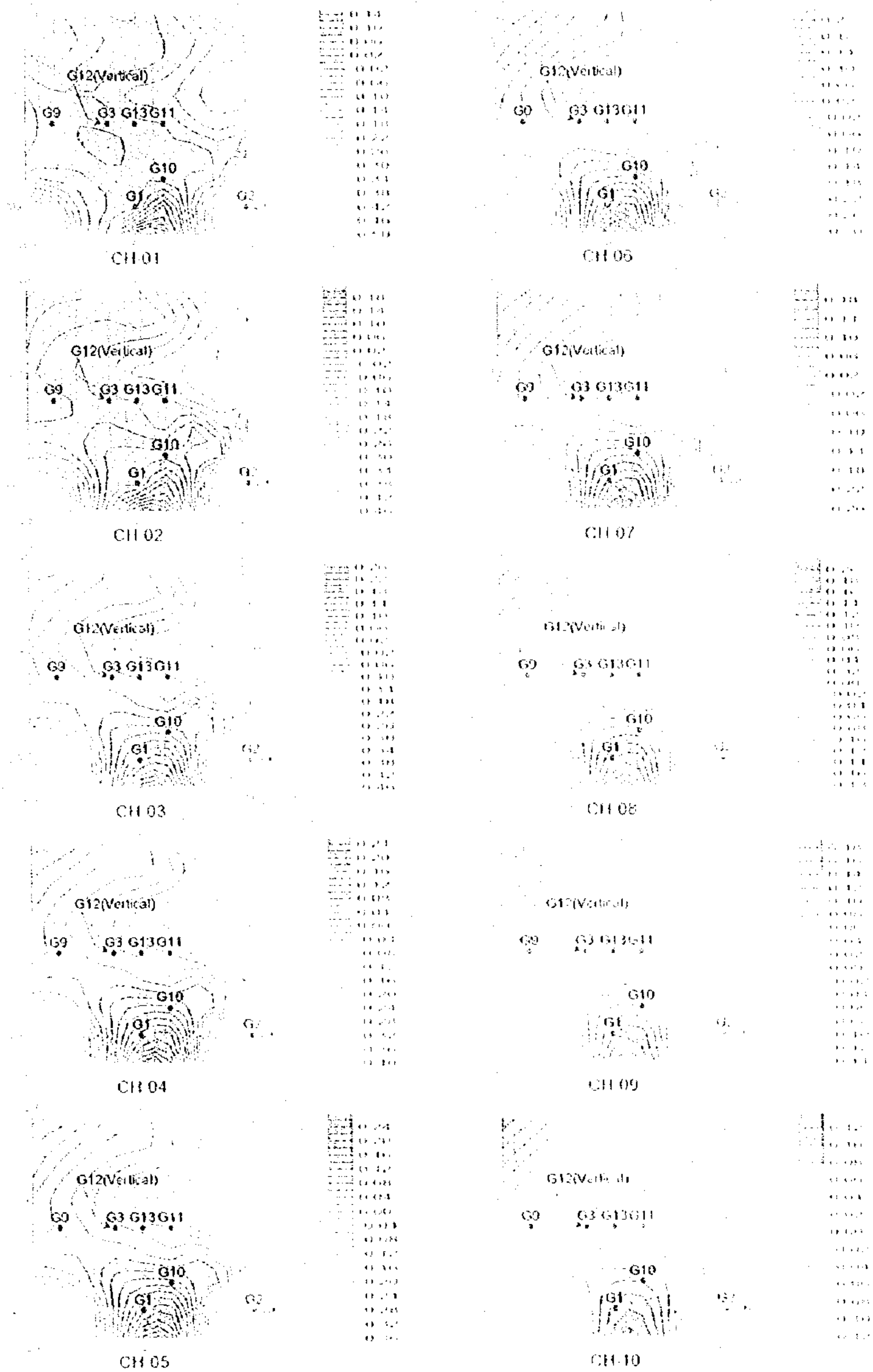


Fig.II-3-12(b) TEM response plane maps of Loop 6 in Glazavn area

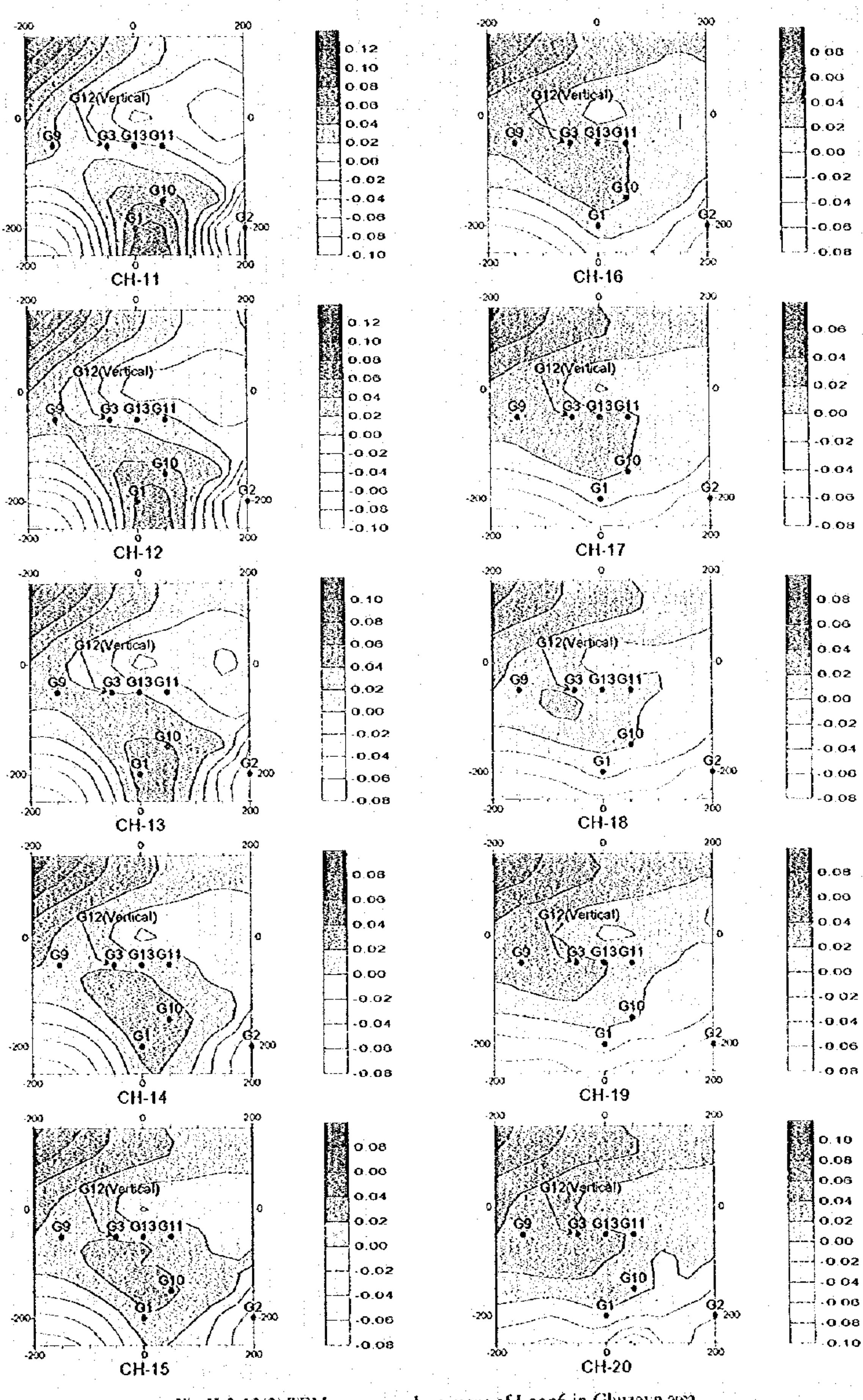


Fig.II-3-12(2) TEM response plane maps of Loop6 in Ghuzayn area

and G13 were selected around G3.

(7) Result of compilation

The TEM response data collected from all the 6 loops were compiled and results are shown as a compiled map in Fig.II-3-13.

For the compilation process it was considered that the same channel number for each loop does not necessarily represent same depth, because average resistivity varies from loop to loop. For this reason, a channel representing the same depth was selected for each loop. The integration of the TEM data were carried out by a digital mosaicking process.

Because the magnitude of the anomalies are normalized, their locations and characteristics can be interpreted.

The compiled map shows the distribution of the TEM response at the depth of about 200 m (Channels 13 to 18).

According to these results, five TEM anomalies are seen:

1) Around the boreholes G5, G14, G15 and G17,
2) about 100 m east of G4,
3) at the eastern edge of gossan,
4) about 200 m south-west of G1, and
5) on the south side of G3.

The anomaly around G5 is due to the massive sulphide ore body intersected by drilling. In the map it is seen as forming elliptical shapes toward north. Accordingly, it is estimated that the massive sulphide ore body extends 150 m in E-W and 300 m in N-S.

The anomaly around G3 is also due to the massive sulphide ore body intersected by drilling. This anomaly is weaker than the anomaly around G5 and for this reason, it is considered that the scale of this massive sulphide ore body is small in comparison with that of G5. The results of drilling support this idea.

The remaining three anomalies are relatively clear, and as such, they may have high potential for the existence of massive sulphide ore deposits.

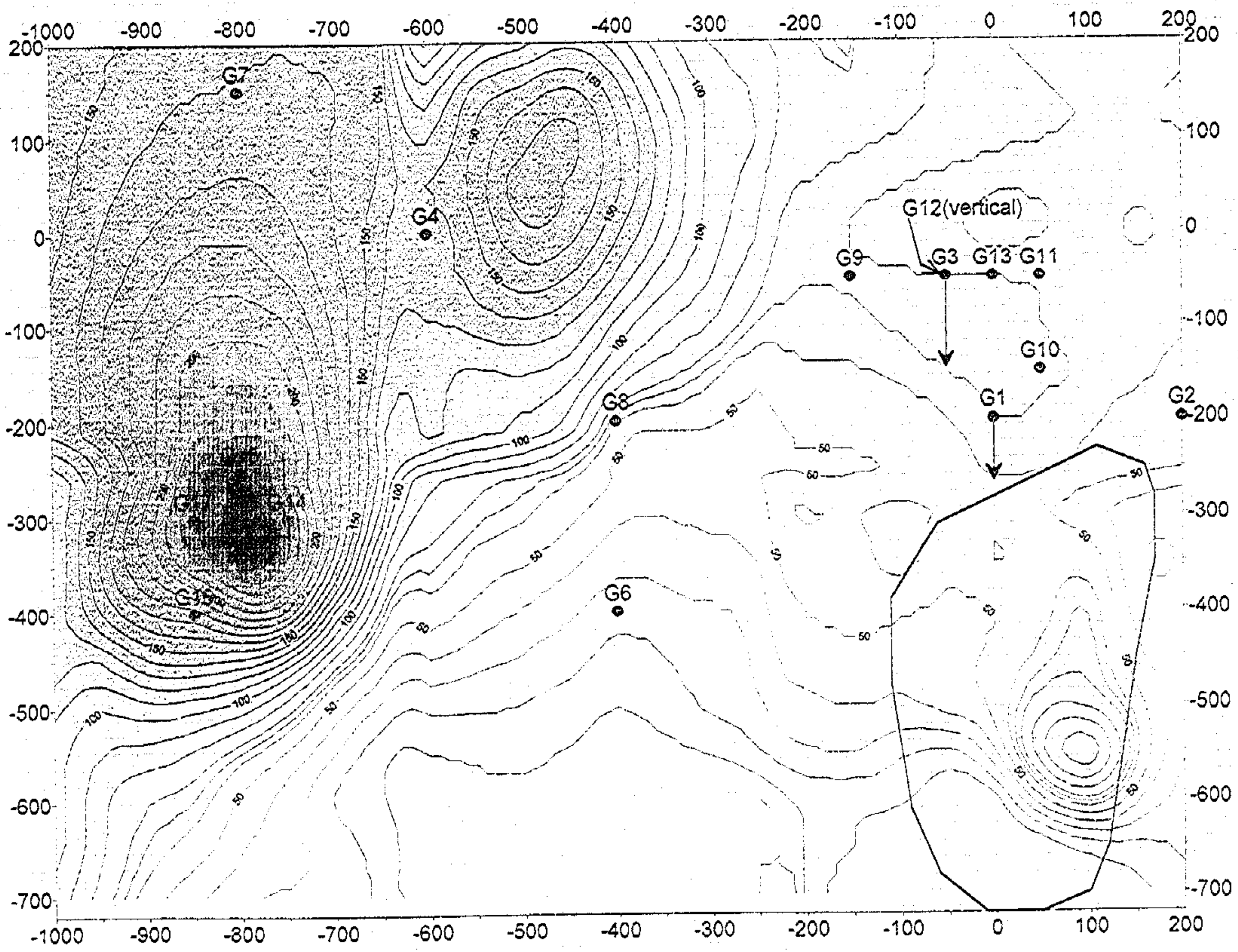
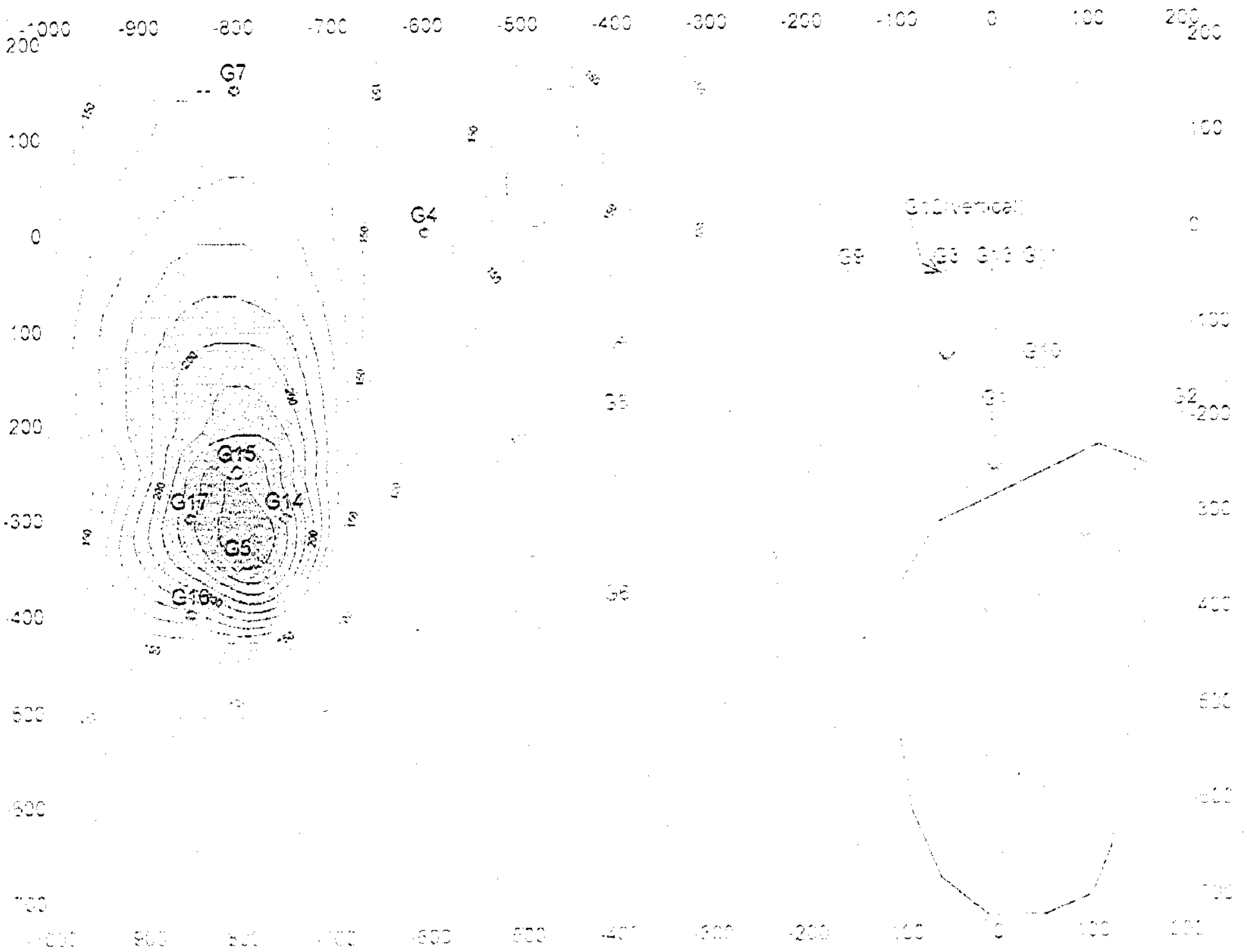


Fig.II-3-13 TEM response compiled maps in Ghuzayn area


G7
G4
G15
G17
G14
G5
G16
G3
G13
G11
G10
G1
G2
G9
G6
G12 (vertical)