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CHRACTERISTIC CURVES FOR RAPID AND ACCURATE INTERPRETATION OF GRAVITY ANOMALY DUE TO INCLINED FAULTS

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ABSTRACT

The families of curves present here have been carried out in order to find a simple technique for rapid and accurate determination of fault parameters. These curves are used in fitting inclined faults to gravity anomaly.

The families of curves depend on the theoretical formula of jung (1961). These curves are divided into groups, which contain therietical models, of faults ranging in dip between 10° and 80°. The depth is constant along each group and is different from one group to another. In order to complete the interpretation, the values of horizontal gradients, vertical gradient and amplitude were calculated and listed in separated tables.

It is impracticable to present these curves for whole ranges of dip and depths. Visual interpolation between these theroretical curives should permit reliable interpretation of any field curves.

INTRODUCTION

Many methods have been suggested for the interpretation of gravity anomalies over an inclined fault, Rho *et al* (1973) formulate functions of the anomaly at several distances from an arbitrary point and the linear equations. Chuta Raoand Ram Babu (1980), describe methods based on Hilbert transform (1980). Hammer and Anzoleaga (1975). Green (1975) stanley and Green (1976), and Abd El-Rahman and Meissner (1983), however, introduced a different method for evaluation of fault parameters the other methods mentioned involve reduction of field curves and matching with master curves.

The familie of curves present here have been carried out in order to find a simple technique for rapid and accurate determination of fault parameters. These curves depend on the theoretical formula of Jung (1961). They are divided into groups; each group contains a theoretical model of inclined fault ranging in dip between 10° and 80°, the depths are constant along each group and are different from one group to another.

The difficulty lay in the great number of curves required to represent all inclined faults for all values of density contrast, to overcome this difficulty we use the knowing values of T1T2 (where T1 and T2 are depth to the upper and lower sueface) and in determing the density contrast along each profile; also visual interpolation between these theortical curves should permit reliable interpretation of any field curve. Keep in mind that these curves should fulfill the following conditions :

1- Accurate enough to furnish diagnostic interpretataion yet.
2- Simple enough to permit rapid application.

To complete the interpretation, the value of vertical gradient, amplitude and the amplitude function of the analytical signal of higher order were calculated to choose values of dip in each group and list them in separated tables (Table "I". "II").

Theoretical Background :

The gravity effect due to the inclined fault, Fig. (1) in given by Jung (1961) as :

$$g(x) = 2G\rho\ [(x\text{-}b)\ \mathrm{Sin}\ \alpha\ (\mathrm{Sin}\ \alpha\ \mathrm{LN}\frac{r_2}{r_1} + \mathrm{Cos}$$

$$(\psi_2 - \psi_1) + T.\psi_2 - T\ \psi_1)]$$

where :

G : is the universal gravitational constant;

ρ : is the density contrast between the body and its surroundings;

α : is the dip angle of the body flanks;

T_1 : is the depth of the upper surface of the boried body

T_2 is the depth of the lower surface of the byried body.

r_1, r_2 : are the distance between the corners 1, 2 of the causative body and the observation point.

ψ_1, ψ_2 : are the angle between x axis and r1, r2.

The vertical gradient gz(x) of gravity is/

$$gz(x) = 2\ G\rho\ [\mathrm{Sin}\ \alpha.\ \mathrm{Cos}\ \alpha.\ \mathrm{Ln}\frac{r_2}{r_1} - \mathrm{Sin},\ (\psi_2 - \psi_1)\ ] \quad \text{...........(2)}$$

The vertical gradient of gravity can be calculated from the horizontal gradient of gravity using Hilbert transform techniques (Bracerell 1965) thus we have :

$$gz(x) = g\ x\ (x) * \frac{(-1)}{\pi X}$$

Where :

$\frac{(-1)}{\pi X}$: is the Hilbert - transform of the derac Delta impulse.

gx (x) : is the Horizontal gradient

The modulus of the analytical signal is given by

$A(x) = [gz\ (x)^2 + (gx\ (x^2)]^{1/2}$ ....(4)

The modulus of the amplitude function of the analytical signal of thrid order is calculated according to the equation :

$A(x) = [gzxx\ (x)^2 + gxxx\ (x)2]^{1/2}$..(5)

Evaluation of the density contrast using the known values T_1 T_2 and : α

The gravity values at point (c) on the ground surface (Fig. (2), the equation (1) reaches maximum values as at $\psi_1 = \psi_2$.

Thus, the entire interpretation process for evaluation of the density contrast is summarized in the following steps.

1- A vertical line is drawn vertically from maximum values of gravity profile over the inclined fault, this line intersec with the ground surface in point (c).

2. A line with the angle α drawn from the point C fig. (2) intersects the two horizontal lines A and B which represent the depths to the upper and lower, surfaces of the known fault.

3- The previous steps are used to draw the models of fault from these models and by applying equation (1) and from knowing the values of T_1, T_2 and α we can determine the density contrast.

Interpretation procedure :

For rapid interpretation of gravity profiles using the constructed curves, the

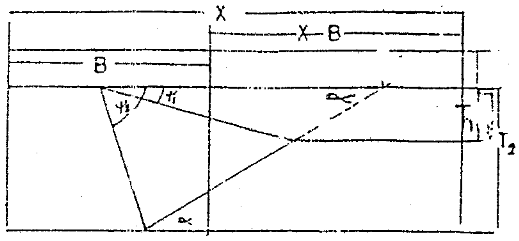

FIG (1) GEOMETRY OF FAULT PARAMETERS

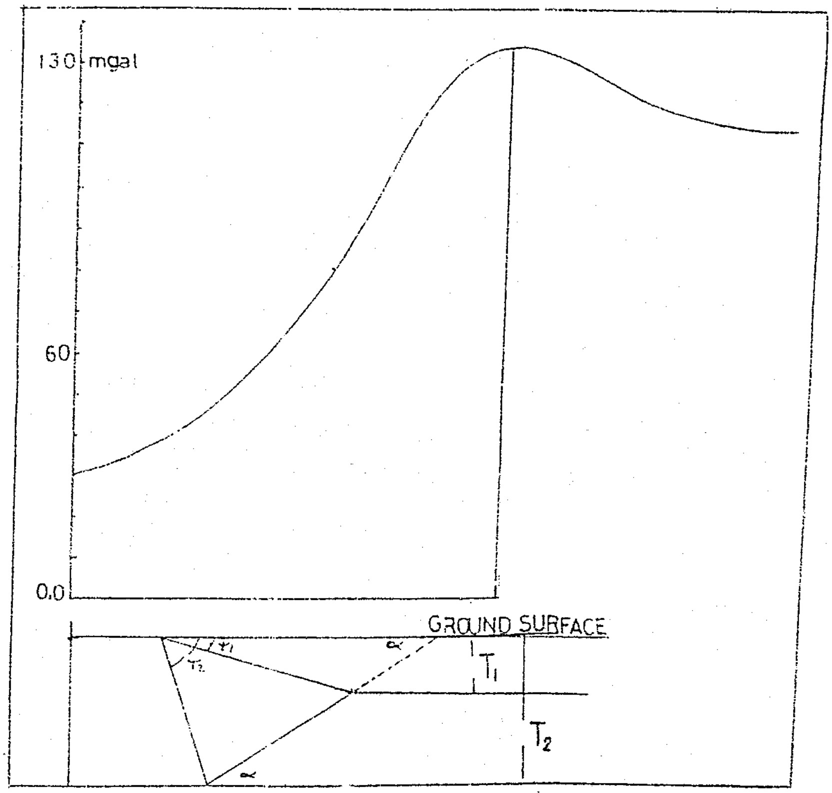

FIG (2) EVALUTION OF THE DENSITY CONTRAST USING THE KNOWING VALUES T_1 tand following procedure is recommended.

1- The selected profile is taken perpendicular to the strike of the fault.

2- A dastement of horizontal scale of gravity profile with the horizontal scale of the theoretical curve is made.

3- The curve matching process is carried out between the theoretical and selected profiles.

4- When the selected profile coincides with the theoretical profile we use the known values of T1,T2 and (α) to evaluate the density contrast as explaines in the previous positions.

5- Using tables (1, 2) in completing of the interpreation. we get vertical gradient, amplitude and amplitude functaion of the analytiacal signal of higher order.

ACKNOWLEDGEMENTS

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Table (1) : The calculated values of Gz (x), A (x) and Az (x)

$T_1 = 1.5km$ $T_2 = 3km$					$T_1 = 1.0km$ $T_2 = 2km$					$T_1 = 1.0km$ $T_2 = 3.0km$					$T_1 = 1.okm$ $T_2 = km$			
No		Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)
1		-1.66	1.145	0.145	1		-0.65	1.78	.134	1		-1.66	4.66	.15	1		-3.13	6.1
2		-2.13	6.025	0.57	2		-0.75	2.05	0.054	2		-2.13	6.025	0.57	2		-3.55	6.9
3		-2.97	8.49	1.7	3		-0.99	2.74	0.27	3		02.97	8.49	1.7	3		-.99	7.8
4		-4.64	9.216	0.31	4		-1.42	3.97	1.2	4		-3.28	9.45	2.83	4		-4.7	9.11
5		-3.93	11.5	0.32	5		-1.98	5.61	4.96	5		-3.94	11.5	.31	5		-5.11	10.4
6		-4.0	11.84	0.287	6		-4.32	12.46	0.7	6		-4.0	11.84	0.28	6		-6.25	12.31
7	20°	-4.08	11.84	0.29	7	20°	-4.84	14.1	0.71	7	20°	-4.0	11.84	0.26	7	20°	-7.08	14.01
8		-3.73	11.23	1.62	8		-4.47	13.2	0.39	8		-3.73	11.23	1.62	8		-8.21	16.31
9		-9.03	18.01	1.52	9		-3.72	11.23	0.35	9		-4.53	13.28	0.79	9		-9.03	18.01
10		-0.55	1.92	.083	10		-3.28	9.99	0.6	10		-4.6	13.55	0.65	10		-9.79	19.61
11		0.59	0.18	0.84	11		-2.56	7.94	1.69	11		-4.58	13.56	0.47	11		-10.44	21.1
12		0.5	1.23	0.22	12		-1.8	5.75	3.65	12		-4.45	13.28	0.24	12		-10.57	21.42
13		0.16	0.28	0.127	13		-0.76	2.67	1.44	13		-4.3	12.87	0.14	13		-10.19	20.8
14		0.17	0.28	.059	14		0.24	0.55	0.11	14		0.17	0.29	0.28	14		-8.2	17.1
1		-3.01	4.63	.06	1		-1.59	2.45	0.015	1		-3.01	4.63	0.06	1		-5.04	10.2
2		-3.5	5.4	0.32	2		-2.0	3.08	0.02	2		-3.5	5.4	.032	2		-5.77	8.9
3		-6.51	10.4	0.068	3		-6.55	13.11	0.24	3		-4.17	6.43	0.14	3		-6.3	10.1
4		-5.15	7.98	0.37	4		-3.17	4.9	0.22	4		-5.15	7.98	0.37	4		-4.64	9.11
5		-6.95	10.8	0.26	5		-4.33	6.7	1.036	5		-6.95	10.8	0.25	5		-8.58	13.25
6		-8.65	13.5	0.29	6		-6.29	9.8	3.3	6		-8.65	13.5	0.3	6		-9.9	15.31
7		-10.3	16.21	0.24	7		-7.7	12.09	6.45	7		-10.3	16.2	0.24	7		-11.44	17.6
8	40°	-13.07	20.3	0.86	8	40°	-4.8	7.72	5.49	8	40°	-6.62	10.55	0.12	8	40°	-12.1	20.1
9		-1.16	2.1	0.29	9		-.07	2.47	0.24	9		-1.16	2.07	0.29	9		-14.93	23.4
10		0.79	1.04	0.25	10		1.1	1.55	0.81	10		0.79	1.04	0.25	10		-14.93	25.4
11		1.1	1.54	0.19	11		1.56	2.32	0.45	11		1.1	1.54	0.19	11		-21.9	13.97
12		1.41	2.06	0.135	12		1.21	1.8	0.25	12		1.4	2.06	0.14	12		-21.4	9.48
13		1.39	2.1	0.1	13		1.2	1.8	0.15	13		1.4	2.1	0.1	13		-4.68	24.9
14		1.05	1.55	0.08	14		0.86	1.29	0.1	14		1.05	1.54	0.08	14		0.312	0.41
1		-4.2	4.85	.026	1		-2.71	3.12	.049	1		-4.2	4.85	.003	1		-7.86	9.19
2		-5.1	5.9	0.04	2		-3.61	4.16	0.071	2		-5.1	5.89	0.036	2		-8.75	10.23
3		-5.7	6.58	0.18	3		-4.8	5.54	0.38	3		-7.5	8.66	0.62	3		-10.2	11.8
4		-7.5	8.67	0.63	4		-3.61	4.16	0.071	4		-8.38	9.7	0.184	4		-11.11	12.83
5		-8.38	9.7	0.18	5		-4.8	5.54	0.04	5		-7.5	8.66	0.62	5		-12.3	14.56
6		-9.71	11.26	0.45	6		-6.31	7.28	0.18	6		-8.38	9.7	0.184	6		-14.3	16.82
7		-16.5	19.06	0.37	7		-11.3	12.8	8.6	7		-9.71	11.27	0.45	7		-16.4	19.6
8	60°	-4.38	5.2	0.65	8	60°	-9.55	11.1	0.43	8	60°	-11.32	11.3	0.2	8	60°	-21.6	0.52
9		1.61	1.74	0.37	9		-4.4	5.2	2.58	9		-4.38	5.2	0.65	9		-19.7	22.9
10		3.69	4.16	0.23	10		2.76	3.12	1.25	10		1.61	1.75	0.37	10		-18.13	21.2
11		3.97	4.51	0.15	11		3.67	4.16	0.52	11		3.69	4.16	0.23	11		-10.53	12.5
12		3.48	3.4	0.1	12		3.95	4.4	0.22	12		3.97	4.5	0.15	12		6.48	7.29
13		4.19	4.9	0.2	13		2.73	3.12	0.13	13		3.96	4.5	0.1	13		6.6	7.5
14		3.04	3.5	0.42	14		2.8	2.8	0.4	14		4.19	4.9	0.2	14		7.6	8.7

Table (II) : The calculated values of Gz(x) and Az(x) containued.

		$T_1 = 2km$ $T_2 = 6km$					$T_1 = 3.0km$ $T_2 = 6.0km$					$T_1 = 3km$ $T_2 = 7km$					$T_1 = 1.0km$ $T_2 = 4.0 km$		
No	Gz	Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)	A3(x)	No		Gz(x)	A(x)	A3(x)
1		-3.56	10.68	0.14	1		-2.6	7.39	0.27	1		-2.37	6.71	0.053	1		-1.3	3.56	0.41
2		-2.62	7.94	0.14	2		-2.97	8.49	0.33	2		-2.65	7.53	0.26	2		-1.27	3.56	0.01
3		-2.76	8.35	0.13	3		-3.33	9.58	0.65	3		-2.98	8.49	0.41	3		-1.5	4.1	0.081
4		-3.25	9.31	0.54	4		-1.73	10.6	0.1	4		-3.25	9.31	0.54	4		-1.73	4.87	0.19
5		-3.62	10.21	0.37	5		-3.68	11.22	0.103	5		-3.58	10.26	0.73	5		-2.02	5.61	0.42
6		-4.08	12.12	0.082	6		-4.04	11.84	.095	6		-3.84	11.09	0.78	6		-2.36	6.57	0.36
7	20°	-4.92	14.51	0.22	7	20°	-4.2	12.19	12.19	7	20°	-4.0	11.77	0.82	7	20°	-2.84	8.01	1.68
8		-5.03	14.8	0.46	8		-4.03	11.98	.043	8		-4.4	12.6	0.86	8		-3.17	8.97	3.01
9		-5.1	14.92	0.86	9		-3.72	11.23	0.04	9		-4.53	13.28	0.79	9		-3.98	11.36	4.02
10		-5.23	15.2	1.79	10		-3.28	9.98	0.6	10		-4.6	13.55	0.65	10		-4.62	13.28	4.13
11		-5.36	15.47	4.07	11		-2.56	7.94	1.69	11		-4.58	13.56	0.47	11		-5.1	14.8	3.5
12		-5.39	15.5	10.62	12		-1.8	5.75	3.65	12		-4.45	13.28	0.24	12		-5.44	15.9	1.2
13		-5.25	14.9	27.2	13		-0.76	2.67	1.44	13		-4.3	12.87	0.14	13		-5.7	16.77	1.53
14		-4.82	13.55	85.34	14		-.38	1.51	0.93	14		-3.83	11.64	1.56	14		-5.9	17.0	12.6
+1		-4.43	9.0	0.12	1		-9.12	11.23	0.94	1		-6.81	10.55	.046	1		-2.3	8.3	.086
2		-5.04	10.2	0.11	2		-9.34	12.35	0.09	2		-7.6	11.84	0.74	2		-3.4	9.78	.025
3		-6.55	15.11	0.24	3		-9.07	11.59	.092	3		-9.76	15.18	0.121	3		-4.25	10.9	.1
4		-7.27	14.61	0.14	4		-8.34	11.04	0.13	4		-10.4	16.2	0.166	4		-5.31	12.08	.02
5		-8.0	16.1	0.51	5		-3.6	4.91	.092	5		-10.9	16.98	.23	5		-7.8	14.66	.044
6	40°	-8.94	17.81	.07	6	40°	-1.49	2.16	.068	6	40°	-10.6	16.72	0.27	6	40°	-9.04	17.11	.09
7		-9.29	18.41	3.93	7		-1.49	2.16	.08	7		-10.63	16.7	.029	7		-16.64	18.9	.148
8		-8.74	17.2	10.69	8		-9.08	0.212	.04	8		-9.81	15.44	.31	8		-15.8	16.92	0.26
9		-15.7	16.92	0.26	9		1.29	1.54	.132	9		-6.26	10.4	.28	9		-16.9	17.5	0.3
10		-6.24	12.01	9.7	10		1.99	2.45	.4	10		-5.59	9.0	0.18	10		5.46	5.66	.06
11		-304	8.09	10.4	11		1.9	2.45	.052	11		-4.59	7.5	.083	11		2.04	2.09	.09
12		-2.4	3.48	6.53	12		2.19	2.76	.07	12		-1.78	3.1	.03	12		9.09	9.59	.068
13		-.82	1.22	5.12	13		2.1	2.7	.03	13		-.66	1.3	.066	13		6.77	7.2	.07
14		-4.8	13.55	8.34	14		-.38	1.51	0.93	14		-3.8	11.64	1.56	14		7.8	7.2	0.8
1		-11.4	13.17	0.14	1		-9.56	11.1	0.1	1		-10.5	12.13	.055	1		-.38	5.7	.41
2		-12.51	14.4	0.64	2		-7.08	8.23	0.154	2		-11.93	13.87	0.14	2		-.34	6.4	.1
3		-13.86	15.59	0.128	3		-8.29	10.4	0.145	3		-12.25	14.2	.063	3		-.3	7.7	0.23
4		-7.27	14.61	.135	4		-8.34	11.4	0.13	4		-11.0	17.24	0.25	4		-.25	9.1	1.05
5		-14.23	16.3	1.69	5		-3.47	4.15	0.14	5		-11.9	13.8	.018	5		-.21	11.9	1.06
6		-12.7	14.56	5.08	6		-.17	.43	.06	6		-9.77	11.5	.019	6		-.18	13.11	0.55
7	60°	-9.29	18.41	3.91	7		.135	.93	3.81	7		.15	-296	.098	7		-.15	15.81	1.81
8		-4.7	5.21	8.45	8		3.37	3.81	.041	8		1.63	1.8	.08	8		-.13	18.21	2.33
9		3.9	3.12	8.6	9		3.66	4.15	.05	9		3.11	3.47	.09	9		-.11	19.62	2.52
10		2.73	3.12	0.1	10		3.55	3.81	.03	10		3.7	4.16	.07	10		-.15	20.3	2.22
11		3.93	4.5	.06	11		3.6	3.65	.05	11		3.9	4.51	.08	11		-.16	21.1	2.6
12		4.1	4.6	.07	12		3.7	3.71	.03	12		4.0	4.6	.081	12		-.163	18.1	2.5
13		4.2	4.7	.072	13		3.8	3.65	.06	13		4.1	4.7	.091	13		-.17	19.1	2.6
14		3.9	4.3	.08	14		3.9	3.7	.07	14		4.2	4.5	.93	14		-.18	20.1	3.5

Plate-1

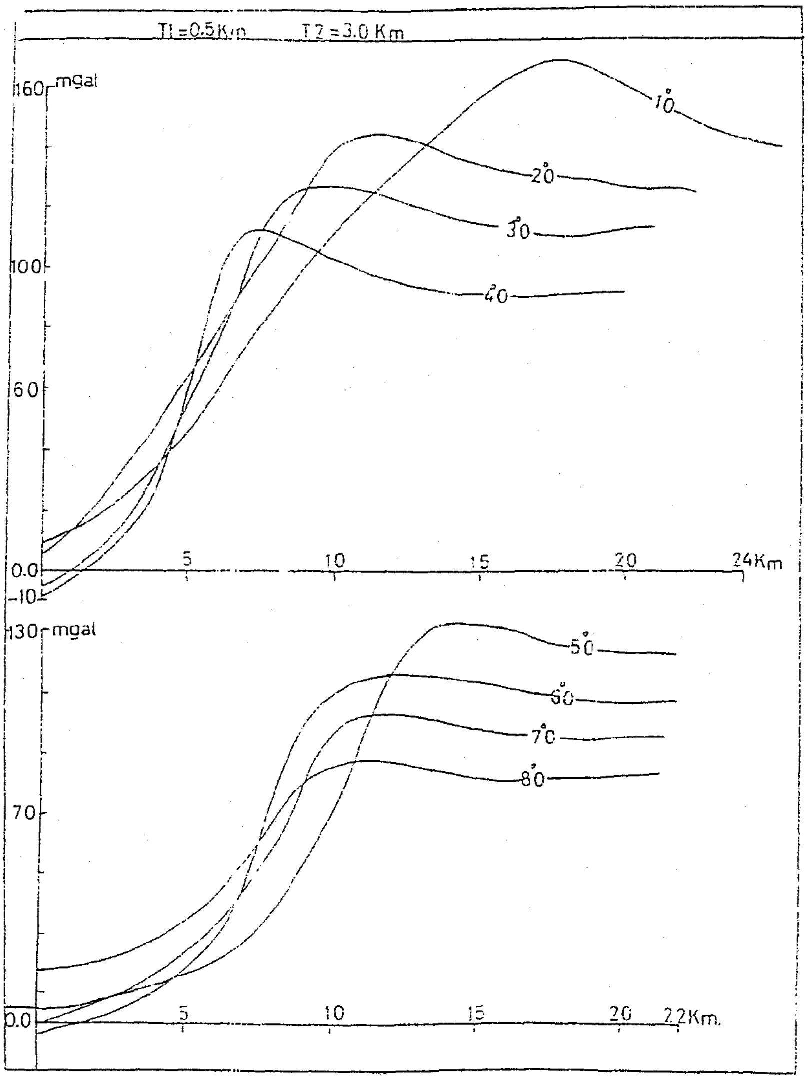

Plate 1 :

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = depth to upper surface = 0.5 Km

T_2 = depth to lower surface = 3.0 Km

α = angle of dip ranging from 0-80^o

Plate-2

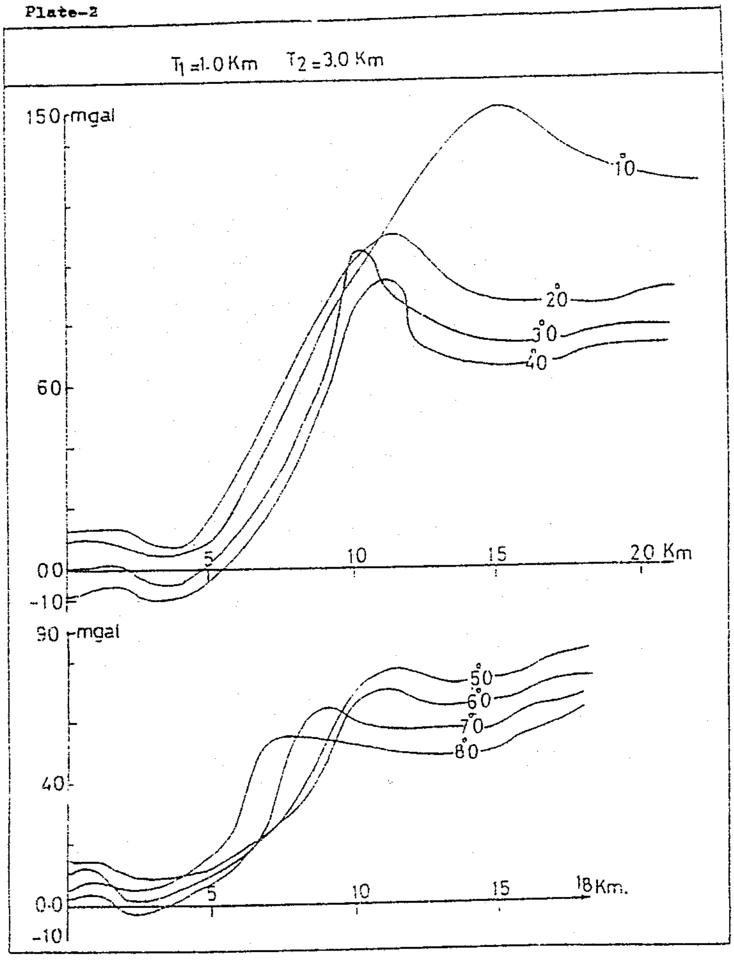

Plate2:

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = 1.0 Km T_2 = 3.0 Km

α = angle of dip ranging from 0-80°

Plate-3

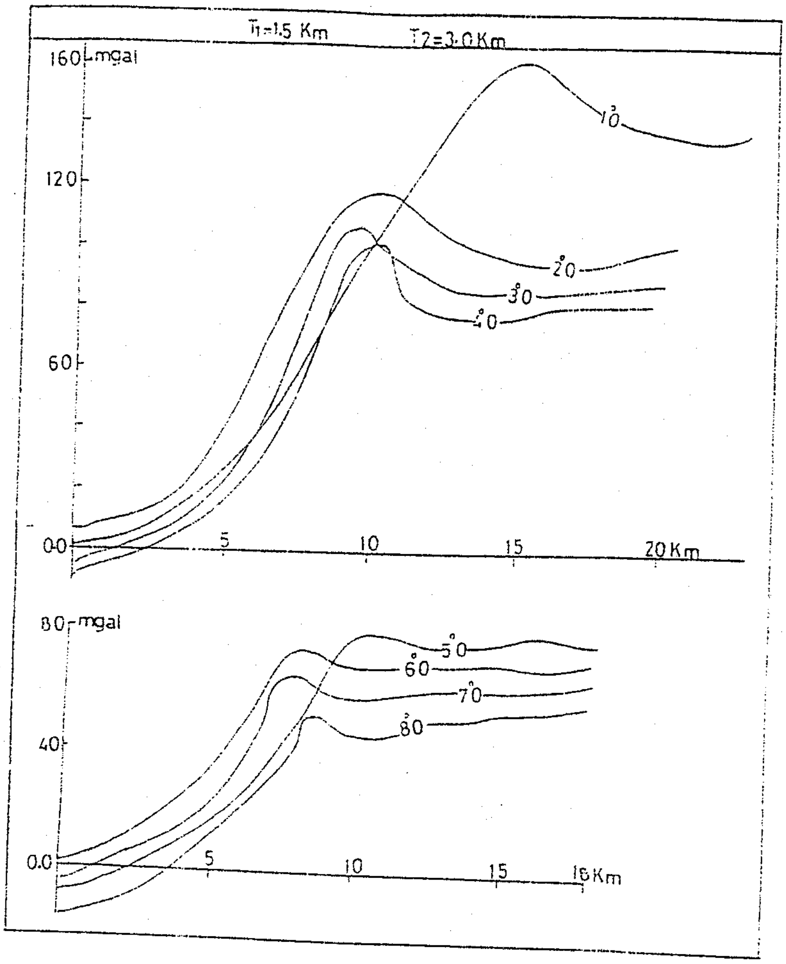

Plate3:

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = 1.5 Km T_2 = 3.0 Km

α = angle of dip ranging from 0-80°

Plate-4

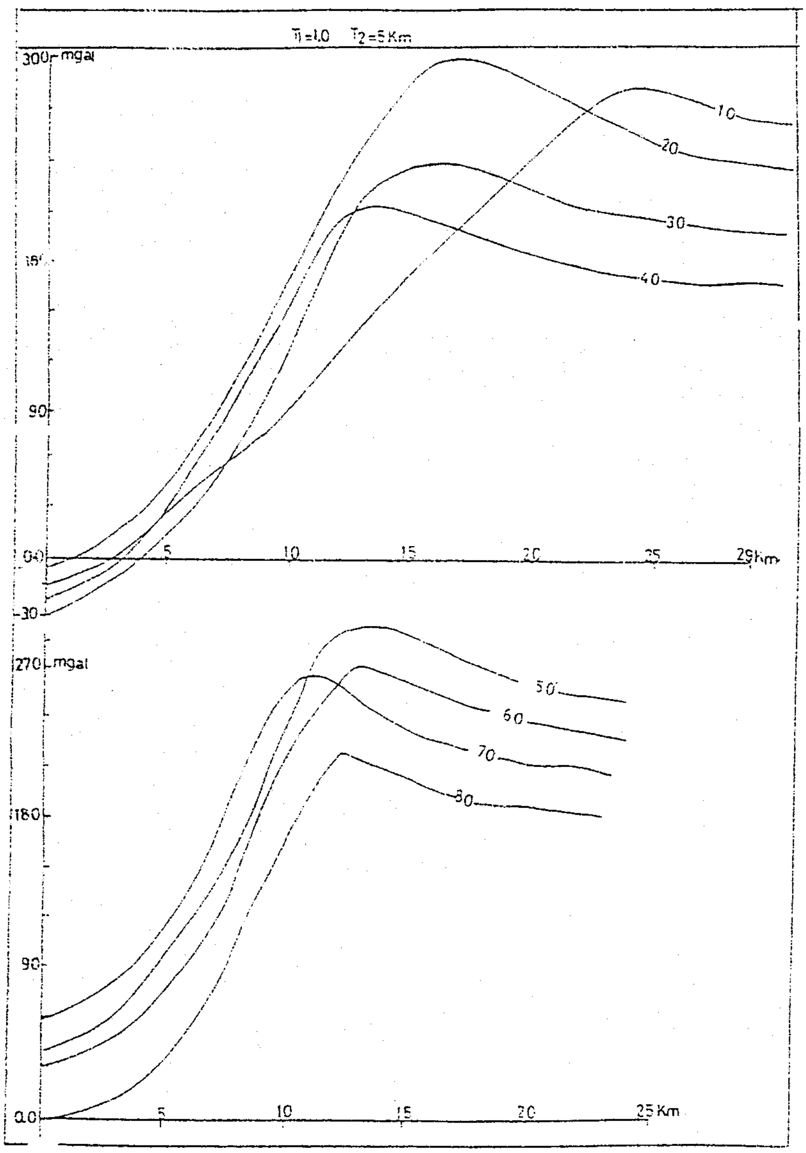

Plate4 :

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = 1.0 Km T_2 = 5.0 Km

α = angle of dip ranging from 0-80^{o}

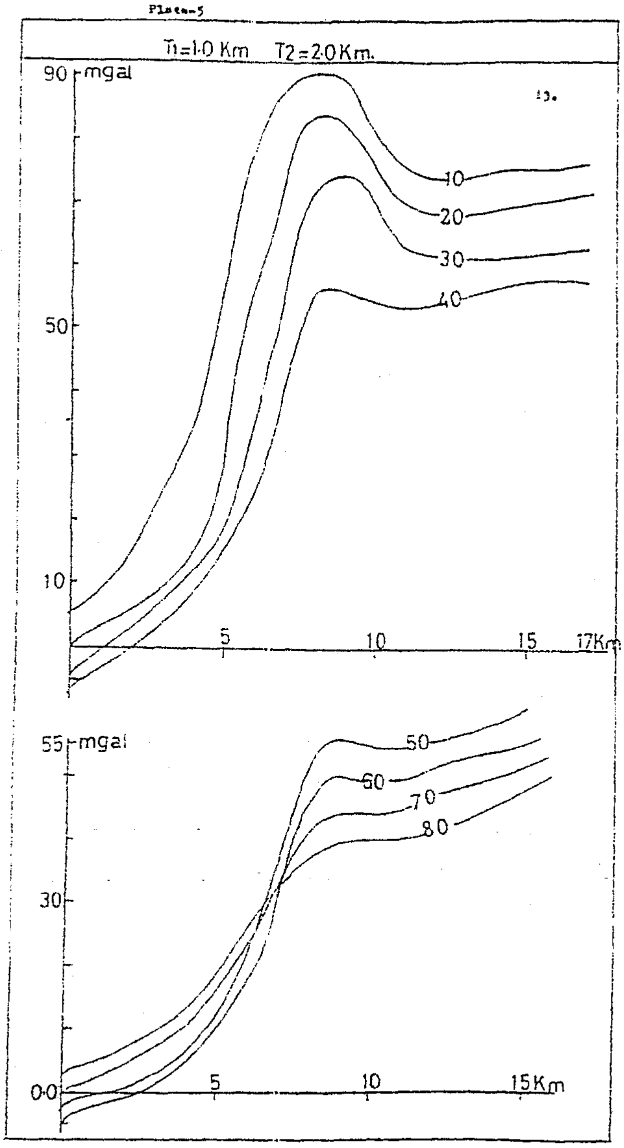

Plate5:

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = 1.0 Km T_2 = 2.0 Km

α = angle of dip ranging from 0-80°

Plate- 6

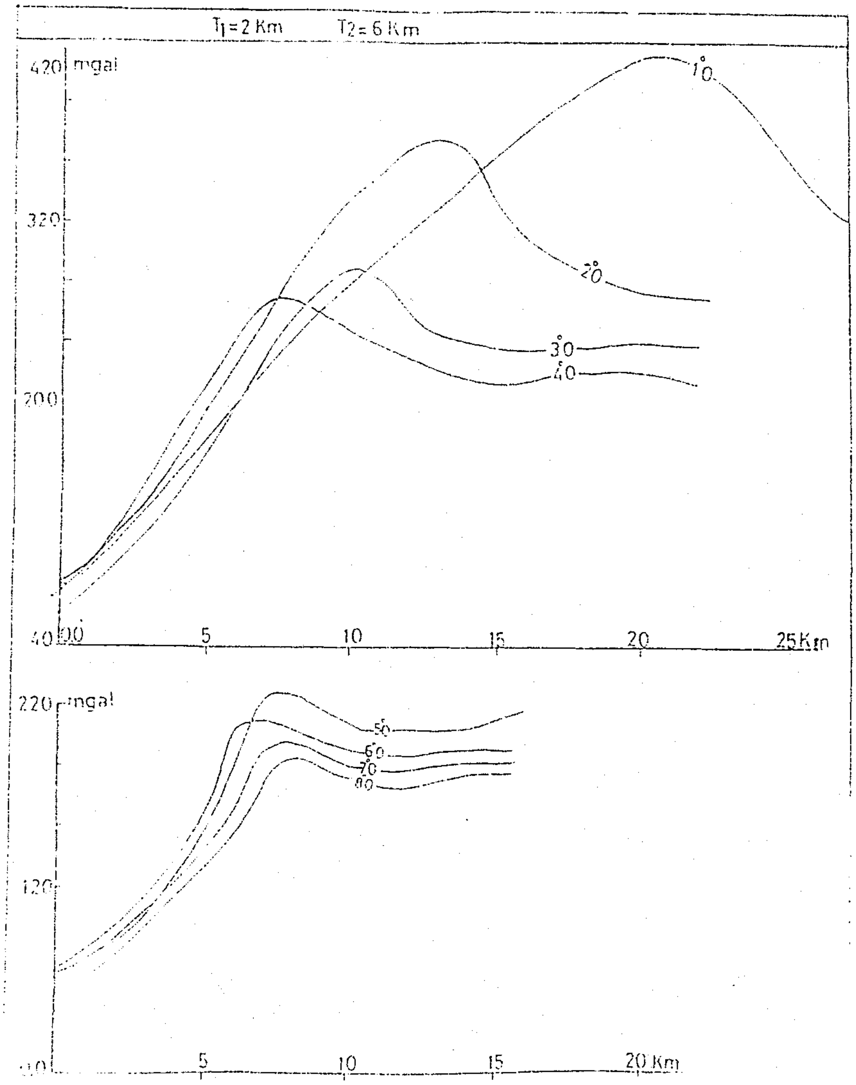

Plate6:

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

T_1 = 2.0 Km T_2 = 6.0 Km

α = angle of dip ranging from 0-80°

Plate - 7

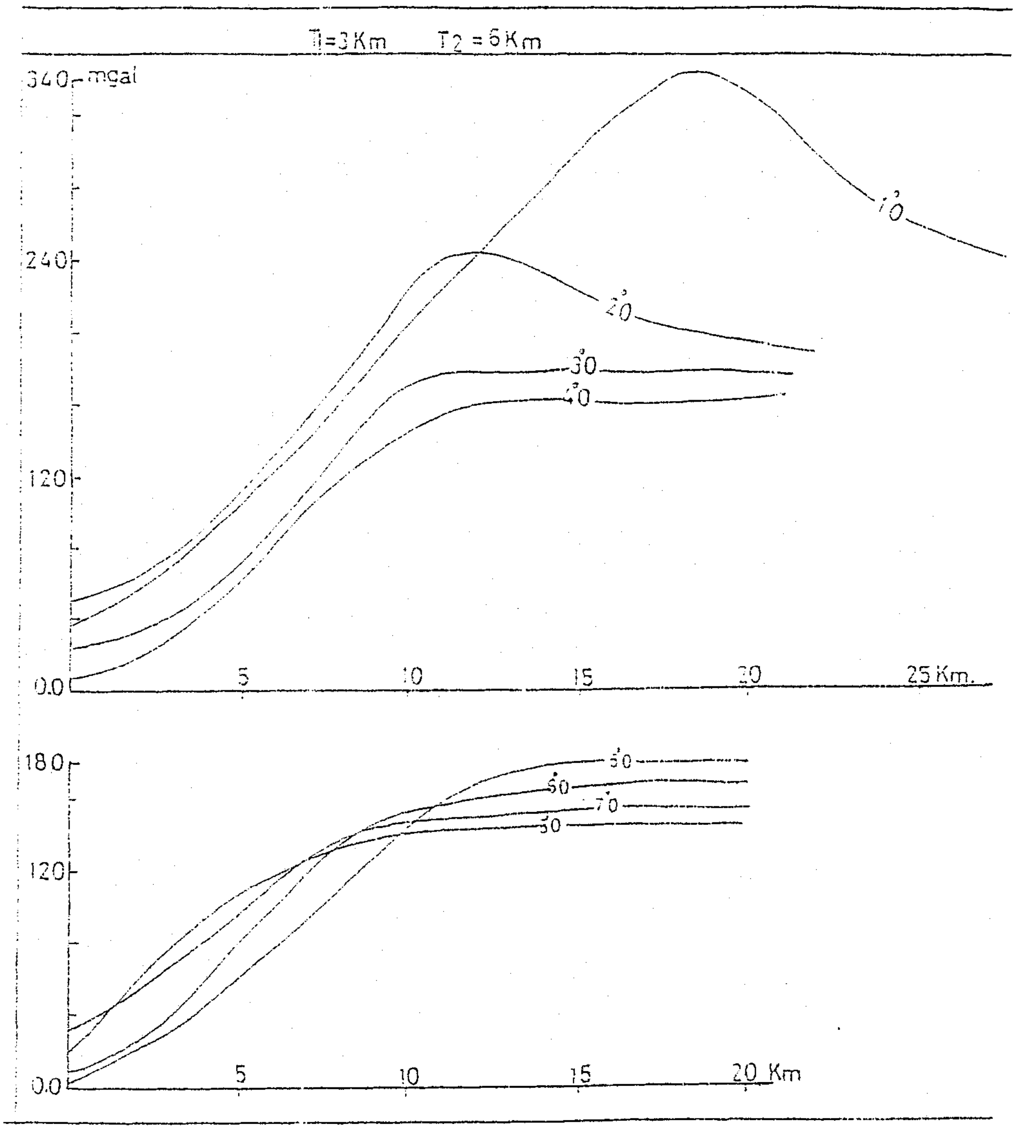

Plate7:

Master Curves for interpritation Gravity anomaly due to inclined Fault
Where :
T_1 = 3.0 Km T_2 = 6.0 Km

a = angle of dip ranging from 0-80°

Plate-8

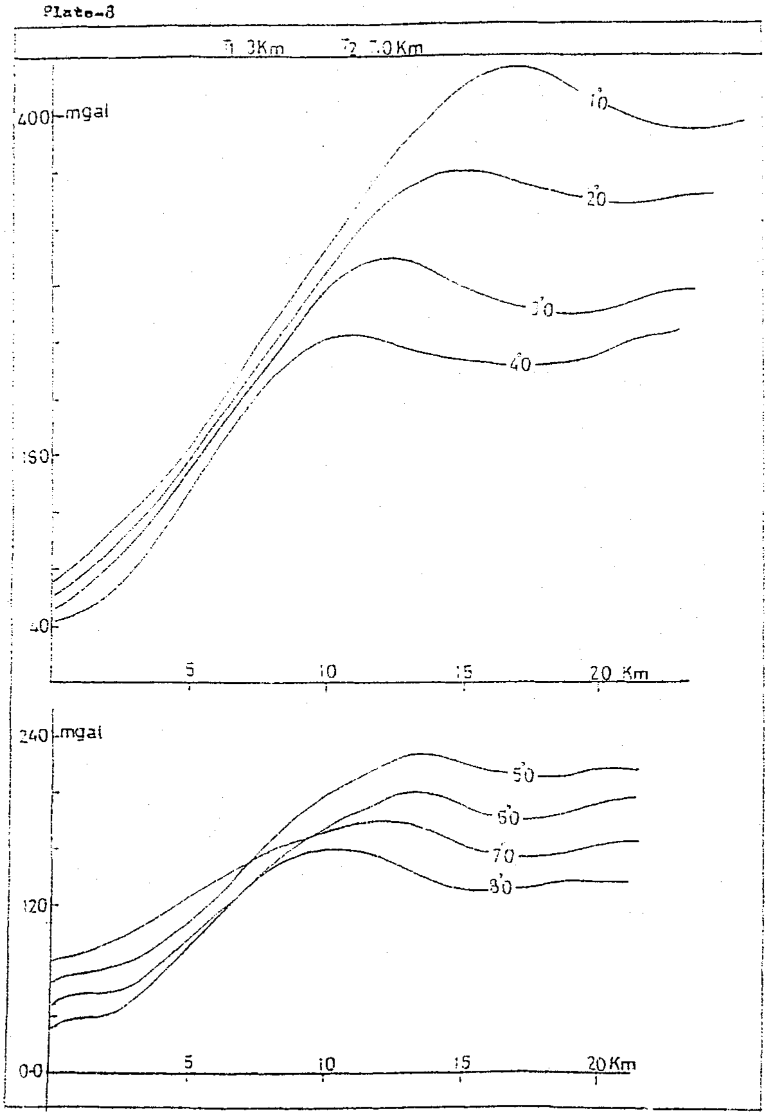

Plate8:

Master Curves for interpritation Gravity anomaly due to inclined Fault

Where :

$T_1 = 3.0$ Km $T_2 = 7.0$ Km

α = angle of dip ranging from 0-80°

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المنحنيات المميزة التى تساعد به على سرعة ودقة التفسير للفوالق المائلة

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هذه المجموعة من المنحنيات المميزة تم تصميمها من أجل أيجاد طريقة سريعة ودقيقة لتحديد معاملات الفوالق المائلة وذلك من خلال التباينات التثاقلية لها .

وتعتمد هذه المنحنيات علي المعادلات النظرية للعالم يانج ١٩٦١ وكذلك على الأسس النظرية التى وضعها العلماء السابقون فى تفسير الفوالق المائلة ، وقد تم تقسيم هذه المنحنيات إلى مجموعات تحتوى كل مجموعة على قيم ثابتة للعمق مع تغيير قيم الميل فى المجموعة الواحدة من ١٠ وحتى ٨٠ وذلك حتى يتم تغطية جميع درجات الميل بالنسبة للعمق الواحد ، واستكمالا للتفسير الدقيق وحتى تكون المعطيات كاملة فقد تم حساب قيم التدرج الرأسى والأفقى وكذلك قيم الدالة التحويلية ذات التدرج العالى وذلك للقيم المختلفة للعمق والميل وتم وضعها فى جداول منفصلة ويتم من خلال هذه القيم حساب قيم الكثافة وذلك باستخدام خواص الدالة التحويلية وباستخدام معادلة الفالق المائل .

وهذه الطريقة تتميز بالسهولة وكذلك الدقة وايضا باتساع نطاق التطبيق لها .