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A Study of The Neogene Rocks Density Around The Greater Zab

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ABSTRACT

Samples from the outcropping rocks of Bai Hassan, Muqdadyia , Injana , Fatha and Pila Spi formations have been collected for density measurements supporting a gravity survey that has been planed over the area on either side of the greater Zab river. The results are compared with densities measured from seismic stacking velocities made over four long seismic lines that have been shot previously in the same area. Furthermore , a single velocity log from a well that penetrates these formations has also been used . The results are presented and discussed .

دراسة كثافة صخور النيوجين حول منطقة الزاب الكبير

الملخص

تم جمع نماذج صخرية من التكاوين الجيولوجية باي حسن والمقدادية وانجانة والفتحة والبلاسبي لغرض اجراء قياسات الكثافة لدعم المسح الجذبي المنفذ في المنطقة الواقعة على جانبي نهر الزاب الكبير. تم مقارنة النتائج مع قياسات الكثافة المستحصلة من معلومات السرع الزلزالية المعدلية والتي تم الحصول عليها من المسوحات الزلزالية لأربعة خطوط تم تفجيرها سابقاً في المنطقة، كما تم استخدام المعلومات التي تم الحصول عليها من مجس السرع في احد الآبار الذي اخترق هذه التكاوين . تم تمثيل النتائج ومناقشتها.

INTRODUCTION

Inaccurate density information or the lack of it invariably creates a problem in gravity calculations and interpretations. Information on rock's density in Iraq is generally rare, and it is specially so with the Neogene rocks . Ditmar et. al. (1971) gave average densities of major stratigraphic units . Such group densities are not adequate for interpreting local gravity surveys. Al – Shaikh et. al. (1975) made some density measurements of outcropping Tertiary formations for the purpose of interpreting gravity anomalies at Shaqlawa – Harir area, (Table 1) .

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Table 1: Density measurements of rock at Shaqlawa- Harir area (After Al-Shaikh et al., 1975).

Age	Formations	Density ($gm.cm^{-3}$)
Tertiary	Surface soils	2.00 ± 0.1
	Injana	2.25 ± 0.05
	Fatha	2.45 ± 0.05
	Pila Spi	2.50 ± 0.05
	Gercus red beds	2.30 ± 0.05
	Kolosh	2.30 ± 0.05
Cretaceous	Shiranish	2.60 ± 0.02

These results, as will be seen, seem higher than those obtained from the present area especially for Injana and Fatha formations. This may be explained as due to the lateral variations in the lithologies of these formations .

Al–Kadhimi and Al-Attar (1981) , conducting a gravity survey over Kirkuk – Badra area, have made extensive density measurements on rock samples of Recent and Tertiary ages and have included them in an unpublished report.

This paper describes various methods used for density measurement of Neogene rocks made during gravity survey over four long seismic lines around the area of Demir Dagh – Aski Kalak, NE Iraq . These density measurements are included in two unpublished M.Sc. theses : these are Mutib (1980) and Ahmed (1980).

2- Location of the area and geology

The gravity lines studied lie in a general NE- SW trend on either side of the greater Zab river (Fig.1). The area consists mainly of flat- lying terrain with sporadic elongated elevations that represent anticlinal structures. These anticlines are gentle undulations of Tertiary strata separated by broad synclinal stretches. The geological map of fig. (1) shows the anticlines of Qara Chauq, Guwair, Kirkuk in the south Demir Dagh in the center and Ain Safra and Maqlub in the north and the northwest. These structures include rocks that range in age between U. Cretaceous to Pliocene , with the older rocks occupying the cores. In the present study of rock density, sampling is made from Pliocene, Miocene and Eocene only .A brief description of the lithology of these rocks is given below.

The Pila Spi formation (M-U Eocene) is chiefly hard, dolomitic and crystallized limestone with some beds of chalky limestones and marl. In this area the formation is about 125 m thick.

The Fatha Formation (M. Miocene) consists of gypsum , limestone, marl and occasional salt beds. These lithlolgies are repeated in a cyclic pattern with complete and incomplete cycles depending on its depositional history. Its thickness is variable averaging 180m in this area and becomes 240m thick in Kirkuk well 213 in the south; Mutib (1980) .

The Injana Formation (U. Miocene) is composed of loosely packed sandstones and siltstones and has an average thickness in the area of 400m.

The Muqdadyia Formation (L. Pliocene) is dominantly pebbly sandstones with intercalations of claystones. Its thickness is about 300m.

The Bai Hassan Formation (U. Pliocene) consists of massive conglomerate that is well cemented. It has an estimated thickness of 160 m.

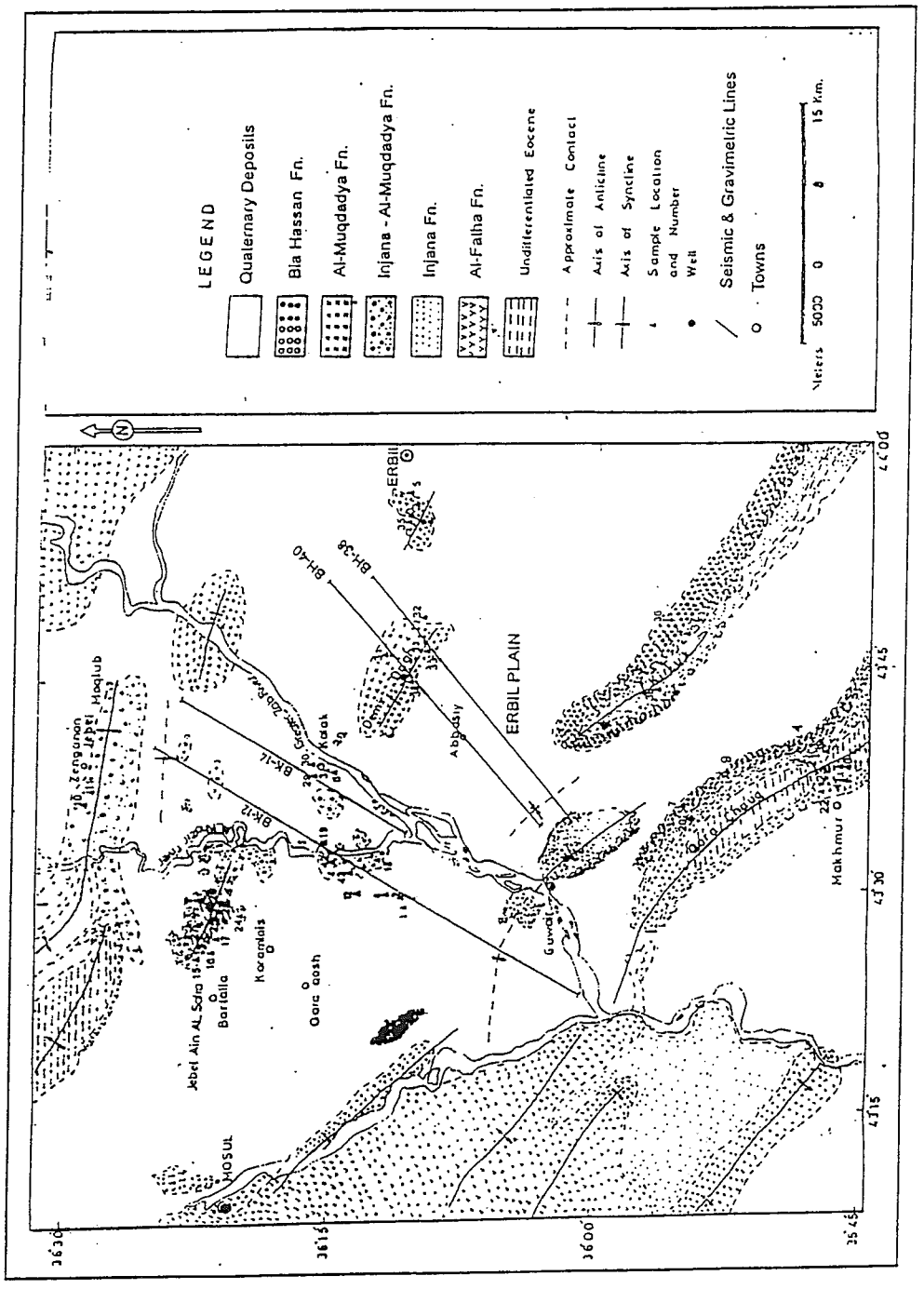

Fig. 1: Geological map of the studied area and surroundings (modified after parsons, 1955).

3- Density measurements

Three methods were followed for density measurements :

3-1 Measurements on collected samples.

In spite of its limitations, the method of collecting samples from various outcropping formations and then measuring their densities in the laboratory is employed due to the near absence of density data in and around the study area. Lack of outcrops , friability of samples and the possibility of bias in the collection are but some of the difficulties of the procedure. Most of the samples have been collected from the structures described above. A total of 184 samples are collected distributed among the formations as follows and some of their locations are shown on fig (1).

Formation	Number of samples
Bai Hassan	54
Muqdadyia	34
Injana	31
Fatha	34
Pila Spi	31

The usual procedure of laboratory density measurement is followed with each sample. It was soaked in water for 24 or 48 hours then its saturated density was measured by weighing it in air then measuring the water corresponding to its volume. Fig.(2) shows the density histogram for the various formations . It seen that the density of Bai Hassan ,Muqdadyia and Injana show some variations that may reflect their heterogenous nature . The density of the Fatha and Pila Spi formations on the other hand seem to be more uniform. Table (2) shows the average saturated densities of these formations.

Table 2 : Saturated densities of the different formations

Formation	Density (gm. cm $^{-3}$) ± S.D.
Bai Hassan	2.41 ± 0.05
Muqdadyia	2.18 ± 0.04
Injana	2.08 ± 0.04
Fatha	2.30 ± 0.02
Pila Spi	2.45 ± 0.02

3-2 Density from seismic velocity

Analysis of the seismic results obtained from the four seismic lines shown on Fig. (1) give average stacking velocities down to identified reflectors. On these particular lines two reflectors have been identified. These are : top of the Fatha , top of the Pila Spi, average stacking velocity to each of these reflectors is obtained from the four seismic lines . From these average velocities, average densities have been calculated using the hyperbolic relation between velocity and density of sedimentary rocks suggested by Nafe & Darke (1963) , which is :

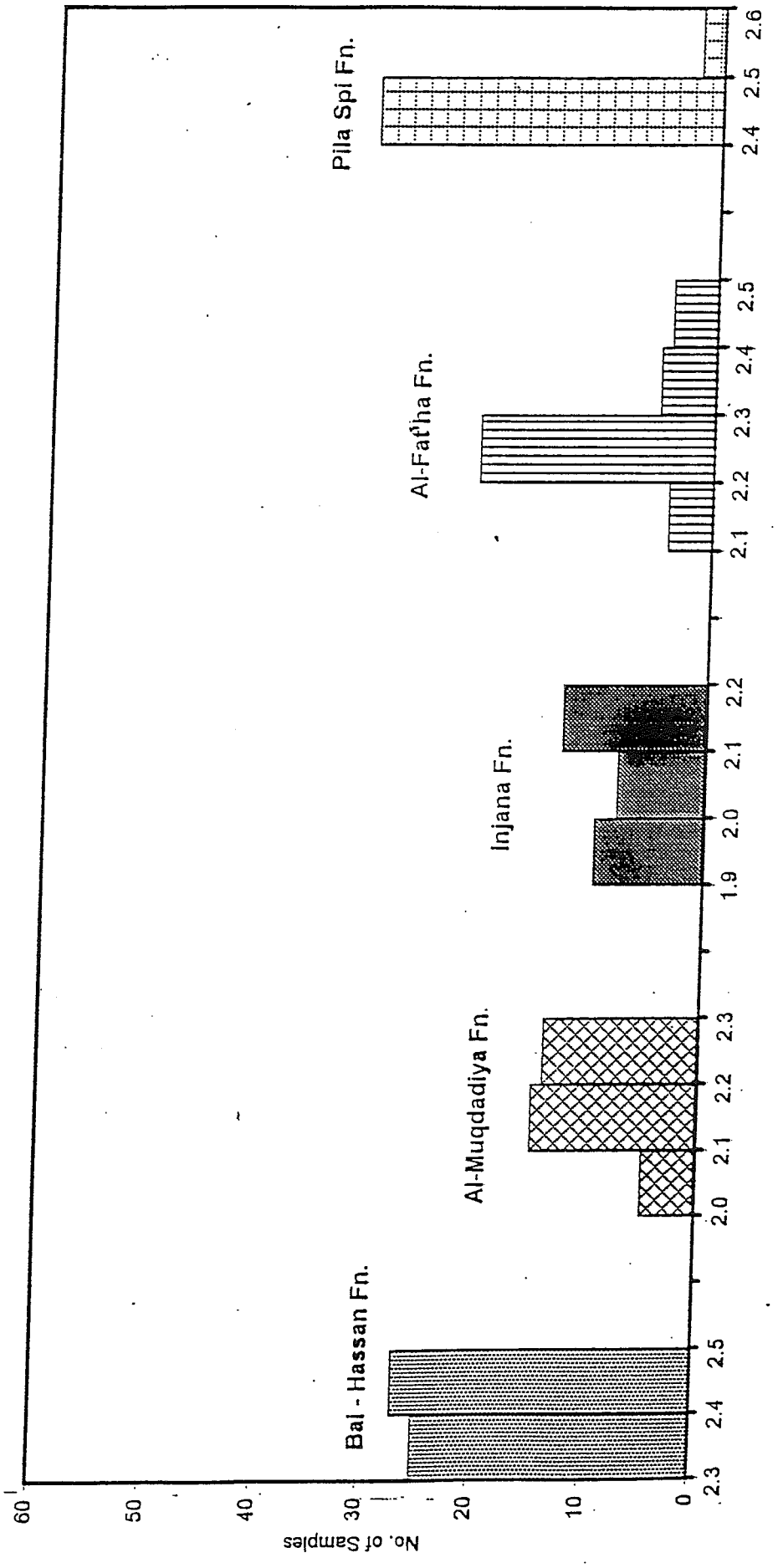

Fig. 2: Density histogram of collected samples.

$$P = 0.23\ V^{0.25}$$

where P is the density in gm.cm.$^{-3}$

where V is the velocity in m.sec^{-1}.

Fig. (3) shows the variations in the average density down to the two horizons along the seismic lines. It shows that the two horizons show marked increase in density towards the northeast where they become deeper. The average densities down to the two horizons as obtained by this procedure are as follows :

Table 3: Rock densites as obtained from seismic velocities

Formation	Av. Density(gm/c.c)
To the top of the Fatha	2.201 ± 0.002
To the top of the Pila Spi	2.211 ± 0.002

Generally these values seem lower than those obtained by sampling (table 2).

3-3 Density from well logs :

For the present study , unfortunatly , no density log is available. However, velocity log for the Kirkuk well No. 213 ,situated in the southeast end of the area , has been used . Once more , reliance on Nafe & Drake relation (Op.cit.) is made . Interval velocity is first computed, then the corresponding density is evaluated . The results are shown on table (4).

It can be seen that , whilest both Muqdadyia and Injana formations give a density of 2.20 gm.cm^{-3} the Muqdadyia on its own give a density of 2.175 gm/cm^3 . The Fatha section of the log shows definit distinction between the main constituents of the formation
(viz. gypsum , salt , mudstone, marl , and marly limestone). From the individual density of these constituents and using the thickness of each as a weighting factor , the average density of the Fatha formation is calculated to be 2.35 gm.cm.$^{-3}$.

Table 4 : Rock densities as obtained from velocity log

Formation	Velocity m/sec	Av. Density gm/cm^3
Muqdadyia & Injana	2897	2.200
Injana	2770	2.175
Fatha		
Gypsum & Anhydrite	4951	2.530
salt	4522	2.460
Mudstone	2797	2.180
Marl & Marly limestone	2855	2.190

DISCUSSSION

Table (5) represents a comparison of results obtained from the various methods used.

It can be seen that a number of generalizations are apparent . To start with results from samples tend to give systematically lower densities for the same rocks than those obtained from velocity logs . This is reasonable as rocks of similar nature as those of the present area become more compacted with increasing depth .

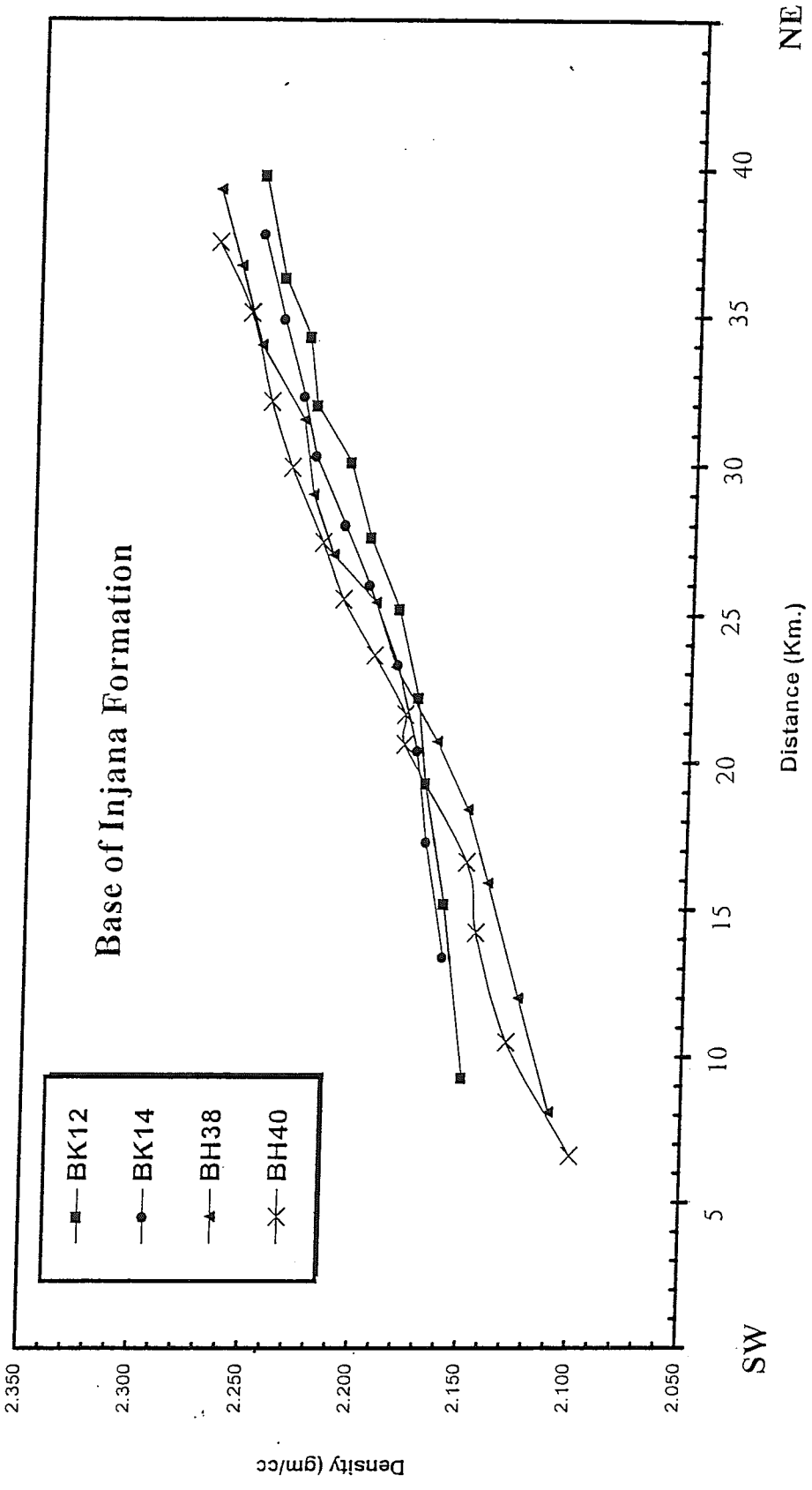

Fig. 3a: Density variations as deduced by stacking seismic velocities (first reflector).

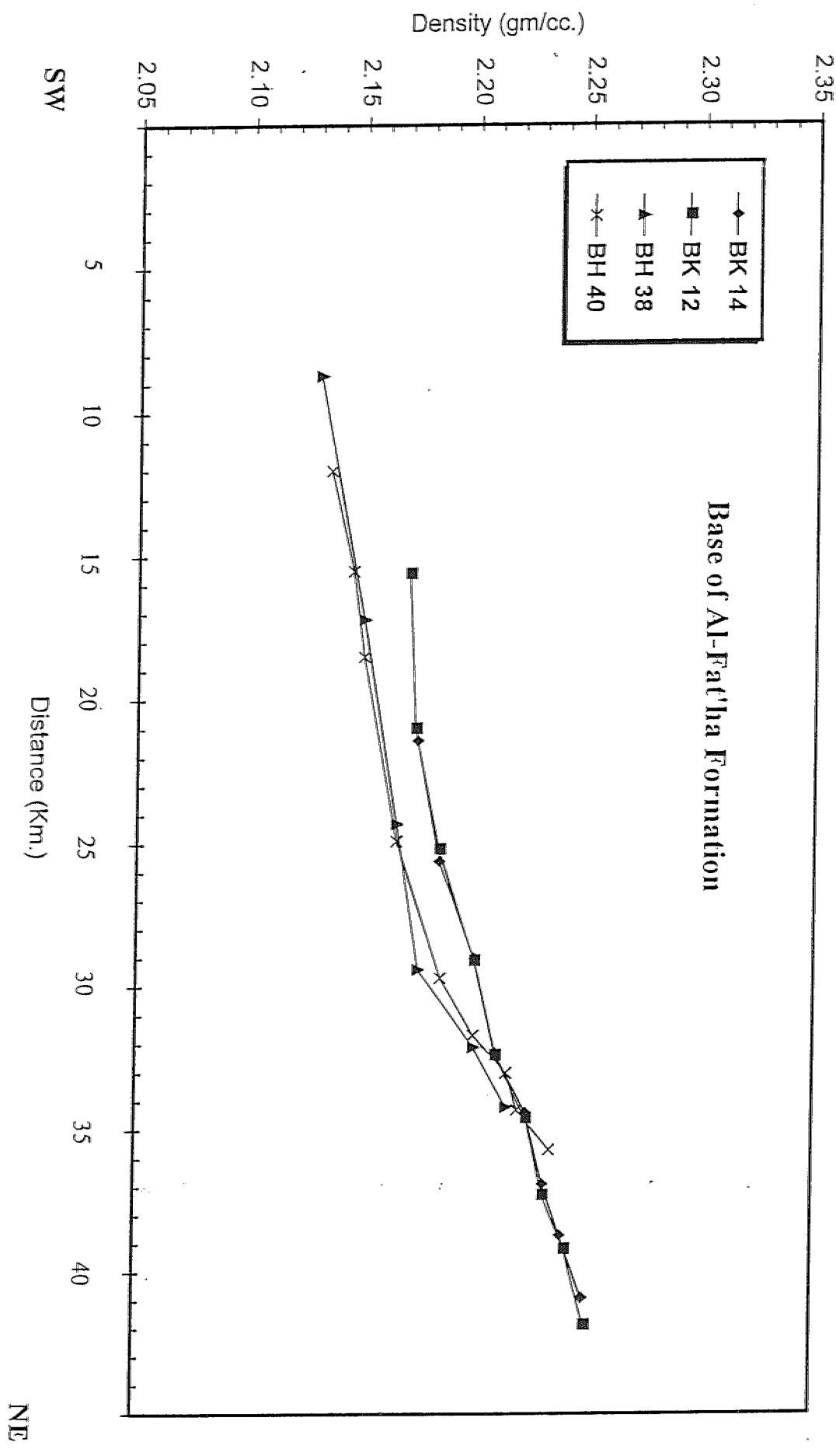

Fig. 3b: Density variations as deduced by stacking seismic velocities (second reflector).

Table 5 : Rock densities as obtained from various methods

Formation	Density (samples)	Density (from velocity)		Density from logs
Bai Hassan	2.41 ± 0.05	2.201 ± 0.002	2.211 ± 0.002	---
Muqdadyia	2.18 ± 0.04			2.220
Injana	2.08 ± 0.04			2.175
Fatha	2.30 ± 0.02			2.350
Pila Spi	2.45 ± 0.02			---

Since the rocks existing above datum level (mean sea level) are Bai Hassan, Muqdadyia and Injana, a weighted density of 2.20 ± 0.01 gm.cm^{-3} can be used for surface corrections in Bouguer anomaly calculations. The weighting factor used is the thickness of the individual rock unit . The values obtained from this procedure gave compatable density results that were obtained from seismic velocity and well log in formation .Examining table (5) , it can be seen that gravity anomalies may arise due to density contrast of 0.22 or 0.175 gm.cm^{-3} between the Fatha and overlying Injana formation. using sampling and logs measurement respectively.

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