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Finite Strain Estimation in Baba Dome Using Fry Method (NE Iraq)

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ABSTRACT

Literatures survey indicates that no such study carried out concerning strain measurement and analysis in the concerned area. The well-known field and laboratory work carried out. An accurate ellipse was determined for each ab, bc and ac planes for each formation exposed in Baba dome using Matlab program with a relatively new toolbox (Polylx). Then for each sample the mentioned ellipses was mathematically compiled to generate strain ellipsoid with long, intermediate and short axes with their orientations using Mathcad software. Then the long and short axes of strain ellipsoids projected on ab plane and delineated. Because Baba dome took the present form during last phase of Alpine Orogeny (Miocene -Pliocene) with contemporaneous deposition of Mio- Pliocene formations, the present study deduced that the strain is directly proportional to the stress i.e. elastic deformation. Therefore, the orientation of short axes of strain ellipsoids should coincide with orientation of maximum stress axes giving rise the orientation of maximum stress direction in sampled station.

Keyword: *Finite strain, Fry method, Strain, Stress*

Kirkuk University Journal /Scientific Studies (KUJSS)
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تخمين الانفعال الكلي باستعمال طريقة فراي في قبة بابا ـ شمال شرق العراق

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الملخص

تدل الدراسات السابقة الى عدم تنفيذ دراسة تخص حساب وتحليل الانفعال في منطقة الدراسة. نفذ العمل الحقلي والمختبري وحسب السياقات المتبعة. حددت اهاليج ثنائية الابعاد لكل من المستويات (ab,bc,ac) لكل تكوين متكشف في قبة بابا وذلك عن طريق استخدام برنامج الماتلاب وتوليف الاهاليج التي تم الحصول عليها من نماذج التكاوين المذكورة انفآ رياضيآ وذلك للحصول على اهاليج ثلاثية الابعاد مع اطوال المحاور: محور الطويل والمتوسط والقصير واتجاه كل محور حيث تم حساب اطوال واتجاهات هذه المحاور عن طريق برنامج الماثكاد. بما ان قبة بابا تكونت في الطور المتأخر للحركات البانية للجبال والتي حدثت في المايوسين – البلايوسين وهو يتزامن مع ترسيب تكاوين منطقة الدراسة، تم الاستنتاج والافتراض: ان الانفعال له علاقة مباشرة مع الاجهاد. واستناداً الى ماتقدم فأن اتجاه المحور القصير لاهليج الانفعال ثلاثي الابعاد يتطابق مع محور الاجهاد الاعظم والذي يمثل اتجاه الاجهاد الاعظم في محطات النمذجة محطات النمذجة.

الكلمات الدالة: الانفعال الكلي، طريقة فراي، الانفعال، الاجهاد

1.NTRODUCTION

Among a large numbers of available strain estimation techniques, the Fry method [1] for point distribution analysis has been used extensively for the last four decades. Based on the relative displacement of material points, typically object centers, the Fry method produces a point distribution with a characteristic central vacancy [1&2]. The central vacancy has the shape of a measurable ellipse and strain determination is straightforward, provided the point distribution was initially isotropic anticlustered and the sample size is sufficiently large [3,4,5&6].

Kirkuk University Journal /Scientific Studies (KUJSS)
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Improvement of Fry method carried out by many researchers, among those: [7&8], this is a powerful tool for measuring fabric in various types of aggregates of packed grains lacking other adequate markers. [9] proposed a bootstrap version of the mentioned normalized Fry method. The image-analysis method [10] uses Gaussian blur filter for distinction between the areas of largest and smallest pixel intensities in a Fry plot image. It then applies the optimal threshold value and an inversion filter for extraction of the sharp central vacancy.

The recent analytical methods, such as the point-count density method, or the continuous function method use a trial and error approach for searching the best-fit ellipse through the central vacancy in a normalized Fry plot [11].

The aim of the present study is to estimate finite strain for various formations cropped out in study area.

2.LOCATION AND GEOLOGIC SETTING

The study area coverd 250 km.^{2} lies within Iraqi territory between longitude (E44°06' 09″ - 44° 31' 38″) and latitude (N 35° 22' 50″ - 35° 43' 01″). The NW end (Amsha saddle) border the Lesser Zab River while the SE end is at Targil area southeast of Kirkuk city, Figure (1).

Tectonically, the study area lies on the NE region of Arabian Plate. It lies within low folded zone of Unstable shelf area and contains many sinuous anticlines (some of them affected by reverse faults on the SW limb) separated by relatively wide syncline filled by fine clastic deposits of Quaternary age, [12]. Baba dome (study area) is one of largest oil trap in the world. Extensive geophysical & geologic works carried out during exploration of oil. This study is a surface contribution to mentioned studies. The present study is considered the first dealing with strain in the study area.

Structurally, the study area on geologic map appears as trace of reverse fault with inclined bed (23°- 60°) toward NE, Figure (2). The fault plane is within sulfurous bed of Middle Miocene causing the SW limb obscure, while depth wise the study area is simple symmetrical fold, [13].

Miocene & Pliocene formation crops out in the study area named: Fatha ((Middle Miocene, 370 m. thick), Injana (Upper Miocene, 1266 thick), Mukdadiya (Pliocene, 840m. thick)) and Bia-Hassan (Pliocene, 906.5m. thick).The mentioned formations (from older to younger) as a bulk

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represent facial change from lagoon to continental passing through lacustrine. These formations have lithology varying from gypsum, marl claystone sandstone and conglomerate.

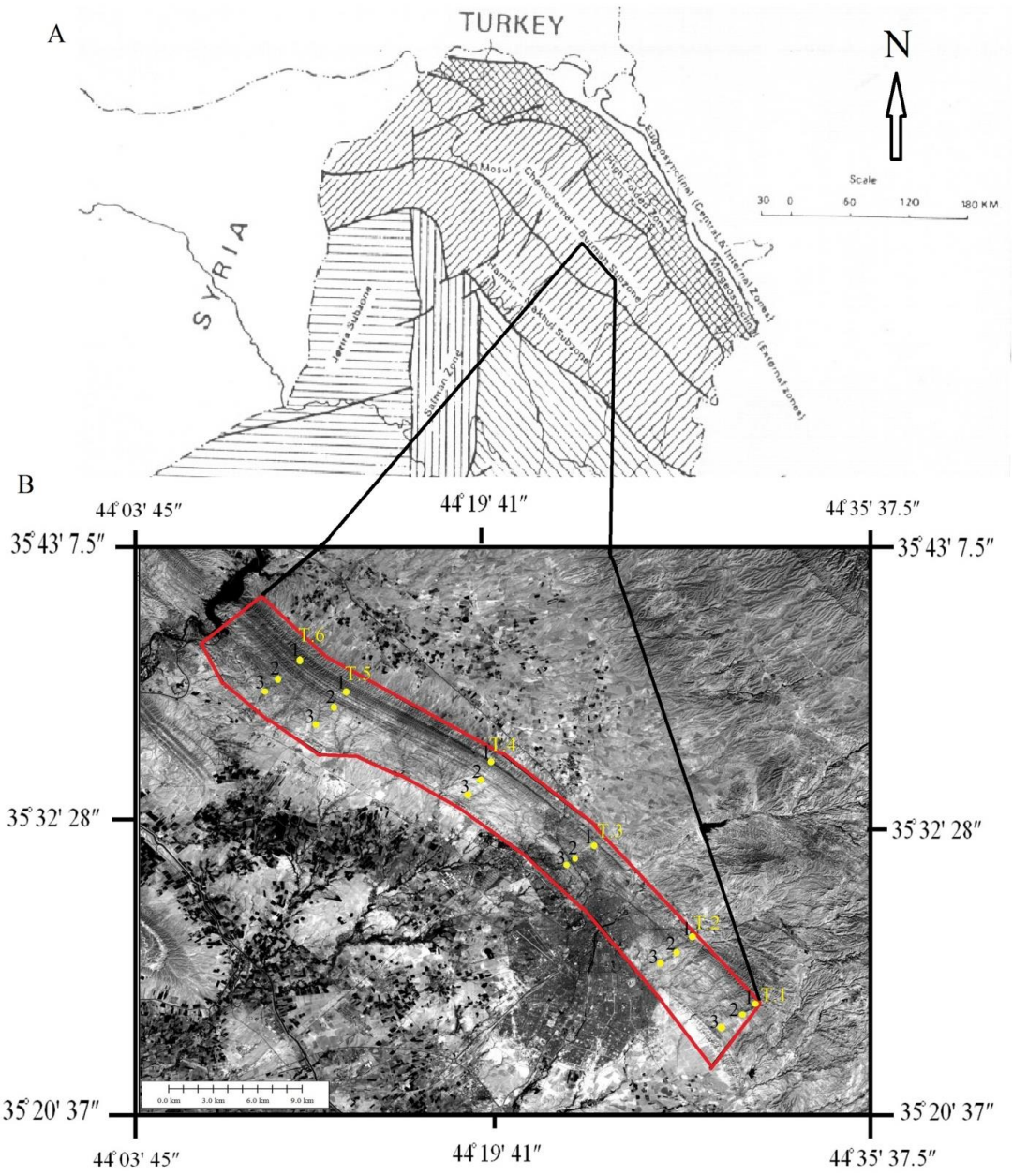

Figure (1): Location map of studied area. A: Tectonic map of the northern part of Iraq, Buday & Jassim 1987 with the location of the study area B: Landsat image, shows the study area and sampled positions.

Kirkuk University Journal /Scientific Studies (KUJSS)
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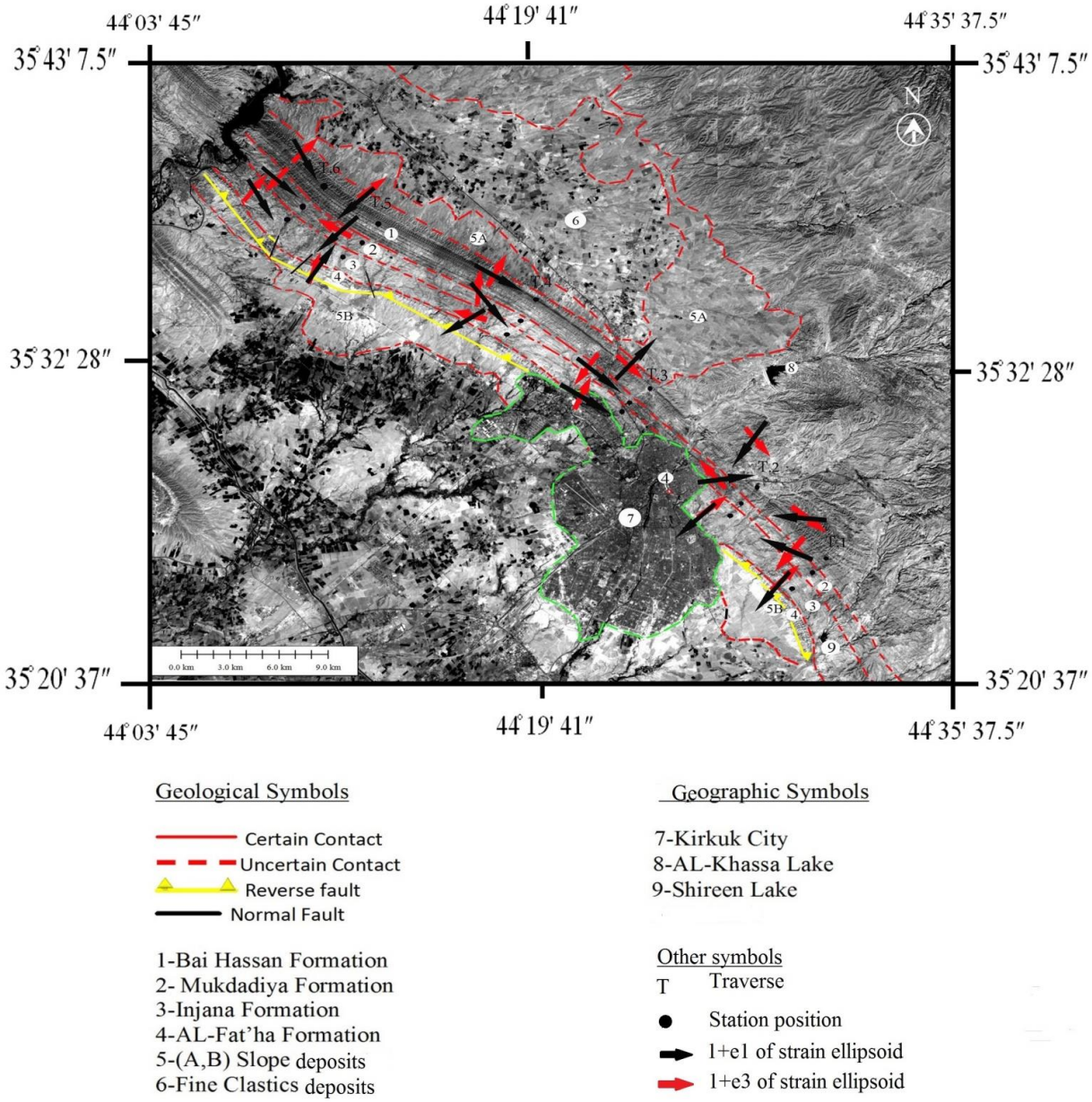

Figure (2): Geological map of study area compiled in the present study with strain axes (long and short) of the determined strain ellipsoid.

Kirkuk University Journal /Scientific Studies (KUJSS)
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3.METHODOLOGY

The systematic actions for this work are as follow:

1- Six traverses (profiles) covering the study area delineated on satellite image. Each with three sampled stations (one sample per formation).

2- Oriented samples due to attitude of beds picked.

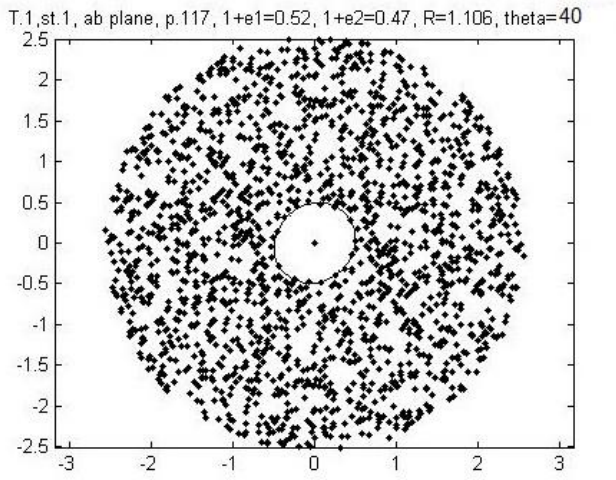
3-Laborotary work includes cutting the samples in the form of cube due to strike, dip direction lines drawn on the surface of the sample producing ab, bc and ac planes due to tectonic axes.

4-Three perpendicular plane are chosen for making slides. Each slide photographed.

5- Matlab software with Polylx toolbox [14] used to extract fry plot for each plane Figure 3. The plot including R (ratio of long and short axes of strain ellipse) and theta (angle of long axis of strain ellipse with x-axis) saved in other file.

6- Using Mathcad software, a compilation of the resulted three ellipses data, carried out for each sample, into an ellipsoid was carried out [15]. Each ellipsoid has the length of three semi axes with their orientations Table (1).

7- The long and short axes of strain ellipsoid projected on bedding plane and delineated on satellite image, Figure (2).



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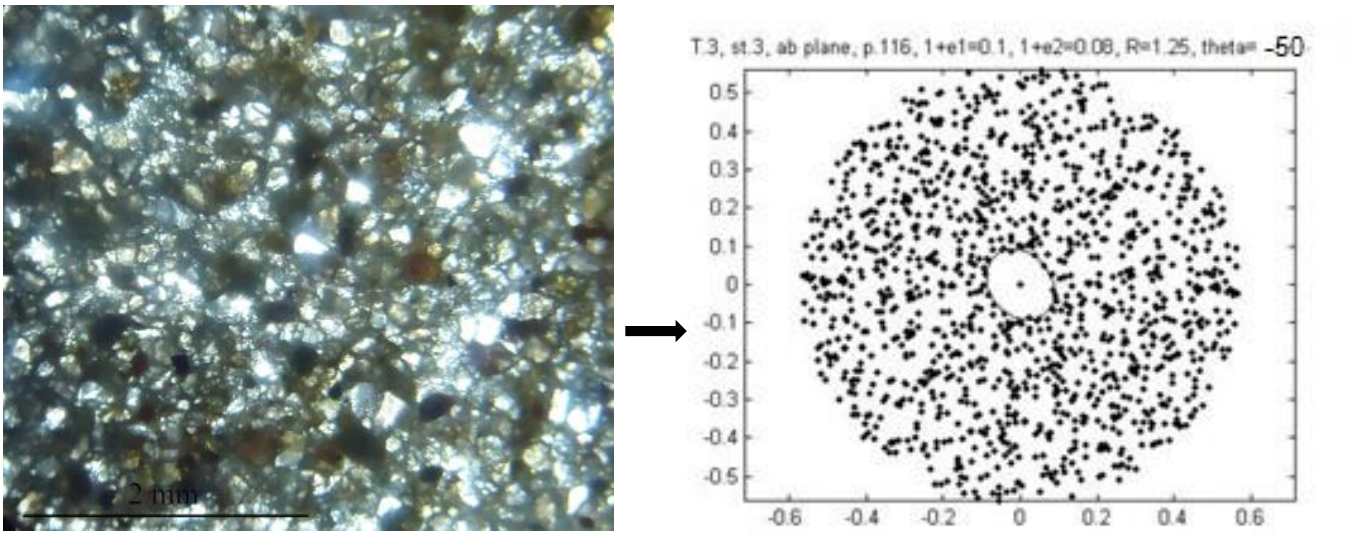

Figure (3): Examples of the extracted strain ellipses from microphotograph of the picked samples.

Table (1): Details of the calculated strain ellipsoid

Traverse/ station	Formation	Attitude of bed			Lengths of strain ellipsoid axes			Orientation of strain ellipsoid axes/ plunge		
		Strike	Dip direction	Dip angle	Long	Intermediate	Short	Long 1+e1	Intermediate 1+e2	Short 1+e3
1/1	Bai-Hassan	317	47	50	1.356	1.085	0.436	275.231/ 87.312	21.396/ 16.38	127.169/ 87.234
1/2	Mukdadiya	329	59	41	1.301	1.152	0.334	292.457/ 59.966	4.398/ 41.99	229.631/ 82.913
1/3	Injana	319	49	42	1.393	1.024	0.597	221/ 77.03	318.544/ 0.63	47.641/ 83.015
2/1	Bai-Hassan	317	47	20	1.248	1.083	0.55	216.55/ 25.221	150.245/ 52.373	139.462/ 57.157
2/2	Mukdadiya	323	53	46	1.262	1.217	0.328	82.698/ 78.344	255.054/ 30.597	317.549/ 88.454
2/3	Injana	322	52	26	1.312	0.907	0.827	229.002/	313.781/	53.451/

Kirkuk University Journal /Scientific Studies (KUJSS)
Volume 10, Issue 3, September 2015 , p.p(192-204)
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								54.229	5.221	87.283
3/1	Bai-Hassan	329	59	46	1.415	0.922	0.549	44.345/ 63.939	20.952/ 70.562	131.941/ 53.181
3/2	Mukdadiya	314	44	41	1.369	1.069	0.782	128.342/ 44.325	232.391/ 12.416	216.768/ 61.839
3/3	Injana	313	43	44	1.286	1.05	0.676	120.444/ 46.923	32.633/ 36.228	26.423/ 82.39
4/1	Bai-Hassan	308	38	59	1.259	1.08	0.596	119.056/ 60.031	241.92/ 42.688	30.094/ 73.693
4/2	Mukdadiya	308	38	51	1.366	0.988	0.758	140.515/ 72.408	212.299/ 17.758	4.105/ 67.358
4/3	Injana	304	34	33	1.325	1.03	0.846	239.683/ 49.499	316.136/ 42.61	284.423/ 75.766
5/1	Bai-Hassan	329	59	34	1.245	1.027	0.778	229.343/ 70.015	315.797/ 7.008	55.07/ 87.035
5/2	Mukdadiya	311	41	40	1.282	0.984	0.82	228.83/ 58.3	333.222/ 48.59	297.547/ 75.591
5/3	Injana	301	31	29	1.426	0.909	0.69	35.888/ 61.208	121.419/ 7.008	20.653/ 85.825
6/1	Bai-Hassan	318	48	40	1.374	1.155	0.412	150.435/ 57.338	79.902/ 46.635	46.155/ 78.17
6/2	Mukdadiya	317	47	26	1.275	0.841	0.804	130.087/ 56.531	153.548/ 57.246	223.476/ 36.719
6/3	Injana	331	61	23	1.244	1.141	0.381	148.513/ 47.835	86.863/ 45.89	40.517/ 56.78

4.FINITE STRAIN ANALYSIS

All ellipses in three perpendicular plane lies in zone 2, Figure (4), A,B &C. This zone due to [16] shows dominant shortening in one sector and dominant stretching in another. Due to (op sit) competent layers involved in such strain field shows buckle fold. The change in area (ΔA) is very small and negligible.

Various shape of the determined strain ellipsoid according to Flinn diagram, [16] in the study area. 72% to 28% are the percent of flattening and constriction respectively. All ellipsoids that

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determined from samples of Bia Hassan Formation are of flattened type. In general, flattening and constriction forms divide the study area in to two parts: SW and NE respectively with some exceptions see Figure 4D.

1-	1>k≥0	1/1,3 2/1 3/3 4/1 6/1	flattening: Pankate form (oblate ellipsoid)
2-	k~0	1/2 2/2 6/3	flattening :Uniaxial normal to pankate (Rxy=1)
3-	∞≥k>1	2/3 4/2,3 5/2,3	constriction :Cigar like form (prolate ellipsoid)
4-	k~∞	6/2	constriction: Uniaxial parallel to cigar axis (Ryz=1)
5-	k~1	3/1,2 5/1	Line separating flattening and constriction in Flinn diagram

Note: The symbol ~ means near or close to

The Late Alpine deformations i.e. fold and fault in the study area can be described by two stages: the first "plastic" that was responsible for fold formation, the second "elastic" that was responsible for reverse fault and joint development respectively. Both stages were continuous and the second stage is younger and caused by differential stress with aid of salts layer that prevent fault to continue more downward.

The witnesses that lead to say that finite strain is directly proportion to stress in the study area are:

-The timing of Late Alpine Orogeny, Mio-Pliocene, is close to the age of studied formations. This means that there was no time for strain accumulation pre orogeny.

-The aforementioned elastic stage means that the strain is directly proportion to stress, [17].

Consequently, the orientation of the short axes of the calculated strain ellipsoid axes ($1+e_3$) should coincide with the maximum stress orientation .Hence by drawing the orientation of strain ellipsoids axes on a map may represent the orientation of major principal stress orientation.

Thus, as Figure (2) show there are two main directions of stress: the first runs perpendicular and/or oblique to elongation of the structure which is responsible for structure formation and the second runs with the elongation of the structure and considered her as younger than the first.

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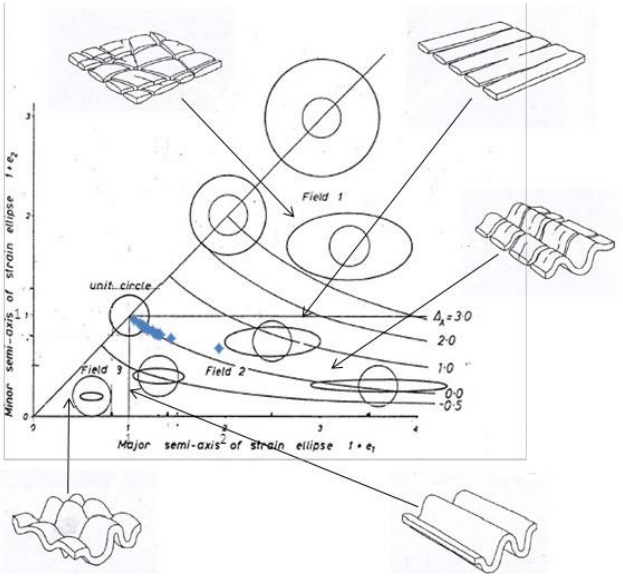
A



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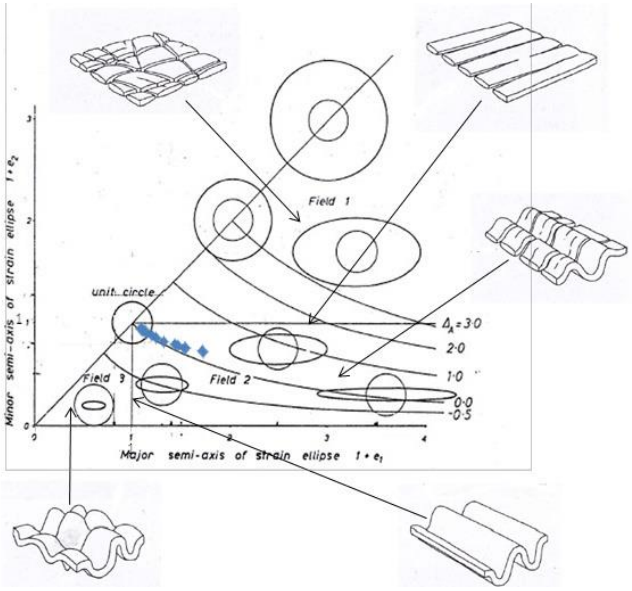

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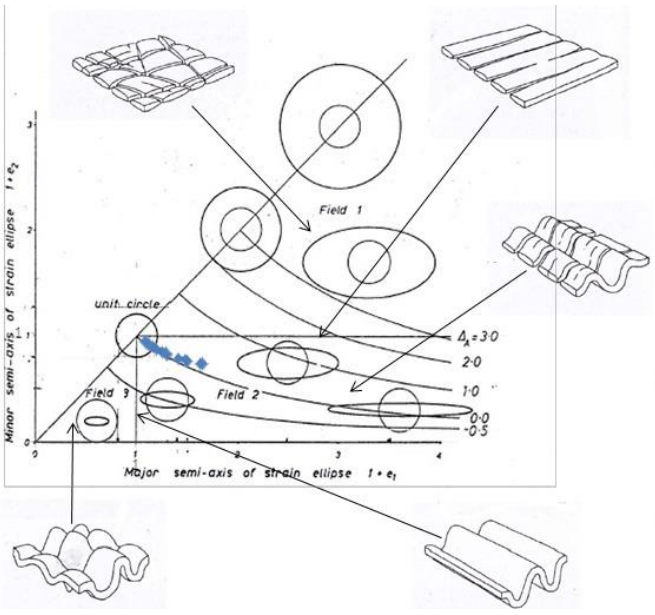

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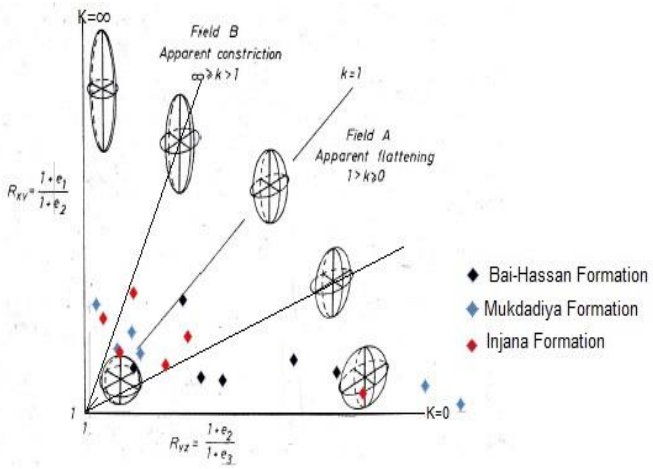

Figure (4): A,B &C: Classification of strain ellipses shapes, original diagram is from Ramsay & Huber, 1983 D: Flinn diagram of the analyzed samples original diagram is from Ramsay & Huber, 1983.

Kirkuk University Journal /Scientific Studies (KUJSS)
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5.CONCLUSION AND RECOMMENDATION

-The work procedure, systematic action, for three-dimension finite strain calculation is shown in this work.

- The finite strain of Upper Miocene and Pliocene has calculated in the form of strain ellipsoids with length of semi axes and their orientations. The shape of ellipsoid is of constriction and flattening type.

-There are three orientations of elongation (due to strike of bed): the first perpendicular, the second is oblique and the third is parallel.

-The shortening in the Pliocene rock (Bia Hassan Formation) is perpendicular to the strike of bed in the NW portion while it is parallel in the SE portion. The Pliocene rock (Mukdadiya Formation) shows the orientations, due to the strike of beds, of $1+e_3$ is: perpendicular, oblique and parallel. The U. Miocene (Injana) Formation shows nearly perpendicular relation with the strike of beds.

- From above mentioned findings, the stress orientations for each station are estimated assuming that strain is directly proportion to stress due to the contemporaneous timing of last phase of Alpine Orogeny and the age of the exposed formations.

-The authors highly recommend another strain calculating method to carry out in the study area to compare the results and to be sure that the present calculation is near to truth.

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