

HISTORICAL DEVELOPMENT OF THE PRESENT DAY LINEAMENTS OF THE WESTERN ZAGROS FOLD-THRUST BELT: A CASE STUDY FROM NORTHEASTERN IRAQ, KURDISTAN REGION

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ABSTRACT

The part of the Zagros within the Iraqi border occupies an area less than quarter of the country. It includes three tectonic zones which can be clearly identified in the field. These are the Low and High Folded, Imbricated and Thrusted Zones. The main lineaments are the axes of the anticlines; transverse and longitudinal faults; lines of distribution of ophiolite and metamorphic rocks; drainage direction discharge and line of distribution of conglomerates. The direction of axes of the anticlines are trending nearly N38W which normal to the direction of the imposed stress by the Iranian plate front. Due to differences in thicknesses and physical properties of the sedimentary rocks, the axes of these anticlines are not continuous they plunge more or less in an echelon pattern and in some cases are bend. The lengths of most of these anticlines are around 10-30km. The first appearance of the anticlines in the High Folded Zone possibly started at the Eocene while those of the Thrust Zone initiated at Maastrichtian. Some of these anticlines are cut by transverse faults whose ages are not known. These faults are trending nearly normal to the axis of anticlines. Other kinds of lineaments are the distribution of ophiolites and metamorphic rocks. Historically the first appearance of trace of ophiolites (as pebbles in sedimentary rocks) has an age of Lower Maastrichtian.

The direction of drainage discharge is nearly towards the south and southwest, which is inherited from that of the Upper Cretaceous and Tertiary paleocurrent directions (sediment transport direction). This direction is related to uplift of the extreme northwestern part of the studied area during Maastrichtian. Evidence for these suggestions is the occurrence of thicknesses of 500m of conglomerates as valley fillings during Late Cretaceous. The depositional axes of the successions was migrated for about 40kms during Cretaceous and Tertiary and becomes younger from northeast towards the southwest as recorded by four narrow belts. The line of migration is nearly coinciding with both direction of present regional slope and the Cretaceous sediment transport.

تاريخ تطورا لتراكيب الخطية الحالية لمنطقة حزام الزاجروس الغربية المطوية والمندفعة: دراسة خاصة باقليم كردستان، شمال شرق العراق

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المخلص

ان الجزء الواقع في العراق من منطقة حزام الزاجروس الغربية يحتل اقل من ربع المساحة السطحية من البلاد و يتضمن ثلاثة أنطقة تركيبية واضحة المعالم في الحقل. وهذه الانطقة هي نطاق الطيات الوائنة والعالية ونطاق التراكب و نطاق الزحف. ان التراكيب الخطية الرئيسية ، في منطقة الدراسة ، عبارة عن محاور الطيات و الفوالق الطولية والعرضية و خطوط توزيع الاوفيولات و الصخور المتحولة و واتجاهات تصريف الرسبيات و خطوط توزيع تجمع المدملكات. و تتجه محاور الطيات الحالية الى 38 درجة شمال غرب و تكون عمودية على اتجاه الضغط الناتج عن حركة الصفحة الايرانية. و بسبب عدم تجانس الخواص الطباقية الحركية و الاختلاف في تقدم مقدمة الصفحة الايرانية يظهر عدم استمرارية و التواء في محاور الطيات. و يراوح طول المحاور من 10 الى 30 كم و إن اول ظهور للطيات يرجع (على الأرجح) الى الايوسين في نطاق الطيات العالية بينما في النطاق الزاحف يرجع الى الماسترختيان المبكر . و بعض الطيات تتقاطع بواسطة الفوالق العرضية(كالتراكيب الخطية العمودية على محاور الطيات) ذات العمر غير المعروف. و النوع الاخر من التراكيب الخطية هي خطوط توزيع الاوفيولايت و الصخور المتحولة حيث ان خطوط ربط هذه الصخور يوازي (في النطاق) محاور الطيات تقريبا. يرجع اول ظهور للاوفيولايت (كحصوات في الصخور الرسوبية) الى الماسترختيان الاسفل. و يتجه مسار تصريف الرسوبيات والمياه الى الجنوب و الجنوب الغربي و هذا الاتجاه موروث من اتجاه التيار القديم و تطور تكتونية الكريتاسي العلوي و العصر الثلاثي

حيث بدأ اول جريان جنوبي للرسوبيات في الكريتاسي المتاخر. الدليل على هذا الاتجاه وجود 500 حوالي م من المدملكات (ترسبات الوديان) في الكريتاسي المتاخر. و لوحظ هجرة مستمرة للتتابعات السميكة من المدملكات(كالتراكيب الخطية) لمسافة 40 كم نحو الجنوب الغربي خلال عصر الكريتاسي و الرباعي. ان اتجاه مسار ترسيب المدملكات يتطابق تقريبا مع اتجاه الانحدار الاقليمي لمنطقة الدراسة وكذلك اتجاه نقل الرسوبيات في الكريتاسي المتاخر.

INTRODUCTION

The present study deals with the Western Zagros Mountain Belt that is located in Iraq and is elongated parallel to Iran-Iraq border (Fig.1 and 2). On the regional scale the Western Zagros mountain belt consists of relatively straight and continuous series of high mountains that runs from southeast of Arabian Gulf to the eastern part of Anatolia at the northwest. The series has the elongation trend of northwest-southeast. The tectonic zones (Thrust, Imbricated, High and Low Folded Zones, fig.2) of Buday (1980) and Buday and Jassim (1987) have more or less local disturbances in the directions of elongation. When the ideas of Turrini, *et al.* (2001), Schreuer, *et al.* (2001) and Marshak (2004) are considered, these disturbances could be attributed to the difference of mechanical properties of stratigraphic units. According to the same authors, the local difference of the compressional stress in the orogenic wedge (the southwest thrusting of Iranian plate front) and local structures have affected on these disturbances (Fig.1 and 2). The field study showed that the belt contains clear large lineaments which have great importance in the studying of the depositional and tectonic history of the area where the sedimentary, igneous and metamorphic rocks and deformational lineaments are all combined mutually with the paleocurrent directions. Therefore the present study deals with the location, types and historical development of these lineaments. In literature, many studies, as a part of a structural geology, have been conducted for lineament analyses (without their historical developments) of the northeastern and northern Iraq such as Omer (2006) and Al-Brifkani(2008).

LINEAMENTS

Northeastern Iraq which is part of Western Zagros Mountain series shows well developed large lineaments which could be seen in the field and by aerial photography and satellite images. These lineaments generally reflect the effect and direction of the thrusting front of Iranian plate which has the general direction of S38W and may have local variations of plus or minus 10 degrees. These lineaments are as follows:

1- Axes of the anticlines

The main and wide spread lineaments are the axes of the anticlines which have the general direction of Zagros Fold-Thrust Belt (Fig.1). The trends of these axes are nearly normal to the direction of the imposed stress (S38W). Due to differences in the

thicknesses and mechanical stratigraphy of the sedimentary rocks, the axes of these anticlines are not continuous but plunge in an en echelon pattern. This can be seen in Dokan area where Piramagroon, Sara and Kosrat anticlines are arranged in this pattern from southeast to northwest. The same thing is true for the area between Arbat and Said Sadiq town where this pattern can be seen to the north of the road where many anticlines plunge under the Sharazoor plain in en echelon pattern. The lengths of most of these anticlines are around 10-30km. Some of these anticlines are cut by transverse faults.

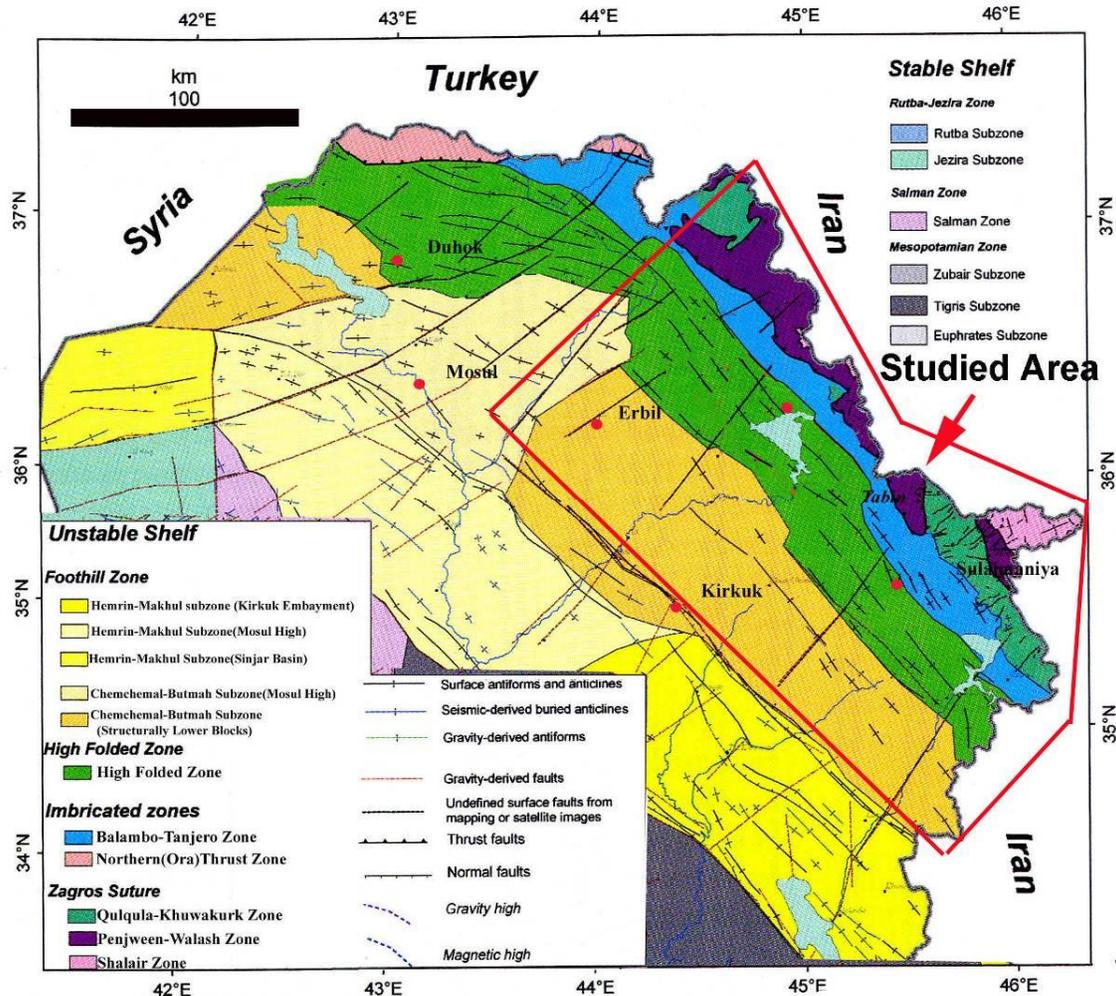


Fig. 1: Tectonic map of Northeastern Iraq (Al-Kadhimi et al, 1996) shows location of some of the prominent lineaments of the studied area.

The historical development of these anticlines is still controversial and is related to the collision of the Iranian and Arabian Plates, and the migration of the tectonic deformation towards the southwest inside Iraq. According to, Buday (1980), Buday and Jassim (1987), Numan (1997, 2000, and 2002) and Al-Qayim (2000) the collision of the continental parts occurred in the Eocene. Recently, Karim, (2004) Karim and Surdashy (2005a and 2005b) inferred from sedimentologically evidences that, the collision of the continental parts

occurred in the Campanian. According to these the main thrust fault developed at the Campanian and a foreland basin was generated directly to the southwest (Fig.3A and B).

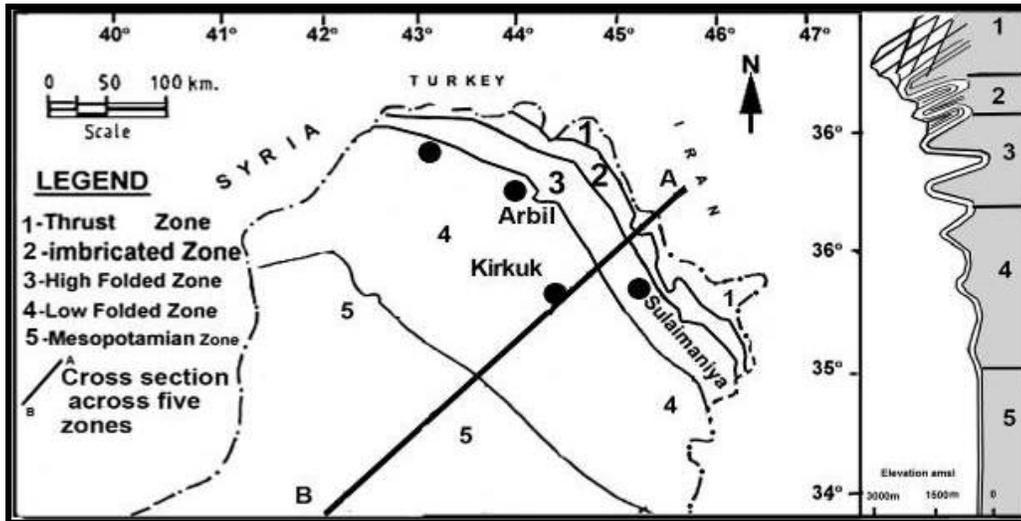


Fig. (2) Boundaries of the tectonic subdivision of the Western Zagros in Iraq (modified from Buday and Jassim, 1987).

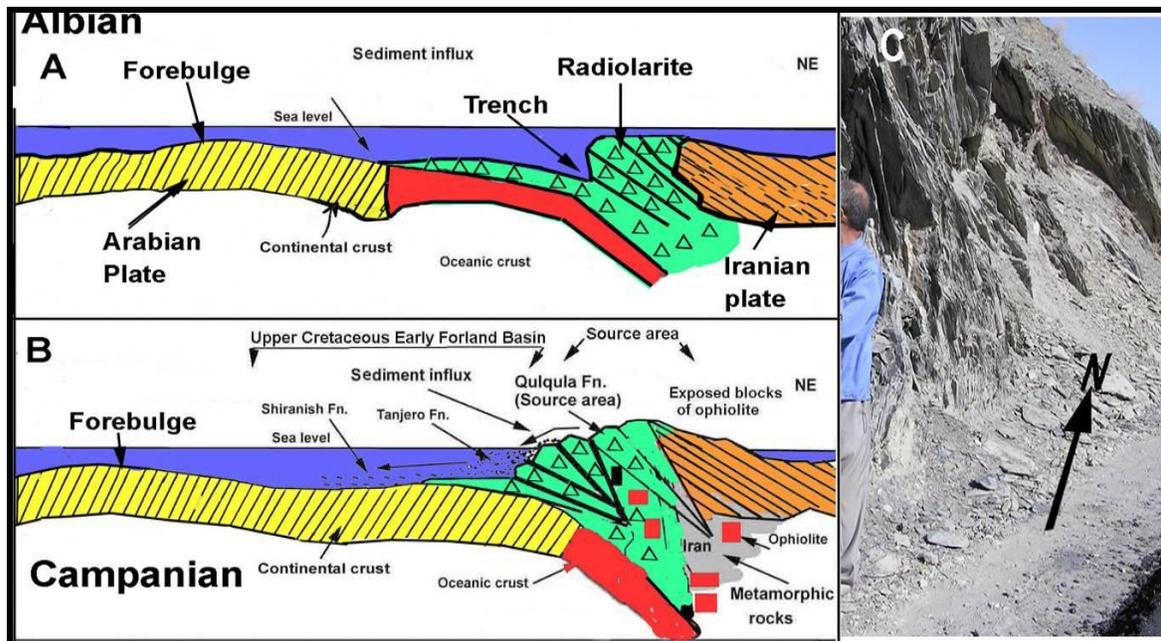


Fig.3: A) Tectonic model of the studied area during early Cretaceous showing accumulation of the radiolarites as accretionary prism and forming foreland forebulge. B) Development of foreland basin and southwestern drainage discharge (sediment transport) by uplift of radiolarite due to collision of Arabian and Iranian plates. C) Shelair phyllite formed by the stress of the two plates.

Therefore, the first folding, in Iraq, in the present Thrust Zone occurred during the Campanian. Among the anticlines that most possibly related to that time is Avroman Anticline in the Thrust Zone. Later on, the tectonic front migrated towards the foreland interior (towards the southwest) and reached the High Folded Zone during Middle Eocene. A positive land was generated during this age in the present position of the Shinarwe, Goizha, Kewa Rash Mountains in the high Folded Zones (Karim *et al*, 2008). This positive land, as possible anticlines, separated the early Foreland basin into two minor basins. Towards Late Miocene the tectonic deformation (folding) migrated southwestward and reached the Low Folded Zone (Karim et al, (Karim *et al*, 2008).

2- Distribution of Igneous and Metamorphic rocks

The igneous rocks, as ophiolite complexes, are distributed along a more or less straight line near the borders with Iran which studied by Jassim and Al-Hassan (1977) and Buday and Jassim (1987), Aswad *et al* (1991) Aswad (1999). This lineament has the black or dark violet color on satellite images and its direction coincides nearly with the Zagros Suture Zone and the schistosity of metamorphic Rocks (slate, phyllite that are exposed around Garmik and Penjween towns) (Fig.3c) with attitude of 320° , 70° as arranged according to right hand rule. The distribution of igneous rocks is not continuous but has occurred as separate spots or blocks (Fig.1). Some blocks are dislocated from the straight line; an example of such blocks is the Mawat ophiolite complex which has been thrust further towards southward than the other blocks. Karim (2005) attributed this dislocation to the existence of graben in the area which acted as privileged direction for thrusting. When these blocks are connected by a line they give clear and large lineament which is nearly parallel to the axes of the anticlines.

3-First appearance of ophiolite

The age appearance of this lineament is not exactly known exactly, but Aswad and Elias (1988) stated that it appeared in the Albian-Cenomanian. Karim (2004, 2006b) found gravels and boulders of gabbro and peridotite in the conglomerate of the Tanjero Formation (Fig.4A). The age of this conglomerate is Early Maastrichtian determined by planktonic foraminifera zonation of hemiplagite by Abdel Kareem (1986b). Karim (2004) showed that the interbedded marl and sandstone of the distal area is equivalent to the conglomerate at proximal (coastal) area.

The appearance of these clasts is important as it indicates that the emplacement of ophiolite in the suture zone of Zagros belt started at the Maastrichtian. Another importance of these clasts is the possible indication of dissection of newly uplifted Upper Cretaceous positive land (foreland) by deep valleys causing the emplaced igneous bodies to be exposed to erosion processes. In this connection Karim and Surdashy (2006) found four incised valleys in the sediments of Tanjero Formation during Maastrichtian (fig.5B).

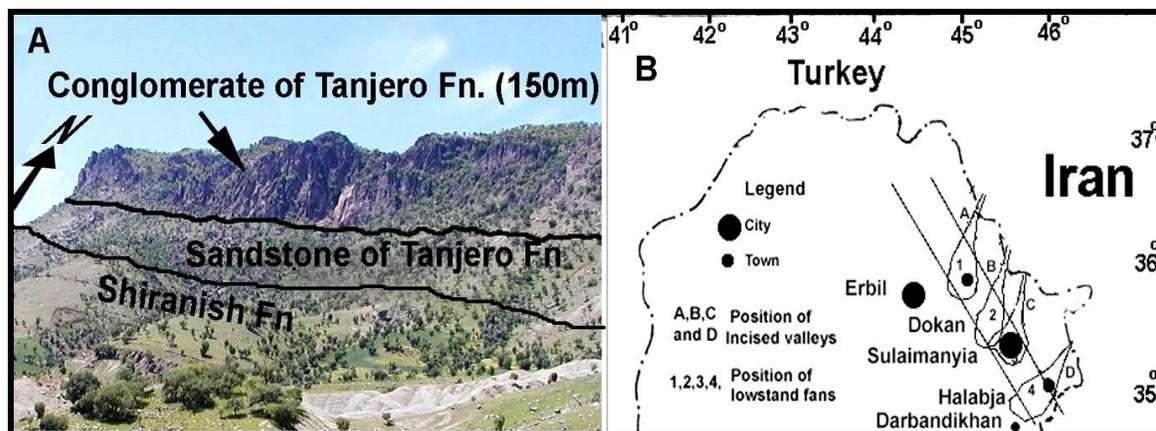


Fig.4:A) Conglomerate bed of Tanjero Formation that contain first appearance of boulders and gavels of Gabbro in history of Iraq, West of Shekhan village, Qandil mountain towards the at east of Kometan village. B) Four ancient valleys (Maastrichtian) that drain the surface runoff of the hinterland into the foreland basin (Modified from Karim and Surdasy, 2006).

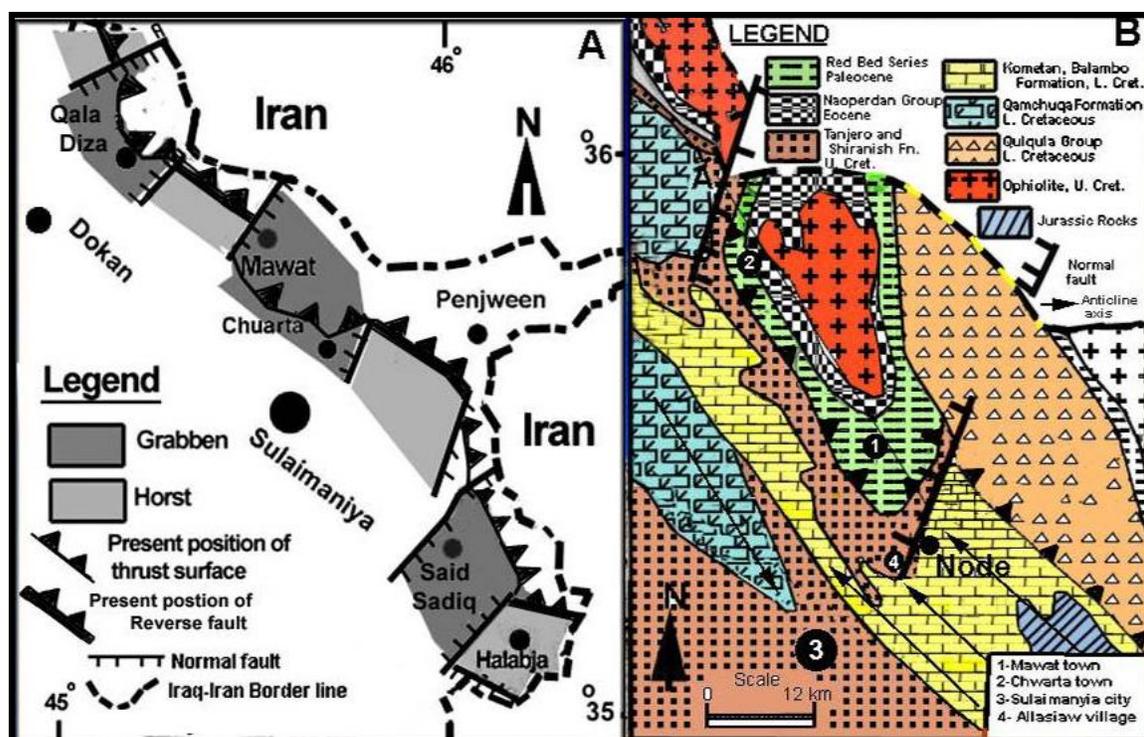


Fig.5: (A) Division of the studied area (thrust and imbricate zones) into several blocks transversally by normal faults. (B) Position of the two normal faults that bound Mawat graben.

4- Transverse faults

In addition to the main thrust faults, there are many transverse normal faults that cut across (nearly normal to) the axes of the anticlines and main Zagros Thrust Fault. These faults divide the area into many uplifted and subsided blocks (Fig.5A). These blocks make horsts and grabens which are bounded by normal faults and their traces, on the surface, die out towards the southwest and obscured towards northeast by the southeast thrusting of the front of Iranian plate. The erosion is highly modified the topography of these faults but they could be identified in the field. They are difficult to be identified from satellite images and could be indirectly inferred from the large elevation and depressions that bound these faults (Fig.5A).

The most important feature that is associated with blocks is, the Zagros Thrust Fault which makes a reverse faults with horst (light grey blocks of the fig. 5A) and low angle with the grabens (dark blocks of the same figure 5A). The thrust can be seen in several areas such as the Chuwarta-Mawat and Said Sadiq areas, while the reverse fault could be seen in the two areas between Chuwarta-Sadiq and Halabja areas. In these areas the Qulqula Radiolarian Formation (as a thrust front) climbs over Balambo Formation (or Jurassic Rocks) with an angle nearly equal to about 40 degrees. The age of these transverse faults is not known but they appear, from stratigraphy, that most of them are younger than Eocene. The evidence of the two of these faults is discussed in detail by Karim (2005a) (Fig.5B).

5-Drainage discharge direction (sediments transport direction)

Another kind of lineament is the direction of the drainage discharge (direction of sediments transport) which trending now from northeast to northwest. This trend has close relation to the geologic, geomorphologic and tectonic history of the studied area. The first uplift in the extreme northeast of Iraq and its migration towards southwest is the main factor for shaping of this lineament. The chronology of this uplift is controversial and according to many studies it occurred during Eocene (Numan,1997 and Al-Qayim, 2000). Other studies mentioned the occurrence of uplift at the Campanian, among these (Karim 2004b, Karim and Surdashy, 2005b). According to the last study and that of Al-Barzinjy, 2005) and Karim et al (2008) the paleoslope and drainage directions were nearly in the same direction from Campanian to Eocene (Fig.6). The first uplift of the northeastern part of the studied area started near the Iran-Iraq border. Al-Barzinjy, (2005) and Karim et al (2008) indicated that paleocurrent was towards the south and southwest during Upper Cretaceous, Paleocene and Eocene. The measurements of the paleocurrent of Upper Bakhtiary by imbricated pebbles, in the present study, reveal nearly the same direction of that in the Tanjero Formation and Red Beds Series. The data of paleocurrent as collected from cross bedding and imbricated pebbles are well documented in Karim (2004) and Al-Barzinjy (2005) (for the last two units.)

As concerned to sediments transport and drainage discharge, Karim and Surdashy (2006) found four large incised valleys in the sediments of the Maastrichtian filled with boulder and pebble conglomerates (Fig.4). They mentioned that each valley was

associated with low stand delta, submarine fan and channels. During the above mentioned ages the studied area was occupied by large foreland basin which was located in front of the advancing head of the Zagros thrust fault (Fig.6). Therefore the discharge direction, in the past and present, is closely related to the tectonic uplift of the area now called Zagros Fold-Thrust belt and foreland basin in front of it. It is generally accepted, , that the main streams such as Dilla, Little and Great Zab Rivers are flowing on the large transverse faults that cut both the basement and sedimentary strata. Therefore, the drainage discharge is an important type of lineaments which is related to uplifting and fracturing developed by collision of the Arabian and Iranian plates.

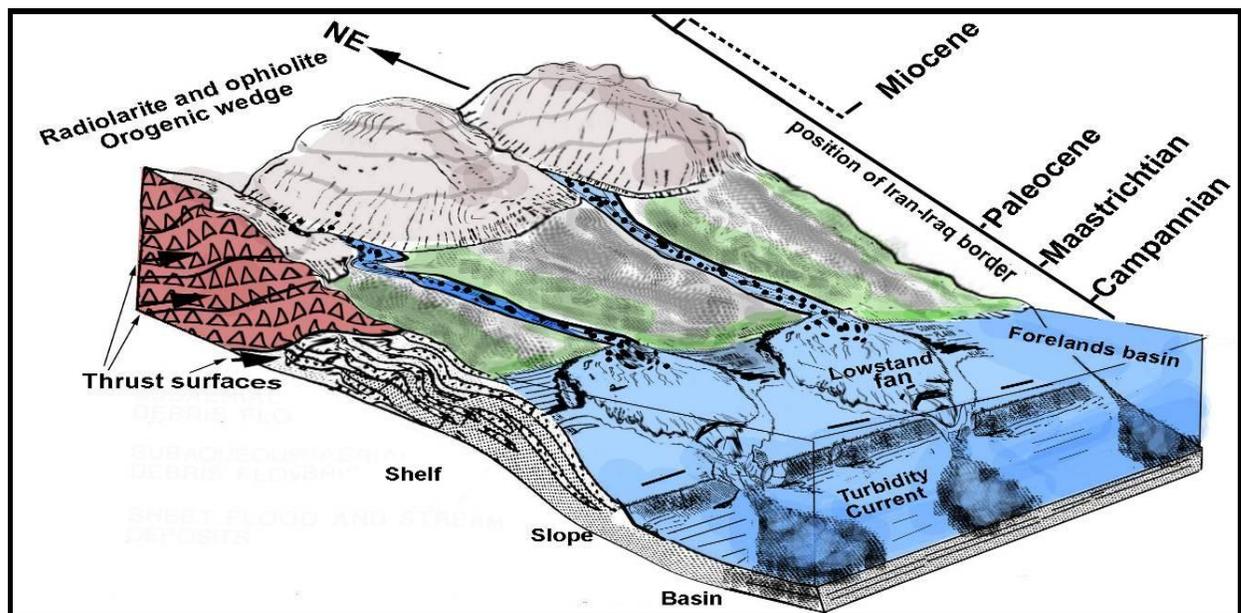


Fig.6: Tectonic and paleogeographic models for the sediment transport. It shows the location of the shoreline (Location of deposition of the studied conglomerates) as respected to present location of Iran- Iraq border (During Maastrichtian, the shoreline was nearly coinciding with the present border).

6-Direction of the maximum facies change

Other types of the lineaments are the direction of the maximum facies change that can be detected from facies maps and satellite images as well as from field observation across the strike of strata. In the field, the coarse grain clastic sediments (facies) of Upper Cretaceous, Tertiary to Recent change to fine grain ones towards southwest. The sedimentary facies are arranged in down lapped fashion on each other towards the southwest from shallow to deep facies. Karim (2004) described facies changes of Maastrichtian from boulder conglomerates to marly limestone passing through sandstone and shale. The trend of the facies change is toward southwest beginning from conglomerate, from extreme northwest (near Chuwarta and Mawat), to marly limestone at the southwest (near Chamchamal town). This type of facies change was continuous and migrate towards the southwest and can be seen from satellite image across the limbs of

anticlines. The facies change can be applied to metamorphic facies also. They show variations from schist to slate passing through phyllite from inside Iran to Iraq then changes to fresh sedimentary rocks at 20km inside Iraq. The metamorphic facies are related to depth of metamorphism and dynamic of the plate collision.

RECORDED CONGLOMERATE IN THE STUDIED AREA

The facies change is clearer in the case of clastics dominating successions that start from conglomerate in the coastal area and ends up by shale or limestone in the offshore or (distal area) (Pettijhon, 1975, Blatt et al 1980 and Tucker, 1990). These two end members pass through intermediate facies such as sandstones and siltstones. The change of position of the conglomerates with time is a direct reflection of the tectonic activities in the studied area and is represented by juxtaposition of fine clastics by conglomerate in the foreland basin toward southwest. This is attributed to rejuvenated erosion by continuous uplift and advance of Iranian plate towards the southwest. Many thick conglomerate successions are found by the present authors and other workers (Al-Barzinjy, 2005, Karim, 2004) which have the depositional axes parallel to the axis of main Zagros thrust fault (Fig.6). Each conglomerate successions could be assigned to a certain age and location. The paleocurrent and tectonic migration directions are indicated by Imbricated pebbles and cross bedding. The migration has resulted either from migration of the thrust front or southwest moving of the folding or deformation front. This southwest migration of the conglomerate depocenter shows more than 60km of movement from the Upper Cretaceous to Pliocene time (Fig.5 and 6). These conglomerates are as follows, arranged from older to younger:

1-Lower Maastrichtian conglomerate

This is a very abundant conglomerate and located at the base of the Tanjero Formation. The maximum thickness is 500m and exposed at Chuarta, Mawat, and Qandil areas near the border of Iran and was studied by Karim (2004) and Karim and Surdashy (2005). These workers put this conglomerate at the lower part of Tanjero Formation by correlation (stratigraphically and lithologically) with 400m of sandstone and shale beds south of Sulaimanyia City and Dokan area (Fig.8). The conglomerate thickness is at maximum in the location of the paleo-incised valleys. It is possible that this conglomerate is an indicator of the first appearance of some of the present lineaments such as the ophiolite and thrust fault.

2-Upper Maastrichtian-Eocene conglomerate

The strata of Late Maastrichtian to Eocene contain several lensoidal conglomerate beds and successions. They include the upper part of Tanjero Formation, Kolosh Formation and Red Bed Series in addition to Sinjar and Gercus formations. Their thicknesses are variable and change from proximal to distal areas and range from 20cm to 1000m. Geographically these conglomerates are not found in all places as they appear in some places and disappear in others. In north of Darbandikan town, they reach about(60m) and belong to Gercus Formation while toward Haibat Sultan Mountain they are intermittently exposed as thin lenses. Al-Barzinjy (2005) correlated this conglomerate (in Darbandikan area) with the unit three (1000m thick) of the Red Bed Series and indicated the southwest paleocurrent direction (fig.9 and 10A). Some of these conglomerates are deposited in the

coastal area of the foreland basin while others are transported to distal area by debris flow. These conglomerates are discussed in detail by Buday (1980), Karim (2004) and Al-Barzinjy (2005).

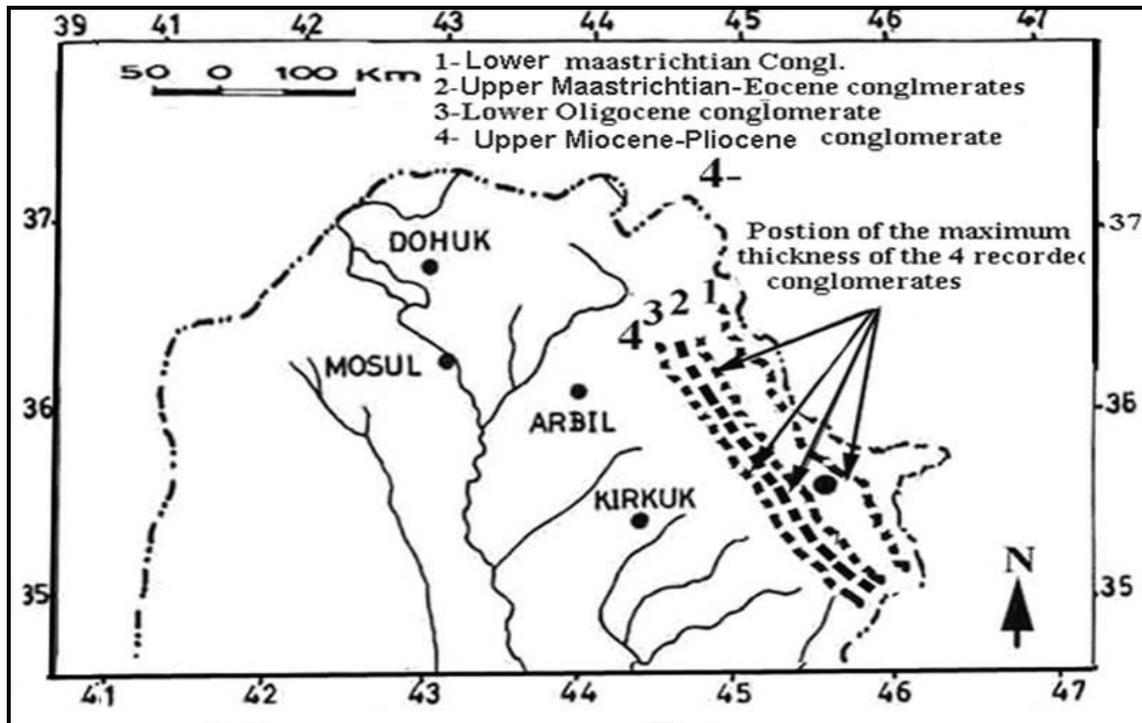


Fig.7: Present location of the maximum thickness of the recorded conglomerate succession in the studied area from Lower Maastrichtian to Pliocene

3-Lower Oligocene conglomerate

This conglomerate consists of (2-10m) of well developed conglomerate and located between Pila Spi and Fatha Formation at the boundary between Low and High Folded Zones. It is indicates as (conglomerate) no.3 on the map (Fig.7) and on the stratigraphic column (Fig.8).

4-Upper Miocene- Pliocene conglomerate

This conglomerate succession is the conglomerate of no.4 in the (fig.7), consists of very thick pile of pebbles, pebbly sandstone and interbedded with red claystone and erosional surfaces. This pile includes Mukdadyia and Bai Hassan (Lower and Upper Bakhtiary) Formations and studied by Bellen et al (1959) and Buday (1980). The thickness of this conglomerate is more than 1500m and is located mainly in the Low folded Zones. The paleocurrent of this conglomerate is towards southwest (Fig.10B).

Areas	Thick. (m)	Lithologic symbols	Lithologic description	Formation	Conglomerate	
Low folded Zones	0-200		Mixture of clay, sand gravel and boulder		Quaternary	
	1500		Alternation of conglomerate, sandstone and claystone.	Upper Bakhtiary	Upper Miocene-Pliocene Conglomerate	
	1500		Alternation of Pebbly sandstone and red or brown claystone.	Lower Bakhtiary		
	200-800		Alternation of gypsum, marl and claystone beds with some sandstone and limestone	Lower Fars		
				0- 10m conglomerate		Oligocene Con.
	60-150		Alternation of medium beds of chalky and dolomitic limestone	Pila Spi	Middle Eocene (no cong.)	
High and Imbricated Zones	120-1500		Alternation of sandstonered claystone at distal area which change to conglomerate at proximal area	Gercus and Red Bed Series	Upper Maastrichtian-Eocene Conglomerate	
	70		Reefal limestone at distal and proximal area, while change to fine clastics	Sinjar , Naoperdan and Red Bed Series		
	1000		Alternation lensoidal conglomerate and claystone	Kolosh Fn.		
				Reefal limestone at proximal area which change to bioclastic limestone at distal area	Aqra lense	Lower Maastrichtian Conglomerate
	500-1000		Alternation of sandstone and shale or marl with lenses of conglomerate change to cong. at proximal area.	Tanjero		
	120		Alternation of sandstone and shale	Base of the Tanjero		
	70		marl at the top while changes downward to marly limestone (hemipelagite)	Shiranish Fn	Albian -Maastrichtian (no cong.)	
70		Well bedded and white pelagic limestone with abundant planktonic forams	Kometan Fn			
600		Massive reefal limestone change to pelagic limestone and hemipelagite toward north and northeast	Qamchuqa and Balambo	Jurassic -Albian (no cong.)		

Fig. 8: Stratigraphic column of the exposed units of the studied area showing the position of the studied conglomerates.

COMPUTOR PLOTTING OF THE DATA

Paleocurrent indication is important for knowing the paleoshore line, sediment transport direction, direction of the elongation of the submarine fans, incised valleys and direction of the facies changes. Therefore imbricated pebble analysis is important for the history and elongation of the lineaments. In the present study, the outcrops of the conglomerate of Gercus and Upper Bakhtiary formations have been surveyed (for Tanjero Formation and Red Bed Series see Karim, 2004 and Al-Barzinjy, 2005). For rose diagram plotting, the azimuth of the direction of the plunging of the pebbles are taken by compass and tabulated. The plunging direction is reversed 180 degrees to change the plunge to the direction of the imbrication (direction of paleocurrent as seen in table1). The data of each station are entered to the Rockwork software as one column. Then the unidirectional option is activated in the program when the activated rose diagram gives the paleocurrent direction as shown in the figure 11.

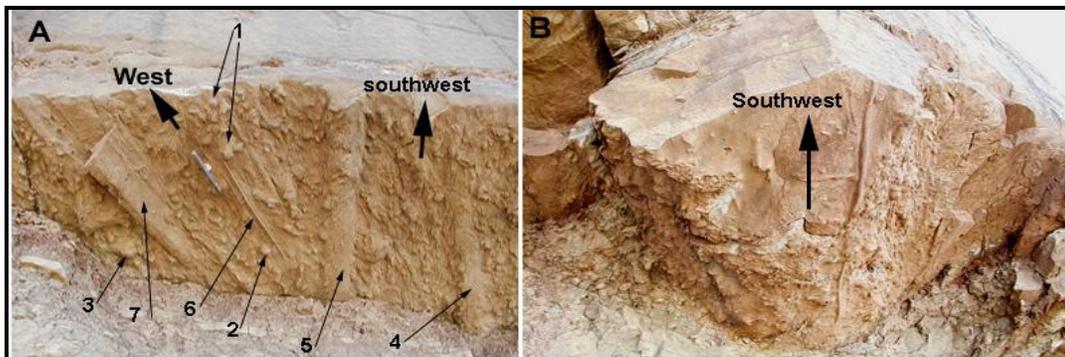


Fig. 9: A) Under side of a thick pebbly sandstone bed (1.5m wide) of the unit one of Red Bed Series showing paleocurrent direction toward southwest during the Paleocene. Flute casts (1, 2, and 3), small and large groove casts (4, 5) and striation casts (6, 7). B) Small eroded channel (30cm wide) showing groove cast in the red claystone of the same unit in the same bed (Al-Barzinjy, 2005).



Fig.10: (A) Eocene (Gercus Formation) conglomerate about 60m thick forming a mountain called “Barda Asin” at northwest of Darbandikhan town, southwest of Zarayen town. B) Upper Bakhtiary Formation (Pliocene) conglomerate shows southwest paleocurrent direction. The arrows indicate paleocurrent direction and bedding surfaces while small inclined lines indicate directions of pebble imbrications.

Table1: Direction of the imbrication of gravels and boulders in the conglomerate of Formation and Upper Bakhtiary Formations.

Eocene Conglomerate (Gercus Formation)				Upper Miocene-Pliocene (Upper Bakhtiary Fn.)			
Barda Asin Mountain South of Zarayeen town		Sartak Bamo		South of Darbandikhan Town		South of Chamchamal Town	
220	170	181	141	291	185	234	244
231	193	145	166	360	171	332	200
68	205	285	228	233	231	178	281
276	230	200	251	257	248	356	230
254	211	123	185	197	313	259	168
238	261	287	239	240	172	203	282
245	178	142	260	187	189	170	145
120	305	202	191	244	231	267	232
190	270	235	298	197	197	185	239
187	23	222	198	210	131	45	231
253	249	278	189	236	170	122	238
92	111	311	131	142	251	346	288
274	270	340	270	270	247	247	300
170	256	285	170	135	214	283	273
251	237	272	131	128	165	235	282
170	248	255	196	190	199	200	222
188	244	261	178	183	197	244	261
202	213	213	186	174	155	159	230
283	350	156	175	175	177	123	306
245	257	170	211	230	260	340	122
231	256	254	232	212	224	360	267
270	345	186	131	233	220	248	334
350	150	322	154	256	215	205	124
246	200	232	189	195	112	212	267
199	198	187	242	277	154	305	189
206	207	193	78	241	181	314	188
241	218	203	186	176	223	256	199
295	215	216	175	199	223	279	109
257	241	230	194	194	210	300	230
211	277	143	222	226	230	33	143
185	269	266	200	220	325	267	266
233	217	177	220	163	150	267	177
241	88	199	166	215	209	289	199
206	254	190	280	261	244	236	190
247	306	255	184	236	176	233	255
264	340	160	309	344	254	278	322
356	289	233	290	266	258	190	108
290	301	268	68	206	150	45	268
307	177	111	304		190	309	187

LINEAMENT OF THE NORTHERN IRAQ

It is possible that the same or most of the lineaments occurring in the northern Iraq, including North Thrust Zone, have nearly same the historical development but with different direction and all are diverted anticlockwise by about 40 degrees as compared to the northeastern Iraq (Zagros Fold-Thrust belt). The anticlines and thrust front are trending nearly east-west. It is possible that the drainage, facies migration direction was towards south instead of the southwest. The main factor for diversion of the trend of the lineament is the collision of Arabian and Turkish plate which generated the Tauros mountain belt. Al-Brifkani (2008) has mentioned that most lineaments, in this area, are trending towards north-south and east-west.

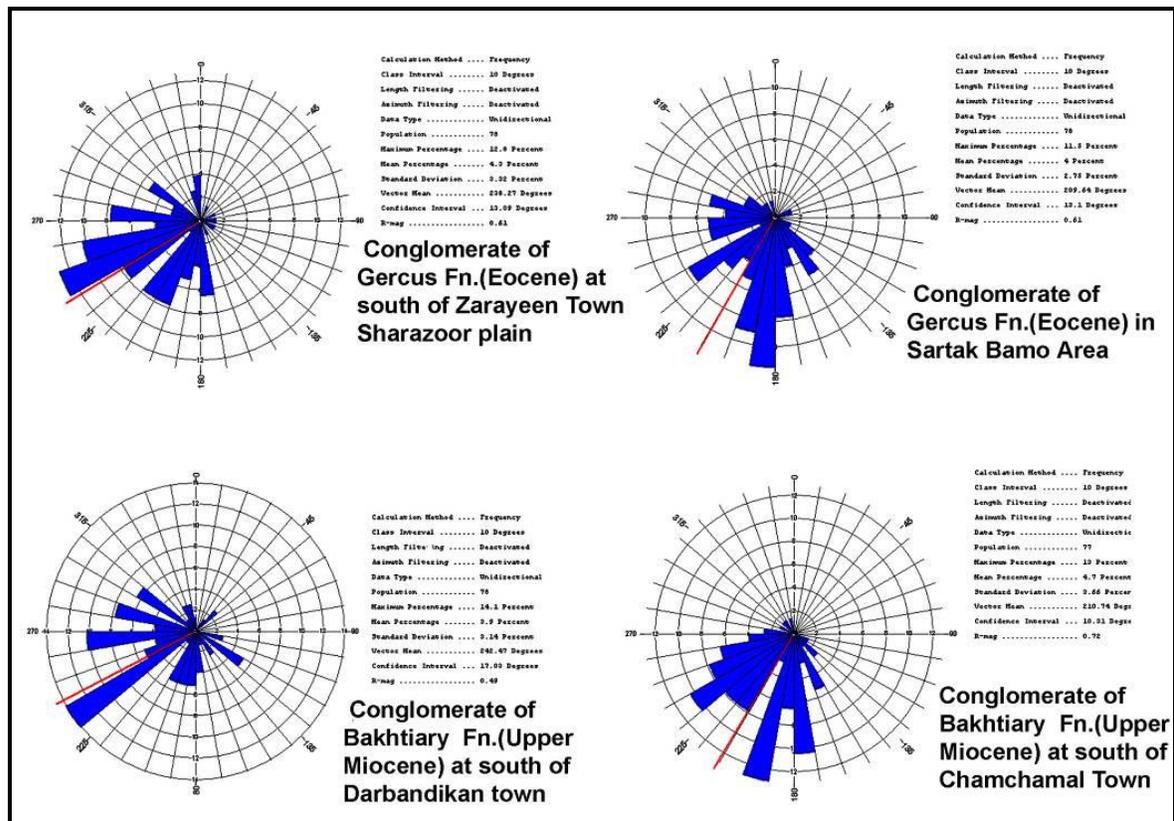


Fig.11: Rose diagrams show paleocurrent direction (sediment transport direction) as indicated by imbricated pebbles of conglomerate of Eocene and Pliocene.

CONCLUSION

This paper has the following conclusions:

- 1-The most important main lineaments are axes of anticlines; transverse faults; line of distribution of ophiolites; drainage discharge direction and maximum thickness of conglomerates.
- 2- It is found that the trends and history of these lineaments are closely related to the development of the Zagros Fold -Thrust Belt.
- 3- The first appearance of ophiolites (as gravel and boulder in clastic sediment) was at Lower Maastrichtian.

- 4- The first appearance of anticlines is Campanian age, but it is Eocene and Upper Miocene in the Thrust, High and Low Folded Zones respectively.
- 5- The first appearance of southwest direction of drainage (sediment transport) is aged Upper Cretaceous as indicated by incised valleys and imbricated pebbles.
- 6-The trends and positions of conglomerates could be considered as a lineament with a southwest trend of migration for about 50km from Upper Cretaceous till the Pliocene.

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