# HISTORY AND GEOLOGICAL SETTING OF INTERMONTANE BASINS IN THE ZAGROS FOLD – THRUST BELT, KURDISTAN REGION, NE IRAQ

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## ABSTRACT

It is mentioned previously that the intermontane basins, in northeastern Iraq, are developed in Early Paleocene. In present study, the timing, geographic location and geological setting of these intermontane basins are studied from Iraqi Zagros Fold – Thrust Belt during Tertiary. This study is achieved in accordance to the previous literature and recent sedimentological studies. The terrigenous clastic cutoff and facies comparison with their distribution are used as evidences for spatial and temporal development of intermontane basins. The study concluded that the first intermontane basin is developed during Middle Eocene.

It is observed that the present position of the Thrust and Imbricated Zones of Iraq was an area of subsidence and generation of the intermontane basin during Middle Eocene. Concurrently, with this subsidence and directly to the southwest of the latter zone a narrow paleohigh was developed, which separated the subsidence area from the main basin. The present position of the paleohigh coincides with the boundary of the High Folded and Imbricated Zones. In these intermontane basins the flysch facies (sandstones and shales of Walash and Naopurdan Groups) are deposited at the beginning while later molasse facies (conglomerate of upper part of the Red Bed Series) are deposited. Concurrently, in the area of the present Low Folded and Mesopotamian Zones (main water body of the main foreland basin) thick succession of pure carbonate (Pila Spi Formation) was deposited signalizing total cutoff of clastic sediments from the latter zones. In contrary, during Early Paleocene till Middle Eocene clastics (conglomerate and sandstone) influx was continued from source area into early Zagros Foreland Basin and mixed (occasionally) with carbonates of Sinjar Formation in many places. During Early Paleocene – Middle Eocene, intermontane basin was not generated as cited in previous studies to trap transferred sediments from source area, except some basin irregularities on which reefal limestones of Sinjar Formation are deposited. The separation of early Zagros Foreland Basin into two smaller basins (Main foreland basin and intermontane basin) decreased the current circulation and wave activity, therefore lagoonal dolomitic limestone of Pila Spi Formation was deposited.

# التأريخ والوضع الجيولوجي للاحواض بين الجبلية في نطاق زاجروس المطوي – الزاحف في إقليم كردستان، شمال شرق العراق

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**المستخلص**

ذكر في السابق أن التطور الجيولوجي للأحواض بين الجبلية في شمال شرق العراق بدأ في الباليوسين المبكر. في الدراسة الحالية درس التوقيت والموقع الجغرافي والوضع الجيولوجي للأحواض بين الجبلية في نطاق زاجروس المطوي - الزاحف في شمال شرق العراق. أجريت الدراسة في ضوء الدراسات السابقة والتطور الحديث في علم

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الرسوبيات، حيث استخدمت توقف تدفق الرسوبيات القارية وتوزيعها ومقارنة السحنات وكدليل للتطور الزمني والجيوغرافي للأحواض بين الجبلية، حيث استنتج بان هذه الأحواض بدأت بالتكون في الإيوسين الأوسط. لوحظ ان الموقع الحالي لنطاقي الزحف والتراكب كان موقع هبوط وتكون الأحواض بين الجبلية في الإيوسين الأوسط. مع هذا الهبوط ومباشرة الى الجنوب الغربي من النطاق الأخير تكون مرتفع حيث أدى الى فصل موقع الهبوط عن الحوض الرئيسي لتكون الأحواض بين الجبلية. ان الموقع الحالي للمرتفع يتطابق مع الحدود بين نطاقي الطيات العالية والتراكب. ترسبت في البداية سحنات الفليش التابعة لمجموعتي والاش وناوبردان المتكونان من الحجر الرملي، الصخور النارية والطفل وبعد ذالك ترسبت سحنات المولاس المتمثلة بمدملكات الجزء العلوي لسلسلة الطبقات الحمراء. في نفس الوقت، ترسب سمك كبير من تتابعات الرسوبيات الكاربوناتية (تكوين بيلاسبي) في نطاق الطيات الواطئة حيث يعكس هذا انقطاع تام للرسوبيات الفتاتية عن هذا النطاق .

وعلى العكس من هذا، استمر تدفق الرسوبيات القارية الى الحوض البدائي (حوض مُقّدم القارة التابع لنطاق زاجروس) من صخور المصدر إثناء فترة الباليوسين المبكر الى الآيوسين الأوسط وامتزاجها، في بعض الأحيان، مع الرسوبيات الكاربوناتبة لتكوين سنجار في مناطق كثيرة. في هذه الفترة، لم تتكون الأحواض بين الجبلية لكي تحجز الرسوبيات المنقولة من صخور المصدر كما ذكر سابقا، باستثناء وجود بعض الارتفاعات (عدم الانتظام) داخل الحوض الترسيبي، حيث ترسب عليها تكوين سنجار. إن تجزئة الحوض الرئيسي (حوض مُقّدم القارة البدائي) الى حوضين ثانويين (الحوض الرئيسي لمقدم القارة والأحواض بين الجبلية) أدت الى تقليل حركة دوران التيارات وفعالية الأمواج ومن ثم أدى هذا الى ترسب الحجر الكلسي الدولوميتي التابع لتكوبن بيلاسبي .

## INTRODUCTION

The studied area is located in the Kurdistan Region, Northeast Iraq near the Iraqi – Iranian Borders (Fig.1). This area forms the three main (present days) tectonic zones of Iraq (High Folded, Imbricated and Thrust Zones) (Buday and Jassim, 1987) (Fig.2). The area is a part of the Western Zagros Fold – Thrust Belt, which is developed from colliding of Arabian and Iranian Plates and sedimentary fills of Neo-Tethys basin (Alavi, 2004). The aim of this study is to record the historical development and geological setting of intermontane basin in the Iraqi part of the Zagros Fold – Thrust Belt. The study is achieved through re-interpretation of the sedimentologic (sedimentary facies) and stratigraphic works of Bellen *et al*. (1959), Buday (1980) and Al-Barzinjy (2005) about the area during Tertiary.

Intermontane basins are commonly elongated, narrow and evolved during late Orogenies and are associated with volcanism (Einsele, 2000). Small superficial, extensional intermontane basin exists in the present Andes Mountain, it is due to warping during subduction (Mail, 1990, p.543). Clevis *et al*. (2004) mentioned basins on the thrust-sheets under the name of "top thrust-sheet basin", which are formed due to detachment faults. They assumed them as common features in foreland basin. Allen and Allen (1990) referred to generation of intermontane basins on the megasuture below thrust-sheets. These basins resemble the intermontane basin of Iraq, where the oldest intermontane basins are those mentioned by Buday and Jassim (1987, p.125) in which molasses are deposited during Paleogene and located in the Tanjero – Balambo Zone. However, published maps (Buday, 1980 and Jassim and Goff, 2006, p.158) (Fig.3) showed that these basins have started from Paleocene and continued till Middle Miocene and located in the present position of the Thrust and Imbricated Zones.

Al-Hashmi and Amer (1985) separated Red Bed Series from Khurmala Formation (time equivalent of Sinjar Formation) by positive land (Fig.4A, B and C). Surdashy (1989) also separated the Red Bed Series as intermontane basin from the basin of Kolosh Formation during Paleocene and Eocene (Fig.4D). In the Tectonic Scenario of Iraq, Numan (1997) separated the Red Bed Series from the main basin of Iraq during Paleocene. He indicated the Red Bed Series in a basin between Kata Rash and Walash volcanic arcs, which resemble more or less the intermontane basin, since it is separated by positive land (Fig.5A). Lawa (2004) mentioned that piggyback (intermontane basin) started in Early Paleocene, which was filled with molasse deposits (Fig.5B and C). According to the above studies, in Early Paleocene, the narrow strip of Halabja, Said Sadiq, Sulaimaniyah City, Ranyia and Rawandoz was the location of a paleohigh (positive land), which separated the area located to the northeast and southwest of these towns. The southwestern and northeastern areas are called (previously) Mio and Eu-geosynclines, respectively, while in the present study they are called Main and Sub-Foreland Basins. The Main Foreland Basin occupies (as assumed in this study) the Low Folded and High Folded Zones, while the Sub-Foreland Basin occupies the southern part of the Thrust Zone and whole Imbricated Zone. But, during Campanian till Middle Eocene one large basin existed, which is called Early (proto) Zagros Foreland Basin (Figs.6C and 7C).

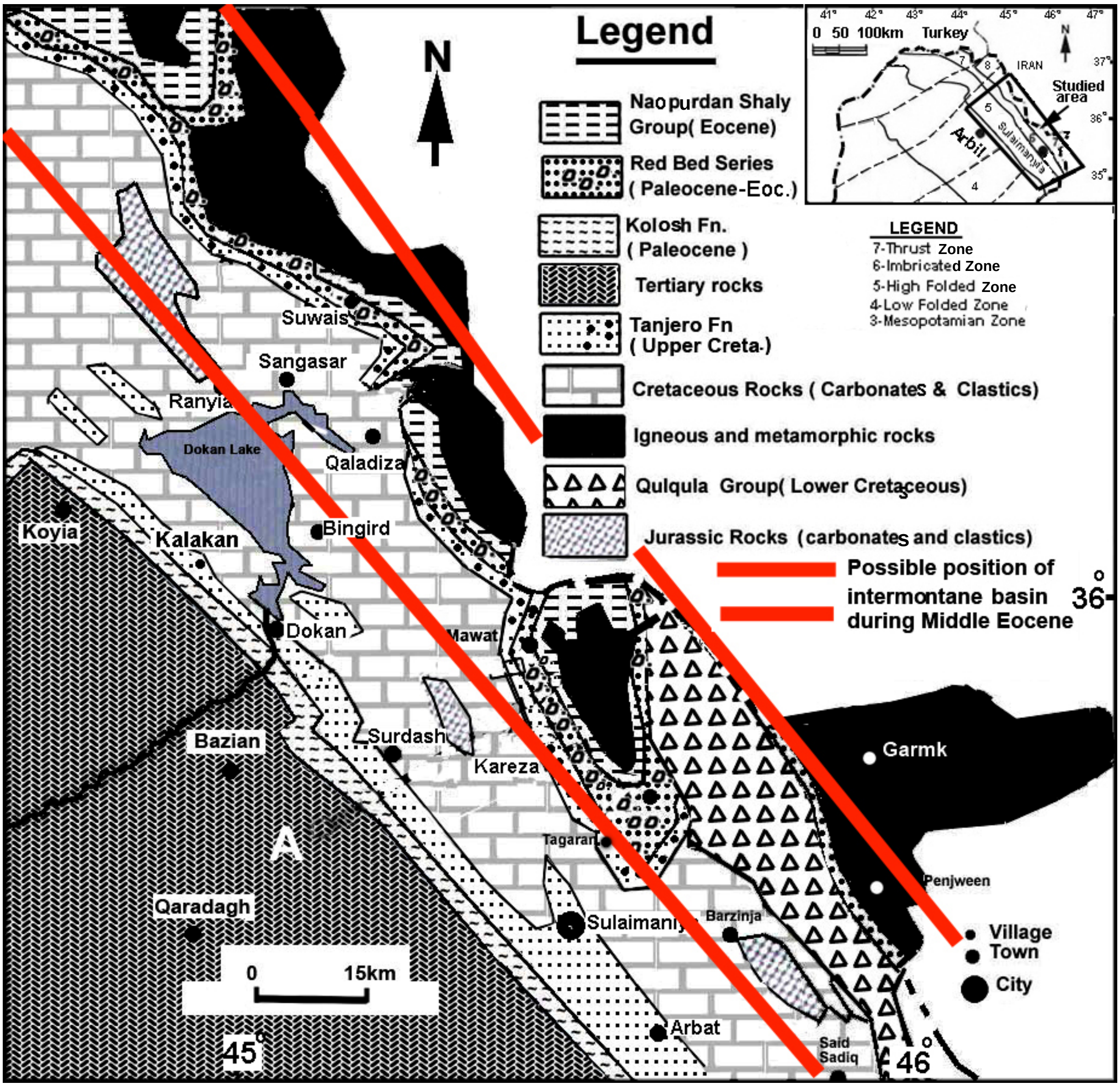


Fig.1: Simplified geological map of the studied area (modified from Sissakian, 2000) showing location of intermontane basin during Middle Eocene

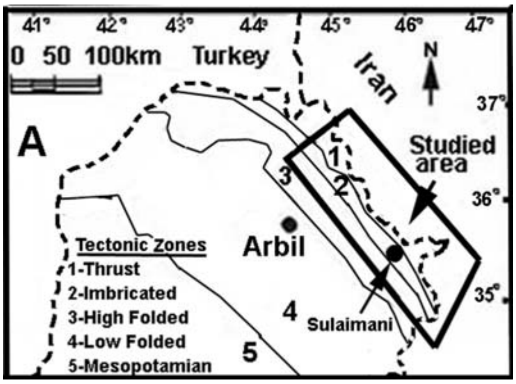


Fig. 2: Location map of the studied area

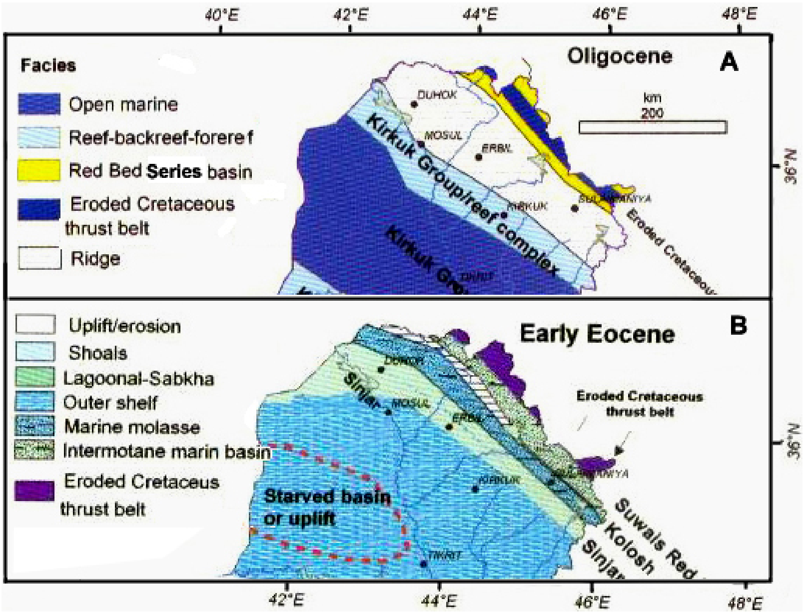


Fig.3A and B: Early Eocene and Oligocene paleogeographic map of Iraq, showing intermontane basin in the northeastern Iraq (after Jassim and Goff, 2006)

## GEOLOGICAL SETTING

The recent sedimentological and stratigraphical studies amended the geology of the studied area through simplifications of the tectonics. Therefore, the geographic position and history of the development of the intermontane basins can be realized, in addition to the type of the separation from main water body. Among the studies that are indirectly related to this idea are the study of Karim and Surdashy (2005a and b), which changed the tectonic setting of Tanjero Formation from subduction trench to early Zagros Foreland Basin, during Maastrichtian. They combined both Mio and Eogeosynclines in one single basin. Another study is that of Al-Barzinjy (2005), which concerned mainly with the relation between Red Bed Series and Kolosh Formation. He concluded that both of them (Red Bed Series and Kolosh Formation) are deposited in a single basin and there was no any paleohigh between the two units during Paleocene and Early Eocene. According to the Al-Barzinjy (2005), the Red Bed Series was deposited in the present position of the Imbricated Zone as coastal facies, while at the same time; Kolosh Formation was deposited in the basin plain, in the location of the present day High Folded Zone.

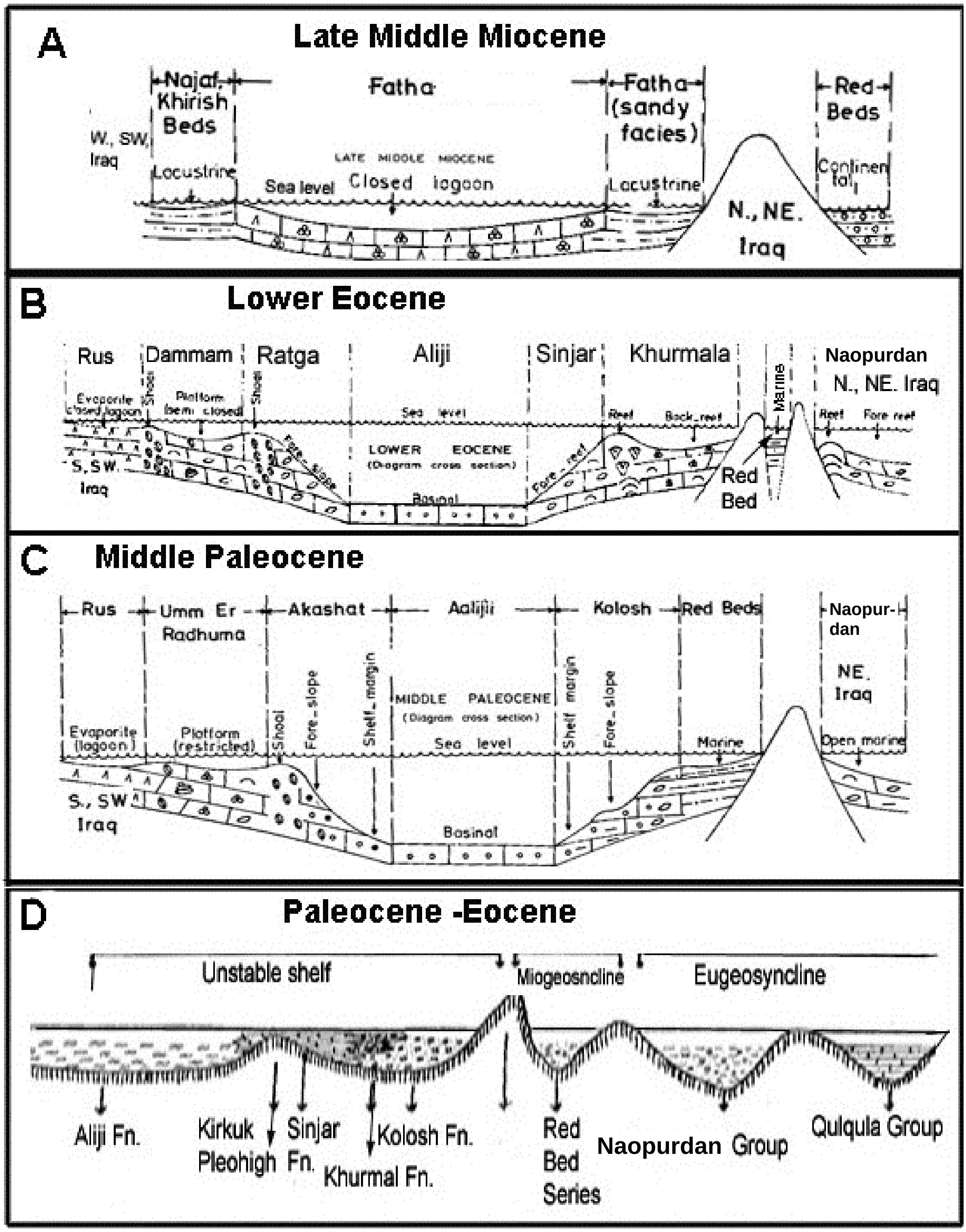


Fig.4: Different ideas about timing, tectonic setting and geographic location of the intermontane basin by different authors
A, B and C: by Al-Hashmi and Amer (1985) and D: by Surdashy (1989)

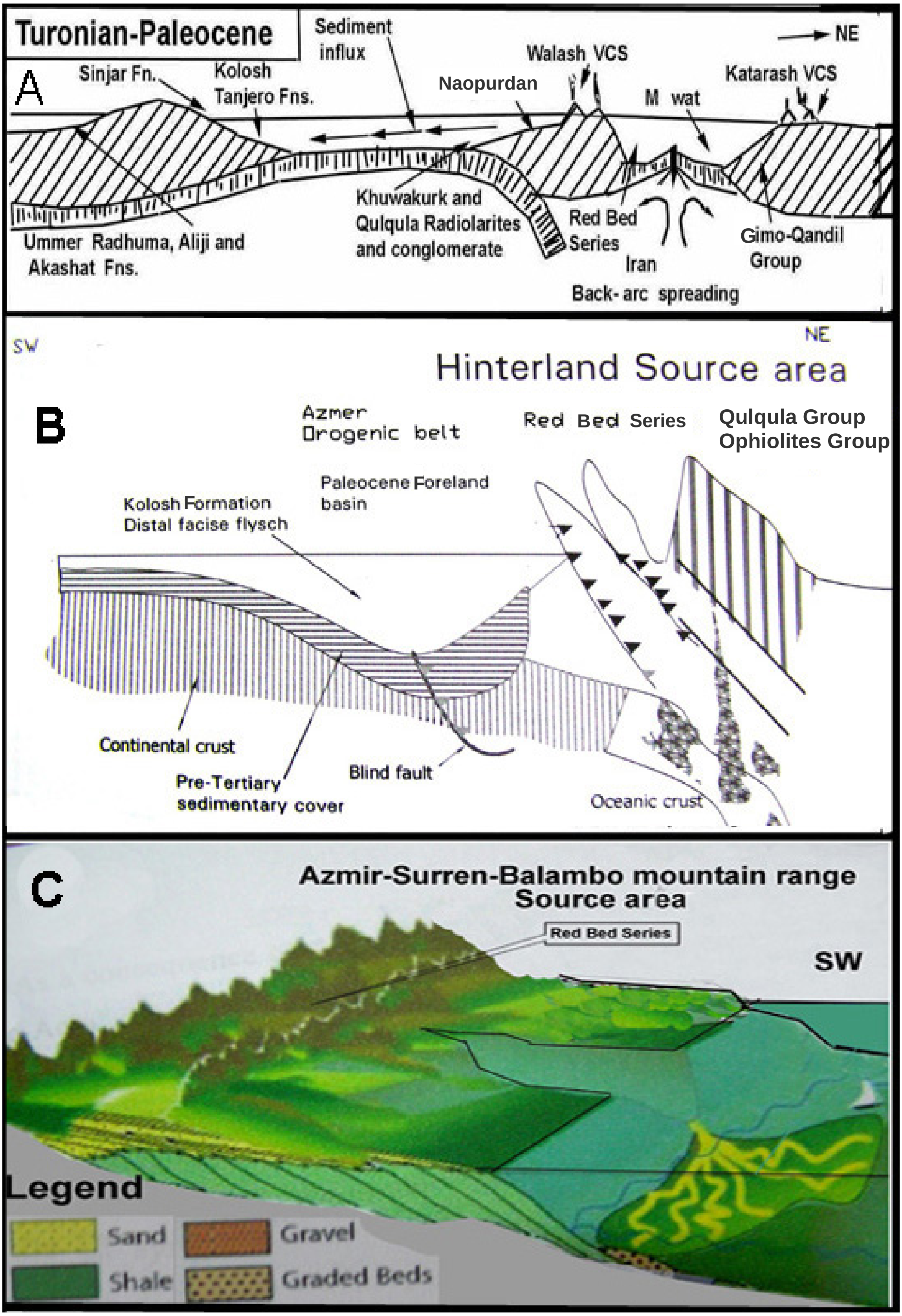


Fig.5: (A) Tectonic position of Red Bed Series between Kata Rash and Walash Volcanics, by Numam (1997), (B and C) Model and cross section of Early and Middle Paleocene paleogeography and tectonic setting of piggy back (intermontane) basin (Lawa, 2004)

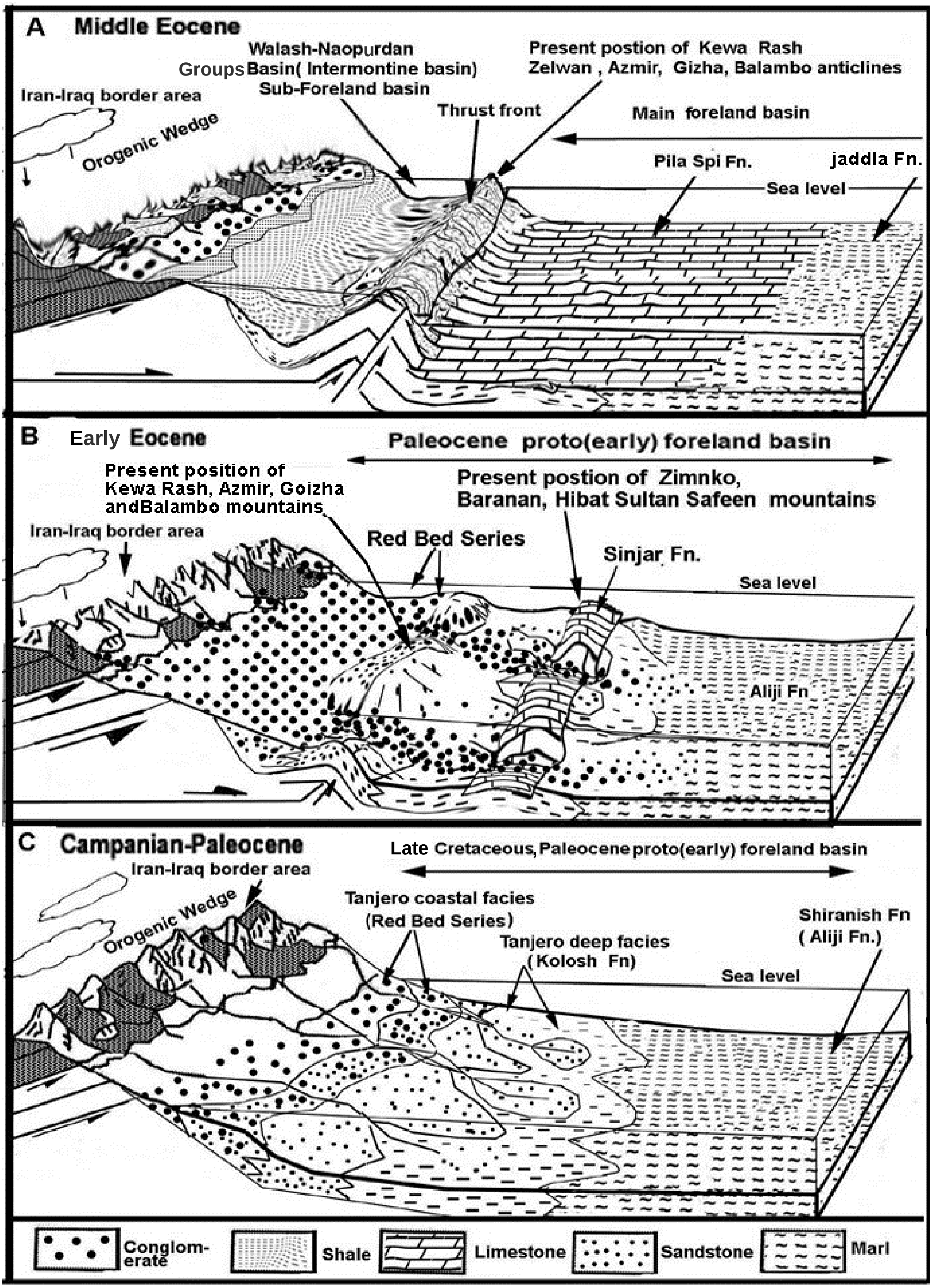


Fig.6: The conclusions of present study as shown by conceptual models of paleogeography and tectonic evolution of the intermontane basins in Iraq
A: Middle Eocene, B: Early Eocene and C: Late Cretaceous – Paleocene

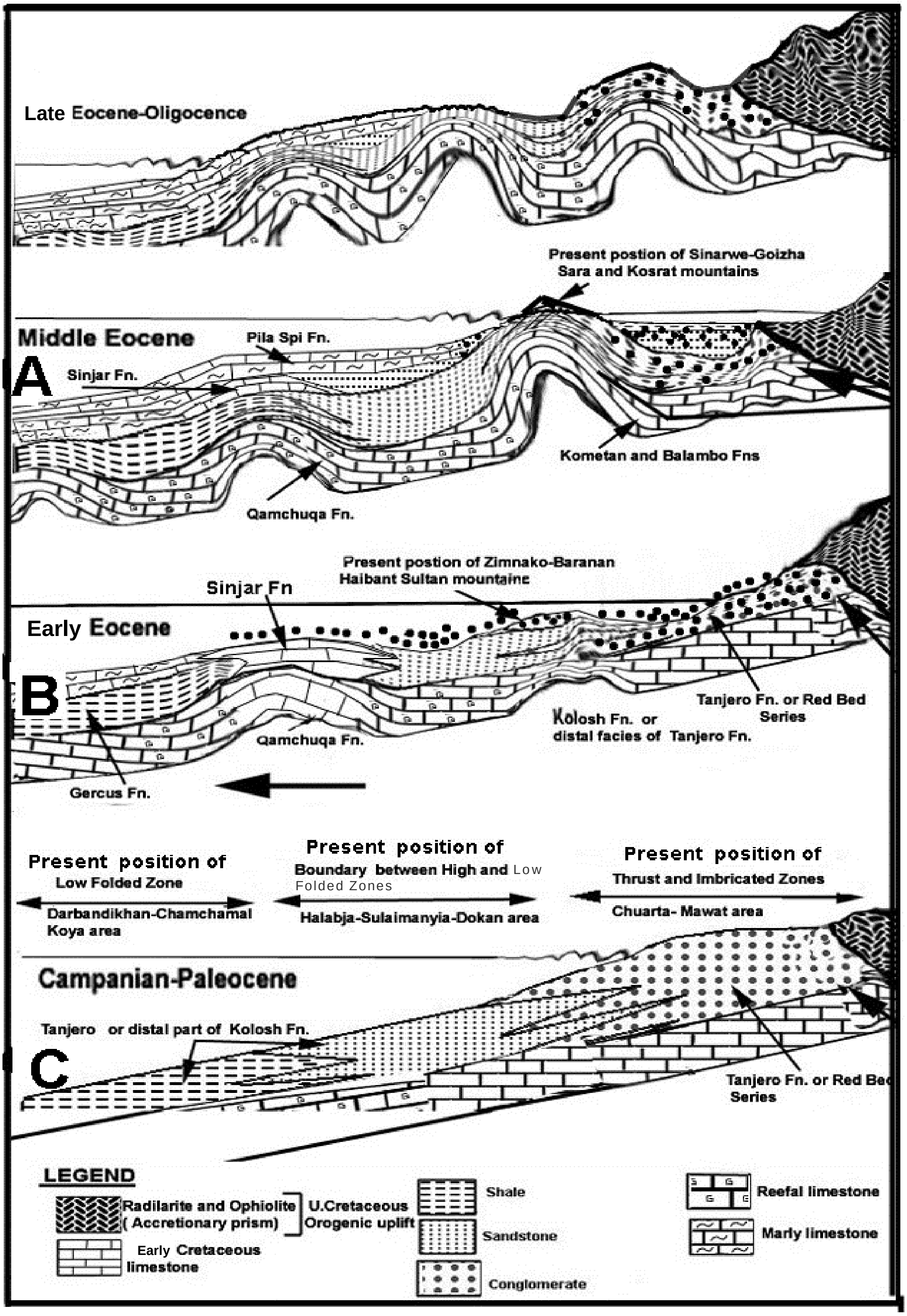


Fig.7: Cross sections of the same ages and models shown in Fig. (6), showing generation of intermontane basin during Middle Eocene, as inferred from present work

## FIRST APPEARANCE OF INTERMONTANE BASINS

The first appearance of the intermontane basins could be known only through a sedimentological study of the studied area. This includes the study of types, calibers and distribution of the terrigenous sediments in both Imbricated and High Folded Zones. During the study of these sediments, the hydrodynamic and lithology (mineralogy) are taken into consideration. The first and the prominent terrigenous sediments cutoff occurred during Middle Eocene. This cutoff is demonstrated by extensive deposition of nearly pure lagoonal carbonates of Pila Spi Formation. This deposition was relatively sudden and covered most part of the northern Iraq, especially the High Folded and Low Folded Zones (Main Foreland Basin). These carbonates lack clastic interbeds, which indicate the separation of the Sub-Foreland (Intermontane) Basin from the Main Foreland Basin by a narrow paleohigh (Figs.6A and 7A). The present position of the paleohigh coincides nearly with the position of the boundary of High Folded and Imbricated Zones. The cutoff of the clastic sediments and deposition of carbonates is well documented by Dunnington (1958) by isopach facies map (Fig.8). He assumed the Imbricated and Thrust Zones as source area and showed that the carbonate deposition is located to the south of the boundary between the High Folded and Imbricated Zones.

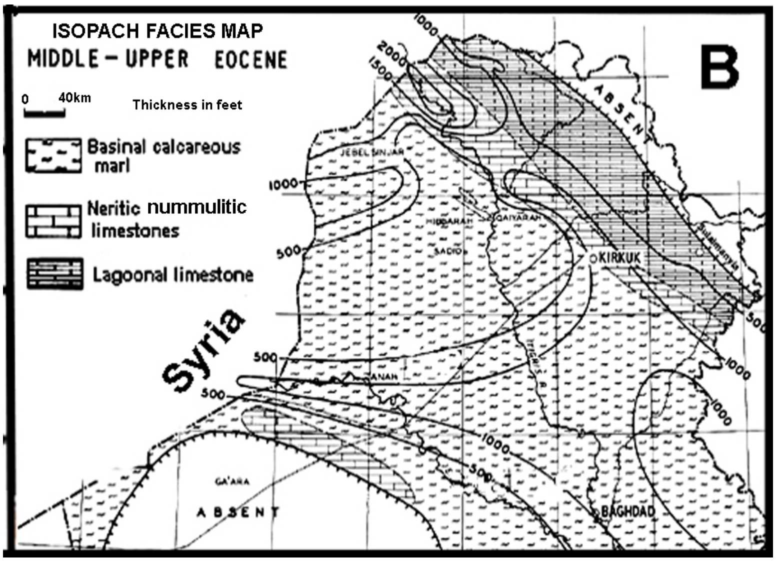


Fig.8: Isopach facies map of Middle – Late Eocene showing extensive carbonate deposition (after Dunnington, 1958)

## INTERPRETATION OF CLASTIC SEDIMENTS CUTOFF

The clastic cutoff and deposition of carbonates are clear evidences for separation of the source area (present days Iraqi Thrust Zone and Sanandij – Serjan Zone of Iran) from the main water body that was covering the rest of Iraqi territory. The deposition of carbonates (Pila Spi Formation) started during Middle Eocene (Bellen *et al.*, 1958 and Buday, 1980) therefore, in that time a paleohigh was developed and led to total cutoff of the clastics and an intermontane basin was formed to the north of the paleohigh. Concurrently, the area that is now covered by Imbricated and Thrust Zones was subsided (Figs.6A and 7A). But, the paleohigh was so narrow to supply sufficient clastics to the main foreland basin to be detected. Instead of transportation of sediments to the south and southwest, the clastics were trapped during post Middle Eocene intermontane basins (areas of subsidence) and deposited as Walash and Naopurdan Groups.

The generation of these basins is associated with the retreat of the source area, northeastwards to a position, which may coincide with the present position of Sanandij – Sirjan Zone, inside Iran. The paleohigh was so small and tight to perform as a new source area. Other consequence for the separation of the Early Zagros Foreland Basin into main foreland basin and intermontane basin was the restriction of current circulation and wave activities in addition to cease of fresh water influx. Therefore, semi-restricted lagoonal sediments (dolomite and limestone) are deposited, which were isolated from sediments and fresh water influx supplied from northeastern source areas. The most important characteristic of the generated intermontane basin is the fineness of the clastic sediments as compared to those deposited in the coastal area of the early (proto) foreland basin before separation. Karim and Surdashy (2005a and b) and Al-Barzinjy (2005) concluded that during Late Cretaceous and till Middle Miocene the area of the sub-foreland basin (previous Eugeosyncline) was deposition locus of thick pile of conglomerates and sandstone (Tanjero Formation and Units One and Two of the Red Bed Series). This position was coastal area for the early foreland basin during Late Cretaceous and till Middle Eocene.

In contrary to the main foreland basin, in the intermontane (sub-foreland) basin, the conglomerates are missing and fine clastics are deposited. These fine clastics coincide with the principle of sedimentation and with the deposition of carbonates (Pila Spi Formation) in the main water body. The fineness of the clastics is attributed to three reasons; the first is retreating of the source area into Iranian land, due to subsidence of the previous coastal area. The second is generation of a barrier (the paleohigh) in front of the paleocurrent direction, which led to decrease of the dynamic energy of transportation and sedimentation. The third is the intermontane basin is formed in the frontal part of the foreland fold – thrust belt, which decreased the accommodated space for submarine turbidity currents. The fine clastics are represented by Walash and Naopurdan Groups (flysch facies), which consist mainly of shale, sandstone, limestone and igneous rocks (Figs.6A and 7A) that deposited at early stage and later on changed to molasse facies (upper part of the Red Bed Series) when the basin was filled with sediments. During the deposition of flysch facies, it is possible that the biogenic carbonates (Naopurdan Limestone) were deposited in shallow areas, where there are no turbidites.

## POSSIBLE PALEOCENE INTERMONTANE BASIN

During Late Paleocene, Sinjar and Khurmala formations were deposited at the boundary between the High Folded and Low Folded Zones, inside the main foreland basin (inside previously called miogeosyncline). These formations consist of reefal facies. They have limited distribution as compared to Pila Spi Formation, which occurs as northwest – southeast strip about 15 Km wide along the above mentioned boundary. The Sinjar Formation is supposed to be deposited in submerged high as reefal facies (Al-Hasmi and Amer, 1985 and Surdashy, 1989) (Fig.4B and D). About this paleohigh and possibility of Paleocene intermontane basin occurrence, this study clarifies two factors. The first is, Sinjar Formation was deposited at the top of Kolosh Formation, which consists of flysch facies (basinal sandstone and calcareous shale). The top of this unit represents the shallowing episode due to filling and tectonic uplift, during which Sinjar Formation was deposited. While in sub-foreland (Intermontane) basin the clastics (sandstone) of the Red Bed Series (Units one and two) were deposited, in Chuarta, Mawat, and Qandil areas (Al-Barzinjy, 2005).

The second factor is, unlike to Pila Spi Formation, Sinjar and Khurmala formations, in most areas, contain coarse clastic interbeds. In Sartak Bamo valley, Baranan Mountain (Fig.9A and B), Barda Asin (east of Zarain town) and Sagrma anticlines and Darbandikhan dam site (Fig.10), Sinjar Formation contains terrigenous conglomerates. According to Al-Banna *et al.*

(2007), in Dohuk area the Khurmala Formation, which is the equivalent of Sinjar Formation contains conglomerates, sandstones, shales and marls (Fig.11). The present authors recognized that the limestones beds are sandy also. This means that the Sinjar and Khurmala formations were not separated by positive paleohigh from the source area and the intermontane basin was not formed yet. The Sinjar Formation was possibly separated partially and intermittently, in some places, by irregularities (submerged high) that prevented high influx of clastics and turbidity currents to the basin of Sinjar Formation (main foreland basin). In these areas, Sinjar Formation is composed of pure limestone and without conglomerate interbeds. In areas, such as Glazarda and Bazian, there are more or less occurrences of pure reefal limestone of the formation (Fig.6B). The map and tectonic setting of the Middle Eocene is shown in the Fig. (12), which indicates the position of the paleohigh and location of the deposition of Pila Spi Formation and Walash and Naopurdan Groups.

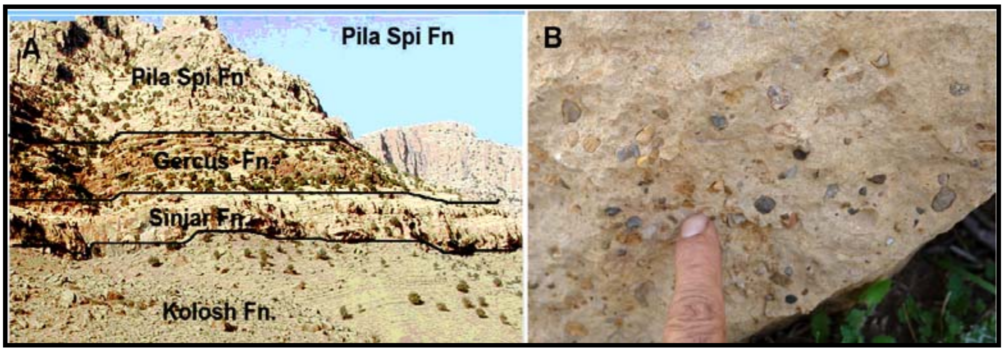


Fig.9: A) Sections of the western side of Sartaq Bamo valley (east of Darbandikhan dam) showing main exposed units, the pure carbonate of Pila Spi Formation can be seen at the top of the section, it is 450 m thick. In many places Sinjar Formation contains conglomerate and terrigenous clasts
B) Pebbly limestone of Sinjar Formation at Baranan (Glazarda Homocline) mountain south of Sulaimaniyah city

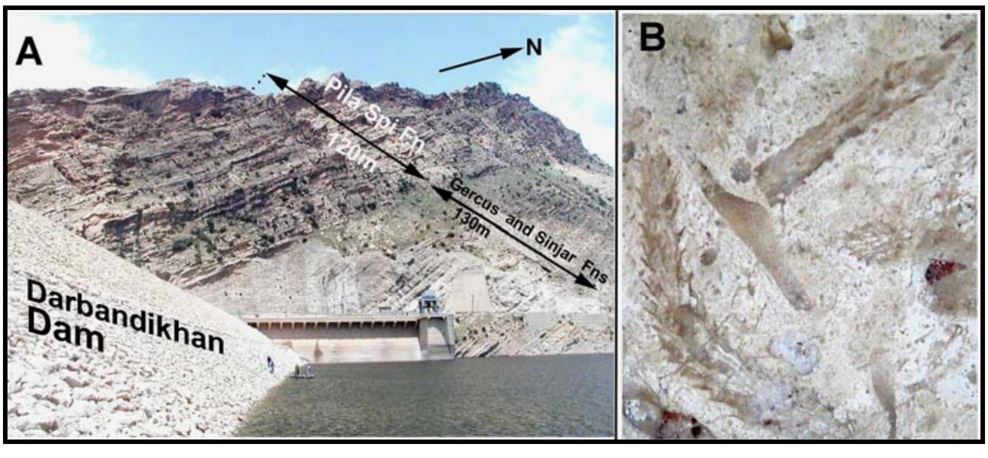


Fig.10: A) Outcrop section of Pila Spi, Gercus and Sinjar formations in the main foreland basin (previous Miogeosyncline). Sinjar Formation contains interbed of conglomerate and sandstone, while Pila Spi Formation is exclusively limestone
B) Polished slab (4 cm wide) of Pila Spi Formation, contains algae

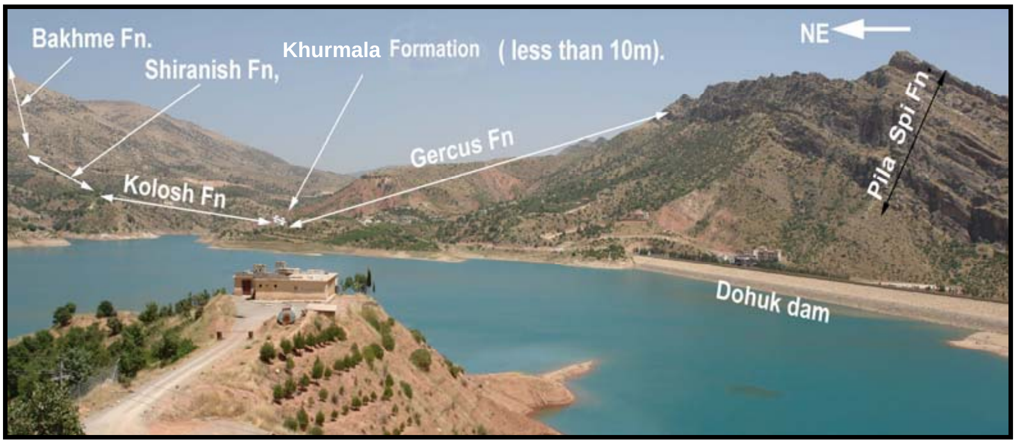


Fig.11: Eastern part of Dohuk dam showing thick outcrop of Pila Spi Formation and clastics of pre Middle Eocene. The Khurmala Formation is less than 10 m thick. The clastic influx cutoff is very clear with deposition onset of Pila Spi Formation

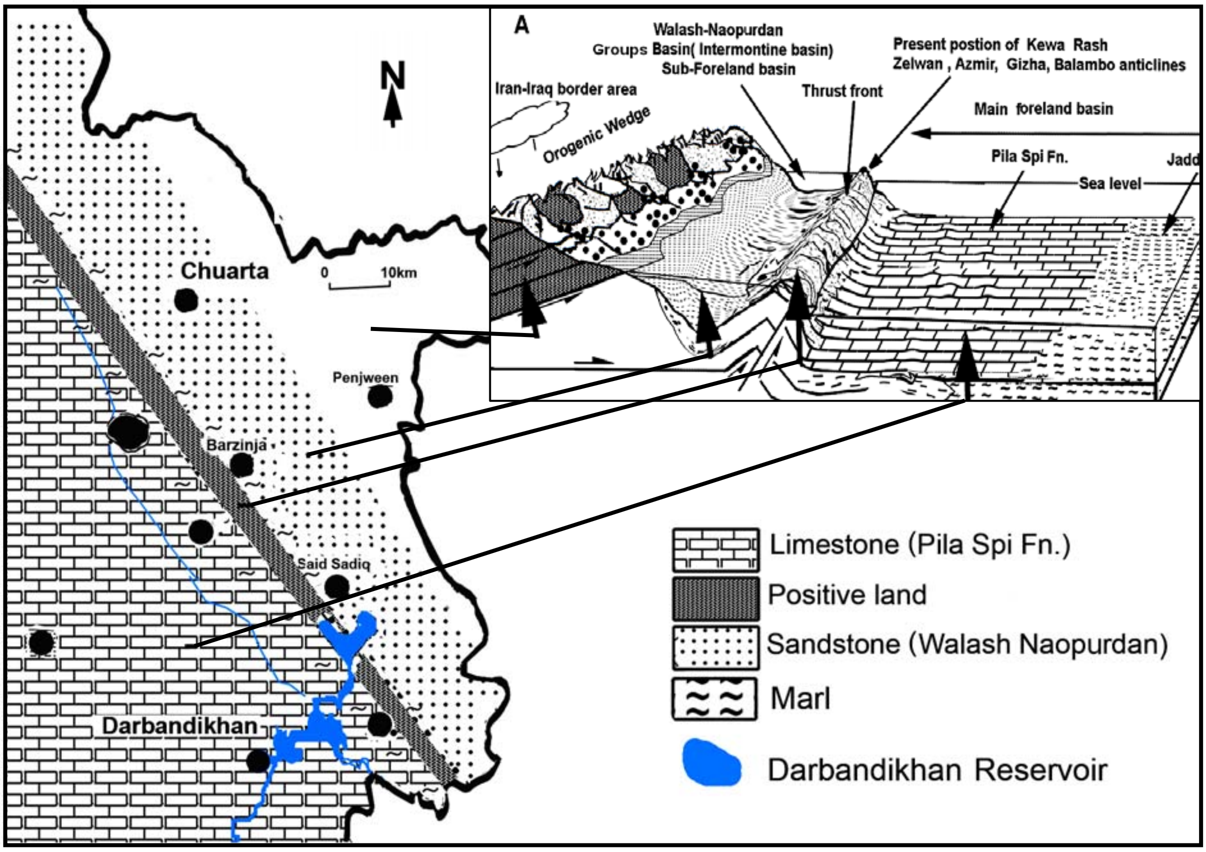


Fig.12: Lithofacies map during Middle Eocene and geologic block diagram of the same age showing intermontane basin as inferred from the present study

## CONCLUSIONS

- The previously known starting point (Early Paleocene) for evolving of the intermontane basins is changed to Middle Eocene.
- The reason for this new dating is the total terrigenous clastic's cutoff influx from source areas to the previous clastic dominated basin.
- The Pila Spi Formation and Walash and Naopurdan Groups are connected with this development as sediments of the main basin and intermontane basin, respectively.
- The study solved the problem of large uncertainty that is associated with history and tectonic of Walash and Naopurdan Groups.

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