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CONCURRENT AND LATERAL DEPOSITION OF FLYSCH AND MOLASSE IN THE FORELAND BASIN OF UPPER CRETACEOUS AND PALEOCENE FROM NE-IRAQ, KURDISTAN REGION

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ABSTRACT

Flysch and molasse facies are recognized in previous studies as syn- and post-orogenic sediments respectively. According to these studies they deposited diachronously and recognized on the basis of difference in lithology. The latter facies consist of mainly sandstone and conglomerate which deposited in nonmarine or shallow marine environment during post-tectonic phase of orogeny. While the former one comprising deep marine sediments of turbidite and other gravity flow origin.

In the present study it is inferred that both flysch and molasse can be deposited concurrently in the same basin as lateral facies change. The deposition of both facies can occur not only by tectonic processes but by global eustatic sea level change. The study is applied on the Kolosh Formation (Paleocene) and its time equivalent Red Bed Series (Paleocene-Eocene) in addition to Tanjero (Upper Cretaceous) in the NE-Iraq, Kurdistan region as an example. The study suggests that the usage of words "flysch" and "molasse" better not to be used. Instead the either coastal and basinal facies or distal and proximal facies can be used.

Introduction

Flysch and molasse facies are well known orogenic sediments and recognized on the basis of difference of lithology, depositional environment and time relation tectonics uplift. The latter facies consist mainly of sandstone and conglomerate with predominance of red color which deposited in nonmarine or shallow marine environment during post tectonic phase of orogeny. While the former one is comprised deep marine sediments (mainly turbidites and other gravity flow sediments) which deposited during syntectonic phase of orogeny (Pettijohn, 1975, Potter and Pettijohn, 1980 and Bate and Jackson, 1980, Mial, 1990, p150), Pettijohn and potter, 1987 and Einsele, 2000, p.607. According to these authors these two facies are neither connected in space nor in time.

The above ideas and characteristics are applied also for the flysch and molasse facies of Iraq by Buday (1980), Buday and Jassim (1987). In this country, the Upper Cretaceous Tanjero and Paleocene Kolosh Formations are the main flysch facies which supposed previously to be deposited in Mio and Eugeosyncline (syntectonic phase) respectively (Fig.1 and 2). In other side, the Eocene Gercus Formation and Red Bed

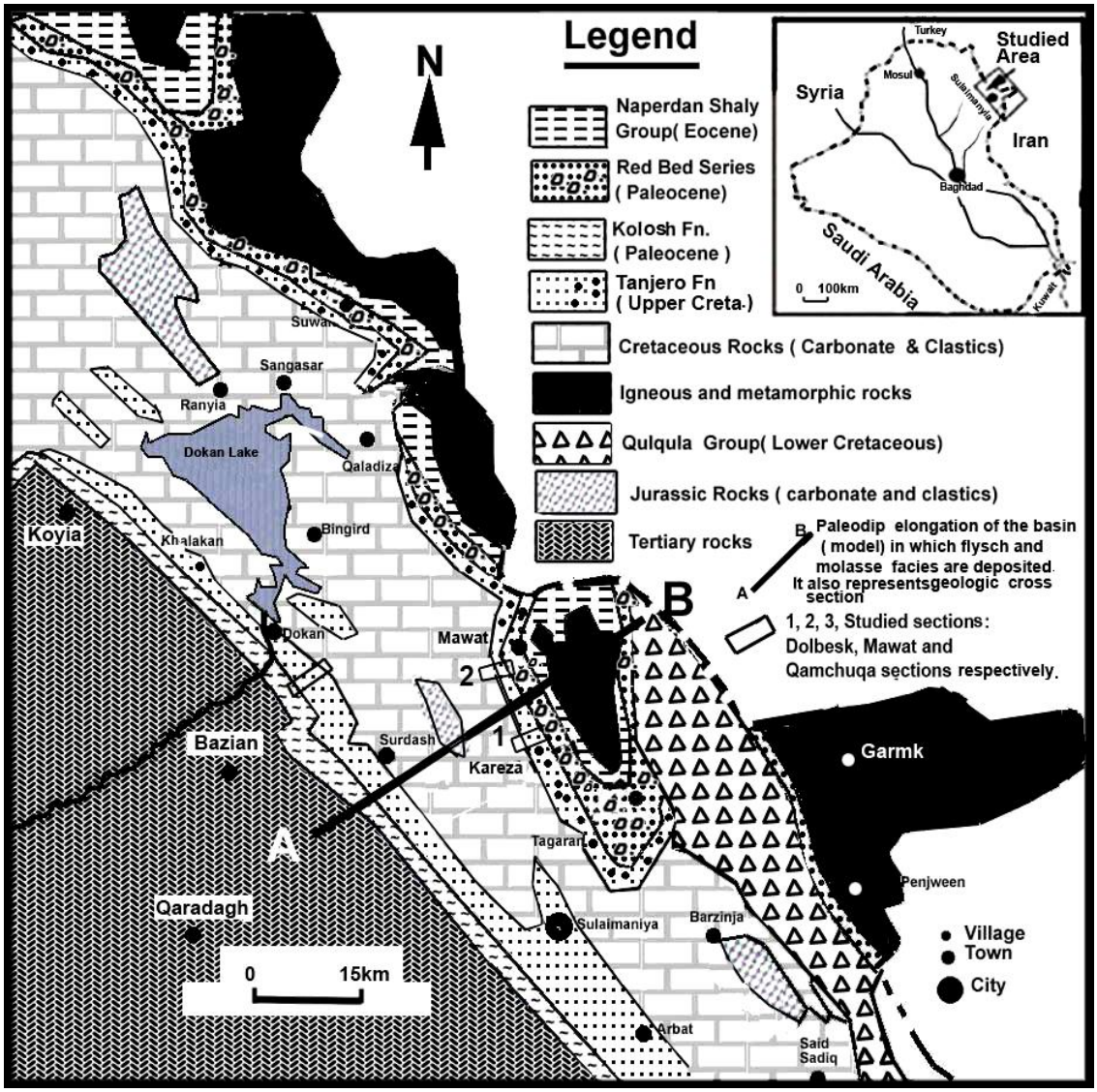

Figure1: Location and geological map of the studied area (Modified from Sissakian, 2000). The black line AB is the direction and position of geologic cross section on page (3).

Series are typical molasse facies (Buday, 1980). Previously, In Iraq, the deposition of Red Bed Series, as a molasse facies and Kolosh Formation, as flysch facies are indicated as time equivalent (both deposited in the Paleocene period) but the basins of both are separated by paleohigh (Buday, 1980; Buday and Jassim, 1986 and Lawa, 2004). This latter author showed by sketch that the Red Bed Series is deposited during Paleocene and Eocene in intermountain basin above the sea level and separated by mountain ranges from the basin in which Kolosh formation is deposited.

Discussion

The present study tries to offer new ideas about the temporal and spatial relations between flysch and molasse facies in one side and their relation to orogeny in other

side. These are achieved by sedimentologic and field study of available outcrops in Western Zagros Fold-Thrust Zones inside Iraq (Fig.1 and 2) . The work includes detail correlation of the different parts of the area in addition to reinterpretation of previous studies. The offered ideas are opposite to the previous ones which are applied either to the flysch and molasse of Iraq or to their world wide occurrence. The aim of the present study is to prove that both flysch and molasse facies can deposit concurrently as lateral facies change in the same basin in same phase of tectonic. The most important studies which re-interpreted are that of Al-Qayim (2000), Karim (2004 and 2005) and Al-Barzinjy (2005).

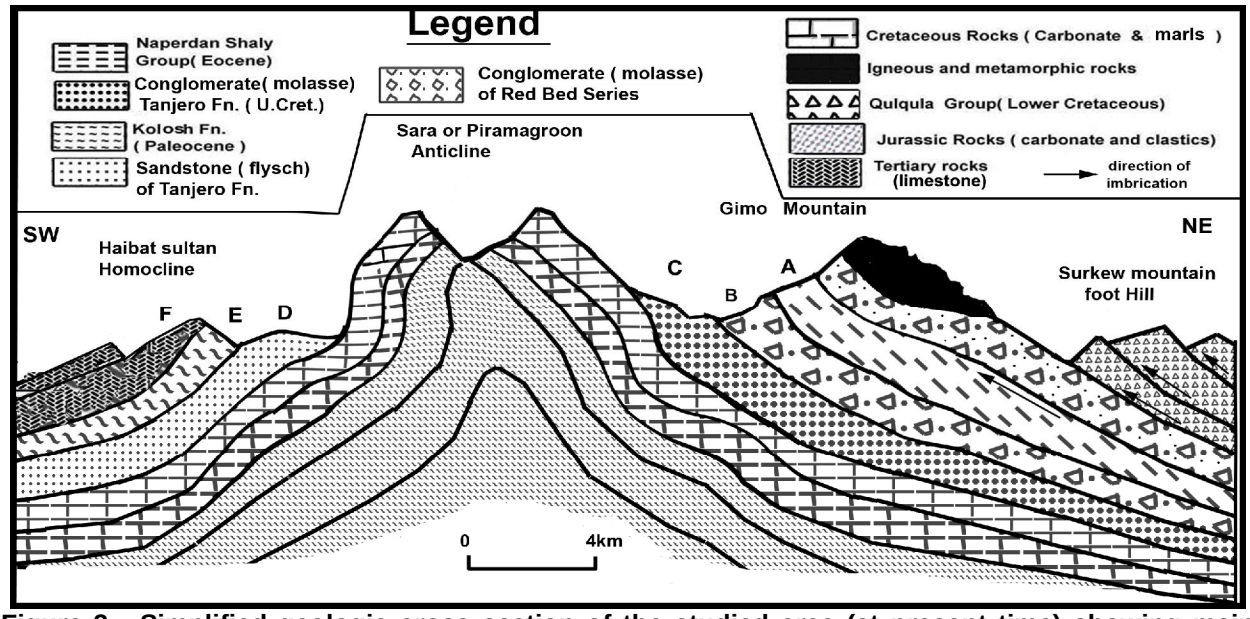

Figure 2: Simplified geologic cross section of the studied area (at present time) showing main structures, stratigraphic units and gradation of molasse to flysch facies from north east to southwest. The units A, B and C are time equivalent of D, C and F respectively.

The first author (Al-Qayim, 2000) studied sedimentation and tectonic environment of the Red Bed Series (Suwais Red Beds) in margin of the Arabian plate, NE-Iraq. He concluded that the unit indicates flysch type sequence of variable facies (alternation of thin beds of different red clastics). Karim, 2004 and 2006) recorded, for the first time, a succession (50m thick) of red clastics in the Upper Cretaceous Tanjero Formation. In this study, this succession is called “Upper Cretaceous red clastics” which is composed of red claystone, sandstone, lensoidal conglomerate and (typical lithology of molasse facies). This author has correlated these red clastic with rhythmic alternation of dark color marls with sandstones (typical flysch as interpreted previously) which contain lensoidal channel sandstone (fig.3). Al-Barzinjy (2005. p) proved that the Early Tertiary Red Bed Series (molasse facies) and Kolosh Formation (Flysch facies) are deposited together in the same foreland basin as lateral facies change.

Another support for the present study for concurrent and lateral deposition of flysch and molasse together is the idea of the sequence stratigraphy. In the models (for

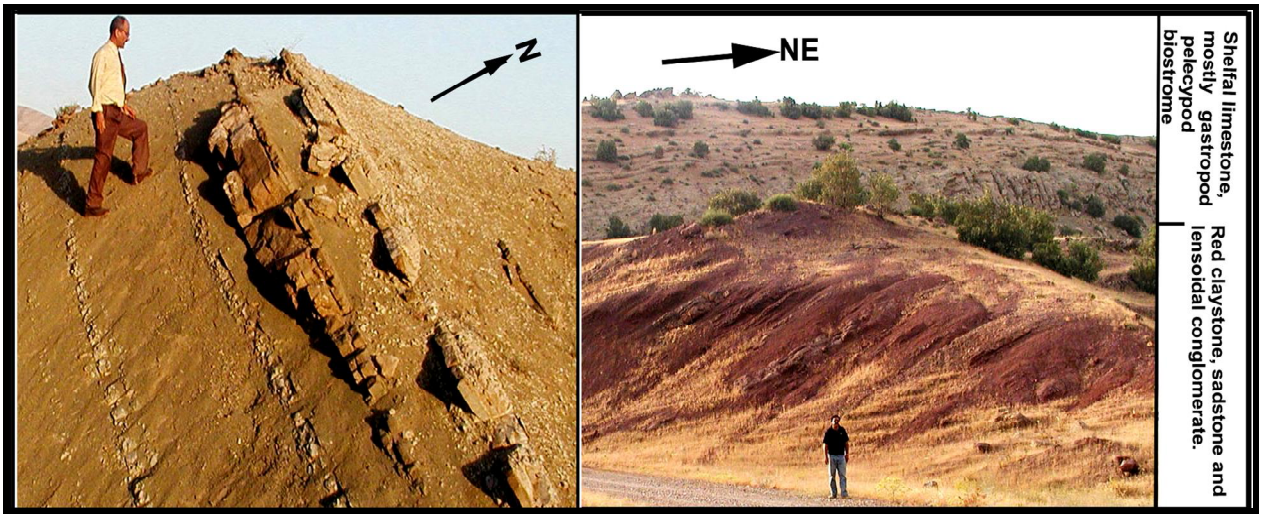

Figure3: Right Photo: The Upper Cretaceous red clastics (molasse facies) which are consist of succession of red claystone and sandstone (50m thick). It is (located at the middle part of Tanjero Formation and overlain by reefal limestone and underlain by 500m thick conglomerate. The succession is change, down paleoslope, to shale and sandstone (flysch facies. The lithology of the section is shown at the left. This section is located at 5km southeast of Chuarta town. Left photo: Upper Cretaceous submarine channel filled sandstone with lensoidal shape. It is found in the calcareous shale in Chachaq valley west of Sulaimanyia city at the distal area.

depositional system and system tracts) that are drawn by Vail et al (1977a), Gallaway,1989; Allen and Allen,1990; Haq,1991;Emery and Myers,1996; Vincent, et al. ,1998;both molasse and flysch are shown, indirectly contain coastal or fluvial (molasse facies) and deep marine clastics deposition (i.e. Flysch facies). According to these models (for passive and active continental margins) it is possible that the alluvial fan (molasse) may be activated and progrades in to the coastal area of deep basin forming low stand fan delta (Molasse facies). From coastal area, the fan sediments area reworked into deeper part of the basin forming the flysch facies. This case is seen by Higgs (1990) and Karim and Surdashy, 2006. These two authors found 500m of conglomerate (deposited during LST) which toped by 50m of fine red clastics (deposited during HST) at the proximal area of Tanjero Formation. Both the conglomerate and red clastics have prerequisite of molasse facies since they have red color and show no sign of turbidite and ended by rudist bearing limestone (Fig.8).

At the distal area (slope and basin plain), the conglomerate is laterally changed to thick alternation of 400m of thick alternation of thin bedded sandstone and shale. These laterally deposited lithologies are indicated as LST wedge by Karim and Surdashy (2006). These lithologies are showing typical signs of turbidite and regarded as flysch facies by Buday, 1980; Al-Rawi, 1982; Jassim and Goff, 1996. The upper Cretaceous red clastics (50 sandstone and red claystone of HST) are changing to alternation of shale and marl with occasional lensoidal sandstone indicating submarine channel

(Fig.3). These facts aid the result of this study that molasses and flysch facies are not necessary to be related to tectonics or deposited in different basin setting.

But they may be deposited as direct relation to global eustatic sea level change which controlled by astronomical force not tectonics.

Recently, Zelilidis et al. (2002) studied similar occurrence of gradation environment from alluvial fan in to deep marine turbidite. In his study of Mesohellenic Basin evolution of Greece (Miocene-Oligocene), he showed that the basin (like that of Iraqi Paleocene) is divided into several formations. The proximal area (near shore), shelf and basin consisted of conglomerate (Fan delta conglomerate), sandstone and deep sandstone and shale respectively. Therefore, this arrangement of the sediment and environment as studied from Greece by Zelilidis (op. cit) is indirectly assist the conclusions of the present study included in the (Fig.2 and 6) which is combining the previously called molasse and flysch during Upper Cretaceous and Early Tertiary.

This discovery changes the old view of molasse, as post tectonic, and flysch, as syntectonic facies to an idea of occurrence of both facies together in the same basin and during the same tectonic phase. This discovery can be applied in the science of geology universally for all foreland basins. This is because each foreland basins have a deep basin plain and slope where flysch facies occurred. They have also shelf (or delta) and coastal area where molasse facies occurs. Therefore, no foreland basin can exist without molasses and flysch sediments but their geologic record both together depend on their amount and chance for exposing without removing by erosion.

Field examples

For further proof of the occurrence of flysch and molasse together, four outcrops sections are selected for correlation at the proximal and distal area in the Iraqi Zagros Foreland Basin during upper Cretaceous and Paleocene.

Molasse facies of Dolbeshk section

This section located in the Mawat area about 30km north of Sulaimanyia city on the right bank of Qala Chulan stream, 500m east of Dolbeshk village (Fig.1 and 4). At this location the section consist of 175m of pebble and boulder orthoconglomerate with brown color. The conglomerate is clast-supported and contains pebbles and boulders of chert and limestone which both derived from Qulqula Radiolarian Formation. Above the conglomerate occur 115m of thick succession of fossiliferous limestone. The succession consists of alternation of massive beds of rudists, gastropods and large forams bearing limestone or beds of reworked bioclastic of the mentioned skeletons. The grain size decreases toward south. The maximum grain size is observed in the Dolbesk section where

the boulder conglomerate and rudist can be seen in (Fig. 4, 6 and7A). At 25km south of this section these coarse lithologies change to medium

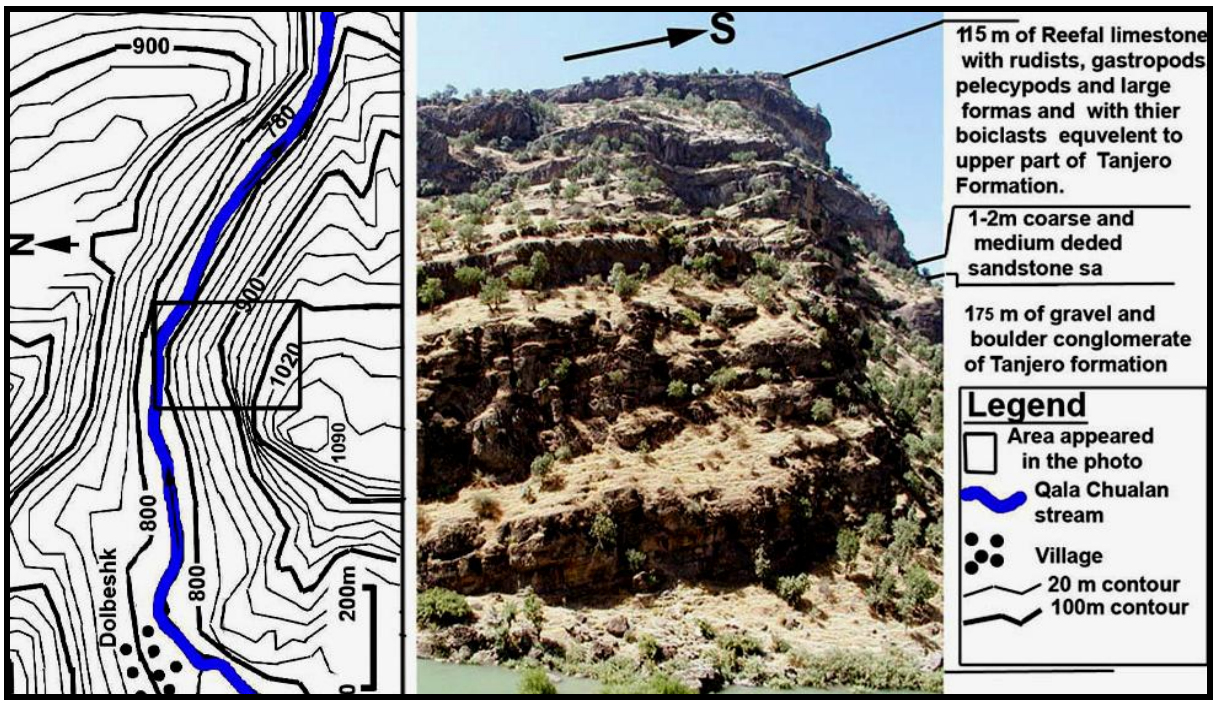

Figure 4: Dolbeshk section with location map, the lower 115 m of conglomerate is assigned as molasse facies.

sandstone (Fig.6). In our interpretation, the conglomerate is a molasse facies especially it either overlain by reefal limestone or red claystone as can be seen near Qashan Bridge. The red claystone is belongs to well known Early Tertiary Red Bed Series which indicated as molasse facies by Al-Mehaidi (1975), Al-Qayim (2000). This red claystone is correlated, by Barzinjy (2005), with Kolosh Formation which constituent one of the typical flysch facies of Iraq. This latter formation is mainly crops out at the area of south of Sulaimanyia and Dokan area (Fig.1).

Molasse facies of Mawat section

This section is located about 7 km to the west of the previous one at the southwest of Mawat town. At this location the conglomerate of Tanjero Formation has more thickness (more than 200m) and the limestone is absent (Fig.5). The conglomerate is overlain directly by Early Tertiary red clastics of Red Bed Series. The succession is more than 2000m thick and considered as typical molasse in Iraq. In contrast to Dolbesk section, the reefal limestones are absent between the two units. This may be attributed to termination of limestone against the coastal area where the source area is closer than the other sections.

Both Tanjero conglomerate and the red claystone can be considered as typical molasse facies which are correlated with flysch facies according to age and lateral facies change. The flysch is now exposed at distance of 25 km to the southeast in area

located between, Dokan and Darbandikhan Dams. This area was consisted of distal area of the foreland basin during Upper Cretaceous and Paleocene. The flysch facies is coincides exactly

with deeper part of the basin in which the Tanjero and Kolosh Formations are deposited (Fig.9). In all previous studies, the area of occurrence of these two sections are supposed to be separated by positive paleohigh, therefore no correlation was done with other sections that located to other

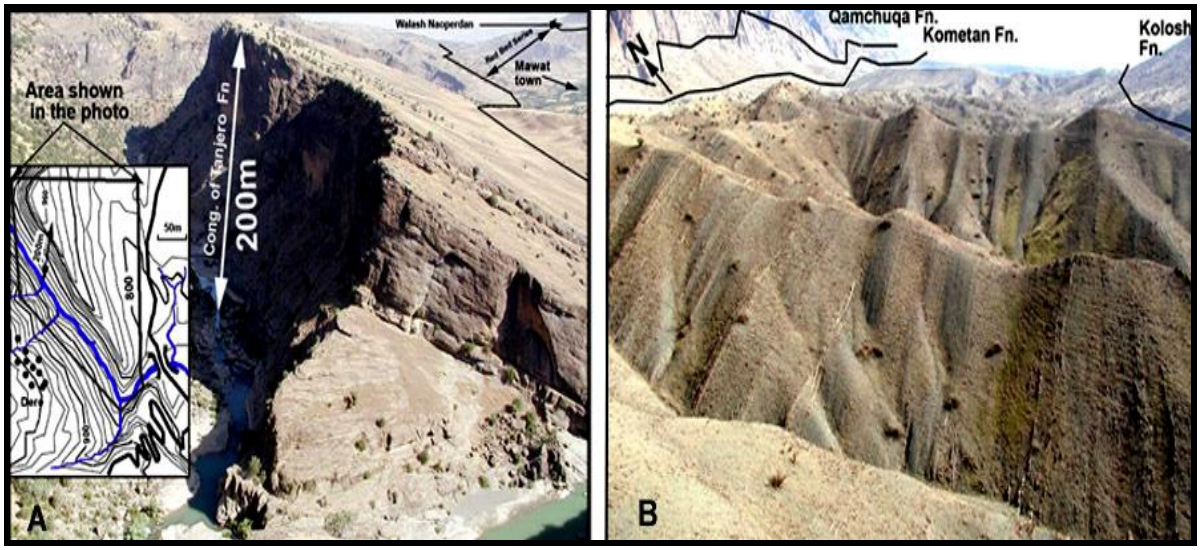

Figure 5: A: Mawat section near Qashan Bridge as shown by photo and contour map. The section totally consists of molasse facies (conglomerate and red sandstone and claystone). B: Low stand wedge (350m thick) which consists of alternation of medium des of sandstone and calcareous shale. This wedge is as flysch facies is correlated with conglomerate of Mawat and Dolbeshk sections.

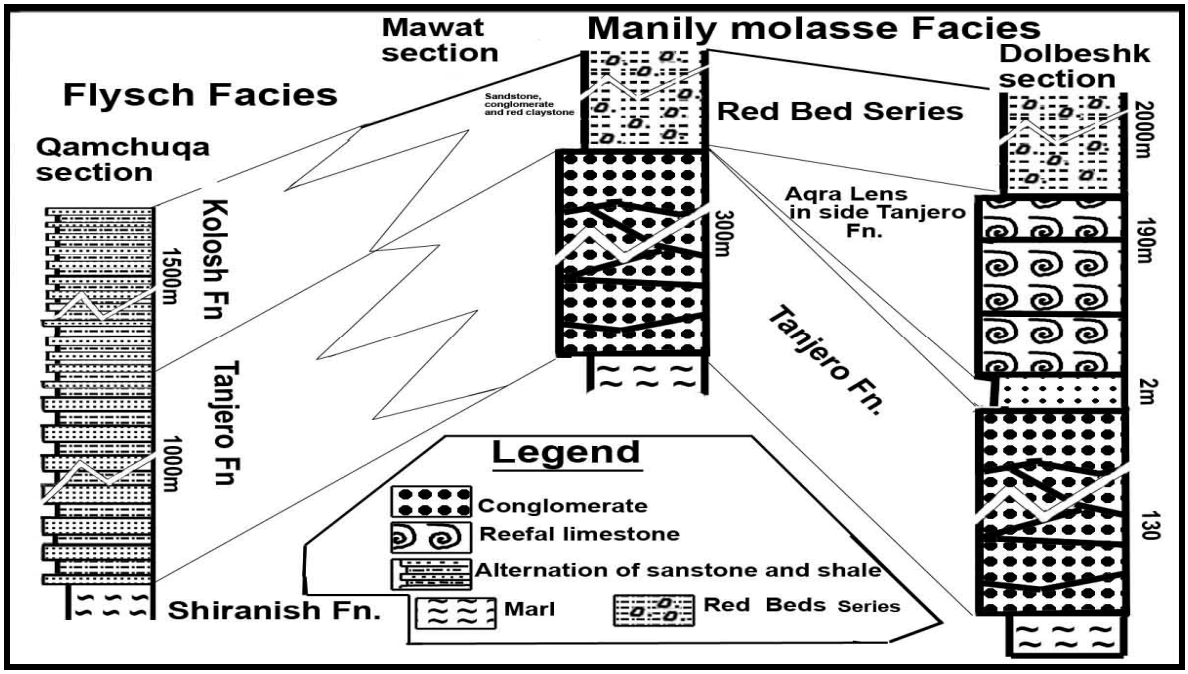

Figure 6: Correlation of outcrops sections of molasse and flysch facies in the Cretaceous and Tertiary foreland basin of north eastern Iraq.

side (southern side) of proposed positive land. As mentioned before, in this study, this paleo high proved that not existed in Upper and Cretaceous and Paleocene. This done by field tracing of the outcrop down paleodip with considering proper gradation of grain size clastic sediments from conglomerate to sandstone and shale (Fig.2, 6 and 9).

Flysch facies of Qamchuqa section

This section is located about 5km to the southwest of Dokan town near New Qamchuqa village at the south (Fig.1and 5B). The outcrop section consists of the succession of thin bedded of Tanjero Formation and overlaid by Kolosh Formation. In this section, Tanjero Formation consists of typical lithology of flysch facies i.e. alternation of thin beds of sandstone and calcareous shale. As seen in the figure (6) this section is correlated with the conglomerate of Dolbesk and Mawat sections.

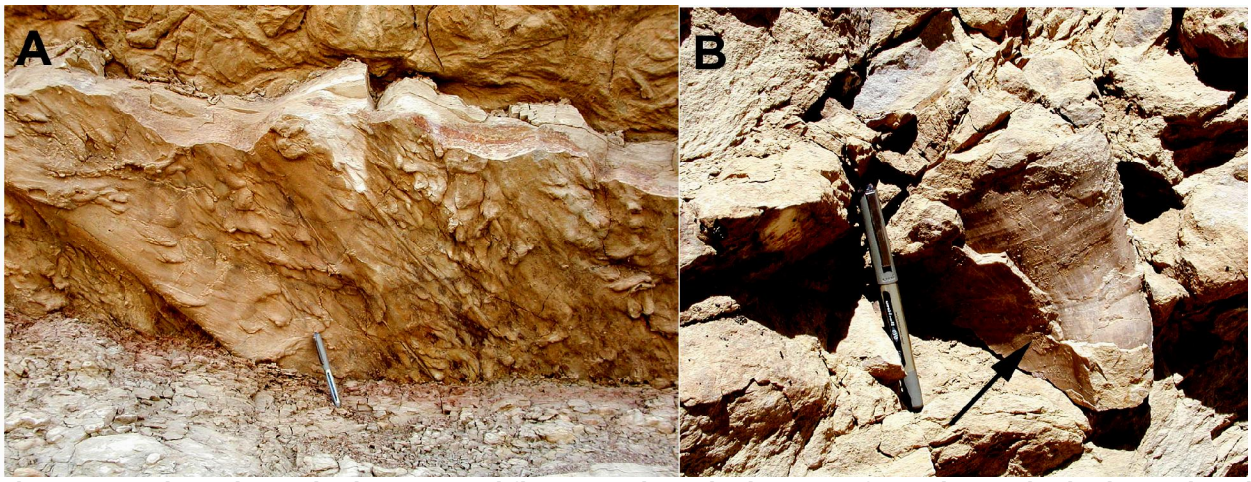

Figure7: A: The sole marks (groove and flute casts) on the bottom of sandstone bed the Red Bed Series (assigned previously as molasse facies) which represent the signals for transition between molasse and flysch facies . B: Rudist skeleton in its growth position in the limestone at the top of the red clastics of Tanjero Formation which indicate shallow water environment.

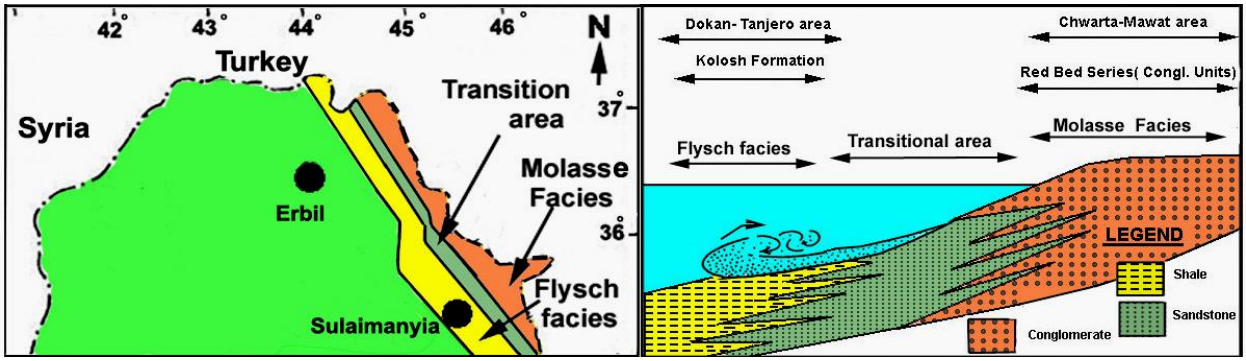

Figure:8: left: The position of the deposition of molasse and flysch facies during Maastrichtian and Paleocene in the northeastern Iraq. Right: simplified geologic cross section of the studied area during Campanian till Eocene showing how molasse and flysch facies can be deposited in one foreland basin.

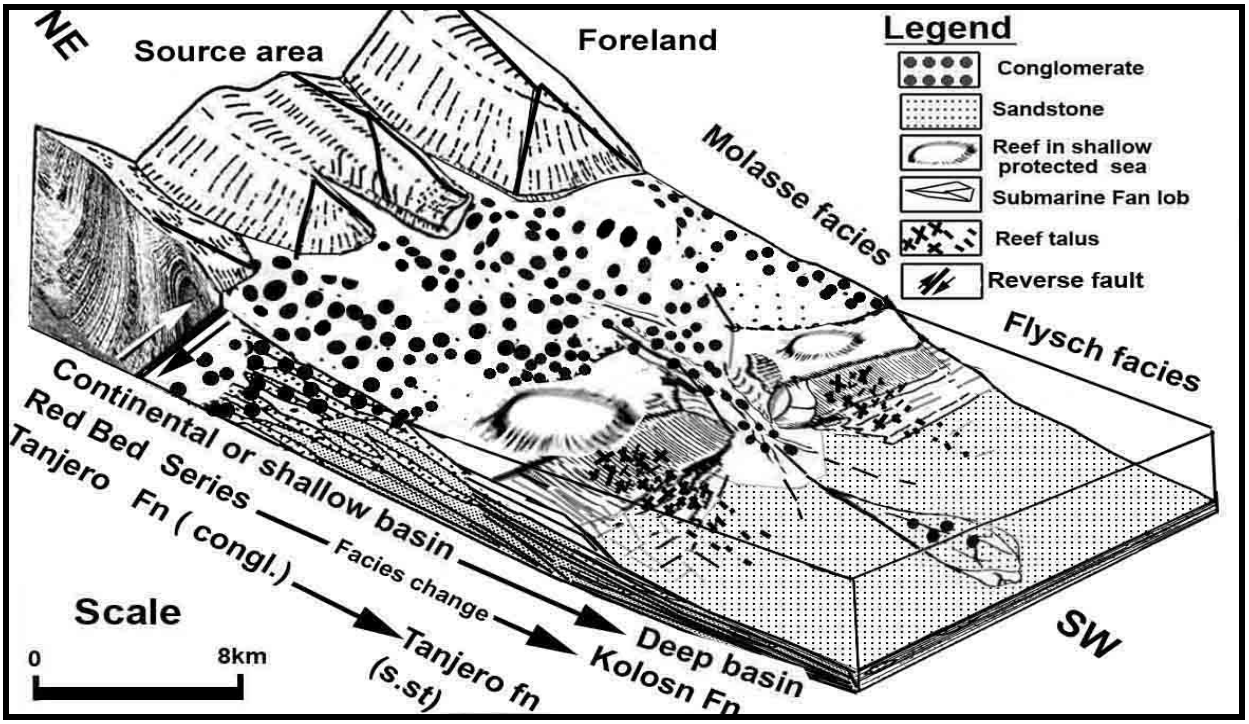

Figure9: Conceptual model (generalized) shows possibility of deposition of Molasse and flysch facies in a single basin concurrently in foreland basins. The model can be applied for Upper Cretaceous and Paleocene-Eocene basins in NE-Iraq and for most foreland basins everywhere.

In this section and above Tanjero Formation comes Kolosh Formation which has nearly the same lithology of the former formation only their ages differ. This latter formation, as flysch facies, is correlated by Barzinjy(2005) with 1500m of orthoconglomerate of Red Bed Series in Chuarta area and he proved that both deposited in the same basin in proximal (near shore area) and distal area (basin slope and plain). His conclusion is based on field study, paleocurrent, and lithologic similarities. In the (Fig.5B and 6) this section, as flysch in the distal area and in front of previous supposed paleohigh (which is refused in this study), is correlated with the 175 m and 200m conglomerate of Dolbeshk and Mawat sections to show flysch and molasse relations.

Transition Zone and lithology between molasse and flysch facies

Al-Barzinjy (2005) found very clear sole marks inside the rocks previously called molasse facies in the Red Bed Series. The sole marks include flute casts, small channels and groove marks (Fig.8). These sedimentary structures are located at the nearest point between molasse, at the northeast, and flysch facies at the southwest. Now the transition zone coincides with the present position of Shinarwe, Goizha, Azmir, Kewa Rash anticlines. Unfortunately now most of the rocks of Upper Cretaceous and Early Tertiary can not be seen due to erosion. However, there are few places one can observe the transition zone (but not the ideal one) such as 2km west to Qala Chwalan town. The probable lithologies at this zone are consisted of alternation of relatively deep and shallow facies (alternation of grey fine and red medium terrigenous clastics).

According to the location of these structures and lithology of the two facies, transition zone is located at the present position of Goizha, Azmir, Daban, Sara and Kewa Rash mountains or anticlines (Fig.8).

Conceptual model

The model for concurrent deposition of flysch and molasse facies is valid, at least, for foreland basin where the deposition and subsidence are relatively high and effected both by tectonic and eustatic sea level changes. The input data are collected and inferred from field work in the areas where outcrops of Cretaceous and Tertiary foreland basin of western Zagros are widely exposed. These outcrops are traced both along paleodip and strike for more than 35km in the northeastern Iraq, Kurdistan region. In addition to field data, the data that included in the studies such as Karim, 2004b, Al-Barzinjy (2005), Baziany (2006), Karim et al. (2006) .are utilize for constructing the model.

The lithologic types, facies, thickness, paleocurrent direction and grain size variations are main factors for indicating the configuration of the paleogeographic and tectonic setting of the model. The source area (thrusting sheets) is mainly consisted of radiolarite and ophiolite with minor amount of limestone. The shelf and coastal areas where molasse facies are deposited are inferred from faunal types, clasts supported boulder, sedimentary structures, conglomerate and reefal limestone (when there are no terrigenous sediments influx). In other side, the slope and basin plain, where flysch facies are deposited, are assigned according to planktonic forams bearing marl interbedded with turbidite sandstones (Fig.3right). The paleocurrent direction is inferred from lateral facies change (during HST) of in situ reefal facies to reef talus then to fine grain bioclast from shore line to the outer shelf. During LST the paleocurrent is indicated by imbricated pebble and grain size change of terrigenous sediments in addition to sedimentary structures (Fig.3A and 7A).

The literature reviews are also used for establishment of the model. There are many studies that showed the coexistence of flysch and molasse indirectly. Without referring to the flysch and molasse, they showed deep marine siliciclastic sediments as lateral facies change of continental or shallow marine sediments. The most important one is the model of Einsele (2000,p. 323) who showed rapidly prograding lowstand system tract fed by braided river in basin of passive margin. This model contains braided river, deltaic plain and delta front siliciclastic sediments. In our interpretation these continental and shallow marine sediments are same as molasse facies. He also showed, in the deeper part of basin, turbidite and mass flow as submarine fan. According to definition of flysch facies by Bates and Jackson (1980) the turbidite is included in the flysch facies. What shown by Einsele (op. cit) also shown, In Iraq, by Barzinjy (2005) and Karim and Surdashy (2005, 2006) for correlation between Kolosh Formation (flysch facies) and Red Bed Series (as molasse facies) by former author and correlation of continental sediment and deep marine ones of Tanjero Formation. In the models drawn previously, the paleohigh is indicated between the basins in which flysch and molasse but in the previous study it is cancelled.

CONCLUSIONS

The deposition of flysch and molasse facies is studied in the outcrop sections of the part of Zagros Foreland Basin in Northeastern Iraq, Kurdistan Region. It was shown that both facies can deposit in one basin concurrently as lateral and down dip facies change. The study refuse the old idea about the two facies which is indicated them as syn-tectonic and post-tectonic facies that deposited diachoronously. The study suggests that the usage of words “flysch” and “molasse” better not to be used. Instead the either coastal and basinal facies or distal and proximal facies can be used in stead of the two facies.

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