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Petrography of Mukdadiya (Lower Bakhtiari) Formation at Bastora Vifiage: Erbil. Iraq

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Abstract

The clastic succession of Mukdadiya (Lower Bakhtiari) Formation (Pliocene) at Bastora area is commonly repetitive. The petrographical and heavy minerals analyses refer to a short distance transportation of sediments and they reveals a typical Mol;asse sediments characters. They might have been accumulated during Pliocene by rapid erosion of adjacent uplifted thrust zone rocks at North and Northeastern Iraq.

بتروغرافية تكوين المقدادية (البختاري الاسفل) في قرية باستورة - اربيل - عراق

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الخلاصة

يتسم التعاقب الفتاتي لتكوين المقدادية (البختاري الاسفل سابقاً) ذي العمر البلايرسيني في منطقة باستورة بالتكرارية ، وتشير التحاليل البتروغرافية والمعادن الثقيلة للترسبات الى ان مسافة نقلها كانت قصيرة، وانها تظهر سمات ترسبات المولاس المثالية، ويبدو ان هذه الترسبات قد تراكمت خلال عصر البلايوسين بفعل التعرية السريعة لصخور مرتفعات نطاق الزحف المجاور في الشمال الشرقي من العراق.

Introduction

The ciastic sequence of Mukdadiya (formerly, Lower Bakhtiari) Fortnation (pliocene) is widly distributed in the Foothill and the Mesopotomian plain zones. Due to its thickness (Maximum 2050m.) and its stratigraphic position, it plays an important role in the geology of Middle East (Ali and Khoshaba, 1981). This formation was first descri,bed from Iran by (Busk and mayo, 1918). According to Numan (2001), the depoition of a two and half kilometers of thick succession of conglomerates of Mukdaya Formation and subsequent Bai Hassan Formation represent the paroxysmal phase of the Alpine Orogeny in the Pliocene.

The investigated area (Bastora Village) is situated in the Foothill Zone, north Erbil City (Fig. 1). The scope of this work is mostly occupied by petrography of the Mukdadiya Formation in northeastern Iraq. This formation is characterized by variable thickness and it has markedly diachronous boundaries, with underlying Injana (formerly Upper Fars) Formation and overlying Bai Hassan (formerly Upper Bakhtiari) Formation. According to Mail (1992), the vertical succession of such sand facies is commonly repetitive or cyclic, and indicates progressive changes in depositional conditions. This formation reveals a decrease in grain size and in scale of cross bedding. The Mukdadiya Formation is of Pliocene age based on dating that uses the occrFènce of invertebrate Hipparian species (Bellen, *et al.*, 1959).

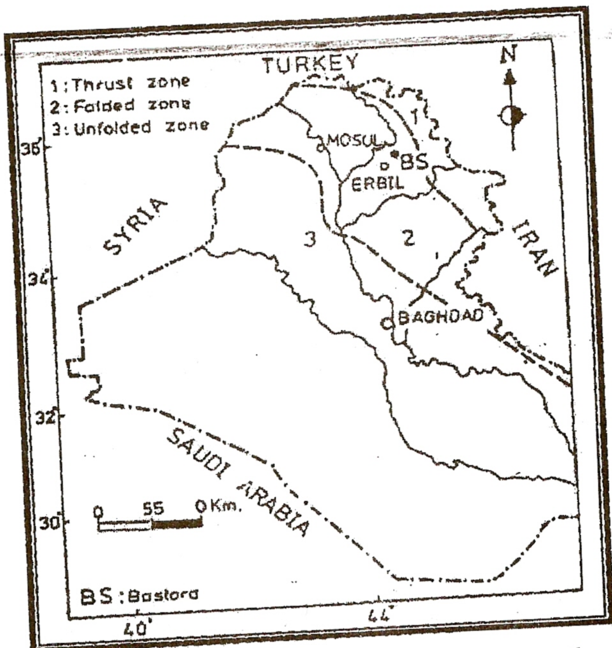

Fig (1): Location map of the studied section

The Mukdadiya Formation has been studied by many authors (e.g. Kukal and Al-Jassim, 1971; Saadallah and Al-Jassim, 1974; Khoshaba, 1978; Phillip *et al.*, 1980 and Au and Khoshaba, 1981). The present work is undertaking the study of Mukdadiya Formation at Bastora Village, Erbil (Fig. 1) in an attempt to understand its characteristics.

Petrography

The petrography of sandstone is obtained from thin section study of 30 samples. Their modal analysis is determined by point counting. The heavy minerals work includes the study of 21 samples, which will be discussed respectively.

The sandstones of Mukdadiya Formation at Bastroa village are carbonate rich sediments. Rock fragments comprise (6.73%) (of the total components including (27.73%) carbonate, (11.24%) igneous, (6.19%) metamorphic, (5.9 1%) argillaceous and (5.66%) ehert rock fragments. The other major components are feldspars (13.65%) and quartz (11.35%). The sandstones also include lesser amounts of clay matrix (2.76%). They are variably cemented by about (14.35%) of carbonate, in addition to gypsum and ferruginous cements (1.25%). Figure (2) *represents a summary* of modal analysis.

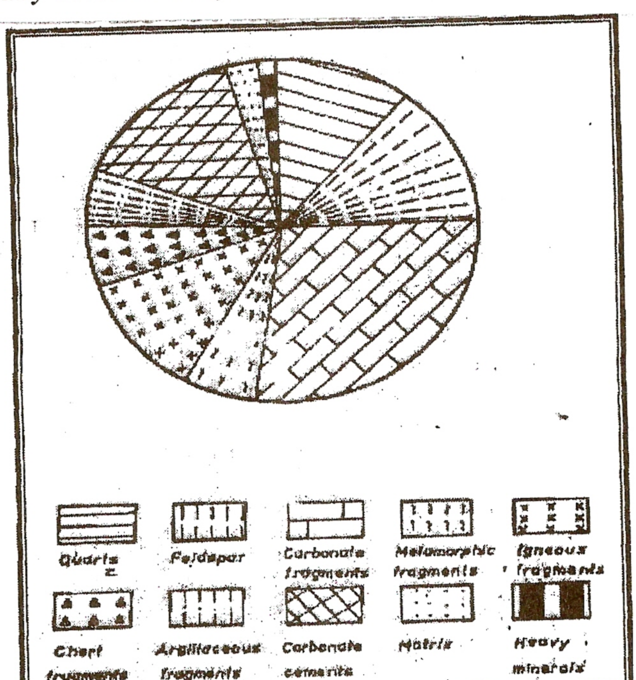

Fig. 2: Average content for various mineralogic constituents of sandstone at bastora area.

The grains are generally angular to sub-rounded. No major difference in the roundness of the various originated grains is observed, except that the carbonate rock fragments generally tend to be more rounded than other constituents. Below is a brief description of the nature and distribution of each component.

1. Rock Fragments:

This major component comprise (5615 %) of the total Mukdadiy sediments, as follows:

A. Carbonate Rock Fragments:

By far, carbonate fragments are the most abundant constituents of the Mukdadiya Formation with an average of (27.73%). They are generally micritic, fossiliferous, dolomitic. and occasionally recrystallized. The grains are rounded to subrounded.

B. Igneous Rock Fragments:

Igneous rock fragments content is relatively high within the Mukdadiya sediments with an average of (11.24%), ranging from (1.5-23.0%). They are generally composed of unidentified basic volcanic and acidic plutonic rocks. The volcanic fragments are often oxidized. The grains are generally angular to subrounded. The relatively high contents of the volcanic and plutonic rock fragments as well as that of quartz (mentioned below) indicate high existence of these rocks in the source area.

C. Metamorphic Rock Fragments:

Metamorphic rock fragments content is relatively low, ranging (2-14%) with an average of (3.19%) represented by chioritized and serpentinized rocks and few phyllite and sctt' These fragments have a less resistant nature than the others, and indicate a short distance of transportation. Their source rocks are more likely to be from the adjacent northeastern thrust zone.

D. Chert Rock Fragments:

The sandstones at this locality are characterized by low content of chert rock fragments with an average of (5.66%) and a range of (0.5-14%). These fragments include cryptocrytalline, microcrystalline, jaspery-nd radiolarian chert. The source rock must be partly existing in the radiolarian chert in the Thrust Zone Cretacaeous Quiqula Series and partly in the chert-rich carbonate formations.

E. Argillaceous Rock Fragments:

They are relatively low in sandstone beds at this locality with an average of 5.91% (range 1.0-18.0%). Their fragments are relatively soft, and in many instances squeezed and deformed due to compaction. As a result, it is a common sense to conclude that they have been transported for a short distance and their source area must be very near.

2. Feldspars:

The feldspars content is relatively high and ranges from *(4.5-28.5%)* with average (cI55) While plagioclase forms majority of the feldspars, only few V grains repreh(K-feldspars. Fresh feldspars and slightly sericitized ones are observed, and the replacement by calcite is common. The feldspar grains seem to be derived from plutonic igneous rocks of Cretaceous and Tertiary igneous complexes. The presence of calcic plagioclase at the expense of k-feldspars suggests the basic nature of igneous source. The possibility of derivation from intermediate or acidic igneous rocks though limited but can not be ruled out. Generally, the petrographical analyses revealed that the chemical weathering did not act as much as the mechanical one. The nature and character of the fresh feldspars are of great importance in determining the source of Mukdadiya sediments, and as a good tool to indicate short distance transportation and the dominance of dry to semi-arid conditions.

3. Quartz:

Quartz occurs in rather smaller amounts in the sediments of the Mukdadiya Formation. Its content is (11.35%) with a range of (4-19%). Generally, quartz grains are angular to subrounded, mainly monocrystalline, with only few grains being polycrystalline. The bad roundness may refer to a short distance of transportation (Johnsson, *et al.*, 1988). The quartz grains show straight to slightly undulose extinction.

As quartz forms a small fraction in comparison with other constituents like carbonate rock fragments, its source rocks must be of very limited occurrence in the source area, especially in the light of its high resistance compared with other constituents (Folk, 1974; Pettijohn, 1975).

4. Matrix:

The sandstones of the Mukdadiya Formation contain relatively low amounts of clayey matrix of an average of (2.76%) ranging from (0.5-9%). Based on their low content, it is possible to conclude that the role of the chemical weathering in the source area was negligible and perhaps the relative paucity of the rocks weathered into clay minerals (Al-Rawi, 1982).

5. Carbonate Cement:

Carbonate cement forms the most abundant type of cements, which are present in all sandstones samples. Generally, these cements comprise a major constituent of the rock with an average of *(14.35%)* with a range of *(6.5-25%)*. Carbonate cement occurs in several forms e.g. matrix-like cement, slightly coarse granular cement and coarse crystalline sparry mosaic cement. The cement may partially or completely fill the interparticle pore spaces. The matrix-like micritic cement is probably of detrital origin representing the finer-grained detritus from the carbonate source area. The slightly coarse granular cement is probably recrystallized micritic cement.

The coarse-grained mosaic carbonate crystals are of post depositional diagentic origin formed by dissolution and reprecipitation of carbonate material (micrtic matrix or sand grains) as a cement or less likely precipitated from waters that*re introduced into rocks already carbonate saturated.

6. Other cements:

These include occasional gypsum and ferruginous cement. In all cases, these cements occur in very small amounts (1.25%) and in localized parts of this lithological section. These cements are volumetrically unimportant and their textural relationships indicate that they are of later origin than the carbonate cement.

Classification of Sandstone

According to pettijohn (1975) classification, which depends on the compositions, the Mukdadiya sandstone is lithic arenites (Fig. 3a). This sandstone falls very close to rock fragments end member of this classification Since the Al-Rawi sandstone studied sandstone are rich in carbonates, the classification proposed by (1979; 1982) exhibits more satisfied classification of the studied as caiclithic to carbonate arenites (Fig. 3b).

According to the separation method suggested by Carverk(1 971), heavy mineral analyses was carried out on (21) samples. The microscopic identification revealed that the heavy mineral content is low in sandstone of Mukdadiya Formation. It is mainly composed of opaque minerals (mainly magnetite and haematite), in addition to smaller amounts of epidote, amphiboles, pyroxenes and garnet, with still lesser amounts of tourmaline. Rare occurrence of rutile, staurolite, kyanite and chlorite are also recorded in the studied samples. Table (1) exhibits the abundance of the heavy minerals present in the sandstone of Mukdadiya Formation.

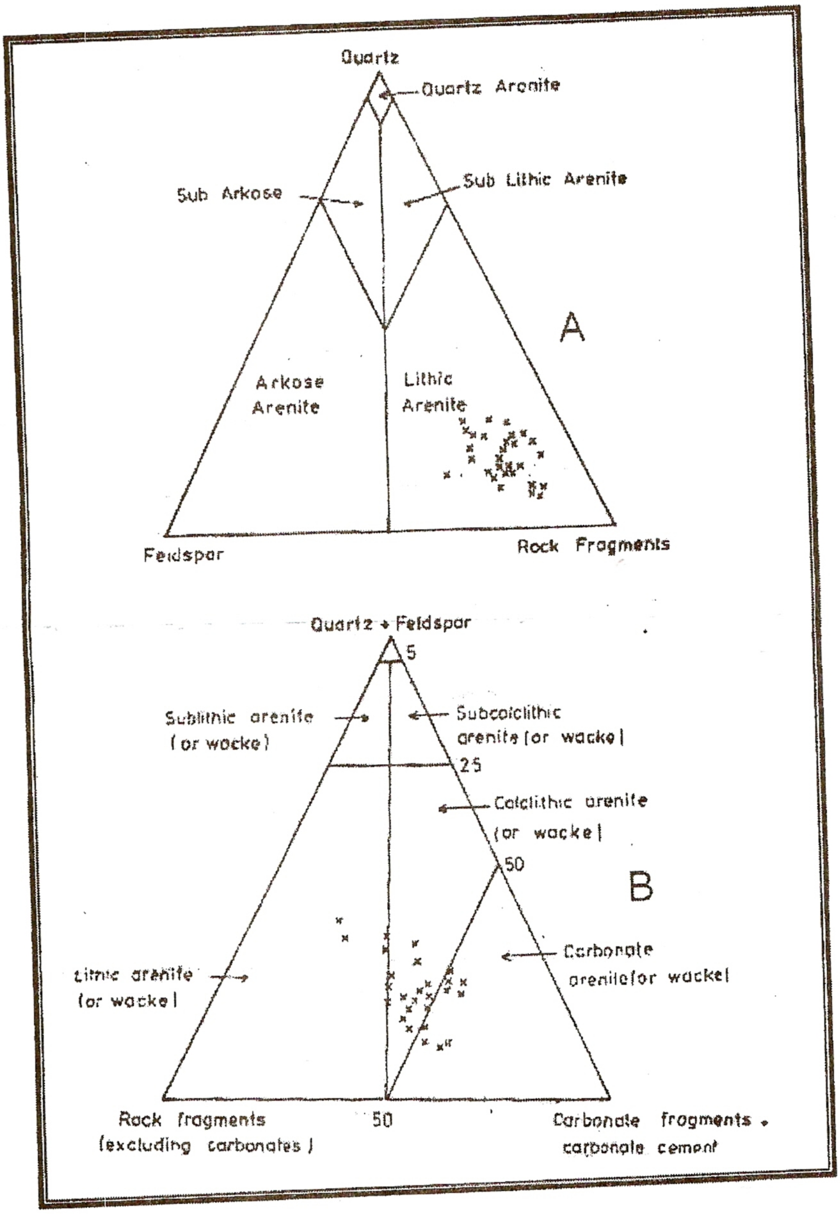

Fig. 3: Petrographic classification of Mukdadiya sandstone at Bastora area: A:On triangular plots of quartz, feldspar and rock fragments (Pettijohn,1975). B: On ternary diagram of carbonate rich sandstone (Al-Rawi, 1979).

Heavy Minerals

The occurrence of magnetite and rutile together suggest that the basic igneous rocks form all least part of the source area (Singh and Singh, 1988). According to Al-Rawi (1980), the Ophiolite complex in the northeastern part of Iraq could be the most probable source for minerals. The metamorphic source is indicated by the existence of garnet, kyanite, chlorite and blue green homblende (Friedman & Johnson, 1982). The occurrence of well-rounded zircon grains with the angular ones could possibly suggest the reworking of sandstone that was exposed at or in the way from the source area (Pettijohn, 1975; Friedman and Johnson, 1982). In conclusion, the heavy mineral assemblages of the Mukdadiya Formation atthisJcality,suggest ource area characterized by preexistence of sedimentary, igneous and metarnorphic rock complexes.

Discussion and Conclusions

The short distance transportation of Mukdadiya clastics is deduced by the abundance of carbonate and argillaceous rock fragments, assemblage of less resistant metamorphic rocks, availability of fresh feldspar minerals and angulanty of quartz grains. On other side, the relatively high content of volcanic and plutonic rock fragments and the occurrence of magnetite and rutile together with abundant radiolarian chert, suggest that the Ophiolite complexe and their other sediments implications in the adjacent north and northeastern parts of Iraq , (i.e), thrust zone may form the main parts of the studied sediments source area.

The coarsening upward sequence of Mukdadiya pebbly sands constituents and subsequent conglomeratic Bai-Hassan Formations indicate postorogçny mo lasse sedimentation. According to Numan (2001), the orogeny, which produced such tectonic facies was a paroxysmal phase of the Alpine orogeny in the Pliocene with accelerated isostatic uplift of Iraqi thrust zone.

Furthermore, the present study of Mukdadiya Formation at Bastora area comes to the following conclusions:

1. Rock fragments, especially the carbonate ones, are the main constituents of the sandstone of Mukdadiya Formation at this locality, and therefore, they have

been classified as lithicarenites (Calcithic). The great content of the carbonate rock fragments also indicates that the source area is largely carbonate.

2. The mineralogical and petrological data from this locality strongly indicate the complexity of the source area, which would necessarily be related to the adjacent organic belt. North and northeastern terrains of Iraq (Thrust and High Folded Zones) provided the source material for the sandstone of Mukdadiya Formation. –
3. The heavy mineral assemblage refers to a combination of igneous and some metamorphic source rocks.
4. The gross petrographic characters and mineralogical composition of Mukdadiya sediments at this locality show no significant variations from the same sediments in other localities.
5. Generally, it is dedud that the Mukdadiya clastic sequence is a typical tectonic Mol. asse facies, which had been accumulated by rapid erosion of Iraqi north and northeastern thrust zone.

Sample No.	Opaque	Pyroxene	Hornblende	Staurolite	Actinolite	Garnet	Topaz	Epidote	Rutile	Cordierite	Tourmaline	Zircon	Andalusite	Chlorite	Fluorite	Zoisite	Apatite
1	A	R	-	-	FC	R	-	R	-	R	-	R	-	R	-	-	-
2	A	-	-	-	R	R	-	-	-	R	R	R	-	-	-	-	-
3	A	R	-	-	R	-	R	-	R	-	-	R	R	-	-	-	-
4	A	R	-	-	FC	-	FC	FC	R	FC	-	R	R	-	-	-	-
5	A	R	-	R	R	R	FC	FC	-	R	-	R	R	-	-	-	-
7	A	R	-	FC	R	R	-	-	-	R	-	R	-	R	-	-	-
8	A	-	-	R	-	R	-	R	-	-	R	-	-	-	-	-	-
9	A	R	-	-	VC	R	R	R	-	-	-	-	-	-	R	R	-
10	A	R	-	-	VC	R	R	R	-	-	-	-	-	-	-	-	-
11	A	R	R	S	R	R	R	R	R	R	-	-	-	-	-	-	-
12	A	FC	R	R	R	R	R	R	R	R	-	-	-	-	-	-	-
13	A	-	-	C	R	-	-	R	R	-	-	-	-	-	-	-	-
15	A	-	-	-	VC	R	-	-	-	S	-	R	-	-	-	-	-
16	A	R	-	-	R	R	R	-	-	-	-	R	R	-	-	-	-
21	A	R	-	-	R	R	R	-	-	-	-	R	-	R	-	-	R
23	A	FC	R	-	R	-	R	-	-	R	-	FC	R	-	-	-	-
30	A	-	-	-	R	-	R	-	-	-	-	-	-	-	-	-	-
35	A	FC	-	R	R	R	R	-	-	R	R	-	-	-	-	-	-
36	A	-	-	R	-	-	-	-	-	R	R	-	-	-	-	-	-
37	A	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	-
38	A	R	-	-	-	-	R	R	-	-	-	-	-	-	-	R	-

Table-1: The relative abundance of the heavy minerals in the Mukdadiya Formation at Bastora Village. {A = Abundant (30-60%); VC = Very Common (7.5-15%); C=Common (3-7.5%); FC=Fairly Common (2-3%); S = Scarce (1-2%); R=Rare (<1%)}.

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