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Environment of Tanjero Formation as Inferred From Sedimentary Structures, Sulaimaniya area , Kurdistan Region, NE-Iraq

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Abstract

Many sedimentary structures are found in Upper Cretaceous Tanjero Formation, these structures are all new as concerned to the formation. These structures are discussed in detail according to classification, morphology and environments with providing high-resolution photos as illustrative tool for showing sculptures and microstructures. By these sedimentary structures, it was proved that lower and upper parts of the formation were deposited in shallow water and middle part deposited in deep one. These structures are large-scale cross- bedding, skolithos dwelling, and escape structure, cruziana trace fossils, boring, and plant debris and plant body fossils. Most of these structures are found in the lower part (in the lowstand sandstone wedge) and few ones in the upper one while the middle part contains none of them. The rate of sedimentations of the formation is estimated from the skolithos escape structures and large cross bedding which exceeded, in some cases, 30 cm in a day. The occurrence of plant body fossils and plant debris in Tanjero Formation is attributed to humid, warm and stormy climate of the Maastrichtian age at the studied area, which may be affected by termination of greenhouse effect of Cretaceous. The study is proved that the lower and upper parts are deposited in shallow marine environments while the middle one deposited in deep basinal one.

Keywords:- Kurdistan geology, sedimentary structures, trace fossil, Tanjero Formation,

Introduction

Tanjero Formation is an Upper Cretaceous unit (Campanian-Maastrichtian), which crops out within the Imbricated and High Folded Zones in Northeastern Iraq Buday (1980)[1] and Buday and Jassim (1987)[2]. It stretches as narrow northwest-southeast belt near and parallel to the Iranian border (Fig. 1). The formation consists mainly of alternation of clastic rocks of sandstone, marl and calcareous shale with occurrence of very thick conglomerate and biogenic limestones (Bellen *etal*.1959) [3]. Al- Rawi (1981) [4] mentioned that lower part of Sulaimanyia section has shallow environment. Jaza (1992) [5] recorded many deep marine sedimentary structures and inferred trench environment for the formation.

Newly, on the basis of main lithological distribution, Karim (2004) [6] has divided the formation into three parts (lower, middle and upper parts). In his study, these parts are correlated across eight different sections, which represent the available outcrops in Sulaimaniya Governorate in addition to one section inside Iran (Fig. 2). His correlation is based on lithology and stratigraphic position of distinctive conglomerate and its derivative sandstones,

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localities. The lower part is mainly composed, on the lower slope and basin, of thick aggradation of sandstone (100-400m), whereas on the shelf it is dominated by 500m thick succession of conglomerate (in his study, he called it Kato conglomerate). The middle part is composed of 100-300m of bluish white marl and marly limestone on the slope and basin whereas it changes to calcareous shale on the shelf and to 20-50m thick of red claystone inside incised valleys along lowstand coastal area. The upper part (upper regressive part) chiefly consists of 50-200m thick-mixed carbonate-siliciclastic succession (in his study, it is named Kato mixed carbonate-siliciclastic successions). According to latter author, the constituents of this succession are alternation of biogenic limestone and calcareous shale with minor amount of sandstone and conglomerate.

Discussion of the structures

Many sedimentary structures, such as, mechanical (physical) and biogenetic sedimentary structures are found in the lower and upper parts of the formation. Except bedding, no other sedimentary structures are found in the middle part. Most of these structures, as allocated to Tanjero Formation and to the author's knowledge, are recorded for the first time in the Tanjero Formation. All these structures have environmental and paleocurrent importance, which can be very useful in basin analysis of the formation. The deep environment of previous workers is attributed to the fact that opportunity for shallow environment structures preservation is less than that of deeper ones in sedimentary records. Wave and current erosion and bioturbation commonly attack and obscure shallow ones while deep structures normally away from these enemies. Eustatic sea level change and tectonic activity cause the exposure of shallow environment (shelf and upper slope) to weathering which destroy the sedimentary structures. Bowen and Weimer (2003) [7] studied these shelves which contain incised valleys.

Tanjero Formation has gradational and intertonguing stratigraphical relationship with Shiranish Formation (Bellen *et al.,* 1959) [3], therefore, some parts of the formation show deep environment. The good preservation of sedimentary structures in these deep parts was highly over estimated and applied to overall formation.

In the present study, at least half of the formation thickness is proved to be deposited in shallower water than that assigned before (regarded as trench or geosyncline). The lower and upper parts are deposited in shallow environments, which is equivalent to slope and shelf environment while the middle part (of Karim 2004) [7] is deposited in deep basinal environment. This is also true for lithologies near the base of the lower part, which represents transitional interval with Shiranish Formation. These are all inferred from the following structures:

Cross-stratification

It is defined as arrangement of strata inclined at an angle to the main stratification. In the Tanjero Formation it is subdivided in to the following:

A) According to thickness of the strata as cited by Blatt et *al*. (1980) [8]:

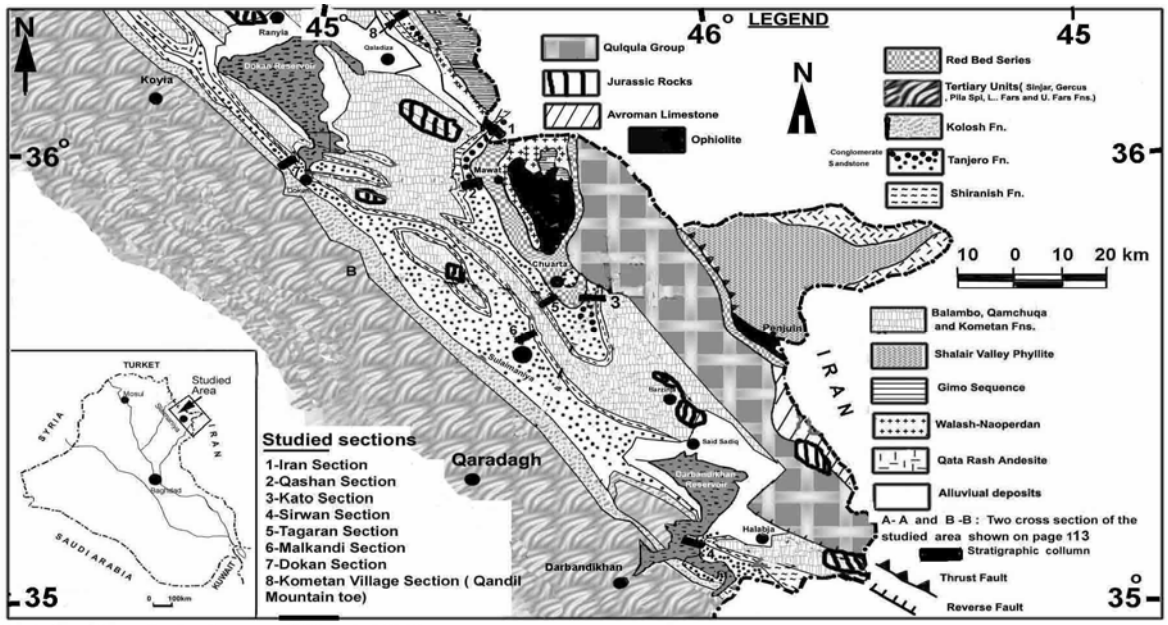


Fig. (1) Geological map of the studied area (modified from Jassim and Al-Hassan, 1977) (9)

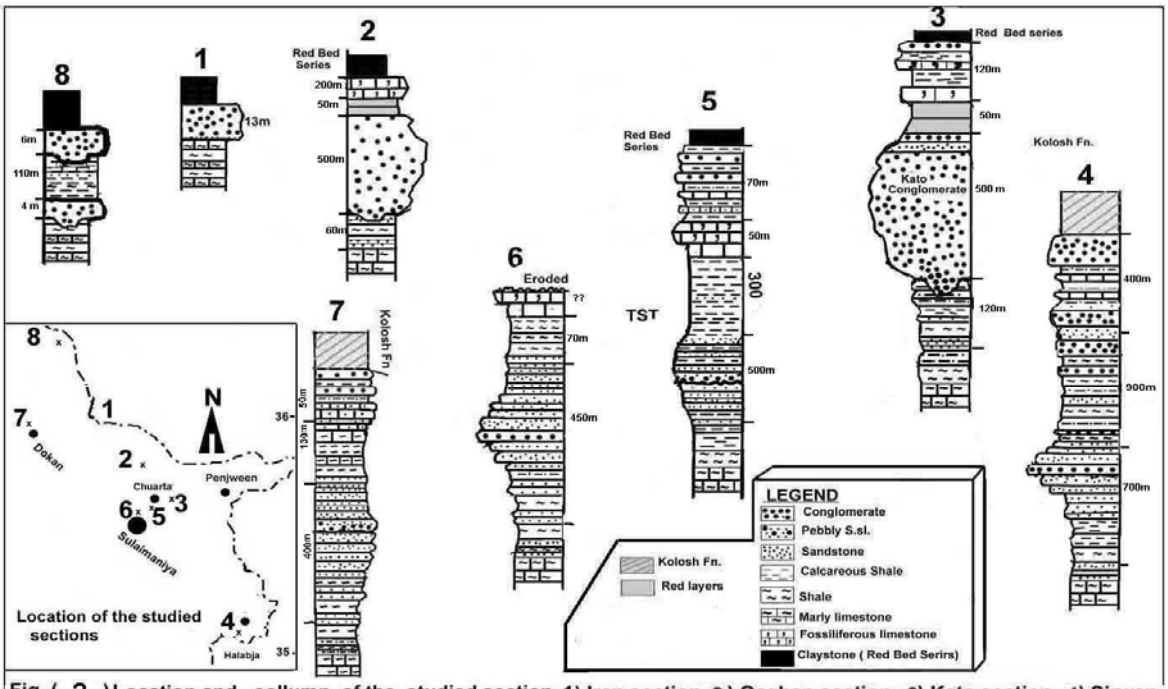
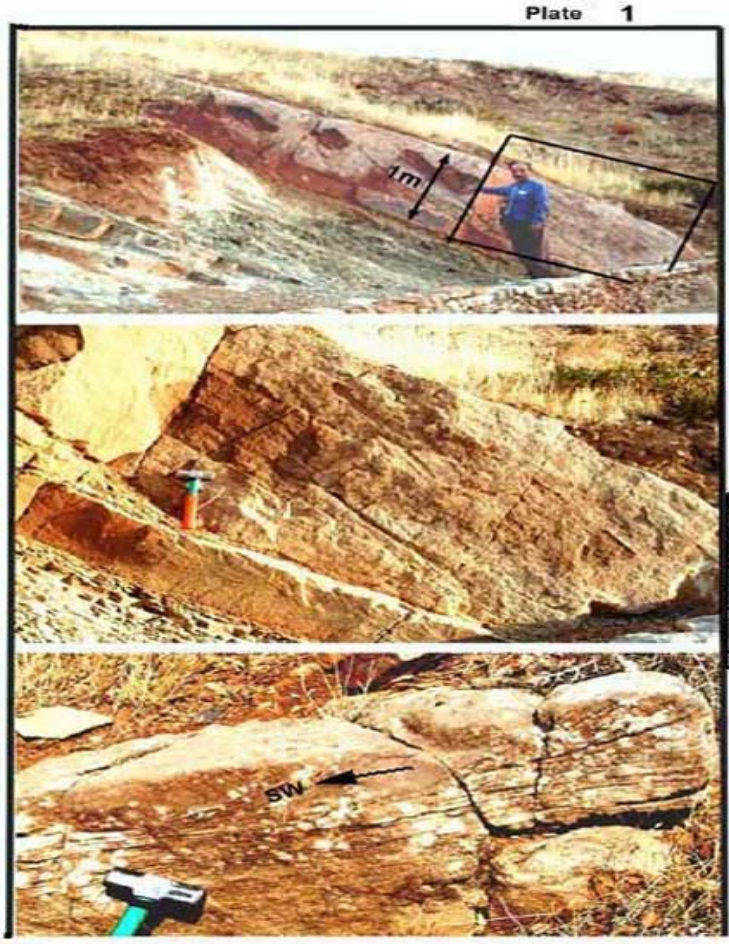


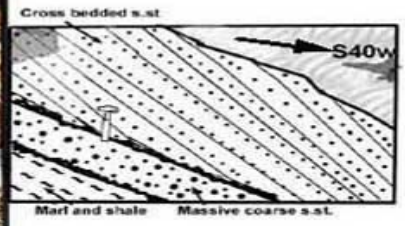
Fig. (2) Location and collumn of the studied section, 1) Iran section, 2) Qashan section, 3) Kato section, 4) Sirwan section, 5) Tagaran section, 6) Malkandi section, 7) Dokan section, 8) Kometan village section(Qandil Mountain toe) (after Karim, 2004) (6)

Plate 1

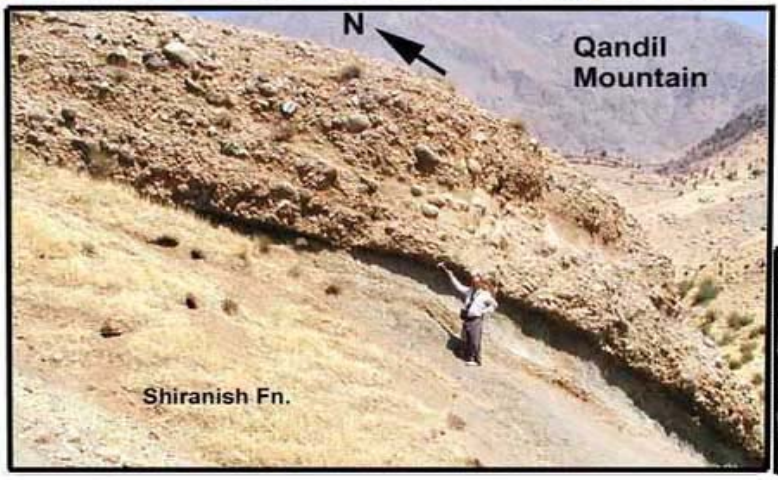


(1) Thick bed of coarse and cross bedded sandstone exposed at 1km to the north of Sulaimaniya City on the Malkandi Hill west of water tank at latitude: 35° 35' 21.6" and longitude : 45° 27' 47.8" This cross bedding is the largest one found in Tanjero Formation.

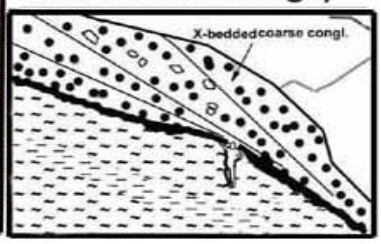
(2) This photo shows the part enclosed in the black frame in the above photo. As . . found in lower part (LST) therefore, it formed in shallow high energy environment .



(3) Trough cross-bedding at the southwest limb of Azmir Anticine. Along the toe of this anticline from Qirga to Qizlar villages, different type and scale of cross beddings and laminations are existing, most of them



(4) Cross bedded boulder conglomerate resting on Shiranish Fn. unconformably at 1km to the west of above village. It is represents SB1 of the upper sequence (same position as Kato congl.)



1-Cross lamination, where the cross strata are thinner than 1cm.
2-Cross bedding, in which the cross strata thicker than 1cm.

Cross laminations are present in the lower part of Tanjero Formation in the distal area (Dokan town, south of Sulaimaniya City and Chaqchaq valley).They are commonly associated with ripple mark and bioturbation of escape structures (Plate 2.1 and 2.2). They are found mostly in fine- to medium-grained sandstone. According to Allen and Allen (1990, p.271) [10], they forms by migration of ripple marks (wave ripple marks) and confined to less than 200 m depth. In the upper part few cross lamination is found in bioclast limestone in Chuarta area (500 m to the southeast of Zardabe Village). In this locality it is associated with cross- bedding, while in the middle part, this type of sedimentary structures is not found.

B) According to shape, into the following types:
1. Trough cross- bedding.
2. Planar cross-bedding.

Many large and medium scale trough and planar cross bedding are found in the lower part in the Malkandi section and Chaqchaq valley. These structures are observed in medium and coarse-grained clean (arenite) sandstone, while in the upper part they only exist in the bioclastic limestone at the south of Tagaran village. In the lower part, the largest cross bedding is seen in a bed of coarse sandstone (1.5m thick) at north of Sulaimaniya City (Plate 1.1, 1.2 and 1.3).

Cross bedding exists in several environments; they are more common in river point bars, tidal channels, and delta and shelf environment. In this connection, Potter *et al*., (1980) [11] included cross-bedding in shallow shelf only, while Blatt *et al.,* (1980) [8] showed trough cross bedding, found in tidal flat. They are also mentioned to occur in clastic dominated shelves. According to Nichols (1999, p.206) [12] trough cross-bedding are normally absent in depth greater than 100m.

As will be discussed later, the cross-laminations are formed below fair weather base (above storm wave base) in relatively deep environment while the cross bedding are formed above fair weather base in the mid or inner shelf at the time of maximum regression phase. The presence of these shallow environment cross beddings in Tanjero is attributed to the fact that during the lower part the sea level was so lowered and became shallow water in deep basin (equivalent to shelf as concerned to water depth). In the area of Qandil foothill area (Naudasht valley) exceptionally large cross bedding is found (Plate 1.4) which shows south paleocurrent directions. But most cross- beddings and cross laminations show southwest paleocurrent direction. It is worth to mention that the middle part of the formation contain is no cross bedding or cross laminations because of deep environment of deposition.

Biogenic sedimentary structures

Both Frey (1973) [13] and Simpson (1975) [14] used the term biogenic sedimentary structure "bioturbation structures" for all sedimentary structures formed by organisms. According to Einsele (1998) [15], the bioturbation structures are common in shallow marine environments

where different tempestites are deposited. In Tanjero Formation these structure are as follows:

Skolithos

They are simple, tube-like, vertically oriented burrow that typically show a much greater length versus width. *Skolithos* is interpreted as a dwelling burrow made by a suspension-feeding animal. These structures are found in coarse and medium grained sandstone beds of the lower part of Dokan section and Malkandi section (Fig. 1 and 2). They appearing as straight or slightly inclined burrows and most of them are arranged normal to bedding planes. These traces are 5 to 50cm long and 2 to 3.5 cm diameter. They are found in calcareous shale, siltstone and sandstone and two types of this structure are found:

Skolithos escape structures

They consist of vertical shafts in the laminated sandstone. In the longitudinal section, the shaft laminae are deflected downward forming U-in-U laminations and spreites structures (Plate 2.2 and 6.2). The laminae in some cases are continuous across the structure, while in cross section the structure consisted of circular laminae arranged concentrically. They exist in a laminated medium to thick beds of sandstone. These beds are coarse grained and 10 to 30 cm thick, which may be cross-bedded and rippled at the top (Plate 6.3). These traces exist in laminated sandstone. Under the microscope, two types of laminae can be recognized. They consist of alternation of dark and light color lamina. The dark one contains more limestone grain than the light one which is rich in chert.

Those found in Malkandi section have large size and showing clear and well-developed Spreites (Plates 2.2 and 6.2), while those of Dokan sections have no obvious Spreites. In less than half meter three structures of this type are observed in the same bed (Plate 2.1 and 6.3). These structures, occasionally, are wider at the bottom than at the top. They clearly represent behavior of the gastropod and bivalves in respect to the rate of sedimentation in shallow marine environments.

Simpson (1975) [14] called this type of structure *fugichina* (escaping structure). Rhoads (1975, p.155) [16] mentioned that organism buried below the unit would burrow this newly upward deposited sediment to make connection with sediment surface for escape. He showed escape structure similar to those exist in the formation made by recent bivalve *Mya arenaria* in tidal flat sediment of the North Sea. He also mentioned that after a storm, sediments are rapidly deposited, producing laminated post storm unit (tempestite unit). Seilacher (1967) [17], Doyle and Bennett (1998) [18] included similar structure in *Skolithos* ichnofacies, which exists in high energy near shore environment. Lawa (1998) [19] studied similar structures in Injana and upper part of Fatha (Lower Fars) Formations. He attributed these structures to brackish coastal and fluviatile environments.

The dwelling structure

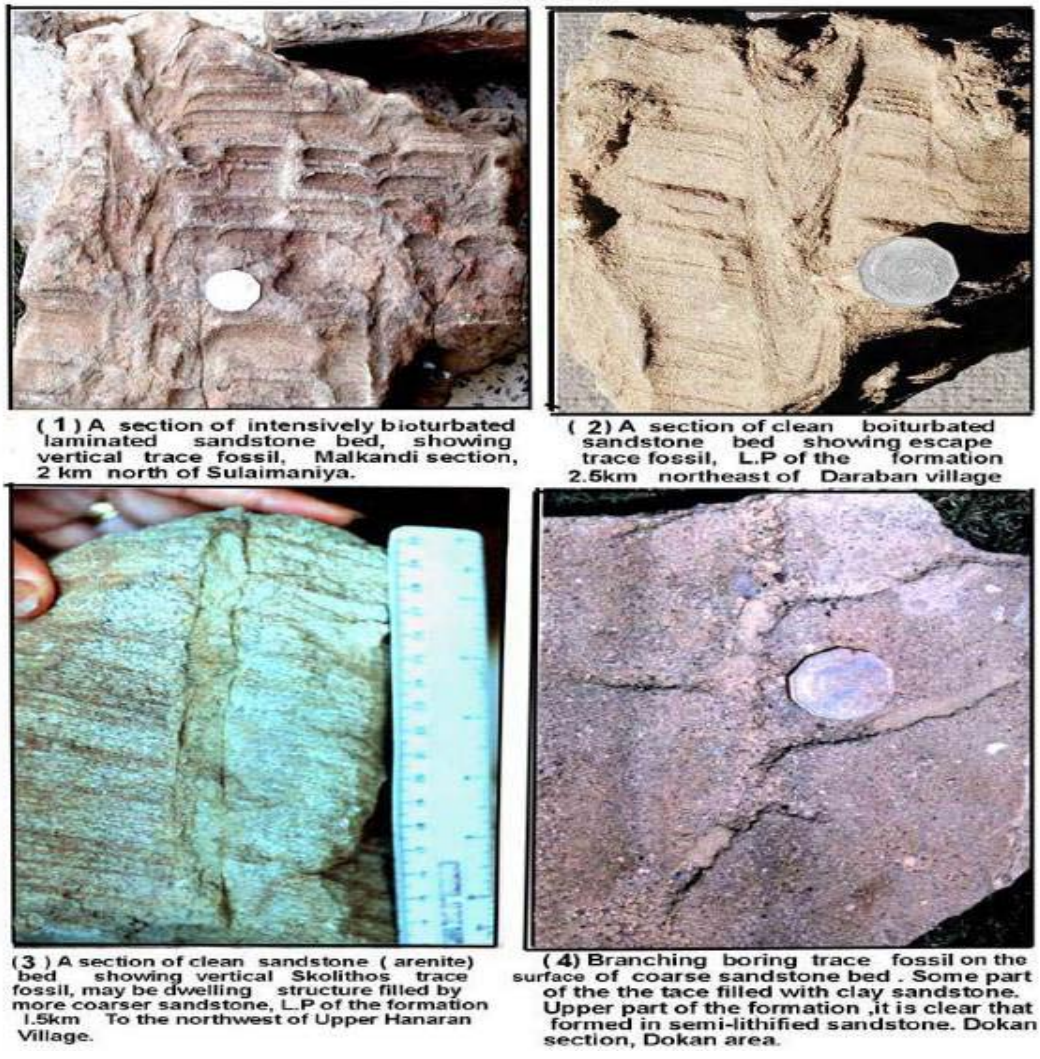
These consist of smooth vertical cylindrical burrows without spreites. As compared to the host rocks, they are filled with finer sediments. They are about 15- 50

cm long and with a diameter of 2-3 cm (Plate 3.1, 3.2 and 3.3). They are found in the lower part of the formation in both Malkandi and Dokan sections.

Horizontal and inclined borings

The horizontal types of these biogenic structures are found in the lower part of Dokan sections and the inclined ones exist in the lower part of Chaqchaq valley. The former consists of branching horizontal grooves about 1 cm wide, 0.5 cm deep and 40 cm long. It is found on the upper surface of coarse sandstone bed. They are branching from both sides to secondary groove (Plate 2.4). It is obvious from the constant diameter of the boring that it, as a whole, is made by single organism for protection against predators. It is possible that the boring is made at the interface of sandstone,

Plate 2



(1) A section of intensively bioturbated laminated sandstone bed, showing vertical trace fossil, Malkandi section, 2 km north of Sulaimaniya.

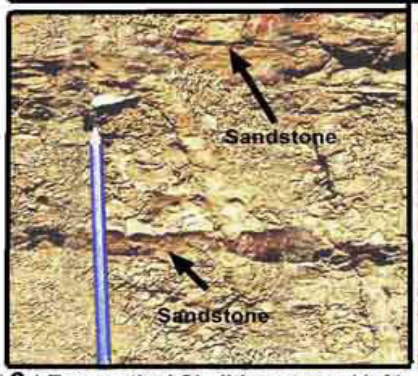
(2) A section of clean boiturbated sandstone bed showing escape trace fossil, L.P of the formation 2.5km northeast of Daraban village

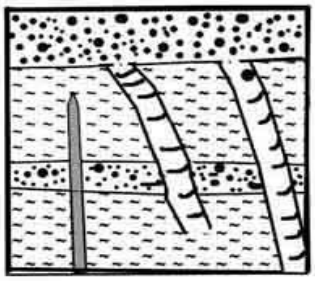
(3) A section of clean sandstone (arenite) bed showing vertical Skolithos trace fossil, may be dwelling structure filled by more coarser sandstone, L.P of the formation 1.5km To the northwest of Upper Hanaran Village.

(4) Branching boring trace fossil on the surface of coarse sandstone bed . Some part of the the tace filled with clay sandstone. Upper part of the formation ,it is clear that formed in semi-lithified sandstone. Dokan section, Dokan area.

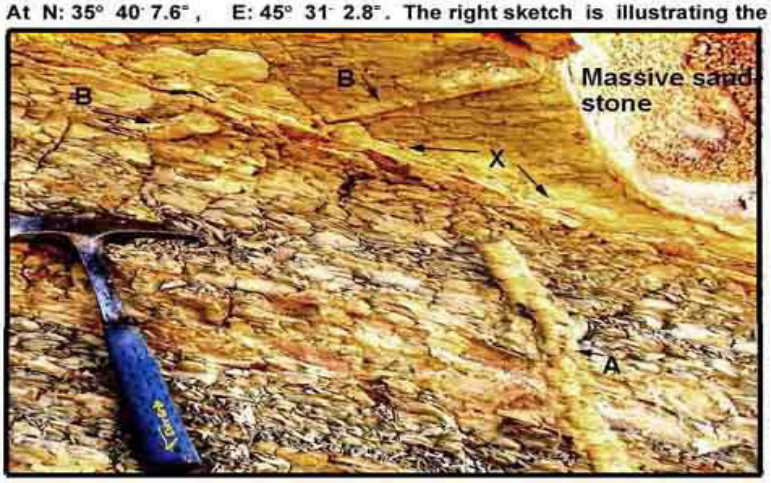
Plate 3

(1) Vertical branching Skolithos trace fossil in silty marl of the L.P. of Tanjero Formation. The trace lead to the overlying massive sandstone bed which is totally bioturbated (A). The marl is deposited below fairweather base and the sandstone is deposited by storm event. Malkandy section, 1km north of Sulaimaniya City.





(2) Two vertical Skolithos trace (left) fossils in the silty marl of L,P. of Tanjero Fn. The Traces pass the sandstone bed in the middle of the photo along the way to upper massive sandstone bed in response to rapid sedimentation. GPS Location is N: 35° 35' 21.6", E: 45° 27' 47.8". The right Phpto shows branching Planolite trace fossils found in one of the limestone bed of upper mixed carbonate - sliciclastic succession. Location is 2km northeast of Siramerg Village, Chuarta area At N: 35° 40' 7.6", E: 45° 31' 2.8". The right sketch is illustrating the elements of left photo.



(3) Association of the inclined Skolithos(A) and Horizontal (B) trace fossil in silty marl of the L.P. of Tanjero Formation. The traces pass to thick massive sandstone bed.The sharp contact (X) between the sanstone and the boiturbated marl are deposited in outer & inner shelfs respectively. During the LST, this part of the basin was so shallowed that became a shelf as concerned to depth of water.

from below and shale above, but later the shale is removed by erosion.

The inclined borings consist of inclined shafts drilled in medium grained sandstone and filled by course sandstones; the boring nature of these traces is clear because:

A-The horizontal boring has no side ridges (flank) as borrowings have. This means that the sediment was semi-lithified when boring was formed. Moreover the sediments that fill the interior of the trace are different from that which makes up the wall of the trace.

B-Both horizontal and vertical ones have sharp boundaries and contrasted lithologic differences.

When all published classifications (e.g. Seilacher, 1967 [17], Tucker, 1991[20] and Potter *et al.,* 1980 [11] of trace fossils are surveyed, the position of this type is not accurately clear. But Warme (1975, p.205) [21], showed meandering and slightly inclined boring of polychaete worm in intertidal of California. This boring is similar, in many aspects to that found in Tanjero Formation, especially that both have branching and same size (Plate 2.4). It seems that this trace is transitional type between *Trypanite* and *Glossifungite* ichnofacies as it may be excavated in slightly consolidated sediment of shallow environment.

Cruziana assemblage

These structures are found on the top of medium and coarse-grained sandstone, nearly in all sections. In Malkandi section, medium thick sandstone (lithicarenite) beds of the formation are excavated for building stones in the past. There, the lithology of the formation is organized in beds of both coarse and medium grained sandstones with many interbed of conglomerate. The burrows are very common and can also be seen on surfaces of building stones used in the past inside Sulaimaniya City.

The burrowing traces mostly consist of straight and horizontal or slightly curved burrows (Plate 4.1). Most of them have smooth surface while few have side ridges (Plate4.2). In some cases, they are branching (Plate 3.2) especially those found in the upper part of the formation (in limestone beds of mixed carbonate-siliciclastic succession). In literature, similar structures are considered to *Thalassinoides and Planolite* trace fossils, which are included in Cruziana assemblage by Kennedy (1975) [22]. Latter traces are found in both shallow and deep environment, by Chamberlain (1975, p.446) [23] who published sketches of burrowing of recent non-marine aquatic environments, which closely resemble those found in Tanjero Formation. He attributed these structures to moving snail, shrimp, and mayfly and caddisfly larvae on the soft sediments.

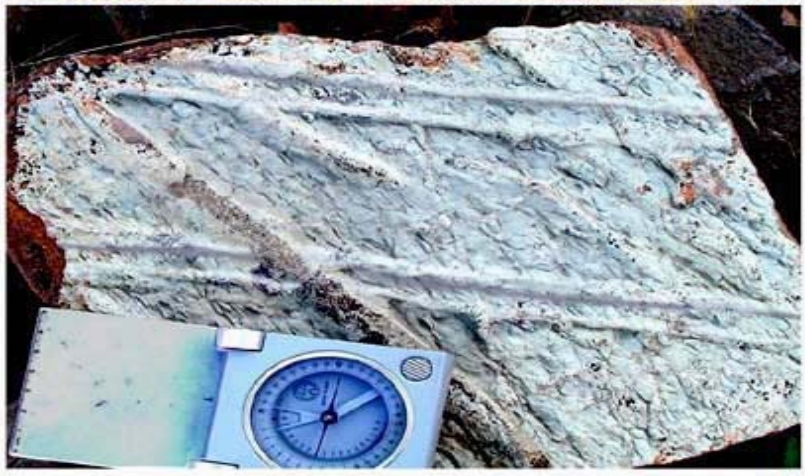
In the Tanjero Formation, most of Cruziana and *Skolithos* trace fossils are attributed to either pelecypods or gastropods. The are only the fossil recorded in the lower part, which may be responsible for above traces, is pelecypods. But in the upper part both fossils are very abundant especially in the fossiliferous limestone beds.

Finally it is worth to mention that these traces belong to Cruziana Ichnofacies because:

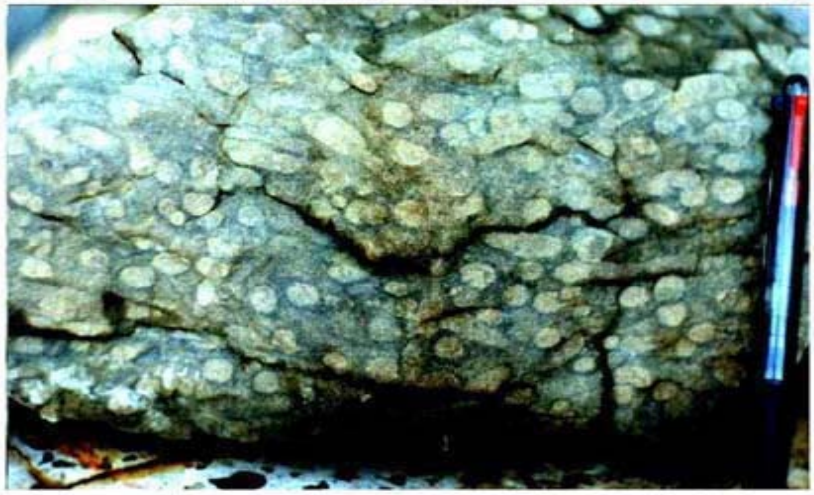
1-They exist, as *Cruziana*, in coarse and medium grained sandstones and they

Plate 4

(1) Horizontal burrows (planolite) on a thick, coarse and clean sandstone bed in L.P. of Tanjero Formation. In this study it is regarded a type of Cruziana assemblage as done by Kennedy, (1975). They are formed below fairweather base after the event of storm or turbidity current when the envirnnment became calm. Malkandy section, 2km north of Sulaimaniya.



(2) Two ridged horizontal trace fossils of genus Aulichnites (Cruziana ichnofacies) intersecting with cylindrical burrow on lower surface of sandstone bed. L.P of Tanjero Formation at about 350 m east of Mara Rash V illage, Chuarta area.



(3) Highly bioturbated sandstone bed showing cross section of horizontal trace fossils. The diameter is abuot 1cm so it may be belong to Planolite genus. It is found in the Middle Part, about 50m above its contact with the Lower Part in Chuarta area at the valley of Azira Bichkolla. It is mostly consisting of condensed section (MFS). The penci is 16cm long and 0.6cm thick.

Location:
Latitude: 35° 39' 36.4"
Longitude: 45° 30' 6"

Plate 5

(1) Carbonized 50 cm long plant stem found in coares sandstone of Lower Part of Tanjero at 450m southeast of Qamar Telly village, the elongate axis is directed toward S-N which indicate southern direction of Paleo-current.

(2) Petrified 15 cm long and 3cm thick plant stem found in thick conglom-erate bed of the lower part of Tanjero at 50m northeast of Nawar Village, Sirwan Valley, Halabja area, type section of the formation.

(3) Petrified grass body fossil found in thick pebbly sandstone of L.P of the formation at 2km to the south of Dokan Dam on the right bank of Little Zab River (Qashqully stream). The nedle is 2.5cm long.

(4) General view of the above sample, the area enclosed in the white circle is enlarged in the above photo. These grass body fossils possibly belong to genus Crinum.

resemble them except in the lack of striate markings on the lobes (flanks).

2-They exist in the lower part of the formation, which contains coarsest sediment (e.g. Kato Conglomerate). Therefore this part is deposited in shallow water during sea level fall.

Body fossils plant remains (debris or fragments)

Nearly all sections and outcrops of lower part of Tanjero Formation, as Dokan, Chuarta, Malkandi, Qrga, Chaqchaq Valley and Sirwan sections contain plant remains, such as, folio, piece of branches and worn parts of cuticles (Plate 5. 1 and 6.4). So these remains can be regarded as incomplete body fossils. These remains are found on the surface or inside the medium bedded sandstone and they commonly appear as light or dark carbonized brown pieces of different size. Under binocular microscope minute plant structures (fibers) of this debris can be seen (Plate 6.1). In Sirwan section (type section) a petrified non- carbonized or non-oxidized wood is found (Plate 5.2) in thickbed of conglomerate. This piece seems like a piece of recent dried wood.

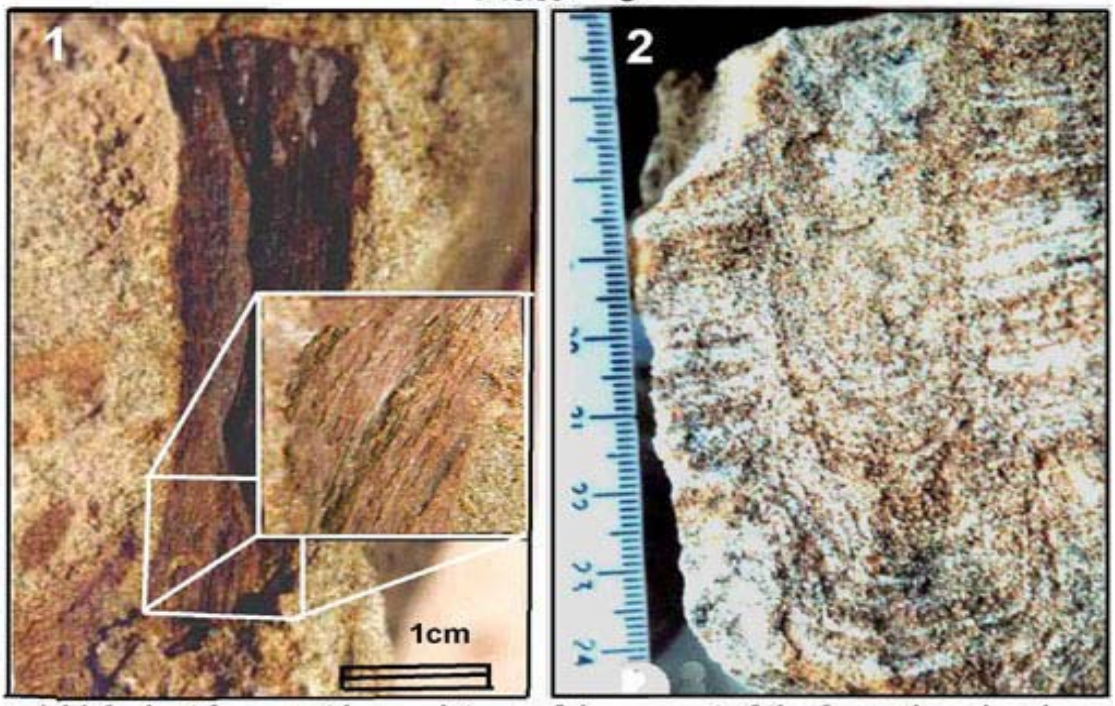
In some sections such as Chaqchaq valley, between Fayal and Lower Hanaran villages (northwest of Sulaimaniya city) and Malkandi hill, more than 15 horizons are found in an interval of 20m at the lower part of the formation, which contains clear and densely distributed plant remains. Moreover they are occasionally associated with cross lamination, and included in beds that generally have light color (light brown).

In Tanjero Formation these fragments are transported to the basin from coastal area through or by incised valleys or from source area by river flooding. They may be introduced to the basin from the incised valleys by large current generated by storm and deposited in shallow environments with sand or gravels. They may be reworked by storm as tempestite sediments and transported to deeper environment by turbidity current through the fan channels. Another possibility for presence of plant debris is that mentioned by Einsele, 2000) [24] that supratidal seaweed and other plants might be eroded by storm and then deposited, forming tempestite in the beach. Ainsworth and Crowley (1994, p.683) [25] mentioned that concentration of plant debris suggests proximity to shore. Smith and Jacobi (2001, p.336 and p.338) [26] found carbonized wood fragments in lowstand sand sediments in the Canadaway Group from New York State. The fragments found by them are similar to those found in Tanjero Formation. In Jurassic fluvial sediment of China, Shao et al. (2003) [27] recorded occurrence of tree trunk in conglomerate and sandstone. Phillips (2003) [28] found large carbonitized wood fragment up to 20cm thick in the sediment of flood plain in the Cretaceous sediment of Alaska.

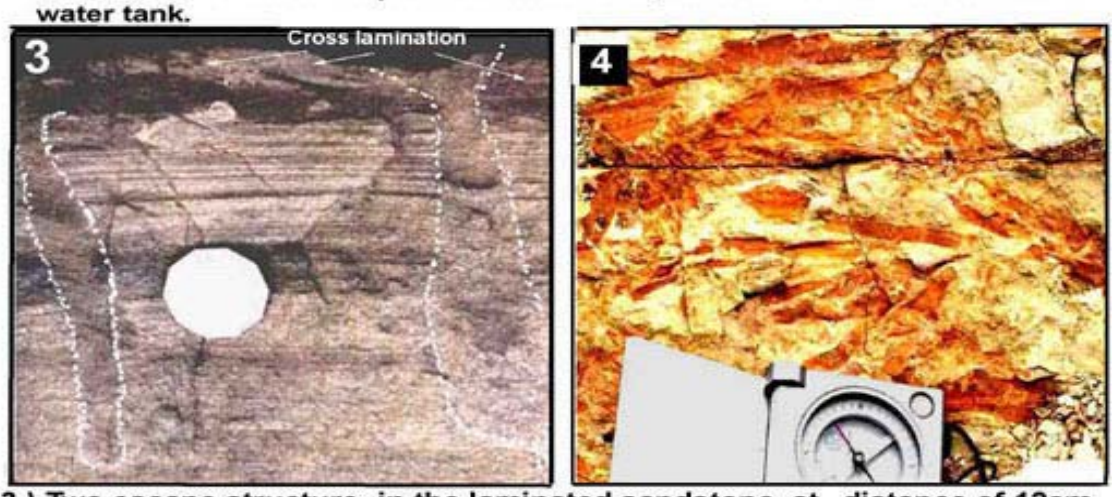
Grass structure

This type of structure is found in the uppermost part below the contact with Kolosh Formation in Dokan area. It is located on the left bank of Little Zab River about 400 meters down stream of the Dokan Bridge (Plate 5.3 and 5.4). It is known as

Plate 6



(1) A plant fragment in sandstone of lower part of the formation showing minute structues of the origional plant. Dokan section.
(2) U-U-shaped escape structure in clean and well sorted coarse sandstone of the lower part at Malkandi hill, at 1km to the northwest of water tank.



(3) Two escape structures in the laminated sandstone at distance of 12cm , the sample is cross laminated at the top.
(4) Oxidixed brown plant debris, showing parallel arrangment found in the lowstand sandstone wedge at 500m southwest of Fayal village in Chaqchaq Valley. They are directed southeast northwest as shown by compass neddle which indicates paleocurrent.

Qashqully picnic area. There, the upper part of the formation exists as a 50 m thick package of light brown calcareous sandstones, with occasional pebbly sandstone. These beds form many small ridges along the river. Some of these beds contain iron oxides laminae and concretions, which are possibly deposited in shallow environment. On the surface of one of these beds, the author has found many small clusters of complete herb-body fossils.

These structures consist of the mold of complete grass, which directly reflect morphology of the plant at the time of its burial. The framework of the plants consists of main stems, dendritic branches and small bulbous elongate leaves. The leaves exist at the end of each branch (Plate 5.3). The roots of these plants are not found with them so this means that they are transported to the site of deposition from continental source area. As there is no carbonaceous remain with these fossils, so it is evident that the grasses were buried when they are alive and green.

Sarjent (1975, p.163) [29] interpreted this structure as body- fossils. This is because, as he added, it reflects the shape of the plant at the time of death. In Tanjero Formation, these plants with associated lithology prove the shallowness of the upper part of the formation. This is because, brown color, iron oxides, pebbly sandstones and grass molds collectively indicate shallow environments for deposition of this interval. In this study the shallowness of the upper part is due to sediment fill. The occurrence of plant body fossils in Tanjero Formation proves wet, worm and stormy climate of the Maastrichtian age at the studied area.

Sedimentary structures and rate of sedimentation in Tanjero Formation

The source area is characterized by relatively soft rock (erodible rocks) and high tectonic activity. Therefore huge quantity of sediments is delivered to Tanjero depositional basin by rivers. This fact is truly demonstrated by habit of the organism during high rate of sedimentation. Blatt *et al*. (1980, p.196) [8], mentioned that the organisms, resting just below sediment surface, are covered by rapid influx of sediment, they will burrow (vertically) to new surface and produce new sets of resting traces. The following examples manifest the response of organism to high rate of sedimentation in Tanjero Formation:

At the distal area of Tanjero basin (slope area) such as at Dokan area, several 10cm thick beds are penetrated by Skolithos escape trace fossils (Plate 6.3). At the middle distance between distal and proximal area slope such as north of Sulaimaniya city, many 30 cm thick beds can be observed penetrated by the escape traces. At the latter locality one can see abundant dwelling Skolithos trace fossils (Plate 3.1and 3.3). Some of these traces are more than 70cm in length and found in both silty marl and in clean sandstone (Plate 2.3). It is most possibly that these traces are imprinted in tempestite (storm deposit) and in small-scale turbidity flow. But large-scale turbidity flow gives no opportunity to the organism to make escape or dwelling traces as they may be wiped out from the previously deposited beds. The maximum time span for escape trace fossil is no more than one day. It is possible that some bed, which contains escape structure, is

deposited in one day. From this, it appears that the sedimentation rate was very high. In some cases, it possibly reached more than 30cm in one day. The rapid deposition is associated with erosion so that the calculation of actual time (in years) of deposition of the Formation cannot be done from the thickness of the sediments divide by the number of beds. This erosion is indicated by truncation of sandstone beds by storm or turbidity currents.

At Malkandi section and Qandil foothill area (Naudasht valley), large cross bedding is found (Plate 1.4). A large scale cross bedding is exceptionally found with foresets thickness of more than 1.5m thick (Plate 1.1and 1.2). According to Blatt et al. (1980, p.132) [8], single cross-stratified bed without major break, may be deposited in a period not exceeding a few days. So the rate of sedimentation is sometimes about nearly 1m in a week.

Inferred environment of the formation

As mentioned in the introduction divided the formation into three parts. All the sedimentary structures mentioned in this paper are found in the lower and upper parts. The middle part contains none of them. The presence of these structures and the type of the lithology prove that the lower and upper parts were deposited in shallow marine environments whereas the middle part was deposited in deep basinal environment. During Upper Cretaceous, Chuarta, Mawat and Qandil area were covered by the shallow environment of shelf, while the areas to the south of Azmir, Goizha, Daban, and Sara Anticlines were covered by slope environment. The occurrence of plant debris and body fossils in Tanjero Formation proves wet, warm and stormy climate of the Maastrichtian age at the studied area.

The environment may has been controlled by the greenhouse effect which prevailed during Cretaceous and terminated at the end of Maastrichtian Stage. This stage marks the last eight million years of the Cretaceous and with falling sea-levels and reduced temperature appears to mark the end of the Cretaceous "greenhouse" world which ended at the Cretaceous –Tertiary boundary.

Conclusions

The study revealed the following results:

1-The the Tanjero Formation many new sedimentary structures are found for the first time. These structures as large scale cross bedding skolithos dwelling and escape structure, cruziana trace fossils, borings, and plant debris and plant body fossils

2. These structures prove that the rate of sedimentation of the formation was high, in some case more than 30cm in a day.

3. The lower and upper parts of Tanjero Formation were deposited in shallow marine environment while the middle one deposited in deep basinal environment.

4. All the structures are described environmentally and morphologically with giving the accurate geographical location. The description is aided by clear photos as visual prove to what has been found by us.

Reference

[1]-Buday, T. . In: *Regional Geology of Iraq*1, Stratigraphy, D. G. Geol. Surv. Min. Invest. Publ. **1980,** 445.

[2]-Buday, T. and Jassim, S.Z. . The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism , Baghdad, **1987,** 445**..**

[3]-Bellen, R. C. Van, Dunnington, H. V., Wetzel, R. and Morton, D., Lexique *Stratigraphique, Interntional. Asie, Iraq*, **1959.** 3**c** (10a), 333.

[4]Al-Rawi, I. K ,**.** Sedimentology and Petrology of Tanjero Clastic Formation in north and northeastern Iraq. Unpublished Ph.D. Thesis, University of Baghdad, **1981,** 295 .

[5]Jaza, I, M. **1992.** Sedimentary facies analysis of the Tanjero Clastic Formation in Sulaimaniya district, northeast Iraq. Unpubl. MSc thesis, Salahaddin University,121p.

[6]-Karim, K.H. Basin analysis of Tanjero Formation in Sulaimaniya area, NE-Iraq. Unpublished Ph.D. Thesis,**.** University of Sulaimani, **2004,** 135.

[7]-Bowen, D. and Weimer, P., *Regional sequence stratigraphy setting and reservoir geology of Morrow incised –valley sandstone (Lower Pennsylvanian) Eastern Colorado and Westrn Kansas*. *AAPG Bull*. **2003,** 87 **(**5).781-815..

[8]-Blatt, H., Middleton, G. and Murray, R. *Origin of Sedimentary Rocks.* Second edition, Prentice Hall Pupl. Co., New Jersey, 782**. 1980**.

[9]- Jassim, S. Z. and Al-Hassan. Petrography and Origin of the Mawat and Penjuin Igneous Complexes. Jour. Geol. Soc. Iraq. Special Issue on 4th Iraqi Geol. Conf., Baghdad,**1977.**

[10]-Allen, P. A. and Allen, J. R., Basin Analysis: Principles and Application. Blackwell Scientific Publications, **1990,** 450**.**

[11]-Potter, P.E., Maynard, J. B. and Pryor, W.A.. Sedimentology of Shale: Study Guide and Reference Source, Springer-Verlage, **1980,** 306**.**.

[12]-Nichols, G.. *Sedimentology, and Stratigraphy,* Blackwell Science Ltd., **1999,**355.

[13]-Fray, R.W. *The Study of Trace Fossils*. Springer-Verlage, Berlin, 562, 1975.

[14]-Simpson, S. , Classification of trace fossils. In R. W. Fray. The Study of Trace Fossils. Springer-Verlage, Berlin New York, **1975,** 562p**.**

[15]-Einsele, G. **.** Event Stratigraphy: Recognition and interpretation of Sedimentary Even Horizons, in: Doyle, P. and Bennett, M. R. (editors). Unlocking the Stratigraphical Record, John Wiley & Son, New York, 1998**,** 532.

[16]-Rhoads, D. C. The paleoecological and environmental significance of trace fossils: In Fray ,R. W.. *The Study of Trace Fossils*. Springer-Verlage, Berlin New York,, 1975, 562 .

[17]-Seilacher, A. Bathymetry of Trace Fossils; Marine Geology (5) ,**1967** p. 413-429.

[18]-Doyle, P. and Bennett, M. R.Interpreting paleoenvironments from fossils, in*:* Unlocking the Stratigraphical Record (Advance in Modern Stratigraphy*).* John Wiley & Sons, New York. **1998**

[19]-Lawa, F. A. . Marine and non-marine ichnofossils of the Middle and Upper Miocene sediments in the area between Mosul and Qaiyarah, N-Iraq. *Iraqi Geological Journal,*. **1998.**28 (2) pp.185-194

[20]-Tucker, M. E., Sedimentary Petrology, Blackwell Science Publication Co. **1991,** 260p..

[21]-Warme, J. E. R . Borings as a trace Fossils, and the processes of marine bioerossion: in Fray, R. W. The Study of Trace Fossils, Springer-Verlag, Berlin, New York, **1975,** 560,

[22]- Kennedy, w. J. . Trace fossils in carbonate rocks, in: Fray, R. W. The Study of Trace Fossils, Springer-Verlag, Berlin, New York, **1975,**560 **..**

[23]-Chamberlain, C. K. . Recent lebensspuren in nom marine aquatic environments. In R. W. Frey, *The Study of Trace Fossils,* Springer-Verlag, Berlin, New York, 560p. 1975.

[24]-Einsele, G., Sedimentary Basin: Evolution, Facies and Sediment Budget. 2nd ed. Springer, 792p**. 2000.**

[25]-Ainsworth, R. B. and Crowley, S. F. Wave–dominated near shore sedimentation and "forced" regression: post abandoned facies, Great Limestone Cyclothem, Stainmore, UK. *Journal of the Geological Society, London*. **, 1994.**151(2), pp.681-695

[26]-Smith, G. J. and Jacobi, R. D.Tectonic and eustatic signal in the sequence stratigraphy of the Upper Devonian Canada way Group, New York State, *AAPG Bull.* **2001,**85(2), pp. 325-360..

[27]-Shao, L., Zhang, P., Hilton, J., Gayer, R., Wang, Y., Zhao, C. and Luo, Z.,. *Paleoenvironment and paleogeography of the Lower and lower Middle Jurassic coal measures in the Turpan-Hami oil-prone coal basin, northwestern China*. **AAPG** *Bulletin* , **2003** 87(2). Pp.335-355..

[28]-Phillips, R.L. *Depostional environment and processes in upper Cretacous nomarine and marine sediments, Ocean Point dinasour locality, North Slope Alaska, Cretaceous* Research,**2003.** 24**,** pp.499-523.

[29]-Sarjent, W. A. S. Plant traces fossils: In R. W. Fray. *The Study of Trace Fossils*. Springer- Verlage, Berlin New York, 562p. **1975.**

ژینگەی کۆنی پیکهاتووی تانجەڕۆ کە بەهۆی دروست بووی نشتوویی دۆزراوەتەوە لە پارێزگای سلێمانی، هەرێمی کردستان , باکووری رۆژهەلاتی عێراق

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پووختە

لەم لێکۆڵینەوەیەدا گەلێك دروست بووی نشتوویی دۆزرایەوە لە پێکهاتووی تانجیرۆ (کریتاسی سەروو) دروست بووانە هەموویان بۆ یەکەم جار دۆزراوەتەوە لە ناو لە پێکهاتووی تانجیرۆ وە هەموویان باس کراون بە درێژی لە ڕووی وەپۆلێن کردن و شێوەو ژینگەوە لە گەڵ گرتنی وێنەی زۆر وورد بۆیان وەك ئامێریکی ڕوونکردنەوە . بە هۆی ئەم دروستبوونانەوە سەلێنراوە کە بەشی خوارەوەو سەرەوەی پێکهاتوەکە لە ژینگەیەکی کەم قووڵدا نیشتوە بەڵام بەشی ناوەراست لە دەریای قوڵ دا نیشتوە. ئەم دروست بووانەش وەکوو :چینەیەك یەکتربڕپوە گەورەکان و ئاسارە بە بەرد بووی جۆری سکۆلیسۆسی دەرباز بوون و خانەیی وە کروزیانە وە شوێنەوارە هەڵکەندن و ووردە درەخت و هەیکەلی گییایی بە بەردبوو . زووربەی ئەمانە لە بەشی خووارەوەدا دۆزراوەتەوە وە هەندێکی تریان لە بەشی سەرەوەدا بڵام بەشی ناوەراست هیچ لەم دروست بوانەی تێدا نیە . بەهۆی ئەم دروست بووی نشتوویانەوە توانرا کە بسەلێنرێت کە ڕێژەی نیشتن زۆربوە لە ژینگەی تانجرۆدا ، زیاتر بووە لە 30 سم لە یەك ڕۆژدا وە بەشی خووارەوە و ناوەراست لە ژینگەی تەڵك دا نیشتوە وە بەشی ناوەراست لە ژینگەی قوڵ دا نیشتوە.

البيئةالترسيبية لتكوين تانجرو المستنتجة بواسطة تراكيب الرسوبية في محافظة السليمانية ، اقليم كردستان, شمال شرق العراق

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الخلاصة

يشمل التكوين بصورة رئيسية من تبدل من صخور الفتاتية الرملية ولغرينية و المارل(أو الطفل الجيري) ويتغير إلى سمك كبير من مدملكات و الحجر الجيري ذات اصل حياتي في المنطقة قريبة من المصدر.
تم أيجاد كثير من التراكيب الرسوبية ضمن تكوين تانجيرو (الكريتاسي الأعلى) و هذه التراكيب كلها سجلت لاول المرة في التكوين. بواسطة هذة التراكيب استنتج ان الجزئي العلوي و السفلي ترسبا في بيئة ضحلة نسبيا اما الجزئي الوسطي فقد ترسب في بيئة عميقة. من هذه التراكيب : الطبقات المتقاطعة الكبيرة و تراكيب آثار المتحجرات مثل تراكيب السكوليثوس الإفلات والسكن و كروزيانا و وركام النباتي و الهيكل النباتي المتحجر . معظم هذه التراكيب وجدت في الجزء السفلي و بعض الأخر في الجزء العلوي ولكن الجزء الوسطي لا يحتوي على هذه التراكيب . بواسطة هذة التراكيب استنتج بان الترسيب في البيئة الضحلة كانت عا لية نسبيا حيث تجاوزت 30 سم في اليوم الواحد وان الجزئي العلوي والسفلي ترسبا غي بيئة ضحلة ام الوسطي ترسب في بيئة عميقة.

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