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Investigation of Sand Dunes Sedimentary Structures – Najaf Governorate – IRAQ

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Abstract

This research concerns with the study of the sand dunes sedimentary structures in two areas from dunes field of Najaf governorate these are; 1)Al-Rahimiya and 2)Ain Mazlun areas, where the first area consists from barchans, barchanoid, and nabkha dunes types, while the second area has the dome, longitudinal, nabkha, and sand sheet dunes types.

The affected prevailing wind direction is obvious on the study area, where has the NW-SE bearing and the sedimentary structures were influenced by prevailing and local wind directions in studied areas.

Many types of sedimentary structures recognized in the studied areas these are; cross stratification, ripple marks, slump (grain flow), adhesion structures, and bioturbation structures.

The changes in parameters of the depositional environment, which influenced the distribution or formed of special sand dunes sedimentary structures due to changes in climatic conditions at the time.

Keywords: Sedimentary Structure, Sand Dunes, Dunes Field.

دراسة التراكيب الرسوبية للكثبان الرملية في محافظة النجف – العراق

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الخلاصة

يهتم هذا البحث بدراسة التراكيب الرسوبية المرافقة للكثبان الرملية في منطقتين من حقل الكثبان في محافظة النجف،وهي 1) منطقة الرهيمية و2) منطقة عين مظلوم ، حيث ان المنطقة الاولى تتكون من الكثبان الهلالية و كثبان الحواجز الهلالية وكثبان النبخة ، بينما المنطقة الثانية تمتلك كثبان من نوع القبة والطولية والنبخة والصفائح الرملية .

أن تأثير الرياح السائدة واضح في منطقة الدراسة ، حيث ان الاتجاه العام هو شمال غرب – جنوب شرق وان التراكيب الرسوبية متأثره بأتجاه الرياح السائدة والمحلية في مناطق الدراسة .

تم تمييز عدة انواع من التراكيب الرسوبية في مناطق الدراسة ومنها التطبق المتقاطع وعلامات النيم والانهيار الحبيبي وتراكيب التماسك وتراكيب الاثار الاحيائية الناتجة بفعل الاحياء . ان التغير في عوامل البيئة الترسيبية يؤثر على توزيع وتكوّن التراكيب الرسوبية المرافقة للكثبان الرملية بسبب التغير في ظروف المناخ في ذلك الوقت .

1. Introduction

Aeolian sand deposits are distributed in different parts of Iraq [1]. The Najaf dunes field sited in the west and southwest from Najaf city, these filed dunes extend in a prevailing wind NW-SE orientation Figure-1. The study area is located in the western and south-western parts of Najaf city center. The

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first position is located near the village of Al-Rahimiya, Latitude (31º57′42″N), Longitude (44º08′16″ E) and second position located in south of Ain Mazlum, Latitude (31º50′35″ N), Longitude (44º18′13″ E).Figure-2. The dunes field consists of many morphological types of dunes, these are; the Barchan, Barchanoid, and Nabkha dunes in Al-Rahimiya area, while in Ain Mazlum area have the dome, Longitudinal, Nabkha, and Sand sheet dunes. Aeolian sands display various large and small-scale sedimentary structures. The most obvious features are large-scale planar cross beds which characterize the central parts of barchans dunes; their strike is approximately perpendicular to the dominant wind direction [2].

The sedimentary structures in aeolian sand deposits consisted of two wide groups: the first primary sedimentary structures reflected the processes accountable for transport and primary depositional, whereas the second is secondary structures type syn- or post-depositional because of deformation to the first depositional structure [3].

Sedimentary Structures have been used ;(1) as guides to determine the agent or environment of deposition, (2) as guides to stratigraphic order, by determination of top and bottom, (3) to map paleocurrent systems, (4) as indices of flow conditions and (5) to assess chemical changes after deposition [4].

The aim of study investigation of sand dunes sedimentary structures in (Al-Rahimiya and Ain Mazlum) areas in Najaf Governorate, and the comparison between them, and indicated the variety of wind directions in these areas from different sedimentary structures.

2. Methodology:

Two separated methods to be involved in this study:

1- Field Work: which basically is detailed field work in order to study the sedimentary structures, where the measures of dip angles to strata and degrees of bearing by brunton compass, while the measures of thickness bed by tap and rule, and used the GPS devise to indicate the exact points. The morphology of the dunes is indicated in field work and used the field camera equipment.

2- Desk Study Include: The locations of points have the sedimentary structures were located by use (GPS) devise and by using the (Earth Explorer Software). And the data measures calculated by Excel

3- Microsoft office software.

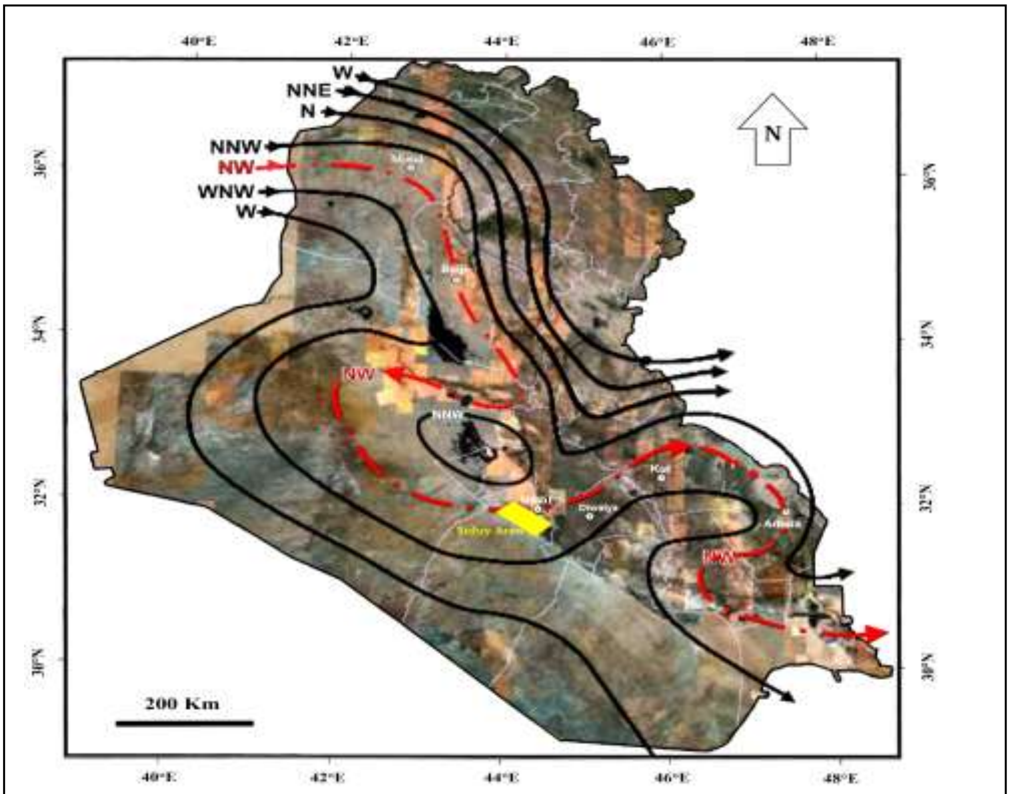

Figure 1-Contour map of wind direction in Iraq [5].

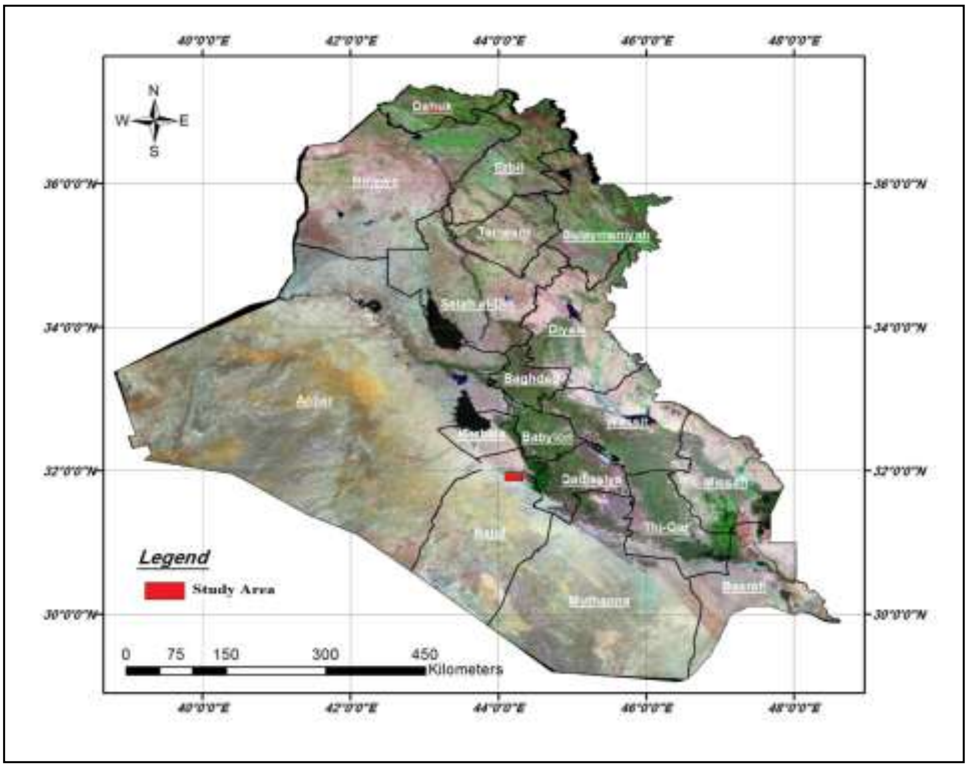

Figure 2-Satellite image of Iraq Shows the Study area

3. Result and Discussion:

Many types of sedimentary structures (primary and secondary) were observed in (Al-Rahimiya and Ain Mazlum) areas from dunes field in Najaf governorate, the descriptions of these structures are discussed below:

1) Cross Stratification:

Closely the bottom of the slip face the foreset laminae often regularly smooth out, giving rise to a concave-upwards profile. Character forest laminae, which are commonly 2.5–5.5cm thick, are grouped together into cross-bed units which can be described with the aid of bounding surfaces. The latter may be planar or curved, even as the cross-bed units may be wedge-formed, tabular, or trough-formed in side view of the section [3] (Fig.3), in Al-Rahimiya area.

The cross-stratified sets that make up the interior of modern aeolian dune- and draa scale bed forms, and ancient aeolian strata, comprise four basic stratification types that occur in various configurations: grainflow strata, grainfall strata, wind-ripple strata, and aeolian plane-bed strata [6].

Cross bedding is ubiquitous within aeolian dune sands and sandstones, and it develops through repeated and continuing lee-slope sedimentation. The interiors of most Aeolian bedforms are composed of cross-bedded sands, and the cross strata provide a record of the successive positions and shape of the bedform lee slope and of the processes that operated on that slope. Where bedforms migrate over one another, cross strata are truncated, and sets delineated by erosive bounding surfaces are generated [7]. The thickness of a cross-bedding unit may vary from a few millimeters to tens of centimeters in all study areas may be the variations in amount of sand supply and energy of transportation.

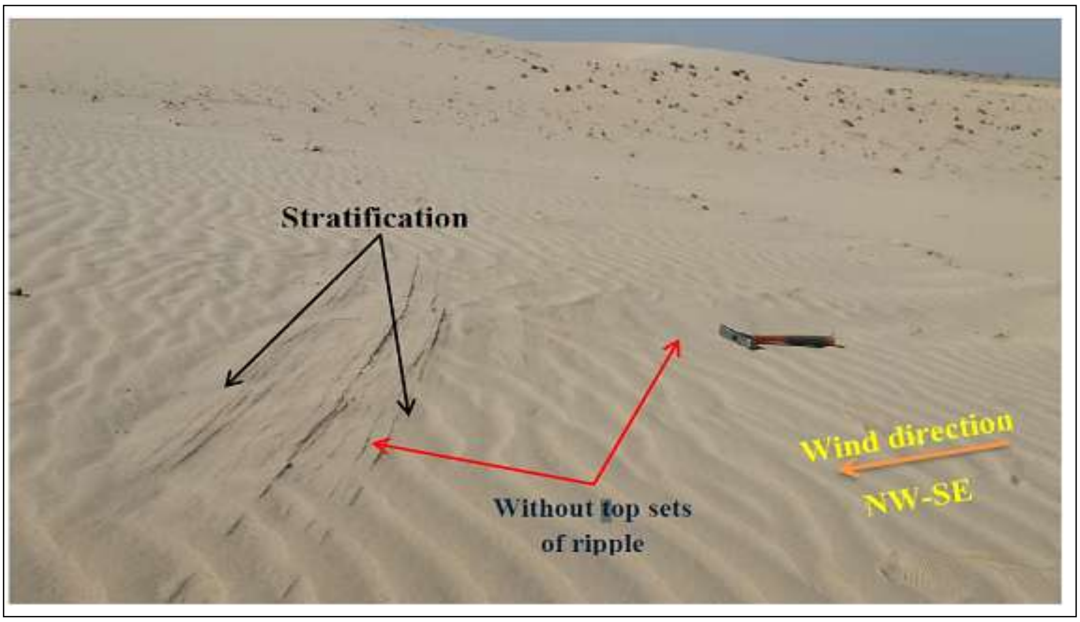

Figure 3-The exposure of stratification from the windward of Barchan dune in Al-Rahimiya area.

Most of cross-bedding classifications are difficult to apply due to the actuality that exposure are usually unsuitable or incomplete exposed .Where the small scale of cross bedding observed in the study area with many of internal cyclicity of deposition and bounding surfaces (Figure-4).

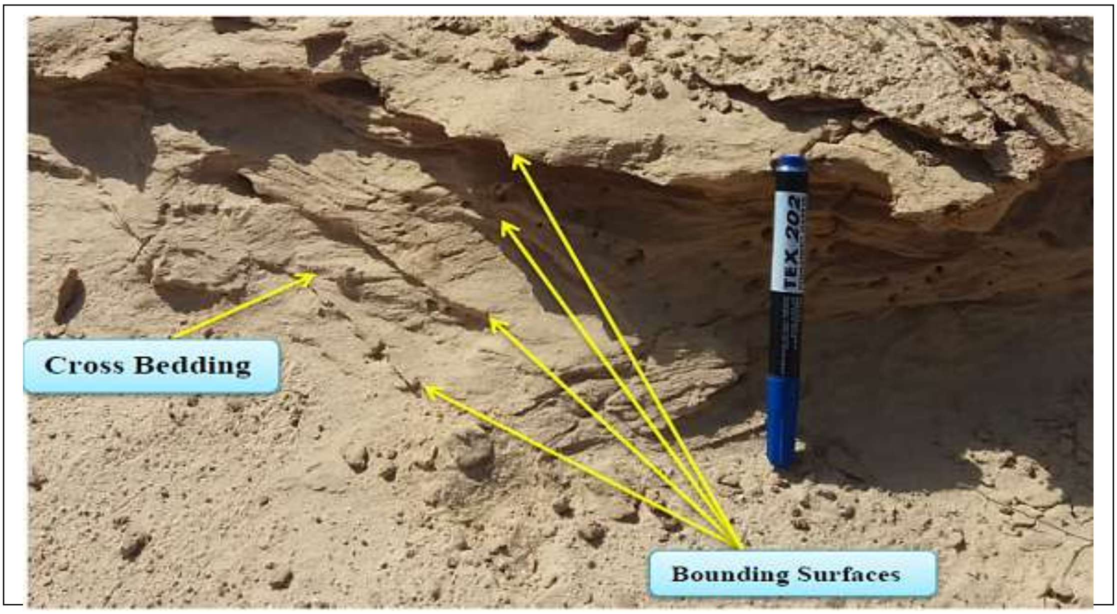

Figure 4-Small cross Stratification with cyclicity of deposition in Al-Rahimiya area, pen scale 13cm.

The planar cross stratification is a characteristic structure of sand dunes formation [8, 9] .Thus this structure is observed in Ain Mazlum area because the reflects slight differences in shape and size, and have a low angle values between the sets of stratification (Figure-5), while in Al-Rahimiya area is Erosional trough surface with 20º-25º values angles between the sets of stratification (Figure-6)

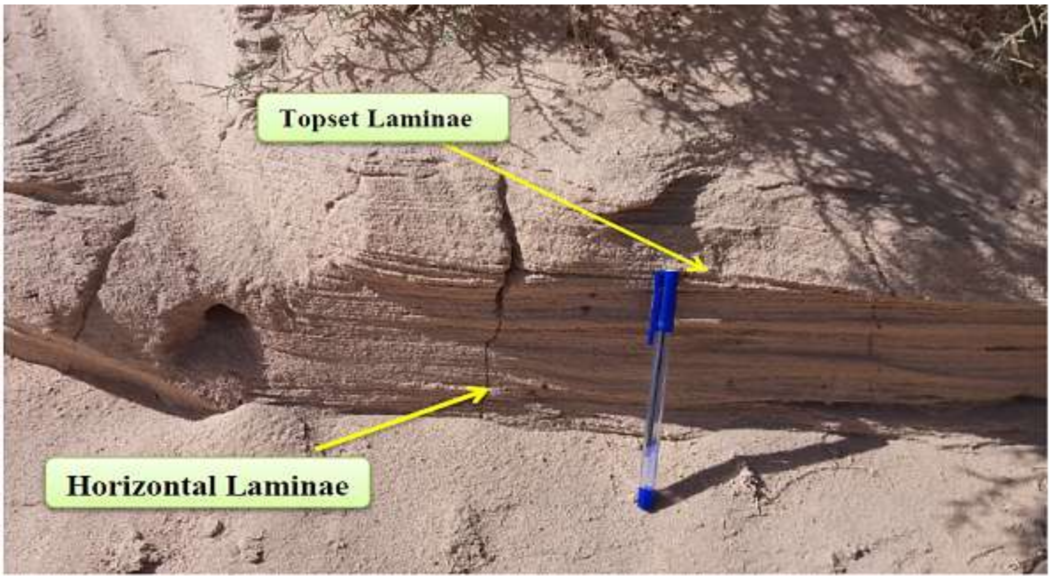

Figure 5-Cross Stratification from Nabkha deposit in Ain Mazlum area have low angle between sets of stratification

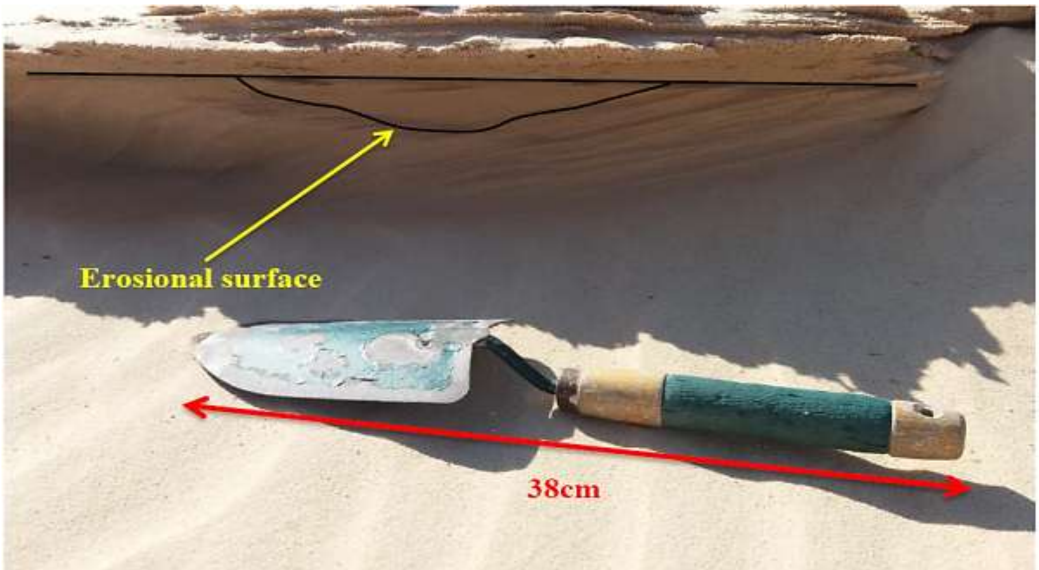

Figure 6-Cross Stratification with trough erosional surface in windward part from barchan dune, in Al-Rahimiya area.

2) Ripple Marks:

Wind ripples are wide spread on all sand surfaces unless those undergoing very rapid deposition and provide a good example of self-governing in aeolian systems [10]. These ripples are elementary restraint of sand surfaces to sand transport by the wind regime, and form because plane sand surfaces on which transport by repetition and saltation occurrences are unstable [11].

The ripples were divided into two main types depending on the size of the ripples:(1) Small ripples have wavelengths of lessthan1cm to 25cm, this type observed in all study area, and (2) Large ripples, describe ridges by [11], but most authors renowned as mega ripples[12-14] this type not presence in study area. Ideal wind ripples have a wavelength between 13 and 300mm and amplitude of 0.6–14mm [10, 15]. The prevailing wind direction on study area is NW-SE (Figures-1and 7), Thus any changing local wind direction the ripples mark changes in their parallel crests are orientated vertically to the wind direction that first site, and in the second site the steeper lee slope on the downwind direction, because the ripples mark are good indicators to wind orientations[3] (Figure-8).

In the cross-section the ripples mark can be partition into four parts:1)Lee slope-side, 2)Crest (peak), 3)Stoss slope-side, and 4)Trough between two crests, Where the aeolian ripples have the maximum slope of the stoss side ranging between 8º to 10ºdgree, whereas that of the lee slope-side ranging between 20º to 30ºdgree. The wavelength of ripples is a function of wind velocity, particle size of sand, and separation with sorting so, that ripples in coarse sands have a greater interval than those in fine sands [16].The asymmetrical ripples marks observed in all study area because of effects of wind direction .

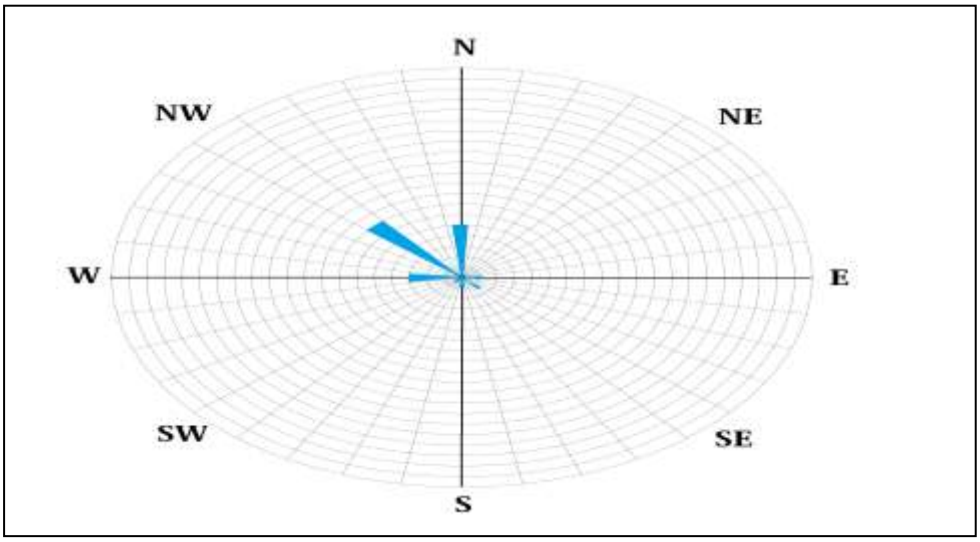

Figure 7-Rose Diagram of prevailing Mean annual wind direction in Najaf Meteorological Station. [17].

Figure 8-Show changing in local wind direction by formed new ripple on exist ripple on windward of barchan dune Al-Rahimiya area.

The examine of relationship between the wavelength (L) and high of two crests(h) result the ripple index (RI) is a dimensionless index, can frequently be used to distinguish the distinctive types of ripples.This index variation in horns, body, and crest of barchans dune is in Al-Rahimiya area , because changing of wind speed and energy is to load of sand fractions.

Fifty readings were recorded to measure the wavelength (L) and height (h) to determine the ripple index (RI) from Crest, Windward body, and Horns sides of barchan dune in Al-Rahimiya area (Table 1) and (Figure-9). The average ripple index of crest position is (21.3), while in the windward body is

(18.13) and on the (west, east) horns are (22.41) and (19.59) respectively. The changes in ripple index indicated change in wind velocity regime and the size of grains sand [16,18].The result of this examined that the speed wind is more than the horns positions in barchans dune, and the index ripples have same values of wind ripples have RI > 10–15, while the water ripples have RI < 10–15, the completed from previous study [19, 20, 11, 16, 21-23].

Table 1-The average of wave length (L), Height (h), and Ripple index (RI) to several barchan dune in Al-Rahimiya area.

Average of reading	*Wave length (L)cm*	*Height(h)cm*	*Ripple index(RI)*
Windward body	**12.71**	**0.71**	**18.13**
Crest	**8.39**	**0.40**	**21.33**
West horn	**10.69**	**0.50**	**22.41**
East horn	**11.12**	**0.58**	**19.59**

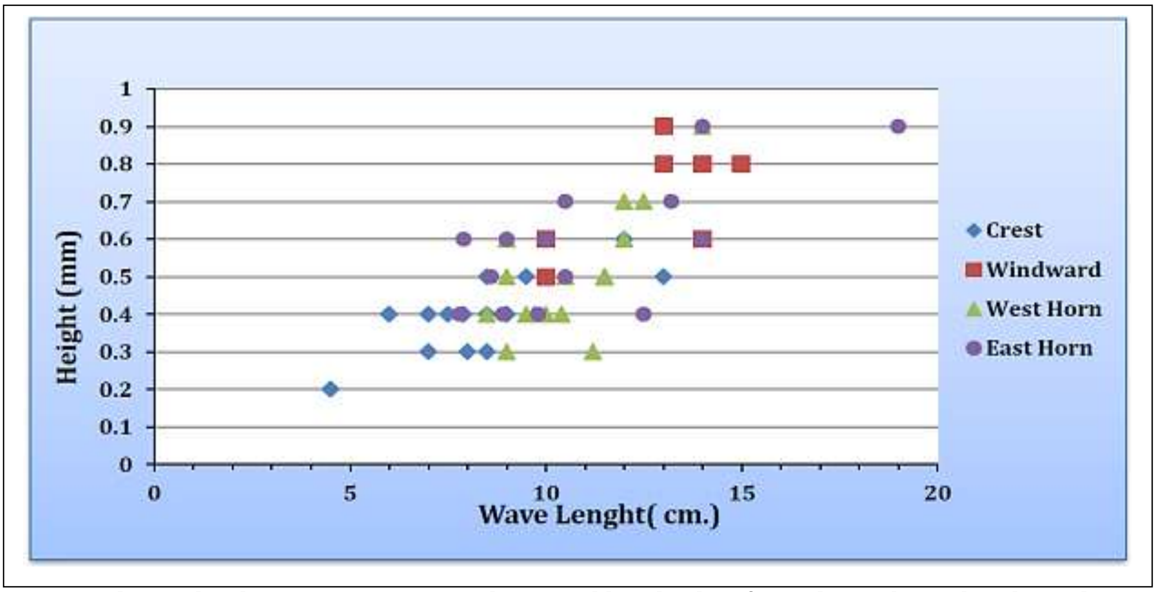

Figure 9- Relationship between Wave Length (L) and height (h) of Ripple marks on barchans dune in Al-Rahimiya area.

Ripple marks are the most common and visible structures in Al-Rahimiya area, wind ripple marks were recognized in the field, these ripples mark clothing most surfaces of the barchan dune and most asymmetrical type, while at Ain Mazlum area weakly present.

According to crest shape of ripple marks,[24] Tucker (2001)classified this phenomenon into six types ;(1)Straight-Crested Ripples,(2)Catenary ,(3)Sinuous Ripples,(4) Lunate Ripples,(5)Lunate, and(6) Wave-Formed Ripples. In the study area observed sinuous and wave-formed ripples in Al-Rahimiya area Figures- (10,11).While the Lunate type and straight- crested ripples in Ain Mazlum area Figures-(12, 13).

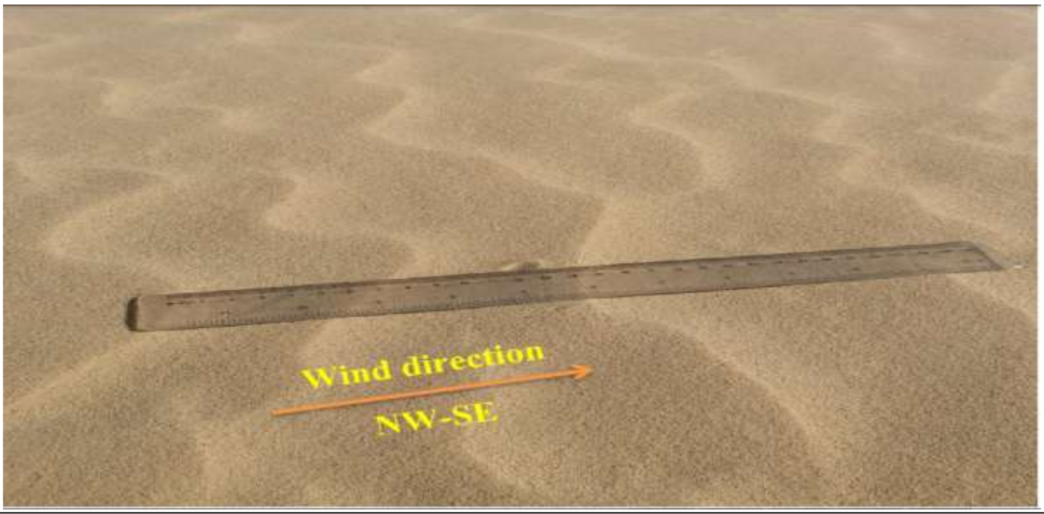

Figure 10- Sinuous ripples in Al-Rahimiya area.

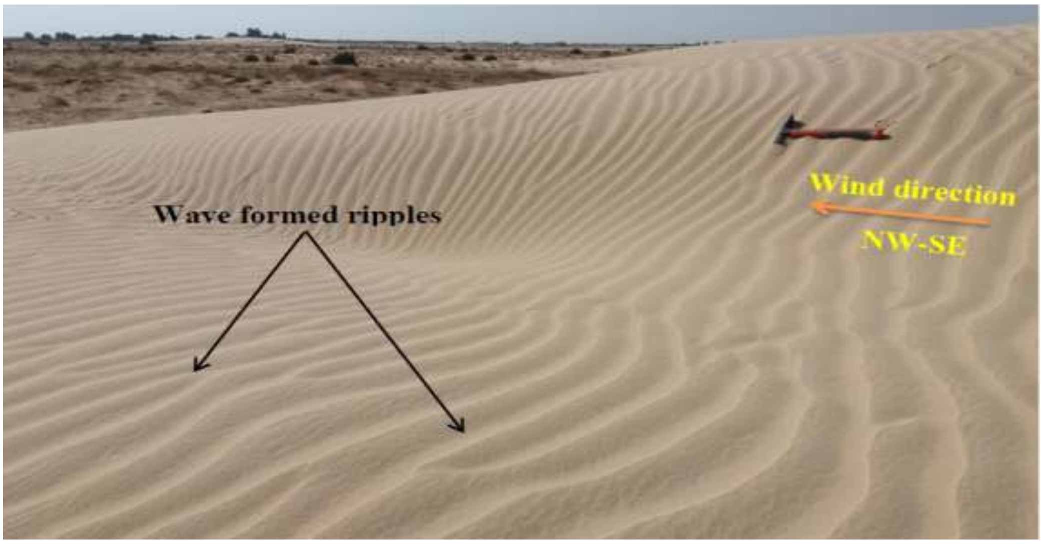

Figure 11-Wave formed ripples in Al-Rahimiya area.

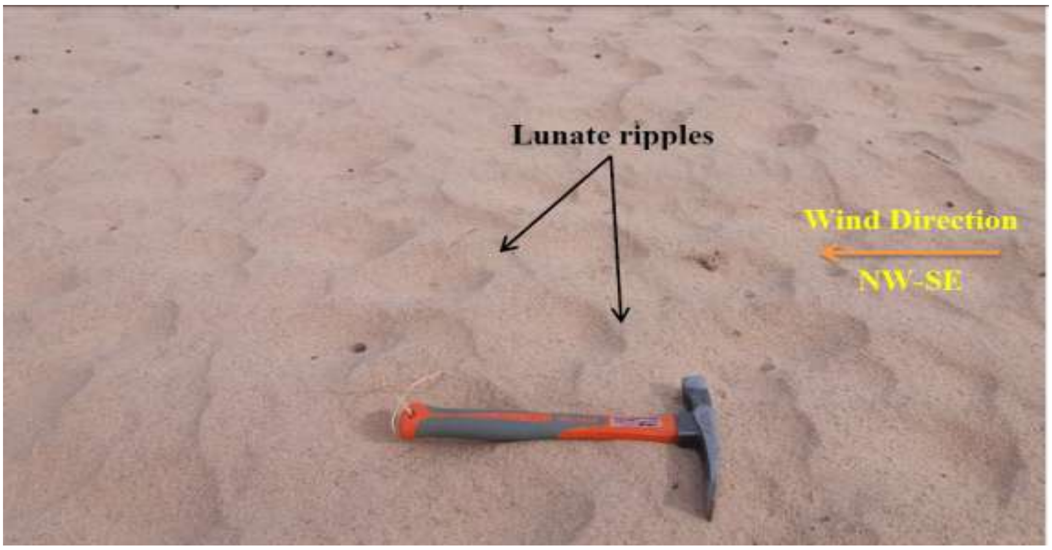

Figure 12- Lunate ripples in Ain Mazlum area.

Figure 13-Straight-crested ripples in Ain Mazlum area.

3) Slump (Grain flow) Structure:

In a similarly to sedimentary structures created via primary aeolian deposition and bed style emigration, the deposits of sand dunes normally show an extensive range of post-or syn-depositional deformation systems. The essential causes of deformation are slumping (collapsing) of soft cohesive of sand assemblage [3].

A classification of grain-slump morphologically is offered that links kinds of influx with wind power and path, turbulent of flow air, and environment of sediment deposition.Slumping structure variety from small, apparent flows to large flows that affect extra quantities of the slipface, transferring great amounts of sediment [25]

Observed the Hourglass grain flows type (Figure-14) in west horn from one barchans dune in Al-Rahimiya area .Wherein this kind fashioned by sediment swelling a quick distance from the dune brink line because of an aggregation of sand sediments via grains downfall, reputation and saltation. The following inception of the grains flow outcomes inside the formation of an alcove thru scarp recession simply underneath the crest that spreads upward and develop laterally [26, 8, 27, 28]. The alcove body composes as sediment flow downslope, and formed a neck at the point of steepest gradient on the lee slope, and then the sediment pile as a fan at the base of horn dune [29]. While in Ain Mazlum area is not distinguished may be the characteristics of dunes type affected to form this structures. And the brink line is critical angle of sand accumulation.

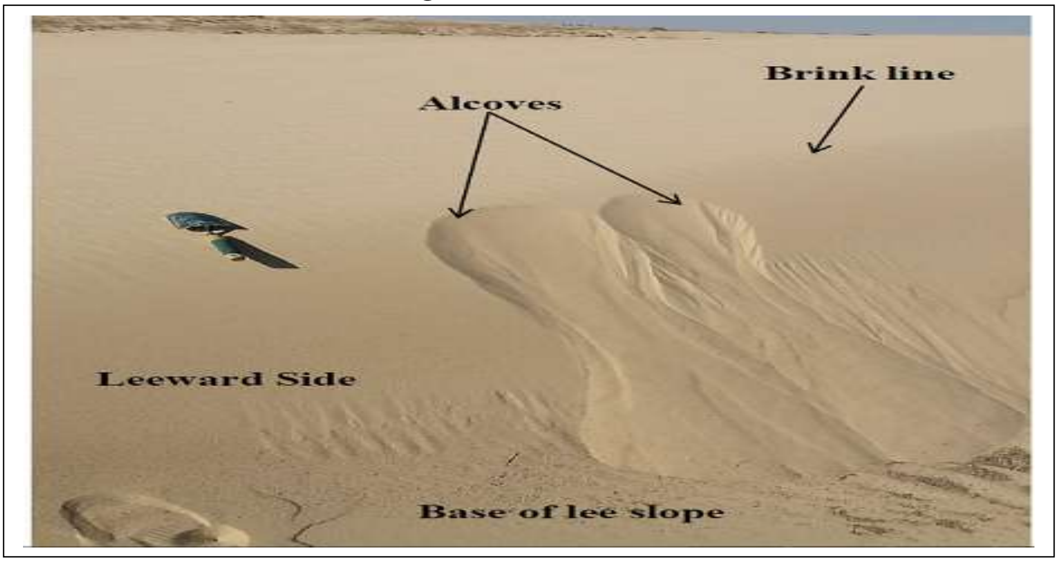

Figure 14-Grain flow (Slump) structure hourglass type, in Al-Rahimiya area.

4) Adhesion Structures:

Adhesion structures form through the coalescing of dry, wind-blown sand to a wetted or moist surface. There are three types of adhesion structures tacks place in dunes: (1) ripples adhesion, (2) adhesion verruca structures, and (3) adhesion flatbed (cohesive laminations) [30].

These systems structure increase broadly by way of dry, blown sand adhering to wet surface of 1 kind to every other, and therefore amassing to form either a convexo-convex mounded structure or an abnormal coat overlaying small scale topographic features [31].

In the Najaf dune field observed the adhesion structures especially in Al-Rahimiya area , these may be considered as one of the ephemeral features that are caused by the abundance of moisture between sand grains which is due to rainfall and moisture, as the cohesive action of water holds the wet sand grains together(Figure- 15).

The blown wind takes part in the deflation and transportation of the dry sand grain from surfaces of wet dunes and leaving the adhesion laminations exposed on dune surfaces in Al-Rahimiya area (Figure-16), and in Ain Mazlum area (Figure-17).

Figure 15- Adhesion laminations from windward surface in Al-Rahimiya area.

Figure 16-Adhesion Structure in surface barchans dune Al-Rahimiya area.

Figure 17-Adhesion structure with wet sand ripples after rainfall day, in Ain Mazlum area.

5) Bioturbation Structures:

The effects of organisms can be retained in the eolian sand if the sand is coherent when its vitality is fragmented, if the organism probably enhances or prefers the burrow or mold, or if the impact is buried quickly [32].Sand adhesive by sedimentation or moisture [11]. The solidarity of aeolian sand by means of wetting is typically stated as the mechanization via which and tracks, trails, and raindrop imprints are preserved in aeolian sand. The burrows that penetrate a solid layer of sand should be preserved, providing that it isn't always destroyed with the aid of weathering and erosion [33, 34].

The effects of biological discoveries can be identified in the primordial sediments developed and some organisms adapt to life in sand dunes, a lot of which make numerous specific styles of burrows [35].Although geologists have long been conscious of the pleasance of burrows, tracks, trails and other biogenic structure in sedimentary rocks, these structures are known collectively called as or Ichnofossils or trace fossils [36]. [37] Frey (1973) classified trace fossils into five principle groups: feeding structure, dwelling structure, crawling traces, resting traces and grazing traces.

Many of bioturbation traces are observed in two studies areas, Boring structure made into hard substrata or hard ground surface (Figures-18 and 19). Tracks are temperament on the surface of a bed of sediment produced by the feet of animals; these may belong to beetles or bird tracks. The trails are groove-like impressions on the sand surfaces of produced by an organism which crawls or drags part of its body. Trails may be straight or curved line in Al-Rahimiya area (Figure-20).

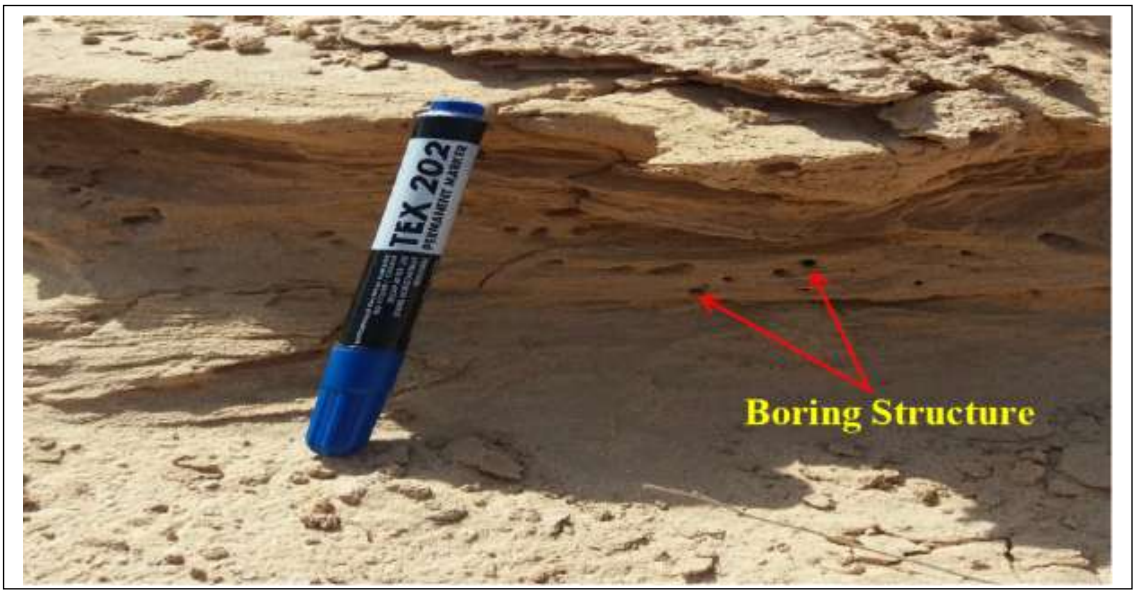

Figure 18- Boring structures in Al-Rahimiya area, the pen scale 13cm.

Figure 19- Borings structures and tracks in Ain Mazlum area.

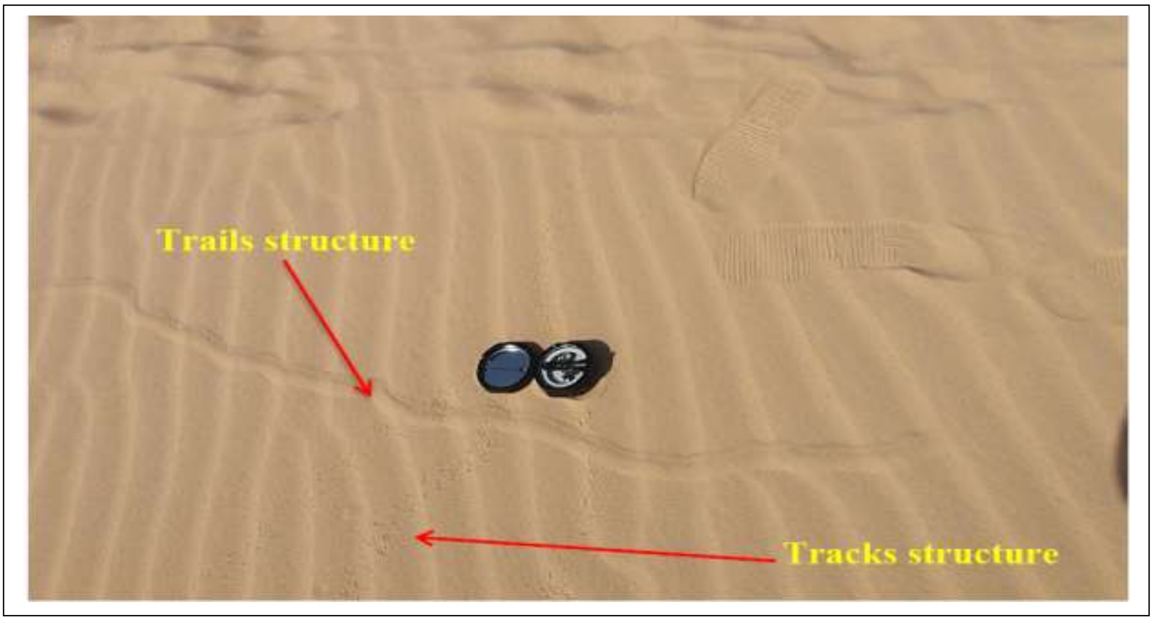

Figure 20-Trails and Tracks structures in Al-Rahimiya area.

6) Dikaka Structure:

The Arabic word is origin of the word "dikaka"; it means scrub-covered of sand dune, has been selected to name the latter form of the structure of plant roots. The structures of plant-root, which are normally associated with low-lying salt-marsh such as environments, have regionally been discovered within the dune sands of arid deserts. This structure preferred cement by using gypsum minerals, is existence where this water has been in especially high briny [38].

The dikaka structure observed in Ain Mazlum area is formed by precipitation of the evaporate minerals and few sand grains around the root or stalks of plants causing preservation of the shape and increasing in size (Figure-21). This structure is not observed in Al-Rahimiya area may be the conditions to build not found.

Figure 21-Dikaka structure in Ain Mazlum area.

6. Conclusions

The variation in angle of cross-stratification is caused by tractional deposition processes on the windward of barchan and small scale in nabkha dunes in Al-Rahimiya area with an upper bounding surface sometimes occur trough erosional surface, while in Ain Mazlum area has low angle of cross lamination.

1. Two types of ripple marks were found in Al-Rahimiya area, sinuous and wave-formed ripples, while the lunate ripples and straight crested ripple in Ain Mazlum area. The average ripple mark index (RI) of the one barchan type in Al-Rahimiya area is (20.36) which fits well with the (RI) values of recent aeolian environments (RI >15).
2. The hourglass grain flow observed in right horn of barchan dune in area Al-Rahimiya, while in the second area not observed because the sand characteristics of a dome and longitudinal dunes prevent occuring of the structure. The adhesion structures indicated paleocurrent of wind and climate area, where the direction of these structures is same in prevailing wind direction in two areas.
3. The bioturbation structures (boring, tracks, and trails) are observed in two of studies areas, while the dikaka structure observed in Ain Mazlum area only.

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