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SEDIMENTARY STRUCTURES OF SAND DUNE FIELDS IN AL-SHEHABI AREA, WASIT GOVERNORATE, EASTERN IRAQ

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Abstract

The present research aims to determine the types of sedimentary structures observed in sand dune fields deposited in Al-Shehabi area, Wasit Governorate, eastern Iraq. Al-Shahabi sand dune field is located within the eastern dune belt in Iraq, which is considered one of the active belts. Inorganic and organic sedimentary structures were observed in the studied area. The major inorganic sedimentary structures determined in the studied area are cross-stratification, lamination, ripple marks, adhesion structures, and slump. The main types of organic sedimentary structures include boring, burrows, footprints, and dikaka. Many types of ripple marks observed in the studied area include straight crest, lunate, and sinuous. From the straight crest the direction of these dunes is North West to South-East as related to the prevailing wind direction in Iraq and the second direction observed in some ripple marks structures is South East to North West.

Keywords: Cross Stratification; Slump; Dikaka; Ripple Marks; Lunate Ripple Marks.

1. Introduction

During the past Fifty years, and due to global climate changes, Iraq has and still suffering from the spreading and expansion of large dune fields in which many new generations have been accumulated, and older ones have expanded leading to the desertification of huge agricultural and urban areas and causing vast environmental problems that have a drastic effect on the lifestyle of the population. The present study represented by the Al-Shahabi sand dune field is located within the eastern sand dune belt in Iraq, which is considered one of the active belts. One significant characteristic of sedimentary rocks is their sedimentary structures. They can be found inside mattresses as well as on the top and bottom surfaces. In regions of folded rocks, they can be utilized to infer the conditions and processes of deposition, the direction of the currents that deposited the sediment (certain structures preserve the current's azimuth of travel), and in areas of folded rocks (Tucker, 1998).

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Geologists are particularly interested in using sedimentary structures produced by a range of sedimentary processes, such as fluid flow, sediment gravity flow, soft sediment deformation, and biogenic activity, as a means of interpreting the ancient depositional environment because they represent the environmental conditions that existed at or shortly after the time of deposition (Boggs, 1995).

The main goal of this research is to determine the types of sedimentary structures that are deposited in the Al-Shehabi dune field in Wasit Governorate, Eastern Iraq, and try to determine their direction and the direction of their migration, as the deposition of these dunes around the lands of farmland is one of the dangerous phenomena that may make the area in a state of environmental degradation and desertification.

2. Site of Study Area

The area of study represents the sand dune fields located in Al-Shehabi area in Wasit Governorate Eastern Iraq. The location of the studied area is along the longitudes (45°42'00") E and (45°06'00") E and latitudes (32°30'00") N and (31°54'00") N covering more than (30 Km²) (Figure 1).

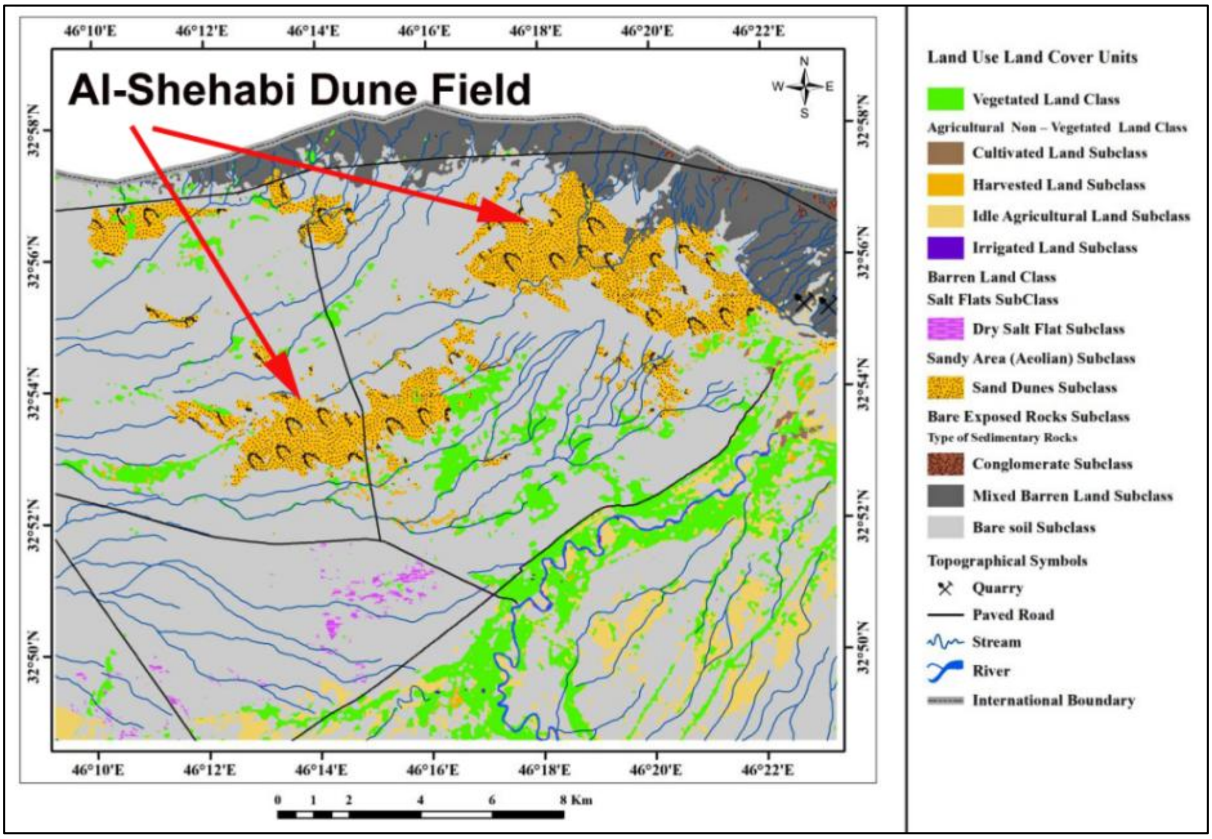

Figure1. Location map of Studied area (Sissakian, 2000).

3. Methodology

Two field surveys were done in December 2023 and February 2024 to determine the main types of sedimentary structures in the studied area to determine prevailing wind direction in the studied area and their longitudinal and lateral extension and measure the dimensions of these sedimentary structures by using a measurement tape, and the direction of the dunes was also measured by measuring the bearing by using Silva compass.

4. Geological Settings

The study area contains recent sediments of the Quaternary of the Mesopotamian plain of the Pleistocene and Holocene. It includes marshes, lacustrine, flood plain, valley fill sediments, dry marshes sediments, inland sabkha sediments, and aeolian sediments represented by deposited sand dunes (Aqrawi in Jassim & Goff, 2006).

Sand dunes deposited in the study area represent a part of the major eastern dune field belt in Iraq; this field is located in the eastern of the Mesopotamian Plain (east of the Tigris River). This field represents an active dune field in Iraq, extending across the Baiji, Dyalah, Badra, Al-Shehabi, Chailat, and Al-Teeb areas (Jasim, 2017).

5. Classification of Sedimentary Structures

Primary and secondary structures are the two main categories into which the sedimentary structures observed in aeolian sand deposits can be divided. While secondary structures develop syn- or post-depositionally as a result of disruption of the primary depositional fabric, primary structures represent the processes that carry out the sand's transportation and initial deposition (Pye & Tsoar, 2009).

Tamar-Ahga and Jasim (2023) state a classification of sedimentary structure in Iraq modified from many past references including (Selley, 1976; Selley, 2000; and Pettijohn, 1975) (Table 1). The following represent the description of sedimentary structures in the studied area:

5.1. Inorganic Sedimentary Structures

Gravity, the physical and chemical properties of the sediment and fluid, and the hydraulic environment interact to produce inorganic primary sedimentary structures. This sorting of sediments according to size, shape, and specific gravity is the result of different settling rates of sediment grains. Thus, inorganic primary sedimentary structures are produced by turbulent diffusion, gravitational avalanching, and boundary shear stress. These structures subsequently reveal important details about the hydrodynamic conditions of the deposition environment (Brush, 1965). The main types of inorganic sedimentary structures include:

Table 1: Classification of sedimentary structures (after Tamar-Agha and Jasim, 2023).

Sedimentary Structures				
Class	**Subclass**	**Group**	**Origin**	**Examples**
Primary	**Inorganic**	**Predepositional (Interbedded)**	**Predominantly Erosional**	Channel Cut and Fill Flute Marks Scour and Fill Groove Mark Tool Mark
		Syndepositional (Intrabedded)	**Predominantly Depositional**	Massive Bedding Graded Bedding Cross Bedding Cross Lamination Lamination Imbrications Horizontal Stratification
		Post Depositional (Deform Interbedded and lntrabedded Structure)	**Predominanty Deformation**	Slump Slide Convolute Lamination Convolute Bedding Recumbent Foreset Load Structures
		Miscellaneous		Rain Print Shrinkage Cracks Mud Balls Ripple Marks Phacoid Rip-Up Clasts Chicken Wire Adhesion Structures Melikaria Salt Pseudomorph
	Organic			Burrows Zoophycos Trails Borings Dikaka
Secondary				Veins Concretions Nodules Geode Stylolites

5.1.1. Cross Stratification

A single layer or sedimentation unit made up of internal lamina (foreset lamina) angled toward the main sedimentation surface is called cross-bedding. A surface of erosion, nondeposition, or sudden change in character divides this sedimentation unit from nearby strata (Reineck, H.E. and Singh, 1980). This definition is nearly identical to the one provided by Otto (1938) and later accepted by Potter & Pettijohn (1963). A cross-bedding unit's thickness might range from a few millimeters to tens of meters (Reineck, H.E. and Singh, 1980).

The three primary forms of cross-bedding are simple cross-bedding, planar cross-bedding, and trough cross-bedding (McKee & Weir, 1953), (Figure 2).

In the dune fields under study, only the planar cross-bedding, or cross-stratification, was seen. One of the distinctive features of sand dune formation is the planar cross-stratification (Hunter, 1977) and (Mckee & Bigarella, 1979).

This structure is observed in studied dune fields, with differences in shape and size, and many have different angle values between the sets of stratification. The small-scale type is more abundant than the large type (mega cross-stratification), the dimension of these cross stratification ranges between 25 cm to 1 m (Figure 3).

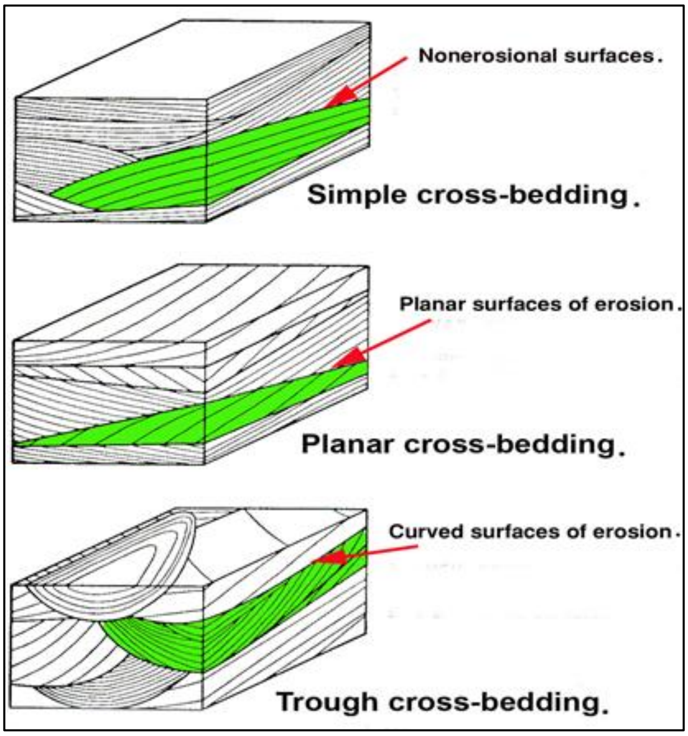

Figure 2. Classification of cross-bedding (after McKee & Weir, 1953).

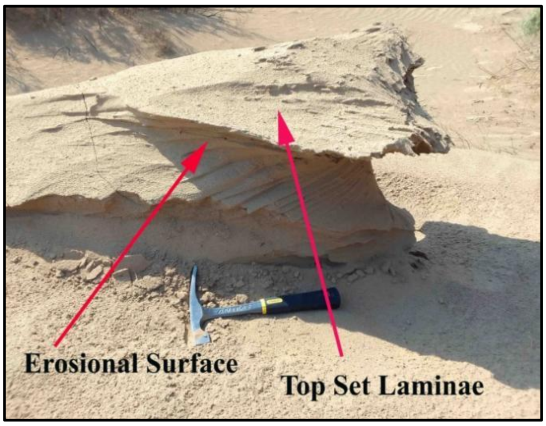

Figure 3. Cross stratification in Al-Shehabi dune Field.

5.1.2. Ripple Marks

Wind ripples tend to run perpendicular to the winds that carry sand, however, Howard (1977) has highlighted how slope affects ripple orientation. Wind ripples give an almost immediate indicator of local sediment transport and wind directions because they can be recreated in a matter of minutes (Lancaster, 2013).

The wavelength of typical wind ripples is between 50 and 200 mm, and their amplitude is between 0.005 and 0.010 m (Bagnold, 1941; Sharp, 1963).

The four components of any ripple profile are the crest, lee slope, trough, and stoss slope (Figure 4). The stoss slope's greatest inclination in the case of aeolian ripples is between 8 and 10°, whereas the lee slope ranges between 20 and 30° (Sharp, 1963).

Three types of ripple marks were observed in the studied area these are straight-crested, sinuous, and lunate Ripples (Figure 5). Differences between these types depend largely on the energy and direction of wind as each area has its own distinctive energy and direction regimes.

One of the field observations in the studied area was that the gypsum grains accumulated in the crest of the ripple marks, where the gypsum grains have been identified under a microscope (Figure 6).

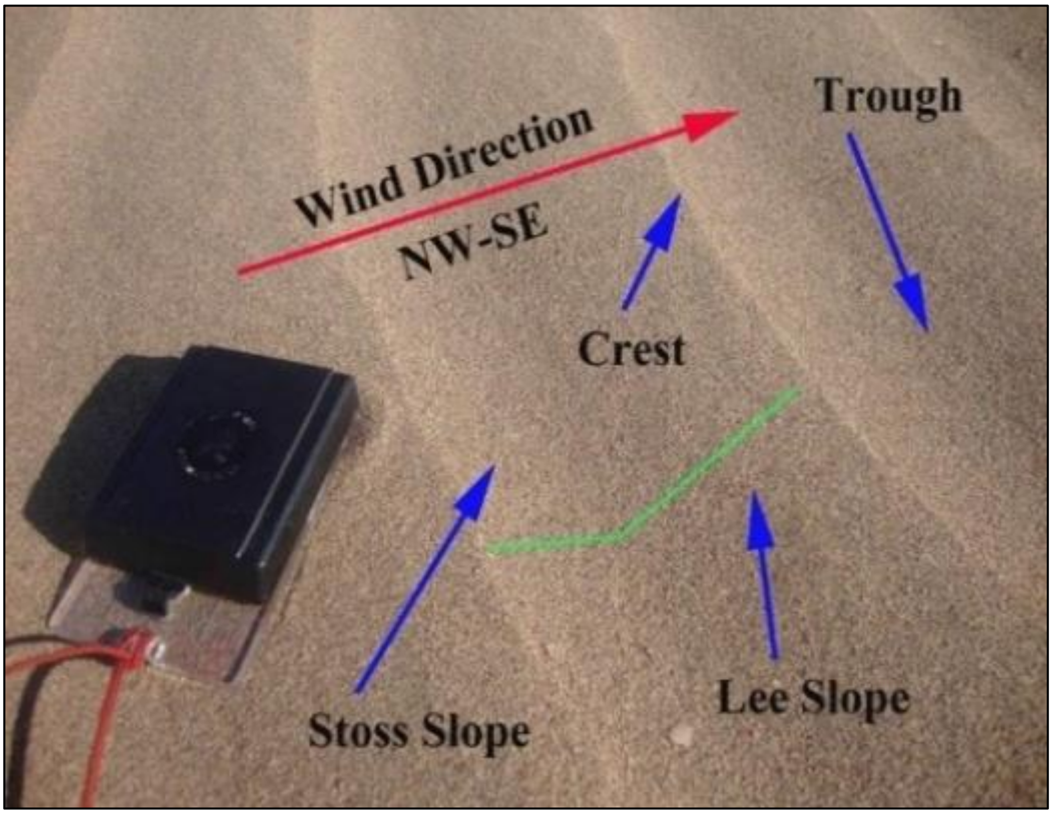

Figure 4. The elements of ripple marks, after (Jasim, 2017).

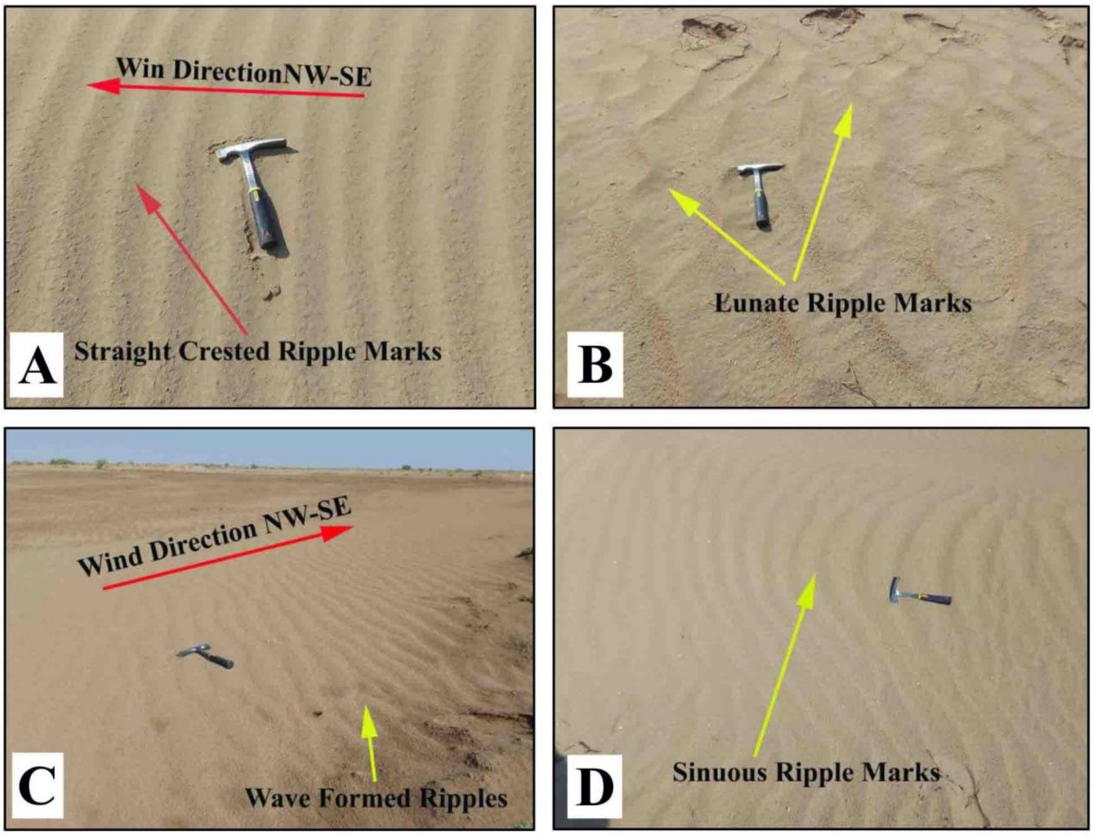

Figure 5. Types of ripple marks observed in the Al-Shehabi dune field were A: straight ripple marks, B: Lunate ripple marks, C: Wave formed ripples, and D: sinuous ripple marks.

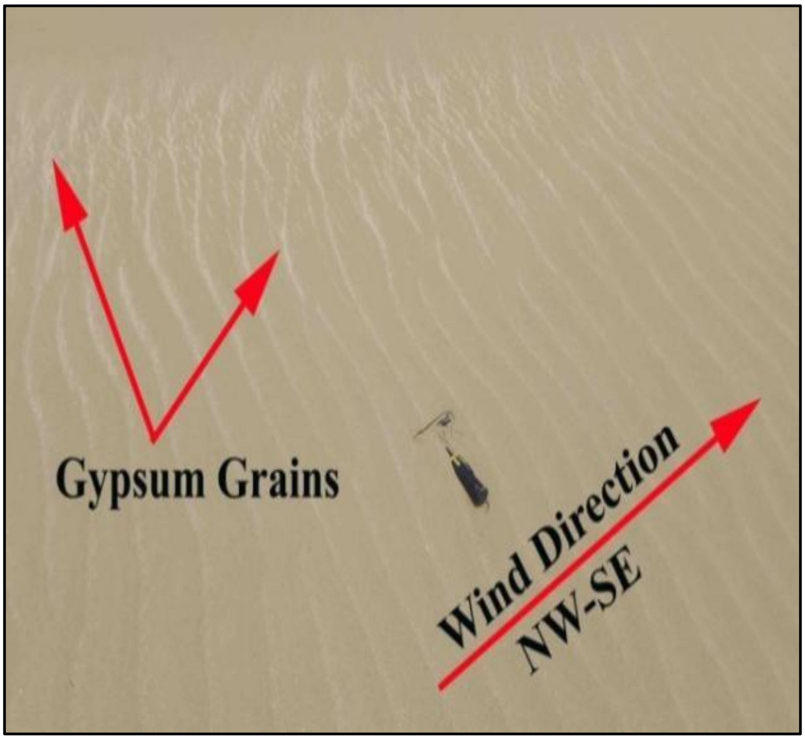

Figure 6. Accumulated gypsum grains in the crest of ripple marks.

5.1.3. Slump structure

All penecontemporaneous deformation structures brought about by the movement and displacement of previously deposited sediment layers are collectively referred to as slump structures, mainly under the action of gravity. Different types of irregularly contorted bedding also belong to slump structures (Reineck, H.E. and Singh, 1980).

Slump structure refers to sand masses that have avalanched down a dune forest or slipface, at or near the angle of repose, with enough cohesion to retain a compact character (McKee, 1982).

Slump structures were observed in Al-Shehabi dune field, and the movement was observed in most cases along the slipface (Figure 7).

Figure 7. Slump structures in the slipface of studied sand dunes.

5.1.4. Adhesion Structures

Dry, wind-blown sand sticks to a moist or damp surface to produce adhesion structures. There are three types of adhesion structures: adhesion warts (adhesion-wart structures), adhesion plane beds (adhesion laminations), and adhesion ripples (climbing-adhesion-ripple structures, adhesion laminations; Kocurek & Fielder, 1982).

These formations are mostly caused by dry, blown sand sticking to various types of moist surfaces and building up to create an uneven drape that covers small-scale topographic features or a lenticular mounded structure (McKee, 1982).

There were adhesion structures seen. Since the cohesive action of water holds the wet sand grains together, adhesion structures may be regarded as one of the transitory features of the Al-Shehabi dune field that result from the excess of moisture between sand grains, which is induced by rainfall and moisture (Figure 8).

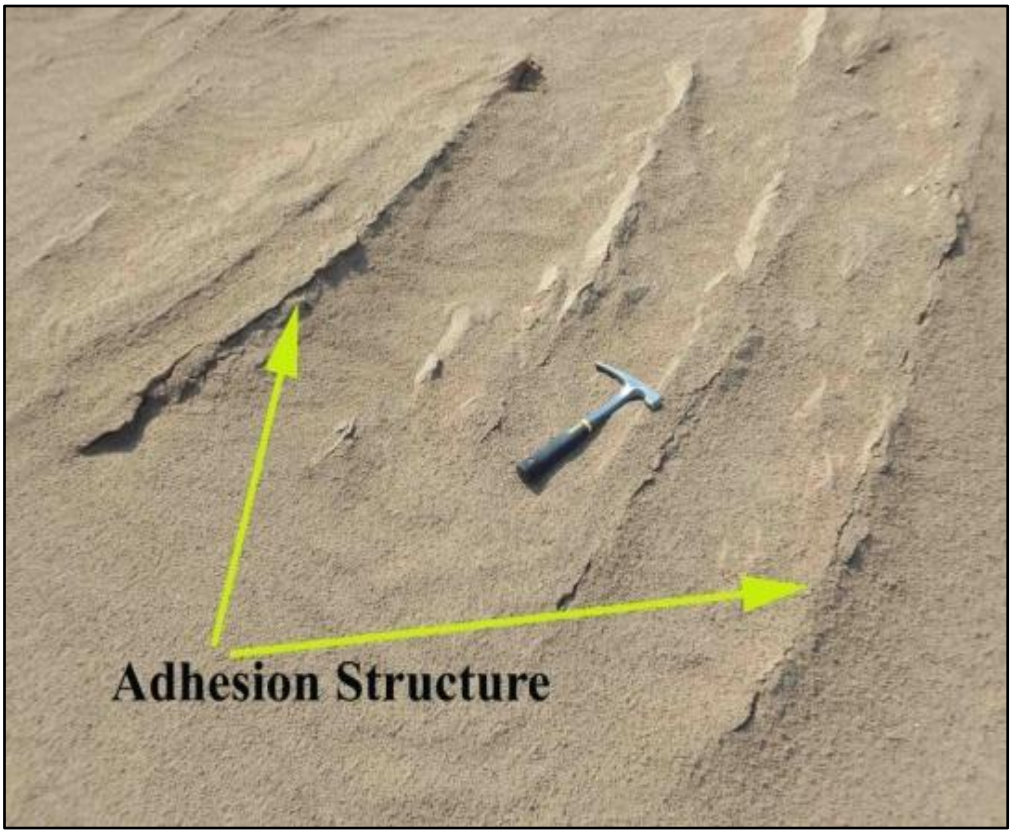

Figure 8. Adhesion structure in the studied dune field.

5.2. Organic Sedimentary Structures

A small-scale but potentially important geologic phenomenon, bioturbation can happen anywhere there are plants or animals. It can appear in a variety of ways, such as plant roots moving earth or silt, animal burrows creating tunnels, or animal tracks (Gingras et al., 2015).

Although geologists have long recognized the burrows, trails, and other biogenic structures in sedimentary rocks, the term "trace fossils" or "ichnofossils" refers to the tracks, trails, burrows, and other structures created by organisms on bedding surfaces or within beds (Boggs, 1995).

Where genuine fossils are scarce or absent, trace fossils (ichnofossils) are frequently prevalent and offer hints about the depositional environment and the rate of sedimentation of these processes (Crimes, T. P., and Harper, 1970; Frey, 1975).

Many biogenetic structures are preserved only as casts on the underside of the sand beds (Pettijohn, 1975).

Dwelling structures, mostly burrows, and boring, are, mainly formed by sessile and semi-sessile endocentric animals, particularly suspension feeders, predators, and scavengers (Tucker, 1985).

Burrows can be oriented horizontally, vertically, or sub-vertically to the bedding, and range in design from straightforward vertical tubes to U-shaped burrows (Tucker, 1998).

From simple vertical tubes to U-shaped burrows, burrows can be oriented horizontally, vertically, or sub-vertically to the bedding (Tucker, 1985).

Borings, burrows, and Foot Print were observed in Al-Shehabi dune fields, the diameter of the boring ranging between (0.3 – 3 cm), (Figure 9).

Footprints of many animals were observed in the studied area such as camel and birds (Figure 9-D), this structure was saved in the sediment after lithified and became a tool for studying the sedimentary environments and facies analysis.

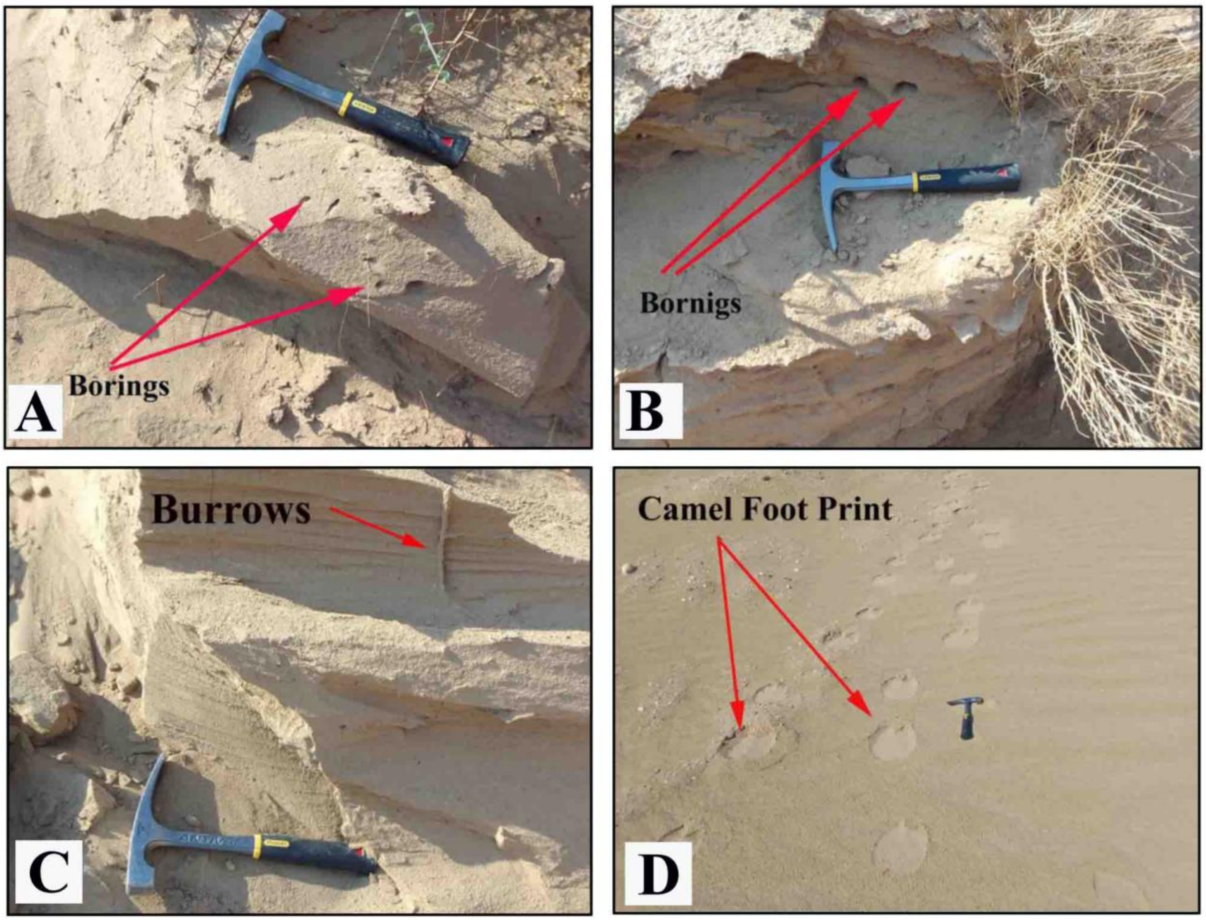

Figure 9. Organic sedimentary structures were A, and B) Boring inside the studied sand dunes, C) Burrows, and D) footprints of camel on the surface of the studied sand dunes.

6. Dikaka Structures

Locally, plant-root structures—typically found in low-lying swamp-like settings—have been discovered in the dune sands of parched deserts. The latter kind of plant structure has been named after the Arabic term "dikaka," which means scrub-covered dune sand. Only Tertiary and newer dune sands have these kinds of formations, which indicate arid ecosystems with at least a patchy water supply (Glennie & Evamy, 1968).

This structure was observed in Al-Shehabi dune fields associated with the roots net of the nearby plants causing preservation of the shape of plants roots. These plant root nets worked as an obstacle to sand movement and played a trap role for the sand causing the formation of dune sand in most cases, they represent fixed dunes that grow with time and may cause the standard shape of the dunes to be obliterated from the barchans or nabkha shape to mount or hill shape (Figure 10).

Figure 10. Dikaka structure in the studied dune field.

7. Conclusions

Several sedimentary structures were distinguished these include: cross-stratification, ripple marks, dikaka, slump, adhesion, and organic sedimentary structures. The cross-stratification and ripple marks represent the prominent types that cover all locations in the studied area. Many types of ripple marks observed in the Al-Shehabi dune field include straight, lunate, sinuous-crested, and wave-formed ripple marks. From the ripple marks the prevailing wind direction in the studied area is Northwest to Southeast. Due to the light-specific gravity of gypsum grains, these grains migrate first and occupy the crest of the ripple marks. The footprints of many animals that were observed on the surface of studied sand dunes were saved later after the lithified of this sediment and became as a tool for determining the sedimentary environment and facies analysis.

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