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Geomorphological Features and Sedimentological Aspects of Some Coastal and Inland Sand Dunes, Jeddah Region, Saudi Arabia

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ABSTRACT. The study reported in this paper illustrates the geomorphologic features and the sedimentological characteristics of coastal and inland sand dunes in the Shuayba coast, the southern Corniche of Jeddah, and along Jeddah and Makkah highway. The geomorphologic features are studied on basis of dune type, modification, wind ripples, and internal structures.

Differentiation between coastal and inland dune sands has been based on grain-size parameters, cumulative curves, bivariat plots and mineralogy. Inland dune sands are finer, and better sorted with single saltation populations as compared to coastal dune sands.

The heavy mineral suites of both sand dune types display a dominance of less stable minerals (*e.g.* amphiboles and pyroxenes) over the stable ones (*e.g.* zircon, tourmaline and rutile).

It is concluded that the local topography and sand-carrying winds affect the distribution and morphology of the inland sand dunes along Jeddah and Makkah highway.

In general, sand dunes have a characteristic morphological appearance related to special ecological conditions. Many sand dunes creep over land and may interfere with human activity.

Inland dunes are common along the Jeddah-Makkah highway. They include, barchan, seif and compounds dunes. The coastal sand dunes occur in the southern Corniche of Jeddah and Shuayba coast running parallel to the shoreline.

The occurrence of dunes on the coast is directly related to sand supply and a favorable wind regime (Davis 1985). Sediments are moved to the shoreline and deposited on the beach by longshore currents and waves. The sand grains are then picked up and moved by winds at low tide.

The main objective of the present work is to study the geomorphological features and the textural and mineralogical characteristics of the sand dunes in Jeddah region.

Methods of Study

Field and laboratory investigations included both coastal and inland sand dunes. Field work consisted mostly of measurements, description, and collecting samples. Fig. (1) shows the location map of the investigated sand dune fields.

Sixteen samples were collected from different sand dune types (coastal and inland sand dunes). Field data are summarized in Table (1).

The samples were sieved at 1ø intervals. Textural parameters of mean grain size (Mz), sorting (σ_I), skewness (SK_I) and kurtosis (K_G) were calculated and computerized using Folk (1968) graphic measures. The grain size parameters were used to evaluate variation in textural parameters between the inland and the coastal sand dunes.

Mineralogy has been performed by separating of heavy minerals using tetrabromoethane (2.89 sp.gr.). The very fine sand fraction was chosen (0.063 mm) for this study. About 2 gm from this fraction was separated into heavy and light minerals. A portion of the heavy and light fraction from each sample was mounted in canada balsam and identified using polarizing microscope. About 200 grains per slide were counted.

Dune Morphology

Concerning the morphology of sand dune field, two scales of landforms have been investigated; small scale landforms (ripple marks) and large scale landforms (types of dunes).

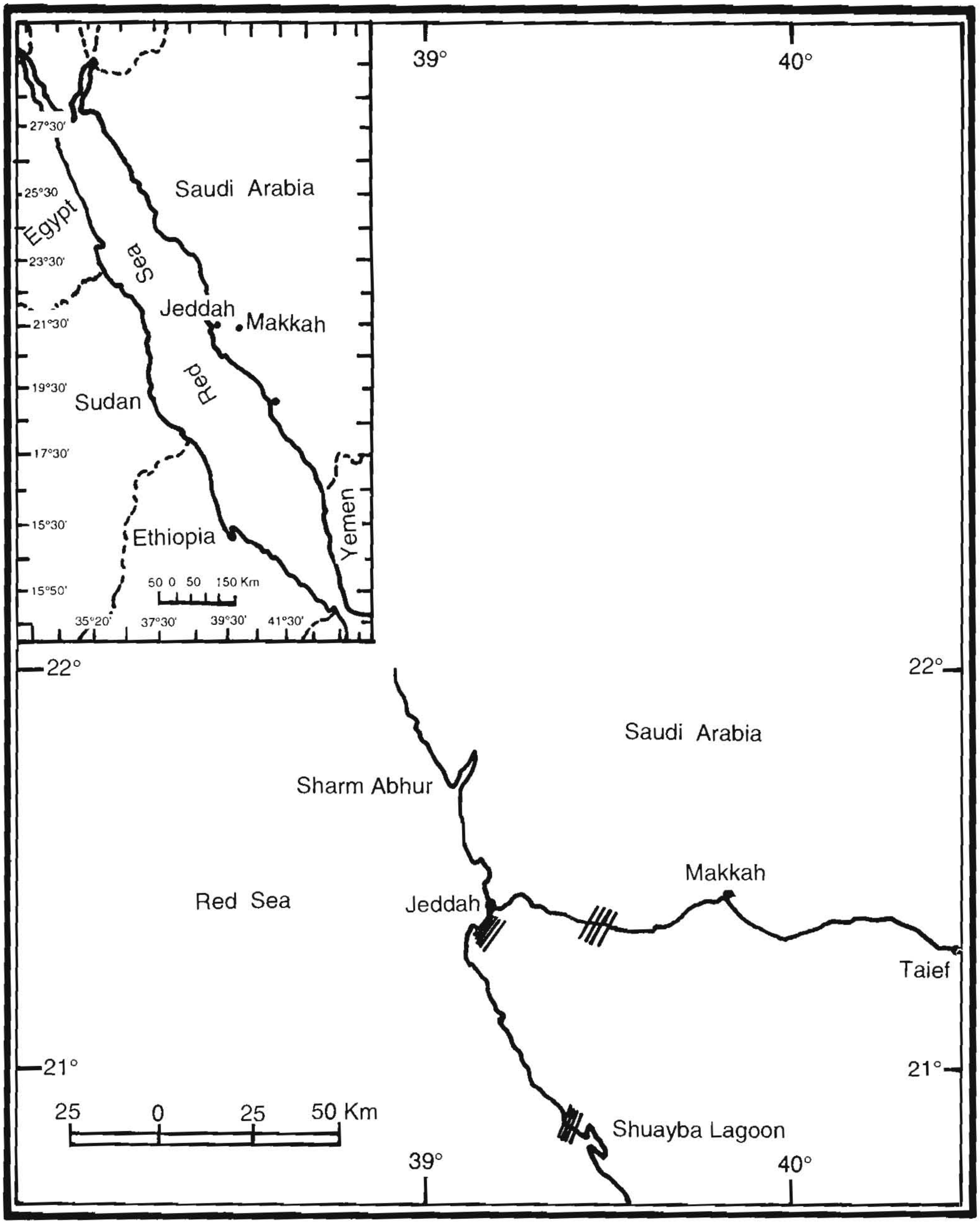

Fig. 1. Location Map Showing Sand Dune Fields (///)

Table 1. Samples, types of sand dunes and their locations

<table>
<tr><th>S. No.</th><th>Sample position</th><th>Location</th><th>Sand dune type</th><th></th></tr>
<tr><td>1</td><td>Surface</td><td rowspan="4">Southern Corniche of Jeddah</td><td rowspan="4">Longitudinal dune</td><td rowspan="6">Coastal Dunes</td></tr>
<tr><td>2</td><td>Subsurface</td></tr>
<tr><td>3</td><td>Subsurface</td></tr>
<tr><td>4</td><td>Subsurface</td></tr>
<tr><td>5</td><td>Surface</td><td rowspan="2">Shuayba coast</td><td rowspan="2">Seif dune</td></tr>
<tr><td>6</td><td>Subsurface</td></tr>
<tr><td>7</td><td>Wind-ward side</td><td rowspan="2">Makkah-Jeddah highway</td><td rowspan="2">Seif dune</td><td rowspan="10">Desert Dunes</td></tr>
<tr><td>8</td><td>Lee-ward side</td></tr>
<tr><td>9</td><td>Wind-ward side</td><td rowspan="2">Jeddah-Makkah highway</td><td rowspan="2">Barchan dune</td></tr>
<tr><td>10</td><td>Lee-ward side</td></tr>
<tr><td>11</td><td>Wind-ward side</td><td rowspan="4">Jeddah-Makkah highway</td><td rowspan="4">Barchan dune</td></tr>
<tr><td>12</td><td>Lee-ward side</td></tr>
<tr><td>13</td><td>Inside the dune</td></tr>
<tr><td>14</td><td>Inside the dune</td></tr>
<tr><td>15</td><td>Wind-ward side</td><td rowspan="2">Jeddah-Makkah highway</td><td rowspan="2">Barchan dune</td></tr>
<tr><td>16</td><td>Lee-ward side</td></tr>
</table>

1. Ripple marks:

Wind ripples are produced by the action of wind on noncohesive material (Reineck and Singh 1975). Aeolian ripples are common on all parts of the dunes. They have straight long, parallel crests and are asymmetrical. They commonly have well developed bifurcating crests. Sand ripples, are composed of well sorted medium to fine -grained sand and they occur on the sides of the dunes. They provide a good indicator of the local wind direction and the complexity of the wind currents around the dune (Bagnold 1954a and Sharp 1963).

Different shapes of ripples are recorded in the study area. The ripples could be classified according to the change in wind strength and wind direction into the following types:

i) *Primary ripples:* They are formed by direct wind action of stable direction and strength Fig. (2A).

ii) *Transitional ripples:* Between primary and secondary ripples. They are due to a change in the wind direction. Fig. (2B, C)

iii) *Interference ripples:* Old ripples superimposed by a near set of ripples. (Fig. (2D).

The study revealed that when the wind direction changes greatly, a new set of ripples is initiated and superimposed on the old one.

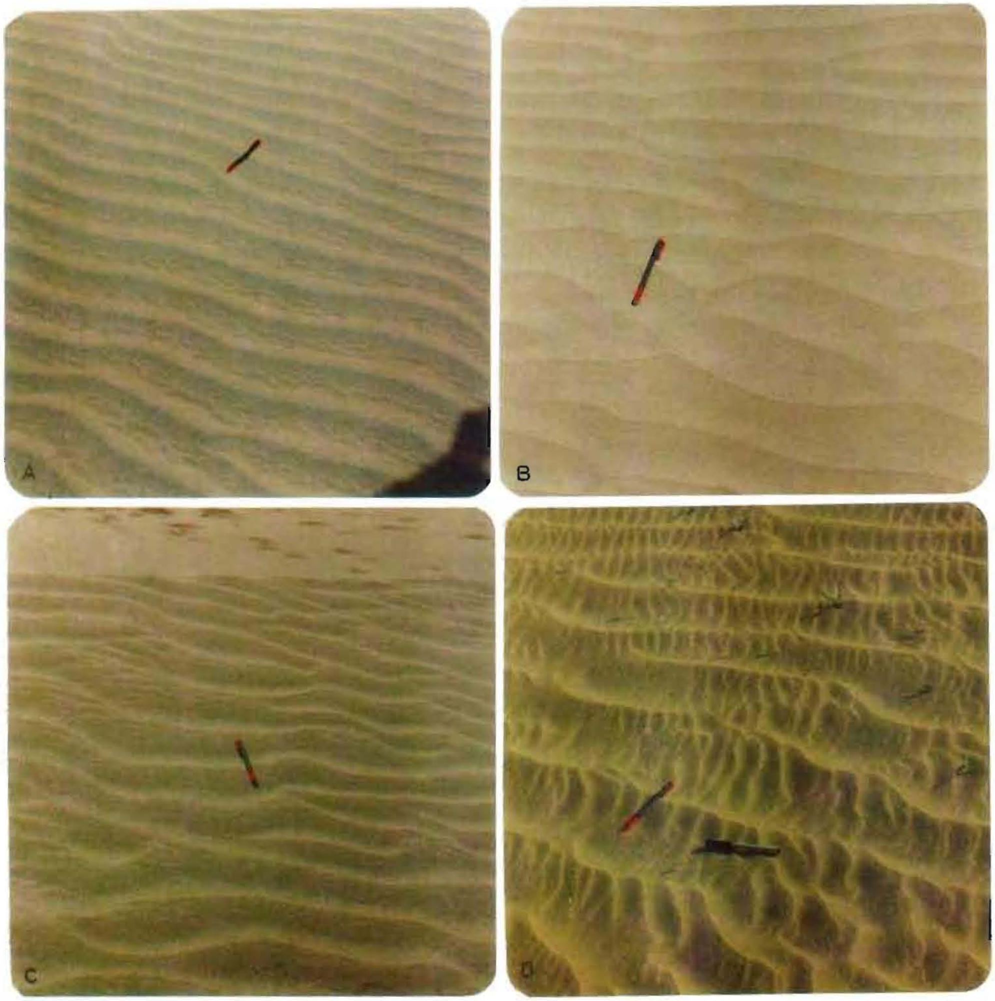

Fig. 2. Wind ripple marks. A-Symmetrical primary ripples with continuous crestline (southern Corniche of Jeddah). B-Asymmetrical wind ripples on a wind blown sandy surface-transitional ripples (Jeddah-Makkah highway). C-Asymmetrical ripples with well developed undulatory bifurcation of crests in the windward direction. The steep slip face appears without any structure. D-Interference pattern in asymmetrical wind ripples resulting from at least two coexisting wind sets.

2. Morphology of dunes:

In the light of the encountered geomorphological features, the following inland dune types are recognized:

A– Barchan dunes:

On the right side of Jeddah-Makkah highway, a series of isolated barchan dunes is observed Fig. (3A). While in the opposite direction of the highway, a longitudinal dune occurs Fig. (3C). These dune fields rest unconformably on the Basement Complex. Crescent-shaped barchan dunes are the classic eolian landform, representing the mature stage. It consists of a gently inclined windward slope and a steep lee side around which are the two horns or limbs of the dune. They occur in complex forms and isolated bodies. The orientation of barchan dunes in relation to wind is NW-SE, where the gently-shaped windward side of dunes is northeast and the steep leeward side is to southwest. The height of the dunes ranges between 1.5 and 3 m above their base level, and depends on the strength of the wind and the grain size (Reineck and Singh 1975). Parallel to wind the length varies from 3 to 8 m and the width across the horns is between 6 to 10 m.

B– Compound barchan and transverse dunes:

These types are formed when the simple barchan dunes are combined with each other at one of the two horns. The degree of combination controls the dune morphology. If the combination is strong enough; and the interdunal area seem to disappears, the resulting form is a transverse dune (Fig. 3B).

C– Longitudinal or Seif dunes:

This uncommon type of dunes occurs as an isolated form along Makkah-Jeddah highway (Fig. 3C), and at the southern Corniche of Jeddah (Fig. 3D) and in complex forms at the Shuayba coast, Fig. (3E) parallel to the shoreline. These dunes are elongated in shape. The height of the dunes ranges between 1 and 6 m and the length between 3 and 180 m. Longitudinal dunes may be modified from barchan dunes due to bi-directional wind (Fig. 3C). They may be originated from a combined action of persistent gentle winds that supply sand to dunes that are then trimmed into long ridges by strong winds. However, the high longitudinal dune is probably formed under unidirectional predominantly gentle winds.

Longitudinal dunes are linear, extend parallel to the direction of the prevailing winds, and are nearly devoid of vegetation. These dunes accumulate where sand is in short supply and the wind direction is constant or varies seasonally as on the coast (southern Corniche of Jeddah) (Fig. 3D). Seif dune fields with connected tips are caused by some fixed obstruction in the path of a sand laden wind, such as small bushes (Fig. 3E). They are most common on the coast of Shuayba.

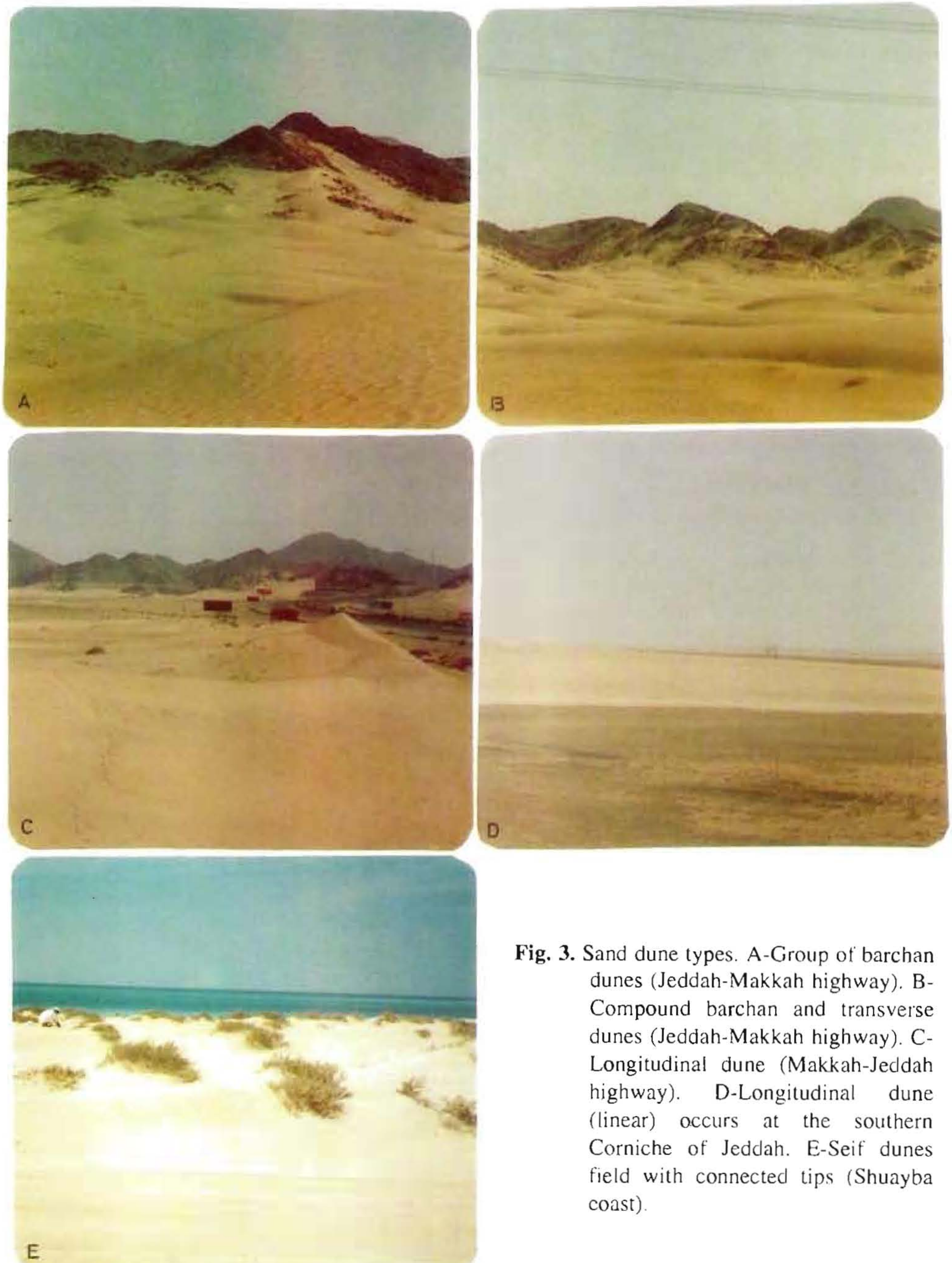

Fig. 3. Sand dune types. A-Group of barchan dunes (Jeddah-Makkah highway). B-Compound barchan and transverse dunes (Jeddah-Makkah highway). C-Longitudinal dune (Makkah-Jeddah highway). D-Longitudinal dune (linear) occurs at the southern Corniche of Jeddah. E-Seif dunes field with connected tips (Shuayba coast).

Regarding the origin of Barchan and longitudinal dunes, Bagnold (1971) indicatėd that barchan dunes occur where the wind is nearly unidirectional and the longitudinal dunes are produced when strong winds blow from a quarter other than of the general drift of sand. However, McKee (1966) suggested that longitudinal dunes are produced in the vector of two converging winds blowing from two quarters about 90° apart, and are formed by modification of barchan dunes. Glennie (1970) assumed that longitudinal dunes are generated where a strong winds of uniform direction occur and that barchan dunes developed at lower wind velocities. We believe that dune morphology is mainly a result of interaction between sand-carrying winds and escarpments and other topographic features. The topography greatly affects the distribution and the morphology of sand dunes, especially those found along the Jeddah-Makkah highway. While beach sands are the source of wind blown sands for the Shuayba dunes. The sand transport is accompanied by an eastward shift from the beach to the dune.

Internal structure of longitudinal and barchan dunes:

Bagnold (1954a) recognized that sand dunes are composed of two types of sand beds; accretion and avalanche deposits. On the windward slope, sand grains move by traction and saltation. If more sand grains are retained than ejected by saltation, a deposit of well-defined laminae is produced. Laminae are thin and horizontal or with gentle dips. The sand is rather firmly packed. On the slip face avalanche laminae of sand are formed. Laminae are rather thick and dip 25° to 34°. The sand is loosely packed (McKee and Tibbits 1964 and Sharp 1963). Reineck and Singh (1975) used descriptive terms such as horizontal bedding (laminated sand) for accretion deposits, and cross-bedding for avalanche deposits.

Three cuts were made in the barchan and longitudinal dunes (Fig. 4A,B,C), one in the windward side near the foot (coastal dune), the second in the barchan horn (Fig. 4B) and the later in the crest (Fig. 4C).

Internal structures observed in the dunes are nearly horizontal to low-angled laminae of sand, commonly found on the windward slopes, on the flanks and near the crest of the sand dunes. They show thinly laminated sand with irregular, bedding surfaces formed as a result of adhesion ripples (Fig. 4A). Heavy mineral rich laminae alternate with heavy mineral-poor ones. A series of deformational structures, such as irregularity of bedding are also observed at the dune bottom (Fig. 4A).

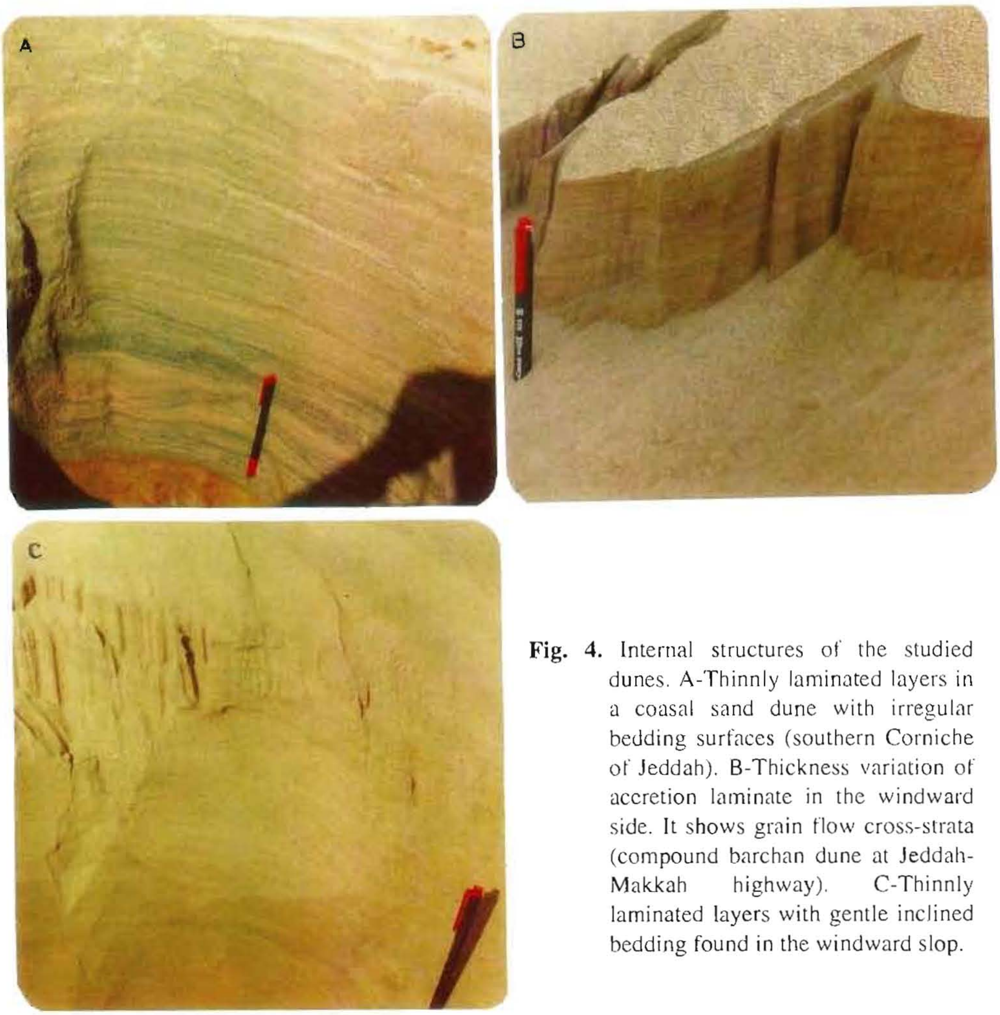

Fig. 4. Internal structures of the studied dunes. A-Thinnly laminated layers in a coasal sand dune with irregular bedding surfaces (southern Corniche of Jeddah). B-Thickness variation of accretion laminate in the windward side. It shows grain flow cross-strata (compound barchan dune at Jeddah-Makkah highway). C-Thinnly laminated layers with gentle inclined bedding found in the windward slop.

Textural parameters:

The statistical calculations of the different grain size parameters; Mz, σ_I, SK_I and K_G for both coastal and inland dune sands are summarized in Table (2). Mechanical analysis data has been represented in the form of histograms and cumulative curves (Figs. 5-7).

The histograms have unimodal distribution with a dominate modal class falling in the medium and fine sand fractions for coastal dunes (Fig. 5), and in the fine-grained for desert dunes (Fig. 6).

Cumulative curves for coastal dunes appear to have two distinct saltation subpopulations which differ in mean size and sorting (Fig. 7), reflecting their origin from the beach which is characterized by swash and backwash as caused by the action of waves. Those constructed for the inland dunes, Fig. (7) show mostly a single segment of saltation population, reflecting a uniformity of the transporting medium (Visher 1969).

The single saltation population is developed in all inland dunes and represents nearly 98% of the distribution. Its sorting as indicated by the slope of the curves is better than that for the coastal dunes. The percentage of the traction population is found to be very small, never more than 2 percent Visher (1969). The presence of a suspension population and the truncation of the coarse population reflects the positive skewness characteristic of dune deposits. However, the dominance of the saltation population here suggests a genetic relationship. The general lack of competence of wind processes to move a coarse population by surface creep accounts for the small percentage of material in the coarse population.

The values of grain size parameters for coastal and desert dunes and the verbal scale equivalents as defined by Folk (1968) given in Table (2). The following observations are recorded.

Mean-size: Mean size data indicate that sands of the coastal dunes are oscillating between medium-grained and fine-grained. While those of the desert dunes are mainly fine-grained.

Standard deviation: Standard deviation values fit into the category moderately well sorted for the coastal dune sands and well sorted to moderately well sorted for the desert dune sands. Sorting, as related to dune morphology reflects better sorting progressively from coastal dunes (longitudinal dunes) to inland dunes (barchan dunes). Within sand dunes, the best sorting occurs in samples highest above the deflation plane.

Table 2. Statistical grain-size parameters of Folk and Ward (1957) for the coastal and desert dune sands

S .No.	Mz	Description	σ_I	Description	SK_I	Description	K_G	Description
Coastal dunes								
1	1.6	Medium sand	0.69	Moderately well sorted	0.19	Fine skewed	0.99	Mesokurtic
2	1.88	Medium sand	0.74	Moderately well sorted	0.23	Fine skewed	1.07	Mesokurtic
3	2.28	Fine sand	0.82	Moderately sorted	–0.04	Near-symmetrical	1.01	Mesokurtic
4	2.11	Fine sand	0.64	Moderately well sorted	–0.09	Near-symmetrical	1.05	Mesokurtic
5	1.9	Medium Sand	0.54	well sorted	0.04	Near-symmetrical	1.07	Mesokurtic
6	1.8	Medium Sand	0.56	well sorted	0.21	Fine skewed	1.12	Mesokurtic
Desert dunes								
7	2.36	Fine sand	0.54	Moderately well sorted	0.12	Fine skewed	0.87	Platykurtic
8	2.55	Fine sand	0.46	well sorted	–0.01	Near-symmetrical	1.05	Mesokurtic
9	.2.56	Fine sand	0.47	well sorted	0.03	Near-symmetrical	1.03	Mesokurtic
10	2.66	Fine sand	0.44	well sorted	0.03	Near-symmetrical	1.05	Mesokurtic
11	2.6	Fine sand	0.4	well sorted	–0.01	Near-symmetrical	0.99	Mesokurtic
12	2.73	Fine sand	0.45	well sorted	–0.01	Near-symmetrical	0.99	Mesokurtic
13	2.32	Fine sand	0.55	Moderately well sorted	0.14	Fine skewed	0.87	Platykurtic
14	2.9	Fine sand	0.52	Moderately well sorted	0.04	Near-symmetrical	1.01	Mesokurtic
15	2.73	Fine sand	.042	well sorted	0.06	Near-symmetrical	1.09	Mesokurtic
16	2.67	Fine sand	0.4	well sorted	0.02	Near-symmetrical	1.04	Mesokurtic

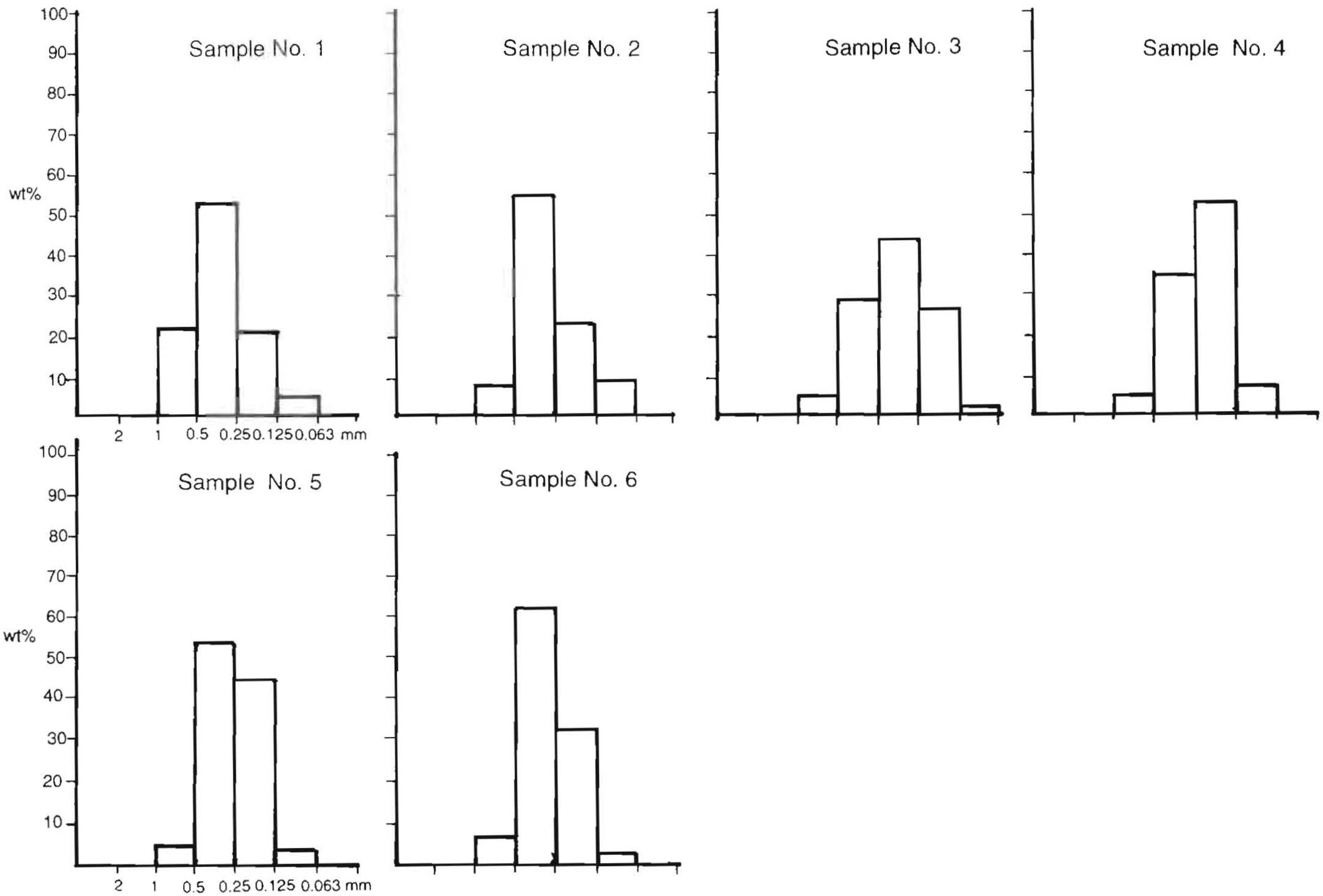

Fig. 5. Histograms of coastal sand dunes.

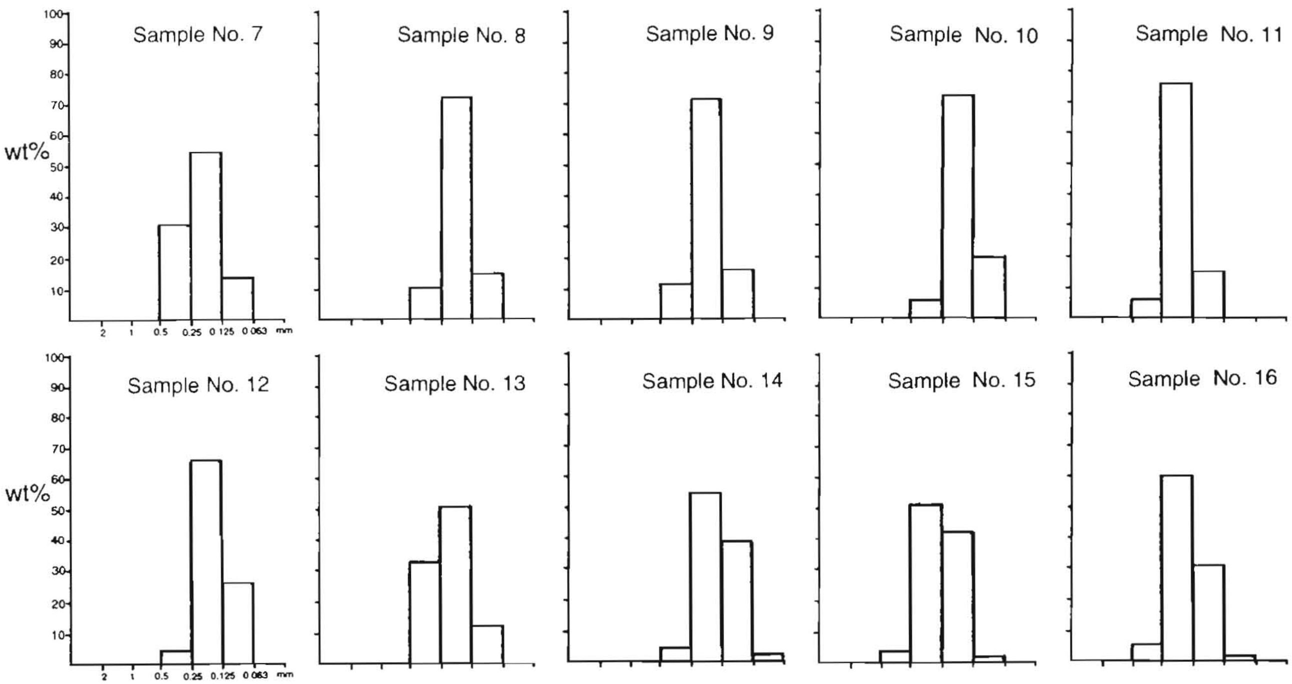

Fig. 6. Histograms of desert sand dunes.

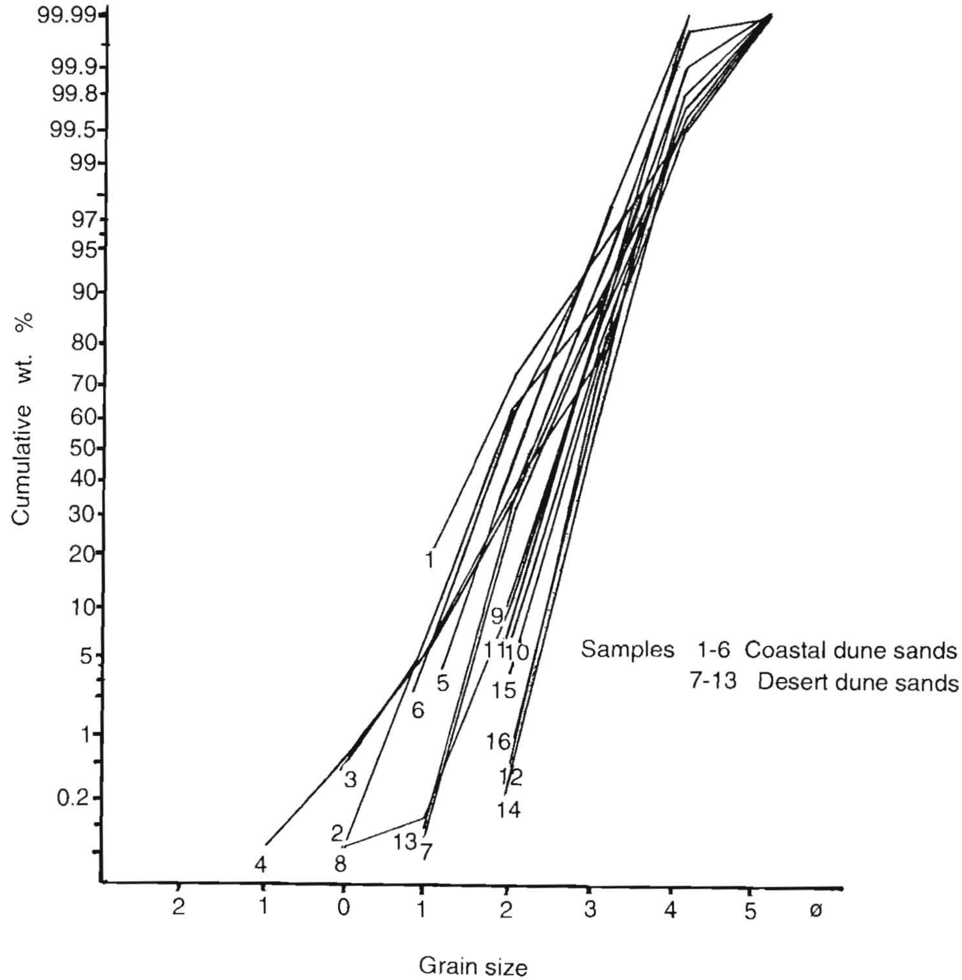

Fig. 7. Cumulative frequency curves for coastal and inland sand dunes.

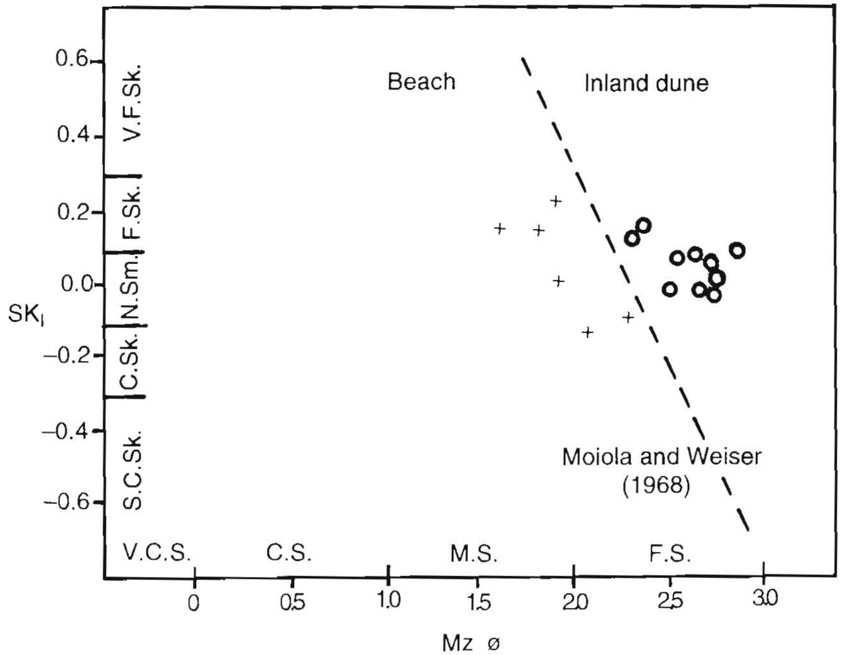

Fig. 8. Mean size versus skewness. (+ Coastal dunes **O** Desert dunes).

Skewness distribution: Values of graphic skewness of the coastal sand dunes are generally fine skewed to near symmetrical. Positive skewness indicates excess fine material. Samples from the desert dunes are mainly near symmetrical.

Kurtosis distribution: The mesokurtic type of distribution is the most common in both coastal and inland dunes.

Mutual plots of the bivariate grain size parameters have been used by many authors for environmental interpretation (Friedman 1961, 1967 and Moiola and Weiser 1968). Plots of pairs of textural parameters were made. It was found that plotting the skewness versus mean size can be used to discriminate between the coastal dune sands and the desert dune sands (Fig. 8).

Mineralogy of the sands:

The very fine sand fraction of sixteen samples was selected for heavy mineral analysis. The heavy minerals were divided into opaque and non-opaque minerals. The opaque grains are expressed as a percentage of total heavy minerals.

Light minerals:

The light fraction (sp. gr. < 2.85) separated from the heavy minerals is mainly composed of quartz, feldspar and mica in the desert dune sands. In the coastal dune sands, it consists of shell fragments, carbonates, and rock fragments. The carbonates probably are from the beach zone which is mainly composed of carbonate grains originating from the disintegration of the carbonate reefal terraces and/or the so called Al-Kassara reef bar in the nearshore by the wave action. Quartz forms the bulk of the light fraction in the desert dune sands. It is stained by a dull yellow to reddish tarnish. Both simple and composite grains with slightly undulatory extinction are present. It seems to have originated from the weathered basement complex.

Heavy minerals:

Heavy minerals represent the accessory minerals of igneous and metamorphic rocks. They are much reduced in quantity as they pass into sediments because they are chemically unstable except for zircon and tourmaline.

Heavy mineral content has proved to be useful in elucidating the source rock of sediments. The non-opaque minerals are most useful in genetic interpretation (Carver 1971).

Newly derived minerals (minerals of the first cycle) are little worn and may present as euhedral crystals or cleavage fragments contain the least stable ones. If the minerals are derived from older sediments, the less stable minerals are not present (having been destroyed) and the more stable ones are rounded (Pettijhon 1975). If on the other hand, rounded and angular grains of the same mineral species occur together, this would indicate a multiple source.

The relative frequency percentage distributions of heavy minerals are expressed in histograms for coastal and inland sand dunes and shown in Figs. (9 and 10).

The identified opaque minerals include, magnetite, ilmenite, hematite and limonite. They range from 33.3% to 13.8% and average 23% in the coastal sand dunes. While those from inland sand dunes vary between 19.6% and 7.6% with an average 13%. It is observed that the content of opaque minerals in the coastal sand dunes is higher than that in the inland sand dunes. Grain sorting processes may concentrate the heaviest minerals (opaque) on the beach surface due to the action of wave in the surf zone (Gheith *et al.* 1994).

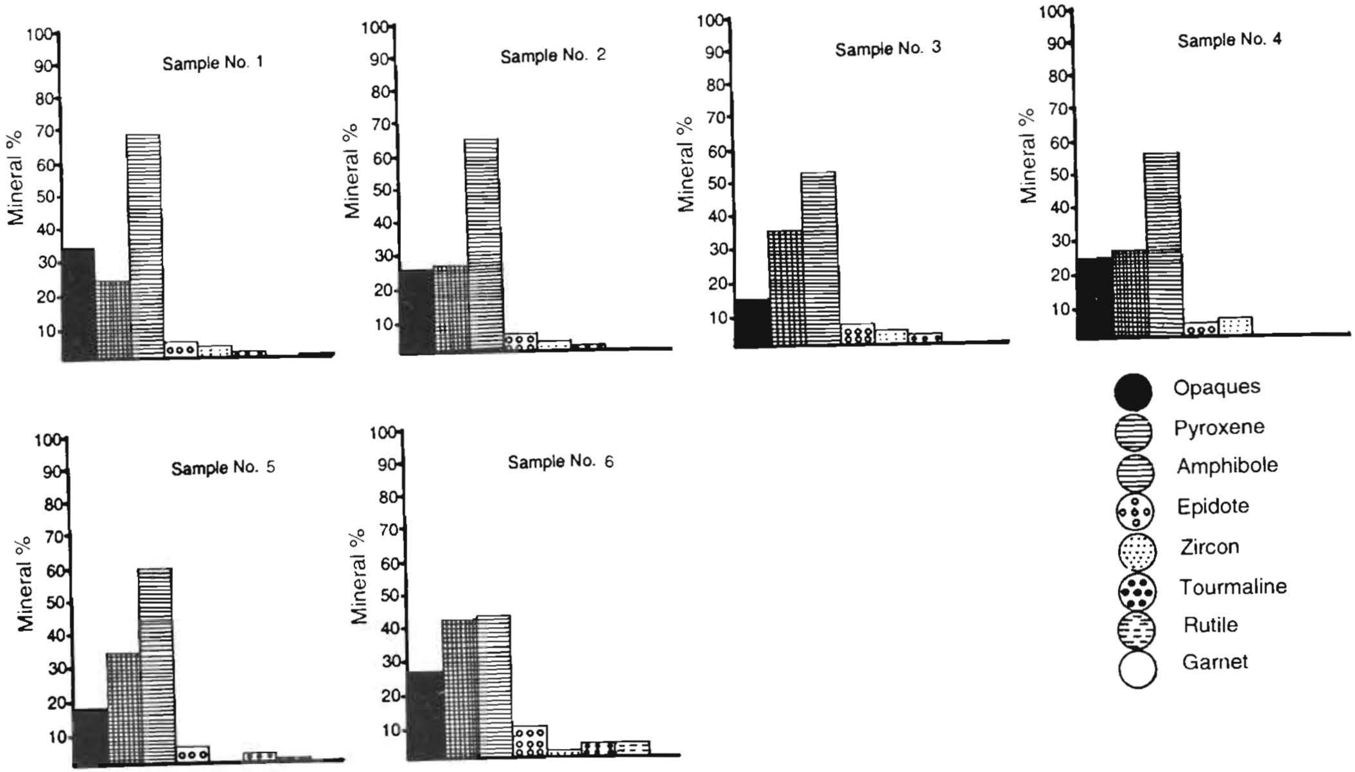

Fig. 9. Histograms showing the relative frequency percentages of heavy minerals in the coastal sand dunes.

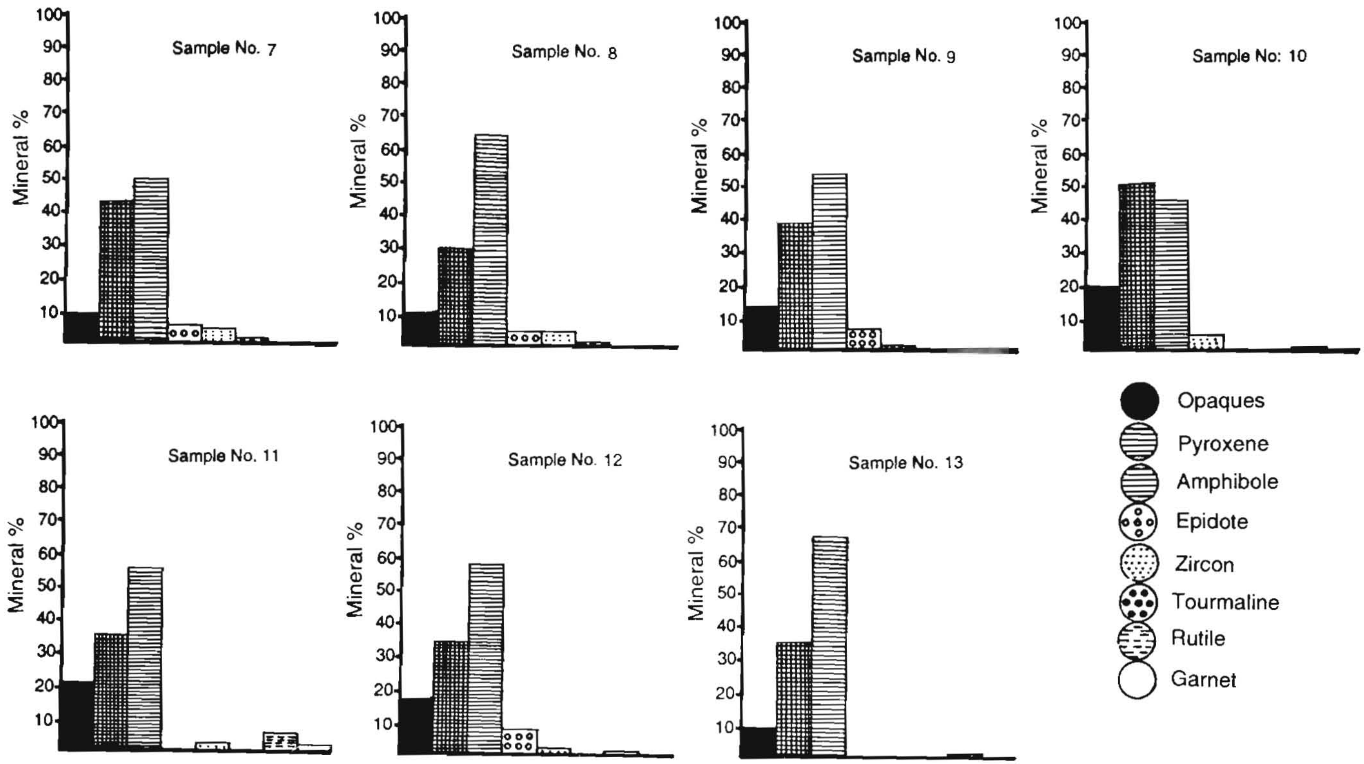

Fig. 10. Histograms showing the relative frequency percentages of heavy minerals in the desert sand dunes.

Amphiboles and pyroxenes are the most common non-opaque minerals present in the heavy fraction. They constitute about 90% to 98% of the total non-opaque minerals in the coastal and inland sand dunes, respectively.

Amphibole grains are represented mainly by green hornblende, basaltic hornblende, actinoilite-tremolite and anthophyllite, they occur as subrounded and prismatic grains. They are relatively more abundant in the coastal sand dunes.

Pyroxenes are represented by augite, diopside, instatite and hyperthene in decreasing order of abundance. The average percentage values of pyroxenes range from 30.6% to 37% of the heavy minerals in coastal and inland sand dunes, respectively. They tend to increase in frequency towards the coast.

Epidotes are present in lesser amounts with average 6% in the coastal dunes and 3.7% in the inland sand dunes. They are represented mainly by yellow pistacite and few grains of zoisite which appear smaller in size.

The stable minerals; zircon, tourmaline and rutile occur in minor amounts with average percentage values of 9% in the coastal dunes and 4% in the inland dunes.

Zircon grains are almost prismatic in shape with subrounded terminations, colorless with high relief and contain inclusions. Rutile is represented by reddish brown varieties with the characteristic high relief. The highest content of rutile is 4.6% in the desert sand dunes. Tourmalines of the brown and green varieties are most common. They are highly pleochroic.

Pyroxenes and amphiboles generally form the bulk of the heavy mineral assemblages in both coastal and inland sand dunes. The most probable sources are the metarmorphic and igneous source rocks (basement complex) near the sand dune field and the Tertiary moutains of the coastal esccarpment.

Conclusions

Field and laboratory studies have been carried out on some coastal and inland sand dunes in the Jeddah region. The following criteria are recorded.

I) Field investigation:

1. Field study proved the occurrence of different types of ripple marks, such as primary, transitional, and interference ripples. These ripples are classified

according to the change in wind direction and wind strength.

2. Morphologically, the coastal and inland sand dunes include, barchan dunes, compound barchan and transverse dunes, and longitudinal or seif dunes. The inland sand dunes rest unconformably on the basement complex, along the Jeddah-Makkah highway, while the coastal dunes rest on the coastal reefal limestone bar at Shuayba coast and/or tidal flat mud at the southern Corniche of Jeddah. It is concluded that the topography greatly affects the morphology and the distribution of the inland sand dunes.

3. The internal structure of the dunes consists of thinly laminated sand with horizontal low angle and irregular laminae common surfaces on the windward slopes and flanks. Heavy mineral enriched laminae alternating with heavy mineral poor ones are also preserved.

II) Textural characteristics:

1. The coastal and inland sand dunes are characterized by a unimodal sand size distribution. Dominant modes of histograms fall in the medium and fine sand fraction for coastal dunes and in the fine-grained fractions for desert dunes.

2. The cumulative curves are characterized by a major saltation population and two segments of distinct subpopulations in the coastal sand dunes reflecting their origin from the beach where swash and backwash (winnowing) are common. The inland sand dunes have a single saltation population reflecting uniformity of the transporting medium. The sorting of this single population as indicated by the slopes of the curves is better in desert dunes than in coastal dunes.

3. Mz is medium to fine grained for the coastal dune sands and mainly fine-grained for the desert dune sands. σ_I values are moderately well sorted and well sorted for the coastal and inland dunes sands, respectively. SK_I is fine skewed to near symmetrical. While K_G shows dominance of the mesokurtic type of distribution.

4. Mean size plotted against skewness is considered as an effective discriminator in recent environments. This plot successfully separates the coastal dunes and desert dunes studied.

Mineralogical investigation:

1. The non-opaque heavy minerals are more common than opaque ones. They

are characterized by the dominance of amphiboles and pyroxenes.

2. The stable minerals, zircon, tourmaline, and rutile generally occur in minor amounts.

3. The frequency distribution of opaque minerals in the coastal dune sands reflects higher concentration than in the inland dune sands. This probably is due to wave action that selectively sorts and concentrates heavy minerals according to their different densities.

4. The light mineral fraction is dominated by carbonate minerals with lesser quartz and feldspars in the coastal dune sands.

5. The heavy and light minerals are guides to the source of sands. Coastal dune sands come mostly from the beach, while the inland dune sands originated mainly from local basement rocks in the dune field.

References

Bagnold, R.A. (1954a) *The physics of blown sand and desert dunes,* London: Methuen. 265 p.

Bagnold, R.A. (1971) *The physics of blown sand and desert dunes.* 5th impression, Chapman and Hall, London. 265 p.

Carver, R.E. (1971) *Procedures in Sedimentary Petrology.* John Wiley and Sons Inc., New York, 653 p.

Davis, R.A. (1985) *Coastal Sedimentary Environments* second Revised, Expanded Edition. Springer-Verlage, New York, 715 p.

Folk, R.L. (1968) *Petrology of Sedimentary rocks,* Hemphills Austin, Texas, 170 p.

Folk, R.L. and **Ward, W.C.** (1957) Brazos River Bar: A study on the significance of grain - size parameters. *J. Sed. Petrology,* **27:** 3-26.

Friedman, G.M. (1961) Distinction between Dune, Beach and River sands from the textural characteristic. *J. Sed. Petrology,* **31:** 514-529.

Friedman, G.M. (1967) Dynamic processes and statistical parameters compared for size frequency distribution of Beach and River sands. *J. Sed. Petrology,* **37:** 327-354.

Gheith, A.M., Abd-Alla, M.A., El-Fayoumy, I.F. and **Toubar, N.** (1994) Mineralogy as indicator of various coastal environments along Burullus area. North Nile Delta, Egypt. *J. KAU: Mar. Sci.* **5:** 73-88.

Glennie, K.W. (1970) *Desert sedimentary environments. Development in Sedimentology.* Elsevier, **14:** 222.

McKee, E.D. (1966) Structures of dunes at white sands, National Monument, New Mexico (and a comparison withstrof dunes from other selected areas). *Sedimentology,* **7:** 1-69.

McKee, E.D. and **Tibbits Jr, G.C.** (1964) Primary structures of seif dune and associated deposits in Lybia. *J. Sed. Petr.* **34:** 5-17.

Moiola, R.J. and **Weiser, D.** (1968) Textural parameters an evaluation. *J. Sed. Petrology.* **38:** 45-53.

Pettijohn, F.J. (1975) *Sedimentary rocks.* Harper Row, New York. 627 p.

Reineck, H.E. and **Singh, I.B.** (1975) *Depositional Sedimentary Environments with reference to terrigenous clastic.* Springer - Verlag. New York. 439 p.

Sharp, R.P. (1963) Wind Ripples. *J. Geol.* **71:** 617-636.

Visher, G.S. (1969) Grain size distribution and depositional processes. *J. Sed. Petrology,* **39:** 1074-1106.

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الظواهر الجيومورفولوجية والسمات الترسيبيه لبعض الكثبان الرملية الساحلية والصحراوية بمنطقة جدة ، المملكة العربية السعودية

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يختص هذا البحث بدراسة الظواهر الجيومورفولوجية والمعاملات النسيجيه والمكونات المعدنية للكثبان الرملية الساحلية والصحراوية التي توجد على شاطئ الشعيبه ، الكورنيش الجنوبي لجدة وعلى طريق جدة - مكه السريع .

ولقد اشتملت الظواهر الجيومورفولوجية على نوع الكثيب ، درجة تحويرة ، نيم الرياح ، والبنيات الداخلية .

التمييز بين الكثبان الرملية الساحلية والصحراوية تم على أساس معاملات الحجم الحبيبي ، منحنيات التجمع ، العلاقات الثنائية والتركيب المعدني ، ولقد وجد أن رمال الكثبان الصحراوية دائما أدق في الحجم الحبيبي وجيدة الفرز عن رمال الكثبان الساحلية كما أنها تمتاز بمستعمرة مفردة لحمل الرواسب القافزة .

وقد تميزت ركيزة المعادن الثقيلة لكل من الكثبان الساحلية والصحراوية بسيود المعادن الغير ثابتة مثل الأمفيبول والبيروكسين على المعادن الثابتة مثل

الزيركون والتورمالين والروتيل .

ولقد استنتج أن الطوبغرافية المحلية واتجاه الرياح الحاملة للرمال تؤثر على توزيع ومورفولوجية الكثبان الرملية الصحراوية . بينما إشتقت رمال الكثبان الساحلية من الشاطئ نفسه .