بحوث في جغرافية
المملكة العربية السعودية

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استخدام الخصائص الحجمية للرمال في تمييز الفوارق بين بيئات ترسيبية مختلفة

د. عبد الحفيظ محمد سعيد سقا

١٤١٠هـ ١٩٩٠م

سلسلة محكمة غير دورية تصدرها الجمعية الجغرافية السعودية
جامعة الملك سعود - الرياض - المملكة العربية السعودية


الله
بسم الله الرحمن الرحيم

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قواعد النشر

١ ـ يراعى في البحوث التي تتولى سلسلة «بحوث في جغرافية المملكة العربية السعودية» نشرها الأصالة العلمية وصحة الإخراج العلمي وسلامة اللغة.

٢ ـ يشترط في البحث المقدم للسلسلة ألا يكون قد سبق نشره من قبل.

٣ ـ ترسل البحوث باسم رئيس هيئة تحرير السلسلة.

٤ ـ تقدم جميع الأصول على الآلة الكاتبة على ورق بحجم A4. مع مراعاة أيكون النسخ على وجه واحد، ويترك فراغ ونصف بين كل سطر وآخر. ويمكن أن يكون الحد الأعلى للبحث (٧٥) صفحة.

٥ ـ يرسل البحث مع ملخص في حدود (٢٥٠) كلمة باللغتين العربية والإنجليزية.

٦ ـ يراعى أن تقدم الأشكال مرسومة بالحبر الصيني على ورق (كلك) مقاس ١٣×١٨سم وترفق أصول الأشكال بالبحث ولا تلتصق على أماكنها.

٧ ـ تقوم هيئة تحرير السلسلة بإبلاغ أصحاب البحوث بتاريخ استلام بحوثهم. وكذلك إبلاغهم بالقرار النهائي المتعلق بقبول البحث للنشر من عدمه مع إعادة البحوث غير المقبولة إلى أصحابها.

٨ ـ يمنح كل باحث أو الباحث الرئيسي لمجموعة الباحثين المشتركين في البحث خمسًا وعشرين نسخة من البحث المنشور.

٩ ـ تطبق قواعد الإشارة إلى المصادر وفقا للآتي:

يستخدم نظام (إسم/ تاريخ) ويقتضى هذا النظام الإشارة إلى مصدر المعلومة في المتن بين قوسين بإسم المؤلد متوبعا برقم الصفحة. وإذا تكرر نفس المؤلف في

مرجعين مختلفين يذكر إسم المؤلف ثم يتبع بسنة المرجع ثم رقم الصفحة. أما في قائمة المراجع فيستوجب ذلك ترتيبها هجائيا حسب نوعية المصدر كالتالي:

الكتب: يذكر إسم العائلة للمؤلف (المؤلف الأول إذا كان للمرجع أكثر من مؤلف واحد) متبوعا بالأسماء الأولى، ثم سنة النشر بين قوسين، ثم عنوان الكتاب، فرقم الطبعة ـ إن وجد ـ، ثم الناشر، وأخيرا مدينة النشر.

الدوريات: يذكر إسم عائلة المؤلف منوبعا بالأسماء الأولى، ثم سنة النشر بين قوسين، ثم عنوان المقالة، ثم عنوان الدورية، ثم رقم المجلد، ثم رقم العدد، ثم أرقام صفحات المقال (ص ص٥ـ١٥).

الكتب المحررة: يذكر إسم عائلة المؤلف، متبوعا بالأسماء الأولى، ثم سنة النشر بين قوسين، ثم عنوان الفصل، ثم يكتب (في in) تحتها خط، ثم إسم عائلة المحرر متوبعا بالأسماء الأولى وكذلك بالنسبة للمحررين المشاركين، ثم (محرر .ed أو محررين .eds)، ثم عنوان الكتاب، ثم رقم المجلد، فرقم الطبعة، وأخيرا الناشر، فمدينة النشر.

الرسائل غير المنشورة: يذكر إسم عائلة المؤلف متوبعا بالأسماء الأولى، ثم سنة الحصول على الدرجة بين قوسين، ثم عنوان الرسالة، ثم يحدد نوع الرسالة (ماجستير/ دكتوراه)، ثم إسم الجامعة والمدينة التي تقع فيها.

أما الهوامش فلا تستخدم إلا عند الضرورة القصوى وتخصص للملاحظات والتطبيقات ذات القيمة في توضيح النص.

تعريف بالباحث:

الدكتور/ عبدالحفيظ محمد سعيد سقا ـ أستاذ مساعد ـ قسم الجغرافيا ـ كلية الآداب والعلوم الإنسانية ـ جامعة الملك عبدالعزيز ـ جدة.

استخدام الخصائص الحجمية للرمل في تمييز الفوارق بين بيئات ترسبية مختلفة

لقد أظهرت عينات رمال أربع بيئات ترسبية مختلفة (كثيب داخلي، كثيب ساحلي، شاطىء ونهر) اختلافات ملحوظة في مؤشرات أنسجة الرمال. هذه الاختلافات ترجع إلى الاختلافات الكبرى في طاقة وسيلة النقل بين البيئات. لقد وجد أن رمال الكثيب الداخلي والنهر أخشن من رمال الكثيب الساحلي ورمال الشاطىء بصفة عامة.

كما أن رمال الكثيب الساحلي والشاطىء أجود تصنيفا من رمال الكثيب الداخلي والنهر. أما بالنسبة للالتواء، فقد وجد أن رمال الكثيب الداخلي والنهر موجبة الالتواء، في حين أن رمال الكثيب الساحلي والشاطىء لها صفة الالتواء السالب، وبالنسبة للتفلطح فقد وجد أن رمال الشاطىء تأخذ صفة التفلطح الشديد في حين أن رمال البيئات الثلاث الأخرى تنزع نحو تفلطح شديد مدبب أو أنها ذات قيم عالية في التفلطح.

لقد أظهرت نتيجة التميز (أو التفريق) بين بيئات الترسيب المختلفة، على أساس مؤشرات أنسجة رمالها، نتائج غير دقيقة بالدرجة المرضية (موقعة كمتغيرات على إحداثيات مستوية «س، س»). على أية حال لقد وجد في بعض الحالات اختلافات واضحة بين البيئات. إن الجدوى من استخدام مؤشرات أنسجة الرمال للتفريق بين بيئات ترسبية مختلفة يعتمد على درجة تباين حجم حبيبات الرمال بين البيئات المختلفة.

وعلى ذلك يمكن القول أن النتائج المتضاربة تحدث بسبب استخدام طرق معملية أو إحصائية غير مجدية أو بشكل غير صحيح.

الإصدارات السابقة:

١ ـ نموذج لتوقيع الكتابة العربية على الرموز في الخرائط العامة والطبوغرافية.	د. ناصر بن محمد عبدالله سلمى
٢ ـ تقدير عدد سكان المدن السعودية الصغيرة باستخدام الصور الجوية.	د. خالد بن محمد العنقري
٣ ـ الحرارة وتكاليف تقدير موسم إنتاج الطماطم في البيوت المحمية المكيفة في واحة الأحساء.	د. عبدالله أحمد الطاهر

Friedman. G.M., (1979): "Differences in size distributions of populations of particles among sands of various origins", *Sedimentology,* v. 26, pp. 3 - 32.

Griffiths, J.C., (1951): "Size versus sorting in some Caribbean sediments", *Jour. Geol.,* v. 59, pp. 211 - 243.

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The result which has been obtained for distinguishing between the environments on the basis of their textural parameters is not very successful. Nevertheless, in some cases good differentiation has been obtained for distinguishing between the environments. In fact, when a wide range of grain size exists between the different environments, successful results can be obtained. In the literature, however, it has been observed that very few authors have used reliable techniques in their studies whether in laboratory or statistical methods. Such techniques as the use of graphical measures e.g., Folk and Ward, 1957, rather than moment measures which are more sensitive to environmental process and give a truer picture of such process (Folk, 1974; Friedman, 1979). One may also add that settling tube for grain size analysis (Shepard and Young, 1961) is unreliable to detect the tails of the size distribution. Therefore, the use of reliable techniques in this study, such as moment measures and calibrated sieves, was important for distinguishing sand textures between the various environments. In conclusion, it should be noted, however, that the usefulness of using textural parameters of sand in order to differentiate sand in various depositional environments depends on how good is the contrast of grain size between these environments.

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ferences in the mode of transport of sands will in turn affect the character of skewness and kurtosis.

Plots of standard deviation versus skewness provide a good separation between four field representing four various depositional environments (Fig. 3 B). The distribution pattern of the plots for the inland dune is distinct from the coastal dune sands. The inland dune sands have the tendency to be positively skewed with moderately well sorted to moderately sorted sands. Whereas, the coastal dune sands are dominated by negative skewness with very well sorted to moderately sorted sand. In contrast, the beach and river sands show scatter plots and therefore no significant distribution pattern. In fact, this result is unlike what has been observed by Folk and Ward (1957, p. 20) as they stated that both sorting versus skewness are function of Mz and will bear a mathematical relation to each other. In the same way, Friedman (1961, 1979) was successful in differentiating beach from river sands. Moiola and Weiser (1968) were also successful in differentiating between river and beach sands (with combination of phi data). In contrast, Shepard and Young (1961) failed to indicate any significant difference between dune and beach sands. Nevertheless, the inconsistent results above can be attributed to different laboratory and measure methods as well as the differences in the mode of transport in each area.

Polts of standard deviation versus kurtosis show that the coastal dune sands are nearly separated from the other three environments (Fig. 3 C). In contrast, the sands of the other three environments show a large field of overlap. The sands of coastal dune have the tendency to be extremely leptokurtic distribution with very well sorted sand, whereas, the inland dune sands tend to be leptokurtic distribution with moderately well sorted to moderately sorted sand. The river and beach sands show no significant distribution pattern.

Conclusions

This study shows that there is a marked variation in grain size distribution for the four varied depositional environments (inland dune, coastal dune, beach and river). The variations were attributed to the large differences in the energy of the transporting medium for each environment and, in turn, the differences in the process of deposition. In general, however, the inland dune and river sands tend to be coarser than the coastal dune and beach sands. The sands of coastal dune and beach are better sorted than those from inland dune and river sands. Skewness values reveal that the sands of inland dune and river are positively skewed, while those from coastal dune and beach are negatively skewed. The inland dune sands exhibit the lowest kurtosis values (leptokurtic distribution), while the other three environments show higher kurtosis values (extremely leptokurtic distribution).

between the four different environments altogather, but they also provided no explanation for their results.

Plots of mean grain size versus skewness show a good separation of the four fields (Fig. 2 B). However, the sign of skewness is not influenced by the mean size of sand. For example, although some of the river sands are in the medium sand interval, they exhibited negative skewness. This result has been attributed to differences in the mode of transport which apparently affect the tails of the distribution. Friedman (1961. 1979) shows nearly a complete separation of field representing beach and dune sands. Moiola and Weiser (1968) found that the combination of mean size versus skewness is most effective to differentiate between beach and inland dune sands, on one hand, and inland dune and coastal dune sands, on the other. By contrast, Schlee and others (1964) have found a large degree of overlap for beach and eolian sands which was attributed to the use of graphical measures which had been formulated by Folk and Ward (1957) rather than the moment measures and the coarseness of the Cape Cod sands (Massachusetts, U.S.A.).

Plots of mean grain size versus kurtosis have not provided a good separation of the four fields (Fig. 2 C): the coastal dune sands show nearly a complete separation from the other three environments. As with skewness, the kurtosis here seems to be a function of the grain size. Apart from inland dune sands, the kurtosis values for the other three environments seem to be rather complex as they tend to be leptokurtic to extremely leptokurtic in the coarse to fine sand interval. This also can be explained by the differences in the mode of transport.

Plots of skewness versus kurtosis show that the inland dune and coastal dune sands can be distinguished from the beach and river sands (Fig. 3 A). Nevertheless, the inland dune sands tend to be positively skewed-leptokurtic grain size distribution, whereas the other three environments show no consistent pattern. In contrast to other results, however, using plots of skewness versus kurtosis, Shepard and Young (1961) did not find any significant trend for distinguishing beach from dune sands. In the same way, Friedman (1961, P. 524) stated that these plots did not contribute diagnostic information of depositional environments and concluded that skewness is environmentally sensitive while kurtosis is not. In contrast, Mason and Folk (1958) found that beach, dune and eolian flat sands are well differentiated by plotting skewness versus kurtosis. Moiola and Weiser (1968) found that with only quarter phi data, skewness versus kurtosis was useful to differentiate between inland dune and coastal dune sands, beach and inland dune sands, and river and coastal dune sands. As mentioned above, skewness and kurtosis reflect the changes in the tails of the distribution and they are very sensitive to transportive mechanism, therefore, any slight difexceptional and opposite results have been observed by some researchers (Friedman, 1961, 1979; Schlee and others, 1964; Sevon, 1966). It should be stressed, however, that some caution must be taken in comparing published results as there are so much variations in the methods and this could induce some negative skewness in the samples (Folk, 1962).

The mean kurtosis values for the various environments show that the coastal dune sands have the higher kurtosis values than those of the other environments, while the inland dune sands display the smaller kurtosis values. As with skewness, the sands of inland dune show the smaller range of kurtosis values when compared with those of the other environments. However, the kurtosis for the sands of all the environments are of leptokurtic distribution (leptokurtic to extremely leptokurtic). Friedman (1961) found that most sands are leptokurtic whether positively or negatively skewed. Moreover, Mason and Folk (1958, P. 224) state that most sands consist of one predominant population with a very subordineate coarser (negatively skewed) or finer (positively skewed) population. Therefore, as with skewness, any slight differences in the mode of transport will apparently affect the tails of the distribution.

The mean grain size versus standard deviation for the sands of the environments (Fig. 2 A) show that the coastal dune and inland dune sands can easily be distinguished from the beach and river sands. It is well established that sorting is closely controlled by the mean size (Inman, 1949; Griffiths, 1951; Folk and Ward, 1957). For example, most of the poorest sorted sands (inland dune and river) occur in the coarse and medium sand interval, while the best sorted sands (beach and coastal dune) take place in the fine interval (Fig. 2 A).

Comparing the above findings with other results elsewhere Mason and Folk (1958) plotted Mz v. SO values for the beach dune, and eolian flat sands of Mustang Island. They found no significant correlation and attributed that to the small range of the mean size and sorting values. Shepard and Young (1961) failed to present any striking difference between dune and beach sands by plotting Mz v. SO values. Folk (1962) commented that they failed because they used the settling tube for grain size analysis rather than a set of calibrated sieves. However, Friedman (1961) plotted Mz v. SO of dune, river and beach sand (a total of 267 sand samples). He indicated the existence of three fields of dune and river sands distinguishable from the beach sands. Although he found a wide overlap, he pointed out that in practice that field of overlap is not a serious matter since the dune sands (desert dune) do not exceed the standard deviation of 0.5 phi, whereas, most river sands do. Moiola and Weiser (1968) found that the combination of mean size versus sorting (with quarter, half and whole phi data) is most effective in differentiating between beach and river sands, on one hand and river and coastal dune sands, on the other. They did not differentiate

The mean grain size of inland dune and river sands tend to be coarser than those from coastal dune and beach. The river sands exibit greater Mz range values than those from other environments, while the coastal dune sands have the smallest range values. The fine character of Mz values of both coastal dune and beach sands, relatively fine sand, can be attributed to the fact that the waves which deposit sand on the beach, which in its turn form a coastal dune, have a greater competency than the wind and water transporting sand onto inland dune and river bank respectively (Friedman. 1961). The results of Mz values in this study have come to the same conclusions reached by some researchers such as; Folk and Ward, 1957; Mason and Folk, 1958; Friedman, 1961; Schlee and others, 1964; Sevon, 1966; Folk, 1971; Abolkhair, 1981, 1985, 1986; and Sagga, 1986.

The sands of coastal dune and beach are better sorted than those from inland dune and river. As with mean grain size, the river sands have the wider sorting range values compared with the other environments while the coastal dune have the smallest. The differences in sorting range may be explained by the low degree and high degree of sorting that occur in the river and coastal dune environments respectively. The same results were observed by Friedman (1961) who found that the beach sands (source material of coastal dune) can be better sorted than inland dune and river sands. He attributed that to winnowing action by waves as one of various characteristics of beach environment.

The mean skewness values for various environments reveal that the sands of inland dune and river are positively skewed, whereas those from coastal dune and beach are negatively skewed. However, the sands of inland dune exhibit the smaller range of skewness values when compared with those of the other environments. In fact, the skewness results seem to be confirmed with what have been observed by many researchers. For example, it is well established that the beach and coastal dune tend to be negatively skewed, while river and inland dune sands are commonly positively skewed (Folk and Ward, 1957; Friedman. 1961, 1979; Shepard and Young, 1961; Mabesoone, 1963; Sevon, 1966; Moiola and Weiser, 1968; Abolkhair. 1981, 1985, 1986; Sagga, 1986). Moreover, it should also be noted that skewness is a sensitive parameter of environments of deposition and any slight change in mode of transport, grain size and roughness of surface would affect the tails of the distribution, and in turn, the character of skewness. Therefore, the negative skewness of coastal dune and beach sands can be attributed to the removal of the fine tail fraction by wind and also to waves action respectively. It has been observed that when sediment is moved by a river or wind, the transportation of sands is generally unidirectional, this probably gives an explanation to the positive skewness of inland dune and river sands (Friedman, 1961). Although the wider existence of negative skewness for beach and coastal dune sands and positive skewness for river and inland dune sands,

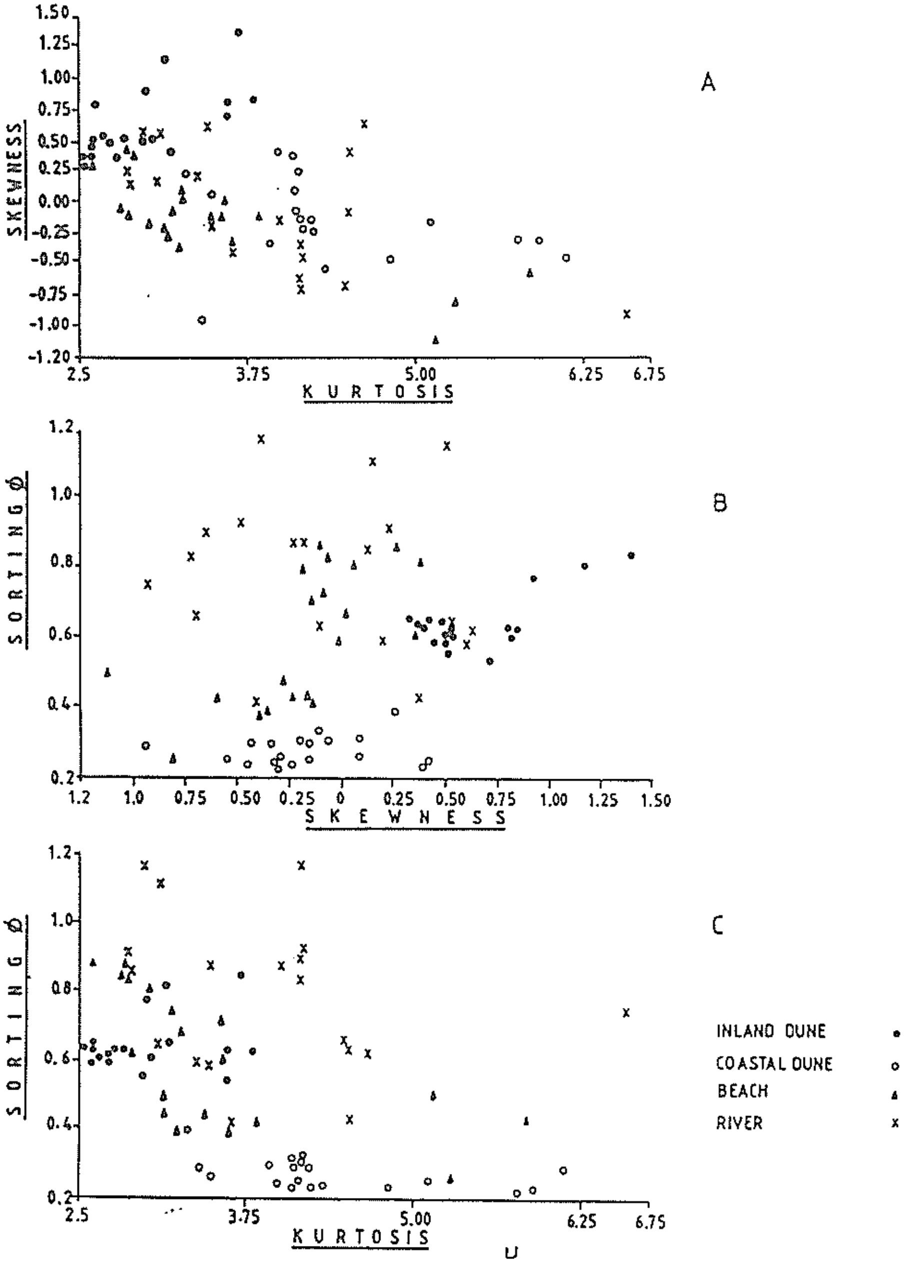

Fig. 3: Scather plots of Skewness versus Kurtosis (A) Sorting versus Skewness (B) & Sorting versus Kurtosis (C)

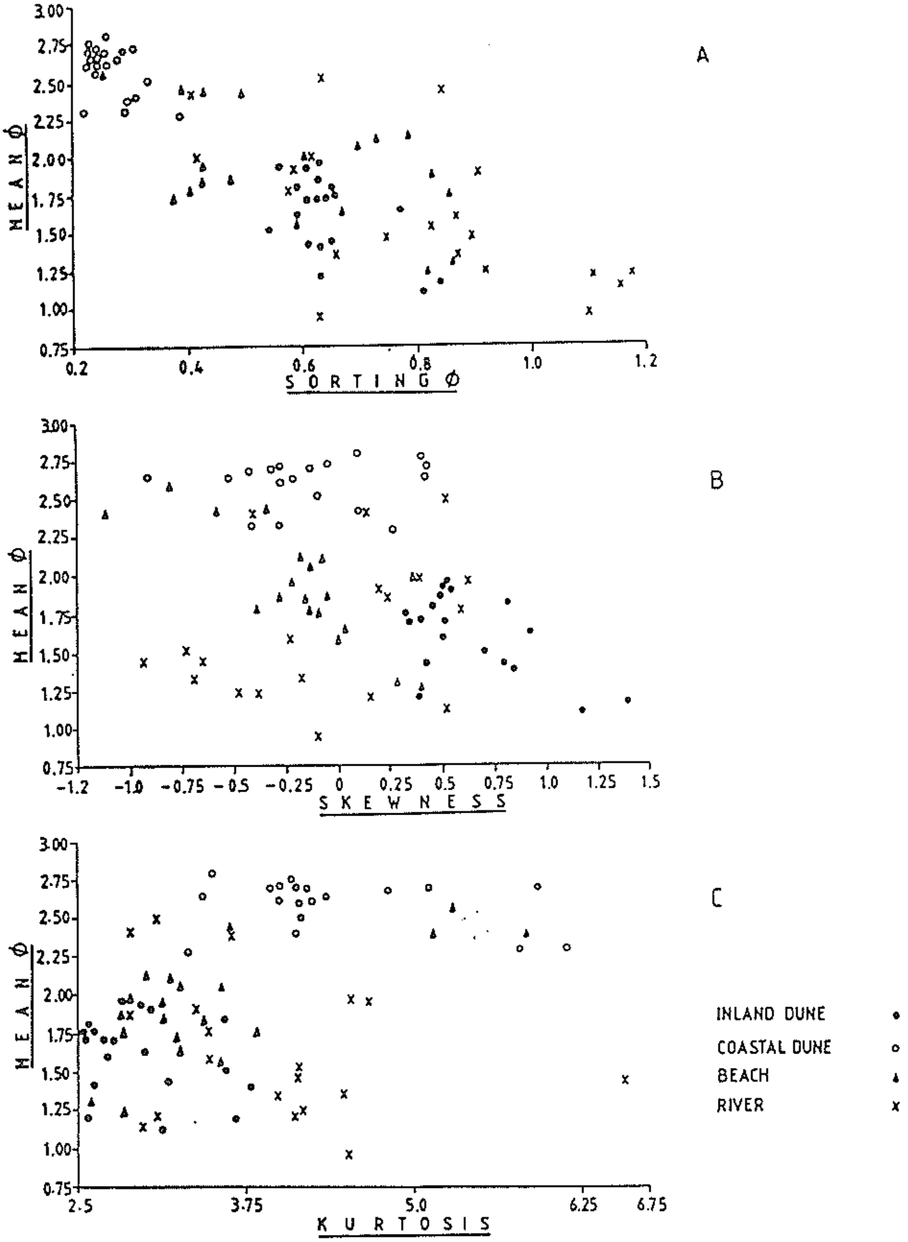

Fig. 2 Scatter plots of Mean Size versus Standard Deviation (A) Mean Size versus Skewness (B) & Mean Size versus Kurtosis (C)

Skewness:

The skewness values reveal that all the inland dune sands are strongly fine-skewed, having an average sk of +0.63. The skewness values of the inland dune sands exhibit, at the same time a normal distribution with most of the sands being concentrated at about +0.70. In contrast, the other three environments show only a polymodal distribution of skewness values; the coastal dune sands show an average sk of −0.14 (coarse-skewed). Thus, the majority of the coastal dune sands are concentrated at −0.20 with a cluster at −0.71 and smaller clusters at 0.00, +0.20, and +0.71. While most of beach sands are concentrated at −0.20 with clusters at −0.71 and 0.00 and smaller clusters at +0.71 and +0.20. On the other hand, the majority of river sands are concentrated at −0.71 with smaller clusters at +0.71. +0.20 and −0.20. All this proves that all of the skewness distribution curves show extremely high degree of overlap between the environments (Fig. 1 C).

Kurtosis:

The inland dune sands have very leptokurtic to extremely leptokurtic values (averaging 2.97) with bimodal distribution. Here, most of the sands clustered at about 2.25 and a small cluster at about 3.47. In comparison with the other three environments, the coastal dune sands display the higher kurtosis values (averaging 4.39). The kurtosis of the coastal dune sands is unimodal and most of kurtosis values clustered at about 4.76. The beach sands show an average k of 3.52 (extremely leptokurtic) with a bimodal distribution. Most of the beach sands are concentrated at 4.5 with a smaller cluster at 2.25. The river sands show a bimodal distribution of kurtosis with an average k of 3.93 (extremely leptokurtic). Most of the river sands are concentrated at about 4.75 with a smaller cluster at about 2.48. Here, all of the kurtosis distribution curves show a high degree of overlap between the environments (Fig. 1 D).

Results and Discussion

In order to evaluate the interrelationship between the textural parameters for the four various depositional environments (inland dune. coastal dune, beach and river sands), scatter plots were made (Folk and Ward. 1957; Mason and Folk, 1958; Friedman, 1961, 1979) to find out distinctive characteristic for distinguishing between them.

The results shown in Figs. 2 and 3 reveal some marked variations in size distribution in the four environments. The differences in size distribution may be due to the large differences in the mode of transport for each environment.

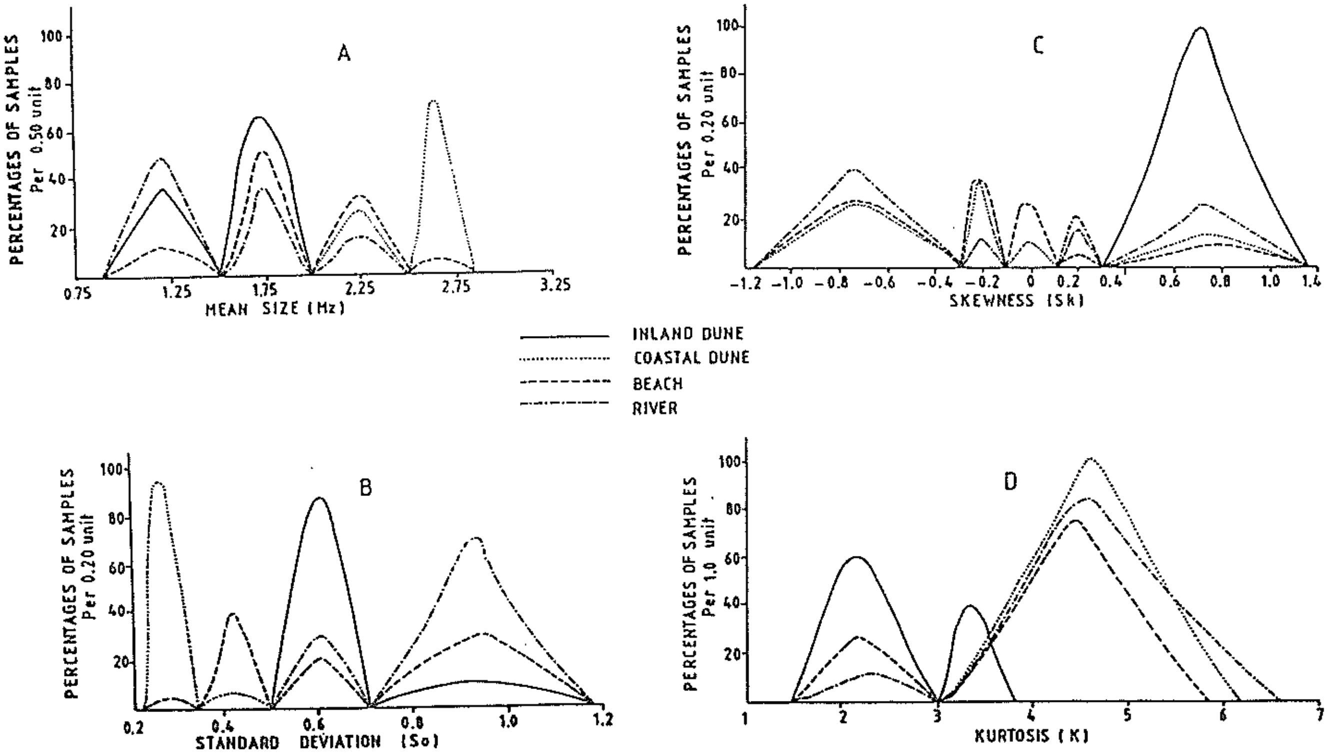

FIG. 1 FREQUENCY DISTRIBUTION CURVES OF (A) MEAN SIZE, (B) STANDARD DEVIATION (C) SKEWNESS AND (D) KURTOSIS

Percentage distribution of grain-size parameters
in the inland dune, coastal dune, beach and river

Parameters	Inland dune	Coastal dune	beach	river	Parameters	Inland dune	Coastal dune	beach	river
Mean size (Mz)					Standard deviation (Sd)				
1.0–1.50	35	–	10	50	less than 0.35	–	95	5	–
1.5–2.0	65	–	50	35	0.35–0.50	–	5	40	–
2.0–2.5	–	25	35	15	0.50–0.71	85	–	20	30
2.5–2.81	–	75	5	–	0.71–1.00	15	–	35	70
Skewness (Sk)					Kurtosis (K)				
−1.00 to −0.30	–	25	35	40	1.11–1.50	–	–	–	–
−0.30 to −–0.10	–	35	35	15	1.50–3.0	60	–	25	15
−0.10 to +0.10	–	10	25	–	over 3.0	40	100	75	85
+1.10 t0 +0.30	–	15	5	20					
+0.30 to +1.39	100	15	10	25					

Table 7

The means and ranges of grain-size parameters
of inland dune, coastal dune, beach and river

Environments	Mean (Mz ∅)			Sorting (So ∅)			Skewness (Sk)			Kurtosis (K)		
	av.	min.	max.	av.	min.	max.	av.	min.	max.	av.	min.	max.
Inland dune	1.60	1.10	1.95	0.64	0.54	0.84	+0.63	+0.33	+1.39	2.97	2.51	3.80
Coastal dune	2.60	2.29	2.81	0.27	0.22	0.39	–0.14	–0.90	+0.43	4.39	3.31	6.12
Beach	1.93	1.23	2.59	0.59	0.25	0.86	–0.17	–1.12	+0.39	3.52	2.59	5.83
River	1.61	0.96	2.51	0.80	0.41	1.18	+0.11	–0.93	+0.63	3.93	2.86	6.58

Table 6

Textural parameters of river sands, New Zealand (Sevon, 1966)

No.	Mz Ø	So Ø	Sk	K
1	1.46	0.90	−0.65	4.14
2	1.21	1.18	−0.38	4.14
3	2.42	0.85	0.13	2.88
4	1.34	0.66	−0.69	4.48
5	1.45	0.75	−0.93	6.58
6	1.87	0.91	−0.24	2.86
7	2.41	0.41	−0.41	3.64
8	1.20	1.11	0.15	3.09
9	1.96	0.62	0.63	4.65
10	1.53	0.83	−0.73	4.15
11	1.91	0.59	0.20	3.38
12	0.94	0.63	−0.10	4.51
13	1.78	0.58	0.60	3.47
14	1.98	0.42	0.38	4.53
15	1.59	0.87	−0.23	3.48
16	1.33	0.87	−0.18	3.99
17	1.13	1.16	0.52	2.99
18	1.23	0.92	−0.48	4.16
19	2.51	0.64	0.53	3.09
20	0.96	1.10	−0.82	4.46
Mean	1.61	0.80	+0.11	3.39

Table 5

Textural parameters of beach
sands, Jeddah, Saudi Arabia

No.	Mz Ø	So Ø	Sk	K
1	2.43	0.43	–0.59	5.83
2	2.59	0.25	–0.81	5.28
3	2.45	0.39	–0.35	3.63
4	1.95	0.43	–0.23	3.13
5	2.42	0.50	–1.12	5.14
6	1.77	0.14	–0.14	3.83
7	1.85	0.48	–0.28	3.14
8	1.83	0.43	–0.16	3.45
9	1.99	0.61	0.36	2.89
10	1.72	0.38	–0.39	3.23
11	1.29	0.86	0.27	2.59
12	1.56	0.59	–0.01	3.57
13	1.64	0.67	0.03	3.26
14	1.23	0.82	–0.39	2.85
15	1.75	0.86	–0.10	2.83
16	1.87	0.83	–0.07	2.81
17	2.06	0.70	–0.14	3.56
18	2.11	0.73	–0.08	3.18
19	2.13	0.79	–0.19	3.01
20	2.06	0.81	–0.06	3.25
Mean	1.93	0.59	–0.17	3.52

Table 4

Textural Parameters of Coastal
dune sand, Ainsdale, England

No.	Mz Ø	So Ø	Sk	K
1	2.71	0.25	–0.13	5.11
2	2.33	0.29	–0.41	6.12
3	2.72	0.23	–0.29	5.91
4	2.73	0.30	–0.04	4.11
5	2.52	0.33	–0.09	4.15
6	2.76	0.23	0.41	4.09
7	2.63	0.24	0.43	3.98
8	2.73	0.24	0.43	3.98
9	2.66	0.28	–0.90	3.41
10	2.41	0.31	0.11	4.11
11	2.32	0.22	–0.28	5.77
12	2.29	0.39	0.27	3.31
13	2.81	0.26	0.10	3.49
14	2.65	0.24	–0.52	4.33
15	2.71	0.29	–0.13	4.18
16	2.63	0.23	–0.21	4.23
17	2.61	0.25	–0.27	4.13
18	2.69	0.23	–0.42	4.81
19	2.71	0.29	–0.31	3.93
20	2.39	0.30	–0.17	4.17
Mean	2.60	0.27	–0.14	4.39

Table 3

Textural Parameters of an inland
dune sand, Al Hassa, Saudi Arabia

No.	Mz Ø	So Ø	Sk	K
1	1.80	0.59	0.45	2.60
2	1.71	0.61	0.51	2.71
3	1.20	0.63	0.39	2.59
4	1.43	0.65	0.42	3.18
5	1.91	0.61	0.53	3.05
6	1.83	0.63	0.81	3.61
7	1.78	0.65	0.49	2.61
8	1.75	0.65	0.33	2.51
9	1.95	0.63	0.52	2.84
10	1.41	0.61	0.81	2.63
11	1.93	0.56	0.51	2.99
12	1.17	0.84	1.39	3.70
13	1.60	0.59	0.50	2.73
14	1.63	0.77	0.92	3.01
15	1.40	0.63	0.83	3.80
16	1.72	0.64	0.35	2.54
17	1.10	0.81	1.17	3.15
18	1.51	0.54	0.71	3.61
19	1.72	0.63	0.39	2.79
20	1.39	0.61	0.51	2.71
Mean	1.60	0.64	0.63	2.97

Table 2

Textural Pattern

The distribution of grain-size parameters in different environments (inland dune, coastal dune, beach and river) are given in Tables 2,3,4 and 5, while tables 6 and 7 show the range and percentage distribution of grain size parameters for the four environments. Meanwhile, frequency distribution curves (Fig. 1) for mean size, standard deviation, skewness and kurtosis were drawn to compare the range of mean size, sorting, etc., in each environment and also to describe the modality and the degree of overlap.

Mean Size:

Mean grain size of the inland dune, beach and river are classified as medium sand, but the sand of beach (averaging 1.93 phi) is close to the boundary of fine sand. In contrast, the mean grain size of the coastal dune (averaging 2.60 phi) is in the boundary of fine sand. The inland dune and coastal dune sands show a bimodal mean grain size distribution. Most of the inland dune and coastal dune sands have Mz values at about 1.75 phi and 2.62 phi with smaller clusters at about 1.12 phi respectively. The beach and river sands show a polymodal mean grain size distribution. The beach samples are concentrated at about 1.75 phi and 2.62 phi. For the river, most of the samples are concentrated at about 1.20 phi with a cluster at 1.75 phi and a smaller cluster at 2.25 phi. figure 1 A shows a complete overlap of all of the mean size distribution curves of the environments.

Standard Deviation (Sorting):

The standard deviation values reveal that most of the inland dune sands are moderately well sorted (averaging 0.64 phi) with bimodal distribution, most of the value clustered at about 0.63 phi and a small cluster at about 0.95 phi. The coastal dune shows that 100% of its sands are in the very well sorted grain (averaging 0.27 phi) with a bimodal distribution; it also displays the best sorting values compared with the other three environments. Most of the coastal dune sands are concentrated at about 0.27 phi with very small cluster at about 0.43 phi. As with inland dune and coastal dune, the river sands show a bimodal distribution, but its sands display the worst sorting values compared with the other three environments (averaging 0.80 phi, moderately sorted); most of the samples are concentrated at about 0.93 phi with a cluster at about 0.63 phi. On the other hand, the beach sands show a polymodal distribution with an average sorting of 0.59 phi (moderately well sorted). Most of the samples are concentrated at about 0.43 phi. As a result, all of the sorting distribution curves for the environments show a high degree of overlap (Fig. 1 B).

skewness and kurtosis were determined by the method of moments. The method of moments (Table 1) has an advantage over the graphic measures (Folk and Ward, 1957), since the first has been "to assign to the tails of the distribution the importance which they deserve in environmental analysis" (Friedman, 1979, p.10). Frequency distribution curves of textural parameters were made to describe the modality, degree of overlap and the range of each parameter. In addition, graphs of all possible two parameters were also made by using an Energraphics X-Y plotter attached to a PC computer.

Moment Measures: Difinition (Pettijohn et al., 1973)

$$\text{Mean } \bar{X}_{\emptyset} = \frac{\sum fm}{n}$$

$$\text{Standard deviation } O_{\emptyset} = \sqrt{\frac{\sum f(m - \bar{x}_{\emptyset})^2}{100}}$$

$$\text{Skewness } SK_{\emptyset} = \frac{\sum F(m_{\emptyset} - \bar{x})^3}{100\ \delta^{\emptyset^3}}$$

$$\text{Kurtosis } K_{\emptyset} = \frac{f(m - \bar{x}_{\emptyset})^4}{100\ \delta^{\emptyset^4}}$$

Where f = weight percent (frequency) in each grain-size grade present.

m = midpoint of each grain-size grade in phi values.

n = total number in sample which is 100 when f is in percent.

Table 1

the type and characteristics of the sediment as well as to distignuish between various environments (see for example Folk and Ward, 1957; Mason and Folk, 1958; Friedman, 1961, 1979; Shepard and Young, 1961; Duane, 1964; Martine, 1965; Sevon, 1966 Awasthi, 1970; Valia and Cameron, 1977). Although the use of textural parameters (plotted as variables on a two-dimensional coordinate system) as a technique for differentiating sand bodies was successful in some studies (Folk and Ward, 1957; Friedman. 1961), its achievement in other studies was only partial (Shepard and young, 1961). Folk (1962) commented that they could not arrive at successful results because they used the settling tube for grain-size analysis of their samples rather than a set of calibrated sieves. As a matter of fact, these conflicting results may be attributed to inconsistent laboratory and statistical methods.

Although the empirical approaches mentioned above were aimed at distinguishing deposits in different environments, little attempt has been made to distinguish depositional sands in different areas (Friedman, 1961, 1979). In the present study an attempt is made to find out the usefulness of grain size distribution measures (textural parameters) for distinction of sands deposited in different environments. The same basic approach, mentioned above, will be followed, the data used in this study from four sources in different areas, namely inland dune sands of Al Hassa, Saudi Arabia, coastal dune sands of Ainsdale, England, beach sands of Jeddah, Saudi Arabia and river sands of new Zealand.

Field and Laboratory Procedures

A total of 60 sand samples (20 samples for each source) were collected from inland dune, coastal dune and beach. samples were collected from a 3-centimeter of sediment layer with a plastic tube 3-centimeter diameters. The river samples (20 samples) are representing some rivers from New Zealand (Sevon, 1966). The sand samples of inland dune (about 5 metres high) were collected from the windward slope of a barchan dune at Al-Hassa Eastern Provinces of Saudi Arabia. Sands from coastal dune were also collected from the windward slope of a dune (about 4 metres high), at Aindale on the Lancashire coast, England, and were characterized by some scatter vegetation at the base and middle of the dune. The sand samples of a beach north of Jeddah, Saudi Arabia, were collected from some localities on backshore and care was taken to avoid sampling from feature zone in order to avoid any sampling problems.

In the laboratory, sand samples were washed and treated with 10% dilute Hcl in order to remove salt and shell material. Aproximately 25 grams of each sample was sieved by the auther for 30 minutes on a Ro-Tap shaker using a 1/4 phi-interval sieve series (from –1.0 to 4.25 phi). Each fraction was weighed to 0.01 gram. Size distribution measures of mean, standard deviation (sorting),

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The Utility of Sand Grain Size in Distinguishing Between Various Depositional Environments

Abulhafiez M.S. Sagga

Abstract

Sand samples from four various depositional environments (inland dune, coastal dune, beach and river) reveal a marked variation in textural parameters. This difference was attributed to the large differences in the energy of the transporting medium between the environments. In general, the mean grain size of inland dune and river sands tend to be coarser than those from coastal dune and beach. The sands of coastal dune and beach are better sorted than those from inland dune and river. The sands of inland dune and river are positively skewed, while those from a coastal dune and beach are negatively skewed. The inland dune sands are leptokurtic distribution, whereas the other three environments show extremely leptokurtic distribution. Not very successful result has been achieved for distinguishing between such environments on the basis of their textural parameters (plotted as variables in a two-dimensional coordinate system). However, in some cases good differentiation has been obtained for distinguishing between environments. Generally speaking, the usefulness of using textural parameters of sand to differentiate sand in various depositional environments depends on how good is the contrast of grain size between different environments. It has been suggested that the use of unreliable technique such as laboratorial or statistical methods may lead to conflicting results.

Introduction

The potential usefulness of using textural parameters of sand to differentiate sand bodies developed in various depositional environments has a long history and voluminous literature (folk, 1966, p. 74). The geomorphological and sedimentological studies have used the textural parameters of sand to describe

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