

Grain Size and Shape of Sand Grains in Ergs of Iran

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Abstract

Large areas of Iran are under the influence of wind erosion thus it is important that we recognize three zones of removal, transportation and deposition. The deposition zone is very important due to more damages and tangible effects. In this study we try to obtain a comprehensive idea to Persian desert with use of laboratory facilities, remote sensing, GIS and field surveying. We survey 28 ergs in this study that they have 6410600 ha area. Area of sand dune is 4172500 ha and we analysis 66 samples from them. the range of grain size is 4000 micron to less than 62 μ . 11% from samples have max grain size of 4000 μ , 3% 1700 μ , 5% 1180 μ 13% 600 μ , 58% 300 μ , 9% 150 μ , 2% 62 μ . 28% samples had min grain size of 75 μ , 13% 62 μ , and 59% less than 62 μ . 3% samples had mod of 600 μ , 3% 300 μ , 59% 150 μ , 30% 75 μ and 3% 62 μ . The samples were transport 1 to 5 km, 2% were transport 5 to 20 km, 72% were transport 20 to 50 km and 23% were transport 50 to 200 km. skewness coefficient of normal charts are -0.2 to 2.95 and most coefficients is in range of 2 that shown fine grain.

Keywords: Sand dune; Grain size; Erg

1. Introduction

About 24 million hectares of Iran have been damaged by wind erosion. About 12 to 15 million hectares of these regions are sand dunes. The situation will be recognized, the behavior and the nature of the hill sandy and separation of the place, transportation and sediment investment wind sediments of special importance.

Studying over nearly the past 80 years have shown that the grain size distributions of dune sands have acted as an important factor on the morphology and dynamic processes of dunes (e.g. Bagnold, 1937; Bagnold and Barndorff-Nielsen, 1980; Tsor, 1986; Pye and Tsor, 1990; Lancaster, 1995). Grain size has been one of the major parameters described when the history of the development of the sand seas is considered (e.g. Thomas, 1988; Lancaster, 1989a; Winspear and Pye, 1995). Grain size distributions of dune sands have been described since the early 20th

century. There are many studies on the grain size of sand-sized sediments at the scale of sand seas (e.g. Folk, 1971; Lancaster, 1981, 1989a, 1995; El Sayed 1999; Thomas, 1988; Winspear and Pye, 1995; Wang et al 2003; Saqqa and Atallah 2004; Rengers and Wohl 2007), different dune types such as linear dunes (e.g. Bagnold, 1941; Lancaster, 1986; Watson, 1986; Livingstone, 1987; Livingstone et al., 1999), crescent dunes (e.g. Barndorff-Nielsen et al., 1982; Vincent, 1984; Watson, 1986), star dunes (e.g. Lancaster, 1989b, 1995) and other dune types.

Furthermore, the grain size characteristics of the dune sands are closely related to factors such as dynamic processes of the dunes, sand availability, vegetation, and the transportation distances from the source zones. (Wang et al., 2003)

There are some arguments on the relations between grain size distributions and dune morphology (Wiggs, 1997; Lancaster, 1995; Livingstone and Warran, 1996).

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2. Material and Methods

The sampling area is located in the ergs of Iran where compound/complex crescent dunes

and chains, compound domes, compound/complex linear dunes and star dunes have developed successively in each erg (Figure 1).

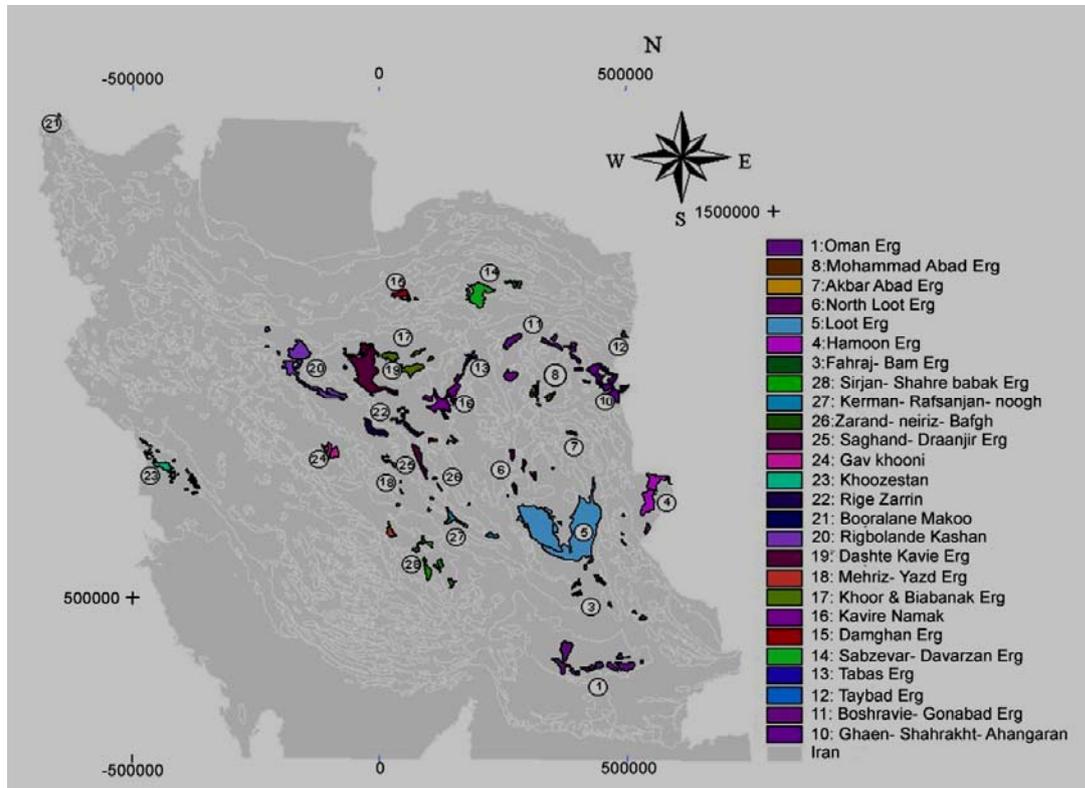


Fig. 1. Location of ergs of Iran

2.1. Satellite images(TM 2000) were used to obtain the geomorphology map of mountains, pediments, piedmonts and ergs.

2.2. Using aerial photo at scale 1:50000 for nominate the aspect and type of sand dunes in erg.

2.3. Using the topographic map at scale 1:250000 for supplement the Iran inequality.

2.4. Using the geology maps at scale of 1:250000 for recognition of geology of deposition regions.

2.5. Delineating the sand dunes in maps at scale 1:1000000

Sediment samples of between 600 and 1000 g were collected from the sand dunes and sand seas.

In order to compare the analytical results with those of other sand seas, 300 g of each sample was sieved at 0.25 μ intervals.

3. Results

27 Ergs were recognized in Iran. They have different area. The smallest of them is Booralan Makou with 16 Km² areas while the biggest is

Loot with 11745 Km² areas. Area of Iran Ergs is shown in Table 1.

In distribution, sand dunes of these ergs are divided into three types: isolated, single chains and coalescing chains. Sand dunes are mainly concentrated in this area that accounts for 95% of the total area in ergs and sand seas accounts 5%.

3.1. Oman Erg

These sand dunes are located in the south east of Iran in longitudes 60° 45' to 57° 20' E and latitudes 25° 20' to 26 ° 45' N this erg is created by moving sand with waves.

These sands have two main sources:

1. Sea source; that named coastal sand dune. These dunes are linear dune with 10 m to up 1 km width.

2. Non sea source; source of these sand dune is dry channels.

The samples of this erg catch from Jask. The mean grain sizes vary between 300 μ and <62 μ with a mean of 125 μ . Distance from sources is about 20 to 50 Km.

The mean value of skewness is 2.16 indicating that the sands are very fine and irregular. They are poorly sorted. Abrasion coefficient of sample is 245 that show a medium abrasion.

The shape of sand grains results of samples in the area of dunes are shown that there are 20% water erosion and 78% wind erosion. The diameter of most particles is finer than 50 μ .

Table 1 Area of Iran Ergs

No.	Name	Area (ha)
1	Oman	277682
2	Iranshahr- Bampour- Jazmoorian	277682
3	Fahraj- Bam	51808
4	Hamoon	18338
5	Loot	1174518
6	North Loot	85962
7	Akbar Abad	10541
8	Mohamad Abad	20212
9	Ghaen- Shahrakht- Ahangaran	292968
10	Boshravie- Gonabad	277682
11	Taybad	17001
12	Tabas	31699
13	Sabzevar- Davarzan	266487
14	Damghan	14212
15	Kavir Namak	267037
16	Khoor & Biabanak	126978
17	Mehriz- Yazd	48946
18	Dashte Kavir	546464
19	Rigbolande Kashan-Qom	231397
20	Booralane Makou	1600
21	Rig zarrin	68257
22	Khoozestan	149784
23	Gav khooni	45822
24	Saghand- Deraanjir	12153
25	Zarand- Neyriz- Bafgh	15420
26	Kerman- Rafsanjan- Noogh	104210
27	Sirjan- Shahr babak	104775
Total		4539634

3.2. *Iranshahr- Bampoor- Jazmoorian*

These sand dunes are located in the east of Iran in longitudes 58°00' to 60°50' E and latitudes 27°00' to 27° 00' N. The sand dunes trend is E–W. They are 9 series of sand dunes. There are range lands, farms and buildings between of them. The sand dunes are 2 series, old and young. There are barchans, barchanoid, and longitudinal sand dune in this erg. Their lengths is more 10s km. these sand dune have damaged many farms and urban as yet. We select 2 areas for samplings. The first Sample of this erg catches from Zabol. The mean grain sizes vary between 300 μ and <62 μ with a mean of 143 μ . The mean value of skewness is 2.95 indicating that the sands are very fine and irregular. They are poorly sorted. Abrasion coefficient of sample is 416 that show a high abrasion. The shape of sand grains results of samples in the area of dunes are shown that there are 55% water erosion and 36% wind erosion and 9% weathering. Mod of this grain is 75 μ .

The second Sample of this erg catch from the north of Systan (Mishdagh pass). The mean grain sizes vary between 300 μ and <62 μ with

a mean of 133 μ . The mean value of skewness is 2.10 indicating that the sands are very fine and irregular. They are poorly sorted.

3.3. *Fahraj Bam erg*

These sand dunes are located in the south east of Iran and south of loot in longitudes 58° 30' to 59° 30' E and latitudes 28° 30' to 29° 00' N this erg have very active dunes. These sand dune have damaged many farms and urban as yet such as Narmashir. There are both small and large dunes in this erg. The sample of this erg catches from Bam. The mean grain sizes vary between 300 μ and <62 μ with a mean of 193 μ . The mean value of skewness is 2.20 indicating that the coarse sands are more than the others. The mean value of Qdeph is 0.81 that show a low abrasion.

3.4. *Hamoon Erg*

These sand dunes are located in the east of Iran near border line of Iran and Afghanistan in longitudes 60° 56' to 61° 10' E and latitudes 30° 00' to 31° 25' N.

There are barchans, barchanoids, seif and silk sand dune in this erg. Hamoon Lake is near these sand dunes. The sources of these dunes are flooding rivers and dry bed rivers of Afghanistan

And also bed of hamoon especially in dry seasons. The Sample of this erg catches from the Hamoon Lake. The mean grain sizes are 210 μ .

The mean value of Q_{deph} is 0.73 that show a medium abrasion.

3.5. Loot Erg

Sand dunes with 1139555.54 ha and sand seas with 34962.93 ha of loot erg are a biggest sand dune and sand seas of the world. Elevation of the star dunes are to 500 m in this erg.

In this erg we can see the biggest yardang in the world. The length of this series is more than 50Km. Due to the impossibility travel, this interesting series of sand dunes, Kaluts and yardangs are still unknown. This series is located in Kerman and Sistan & Baloochestan province in longitudes 57° 50' to 59° 55' E and latitudes 29° 00' to 31° 30' N.

There are barchans, seif, silk sand dune Star dune and longitudinal sand dune in this erg. This series of sand dunes and Yardang is very interesting in terms of ecotourism. To investigate the characteristics of sand dunes, we've sampled from Deyhim and Looote Zangi Ahmad. The mean grain sizes vary between 600 μ and <62 μ with a mean of 120 μ .

3.6. North Loot

These sand dunes are located in Central Plateau of Iran. This collection is comprised of 2060 ha sand dunes and 83902.12 ha of sand seas. The sand dunes are seen individually and scattered in the North Lot. These sand dunes are located in geographic coordinates 57° 20' to 55° 30' E and 31° 00' to 30° 00'.

3.7. Kavire Namak Erg

These sand dunes are located in the central of Iran in longitudes 56° 40' to and latitudes 34° 05' to 33° 00'. There are both small and large dunes in this erg. The area of sand dunes is over 267037.3 ha.

3.8. Dasht Kavir Erg

The area of sand dunes is 546464.4 ha. These sand dunes are located in longitudes 53° 10' to 54° 45 E and latitudes 33° 30' to 34° 15' N.

3.9. Rigboland Kashan- Qom

This series is located in Khahshan, Aran & Bidgol than northern parts such as Vragh Sorkh from Esfeham province in longitudes 51° 00' to 35° 15' E and latitudes 33° 15' to 35° 00' N. There are barchans, barchanoids and seif sand dune in this erg.

The height of sand dunes is reaching up to 120 meters. The area of sand dunes is 223070.8 ha. The mean grain sizes vary between 600 μ and <62 μ with a mean of 167 μ . Mod of this grain is 150 μ . The mean value of skewness is 2.54 indicating that the finer particles are more than the others. Also, based on Morfoskopy surveys, the abrasion %coefficient is 445 that show the abrasion is high. Study of sediments showed, 7% particles have chemical and physical erosion, 18 % have water erosion and 75 % have wind erosion.

3.10. Khoozestan Erg

This series is located in west of khoozestan province in longitudes 47° 40' to 49° 20' E and latitudes 31° 05' to 32° 20' N. The area of sand dunes is 149783.5 ha. Preliminary analysis indicates that the syncline formation and sandstones of west province are the source of these deposits. Although there is some claim that the origin of the sand dunes is from Iraq. Sand dunes of Bostan, Soosangerd and west of karkhe are Secondary source for other dunes in province. The sand dunes have along about 200 kilometers from Einkhosh to southeast of Ahvaz. There are barchans, barchanoids, and longitudinal sand dune in this erg. We catch 9 samples from this erg Include: Ahvaz 130Km, Ein khosh, Albaji, Ahvaz 60Km, Maroon, Mashrahat, Gambooe, Omidiyeh, and west of Karkhe that their shape of sand grains characteristics are shown in Table 2

3.11. Boshravie Gonabad Erg

This series is located in north east in longitudes 57° 30' to 59° 45' E and latitudes 33° 30' to 34° 40' N. The area of sand dunes is 65842.6 ha. There are large and smallbarchans sometimes have a height of 90 m, barchanoids, seif and different types of silk sand dune in this erg. We catch 6 samples from this erg Include: Boshraviye- chahe bangoole, Ferdos- Kalshoor, Gonabad- Sardagh- Bajestan, Gonabad- Khoojhd, Gonabad- Rige omrani, Gonabad- Rige hasan tork that their shape of sand grains characteristics are shown in Table 3.

Table 2. shape of sand grains characteristics of Koozestan Erg

Name	Mod (μ)	range of grain sizes (μ)	Mean (μ)	skewness	abrasion coefficient	chemical & physical erosion%	water erosion%	wind erosion%
Ahvaz 130Km	150	600-<62	144	2.45-irregular fine sediment	447- High abrasion	18	27	55
Ein khosh	75	300-<62	159	2.59- irregular fine sediment	416- High abrasion	4	18	78
Albaji	150	300-<62	133	2.10- irregular fine sediment	-	-	-	-
Maroon	150	300-75	129	2.28- irregular fine sediment	-	0	10	90
Ahvaz 60Km	150	300-<62	126	2.11- irregular fine sediment	377	0	11	89
Mashrahat	150	300-<62	139	2.58- irregular fine sediment	403	0	10	90
Gambooe	150	1700-<62	119	1.61- irregular fine sediment	-	-	-	-
Omidiye	150	300-<62	129	2.25- irregular fine sediment	-	-	-	-
west of Karkhe	300	600-<62	209	1.47-regular medium sediment	-	-	-	-

Table 3. Shape of sand grains characteristics of Boshravie Gonabad Erg

Name	Mod(μ)	range of grain sizes(μ)	Mean (μ)	skewness
Boshraviye- chahe bangoole	75	600-<62	144	1.70-irregular coarse sediment
Ferdos- Kalshoor	150	1180-<62	117	1.62- irregular fine sediment
Gonabad- Sardagh- Bajestan	75-600 ¹	4000-<62	292	1.69- irregular coarse sediment
Gonabad- Khoojhd	75-600 ²	1700-75	241	1.12-
Gonabad- Rige omrani	-	300-<62	129	2.48- irregular fine sediment
Gonabad- Rige hasan tork	150	300-<62	123	1.96- irregular fine sediment

1- Particle diameters have a large variation in this sample. The specific form of curves show Sediment has transport from two different regions. Mod of finer particle is 75 micron and transport from farther areas. Mod of coarse particle is 600 micron and transport from closer areas.

2- Grain size curve of this sample indicates that larger particles than 150 microns have the uniform variation. While 62-150 micron particles distribution is approximately normal. The specific form of curves show Sediment has transport from two different regions. Mod of finer particle is 75 micron and transport from farther areas. Mod of coarse particle is 600 micron and transport from closer areas.

3.12. Ghaen- Shahrakht- Ahangaran Erg

The area of sand dunes is 100038 ha. This series is located in east to north east of Iran in border line of Iran and Afghanistan in longitudes 59° 15' to 60° 45' E and latitudes 33° 00' to 34° 15' N.

There are barchans, barchanoids, longitude dune and parallel dune in this erg. Maximum height of dune is 20 m. Formation of Nebka in margin of rivers is the geomorphologic characteristics of this region. The mean grain sizes vary between 600 μ and <62 μ with a mean of 136 μ. The mean value of skewness is 1.54 indicating that the fine sands are more than the others. Mod of this grain is 150 μ.

3.13. Taybad Erg

The area of sand dunes is 17000.8 ha. This series is located in north east of Iran in border line of Iran and Afghanistan in longitudes 60° 52' to 60° 42' E and latitudes 34° 55' to 34° 40' N. Sand dunes of this erg have been stabilized using Haloxylon since years. There are

barchans, barchanoids, and longitude sand dune in this erg. Sometimes, the heights of sand dunes are 20 m. Mod of this grain is 150 μ. The mean grain sizes vary between 600 μ and <62 μ with a mean of 155 μ. The mean value of skewness is 1.47 indicating that the irregular fine sediments are more than the others.

3.14. Tabas Erg

The area of sand dunes is 43632.4.8 ha. This series is located in east to north of Iran in longitudes 56° 15' to 56° 40' E and latitudes 34° 10' to 34° 25' N. There are barchans, seif, silk and Ghord sand dune in this erg. Sand pyramid (Star dune) heights are to 170 meters.

3.15. Sabzevar Davarzan Erg

The area of sand dunes is 229930.9 ha. This series is located in east of Iran in longitudes 56° 15' to 57° 48' E and latitudes 35° 15' to 35° 55' N. We catch 2 samples from this erg Include: Sabzevar Badghos, Sabzevar Yahya Abad that their shape of sand grains characteristics are shown in table 4

Table 4. Shape of sand grains characteristics of Sabzevar Erg

skewness	mean	range of grain sizes (μ)	Mod(μ)	Name
1.49	163	1180-<62	150-600	Sabzevar Badghos
1.67- irregular coarse sediment	113	600-<62	75	Sabzevar Yahya Abad

Grain size curve of this sample (Sabzevar Badghos) indicates that larger particles than 300 microns have the uniform variation. Particles distribution of 62-300 micron is approximately normal. The specific form of curves show Sediment has transport from two different regions. Mod of finer particle is 150 micron and transport from farther areas. Mod of coarse particle is 600 micron and transport from closer areas.

3.16. Damghan Erg

The area of sand dunes is 14212.3 ha. This series is located in central part of Iran in Semnan Province and in longitudes 55° 35' to 55° 40' E and latitudes 35° 35' to 35° 55' N. These sand dunes expand as an erratic strip to 15 Km in Damghan playa along north- west to east -south. There are barchans, seif and silk sand dune in this erg. We catch 2 samples from this erg Include: Hasan Abad-Damghan and Moaleman road that their shape of sand grains characteristics are shown in table 5.

Table 5. shape of sand grains characteristics of Damghan Erg

wind erosion%	water erosion%	chemical & physical erosion%	abrasion coefficient	skewness	Mean (μ)	range of grain sizes (μ)	Mod(μ)	Name
84	14	2	438- High abrasion	2.60-irregular fine sediment	137	300-<62	150	Hasan Abad-Damghan
88	12	0	352- medium abrasion	2.70- irregular fine sediment	142	300-<62	150	Moaleman road

3.19. Rige Zarrin Erg

The area of sand dunes is 58998.4 ha. This series is located in central of Iran in Yazd and Esfahan province in longitudes 54° 15' to 55° 20' E and latitudes 32° 30' to 33° 40' N. There are barchans, seif & goord dune in this erg. The goord dunes are located in the end of erg and their heights are to 80 m. The mean grain sizes vary between 600 μ and <62 μ with a mean of 146 μ . The mean value of skewness is 2.31 indicating that the irregular fine sediments are more than the others. Mod of this grain is 150 μ . Also, based on shape of sand grain surveys, the abrasion coefficient is 388 that show the abrasion is medium. Study of sediments showed, 0% particles have chemical and physical erosion, 32 % have water erosion and 68 % have wind erosion.

3.17. Koor & Biabanak

The area of sand dunes is 126978 ha. This series is located in central of Iran in Esfahan province.

There are barchans and silk dune in this erg. Maximum height of dune is 60 m. The mean grain sizes vary between 600 μ and <62 μ with a mean of 167 μ . The mean value of skewness is 1.47 indicating that the irregular fine sediments are more than the others. Mod of this grain is 150 μ . Also, based on shape of sand grains surveys, the abrasion coefficient is 299 that show the abrasion is low. Study of sediments showed, 1% particles have chemical and physical erosion, 22 % have water erosion and 77 % have wind erosion.

3.18. Mehriz Yazd Erg

The area of sand dunes is 38509 ha. This series is located in central of Iran in Yazd province in longitudes 54° 10' to 54° 45' E and latitudes 30° 30' to 32° 05' N. There are barchans, seif & silk sand dune in this erg with different height.

3.20. Ghavkhooni Erg

The area of sand dunes is 45821.8 ha. This series is located in central of Iran in Esfahan province. There are barchans, seif & silk dune in this erg. Sometimes, the heights of sand dunes are 60 m.

3.21. Zarand Siriz- Bafgh Erg

The area of sand dunes is 15420 ha. This series is located in central of Iran in Yazd province in longitudes 55° 27' to 56° 35' E and latitudes 30° 55' to 31° 37' N. Siriz dunes are reflectively dune. Zarand dunes are barchan-Bookliye and barchanoids. Bafgh sand dunes are star dunes with high height.

3.22. Kerman- Rafsanjan- Noogh

The area of sand dunes is 104209.5 ha. This series is located in Kerman province in longitudes 55° 30' to 57° 20' E and latitudes 30° 00' to 31° 00' N.

Erg direction is East-West. Rafsanjan erg sand dunes are composed of two old and new generations. These sands have different color. Old sands are amorphous and irregular and new sands are large and small barchans and seif with maximum 30m height.

3.23. Srjan- Shahre babak Erg

The area of sand dunes is 104775 ha. This series is located in Kerman province in longitudes 55° 10' to 56° 15' E and latitudes 28° 55' to 30° 05' N.

3.24. Saghand- Dra Anjir Erg

The area of sand dunes is 12153 ha. This series is located in central of Iran in Yazd province in longitudes 55° 10' to 55° 45' E and latitudes 31° 40' to 32° 30' N.

There are barchans, barchanoids, seif and star dune in this erg. Star dunes of Dra-anjir playa have more than 170m height.

3.25. MohamadAbad Erg

The area of sand dunes is 20212 ha. This series is located in east- north of Iran in Khorasan province in longitudes 58° 45' to 59° 05' E and latitudes 35° 15' to 35° 40' N. There are barchans, transverse dune and silk dune in this erg. The mean grain sizes vary between 1700 μ and <62 μ with a mean of 337 μ . The mean value of skewness is 1.05. Mod of this grain is 75 μ . Grain size curve of this sample indicates that there are two classes. The first class is finer with mod of 75 μ . This class is transported from farther areas and it has high abrasion. The second class is coarser with mod of 600 μ . This class is transported from closer areas and it has low abrasion. The Grain size curve shows that sediment of the first class is lower than the second class.

3.26. Akbar Abad Erg

The area of sand dunes is 10541 ha. This series is located in east- north of Iran in Khorasan province in longitudes 59° 35' to 59° 50' E and latitudes 32° 30' to 32° 35' N. There are barchans and seif dune in this erg.

3.27. Booralan Makoo sand seas

The area of sand dunes is 1600 ha. This series is located in west- north of Iran in west Azarbayjan province. This series is limited and include sand seas. The mean grain sizes vary between 1180 μ and <62 μ with a mean of 241 μ . The mean value of skewness is 1.81. Also, based on shape of sand grains surveys, the abrasion coefficient is 221 that show the abrasion is medium. Study of sediments showed, 35% particles have chemical and physical erosion, 9 % have water erosion and 56 % have wind erosion.

4. Discussion and Conclusion

Totally, 66 samples have taken from sand dunes across the country and completed 330 shapes of sand grains forms. The particles size in the samples tested is from 4000 microns to smaller than 62 microns. 11% samples are 4000 μ , 3% are 1700 μ , 5% are 1180 μ , 13% are 600 μ , and 58% are 300 μ , 9% 150 μ and 2% less than 62 μ . The skewness coefficients varied from -0.2 to 2.95 and most of them are in range of 2 that show fine sediment. The location of erg has special characteristics. Actually, the ergs cannot be established in every region of the desert. The topographic factors can capture some sand and form sand dune such as barchans, but these sand dunes are temporary and will disappear soon. The most important factors to establishment of erg are: soil moisture, roughness of floor and mountains. Iran's main ergs have formed affected by surface roughness. For example, east of loot and best sample of that, Rig bolande Kashan is established in miocene Marl with the approximate length of 90 km. the height of sand dune follow up the height of hills.

There are not studies such as this paper in Iran and only some case studies have been performed in this field.

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