The 2nd International Conf. on Water Resources & Arid Environment (2006)

Use of Remote Sensing for The Study of the Hazards of Ghard Abu Muharik Sand Dune Field, Western Desert, Egypt

El Gammal E.A. and Cherif, O. H

National Authority for Remote Sciensing and Space Science, Cairo, Egypt

Abstract

Ghard Abu Muharik dune field lies in the central part of the Western Desert of Egypt. It extends from the NE of the Baharia depression and runs in a southeastern direction to the depression of Kharga and further southward up to the Egypt-Sudan borders. The dune field is located in an important part of the region, where development plans are foreseen. Sustainable development in the Western Desert of Egypt can be impaired by hazards due to movements of dunes. This paper is a contribution for the study of generation, evolution and mobility of the northern ("tail" and "erg" sections) part of this field and its comparison to its southern part ("head" section of the field), which has been extensively studied by previous workers. Samples collected from the sand of the dunes have been subjected to XRD analysis, mechanical analysis. 3D DEM of some selected areas have been prepared for understanding the relation of the studied dune field to its surroundings. This gives clues to some aspects of the processes involved in the desertification of these regions and their relation to anthropomorphic activities.

Different images acquired at different times (1974, 1984 and 2001) have been used to estimate the movements of single dunes, which proved to be directly proportional to dune sizes. The dunes increase in size and slow down southwards. They move at a speed of 25 m/year in the northern part of the field (near the part of the "erg" section of the field, adjacent to its tail, to the northeast of Bahariya) and at a speed of 12 m/year in the southern part of the "erg" section of the field, near the slope of the limestone plateau, which leads to the Kharga depression. The northern half of the part of the dune field includes many tracks and projects for asphalt roads to rely the Bahariya and Farafra oases to the Nile Valley. The paths of these roads should be carefully planed to avoid hazards caused by dune movements.

Introduction

The aeolian sediments and the landforms produced by wind processes in the Western Desert, have attracted researchers since the beginning of the 20th Century. Significant works are those of Beadnell (1909, 1910, 1933), Bagnold (1941) and Ashri (1970). Ghard Abu Muharik, which is a conspicuous dune field of this part of Egypt, lies in the east-central and east-southern parts of the Western Desert. It extends from the NE of the Baharia depression and runs in a southeastern direction to the depression of Kharga and further southward up to the Egypt-Sudan borders (Fig. 1). The Abu Muharik dune field is the biggest sand dune field in the Western Desert of Egypt. It is located in an important part of the region, where development plans are foreseen. Sustainable development in the

Western Desert of Egypt can be impaired by hazards due to movements of dunes, such as the activity of the Abu Muharik sand dune field. This paper intends to contribute in developing a suitable methodology for the study of generation, evolution and mobility of sand dunes in the Western Desert. Samples collected from outcrops of country rocks have been compared to those of the dunes. Samples from the sand of the dunes have been subjected to XRD analysis, mechanical analysis, and their grains observed under a scanning electron microscope (SEM) to investigate their surface characteristics. A 3D

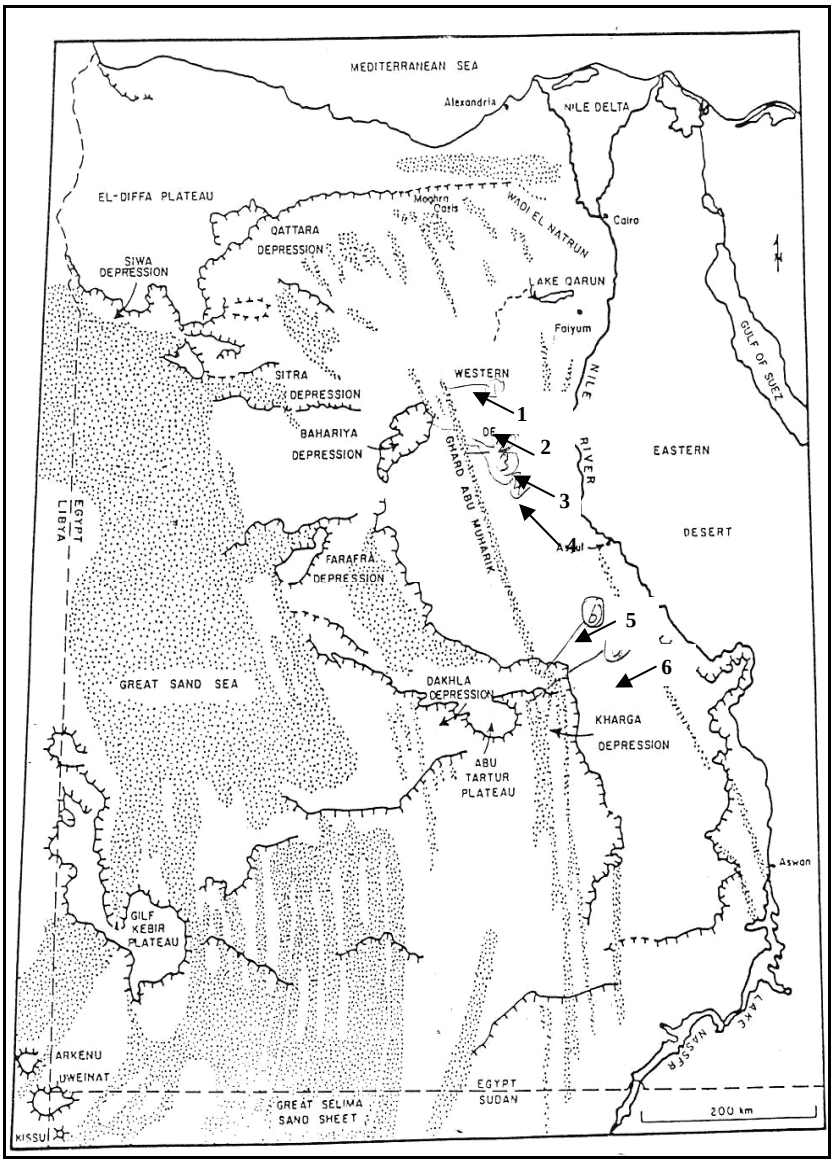

Fig. 1. Location map of Ghard Abu Muharak, Western Desert, Egypt, showing location of samples.

DEM image of the area surrounding the northern half of the area traversed by the dune field (over the Eocene limestone plateau extending from Bahariya to Kharga) have been prepared and compared to the geological map of the same area. These maps are useful for understanding the relation of the studied dune field to its surroundings. Also the Recent Quaternary Geology of the region has been dealt with in order to understand the development of these dune fields as a result of the last climatic changes. This may give clues to some aspects of the processes involved in the desertification of these regions and their relation to anthropomorphic activities.

The use of different images acquired at different times (MSS acquired in 1974, TM acquired in 1984 and ETM acquired in 2001) enables to estimate the amount and direction of movements of single dunes (mainly barchans) and the hazards caused by these movements to the roads and tracks traversing the dune field.

Geology of Area Around Ghard Abu Muharik Dune Field

A geologic map of the area around the "Erg" section of Ghard Abu Muharik has been compiled (mainly after CONOCO 1989) to clarify the relation of the dune field to country rocks. This geologic map shows that Late Cretaceous rocks are only exposed in depressions lying to the west of the Abu Muharik dune field. These are the Bahariya depression and the depression of Wadi Hinnis and Ain Maqfi. Paleocene sediments are also only found in the southwestern slopes of the plateau over which the dune field is located. The surface of the plateau, constituting the floor over which the dunes are moving, consists of Eocene limestone. This limestone is older to the southwest of the Ghard Abu Muharik dune field. Here the Early Eocene rocks are exposed. To the east of these exposures, but still to the west of the dune field, (still of Early Eocene age) constitutes most of the plateau surface to the immediate western vicinity of the dune field. It is interesting to notice that the elongated field stretches in a line parallel to an exposure of the marl and shale, along the contact of this last mentioned rock unit with a younger limestone formation: the Abu Mubarak Formation (a Middle Eocene rock unit) in most of the central part of the mapped area. To the east of the field the plateau limestone consists mainly of Middle Eocene rocks. The northern part of the limestone plateau, over which the dune field starts, is covered by numerous separated elongated fields parallel to the general trend of the Abu Muharik Field. These dunes are moving over a terrain of late Middle and Late Eocene limestone. These limestones include an appreciable amount of terrigenous clastic material (marl, shale and even sand and sandstone beds). To the east, a little farther from the dune field, a wide depression limiting the gently sloping Eocene plateau is filled with Oligocene and Miocene sands and gravels. These sands and gravels cover all the area circling the northern and northwestern limits of the dune fields, suggesting that they may constitute an appreciable source for the sands nourishing these dunes.

Geomorphology of Ghard Abu Muharik Dune Field

Major subdivisions of the elongated dune field

Ball (1927) studied the sand dunes of the African deserts. He mentioned the terms "Tail" or up wind section, "Erg" or central wind section and "Head" or down wind section, to designate the various subdivisions of an elongated field constituting a sand dunes belt. He used these names because these dune fields recall the movement of snakes, as the dunes grow and extend at the southern terminals of the field. Therefore, the Ghard can be subdivided into three parts:

- The First part is the "Tail" or up wind section. It extends from the northern starting part of the dune field, at the NE of the Bahariya depression, up to about 18 km towards the SE. Here, the Ghard is a field of linear dunes. This part of the Ghard extends over a plateau constituted by a hard substratum of Eocene limestone. This zone assumes a southeast direction. This section is composed of small separated longitudinal linear and lee dunes, developed between some hills of limestone (of Middle and Late Eocene age). On aerial photographs and by field check, these small linear dunes vary in their length from 1 to 9 km and in their width from 100 m to about one km.

-The Second part is the "erg" section. It extends also on the Eocene limestone plateau from the end of the tail section of the field, over a length of about 200 km. Here, the Ghard consists of an elongated barchan sand dunes belt to the west. The dunes move on the surface of a depression excavated between high lands of Lower Eocene limestone to the west and Middle Eocene limestones to the east. The surface of the depression here is covered by exposures of Upper Lower Eocene rock belonging to the Minia Formation (see processed TM image in Fig. 2 and 3D DEM of Fig. 3). The plateau is sometimes capped by various Quaternary deposits (lacustrine deposits or alluvial sediments and paleosoils, in addition to wind blown sand). It is interesting to notice that all playa sediments found on the plateau never exceed by far 10 000 years of age. This suggests that all loose Quaternary sediments over the plateau are quite young and that older sediments were wiped out during the last arid phase of the Quaternary in the Sahara.

-The Third part is the "head" section**.** It extends from the southern scarp of the limestone plateau leading to the Kharga depression to the Egypt-Sudan borders, over a length of 250 km. Here, the Ghard is a huge belt constituting a sand sea assuming a lock-like shape. Here the bottom of the depression exposes various sandstones belonging to the Cretaceous or older "Nubia Sandstone", but it also includes various scattered exposures crystalline basement rocks.

The "tail" and "erg" zone of Ghard Abu Muharik dune field

To better understand the relation of the studied dune field to the geomorphologic processes, which have sculptured the landscape surrounding the dunes, a new geomorphological map of the "tail" and "erg" sections of the Ghard Abu Muharik field have been prepared. This geomorphologic map has been prepared by consulting TM, aerial photographs and by field check in some parts of the Ghard, and also by using some topographic maps. The dune field of Ghard Abu Muharik runs clearly in a depressed pediplain limitted to the west by a wide limestone plateau dissected by some EW wadis. All desert paths follow these wadis, which are perpendicular to the estern escarpment of the plateau and establish connections between the plateau and Ghard Abu Muharik. The surfaces of the plateau is strongly affected by karstification. It is to be noticed that the eastern escarpment of the plateau, which faces the dune field, seems to be also directed according to the prevailing winds, which happens also to correspond more os less to the regional dip of strata, as younger Eocene beds are found towards the NE. In the central part of the area traversed by the dune field, the pediplain over which the dunes are moving is limited to the NE by another limestone plateau, whose scarp is directed in a NW-SE direction, but which slopes towards the west (facing the dunes). These two plateau seem to constitute a "channel" directing the wind to act on the dune field. Ghard Abu Muharik, in the "erg" section is formed of both longitudinal and barchan sand dunes.

The Landsat TM images and aerial photography show that the barchan sand dunes are present in the western side of Ghard Abu Muharik dune field over a rugged area exhibiting a relatively higher relief than the area coverd by longitudinal sand dunes. Longitudinal sand dunes are located in the eastern part of Ghard Abu Muharik dune field covering and surrounded by low land. These dunes are striking in a NW-SE direction (parallel to the prevailing winds) and are often constituted by the accumulation of barchan dunes. The eastern tails of the lee side of the barchan dunes are longer than their western tails. Sometimes these tails are coalescing with each others to constitute longitudinal sand dunes . This phenomenon is most probably due to the effect of wind action on the dune and depends on wind direction and on the annual pattern of variations of this direction. It also depends, quite probably on the regional slope ot the substratum, which dips gently towards the east. The part of Ghard Abu Muharik covered by longitudinal dunes shows in a more straightforward way the effect of wind action due to smooth topography of the wide area in the center of the Western Desert over which this part of the Ghard is situated. Longitudinal and seif dunes move to the south according to wind direction. The stages of sand dune initiation and development, and associated modifications to boundary air flow after Kocurek et al., (1990) can explain the extension of Ghard Abu Muharik to the south-east. We can suggest that Ghard Abu Muharik is in the mature or last modification stage of Kocurek

The "head" section of Ghard Abu Muharik (Kharga "depression" area)

The Kharga Oasis is a group of villages scattered in the middle of an open depression, which runs in a NS direction. The elevation of the depression ranges from 4 metres to 98 metres and in few cases it reachs up to 136 metres above sea level. This depression is completely bound from the east and north by limestone plateaus (Eastern and Northern plateaus). To the west, the northern part of the depression is bound by a chalky plateau with few outliers of the overlying formations forming few isolated hillocks on the top. The elevation of these plateaus ranges from 360 metres to 460 metres above sea level. The descent from these plateaus to the floor of the depression is along very steep escarpments (Eastern, Northern and Western escarpments). Comparatively easier paths along the escarpments are used for transport, the individual path being locally known as "Naqb". The most important of these are Naqb Assyut, which is traversed by an asphalt road, Naqb Al Rofouf, which was crossed by the ancient railway road, and Naqb Esna. The erosion surface on the ground of the Kharga depresion, includes some parts coverd with Quaternary gravels, cultivated land and some outliers (isolated hillocks). Salt, playa and sabkha deposits, remnants of Holocene pluvial lakes, are frequently found at the lowest points of various enclosed drainage basins in the Karga depression.

Barchans movement in the Kharga area ("head" section or downwind part of Ghard Abu Muharik) is a wellknown phenomenon in the Western Desert. Beadnell (1910) determined the annual displacement of barchans dunes in this area as varying between 10.8 and 18.8 meters. He also found that there is a negative correlation between dune height and rate of advance. Ashri (1970) studied the 92 barchans in the same area by using multitemporal aerial photographs and obtained the same results as Beadnell (1910). Breed *et al.* (1978), El Baz *et al.* (1978), Embabi (2004) and Essawi and Henawi (1990) studied the movement of barchans dunes in the Kharga depression and determined annual, relatively fast displacements of 20.8 to 100 meters towards the south. The lateral shift of the dunes either to the east or to the west depending on the occasional changes in the wind regimes was calculated by Breed *et al.* (1978) depending on field observations. They used the location of

the tyretrack of Bagnold in 1933. The shift of the same dune was estimated to be 8 m to the west in 40 years.

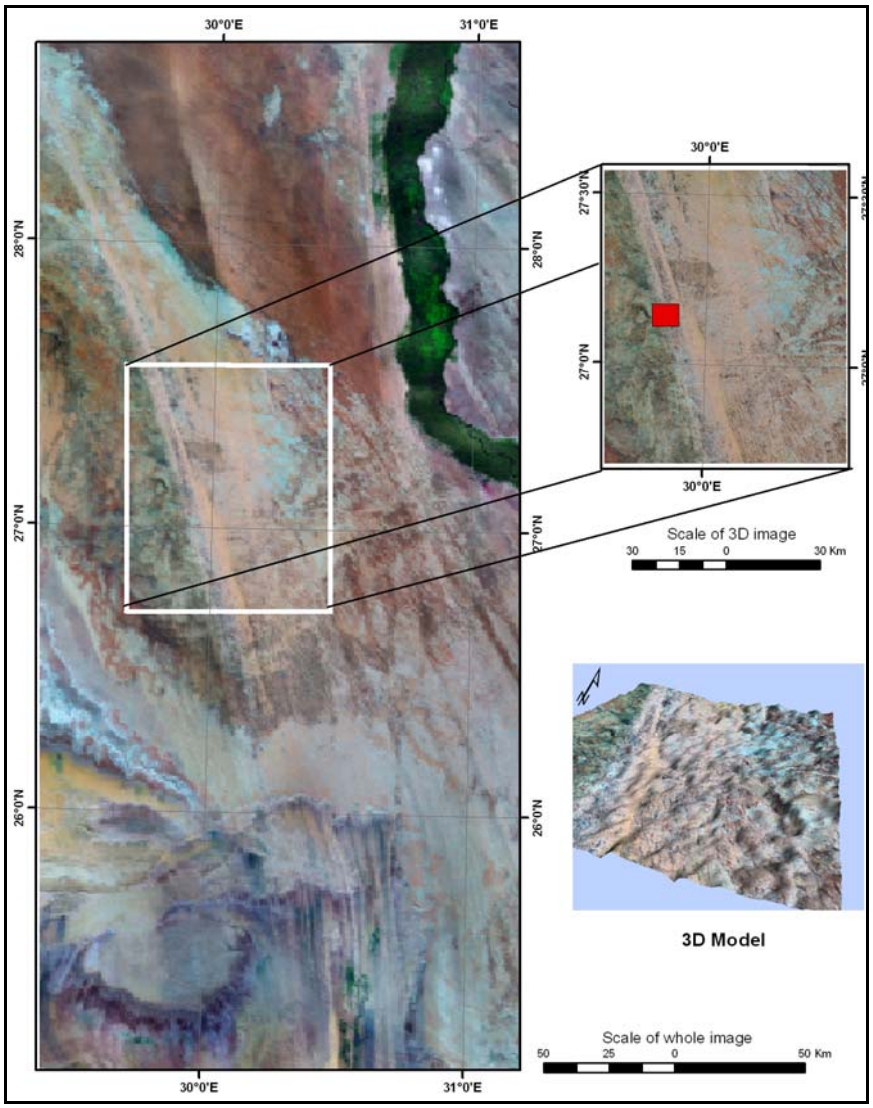

Fig. 2. Preparation of a 3D DEM from a processed Landsat image (bands 7, 4, 2) drapped over a DEM (in Fig. 3). The red square over the area of the 3D DEM represents the area zoomed in fig. 4 to show details of dune movements and their relation to the morphology of the field.

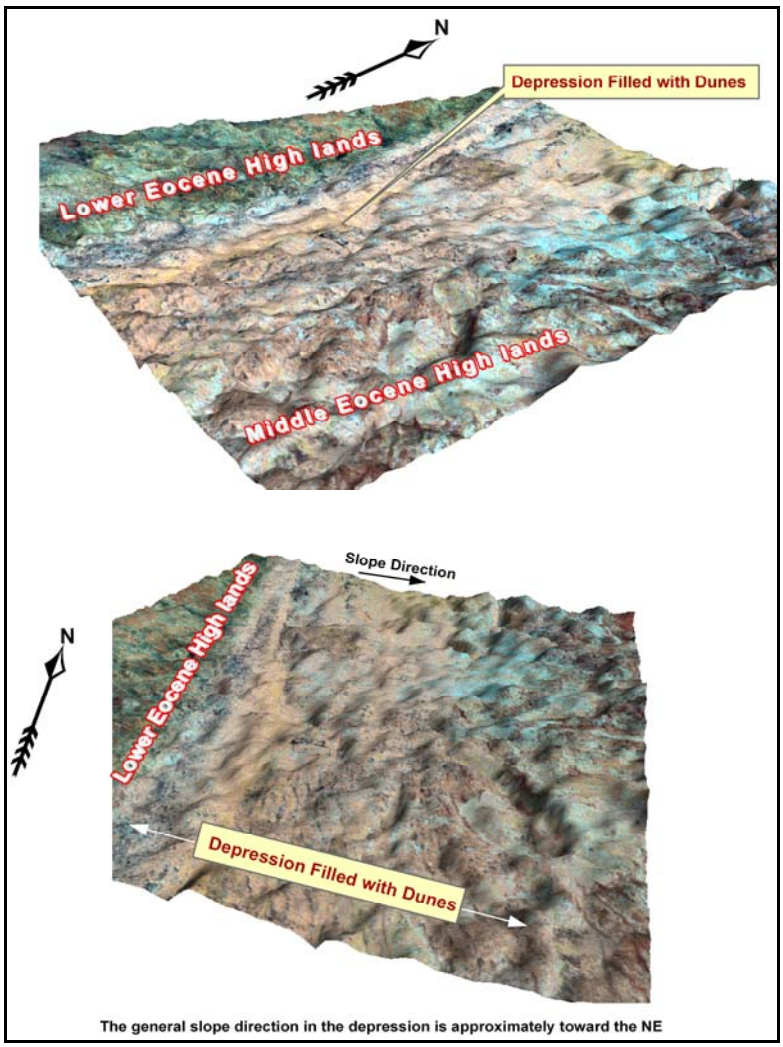

Fig. 3. Different tilted views of 3D image from Landsat ETM+ data (bands 7, 4, 2) with X70 vertical exaggeration.

Granulometric Analysis of Samples From Dunes From the Erg Section of the Field

Aims and material of the analysis

Analysis of the granulometric composition of sand samples is essential for the investigation of the textural features of a deposits. It provides valuable information on the dynamics of the processes, which had formed the deposits and built the relief forms genetically connected with these deposits (Mycielska-Dowgallo 1995). In this work six representative samples collected from dunes in the dune field (see location map of Fig. 1) were analysed and examined. Scieve analysis performed on the collected samples. This is

done to help in establishing the transporting environment, distances of transportation and the sources of the sand grains.

The results of measurments of rounding and frosting of sand grains

Investigation of rounding and frosting of quartz grains of fluvial deposits has shown that these features of grains depend on the original source of the deposit, which comes from previous environments causing variable degrees of abrasion In a river the quartz grains do not undergo further abrasion (Mycielska-Dowgiallo 1995). The abrasion of grains in the aeolian environment is usually characterized by slightly greater homogeneity than the source material. The degree of abrasion of quartz grains of any investigated deposit shoud not be considered separately but should always be compared with the abrasion of grains collected from the source deposit. This comparison enables to evaluate the extent of transformation. The difference between the degree of abrasion of the grains of the investigated and source deposit may indicate the length of time of transport and sedimentation. Mycieiska-Dowgallo (op.cit.), introduce the concept of "degree of aeolisation of deposits" as an index of transformation of the source deposits into aeolian deposits. The degree of aeolization of deposits seems to indicate the duration of aeolian processses, which turned the source deposit into the deposit forming the dune form under investigation.

Morphoscopic classification of grains

The method used here is based on the morphoscopic classification of grains examined under a stereomicroscope taking into consideration both the rounding of grains and frosting of their surface. It has been first introduced by Cailleux and later modified by Cozdzlk (1981) and Mycieiska-Dowgallo (1995). It distinguishes between the following categories: rounded mat grains (RM), rounded shiny grains (EL), rounded, partly mat grains (EM), angular grains (NU), cracked grains (C) and weathered grains (NNE).

The grains of each category in each sample were counted. For each sample the counting was performed on 100 grains. The percentage of each category was represented and also the ratios of rounded partly mat grains (EM) to rounded shiny grains (EL) and rounded partly mat grains (EM) to rounded mat grains (RM) as the first ratio increases for a majority of grains transported under predominantly dry conditions (with some phase of transportation by water for the shiny grains) and the second increases for a majority of grains transported by winds under continental dry conditions. It can be considered that the first ratio is an expression of wind abrasion of grains transported originally by running water, while the second is an expression of degree of aridity of the environment of transportation.

Morphoscopic properties of sand samples of Ghard Abu Muharik

The Morphoscopic properties of sand samples of Ghard Abu Muharik enable to notice the following:

- All samples include small proportions of angular sand grains (NU) suggesting that these sands (mostly with rounded grains) are mature sediments, which suffered appreciable reworking and transportation.

- Samples located in the northern and central parts of the dune field (Samples 1 - 4) yielded an appreciable proportion of rounded and shiny grains (EL). This suggests that part of their grains (originating from sediments subjected to fluvial transportation) have not been intensively "eolinized". Samples 5 and 6, collected from the southern part of the dune field, near Kharga,
- include a small proportion of shiny grains (< 7 %) suggesting that these sediments were subjected for longer time to transportation by winds under arid conditions. This corroborates the conclusion that the source of sediments feeding the dune field lies to the north and that sand movements proceeds from north to south (or rather NW – SE) in the direction of prevailing winds.
- All samples have a high proportions (> 55%) of round and mat grains (RM). However samples collected from the northern parts of the dune field have lower proportions of RM grains (< 60%) than samples collected from southern parts of the field, which include more than 60% of round mat grains. This suggests that the northern samples were nearer to the source of sand feeding the dunes and that their grains were less subjected to the process of "eolinization" than those of samples collected from locations lying further south. This also corroborates the conclusion, reached in the previous paragraph, that sediment transport is from north to south and that the source of sediments lies mainly to the north of the dune field.
- The relatively high value for the proportion of rounded partly mat grains to round shiny grains (EM/EL) in the northern samples (Samples 1 and 2) suggests that these sediments have not been as intensively "eolinized" as the sediments of the southern part of the dune field, where no rounded partly mat grains (EM) were counted (i.e. all grains are "fully" mat and have no trace of their previous "fluvial" origin). These southern samples (Samples 3, 4, 5 and 6), however, include a high proportion of round and mat grains (EM), suggesting that most of their components are "old" eolian material, but that their relatively poorly "eolinized" fraction is an admixture of fluvial sediments added to the predominantly old eolian sediments. In the northern samples (Samples 1 and 2) the sediments are generally more sharply diferentiated into purely "eolian" rounded mat grains (RM) and "fluvial" rounded shiny grains (EL). Partly mat grains (EM), which are remanent of fluvial material not completely "eolinized", are less conspicuous here.
- Weathered grains (NNE) are conspicuous in Samples 1, 2 and 5. They were not observed in Samples 4 and 6. Cracked grains (C) were found in small proportions in all samples. The limited amounts of samples investigated in this phase of the project does not allow for interpretation of these observations.

The sediments of Ghard Abu Muharik seem to have their source from a location found to the north and northeast of the dune field (probably partly the extensive sand and gravel deposits of Oligocene and Miocene age exposed to the north of Bahariya. The last mentioned rock units are fluvial or fluvio-marine deposits. However it is not excluded that part of the sediments of the are old intensively reworked eolian sediments moving in the Western Desert during various arid phases of the Quaternary.

Analysis of Mineralogical Composition of Sand Grains by X-Ray Diffraction

A Philips X-Ray Diffraction equipment model PW/1710 with Monochromator, Cu-radiation (A=1.542A) at 40 KV, 30 MA and scanning speed 0.02 < Vsec were used. The reflection peaks between 20 = 2° and 60°, corresponding spacing (d,A) and relative intensities (1/1°) were obtained. The obtained diffraction charts and relative intensities were compared with ICDD files for mineral identification. X-Ray Diffraction analysis revealed that the samples are composed of the minerals quartz as major minerals, calcite as minor minerals, and feldspares, dolomite and kaolinite as trace minerals It is noticeable from the results that only the two most northerly samples (smples 1 and 2E), which are the closest to the presumed source of sediments in the dune (Oligocene and Miocene sands and clastics) include some traces of clay minerals, probably of fluvial origin.

Age of loose sediments moving on the limestone plateau

The northern part of the Sahara has witnessed several phases of pluvial and arid climates during the Quaternary. These seem to be correlated with glacial and interglacial episodes. Glacial episodes correspond to periods of high aridity, while interglacial episodes correspond to periods of higher pluviometry (Szabo *et al.* 1995, Wendorf *et al.* 1993 and Embabi 2004). Playa deposits in these areas tend to be developed during pluvial phases, while wind action tends to erode their sediments during periods of high aridity. No playa older than 12 000 years were found. This suggests that most playas in this part of the desert are of post- glacial age and that the sediments moving around are not very old. Thus most eolian sediments of the "tail" and "erg" zones of Ghard Abu Muharik should have been derived from nearby exposed "up wind" outcrops of sand or sandstone. These are the Oligocene and Miocene exposures found to the north and north-east of Bahariya.

Study of Dunes Movements by Remote Sensing Techniques

Used procedure

In order to study the movements of sand dunes and their magnitude, three areas were selected on the limestone plateau over which the "erg" part of the Abu Muharik dune field is situated. The areas are from north to south: Area "1", Area "2" and Area "3" (Figs. 4).

Some barchan dunes were selected in each area and properly outlined. Eleven dunes were selected in Area "1", twelve dunes in Area "2" and thirty seven dunes in Area "3" (Fig. 5). Thus, sixty dunes were studied to assess the magnitude and direction of their movements. The same dunes were traced from images taken in two different dates: a TM image acquired in 11/9/1984 (Fig. 4 and 5) and an ETM image acquired in 10/4/2001 (Fig. 5 and 6). The ETM image was merged with its panchromatic band, which has a pixel resolution of 14.25 m, while the TM image has been left with its original pixel resolution of 28.5 m. The MSS image was not used because its resolution of 70 m does not allow good delineation of individual dunes.

In order to evaluate properly the movements of the dunes the three images were geometrically corrected and positioned according to a fixed coordinate system (Universal Transverse Mercator projection zone 36). The nine images obtained are displayed in Fig. 7 (three areas repeated three times for three different dates). Dune positions as traced from the TM and merged ETM images are graphically displayed in Fig. 6 and their geometrical centers in Figs. 6 and 7. The determined Latitudes and Longitudes (in degrees and in UTM metric coordinates) of the centers of each dune in each area are obtained.

To analyze the movements of the dunes and the relation of these movements to different properties of the dunes (as their sizes expressed by their areas and their location shown by their coordinates. The images were used to estimate an additional parameter, namely: the area of each dune.

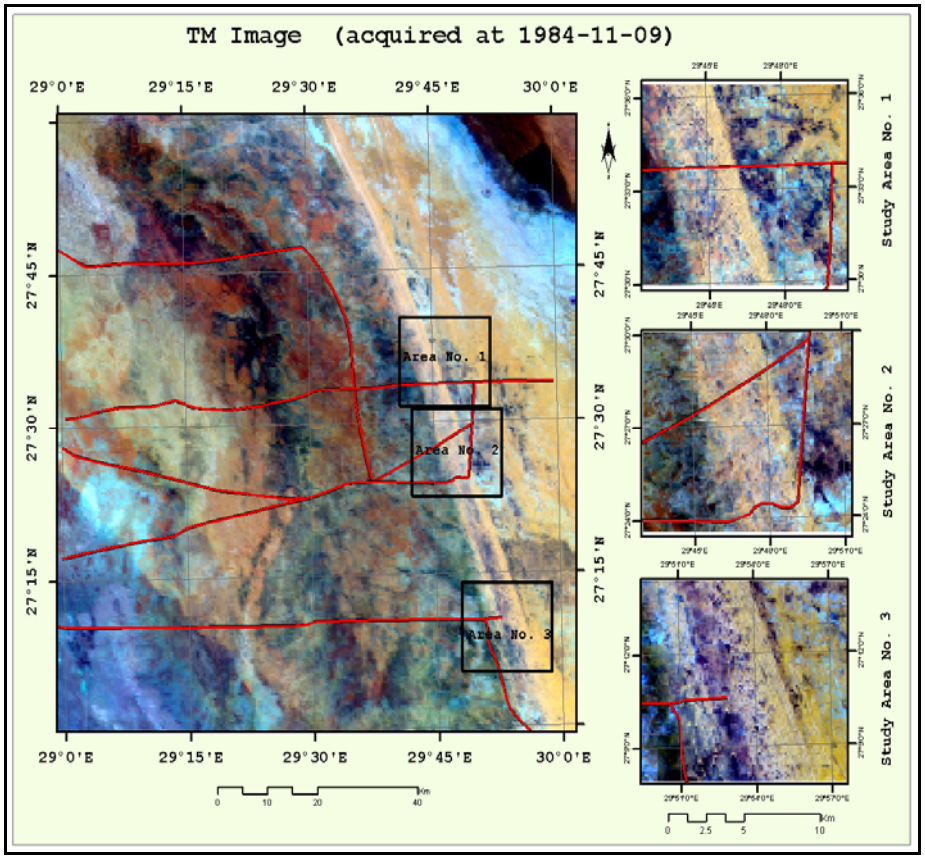

Fig 5. Maps drawn from processed images (TM) for some sand dunes in the 3 areas chosen for the study of dune movements.

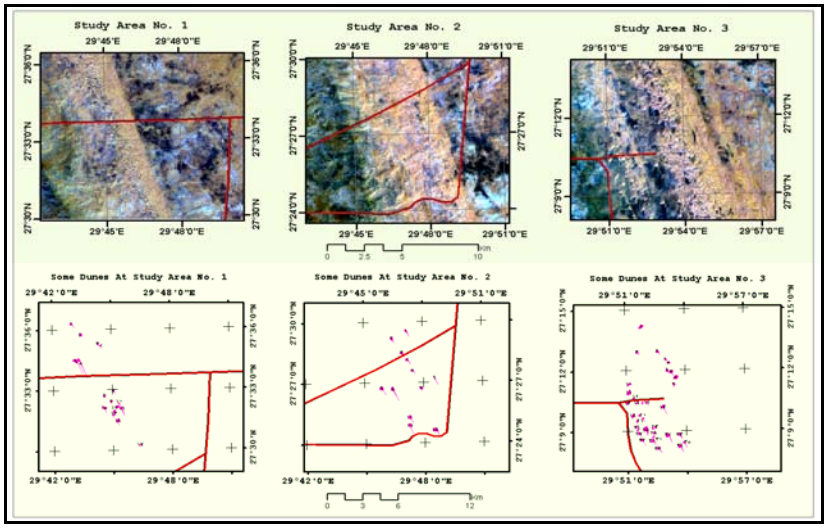

Fig 6. Maps drawn from processed images (ETM) for some sand dunes in the 3 areas chosen for the study of dune movements.

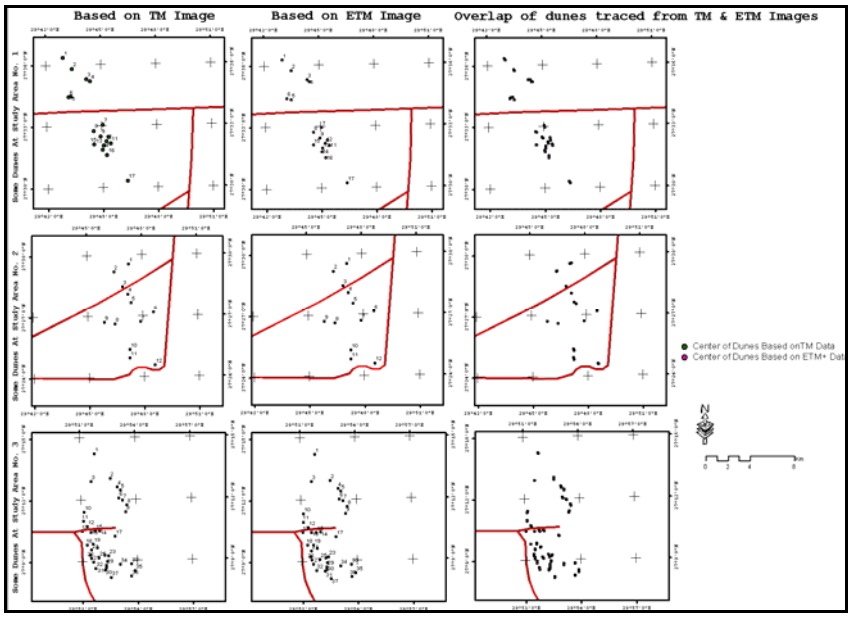

Fig. 7. Maps showing the centers of dunes traced from TM and ETM images for the three areas chosen for the study of une movements. The third column shows the maps for dune centers traced from the two images.

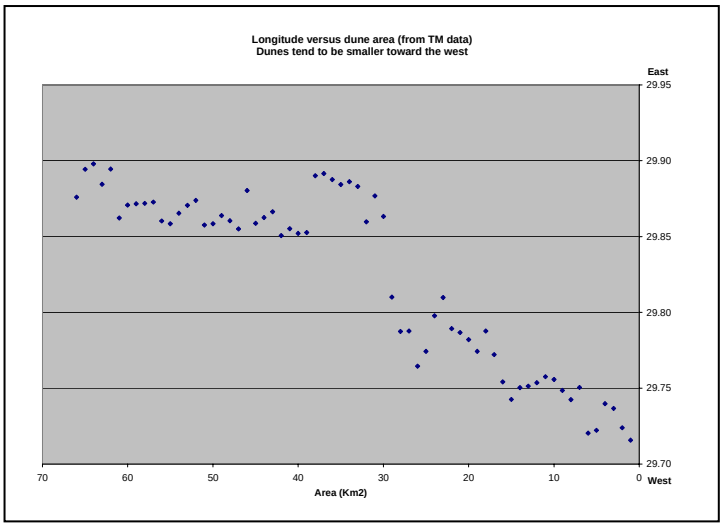

Fig. 8. Scatter diagram showing relation between dune size (area) and position (Longitude).

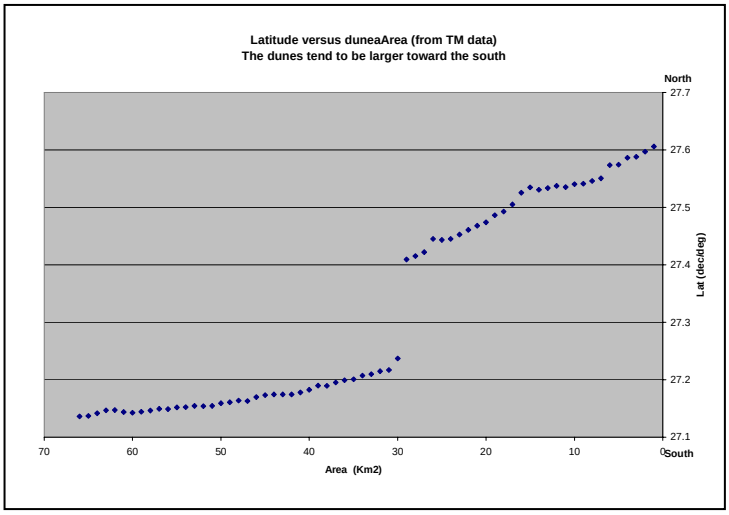

Fig. 9. Scatter diagram showing relation between dune size (area) and position (Latitude).

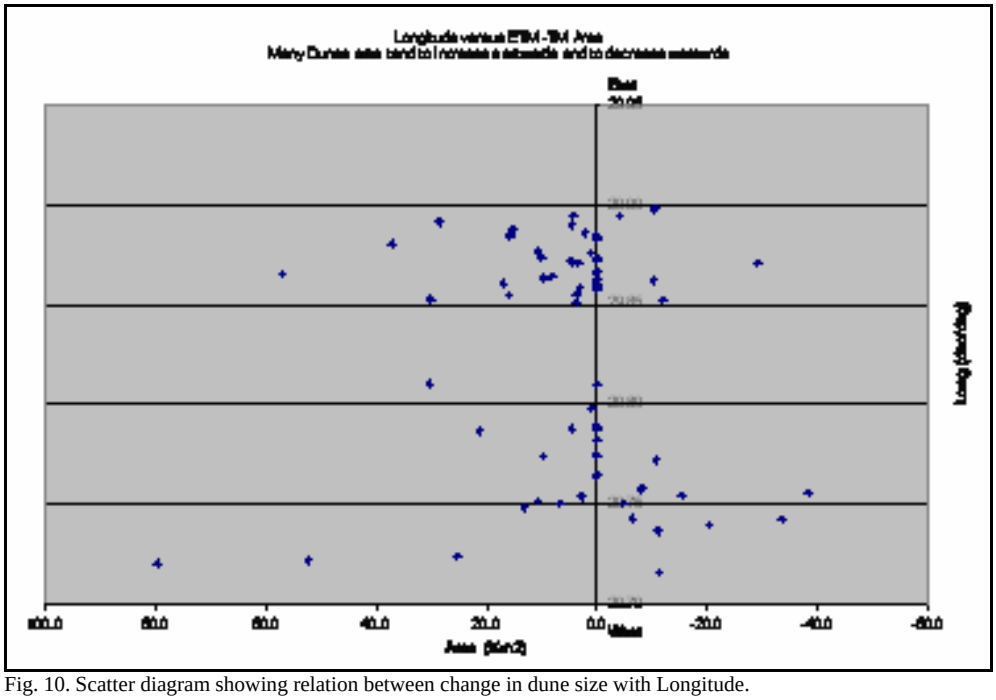

Fig. 10. Scatter diagram showing relation between change in dune size with Longitude.

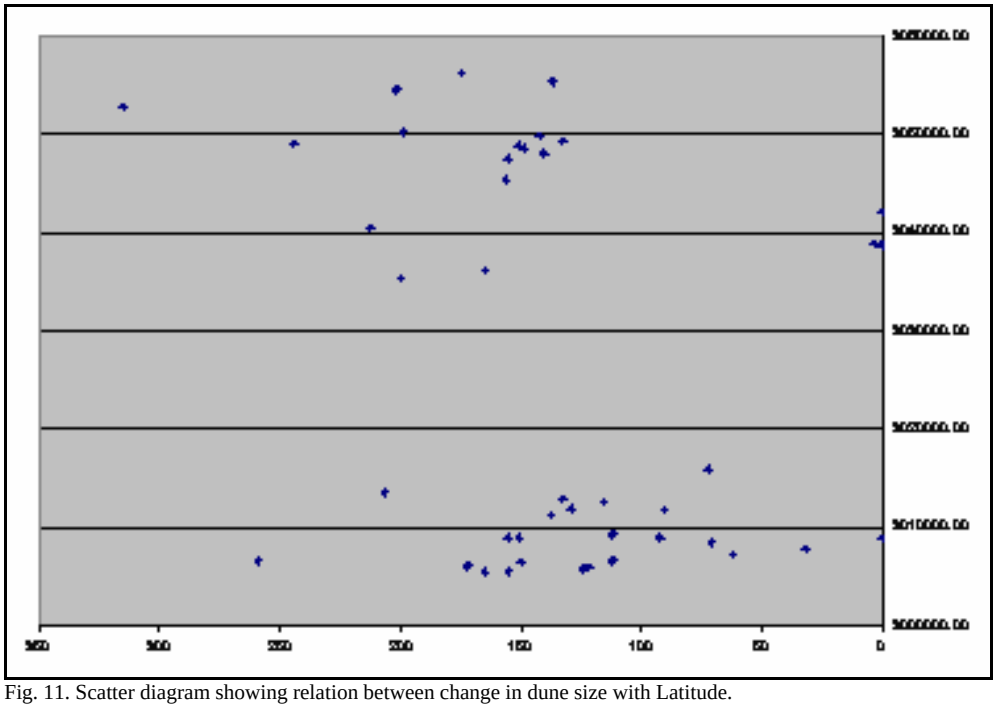

Fig. 11. Scatter diagram showing relation between change in dune size with Latitude.

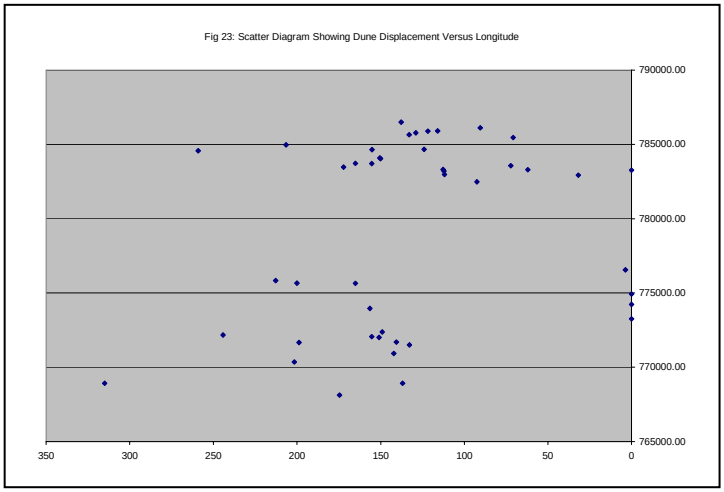

Fig. 12. Scatter diagram showing relation between dune displacement and position (Longitude).

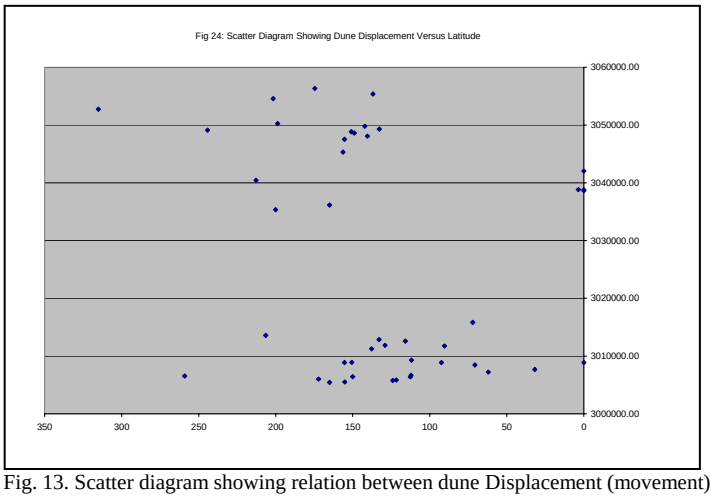

Fig. 13. Scatter diagram showing relation between dune Displacement (movement) and position (Latitude).

Estimation of sand dune hazards on roads connecting the oases with the Nile Valley

Dune "size" in relation to position

The size is expressed by the surface (area) of the dune as estimated from the image by the ArcGIS software. A scatter diagram expresses this relationship (Fig. 8) for the size versus Longitude and Figure 9 for the size versus the Latitude). These diagrams show that the dunes are larger toward the east and smaller toward the west, the relation is an almost perfect linear relation. The same dunes tend to be also larger toward the south,

but with a less perfect linear relation. In general it can be concluded that the dunes are generally larger in the down wind direction (SE direction).

Change in dune sizes in relation to position

To estimate this relation, two scatter diagrams for changes in dune sizes versus Longitudes (Fig. 10) and changes in dune sizes versus Latitudes (Fig. 11) were prepared. The diagram of Figure 10 suggests that many dunes situated in the eastern parts of the dune field tend to increase in size, while dunes situated in the western part of the field do not show particular preferences, some are increasing and others are decreasing. The diagram of Figure 10 shows that dunes situated in the northern parts of the area do not display any preference toward increasing or decreasing in area with time, while dunes situated in the southern parts of the area have a definite tendency to increase in size with time. These relations also support the conclusion that the dunes are increasing in size in the down wind direction (SE direction).

Dune movements in relation to position

To estimate this relation, two scatter diagrams for the displacement of each dune versus Longitudes (Fig. 12) and displacement versus Latitudes (Fig. 13) were prepared. The diagram of Figure 13 suggests that many dunes situated in the eastern parts of the dune field tend to move faster, while dunes situated in the western part of the field are slower. The diagram of Figure 12 shows that dunes situated in the northern parts of the area are faster, while dunes situated in the southern parts of the area are slower. These relations suggests that the dunes are moving in down wind direction (SE direction) and that they tend to accumulate in the southern end of the “erg” part of the dune field, before reaching the “head” of the field in the Kharga depression.

Figure 4 shows the roads and tracks surrounding the study area (in a blue rectangle). The tracks situated in the study area are intended for Safari and tourism, as a well known cave, located in the vicinity of the Abu Muharik dune field, is reached by one of these tracks. Also one of these tracks may be chosen to be a path for an EW road connecting the Farafra Oasis with the Nile Valley, as this oasis is witnessed very rapid development of its agricultural activities and is seeking to improve means of transporting its product to major marketing centers.

Most of these tracks are crossing the central part of the study area (Area “2” mentioned in the previous section, Section 7, of this report). In this area dunes are relatively rare and their average displacement towards the SE is 7. 5 m/year. In area “1”, to the north dune movements are more rapid, averaging 17.5 m/year. In the southernmost studied part of the Abu Muharik dune field (Area “3”) dune movements average 11.5 m/year.

Conclusions and Recommendations

The dune field of Ghard Abu Muharik in the Western Desert has been inverstigated by producing geological and geomorphological maps by using remote sensing techniques for the area surrounding the dune field and by undertaking laboratory investigations on samples collected from various dunes in the "erg" zone of the field. The laboratory investigations involve granulometric, morphoscopic and x-ray analyses of the samples.

The sediments of Ghard Abu Muharik seem to have their source from a location found to the north and northeast of the dune field (probably partly the extensive sand and gravel deposits of Oligocene and Miocene age belonging to the Qatrani and Moghra Formations exposed to the north of Bahariya). The last mentioned rock units are fluvial or fluvio-marine deposits. However it is not excluded that part of the sediments of the dunes are old intensively reworked eolian sediments moving in the Western Desert during various arid phases of the Quaternary. But these sediments should constitute a negligeable part of the dunes material.

Movement of sand is from NW to SW and the sand become more markedly "eolinized" in this direction by including less rounded shiny sand grains and more rounded mat grains. They also include less clay material toward the SE.

Ghard Abu Muharik, in the erg zone is formed of both longitudinal sand dunes and barchan sand dunes. The Landsat TM images, aerial photography and 3D DEM show that the dune field runs in a depression and that barchan sand dunes are present in the western side of Ghard Abu Muharik dune field in rugged area of higher relief than that of the substratum of the longitudinal dunes. Longitudinal dunes are located in the eastern part of Ghard Abu Muharik dune field. They are striking in a NW-SE direction and are formed by collection of barchan dunes. The eastern tails of the lee side of the barchan dunes are longer than the western one and sometimes these tails are connected with each others forming longitudinal sand dunes. This phenomenon is most probably due to wind action and wind direction. However, the slope of the ground over which the dunes move, which is towards the east, may also have an influence on the phenomenon.. The "erg" zone of Ghard Abu Muharik is more effected by wind action than its "head" zone due to the smooth topography and wide area of the center of Western Desert, which is constituted by a wide limestone plateau.

Study of dune movement by remote sensing techniques suggest that the barchan dunes move in a southwest direction and than the speed of their movement decrease in the direction of their movement (from an average of 17.5 m/year in the northern part of the "erg" zone of the field near Bahariya oasis to an average of 11.5 m/year at the southern end of the plateau leading to the Kharga depression). However the lowest average speed of barchan dunes have been recorded in the middle part of the Ghard (an average of 7.5 m/year). In this area roads and other human activities should be the safest as regard to sand dune hazard. The area is crossed by many tracks used by desert

tourism and safari. It should also be crossed by the asphalt road connecting the Farafra Oasis with the Nile Valley.

Stabilization of dunes may take place by building a pavement of gravels on the dune. Ultimately, wind will remove the sand grains while the pavement will form a lag layer and probably this will end in converting the sand dunes into sand sheets. With breakers, higher trees are also important to nullify the power of wind. On the other hand, both wind and solar energy have to play a big role in the oases, There is hardly a place on earth where the wind and the sun are as effective and powerful for almost 365 days each year as they are in the Egyptian Western Desert.

References

Ashri, A.H. 1970. The movement of sand dunes at Kharga Oasis(abstract)in paper presented at the Eighteens Annual Meeting,Geol.Soc. Egypt, p. 21.

Bagnold, R.A. 1933. A further journey through the Libyan Desert. Geograph .J. V. 82; no,2. pp 103-129.

Bagnold, R.A. 1941. The physics of blown sand and desert dune. Methuen and Co., London, pp 265.

Bagnold,R.A., R.F.Peel, O.H. Myers and H.A. Winkler. 1939. An expedition to the Gilf Kebir and Uweinat, 1938.Geograph . J.93, pp 281-313.

Beadnell, H.J.L. 1909. An Egyptian Oasis; Murry, London, p 262.

Beadnell, H.J.L. 1910. The sand dunes of the Libyan Desert. Geograph. J., V. 35, no. 2, pp 379-394.

Beadnell, H.J.L. 1933. Remarks on the pre-historic geography and underground waters of Kharga Oasis; Geograph .J. V. 81, pp 128-139.

Breed, C.S., N.S. Embabi, H.A. El-Etr and M.G. Grolier. 1987. Wind deposits in the Western Desert; In journey to the Gilf El Kebir and Uweinat, south west Egypt; ed. F.El-Baz, Geogr. J.,V.146, part I,, 88-90pp.

David,S. Thomas ed . 1997. Arid zone geomorphology, JonWilly and Sons, New York.

El Aref, M.M. and Lotfy, Z.H. 1985. Genetic karst significance of the iron ore deposits of El BahariyaOasis, Western Desert, Egypt.Annals of Geolgical Survey of Egypt., vol. 14.

El Aref, M.M. Abu Khadrah, A.M., and Lotfy, Z.H. 1987. Karst topography and karstification processes in the Eocene limestone plateau of El Bahariya Oasis, Western Desert, Egypt. Egypt . J. for Geomorph., vol. 31, no. 1, p. 45-64.

El Baz, F. and Wolfe,R. W. 1981. Wind patterns in Western Desert, Egypt Annals of the Geolgical Survey of Egypt.

El Baz, F. and Donna Prestel. 1981. Coating on sand grains from southwestern Egypt Annals of the Geolgical Survey of Egypt.

Embabi, N. S. 2004. The Geomorphology of Egypt, Landform and Evolution, vol. 1, the Nile valley and the Western Desert. The Eg. Geogr. Soc. Spec. Pub., 447 pp., Cairo.

Geological Survey of Egypt. 2003. Geological map of Ghurd Abu Muharik, Western Desert, Egypt, scale 1:250,000

Gerasimov, I.P.and Mescherikov, J.A. 1968. Morpho-structure geomorphology, in the Encyclopedia of geomorphology, Dowden, Hutchison and Ross, pp 731-732

Geological Survey of Egypt. 1981. Geological map of Egypt Conoco, 1987. Geological map of Egypt ,scale 1:5,00,000

Kocurek, G., Townsley, M., Yeh, E., Sweet , M., Havholm,K. 1990. Dune and dune field development on Padre Island, Texas, with implications for interdune deposition and water table controlled accumulation. Journal of sedimentary petrology 62, pp 622-635.

Kropelin, S. 1993. Geomorphology, landscape evaluation and paleoclimates of southwest of Egypt. Catenapp 31-65

Krumbein, W., C., and Monk, G.D. 1943. Permiability as a function of the size parameters of unconsolidated sands . Am inst. Mining Metal. Engineers Tech. Pub. 1492, 11 pp.

Mycielska-Dowgallo, E. 1995. Selected textural features of deposits and their interpretation value, in Researches of Quaternary sediments, Editors by Mycielska-Dowgallo, E. and Rutkowsti, J. Warsaw, Poland.

Powers, M.C. 1953. A new roundness scale for sedimentary particles. Jour. Sed. Petrology 23, pp. 117-119.

Szabo, B. J., Haynes, C. V. and Maxwell, T. A. 1995. Ages of Quaternary pluvial episodes determined by uranium-series and radiocarbon dating of lacustrine deposits of Eastern Sahara. Paleogeography, Paleoclimatology and Paleoecology. Vol. 113, pp. 227-242.

Topographic map scale 1: 250 000 19 Qart el Sewan, Western Desert, Eyptian Survey.

Tsoar , H . 1989. Linear dunes, forms and formation. Progress in Geography, Vol. 13, pp 507-527.

Van Der Meulen F. and J. C Van Huis. 1985. Dune landscape Map of Meijendel, coastal dunes near the Hague, the Netherlands. Scale 1:5.000 Pub. ITC. Journal Holland. Sheet 1.

Wendorf, F. R., Schild, A. E. and Close, R . 1993. Egypt during the last interglacial. The Middle Paleolithic of Bir Tarfawi and Bir sahara East. Plenium Press, New York, 573 p.

دراسه مخاطر حركة الكثبان الرملية لغرد ابو المحاريق في الصحراء الغربية المصريه باستخدام تقنيه الاستشعار من البعد

السيد احمد الجمال وعمر شريف

الهيئة القومية للاستشعار من البعد و علوم الفضاء- القاهرة- مصر

يقع غرد أبو المحاريق في الجزء الأوسط من الصحراء الغربية المصرية وهو حقل مستطيل من الكثبان الرمليـــة يمتد من شمال شرق الواحات البحرية في اتجاه جنوب شرق نحو منخفض الخارجه و يمتد في المنخفض حتي حـــدود السودان. و يقع هذا الحقل من الكثبان الرملية في منطقه هامه علي مسار خطوط الاتصال بين الواحات ووادي النيل وهذا الاتصال من العناصر الهامه لإطلاق التنميه في الصحراء الغربية المصرية وهو يتعرض لمخاطر حركة الكثبان الرمليـــة لغرد ابو المحاريق.

يتناول البحث دراسه نشأه وتطور وحركه الرمال في النصف الشمالي للغرد الذي يحتوي علي قـــسمي الارج و الذيل لحقل الكثبان حيث لا توجد دراسات في جزء الارج وجدير بالذكر ان دراسات عديده جدا تناولـــت الجزء الجنوبي من الحقل(الرأس) الممتد في منخفض الواحات الخارجه وقد تم القيام ببعض القياسات المورفومتريه للنصف الشمالي للغرد و جمع عينات منه وعمل تحاليل كيميائيه لها ودراستها تحت المجهر الماسح الالكتروني لمعرفه منشأ الغرد وعلاقته بما حوله. تبين أن المصدر الرئيسي للغرد هو من صخور عصر الأولوجوسين الموجوده شمال شرق الواحـــات البحرية بالاضافه لوجود ترسيب من صخور الحقب الرابع المحيطه بمنطقه وسط الغرد. والحركة السائدة حاليا هـــي ترسيب هوائي بعد وجود ترسيب نهري.

تم دراسه اتجاه وكميه حركة الرمال بالغرد باستخدام برنامج رسم الحاسوب الالكتروني (ARC Map) و تقنيه الاستشعار من البعد مستخد ما صور فضائيه في ثلاث أزمنه هي 1974 و1984 و2001 لبعض الكثبان المنفصله في نطاق الارج وقد تبين ان حجم الكثبان تزداد وتتحرك تجاه الجنوب بسرعه 25 متر في العام في الجزء الشمالي مـــن الارج من الغرد وتتحرك تجاه الجنوب بسرعه 12 متر في العام في الجزء الجنوبي منه.