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Source of the aeolian dune sand of Toshka area, southeastern Western Desert, Egypt

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ABSTRACT

Sedimentological, mineralogical and geochemical investigations were carried out in order to identify the probable source and mode of origin of the aeolian dune sand of the Toshka area at southeastern Western Desert, Egypt. A hundred and thirty sand samples were collected from the base, crest and slip face of barchan and linear dunes together with windward and interdune area and from lee dunes and sand shadows. Grain size analysis of the collected sediments shows that most of the aeolian sand is generally fine-grained, moderately well sorted, fine skewed and leptokurtic. The anchored dunes (lee and sand shadows) are nearly similar and are the finest and best sorted of all the dune types of Toshka sands. Barchans are coarser while the linear dunes represent the least sorted dune sand. The textural, mineralogical and the geochemical results supported by statistical approach indicate that the Toshka sands were mainly derived from late Pleistocene dune sand with a minor contribution from local sources (Pleistocene alluvial sand and Holocene playa). These sands represent the proposed sources probably derived from the weathering of the Nubian sandstone since the mid-Tertiary by fluvial streams and lakes during earlier humid periods and by aeolian processes during arid periods.

1. Introduction

The aeolian sands occupy significant positions in the geologic history of Egypt in general and in the Quaternary in particular. The way in which these sands are distributed reflects the paleoclimate of the Western Desert. Numerous geologic and geomorphologic studies were carried out concerning the dunes and aeolian sands of the Western Desert of Egypt. Among these are Embabi (1970), El-Baz et al. (1979), Haynes (1989), Hamdan and Refaat (1999), Hamdan (2003), Stokes et al. (1998), Besler (1986, 1998, 2000, 2008), El Gammal and Cherif (2006) and Labib and Nashed (2013). Grain size variations in coastal and desert dune sands have been widely used to infer transport and depositional mechanisms (Bagnold, 1941; Khalaf, 1989; Lancaster, 1995; Wang et al., 2003; Kasper-Zubillaga and Carranza-Edwards, 2005). For example, size coarsening of the dune sands may be due to wind deflation of fine grains leaving behind the coarse fraction in the sands (Khalaf, 1989). In addition, mineralogical and geochemical studies of dune sands provide new insights into the origin and evolution of aeolian sand bodies (Muhs, 2004).

The study area is located in the southeastern part of the Western Desert of Egypt between 22° and 24° 30′ N and 30° 15′ and 33° E. (Fig. 1). Recently, the area attracted the attention of many scientists as well as the governmental authorities, who are interested in the development of this remote area for the establishment of new communities, by increasing the cultivated areas in Egypt. The specific aim of this paper is to observe and interpret the grain size attributes, mineralogical and geochemical differences between the different dune types in the Toshka area, southeastern Western Desert of Egypt. Furthermore, this study provides information on probable source and mode of origin of these dune sands.

2. Physiography and Geology

The study area covers an area of about 50,000 km^2 of the southeastern part of the Egyptian Western Desert. Physiographically, the study area could be subdivided into three regions: (a) the low relief area with elevation less than 150 m above sea level is represented by the Toshka lakes and comprises about 2.1% of the whole studied area; (b) the Toshka plain delineated by the contour line 200 m; represents about 26.9% and the pediments of Sinn el Kadab Plateau with elevation 200–300 m above sea level and represents about 50% of the whole study area; and (c) Sinn el Kadab Plateau

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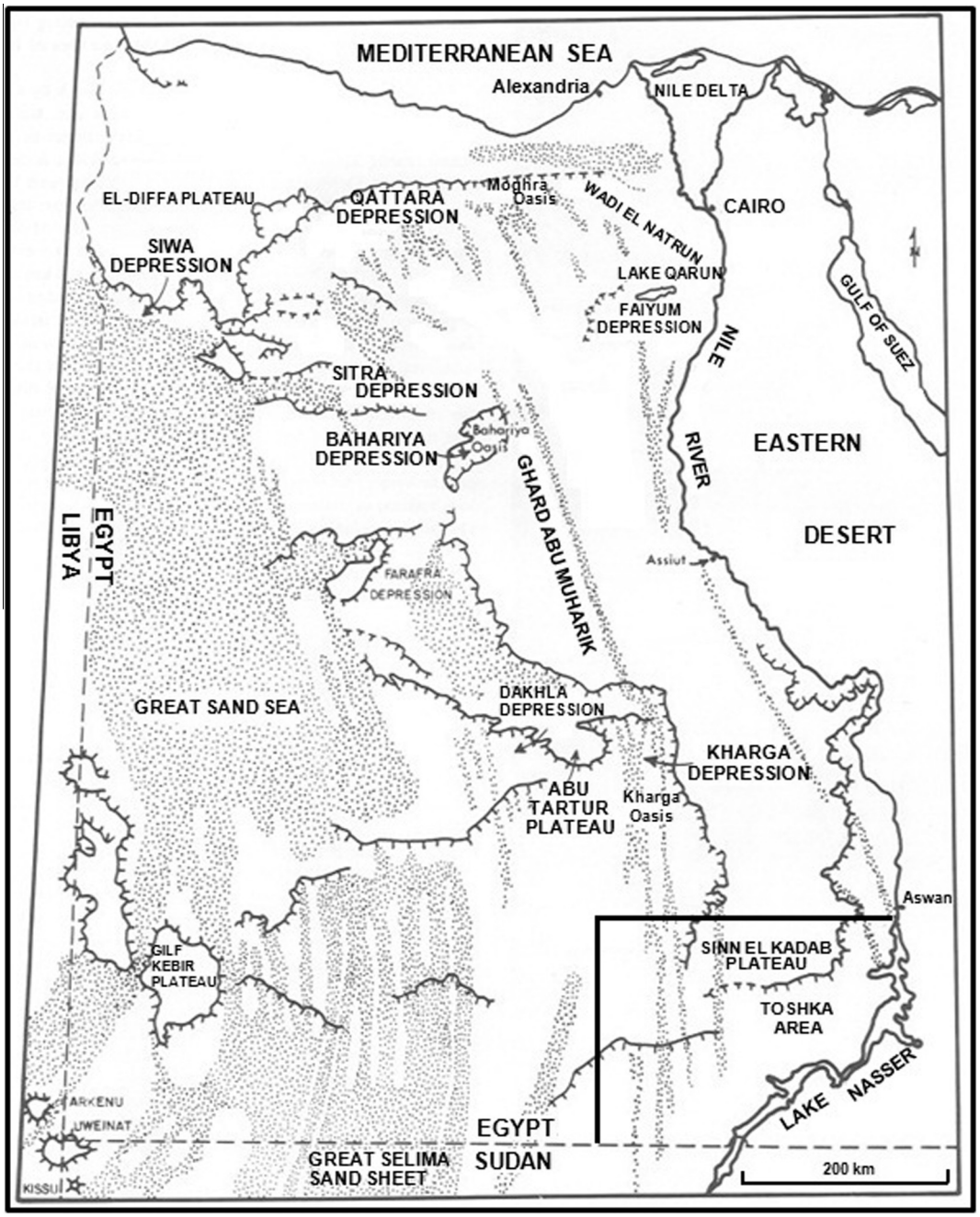

Fig. 1. Map of the Western Desert of Egypt showing the distribution of the major sand dune fields (modified after El-Baz, 1979) and the location of sites that are mentioned in the manuscript. The study area is located at the southeastern part of the Western Desert of Egypt.

represents the high relief area and lies more than 300 m above sea level and comprises about 20.3% of the whole studied area. Precambrian igneous and metamorphic rocks, early Cretaceous Nubian sandstone, late Cretaceous, Tertiary and Quaternary Nile sediments are exposed in the Toshka area (Fig. 2).

Landsat imageries complemented with field studies showed that the dunes of the Toshka area are subdivided into two main categories, free-moving and anchored dunes (Livingstone and Warren, 1996).The barchan and linear dunes represent the former while lee dunes and sand shadows represent the anchored type. The free-moving dunes exist mainly in the Toshka plain (Fig. 3). However, few small barchan dunes are also recorded at the top of Sinn el Kadab Plateau. The anchored dunes exist at both the Toshka plain and pediments of Sinn el Kadab Plateau, where the lee dunes and sand shadows accumulated in the leeward sides of the Nubian sandstone hills (Hamdan et al., 2014; in prep.).

3. Materials and methods

The dune morphology might control the grain size parameters (Lancaster 1983; Watson; 1986; Livingstone et al., 1999; Kasper-Zubillaga and Dickinson, 2001; Wang et al., 2003). The number of samples studied varies from one dune type to another. Five samples were collected from crest, slip face, windward, base and horns of the 10 different barchan dunes. Four samples were collected from the base, crest, slip face and inter-dune of 10 different linear dunes. One sample was collected from each of 25 lee dunes and 15