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Comprehensive geological study on recent surface sediments of a small North African reservoir, Egypt

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ABSTRACT

The present paper is devoted to throw more light on the geological study of recent surface sediments of a small North African reservoir, as well as, the influence of mother country rocks on these sediments which hasn't been thoroughly studied before. The studied sediments have been confirmed to be mostly derived from Ethiopian sources as indicated by the calculated mineralogic indices, where higher pyroxene index (I_{Pyr} = 62.07) was recorded. The Ethiopian Plateau and the local contribution from the surrounding country rocks (Aswan granites, Nubia Sandstone, basement rocks and some volcanic basaltic islands) played the principle role on the distribution of heavy and clay minerals to such sediments.

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Introduction

Man-made reservoirs can help in integrated sustainable management of freshwater resources, fulfilling the rural population need for irrigation, inland fisheries, hydroelectric power generations and domestic water supply. These multiple utilization purposes led to the promotion of strategies designed for the regional development plans in different countries (Fabbro and Duivenvoorden, 2000). The studied area of the River Nile lies between the old Aswan Dam and High Dam, which formed on the River Nile at Aswan area after the construction of the High Dam. Small North African reservoir (Aswan Reservoir) is bounded within Egypt by geographic coordinates extending between

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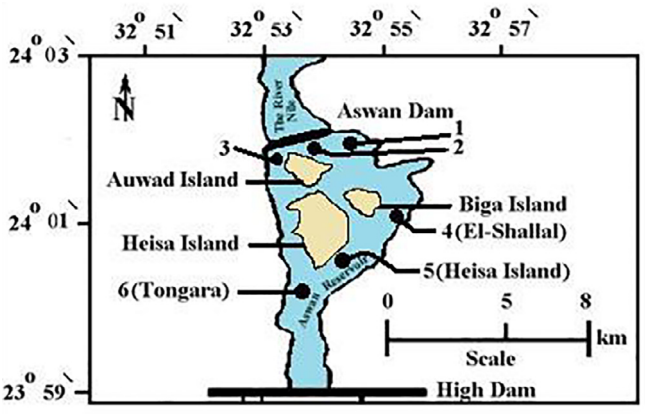

Fig. 1. Location map showing sediment sampling sites in small North African reservoir.

(latitudes 23°59′–24°03′N and longitudes 32°51′–32°55′E) (Fig. 1). In addition to, the geologic rock units exposed in this area on both eastern and western banks of the Nile are represented by Aswan granites, Nubia Sandstone, Quaternary Nile sediments and recent sand sheets. Many studies were carried out on reservoirs (El Dardir, 1994, 1995; Matveev and Matveeva, 1997; Sommer et al., 2001; Gliwics, 2002; Mokhtar, 2003; El-Shabrawy and Dumont, 2003; Hunt and Matveev, 2005; Schnetzer and Caron, 2005; Ali et al., 2007; Sinistro et al., 2007; Iskaros et al., 2008; Chellappa et al., 2009; Iskaros and Gindy, 2009; Iskaros et al., 2011; Iskaros and El-Otify, 2013). The geological studies on the area between the old Aswan Dam and High Dam have received a minor interest. The objective of this study is devoted to throw more light on the geological study of recent surface sediments in the small African reservoir, as well as the influence of mother country rocks on these sediments which hasn't been thoroughly studied before.

Materials and methods

Twenty-four samples representing the studied surface sediments were collected seasonally during winter, spring, summer and autumn of 2017 from two cross sections in a small North African reservoir using Peterson dredge, and research boat from depths ranging between 3 and 18 m below the reservoir water level (Fig. 1). Granulometric analysis of studied sediments was undertaken in the laboratory of Lake Nasser Research Station. This analysis depends greatly on the disaggregation of the samples into its constituent clastic particles. Two techniques were used for the determination of the particles size distribution of the samples. The dry sieving technique for sand fraction (Folk, 1980) was carried out by using a Ro-Tap Mechanical Shaker for 20 min for each sample. The settling velocity technique for the silt and clay fractions (pipette method) after Carver (1971) was adopted. The grain size parameters (M_Z, σ_I, SK_I, K_G and $K_G^{\backprime}$) were calculated according to Folk and Ward's (1957) mathematical equations. Heavy minerals analysis was done on the fraction between 125 and 63 μm was subjected to heavy mineral separation technique by means bromoform liquid (sp. gr. 2.85). The heavy mineral residues were dried and mounted on glass slides and microscopically examined using a standard polarizing microscope. About 300 heavy mineral grains were counted using the point counting stage. Identification of mineral grains was carried out following the method given by Mange and Maurer (1992). Applying the formulae of Hassan (1976), the heavy mineral indices were calculated. The calculated heavy mineral indices are Pyroxene index (I_{Pyr}), Amphibole index (I_{Amph}), and Epidote index (I_{Epd}). Nine representative clay samples of Aswan Reservoir sediments were subjected to clay minerals study. Of these, 5 samples were taken from five stations in the studied reservoir, and 4 samples were taken from El-Shallal (Section 2, east station, sample No. 4) during the different four seasons to study the seasonal variations. The clay fraction of these samples were prepared using the standard pipette sedimentation technique. Oriented slides were prepared from the samples by sedimentation of the clay size fraction (<2 μm) of the suspended material on glass slides. The slides were allowed to dry out slowly at temperature below 60 °C in order to avoid destruction of the crystal structure. In this way, the plate like clay particles settled down with their basal planes parallel to the surface of the slides. Three runs of each sample were carried out, in order to identify the clay minerals present. One run before treatment, the second after glycolation at 55 °C for 24 h, and the third after heating at 550 °C for 4 h. The samples were analyzed using a Philips X-ray diffractometer (at Assiut University) with nickel filter and CuK_{∞}-radiation generated at 40 kV and 20 mA. The samples were scanned between 4° and 30° 2θ with speed rate 1° 2θ/min (Fig. 4). According to the X-ray powder diffraction tables of Chen (1977), identification of clay minerals is based on the basal reflections, mainly the (0 0 1). The relative abundance of the identified clay minerals is determined by measuring the peak height for the individual clay mineral groups according to the method of Biscay (1965) and Griffin (1971).

Results and discussion

Grain size analysis

Grain size composition is an important factor that should be taken into consideration to interpret the distribution of some elements in clastic sediments. The sand fraction constitutes the main bulk of the investigated sediments in Aswan Reservoir (53.5–90%), followed by silt (8–41.3%) and clay fraction (2–11.2%) (Table 1).

Grain size parameters

Table 2 shows the calculated grain size parameters of Folk and Ward's (1957). The investigated sediments show that their mean grain size diameters (M_Z) ranges from 1.43 to 4.50 ϕ (medium sand

Table 1
Percentages of sand, silt and clay of the analyzed surface sediment samples in a small North African reservoir during winter – autumn, 2017.

Section	Station	Sample No.	Depth (m)				Sand (%)				Silt (%)				Clay (%)			
			w.	sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.	w.	sp.	su.	au.
I	East	1	7	6	8	8	72.5	70.8	66.2	70.0	23.5	24.5	26.6	23.2	4.0	4.7	07.2	06.8
	Middle	2	16	10	17	14	90.0	89.2	86.5	85.3	08.0	08.5	09.3	11.0	2.0	2.3	04.2	03.7
	West	3	15	9	18	13	80.0	80.5	81.4	83.4	17.2	16.0	11.6	10.7	2.8	3.5	07.0	05.9
II	East (El-Shallal)	4	6	5	9	7	53.5	60.4	56.6	55.7	41.3	33.0	32.6	34.8	5.2	6.6	10.8	09.5
	Middle (Heisa Island)	5	5	9	10	6	63.4	65.3	64.5	62.8	32.1	29.5	25.0	27.2	4.5	5.2	10.5	10.0
	West (Tongara)	6	5	3	4	6	72.5	68.7	65.4	69.0	22.7	25.9	23.4	20.0	4.8	5.4	11.2	11.0
Average			9	7	11	9	72.0	72.5	70.1	71.0	24.1	22.9	21.4	21.2	3.9	4.6	08.5	07.8
			9				71.4				22.4				6.2			

(w: winter; sp: spring; su: summer; au: autumn).