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SEISMICITY AND SEISMOTECTONICS OF THE WEST KOM OMBO AREA, ASWAN, EGYPT

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ABSTRACT
The study area is located about 40 km north of Aswan City in the Western Desert, between longitude from 32° to 32.9° E and latitude from 24.2° to 24.8° N. On March 22, 2003 an earthquake (M_D 4.0) occurred in the west Kom Ombo area and it was felt in the area and its surroundings. The event was followed by two aftershocks with magnitude 2.7 and 3.0. Due to the importance of Kom Ombo city as a main trade center in Aswan Governorate, in addition to the probability of discovering Oil and Gas in the Kom Ombo area, this study carried out. Rou software program is used to locate the earthquakes of the west Kom Ombo area. The results showed that the spatial distribution of these earthquakes are located roughly in the N-S direction, approximately parallel to the Nile River concordant with the main trend of Gebel el-Barka fault. The frequency-magnitude plot for the data located in the west Kom Ombo area gave a fairly good fit to a line with the form log N = (2.9 ± 0.07) – (0.7 ± 0.04) M. The focal mechanism of the largest earthquake (March 22, 2003) is evaluated by using the polarity of the first arrival P-wave technique. The fault plane solution indicates strike-slip faulting with a normal fault component. The fault plane strikes 355° and dips 57° was taken in consideration because it is nearly parallel to Gebel el-Barqa fault and the spatial distribution of earthquakes in the area. The seismic activity in the west Kom Ombo area may be related to the Gebel el-Barka fault that is one of the Western Desert fault systems. The results of this study may be used for seismic hazard analysis for purposes of land use planning and policy-making.

KEYWORDS: Kom Ombo, seismicity, seismotectonics and focal mechanism

INTRODUCTION

The study area is located about 40 km to the north of Aswan City between longitude from 32° to 32.9° E and latitude from 24.2° to 24.8° N as shown in Fig. 1. Before the occurrence of the famous Aswan earthquake (M_b 5.3) that occurred on Nov. 14, 1981, about 60 km to the south of Aswan at Kalabsha area (Kebeasy et. al., 1987), the area was considered aseismic. No earthquakes had been reported at the area in the catalog of the International Seismological Center (ISC) since its inception in 1920. The largest recorded earthquake that took place in the Aswan area in the recent history is that of 14 November 1981. Since that time the Aswan area considered to be a low active seismic area. After that main shock a temporary network consists of six MEQ–800 seismographs has been installed around the northern part of Aswan lake from Dec. 1981 to July 1982 by the Egyptian Geological Survey and Mining Authority (EGSMA) to monitor the aftershocks following the main shock of November 14, 1981 earthquake (Toppozada et. al., 1988). Beside the microearthqukes recorded around the Aswan lake area during that period, 7 events with magnitudes vary from 2.3 to 3.8 were located around Kom Ombo area, four of them are located in the west Kom Ombo area. These few located earthquakes stimulated the pioneers to recommend a detailed seismic study to be done in and around the Kom Ombo area in the future. Since July 1982, that temporary network was replaced by a permanent telemetered network and operated by the Helwan National Research Institute of Astronomy and Geophysics (NRIAG).

On March 22, 2003 an earthquake (M_D 4.0) occurred in the west Kom Ombo area, it was felt in the area and its surroundings, the event was followed by two aftershocks with magnitudes 2.7 and 3.0. Location of the main shock and its aftershocks were determined and they were found near to the northern part of Gebel el-Barqa fault in the Western Desert.

The main aspect of this study will take into consideration the study of seismic activity and seismoteconics of the west Kom Ombo area; the study will address the relationship between the distribution of earthquakes and regional structures. Also, these earthquakes will be placed in the context of regional tectonic of the Western Desert fault system. The results of this study can be used for seismic hazard analysis for purposes of land use planning and policy-making.

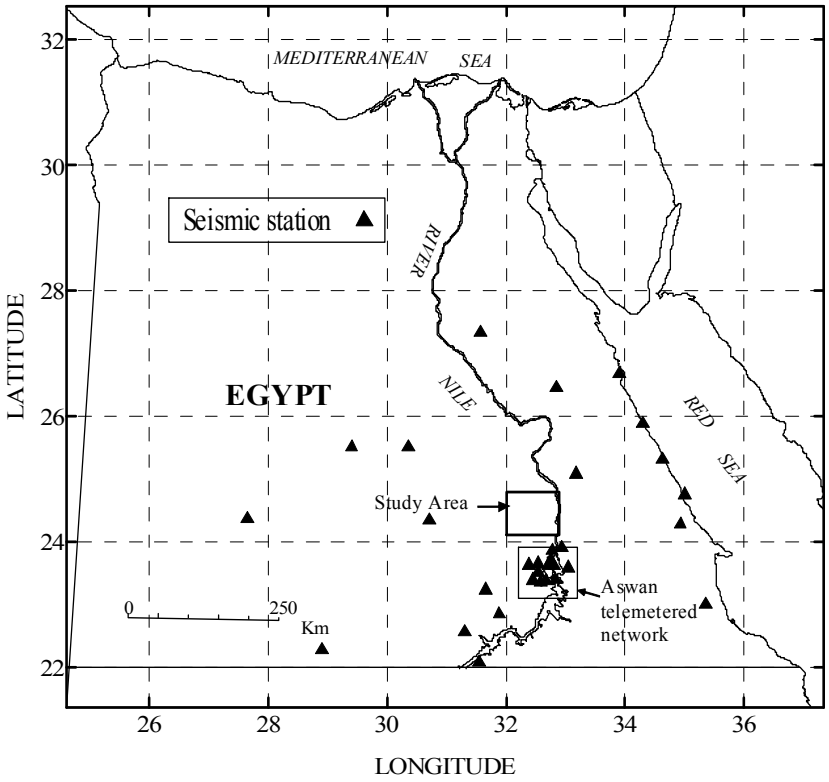


Fig. 1 Location map of the study area, Aswan telemetered network and national seismic network stations.

TECTONIC SETTING

The faults that are potentially significant to the study area are part of the Western Desert fault system; a tectonic model was developed for this fault system by Woodword-Clyede Consultant (WCC, 1985). The Western Desert fault system is related to the active plate margin to the east as a secondary fault system. Although the tectonic behavior of this fault system has been analyzed in substantial detail, the origin of the low-level deformation in the Western Desert is somewhat equivocal. Because the total amount of deformation is small and the area over which it is distributed is large, understanding of the origin of the deformation may continue to be uncertain.

WCC (1985) evaluated the fault system in the Aswan area and report that the Western Desert fault system consists of a set of east-west faults that exhibit right slip displacement, and a set of north-south faults that exhibit left-slip displacement. The significant faults in the area are shown in Fig. 2 and classified as:

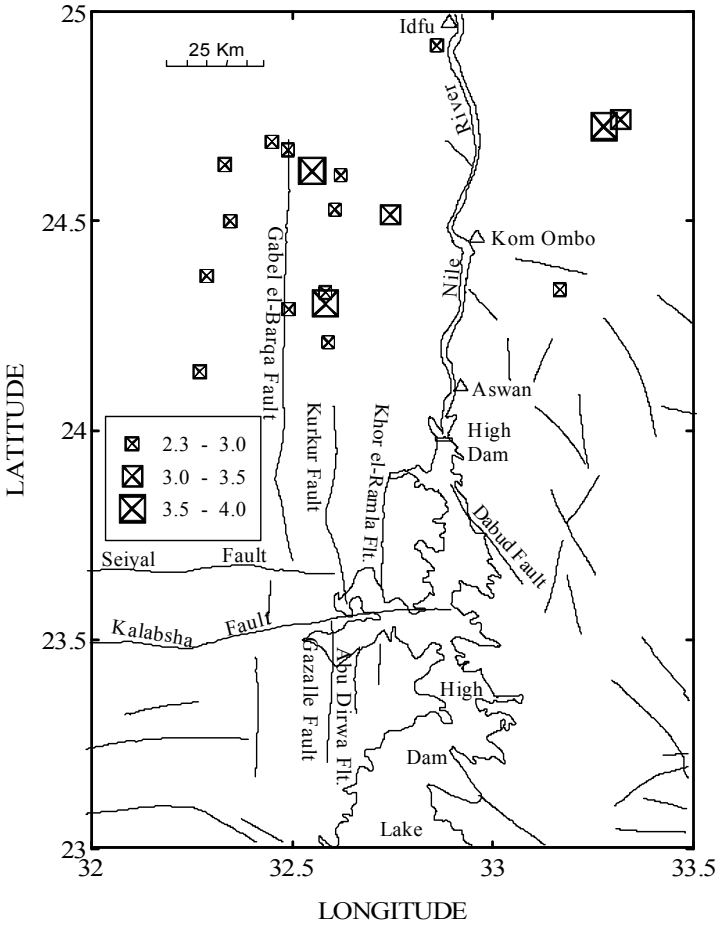
1. East-West trending faults: The most important faults of this system are the Kalabsha fault and Seiyal fault,
2. North – South trending faults: The most important major faults of this system are the Kurkur fault, Abu Dirwa fault, Khor el-Ramla fault, and Gabel el-Barqa fault. Due to the location of the seismic activity in the study area nearby to the Gabel el-Barqa fault, the fault is described in details as follows:

Gabel el-Barqa Fault:

It is located approximately 40 km due to west of the Nile River. The length of the fault is about 110 km; at its closest approach, it is approximately 43 km due to Kom Ombo City. Gebel el-Barqa fault is interpreted to be left lateral strike slip fault. Displaced or warped Quaternary deposits were identified at four locations along the Gebel el-Baraqa fault. The degree of activity of the Gebel el-Baraqa fault is estimated to be low. Displaced or warped Quaternary deposits were identified at four locations along the Gebel el-Barqa fault. The maximum measured vertical displacement of an alluvium-covered pediment surface is 3 m. Warping and small displacements of alluvial units were observed in a trench excavated across the fault (WCC, 1985). No evidence of surface fault displacement of geologically recent wadi deposits or desert lag deposits was observed. This suggests that there has been no measurable surface faulting along the Gebel el-Barqa fault during the past 5000 to 10,000 years. However, warping and displacement of older Quaternary deposits suggest multiple slip events in the past few hundred thousand years.

Table 1 Aswan velocity model (after WCC 1985)

Depth (km)	V_p (km/sec.)	V_s (km/sec.)
00.0	4.0	2.3
00.5	6.0	3.4
05.0	6.8	3.9
20.0	7.5	4.3



Modified from EGSMA (2002)

Fig. 2 The significant faults and earthquake epicentrals distribution in and around the study area during the period from 1981-2003.

SEISMICITY PATTERN OF KOM OMBO AREA

During the operation of the temporary network by EGSMA through the period from Dec. 1981 to July 1982, 7 earthquakes were located 25-50 km around Kom Ombo area. The magnitudes of these events were found to vary from 2.3-3.8. Among these earthquakes, 4 were located in the western side of the Nile River, while the rest were located in the eastern side. During the continuous operation of the Aswan telemetered network since July 1982 and monitoring of the seismic activity in the area, a few number of earthquakes were recorded and located in the western side of the Nile River around the northern end of Gebel el-Barqa fault. Rou software program (Baumbach, 1990) was used to determine the location of the earthquakes that observed by Aswan telemetered network and national seismic network stations in Upper Egypt (Fig. 1). Aswan velocity model is assumed (Table 1). The output of this program is the origin time of the event, latitude, longitude and errors in the horizontal position. The errors with this method are about 10 km for earthquakes with epicentral distances less than 150 km from the Aswan seismic network.

Table 2 Parameters of the observed earthquakes in the study area

EventNo.	Date	O.T		Location		Mag
	Y M D	H	M	Lat	Long	
1*	82 01 24	22	25	24.300	32.583	3.5
2*	82 04 04	08	56	24.726	33.272	3.8
3*	82 05 27	14	36	24.515	32.745	3.6
4*	82 05 28	06	09	24.743	33.318	3.2
5*	82 06 19	05	50	24.529	32.607	2.9
6*	82 06 25	21	07	24.610	32.621	2.7
7*	82 07 03	00	44	24.336	33.167	2.3
8**	83 04 29	05	19	24.635	32.333	2.7
9**	88 08 19	21	52	24.289	32.492	2.5
10**	90 10 16	00	14	24.140	32.270	2.6
11**	97 08 15	19	58	24.369	32.287	2.8
12**	98 12 13	07	20	24.500	32.346	3.0
13**	99 09 28	03	57	24.920	32.860	2.5
14**	01 08 17	06	38	24.330	32.583	2.5
15**	03 03 22	12	32	24.620	32.550	4.0
16**	03 03 22	12	36	24.670	32.490	2.7
17**	03 03 22	12	38	24.690	32.450	3.0
18**	03 05 22	03	17	24.200	32.450	2.8

* Observed by Egyptian Geological Survey
** Aswan Telemetered Network

The computation of earthquakes magnitude is carried out using the Aswan telemetered network formula developed by Fat-Helbary (1989), they found vary from 2.3 to 4.0. Aswan telemetered network formula represented as follows:

$$M = 2.17 \log D - 1.3 + 0.00075\Delta$$

Where:
D = Signal duration
Δ = Epicentral distance in km

The spatial distribution of the located earthquakes in the west Kom Ombo area during the period 1981 - 2003 using the above mentioned method in addition to the 7 events located by EGSMA is represented in Fig. 2 and listed in Table 2. From the figure it is clear that the epicentral distribution of earthquakes are located around the northern part of Gebel el-Barqa fault and nearly in N-S direction parallel to the main trend of the fault.

FOCAL MECHANISM

The orientation of focal mechanism of the largest earthquake of March 22, 2003 (M_D 4.0) that occurred in the area and recorded by a number of seismic stations in Upper Egypt was evaluated by using the polarity of the first arrival P- wave technique. The focal depth was constrained to be 8.5 km. The fault plane solution indicates strike-slip faulting with a normal fault component as shown in Fig. 3. The strike and dip of the first nodal plane are 355° and 57° respectively. While for the second plane the strike is 92° and the dip is 80°. The fault plane strikes 355° and dips 57° is taken in consideration because it is nearly parallel to Gebel el-Barqa fault and the spatial distribution of earthquakes in the area.

FREQUENCY MAGNITUDE RELATION

An important criterion for comparing seismicity of different areas is to consider the b-value for the number of earthquakes relation to the magnitude curve. This curve is determined from the equation of Gutenberg and Richter (1958) as follows:

$$\log N = a - bM$$

Where, N is the number of earthquakes greater than or equal to magnitude M, a and b are constants. The parameter *"a"* is a measure of the level of seismicity and depends on the period of observation, it is found to vary from region to region (Gupta 1976). Whereas, the parameter b describes the relative number of small and large events in a given interval of time. The Gutenberg and Richter (1958) relation can be hold for all magnitude ranges, in all locations and all times (Runddle, 1989). The frequency-magnitude plot for the data located in the west Kom Ombo area gave a fairly good fit to a line with the form of $\log N = (2.9 \pm 0.07) - (0.7 \pm 0.04) M$ as shown in Fig. 4.

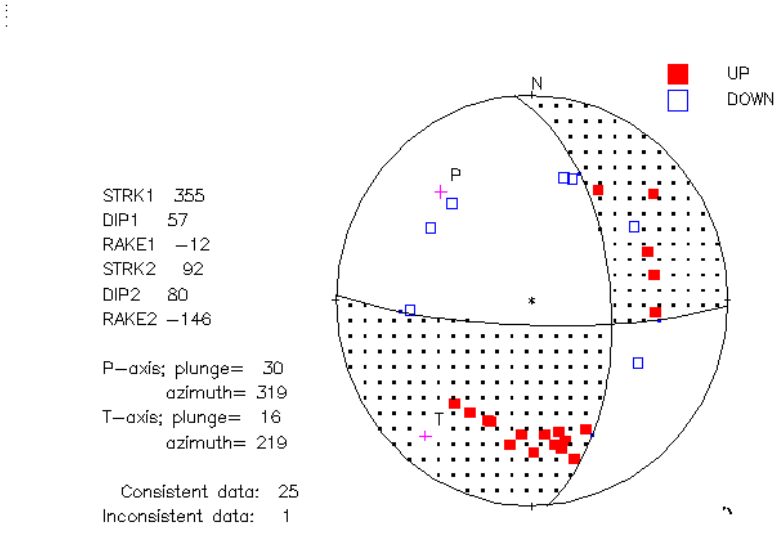


Fig. 3 Focal mechanism solution of the March 22, 2003 earthquake

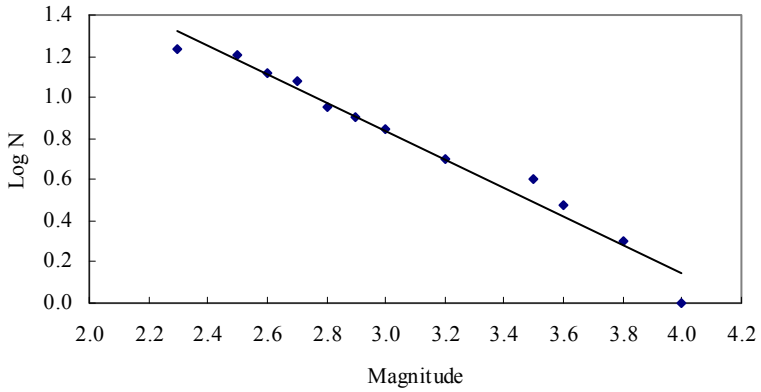


Fig. 4 Magnitude - frequency relation of the west Kom Ombo area earthquakes.

SUMMARY AND CONCLUSIONS

Few of earthquakes occurred in the west Kom Ombo area from 1981 to 2003 were recorded by MEQ-800 temporary network and Aswan seismic network. Rou software program is used to locate the earthquakes that recorded by Aswan telemetered network and national seismic network stations in Upper Egypt.

The spatial distribution of the located earthquakes in the study area showed that these earthquakes were located roughly in a N-S direction, approximately parallel to the Nile River, concordant with the main trend of Gebel el-Barka fault, west of Kom Ombo area in the Western Desert.

The frequency-magnitude plot for the data located in the study area gave a fairly good fit to a line with the form log N = (2.9 ± 0.07) – (0.7 ± 0.04) M.

Focal mechanism of the largest earthquake (March 22, 2003) is determined by using the polarity of the first arrival P-wave technique. The fault plane solution indicates strike-slip faulting with a normal fault component. The fault plane strikes 355° and dips 57° was taken in consideration because it is nearly parallel to Gebel el-Barqa fault and the spatial distribution of earthquakes in the area.

Finally we can conclude that the seismic activity in the west Kom Ombo area is related to the Gebel el-Barka fault that is one of the Western Desert fault system. The Western Desert fault system is related to the active plate margin to the east as a secondary fault system. Hence, it can be concluded that the seismic activity in the west Kom Ombo area may be related to the active plate margin to the east.

The results of this study may be used for seismic hazard analysis for purpose of land use planning and policy-making.

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