

Preliminary Earthquake Catalog for Egypt Without Mantle Events

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1. Introduction

Notable earthquakes that have affected Egypt include the 1992 M_w 5.8 Cairo earthquake [1], the 1995 M_w 7.2 Gulf of Aqaba earthquake [2], and the 1998 M_w 5.5 El Dabaa earthquake [3], with additional events in 2015 and 2016, with magnitudes M_w 5.6 and M_w 5.3, respectively [4]. These events have caused grave concern to the populace as the El Dabaa Nuclear Power Plant (NPP) is currently under construction with future nuclear and energy projects planned across the country.

To ensure NPPs are appropriately designed to withstand earthquake loads, regulatory bodies have required NPP projects to undergo advanced seismic hazard analyses (SHA). SHA estimates the potential for strong shaking at a specific site by computing the seismic hazard integral. Estimating the resultant seismic hazard from the seismic hazard integral typically involves utilizing a set of varying methods and models. These models incorporate seismicity and ground motion prediction equations (GMPEs). Both models, in some form, require or build upon an earthquake catalog relative to the site and region of interest. Due to the form of the seismic hazard integral and the models used, the earthquake catalog should be composed of crustal events.

This study offers a preliminary insight into the influence of mantle earthquakes on an earthquake catalog's composition. By filtering out mantle, or deeper, earthquakes from an earthquake catalog, a user can confidently use it for their earthquake risk and hazard studies, as well as assure the Egyptian populace that their SHA have been appropriately conducted.

2. Methods and Results

2.1 Catalog Compilation

Since this study is only interested in the country of Egypt, a geographical limitation is needed on what or which earthquake sources would affect Egypt. GMPEs developed by the Earthquake Engineering Research Center Next Generation Attenuation West 2 program suggest a site-to-source distance of approximately 400 km is when ground accelerations become minute [5,6]. Therefore earthquakes that occurred within 400 km of the Egyptian border and coast are considered in the compilation of an earthquake catalog. This corresponds to a zone approximated by 21° E to 41° E and 18° N to 36° N.

There are several sources that make earthquake event data available to the public. One of them is Global Centroid Moment Tensor (GCMT) project [7,8]. The earthquake records from GCMT are considered one of the more reliable and will take precedent over duplicate records, however due to computational issues, their records typically only include events with $M_w > 4$. Fig. 1 shows the events compiled for this study. Other sources used in this study include the International Seismological Centre (ISC). Their preliminary catalog compiles events listed in the Unreviewed Bulletin. ISC also offers a Reviewed Bulletin which has undergone staff review to ensure it is a valid record [9,10]. ISC also posts results into an ISC-EHB catalog which is a refined version of the ISC Reviewed Bulletin, while an even further refined version of the ISC Reviewed Bulletin which includes some macroseismic events is termed the ISC-GEM catalog [11]. Moreover, additional macroseismic events from Egypt are also sourced from other publications [12,13,14].

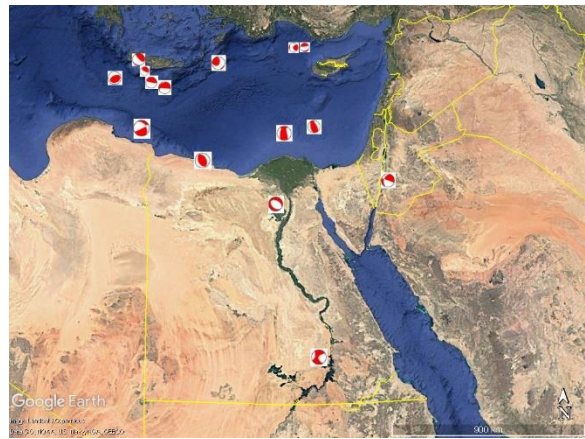


Fig. 1. Earthquake epicenters from the GCMT earthquake catalog.

The preliminary compiled catalog has a total of 43,266 events, including duplicates. Guidance by others suggest how to handle duplicate events [15]. For this preliminary catalog, duplicate events are events whose recorded times were within 60 seconds of each other and estimated epicentral distances were within 110 km of each other. This resulted in 1,997 duplicate events.

Fig. 2 shows the distribution of hypocentral depths listed in the resultant preliminary earthquake catalog. The figure shows most earthquakes occurred at hypocentral depths of about 9 to 12 km. This is quite

shallow. The inset of the figure also reveals several deep earthquakes in the study region with about 99 events occurring 100 to 250 km deep. There were not recorded earthquakes deeper than 250 km in the data sources considered. As mantle earthquakes behave differently when viewed from the surficial crust, these should be removed from the earthquake catalog.

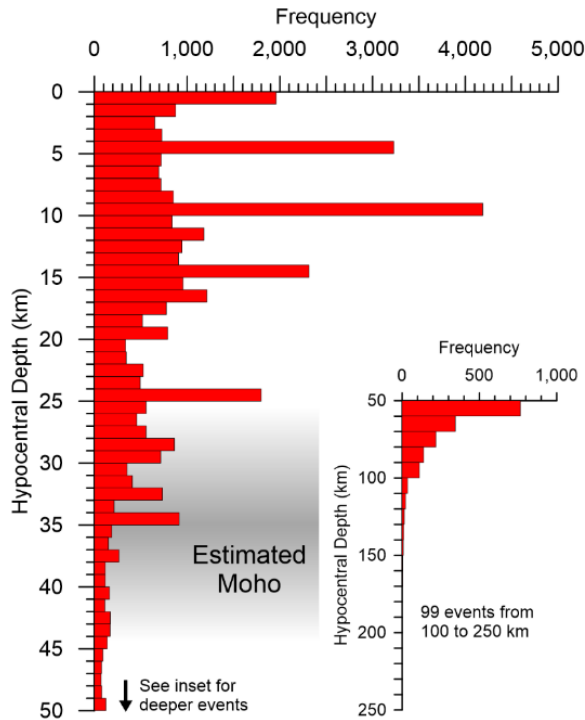


Fig. 2. Distribution of hypocentral depths listed in the preliminary earthquake catalog. Duplicate events were not removed. Deeper events are shown in the inset.

A region termed the Moho can delineate the crust from the mantle [16]. However, different parts of the world have different crustal thicknesses and thus different depths to Moho. Work by others suggest depth to Moho in Egypt varies [17, 18, 19]. Their work suggests a crustal limit anywhere from 25 to 45 km deep. Considering the geography, topology, and earthquake events, a hypocentral depth of 45 km was applied to distinguish crustal from mantle events.

As a result, the preliminary catalog contained 2,121 events. This is about 5% of the preliminary catalog. Fig. 3 shows the distribution of hypocentral depths before and after filtering. It is interesting to observe that there is no obvious discrepancy in earthquake origination location when viewing from hypocentral depths, that the assumed Moho also originated earthquake events.

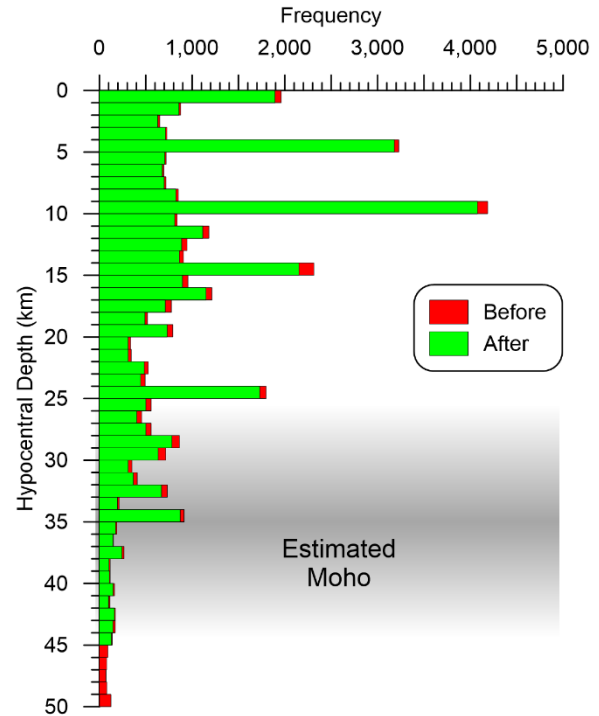


Fig. 3. Distribution of hypocentral depths before and after removal of suspected mantle events and duplicate events.

3. Conclusions

Earthquake event data from international and domestic sources were compiled to construct a preliminary earthquake catalog for Egypt. Datasets from GCMT, ISC, ISC-EHB, GEM, with historical records documenting mainland events resulted in 43,266 events spanning 2200 BC to 2024 and covering an area within 400 km of Egypt's borders.

Previous research combined with the hypocentral depths of the preliminary catalog suggested a depth to mantle of about 45 km. Considering this, a total of 2,121 events in the preliminary catalog originated in the mantle and thus were removed from the preliminary catalog. This process of identifying and removing mantle earthquakes will help future studies on earthquake risk and hazards necessary to ensure the safety of Egyptian NPPs.

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