

Seismic Monitoring Evolution and Extensive Seismicity of Egypt

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Introduction

The occurrence of El Alamein earthquake, 03 September 2015, in uncommon seismic area of north Egypt was the motivation to judge the widespread of present-day seismicity in view of seismic monitoring evolution and tectonic setting along the historical and instrumental seismicity.

Egypt is one of the few countries that have a long historical documented earthquakes since 2200 BC and known as a moderate seismicity region. Instrumental seismicity has started since 1899 with one seismic stations installed south Cairo and increased gradually with time until installing and operating the Egyptian National Seismic Network (ENSN) during 1997-2010 configured through the whole country.

Seismicity of Egypt was studied by many authors, (Papaiouannou and Papazachos, 2000; Badawy, 2005; Abou Elenean, 2010; Deif et al., 2011), to understand the seismotectonic mechanisms, and delineate the seismic source zones map as step to assess earthquake hazards. The seismic source models differed from author to author along the evolution monitoring stages.

The present-day seismicity of Egypt has been changed significantly and widespread to include uncommon seismic zones after operating the ENSN. One of these changes is the widespread of seismic activity to include uncommon seismic sites such as El Alamein earthquake 2015 (figure 1).

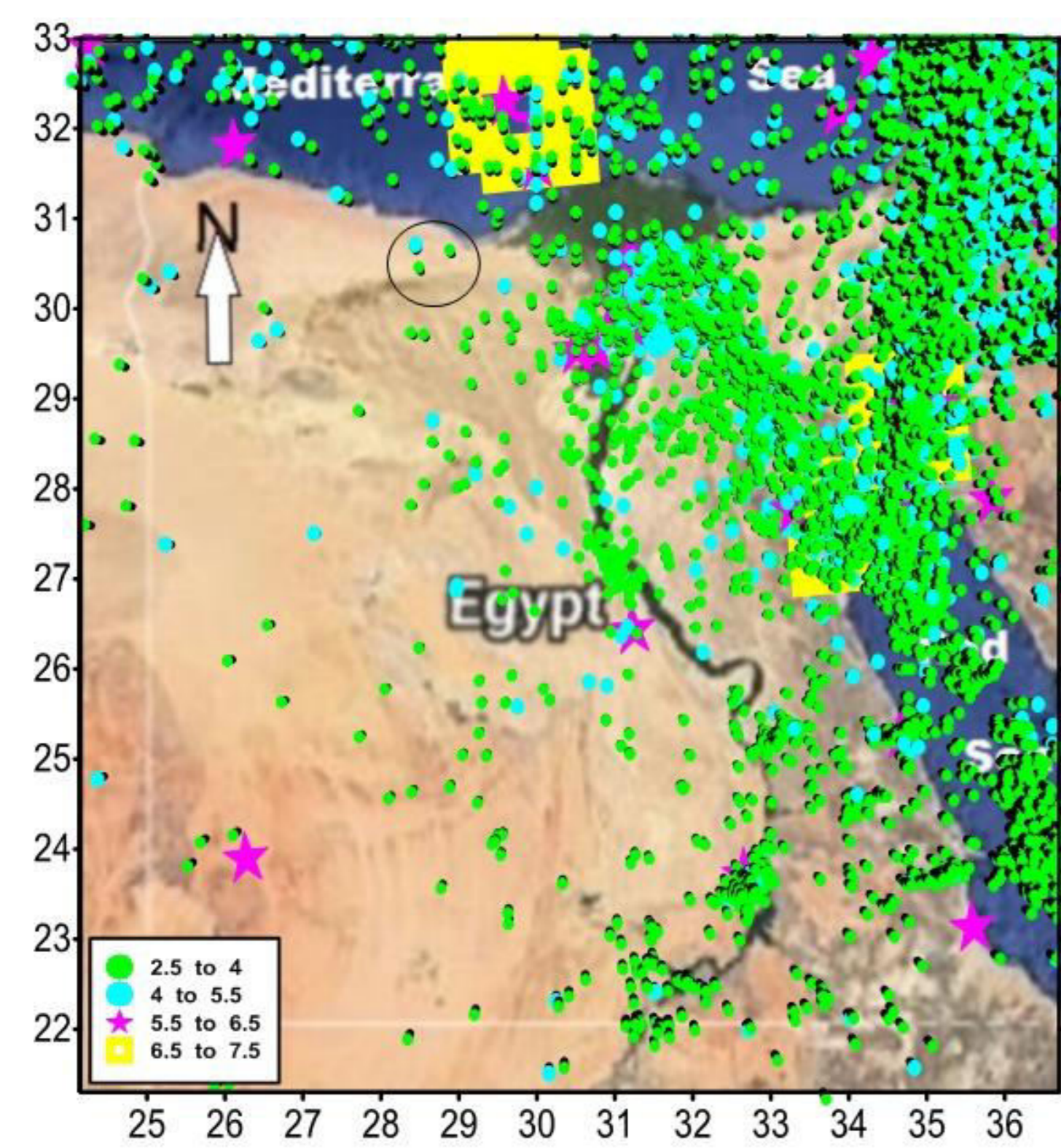


Figure 1. Seismicity map of Egypt through 2200 BC to 2015 period. Black ellipse indicates to the El Alamein earthquake site.

Aim

- Judge the widespread of seismic activity in uncommon seismic areas of Egypt in view of the significant invention stages of the monitoring system.
- Delineate the active seismic source zones of Egypt using the present-day seismicity and the structure elements maps of Egypt.

Seismicity & Monitoring Stages

Historical Seismicity

Egypt is one of the few countries that have a long history documented earthquakes. The historical earthquakes in Egypt cover a long period extended from a very old civilization of 2200 BC to 1899. Most the documented historical were located in north Egypt close to Cairo and some of them located in the Mediterranean Sea (figure 2).

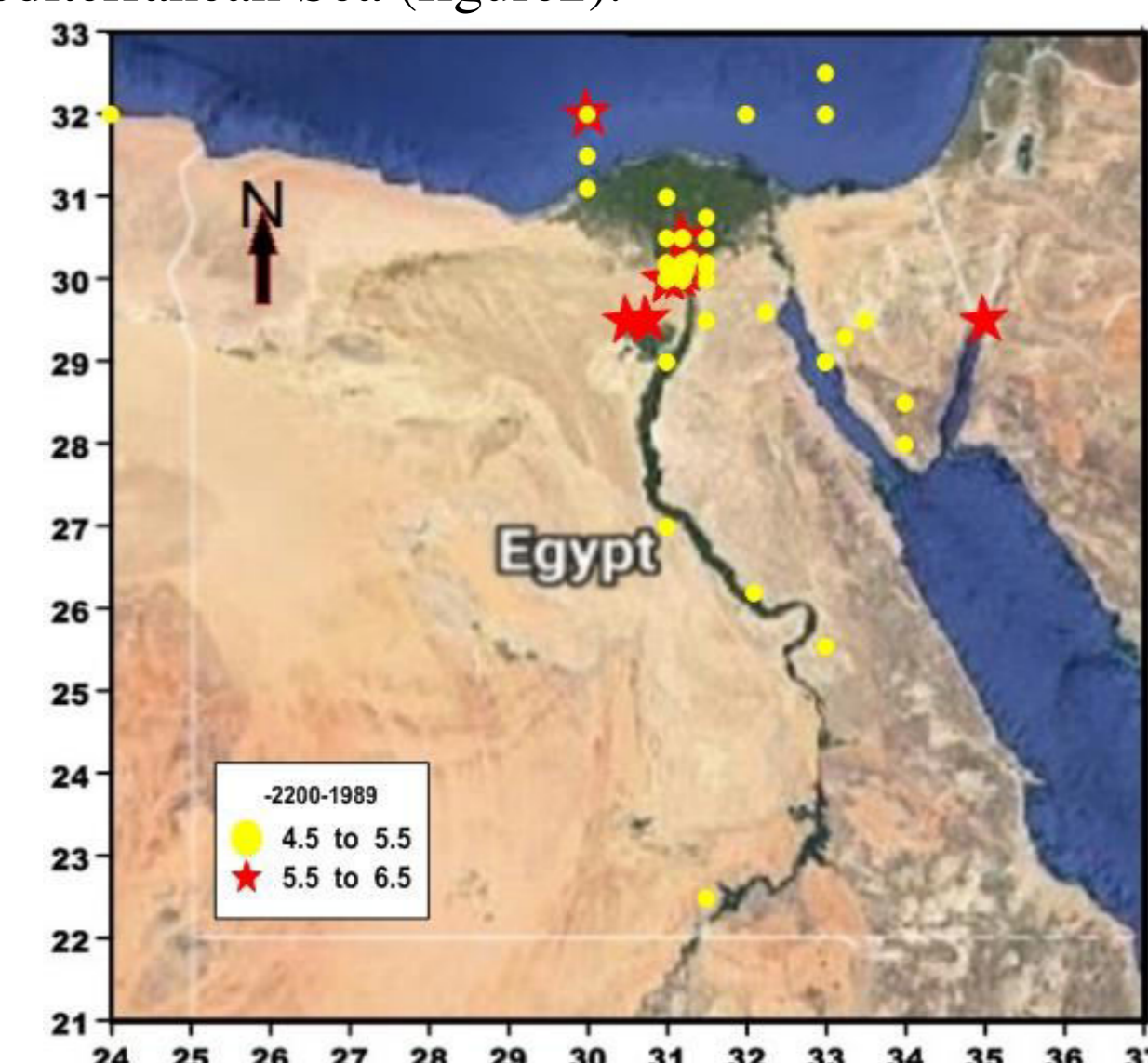


Figure 2. Lateral distribution map of the historical earthquakes.

Instrumental Seismicity

The instrumental seismic observation in Egypt has been started since 1899 with a single component station located in south Cairo at Helwan, the place of NRIAG now. The evolution in the seismic monitoring was developed gradually from single station in 1899 to more than 100 seismic stations in 2010. The real changes in the instrumental seismic observation period can be divided into four main stages based on the number and distribution of seismic stations over the country.

First Instrumental Stage 1900-1974

The Instrumental monitoring system started in 1899 with a single seismic station east-component, located in Helwan, south Cairo, where NRIAG was built. It was upgraded later to three Components and named as HLW (Fig. 3).

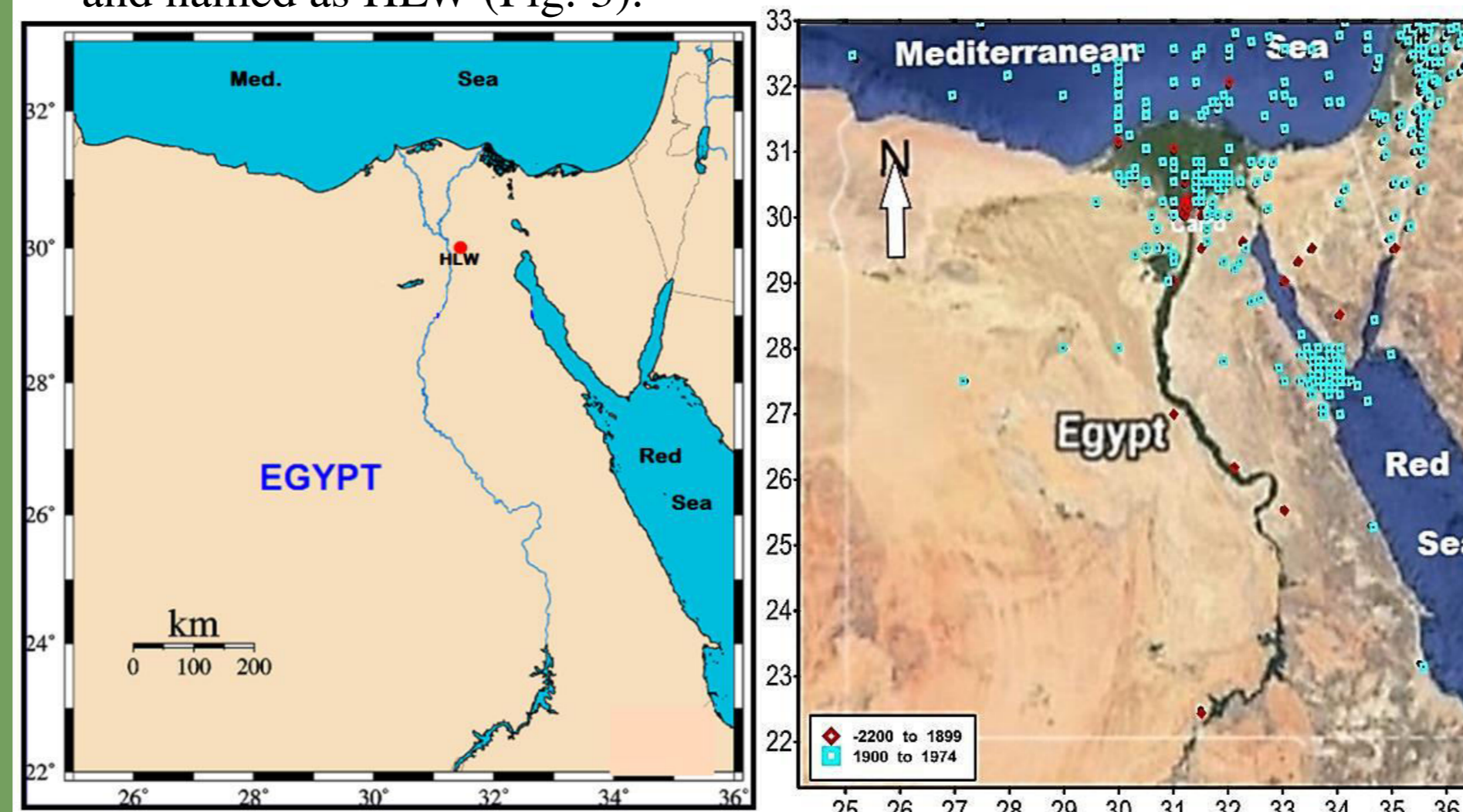


Figure 3. Instrumental & seismicity map up to period < 1975.

Second Instrumental seismicity Stage 1975-1996

In 1975 three seismic stations, were installed in Aswan, Abu Simple and Marsa Matrouh, named ASW, ABS and MAT respectively (Fig. 4). In 1982, after occurrence of Aswan 1981 earthquake, 13 seismic stations were installed and deployed in Aswan as a local seismic network. Few weeks before occurrence of Cairo 1992 earthquake the first broadband station named KEG was installed east of Cairo.

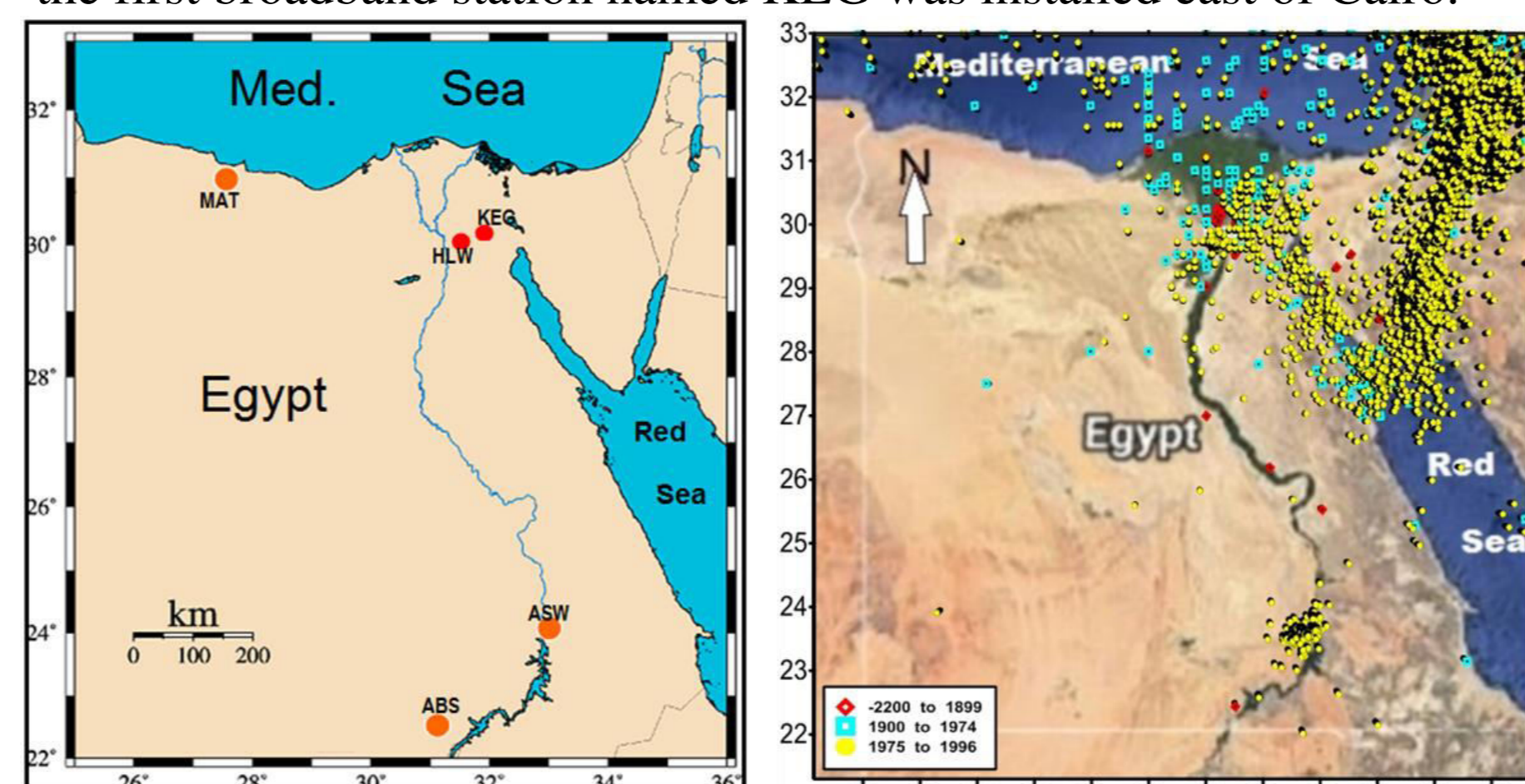


Figure 4. Instrumental & Seismicity map of Egypt up to period < 1997.

Third Instrumental Seismicity Stage 1997-2002

This stage represents the first real changes in the quantity and quality of the monitoring system in Egypt. The first stage of installing and deploying the ENSN to cover the active seismic regions around Cairo, Gulf of Suez, north Red Sea and Gulf of Aqaba (Fig. 5).

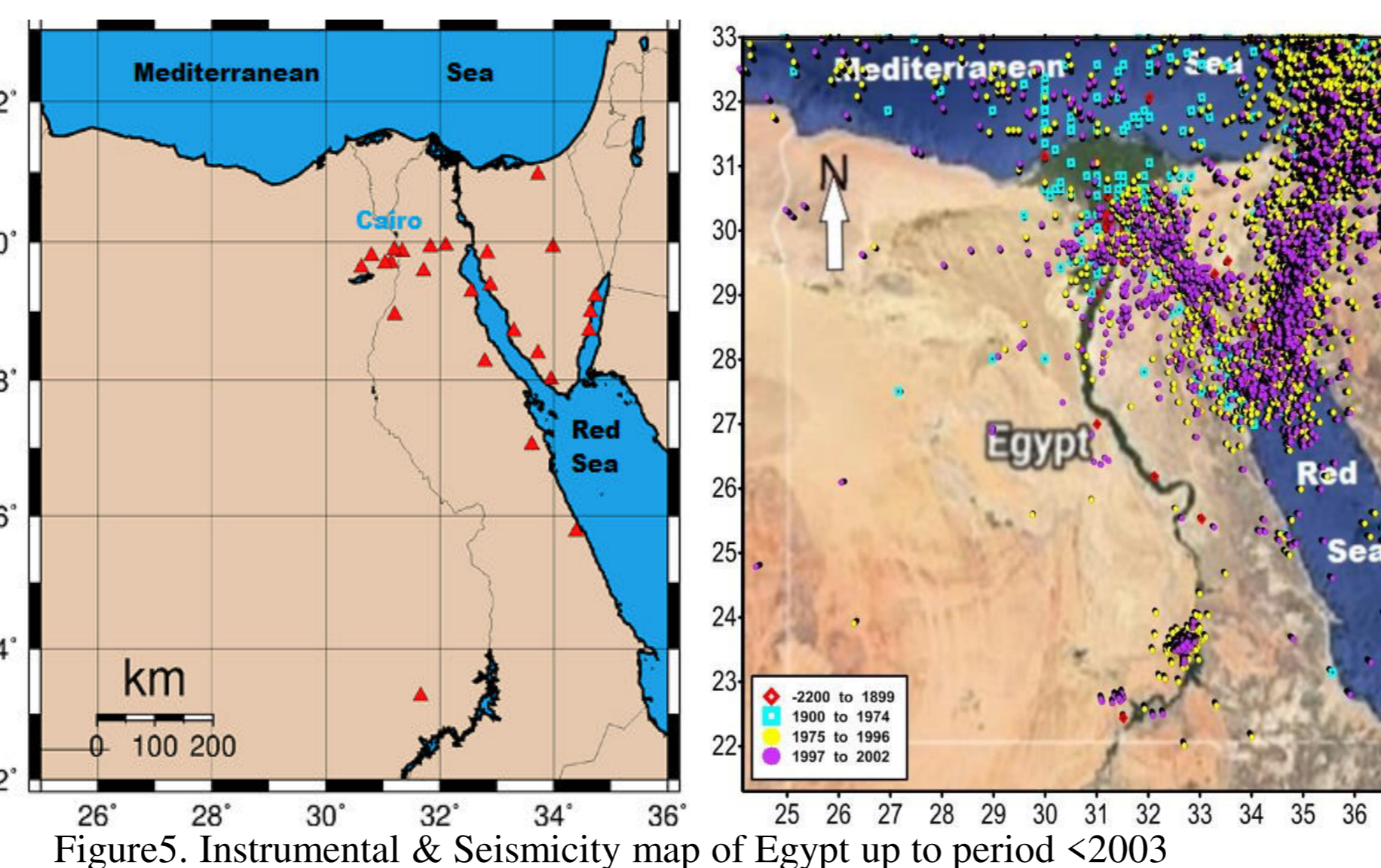


Figure 5. Instrumental & Seismicity map of Egypt up to period < 2003

Final Instrumental seismicity Stage 2003-2015

This is the comprehensive and advanced seismic monitoring period in Egypt. During this period, ENSN is completely achieved to include more than 100 of different types of short, broadband, very-broadband and accelerogram stations covering all the Egypt country from south to north and from west to east (Fig. 6).

Low scattering and a widespread seismicity are noted with the well configured advanced seismic monitoring system over Egypt, where the quality of event detection and location accuracy is high.

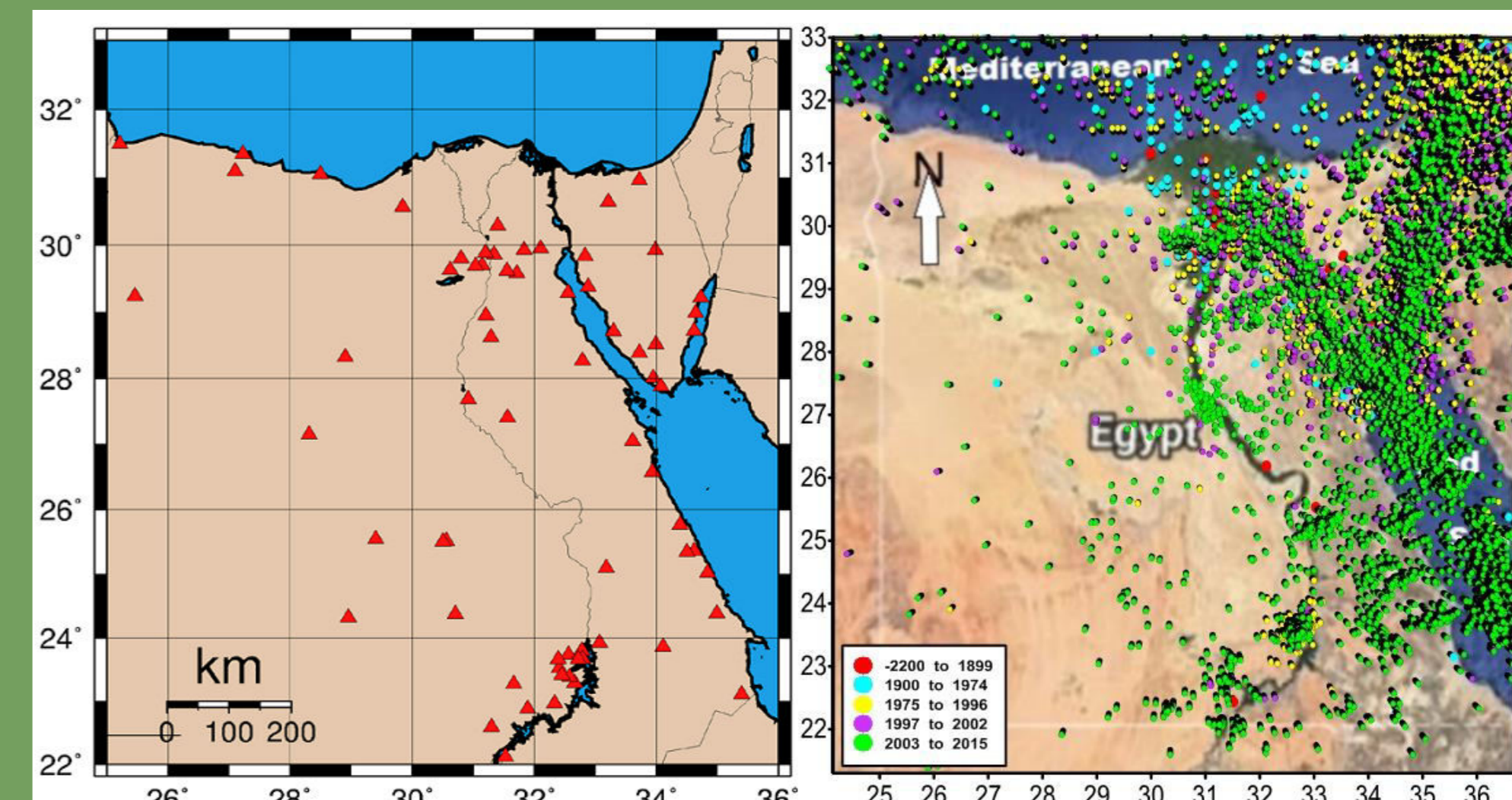


Figure 6. Periodic seismicity along 2200 BC to 2015 through evolution monitoring system.

Active Seismic Source Zones

In this study a new idea was applied to delineate the active seismic source zones using the high quality background seismicity period and 1 earthquake size. The idea is based on eliminating effects of scattering, dislocation, discrimination and misdetection seismic events using the high quality observation period, 2003-2015 $M_w > 2$, as a tracer integrated with the instrumental catalogue 1900-2015 with magnitude $M_w \geq 4.5$ to outline the active seismic sources map (figure 7). Finally, this seismic source zones model was validated in comparing with the structure elements and given a reasonable delineation.

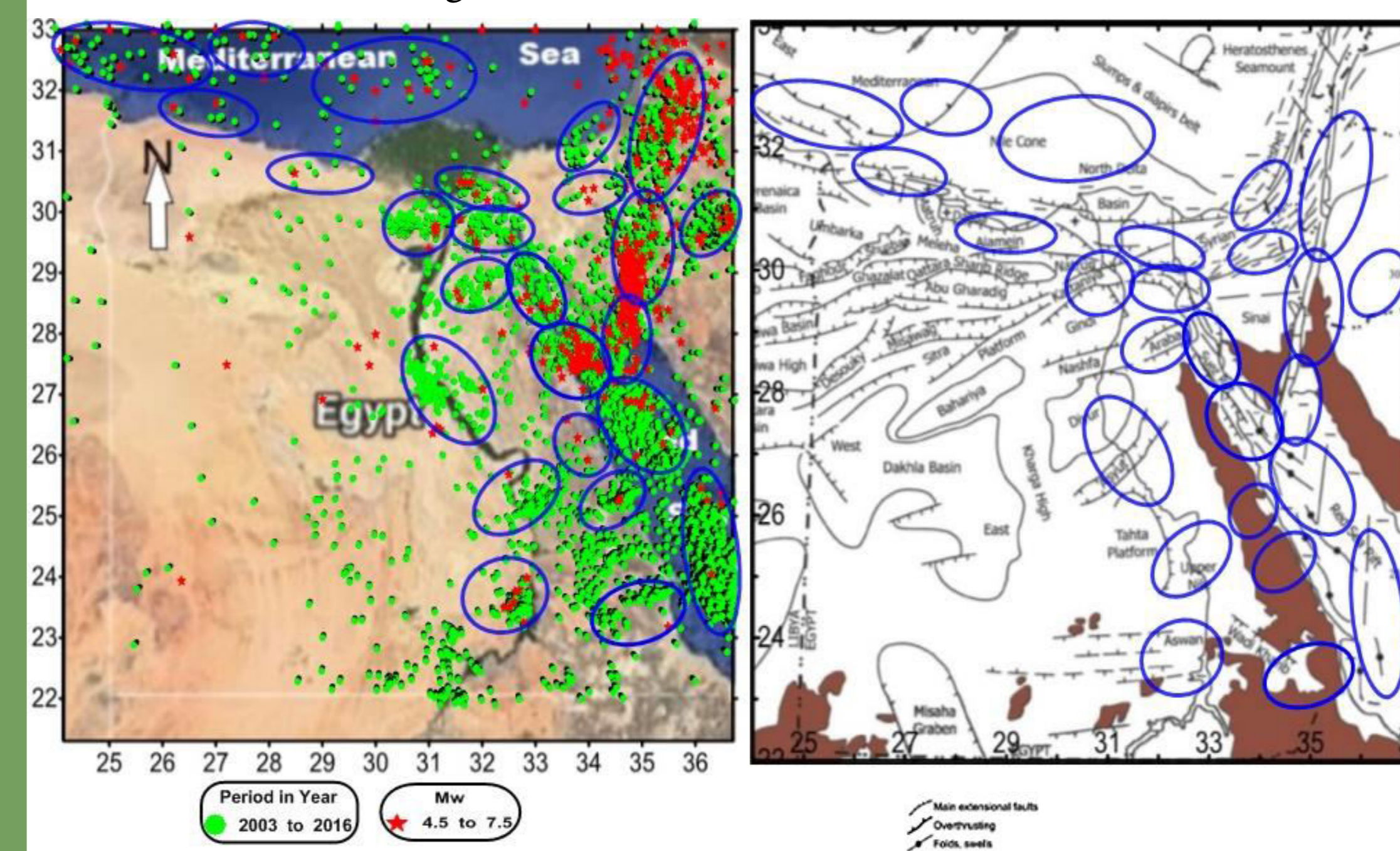


Figure 7. Active seismic source zones map, delineated in blue ellipses.

Discussion & Conclusion

The present-day seismicity map of Egypt was changed significantly after accomplishing the ENSN in 1997-2010. It is widespread to include uncommon seismic sites of western and eastern desert. This change in the seismicity could be due to the invention in the monitoring system and/or to the changes in the regional/local stress regime of the tectonic movements. Because the changes in the tectonic stress regime takes very long time in compared to the very short period of seismicity changes, this study concerned with the of the invention monitoring system at lateral distribution of the seismicity.

Seismicity was outlined through the evolution in the monitoring system along five effective stages, one historical and four instrumental. A strong relation can be appreciated between the seismicity lateral distribution and the invention stages in the monitoring system (Figs. 2-6). The dependence of seismicity map configuration on the upgrading and invention of the monitoring system can interpret the significant changes and widespread of the present-day seismicity. Qualified monitoring system entire Egypt leads to high sensitive detection of micro and small events, good discrimination and high accuracy location. Although the latest monitoring period is almost twelve years only, it can be characterized as the highest accuracy monitoring period and recorded more events comparing to the previous monitoring periods.

Delineation of the active seismic source zones was done using the advanced monitoring period, as a tracer, and the moment magnitude ≥ 4.5 instrumental catalog from 1900 to 2015. The delineated active seismic source zones were compared with the structure elements map and given a good agreement with dominant faults.

This study concluded that the widespread seismicity of Egypt is mainly due to the advanced monitoring system during the last few years after accomplished the ENSN. The assessment hazard studies of Egypt are encouraged to use the present-day seismicity and the active seismic zones maps. El Alamein source zone should be taken in consideration in the assessment hazard studies of the proposed nuclear plant in El Dabaa site.

Acknowledgements

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