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(ENSN)

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Preface

Since 1899, earthquakes have been recorded using instruments in Egypt. The Milnshaw, Galitzen, and Sprengnether seismographs were later replaced with digital technology. Helwan received a seismic station as part of the WorldWide Standardized Seismograph Network (WWSSN) in 1962. This station is still operational to this day. Four analog stations were installed at Helwan, Aswan, Abu Simbel, and Matrouh by the beginning of 1972, one of which is a Japanese short period station, while the others are intermediate Russian Seismographs. The Egyptian Government supported the National Research Institute of Astronomy and Geophysics (NRIAG) to create and deploy the Egyptian National Seismic Network (ENSN) after the October 12, 1992 earthquake in the Dahshour area, 35 kilometers southwest of Cairo. To improve the ENSN's efficiency, NRIAG updated the data communication technology from telephone lines to satellite and Global System for Mobile (GSM) Communication. The seismic field stations had been installed throughout Egypt by mid-2003, and five sub-centers had been built and equipped. Furthermore, an earthquake Disaster Reduction Datacenter (EDRDC) was built, with GIS technology supporting it. During last year, ENSN had recorded some seismic activities at the Mediterranean Sea and the Red Sea. Accordingly, some stations have been re-allocated and others have been proposed for new installation. The Egyptian earthquake bulletin, which includes the recorded earthquakes in Egypt and the surrounding area in 2021, is one of the most important items of the ENSN reports.

PROF. DR. GAD M. EL-QADY

2022

PRESIDENT OF NRIAG

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The Egyptian National Seismic Network Bulletin (ENSNB), is an annual publication of the earthquake parametric data, occurring in the Egyptian territory and surrounding. The Monitoring Specialists (Analysts), and seismologist on duty are the responsible staff to compile the ENSNB. It is published under the Department of Seismology of the National Research Institute of Astronomy and Geophysics (NRIAG).

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Foreword

The Egyptian National Seismic Network (ENSN) is part of the Seismology Department at the National Research Institute of Astronomy and Geophysics (NRIAG). The mission of the ENSN, among other assignments, is the monitoring of seismic activity within the national territory. Within this framework, the ENSN routinely contributes to the databases set up for this purpose and maintained by the Euro-Mediterranean Seismological Centre (EMSC) and the International Seismological Center (ISC).

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Technical details, reported parameter's description, seismic station's information and references are described in the current report.

Chapter

1 Earthquakes Observations

An earthquake is a geodynamic phenomenon. The present seismic activity and the other geodynamic phenomena related to it (e.g. deformation and ruptures of the crust, volcanoes, geothermal manifestation, topographic features, etc.) are results of a relatively recent geologic process, which is usually, called active tectonics.

The general tectonic framework of Egypt can be described in simple terms as comprising three units that have controlled the sedimentological history and the structural make-up of the country; these are the Arabian-Nubian massif, the stable shelf and the unstable shelf. The stable shelf covers a large part of Egypt surrounding the Arabo-Nubian massif. It reflects relative tectonic stability towards the south. Much of northern Egypt belongs to the unstable shelf that suffered intense rock deformations. Egypt is located close to one of the continental fracture system (Hellenic arc) at the convergence boundary of two big lithospheric plates (Eurasia and Africa).

1.1. *Evolution of the Egyptian National Seismic Networks*

On 12th October, 1992, an earthquake with a magnitude (5.9 M_b) occurred in Egypt. This earthquake caused 561 deaths, 9832 injuries and left damage of more than 35 million USD. As a result of this damage, the Egyptian Government supports the National Research Institute of Astronomy and Geophysics ($NRIAG$) to install the Egyptian National Seismic Network ($ENSN$) comprising from both velocity meters and accelerometer instruments (strong-motion).

The Egyptian National Seismic Network ($ENSN$) consists of the weak motion network and the strong motion network, the main center at Helwan and five sub-centers at Hurghada, Burg El-Arab, Mersa Alam, Aswan, and Kharga. The main center receives the seismic data from the near distance stations through telemetry communication and from the remote stations and the sub-centers via satellite and GSM communications. The received data are analyzed for determining the earthquake parameters.

The Egyptian National Seismic Network ($ENSN$) operates a network throughout Egypt in order to acquire seismic data on a long-term basis. The aims of the seismic monitoring are to develop and maintain a national database of seismic activity in Egypt for use in seismic hazard assessment, and to provide a near-immediate response to the occurrence, or reported occurrence, of significant events. An electronic version of these data have been placed as a searchable and updateable database on the NRIAG web page at https://www.nriag.sci.eg/earthquakes-annual-bulletins/. Periodic updates are be made to this digital files to take account of continuing acquisitions and further cataloging. All significant events are published on the Internet (http://ensn.nriag.sci.eg/). This website aims to provide accurate and timely information on significant earthquakes events that may significantly impact the country; and to ensure the accessibility and integrity of earthquake data.

1.2. *ENSN Weak-Motion Monitoring Network*

Recording, monitoring, and analyzing the natural and artificial seismic events are the main objectives of the Egyptian National Seismic Network (ENSN). The main center of the ENSN is located at Helwan, Cairo, besides a group of regional seismic centers covering all parts of the Arab Republic of Egypt. These sub-centers provide expertise and advice to decision-makers in surrounding governorates and regions on the most appropriate sites for development projects and architectural designs in order to achieve comprehensive, integrated and sustainable development.

The distribution of the seismic stations shown in 1.1 are chosen to cover the known seismic sources of Egypt. Also, this distribution covers some regions with known historical earthquakes without any evidence of instrumental activity (e.g. Siwa seismic station). Table 1.1 contains the station's code together with the geographic locations.

Station full name	Code	Lat. N	Long. E	Sensor type
Adendan	AND	22.1224	31.5307	SS1
Abu Ghasoun	AGS	24.3794	34.9866	Trillium 120

East Aweinat	AWT	22.0808	29.7330	Trillium 240
Badr	BDR	29.8610	27.9320	Trillium 120Q
Burg El-Arab	BRG	30.5743	29.8393	Trillium 120
Barnees	BRNS	23.8559	34.1143	Trillium 240
Basata	BST	29.2166	34.7327	SS1
Dahab	DHB	28.7221	34.6188	L4C
Dakhla1	DK1	25.5432	29.4028	SS1
Frafra	FRF	27.1484	28.3105	Trillium 240
Gareib	GRB	28.2705	32.7859	SS1
Gabel Elteer	GTR	25.5096	30.5595	SS1
Wadi Hafia	HAF	25.0889	34.2544	Trillium 40
Hagoul	HAG	29.9530	32.0990	SS1
Helwan	HLW	29.8585	31.3432	SS1
Hurghada	HRG	27.0517	33.6081	Trillium 120Q
Katren	KAT	28.5229	33.9928	Trillium 40
Khafra	KFR	22.5891	31.3047	SS1
Kottamia	KOT	29.9276	31.8292	STS2
Kharga	KRG	25.5032	30.4985	SS1
Kasr	KSR	23.6105	33.0872	Trillium 40
Matrouh Center	MATC	31.3457	27.2305	Trillium 120Q
Mersa Alam	NMRS	25.0630	34.8680	Trillium 40
Masmus	MSM	22.8814	31.8890	SS1
Mayadein	MYD	29.7958	30.8009	L4C

New Abu Dabbab	NADB	25.3405	34.5021	Trillium 240
New Abu Hadid	NAHD	23.8022	32.7780	Trillium 40
Natroun	NAT	29.6329	30.6172	Trillium 120
New Bani Suef	NBNS	28.6226	31.2945	Trillium 40
El Dabaa	NDB3	31.0378	28.5482	Trillium 240
New Edfo	NEDF	24.8903	32.9564	Trillium 120Q
Gabel Marawa	NGMR	23.5217	32.4076	Trillium 40
New Kurkur	NKUR	24.0042	32.6514	Trillium 40
New Manam	NMAN	23.9169	33.0749	Trillium 40
New Aliza	NNAL	23.2931	32.6647	Trillium 40
North Marwa	NNMR	23.7379	32.5621	Trillium 40
New Qena	NQEN	26.1853	32.7384	Trillium 120Q
New Quseer	NQSR	26.1100	34.2640	Trillium 120Q
New Safaga	NSFG	26.7630	33.9380	Trillium 120Q
New Sen El Kddab	NSKD	23.6610	32.3860	Trillium 40
New Sqara	NSQR	29.8832	31.2015	Trillium 120
Nueiba	NUB	28.9893	34.6396	SS1
Paris	PRS	24.3718	30.7126	T120C
10th of Ramadan	RAM	30.2172	31.8705	Trillium 120Q
Ras Mohammad	RASM	27.8378	34.2379	Trillium 240
Abu Ramad	RMAD	29.2982	36.2706	Trillium 120Q
Roudaes	RDS	28.7120	33.2975	SS1
Rayyan	RYAN	29.0825	30.2775	Trillium 120

Shagher	SHG	23.2655	31.6576	SS1
San El Hagar	SHGR	30.9700	31.8800	Posthole
Salloum	SLM	31.4916	25.2123	Trillium 240
Hafiat Salma	SLMA	24.7066	34.3489	Trillium 40
Sohag	SOHG	26.1070	31.7260	Trillium 40
New Qusir	SRM	25.8793	34.3693	Trillium 120Q
Assuit	SUT	27.3967	31.5626	T120C
Suez	SUZ	29.8406	32.8322	SS1
Siwa	SWA	29.2432	25.4556	Trillium 240
Tal El Amarna	TAMR	27.6821	30.9175	Trillium 240
Tour1	TR1	28.0068	33.9521	Trillium 40
Tour2	TR2	28.3853	33.7227	L4C
Zaafarana	ZAF	29.2819	32.5487	Trillium 120
Zeneima	ZNM	29.3761	32.8752	SS1

Table 1.1. *Stations code and location of ENSN velocity-meter weak-motion Stations*

The data presented in this seismological bulletin was recorded during 2021 and was obtained from seismological stations comprising the Egyptian National Seismograph Network (ENSN). Additionally, waveform data recorded by several regional and global seismic networks around Egypt were also considered during analysis. Detail of the equipment comprising the ENSN is provided in Table 1.1 while the geographic distribution of the local ENSN seismic stations is shown in Figure 1.1. Furthermore, Figure 1.2 depicts the geographic distribution of the regional and global seismic networks stations.

During location analysis, online available waveforms of some international stations Figure 1.2 were used to extract any available phases for the earthquake of interest for enhancing our detectability and earthquake location accuracy.

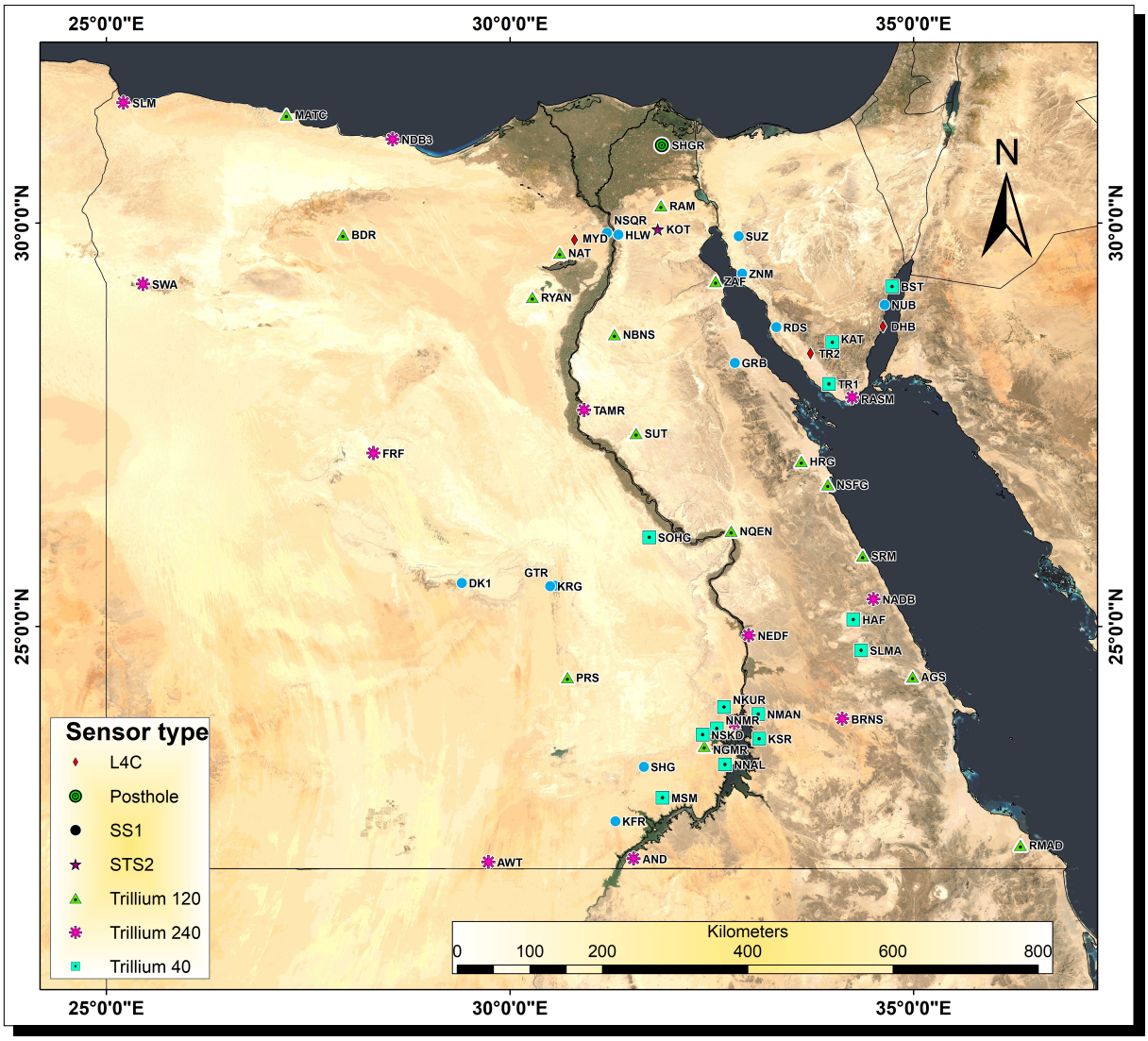

Figure 1.1. *Distribution of weak motion stations of the Egyptian National Seismological Network (ENSN) according to the installed velocity meter sensor type. .*

1.3. *Strong-Motion Monitoring Network*

A strong-motion network has started working since 2008 compressing 5 stations only that cover the Nile Delta region. From 2008 until now, the total number of accelerographs was increased to 17 stations distributed in and around Nile Delta. The main goal is to monitor and record the acceleration produced from the active surrounding seismic zones, especially the Mediterranean Sea, as the Nile Delta is characterized by the thick sedimentary cover which has a bad impact in installing seismographs. Detail of the equipment comprising the ENSM is provided in Table 1.2 while the geographic distribution of the local ENSM seismic stations is shown in Figure 1.3.

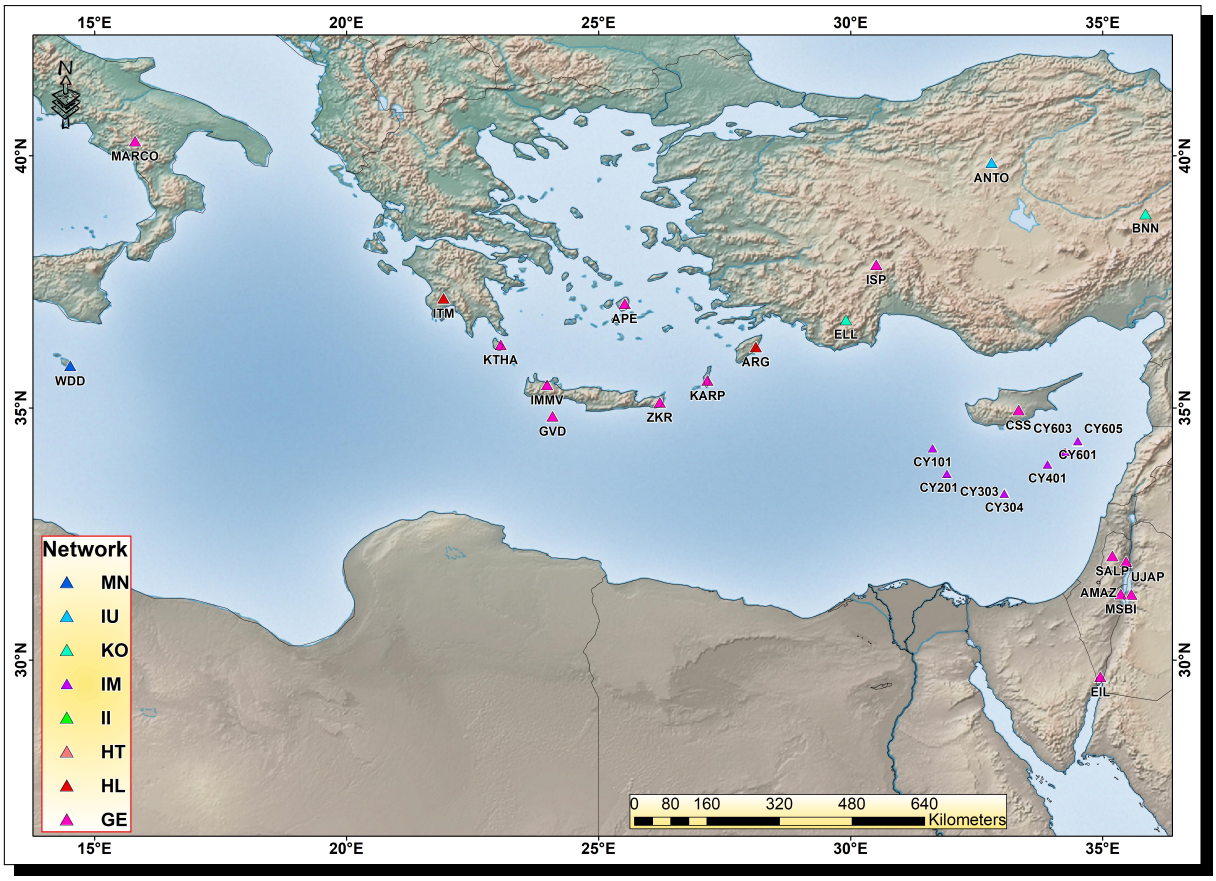

Figure 1.2. *Location of Seismic stations that have been used when it is available for the Mediterranean Sea earthquakes.*

1.4. *Community Service Projects*

Earthquakes are the official language of the earth planet talking about itself to tell us about its internal structure and its contents of natural resources. Seismology Department contributes to achieving the Egyptian 2030 vision for sustainable development through recording and monitoring natural and artificial seismic events with the latest modern Egyptian National Seismic Networks.

1.4.1 Quarry Blast Monitoring project

Applied scientific research that participates in solving the problems encountered by institutions and industry has become a pillar and starting point for every industrial development and economic progress in all countries. Instead, it has become an economic activity, and it plays a significant and vital role in the advancement and growth of industry and the economy. And suppose scientific research and cooperation with various industries is important for developed

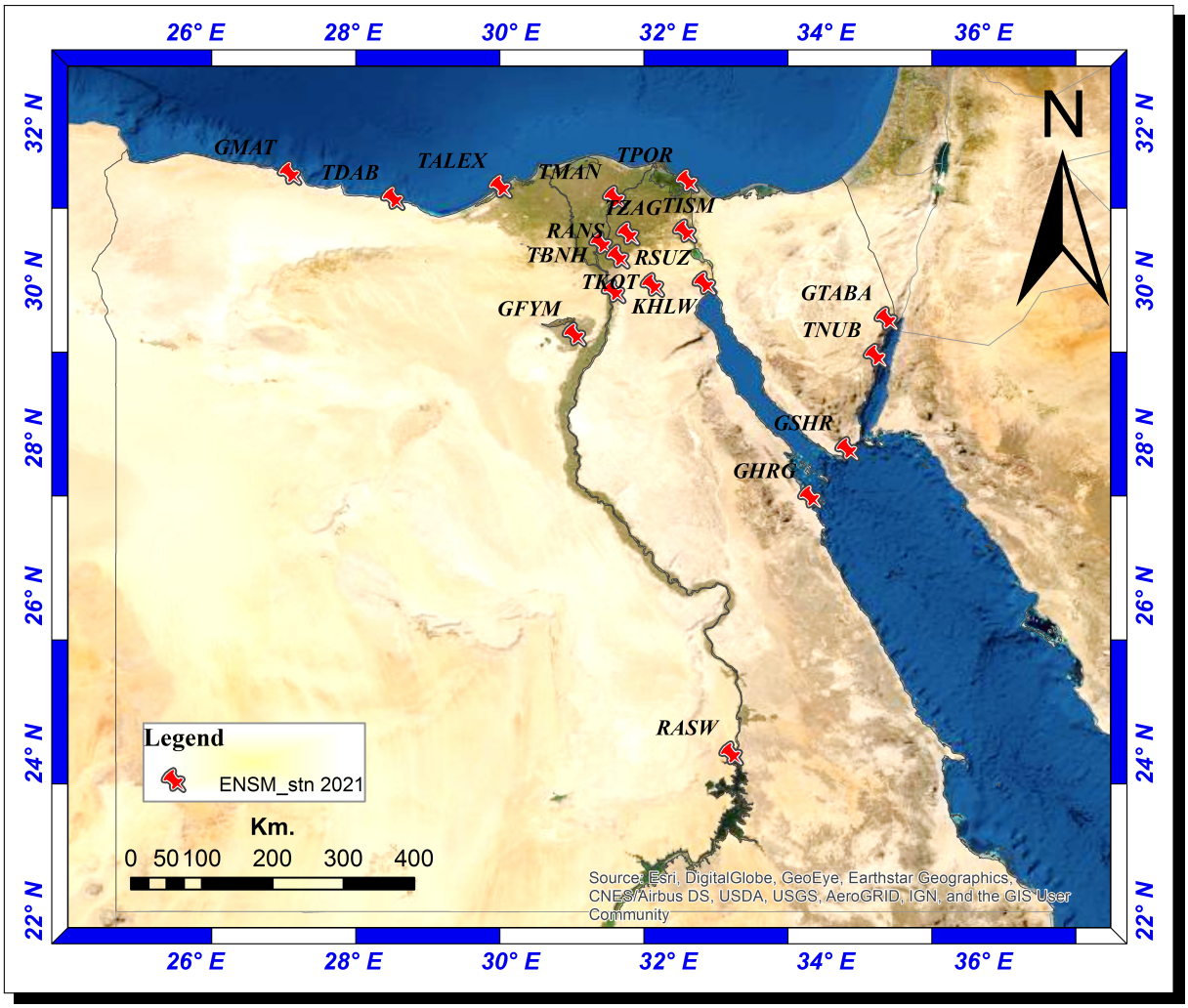

Figure 1.3. *Distribution of strong motion instruments in Egypt.*

countries. In that case, it is for developing countries and institutions more essential and urgent, as employing which plans are set on sound and solid foundations, Mistakes are avoided, losses are paid, performance is improved, and returns are increased. From this standpoint, and in terms of proper planning for the different industry which use the blast to get quarry ores (Cement, Gold, basalt, Dolomite), in terms of selecting its sites and precise control and the inconvenience it may cause to citizens as a result of the explosions that are carried out to obtain raw materials as well as preserving the environment, it has turned to the National Institute for Astronomical and Geophysical Research to monitor the explosions that are carried out in quarries Cement. This is because the institute revives its devices and stations to monitor any (natural or artificial) vibrations within the Egyptian country.

The project had a significant development during 2021. Although we had crises of Covid 19 in the world, including Egypt, the project team made a lot of efforts to overcome the situations

Station full name	Code	Lat. N	Long. E	Sensor Type
Helwan	KHLW	29.85	31.34	Kinametrics
Kottamia	TKOT	29.93	31.83	Titan
Ismailia	TISM	30.61	32.24	Titan
Taba	GTABA	29.5	34.8	Guralp
Portsaid	TPOR	31.25	32.27	Titan
Alexandria	TALEX	31.18	29.9	Titan
Nubia	TNUB	29.03	34.66	Titan
Banha	TBNH	30.46	31.18	Titan
El Daba	TDAB	31.03	28.54	Titan
Mansoura	TMAN	31.04	31.35	Titan
Zazazig	TZAG	30.58	31.52	Titan
Sharm	GSHR	27.85	34.3	Guralp
Matrouh	GMAT	31.35	27.23	Guralp
Hurgada	GHRG	27.24	33.83	Guralp
Aswan	RASW	23.98	32.83	Reftek
Suez	RSUZ	29.95	32.49	Reftek
Anshas	RANS	30.29	31.39	Reftek
El-Fyum	GFYM	29.3	30.84	Guralp

Table 1.2. *Station code and location of ENSM Strong motion stations.*

and extend the service to other industry beside Cement like gold and dolomite quarry.

The Future Vision could be summarized in the following points:

- Arrange and held training courses in some missed Skills (HR, project management),
- To be involved in the national projects,
- To share in the cement industry by other geophysical services.

1.4.2 El-Dabaa Power-Plant Site Monitoring Project

The main aim of El-Dabaa Project is to monitor seismic activity around the campus of the future nuclear power plant site.

Earthquakes are monitored for the Dabaa site and its surrounding areas continuously by the Dabaa Local Seismic Network (DLSN) and the Egyptian National Seismic Network (ENSN).

The continuous development of monitoring stations, as well as the continuous updating of monitoring and analysis methods for the observed data, has increased the capacity of the local Egyptian network in El-Dabaa to monitor and sign small seismic tremors, whether natural or artificial, up to the magnitude of 0.5 on the seismic magnitude scale in a 50 km radius around the nuclear campus. The seismic stations operating in the Dabaa local national network were transferred via wireless communication links to the recording unit located at the Dabaa site from 2005 to 2010. Since 2013 a real-time online monitoring system has been developed for the technical condition of the stations to ensure a quick response to any system defects.

Chapter

2 Operational Procedures

For earthquake information to be usable for scientists and engineers it needs to be expressed in the form of specific physical parameters. The main parameters of earthquake source are the location of focus, origin time and magnitude of an earthquake, whose waves arrive at the times measured on each seismogram. These and other parameters of an earthquake can be determined from the wave data recorded by seismograph stations. Figure 2.1 depicts the whole data acquisition, processing and publishing system. The whole data flow diagram is given in Figure 2.2.

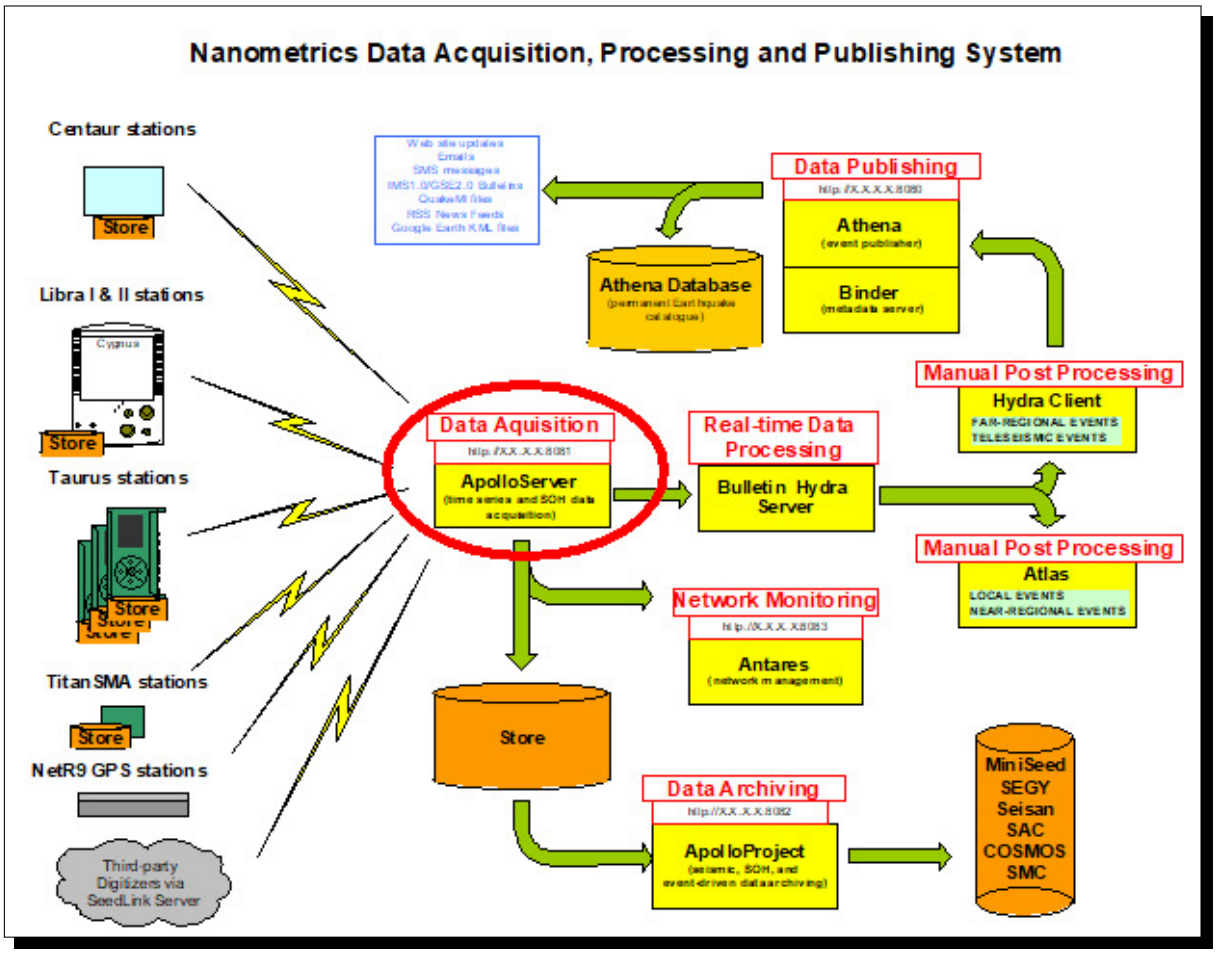

Figure 2.1. *Diagram showing the implemented data acquisition, processing and publishing system.*

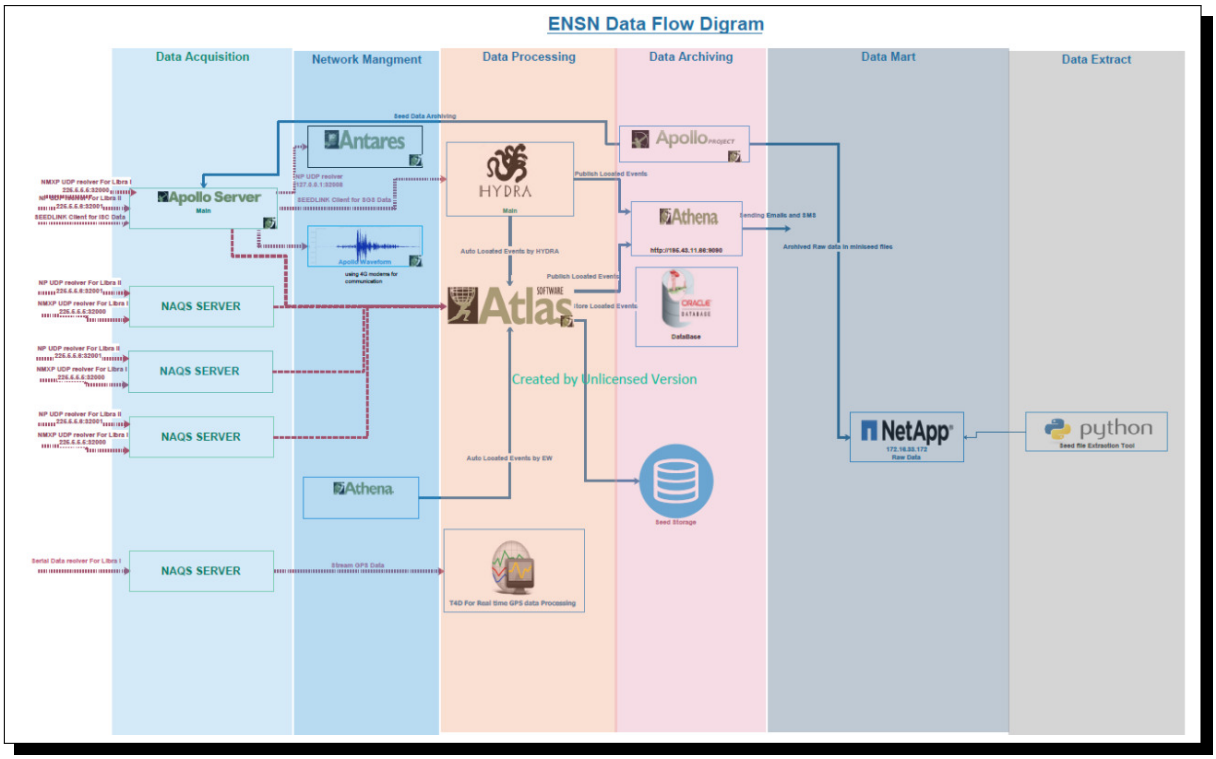

Figure 2.2. *Diagram showing the ENSN data flow.*

2.1. *Data Acquisition*

Seismic data acquisition consists of gathering and recording of continuous seismic signals from seismic stations. Process of automatic acquisition, detection, processing and dissemination of seismic data at Observatory's acquisition center is performed on APLLO server acquisition system. APLLO Server is a data acquisition software application that acquires continuous time series data, state-of-health data, triggers and alerts from a wide range of remote Nanometrics field digitizers and SeedLink data sources (see Figure 2.3).

Packets are indexed to latitude-longitude coordinates, allowing the tracking of instrument changes and notification of users when changes are detected. This index also permits data to be recorded without the need to configure the central site to receive the data. APLLO Server is scalable and well suited for use in real-time networks ranging from small regional arrays to large national networks with hundreds of stations.

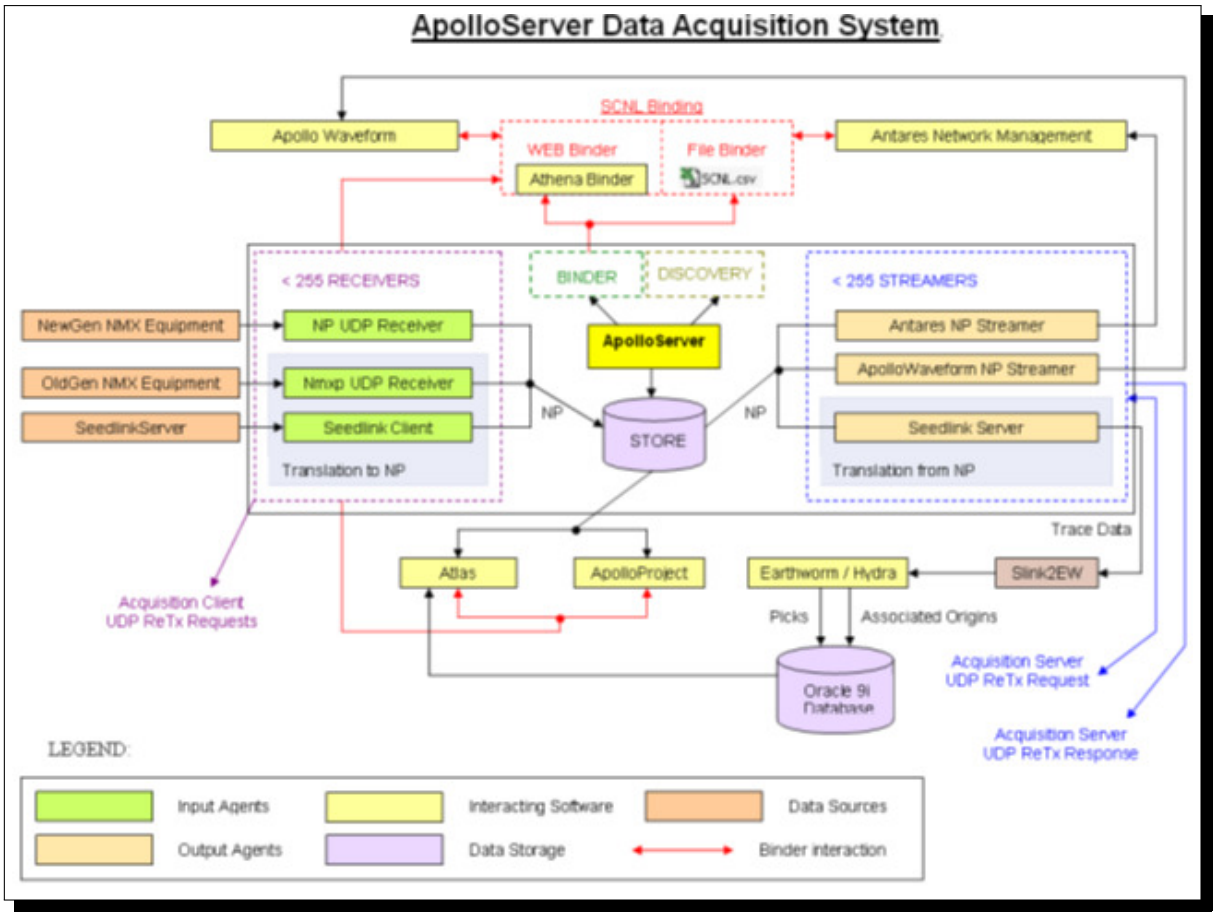

Figure 2.3. *Diagram showing the implemented data acquisition, using APLLO Server.*

2.2. *Data Processing*

A friendly user interface program with powerful tools for routine work is used to extract the digital data of remote stations online from the ring buffer. This software named $ATLAS$ can load, view, manipulate, locate, and save digital data from many sources like Earthworm databases, SEED files, and Nanometrics data servers.

With ATLAS software, we can view and pick events using the intuitive interface, sort traces by first phase time or by channel name, view multiple events simultaneously from several data sources and we can edit events and solutions. ATLAS enables editing events; create phase, duration, and amplitude picks which are important for magnitude estimations.

Moreover, we can use simple and robust methods to create digital filters and apply them individually or as a group to trace data. ATLAS works with fully interactive maps that combine a geographical display of stations and epicenters. Spectral analysis has also done using ATLAS for any trace and easily creates HTML bulletins to view and distribute summaries of events (see,

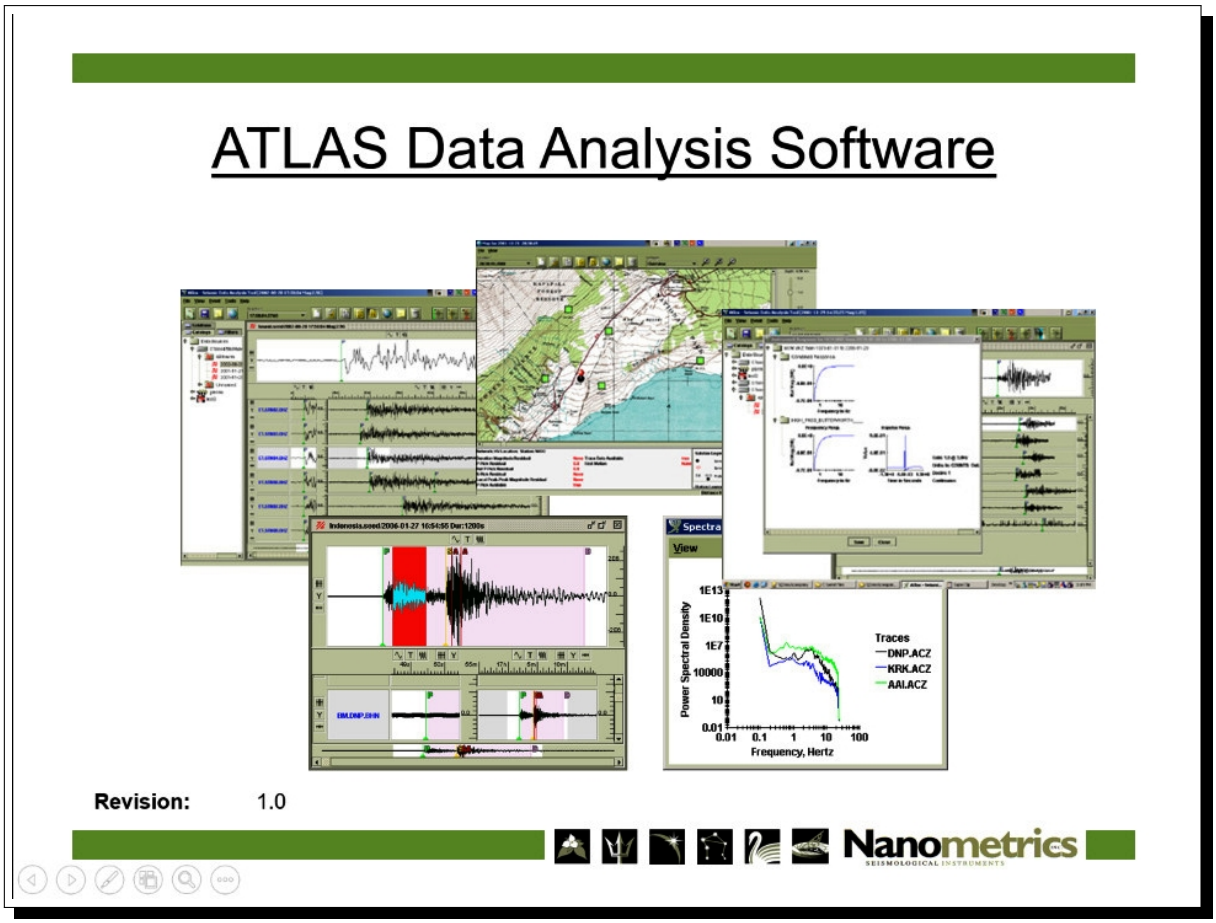

Figure 2.4. *Diagram showing the various capabilities of ATLAS data processing and analysis.*

Figure 2.4).

2.3. *Location Parameters Determination*

2.3.1 Automatic Location Using HYDRA

HYDRA is a software are now implemented as one of the analysis programs in our ENSN system. HYDRA system performs real-time processing, analysis, and catalog production of seismic event data for the U.S. Geological Survey (USGS) National Earthquake Information Center (NEIC). HYDRA was designed with a flexible, modular, and scalable architecture to support (1) seismic event detection, (2) integration of near-real-time and delayed earthquake data from regional and global sources, (3) a robust suite of automatic processing algorithms, (4) a modern tool suite for algorithmic analysis of seismic events, and (5) catalog production. The capabilities of the HYDRA software system fall into four major categories: detection,

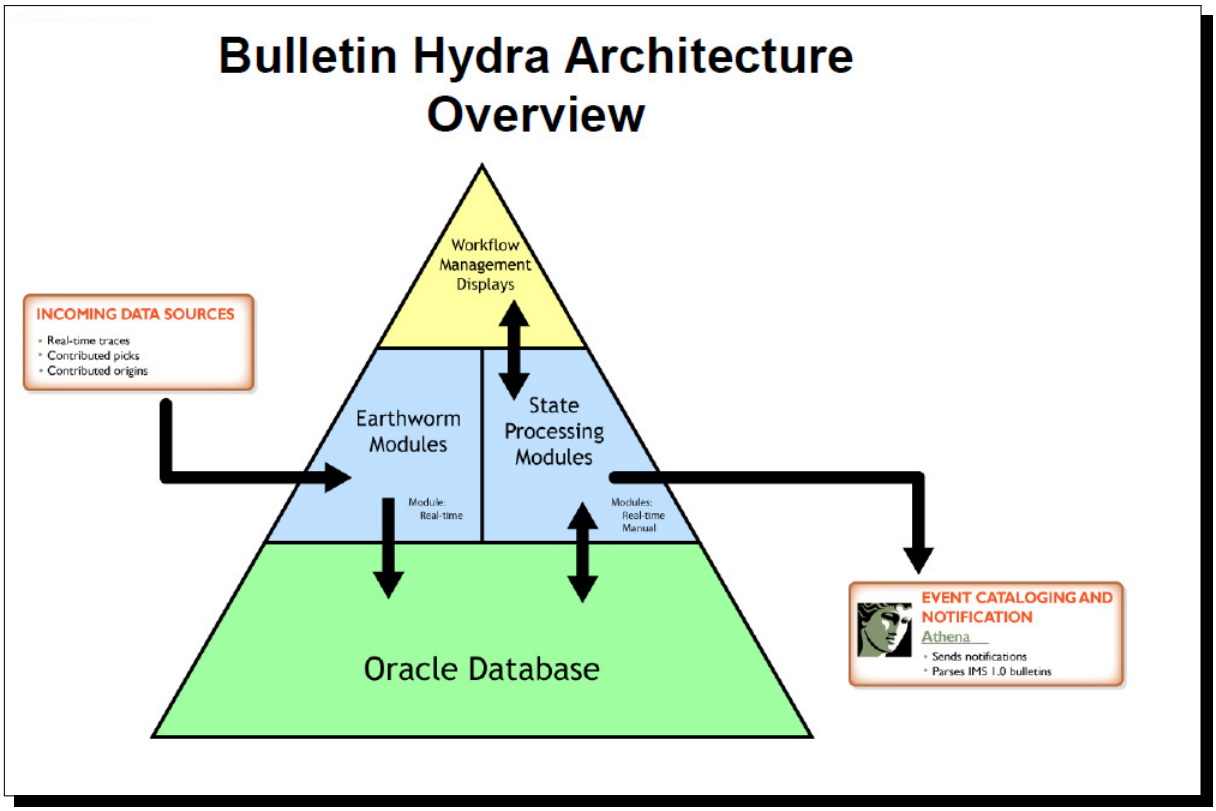

Figure 2.5. *Diagram showing the HYDRA System architecture overview.*

integration, processing, and analysis (see Figure 2.5) for the over all overview architecture of HYDRA.)

HYDRA detects earthquake events using seismic waveform data from thousands of seismometer stations around the world, including stations in the Global Seismographic Network. The seismic waveform data are processed using an automatic, real-time phase arrival-time waveform picking algorithm and a nucleation/association back-projection algorithm. These algorithms are used together to pick and associate seismic phases at local, regional, and global distances and automatically create detections as rapidly as possible. HYDRA integrates earthquake parametric data from multiple sources, including locally detected and externally contributed events. The system performs this integration as part of a near-real-time exchange of earthquake response data and late-arriving, finalized earthquake catalogs from contributing data sources. HYDRA has a robust suite of earthquake-processing algorithms that can relocate earthquakes and perform depth, magnitude, and moment tensor calculations (see, Figure 2.6 for HYDRA System Redundancy design and Figure 2.7 for HYDRA display system showing the automated located seismic events).

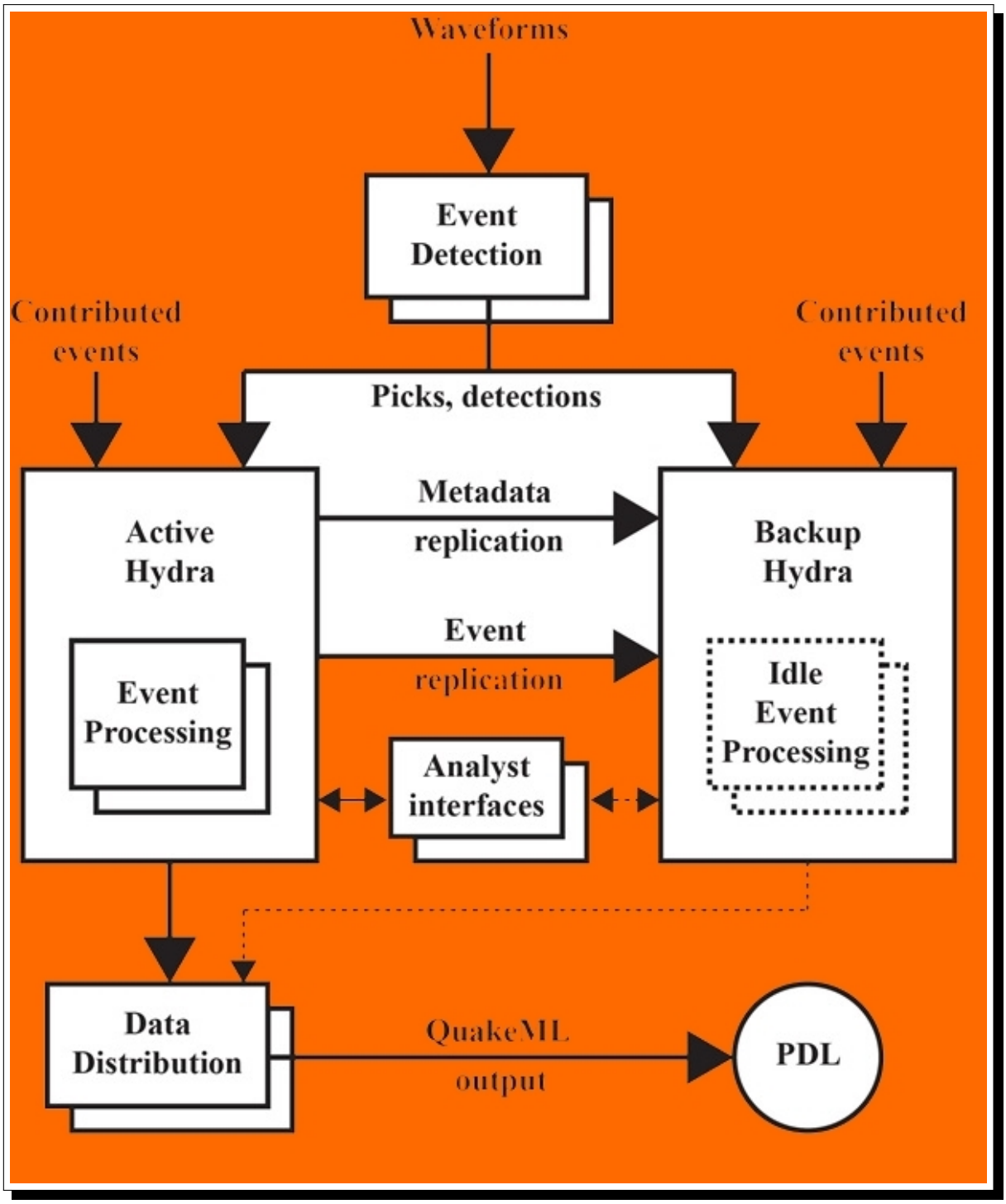

Figure 2.6. *Diagram showing the HYDRA System Redundancy design, including redundant event detection, duplicate inputs to active and backup HYDRAs, replication, analyst interfaces, redundant data distribution, and QuakeML output to the Product Distribution Layer (PDL).*

2.3.2 Revised Location

ATLAS uses Hypo-inverse, a location program written and used by the United States Geological Survey (USGS), to locate earthquakes and calculate magnitudes. This is done by creating an

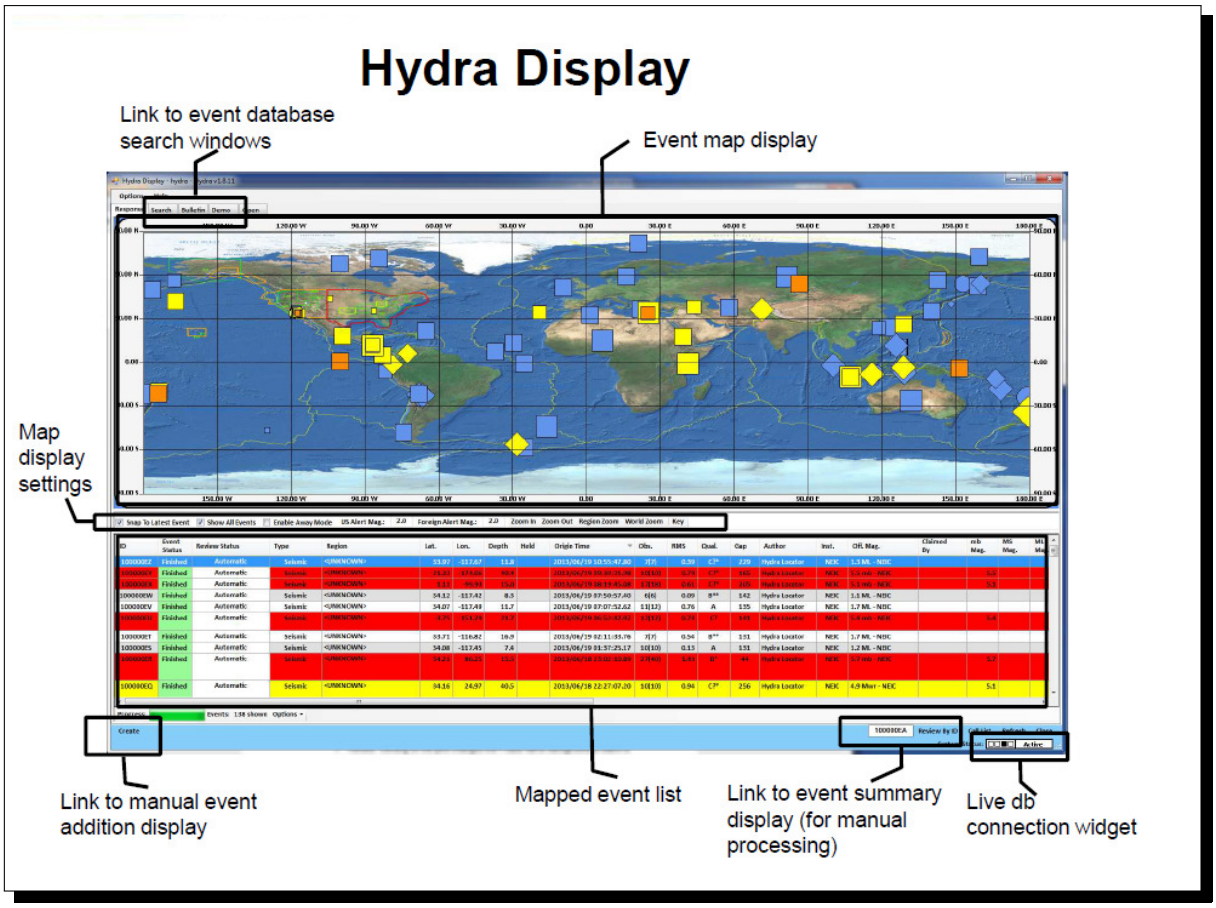

Figure 2.7. *Diagram showing the HYDRA System Display with the automated located seismic events.*

input file listing phases and any magnitude information. For the location: after creating the input file that lists phases, Hypo-inverse operates with a set of files that give instructions for which stations to use in calculations as well as any weights, delays, or corrections to apply, and an important input which is the crustal model that is suitable for the area of interest. In our case, ENSN, different crustal models are used which covers many parts of the Egyptian territory, for example, a model to the northern part and the Mediterranean is applied to events confined to that part, while another one in the northeastern part of Eastern Desert is used, the third one in the central and southern part of Eastern Desert. In southern Egypt, Aswan area, a local crustal model of Aswan is applied. For Dahshour seismogenic zone a local model deduced for a tomographic study is used. A specific model for the northern part of the Red Sea is used as well as another one for the Abo-Dabbab region is applied. Egypt is therefore including different crustal units and types act for a very complex lithospheric structure. The simplest case Hypoinverse handles is one crustal model and one set of station delays used for all epicenters

and all stations. Hypoinverse also allows considerable complexity by using multiple velocity models. In any model, velocity varies only with depth. Multiple crustal velocity models give more reliable earthquake locations which have been combined with different velocity models to reach a more accurate phase picking and precise location for earthquake solution. Due to this ENSN uses a multiple crustal velocity models option of the Hypoinverse -2000 program (Figure 2.8).

An updated velocity model for the Mediterranean region was developed (see Figure 2.9).

2.4. *Magnitude Types Determination*

For magnitude calculations: duration and amplitude magnitudes are two types of magnitudes that can be determined using ATLAS.

2.4.1 Duration Magnitude M_D

The primary traditional duration or coda magnitude (F-P), M_D is considered by ATLAS taking into consideration the phase weight and Eaton's distance correction.

The complete form of the duration magnitude expression is:

$$\begin{aligned} M_D(f-p) = FMA + FMB \times log(f-p) + FMF \times (f-p) + \\ FMD \times D + FMZ \times Z + STACOR + FMGN \times G \end{aligned} \tag{2.1}$$

The FM coefficients are set by the DUR and DUB Hypoinverse commands.

f-P is the end of the coda (F) minus P-time, or duration.

D is the epicentral distance.

Z is the (positive) depth.

STACOR is the duration magnitude correction for the station.

G is the gain correction.

S is the slant distance $S^2 = D^2 + Z^2$.

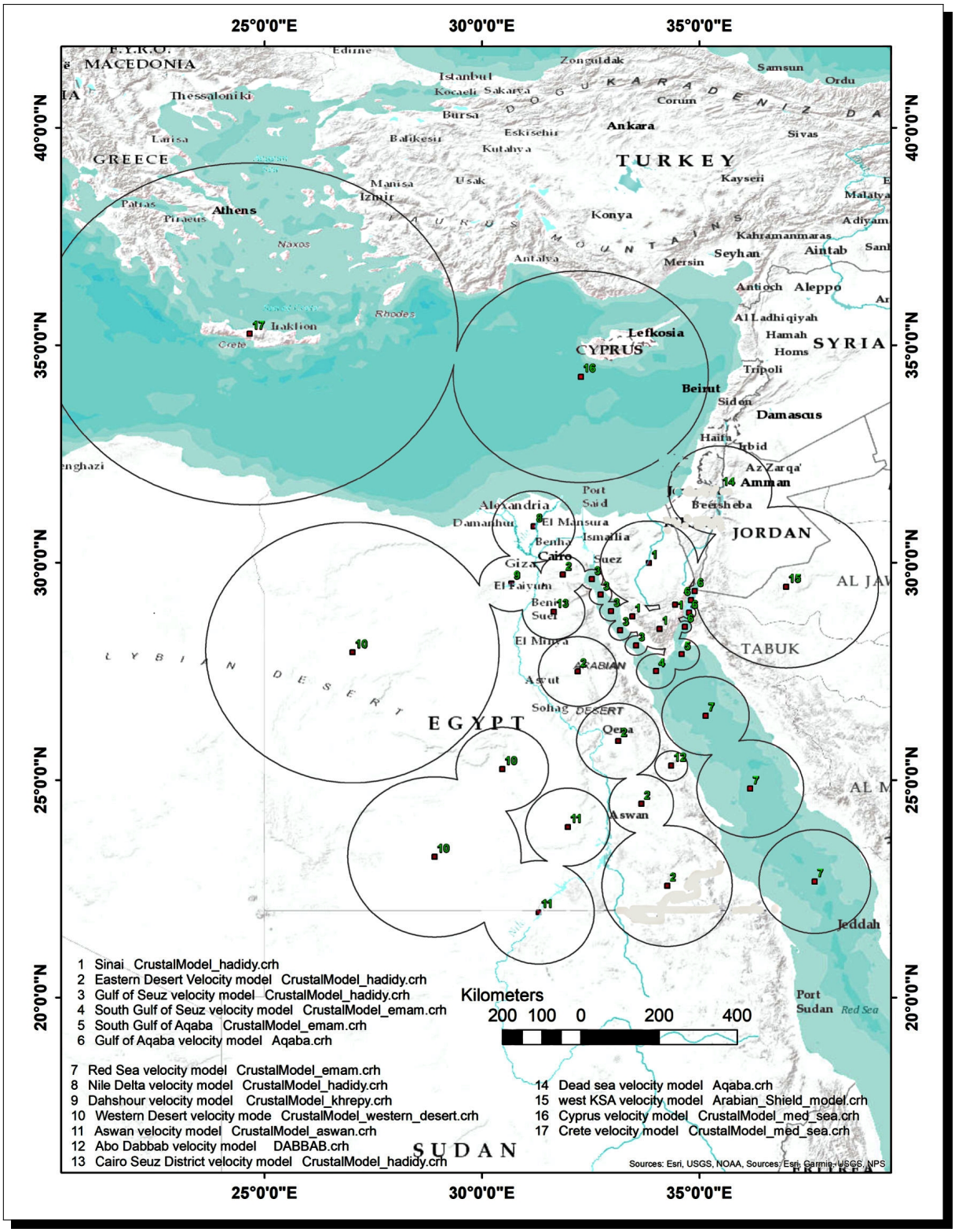

Figure 2.8. *Multiple velocity models used by Egyptian National Seismological Network (ENSN) for earthquake location.*

The form of duration magnitude proposed by Lee and others in 1972 and utilized by ENSN is:

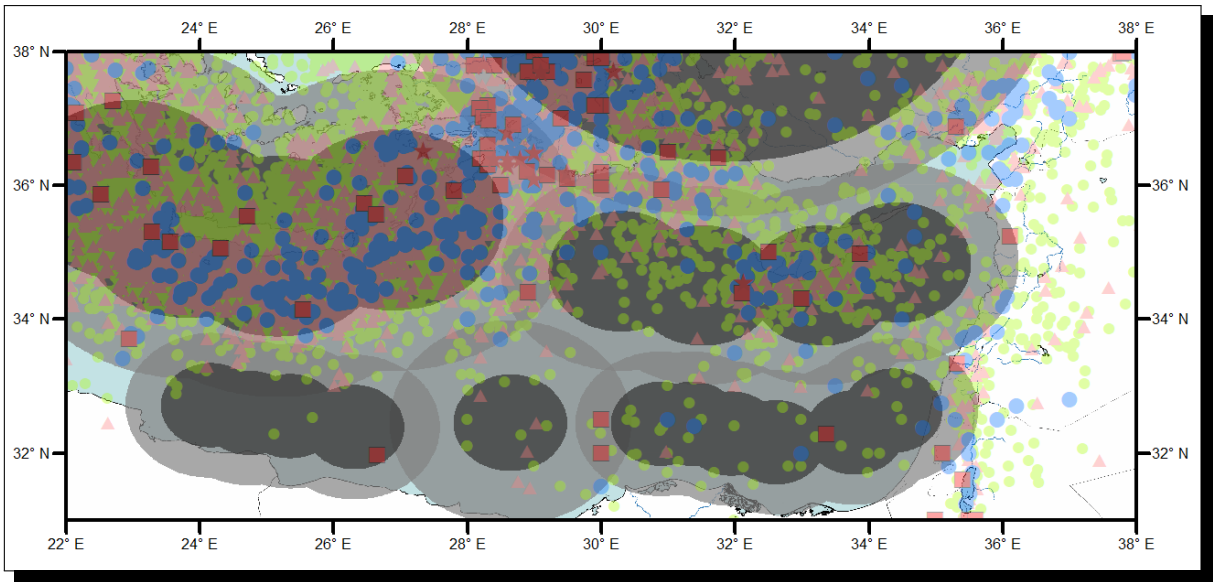

Figure 2.9. *Updated Multiple velocity models used by Egyptian National Seismological Network (ENSN) for Mediterranean earthquakes locations.*

$$M_D(f-P) = -0.87 + 2.0 \times log(f-P) + 0.0035 \times D + STACOR \tag{2.2}$$

2.4.2 Local Magnitude M_L

The second type of magnitude determined by ATLAS is the amplitude (Local) magnitude (M_L). The method for calculating the local magnitude is modeled after the reading of maximum peak-to-peak amplitudes from the standard Wood-Anderson torsion seismograph. If the amplitude is read from an electromagnetic seismometer with velocity output, it is correct to an equivalent Wood-Anderson response using Jerry Eaton's XMAG formulation, the seismometer motor constant, and the response curve of the seismometer and recording system. Digital amplitudes are handled also by using the appreciate system gain. Richter's original formula for the local magnitude is:

$$M_L = log(\frac{A_{wa}}{2}) - log(A_0) \tag{2.3}$$

Where A_{wa} is the maximum peak-to-peak amplitude in mm on the paper record, and $log(A_0)$ is an attenuation term and is a tabulated function of distance. The division by 2 is because of the peak-to-peak reading.

The "X" magnitude formula developed by Jerry Eaton in 1992, for velocity seismometers,

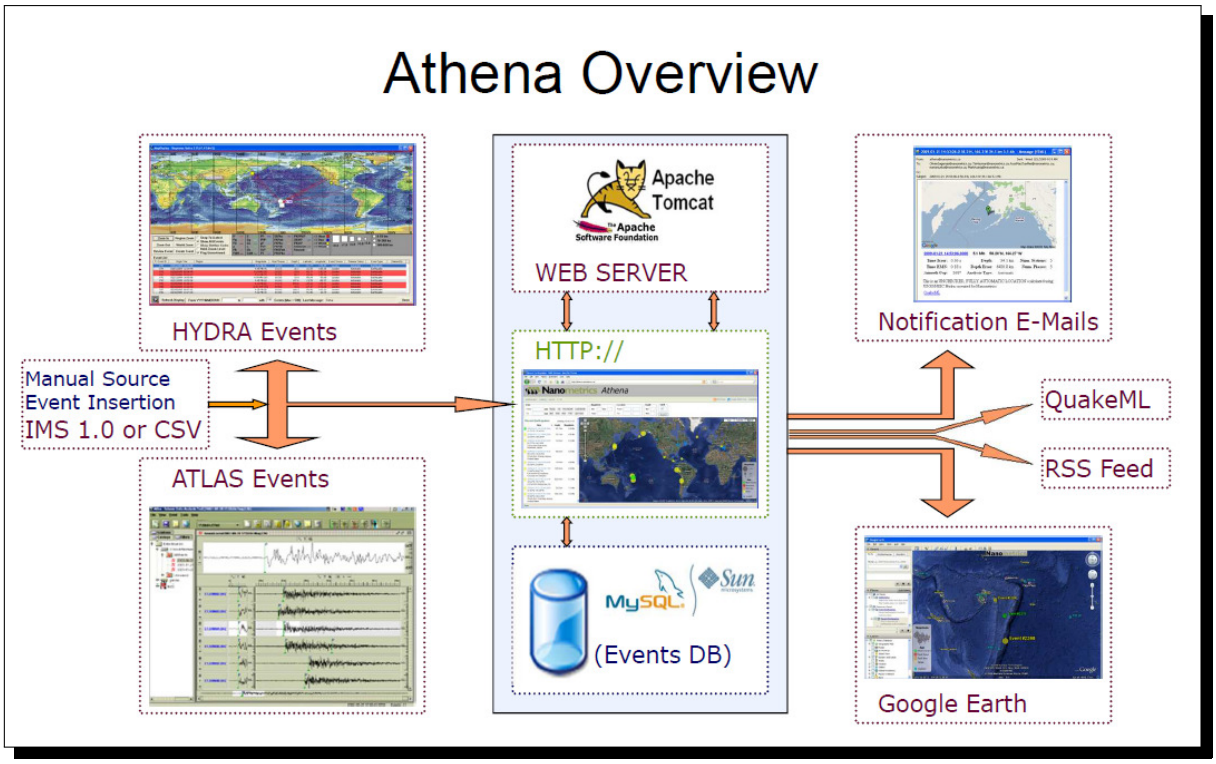

Figure 2.10. *ATHENA event cataloging and notification system*

is used in hypointense. Before the magnitude is calculated, the amplitude is converted to effective Wood-Anderson amplitude using the period at which the amplitude is measured and the response curve for the seismograph type.

The M_X relation is:

$$M_X = log(\frac{A_D}{2 \times CAL \times R(f) \times S}) + F_1(s) + \\ F_2(d) + XCOR_{COMP} + XCOR_{STA} \tag{2.4}$$

Where A_D is the peak-to-peak amplitude, CAL is the dimensionless calibration factor depending on the system gain, R(f) is the frequency-dependent response curve of the USGS system relative to the Wood-Anderson seismometer, S is the seismometer motor constant in volt/cm/sec, $F_1(s)$ and $F_1(d)$ are the $log(A_0)$. The distance correction $XCOR_{COMP}$ s the correction made globally to all components with a given component code and finally, $XCOR_{STA}$ is the individual station correction.

2.5. *Events Cataloging and Notification System*

ATHENA is an easy-to-use data management, event cataloging and notification system. It can be accessed via any web browser, anytime from anywhere using the address:

http://ensn.nriag.sci.eg/

The ATHENA Data Management System is included as part of our seismic monitoring system, allowing interested society and scientific interested personnel to browse up-to-date event catalogs, view all recorded event source parameters, plot frequency/magnitude relationships for event clusters, and track network seismicity rate to manage risks associated with seismicity in real time (see Figure 2.10). Notification alerts are available within minutes of an event and can be customized for specific criteria and event thresholds.

Chapter

3 Stations and Performance

Most of the ENSN stations (listed in Table 1.1) are Broadband seismic stations and use the Trillium seismometers. Such type of seismometers is considered one of the highest perfor ming seismic sensors. The Trillium has a long flat response to 35 Hz and noise below the new low noise model (NLNM) 10 Hz. Its advanced thermal design reduces effects of significant temperature fluctuations, minimizing requirements for external thermal insulation. Its low power consumption is an advantage for remote installations using solar panel batteries. In addition to the sensor's cost effectiveness, it complements the existing electronics and power system.

3.1. *Newly Installed Stations*

During the year 2021 six seismic weak-motion stations and one post-hole station were added to the ENSN namely: Hafia (HAF), Abu Ramad (RMAD), San EL Hagar (SHGR), Hamrat Salama (SLMA) , Sohag (SOHG), Ras Mohamed (RASM) and New qusir (SRM). All are broadband seismic stations, except San EL Hagar (SHGR) which is the first post-hole seismic station within the ENSN network. Spatial distribution of newly installed seismic stations is given in Figure 3.1. Figures 3.2 to 3.3, depict some of the filed-operations during installations of the newly added seismic stations.

3.2. *Stations Performance*

3.2.1 Background Noise

Quantification of spatial and temporal variations of seismic noise is important for many aspects of seismology. Performance of a seismic network is strongly influenced by the noise level of the stations. The ability of a seismic network to detect earthquakes depends on the noise levels at each individual station. Moreover, seismic noise can also be used as signal to evaluate the performance of seismic equipment and vault construction. A thorough investigation of seismic

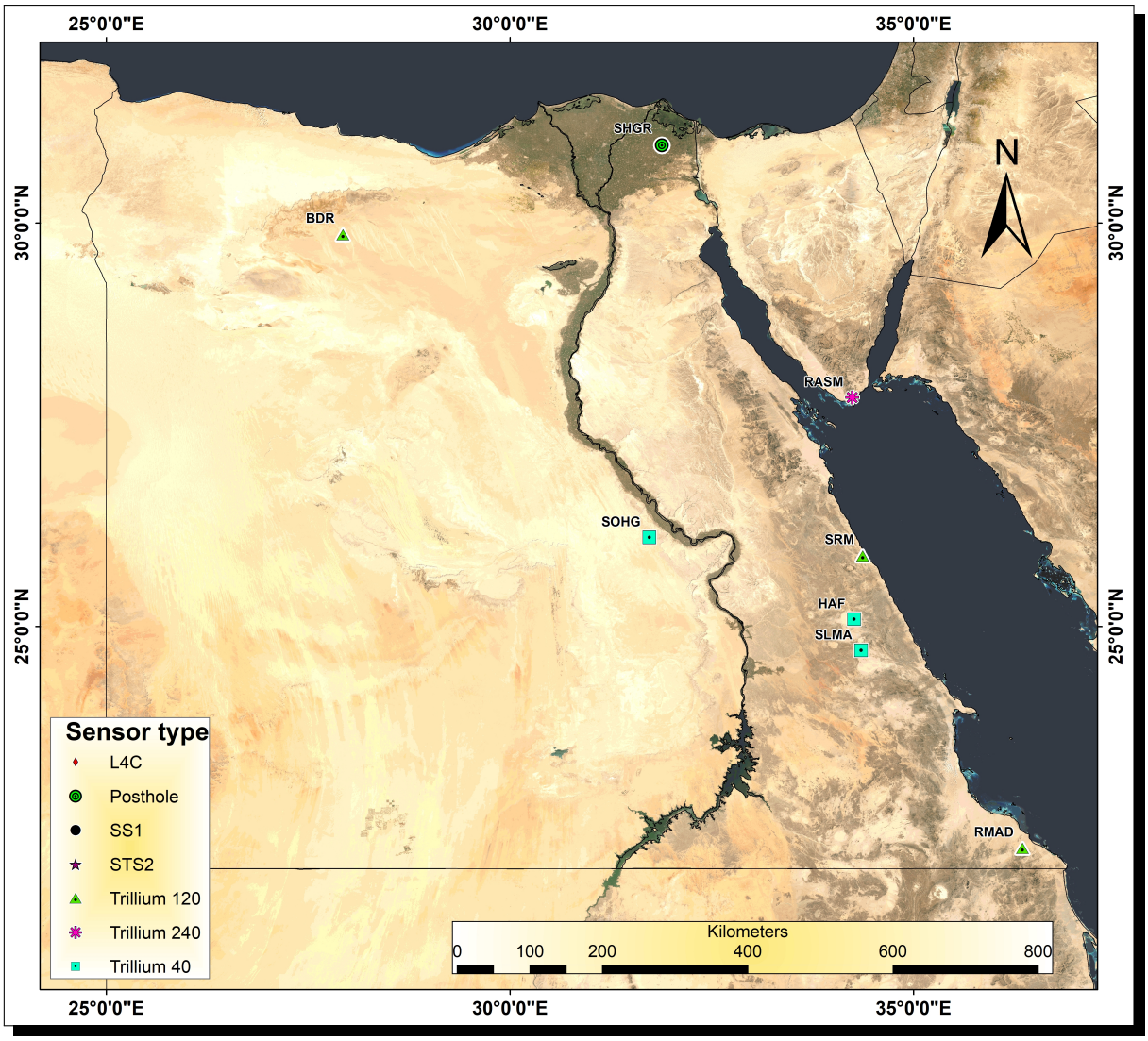

Figure 3.1. *Spatial distribution of newly installed seismic stations in 2021.*

noise including quantification of spatial and temporal variations is therefore important.

The noise level of a seismic station is generally investigated through power spectral density (PSD) of the acceleration signal; it is influenced by the quality of installation and the background noise. We estimated the mean acceleration PSDs of the vertical component of the noise for all stations of the ENSN using PQLX software.

Figures 3.4 and 3.5 show the estimated power of the seismic noise for some of the ENSN stations. It is derived by calculating mean acceleration PSD for each site in the frequency range of 1–12 Hz and applying inverse distance weighting for standardization of the data grid. This makes it possible to present the distribution of noise levels for the entire frequency range over long time periods.

Figure 3.2. *Example of field work construction operations for some of the ENSN stations.*

Figure 3.3. *Another Example of field work construction operations for San ElHagar Post-hole seismic stations.*

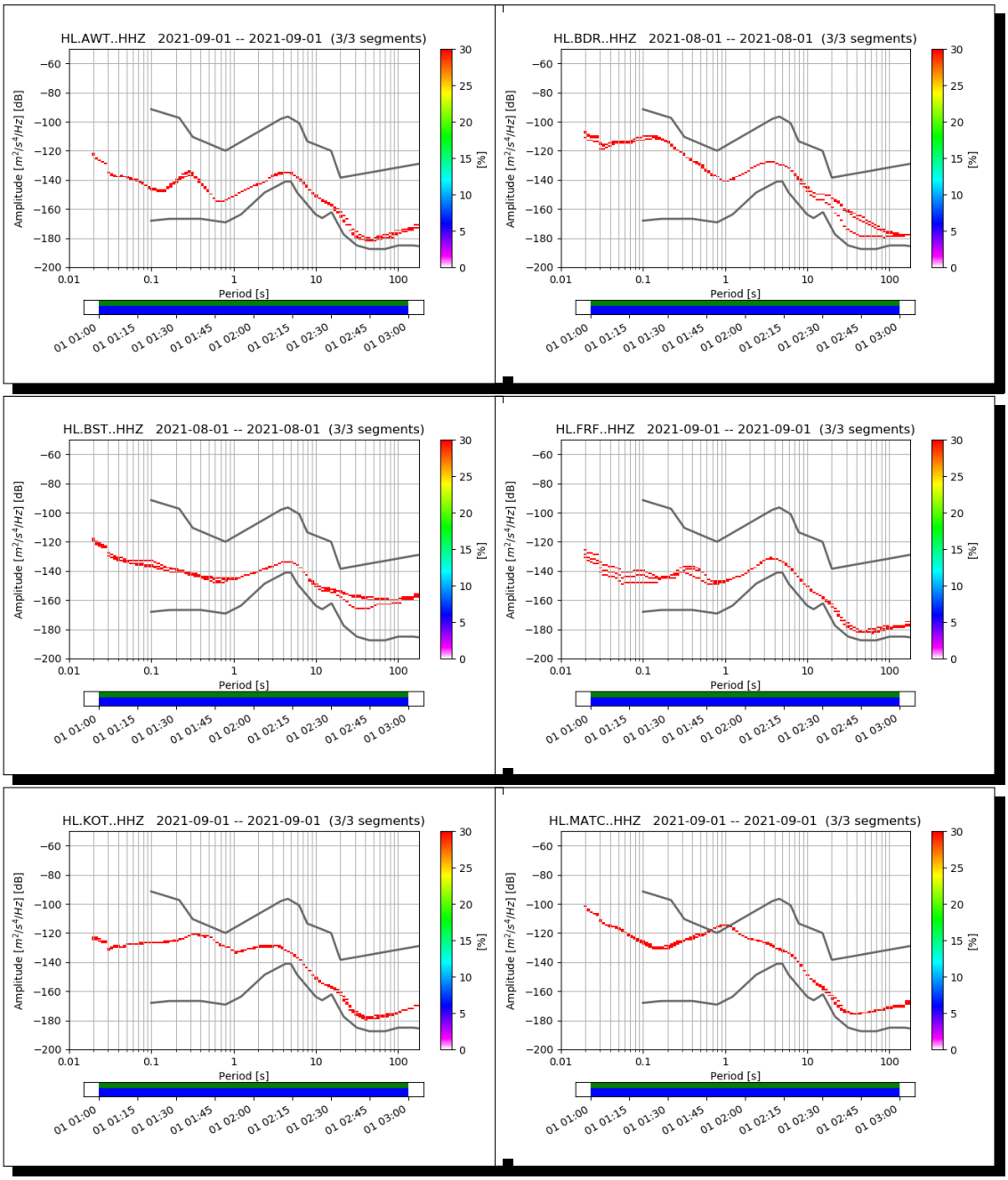

Figure 3.4. *Example of recorded background noise for some of the ENSN stations.*

3.2.2 Data Availability

To evaluate the availability of seismic data, the Egyptian National Seismic Network (ENSN) was divided into six sub-networks. These sub-networks are Cairo, Sinai, Aswan, Red Sea, North Coast (N-coast), and Nile Valley (N-valley) respectively.

According to Figures 3.6 and 3.7, three sub-networks achieved maximum percentage in terms of data availability (100%) for except Aswan (99%), Red sea (98%) and N-Valley (98%).

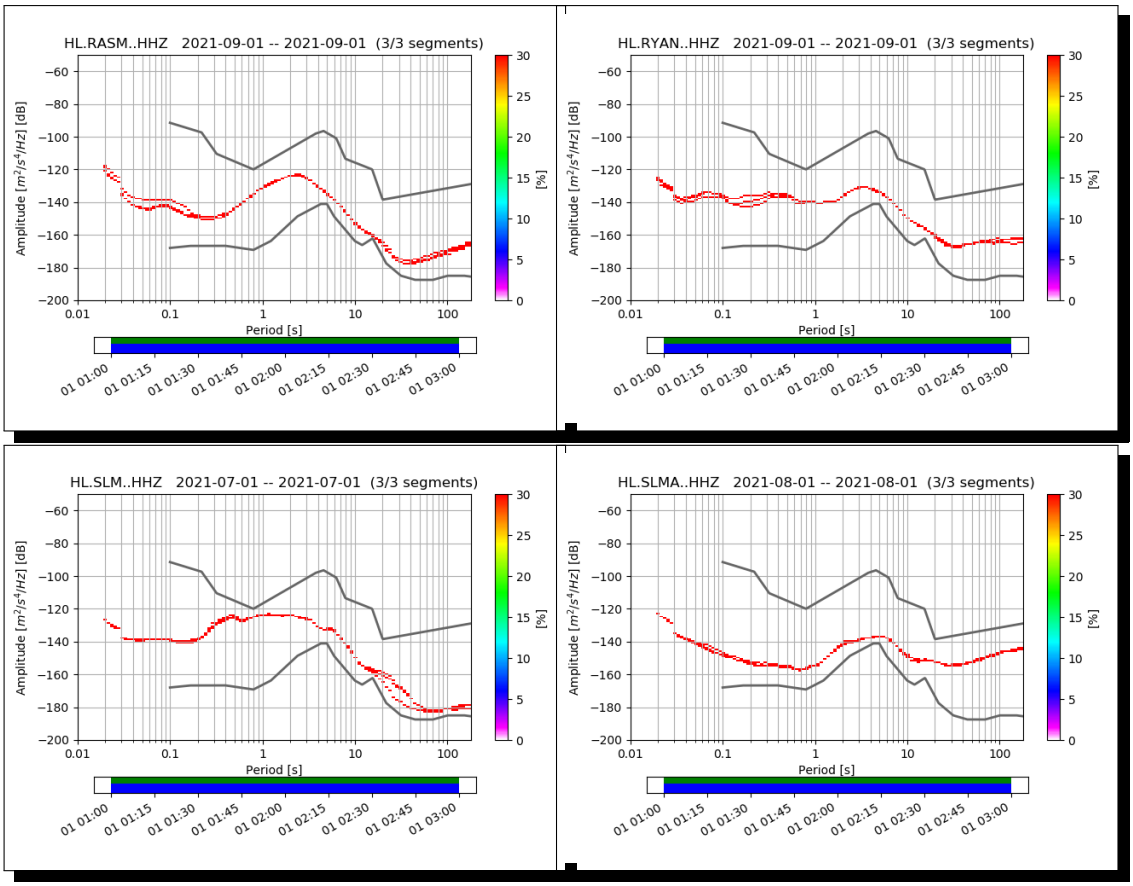

Figure 3.5. *Another Example of recorded background noise for some of the ENSN stations.*

The minimum percentage in terms of data availability was observed in Cairo sub-network was in August 2021. While in December 2021 the minimum was observed Sinai and in October 2021 in Red Sea sub-networks. For the Aswan sub-network, the minimum data availability was in April 2021. The N-coast sub-network reached a minimum data availability in March 2021. The N-valley sub-network has achieved a minimum in October 2021. Most of operational sub-networks reached 97% data availability on average, while N-Valley sub-network was 86% on average. According to Table 3.1, the best performing network during the whole year was Cairo while N-Valley was the worst one.

3.2.3 Automatic Triggering Identification

Quickly detecting and accurately picking the P-wave first-arrival is of great importance in locating earthquakes and characterizing velocity structure, especially in the era of large volumes of digital and real-time seismic data. For ENSN, a newly developed detector capable of finding the onset of the P-wave arrival against the background of microseismic and cultural

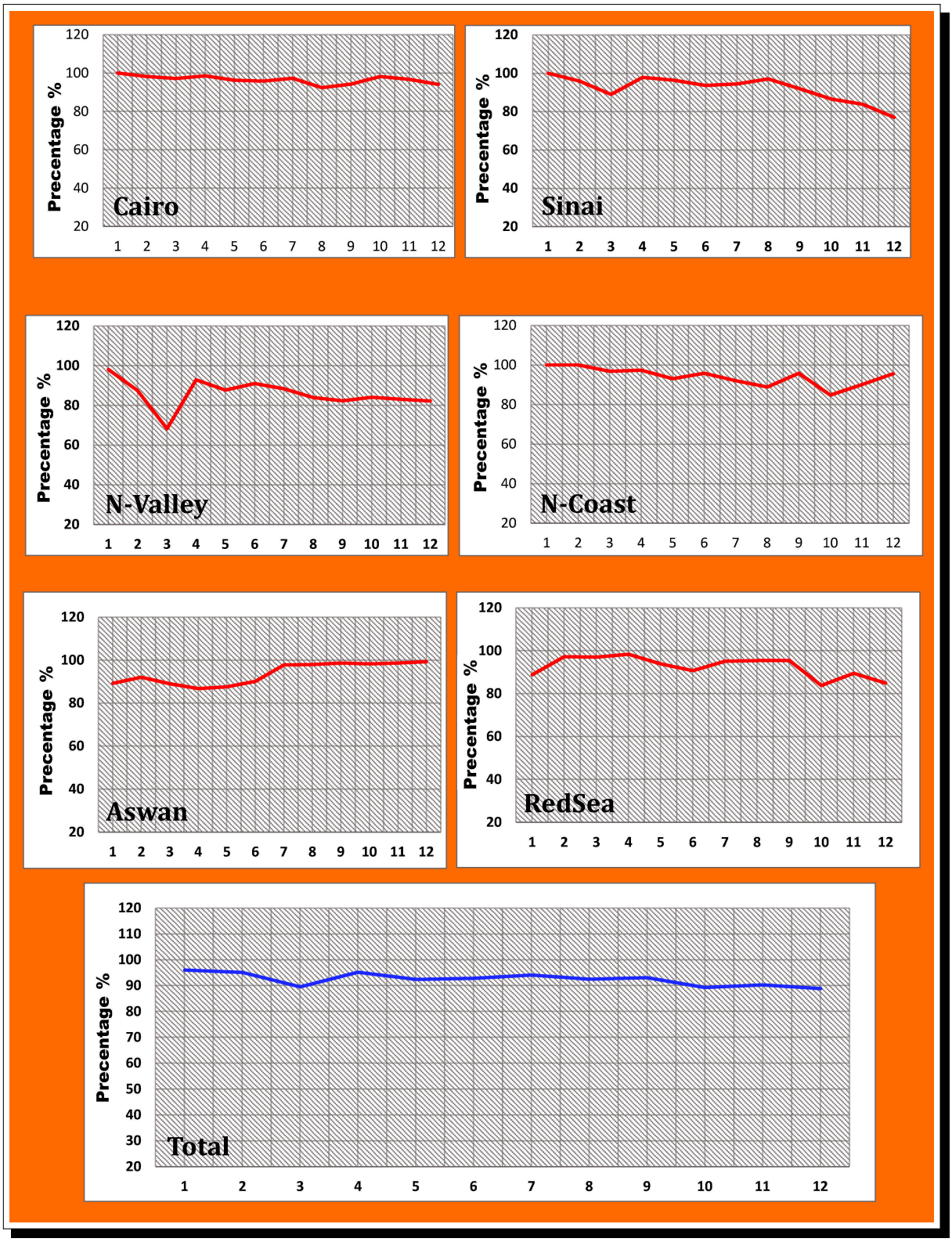

Figure 3.6. *Reported monthly data availability for ENSN sub-networks in 2021.*

noise was implemented.

The newly developed detector algorithm uses discrete wavelet transform (DWT) and this algorithm generates a daily report of all events recorded by this sub-network. Figure 3.8 shows

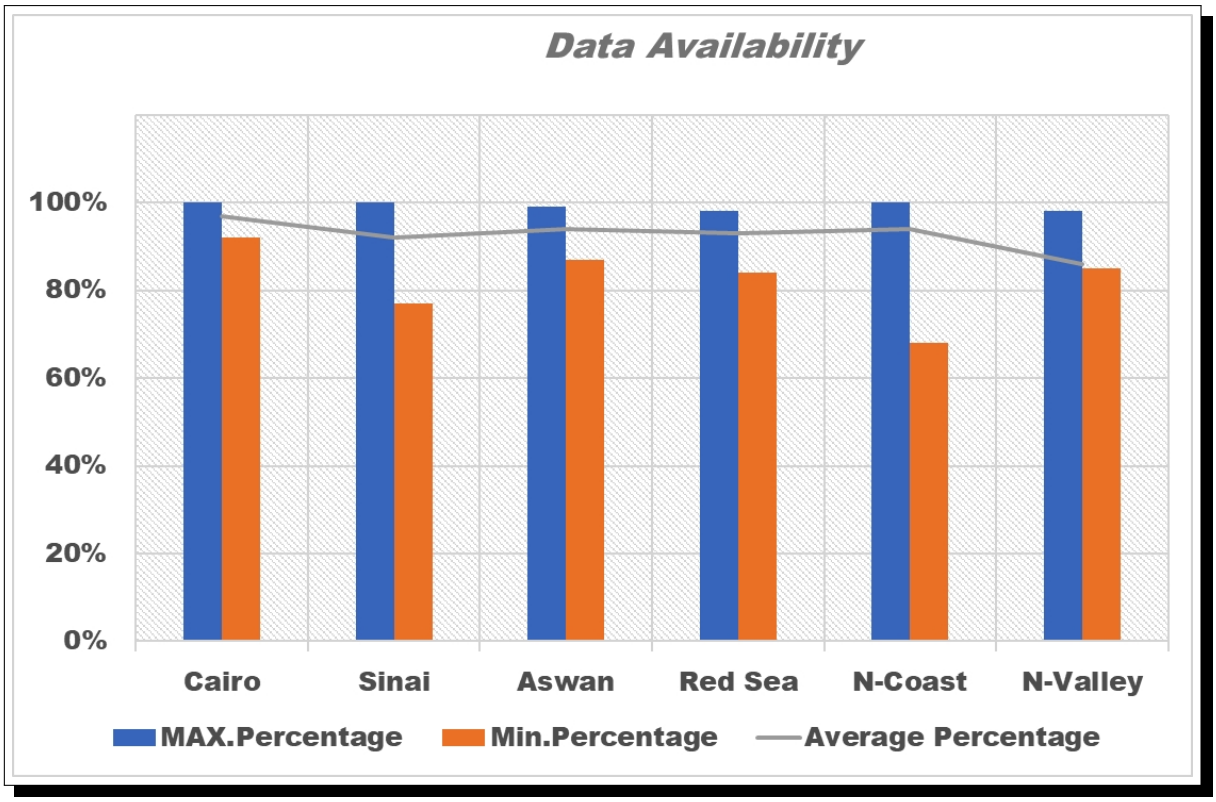

Figure 3.7. *Reported maximum, minimum and average data availability percentages for the six ENSN sub-networks in 2021.*

	Cairo	Sinai	Aswan	Red Sea	N-Coast	N-Valley
Best subnetwork in 2021	*					
Worst subnetwork in 2021						*

Table 3.1. *The average percentage quality for each sub-network in 2021*

example of the implemented detection technique.

We test our method on local and regional earthquake data and find that it can detect about 90% of P first-arrivals correctly. It will detect the wrong P-wave onset when the time window only includes an isolated glitch. When the detector finds the P first-arrival, the picker will determine the onset time and its uncertainty based on the features of the time picks corresponding to the different resolutions. Compared with manual picks, our picker provides onset times and uncertainties with high confidence. Figure 3.9 shows an example event

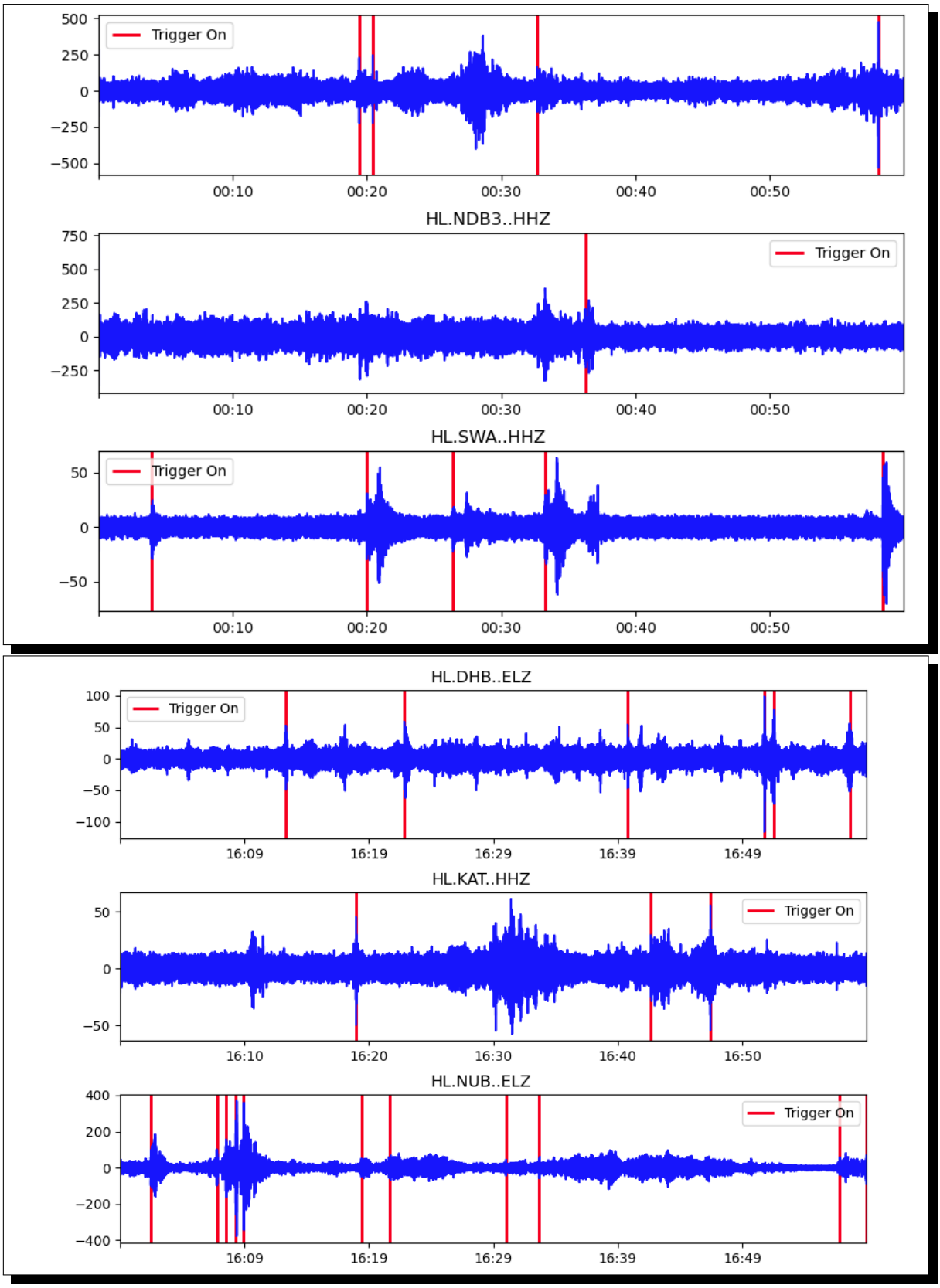

Figure 3.8. *Example of implemented P-wave arrival detection and picking.*

recorded in 2021-06-30_06:11 and comparing with automatic solution.

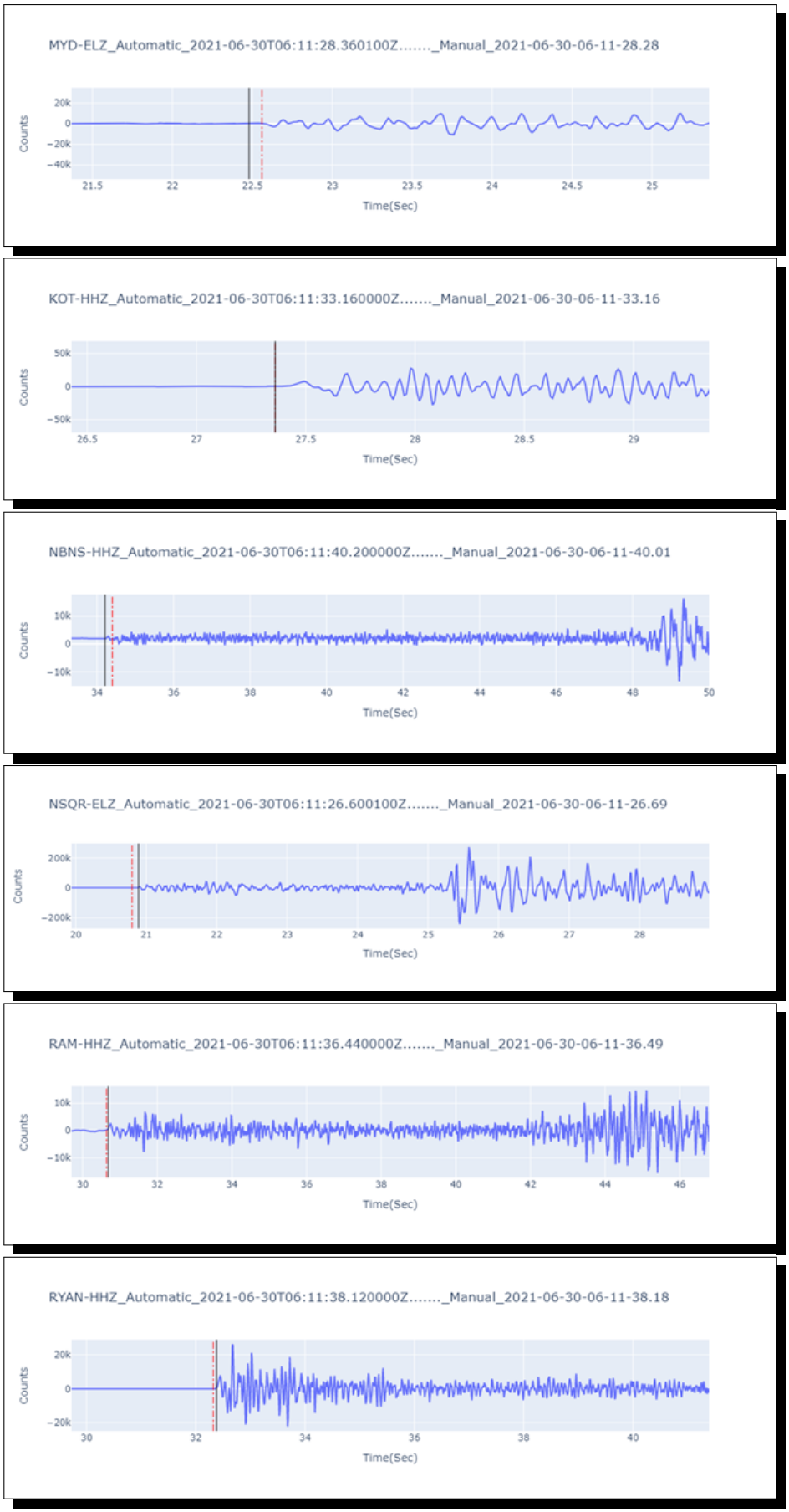

Figure 3.9. *Example of event recorded in 2021-06-30 and comparing manual with automatic P-wave picking for some of the ENSN stations.*

3.2.4 Stations Detectability

Seismic monitoring in Egypt has a great improvement after the newly installation and upgrading the previous analog telemetry networks. Since the operation of the network, a significant number of local, regional, and teleseismic events are located by manually and automatic processing. The detection-location capability of the ENSN has been estimated for 2021. Example of ENSN stations detectability during May 2021 is shown in Figure 3.10.

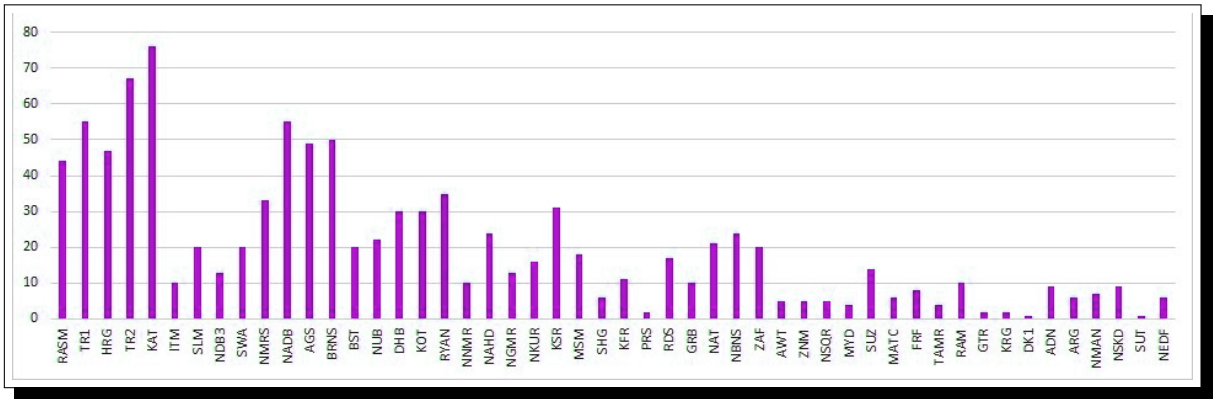

Figure 3.10. *Example of ENSN stations detectability during May 2021.*

Figure 3.11 shows another example of the probability detecting an earthquake with magnitude 3.5 within the Cairo sub-network.

The obtained maps show that the network has the ability to detect and locate earthquakes occurred in Egypt and its surroundings. For the present network configuration and stations characteristics, the technique determines the lowest magnitude of events that the seismic network is able to detect, locate, and estimate errors in both location and origin time for different magnitudes.

In terms of azimuth and distance, the ENSN could record events for a wide range of azimuths and distances as can be see in Figure 3.12.

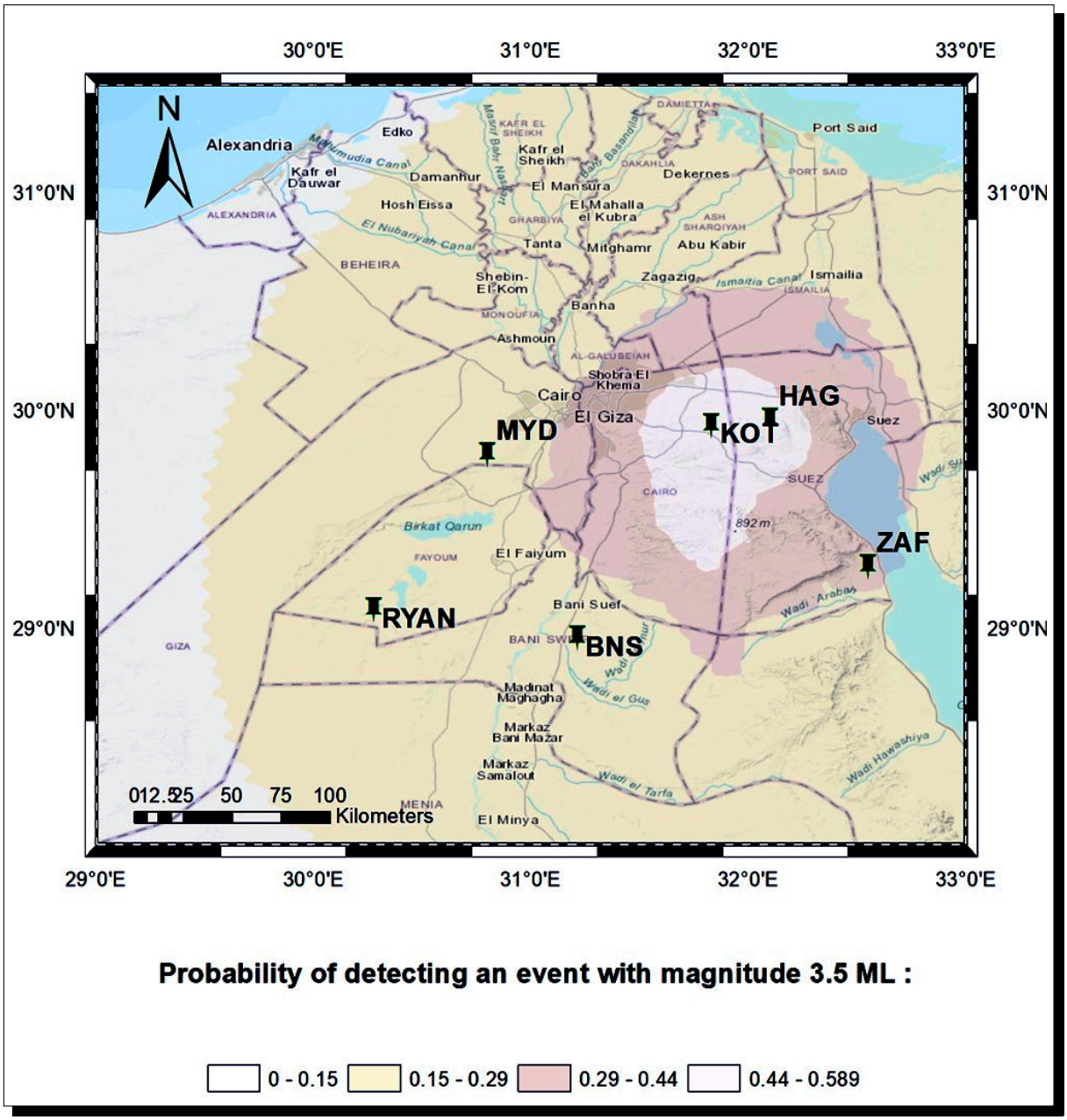

Figure 3.11. *Probability detecting an earthquake with magnitude 3.5 within the Cairo sub-network.*

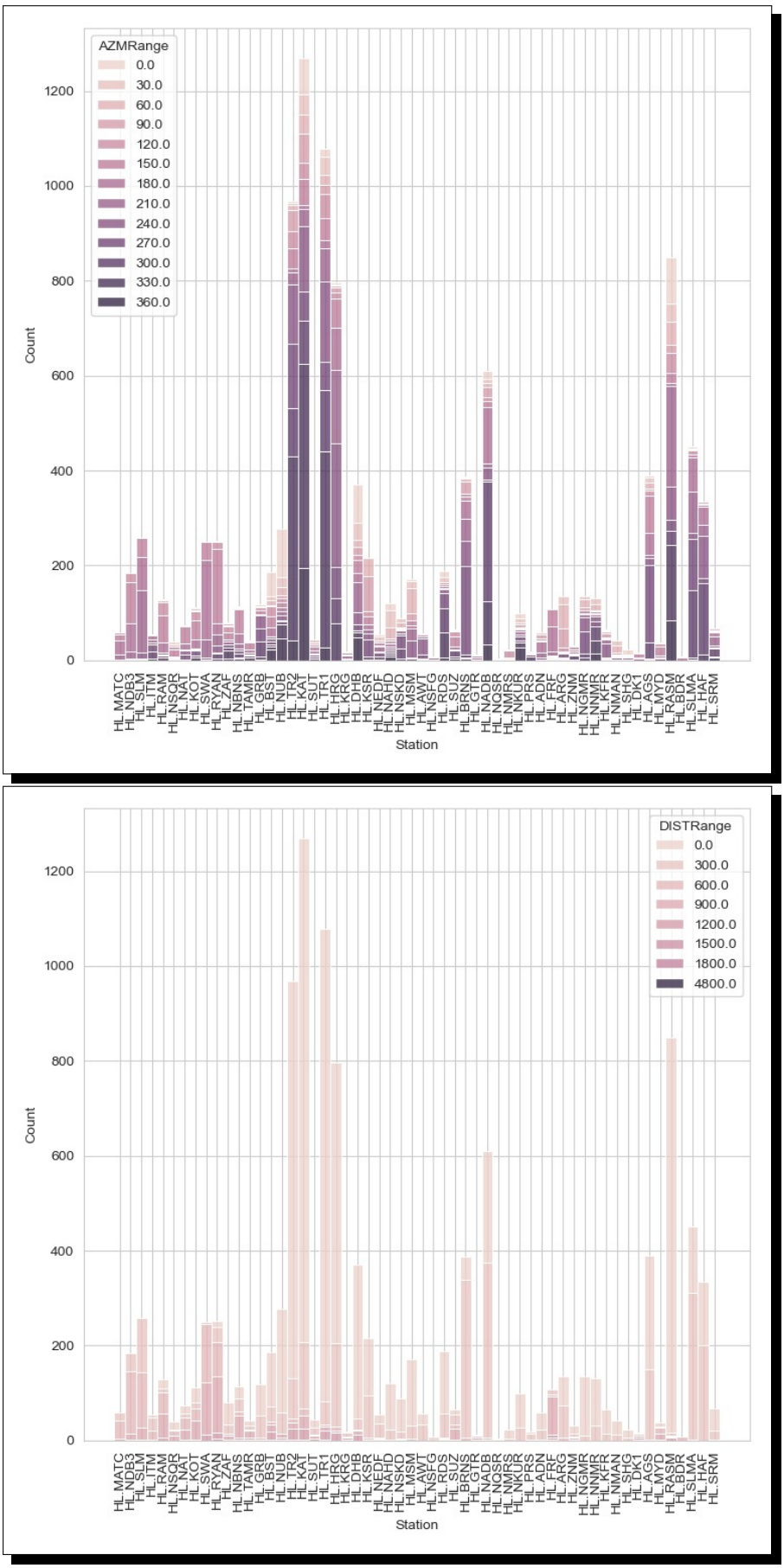

Figure 3.12. *ENSN stations azimuth and distance detectability*

Chapter

4 Reported Seismicity Overview

4.1. *Spatio-temporal Seismic Activity Distributions*

All recorded seismic activity within the year 2021 in and around Egypt (Figure 4.1) reflects the incredible increase in the number of smaller earthquakes.

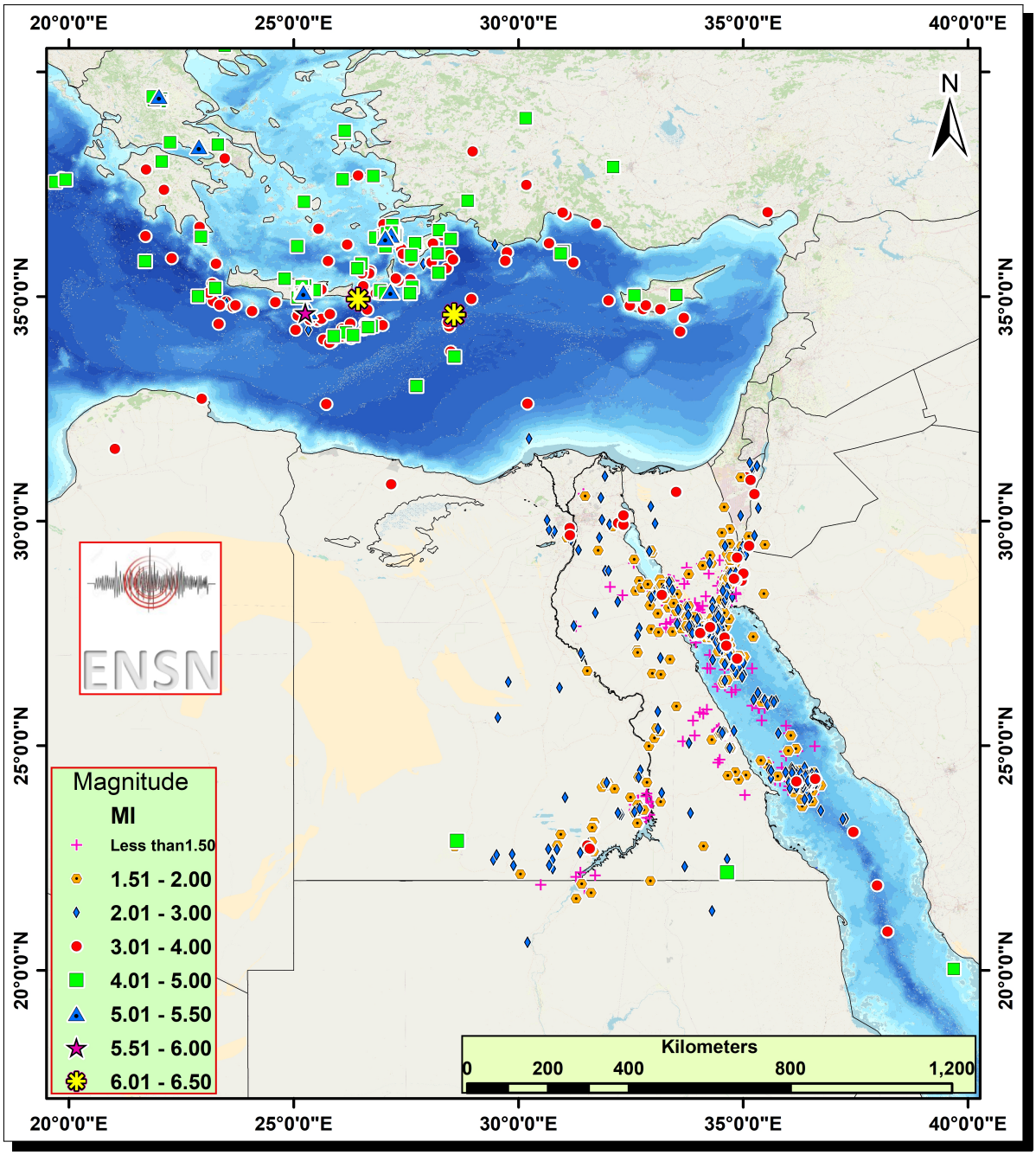

Figure 4.1. *All recorded seismic activity in and around Egypt as recorded by ENSN through 2021.*

These local seismic activities (Figure 4.2) are fit along the previously defined seismic zones during previous years.

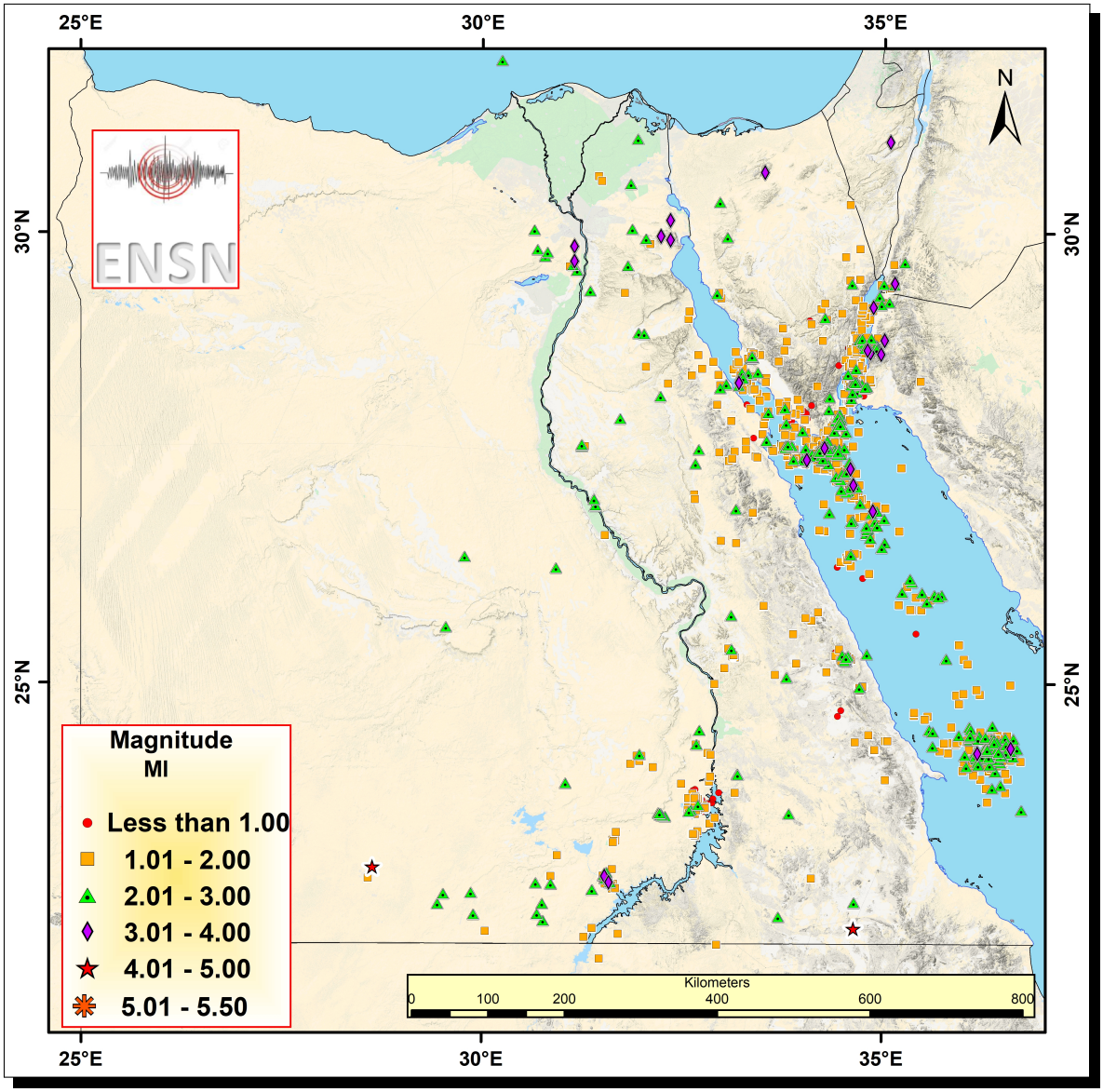

Figure 4.2. *Local seismic activity in Egypt as recorded by ENSN through 2021.*

This large number of events could be attributed to the increase and enhancements of the current seismic station's delectability of ENSN.

Figure 4.3 and Figure 4.4 show zoom in for some selected seismic zone in Egypt superimposed on surface faults.

The regional seismic activities (Figure 4.5) show a cluster of the seismic activity to the southern part of Hellenic and Cyprian arcs.

The seismic activity extends north to the southern part of Greece and Turkey. Few events

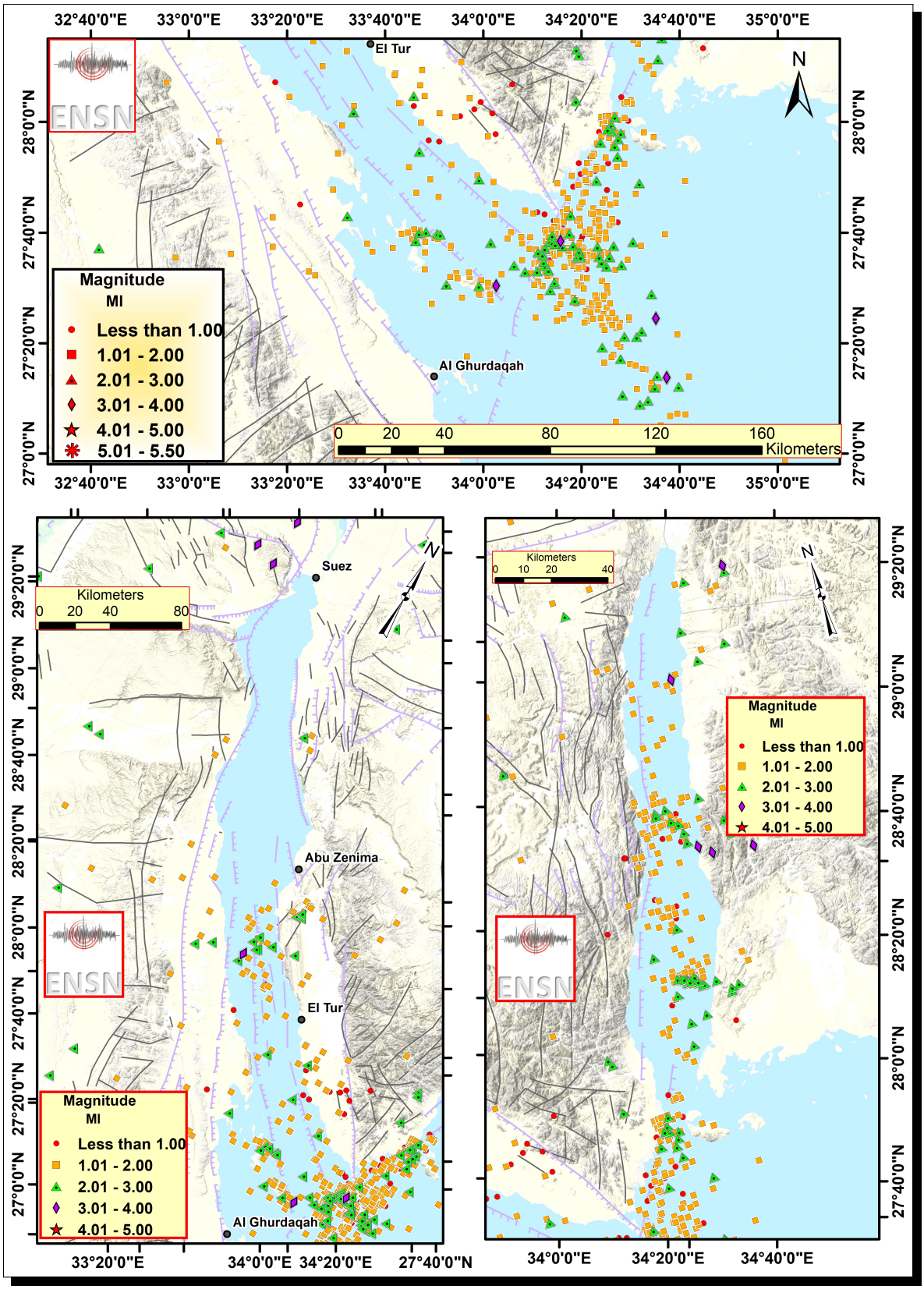

Figure 4.3. *Local seismic activity in Egypt as recorded by ENSN through 2021 zoomed-in Gulf of Suez, Gulf of Aqaba (lower figures), and their entrance (upper figure) superimposed on surface faults.*

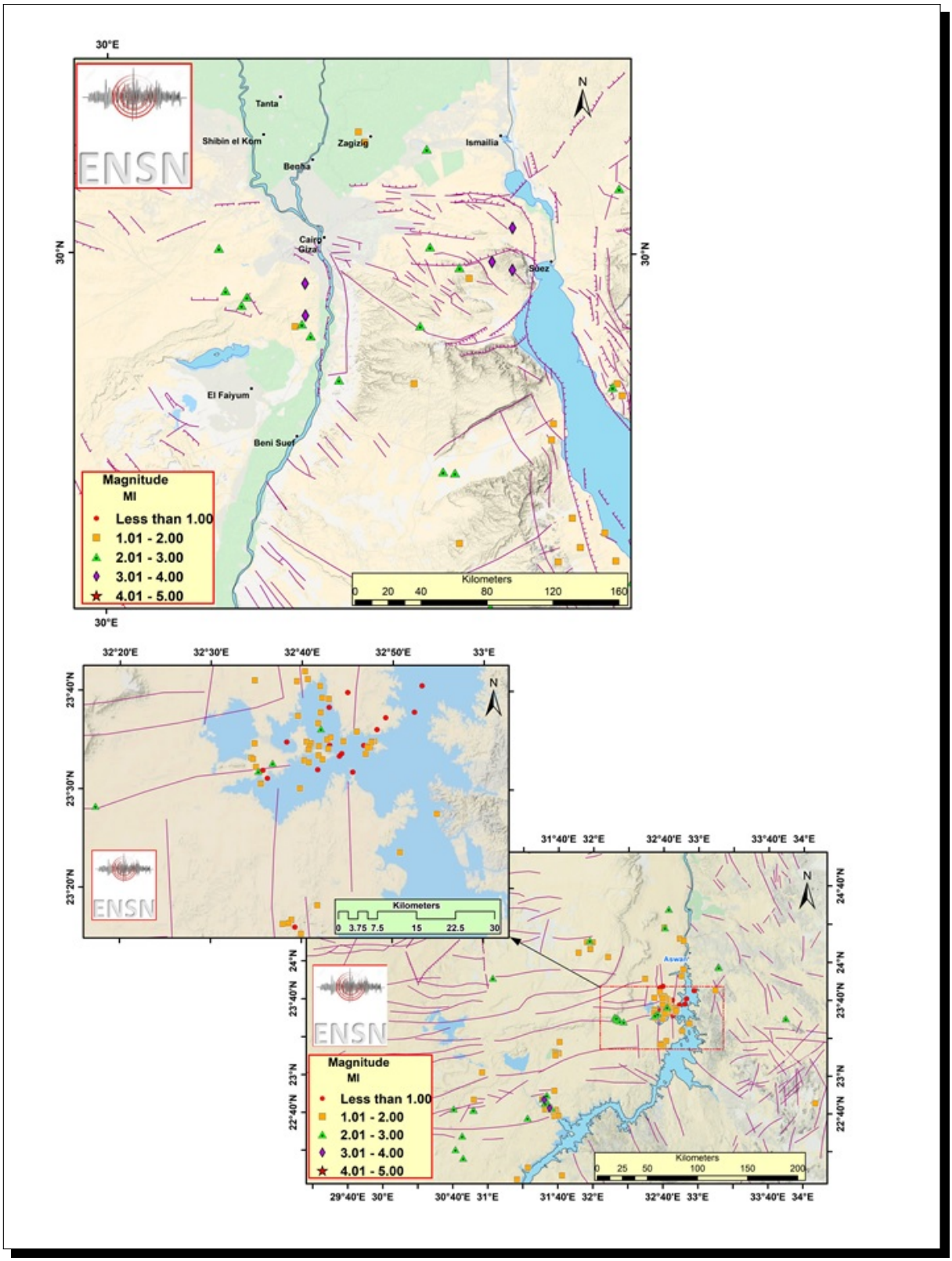

Figure 4.4. *Local seismic activity in Egypt as recorded by ENSN through 2021 zoomed-in Cairo- Suez district (upper figure) and Aswan region (lower figure).*

are located along with Southern Jordan, Northern Sudan, Central Red Sea, and along with the Dead Sea Transform Fault System.

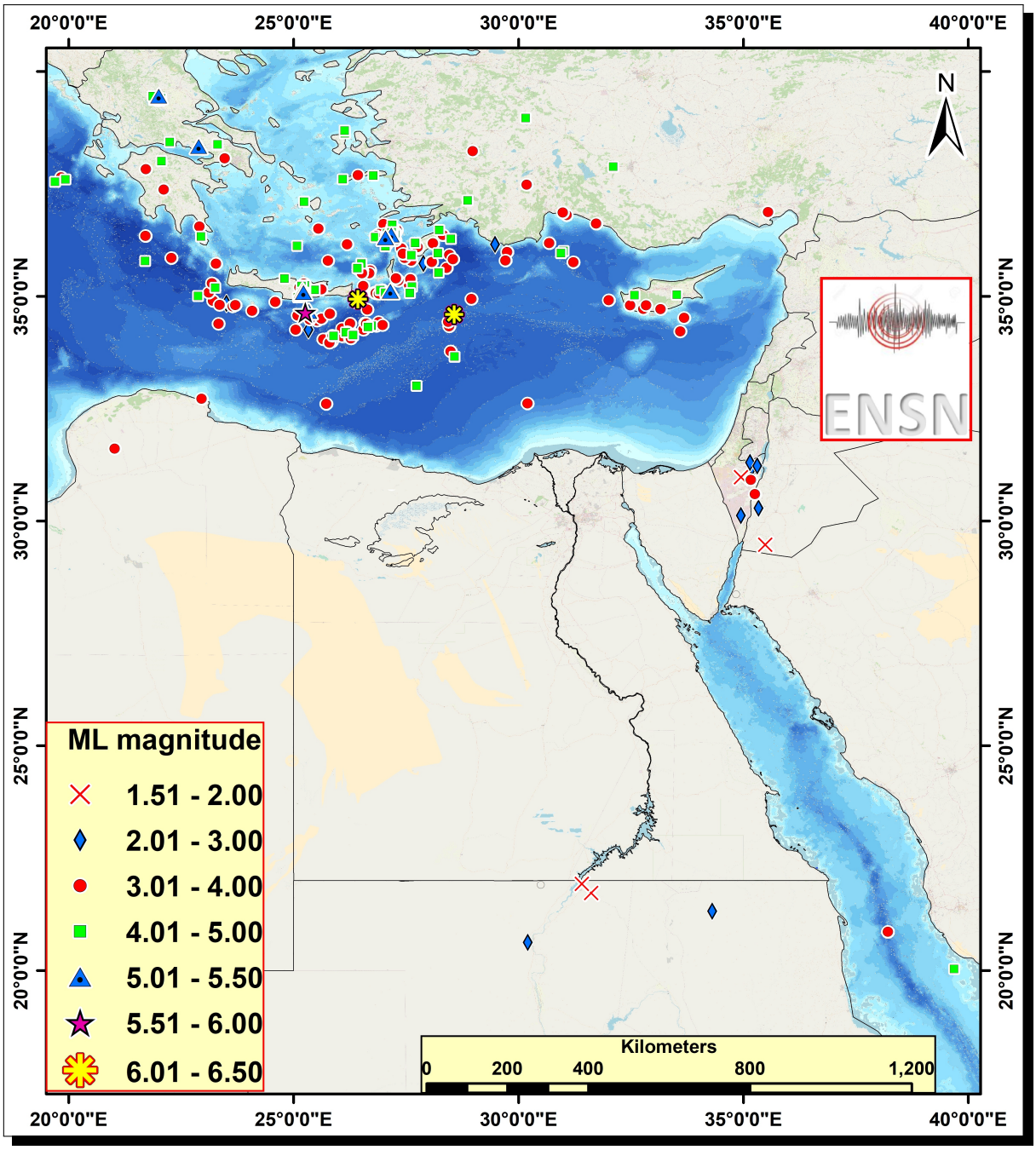

Figure 4.5. *Regional Earthquake activity around Egypt as recorded by ENSN through 2021.*

Temporal distribution in terms of month of the origin time, Julian date, calendar date and origin date based on geographic region is shown in Figure 4.6.

4.2. *Completeness of the ENSN Bulletin*

In the recent past most methods to evaluate performance of a seismic network were based on magnitude of completeness (M_C). It is the magnitude above which the seismic network provides

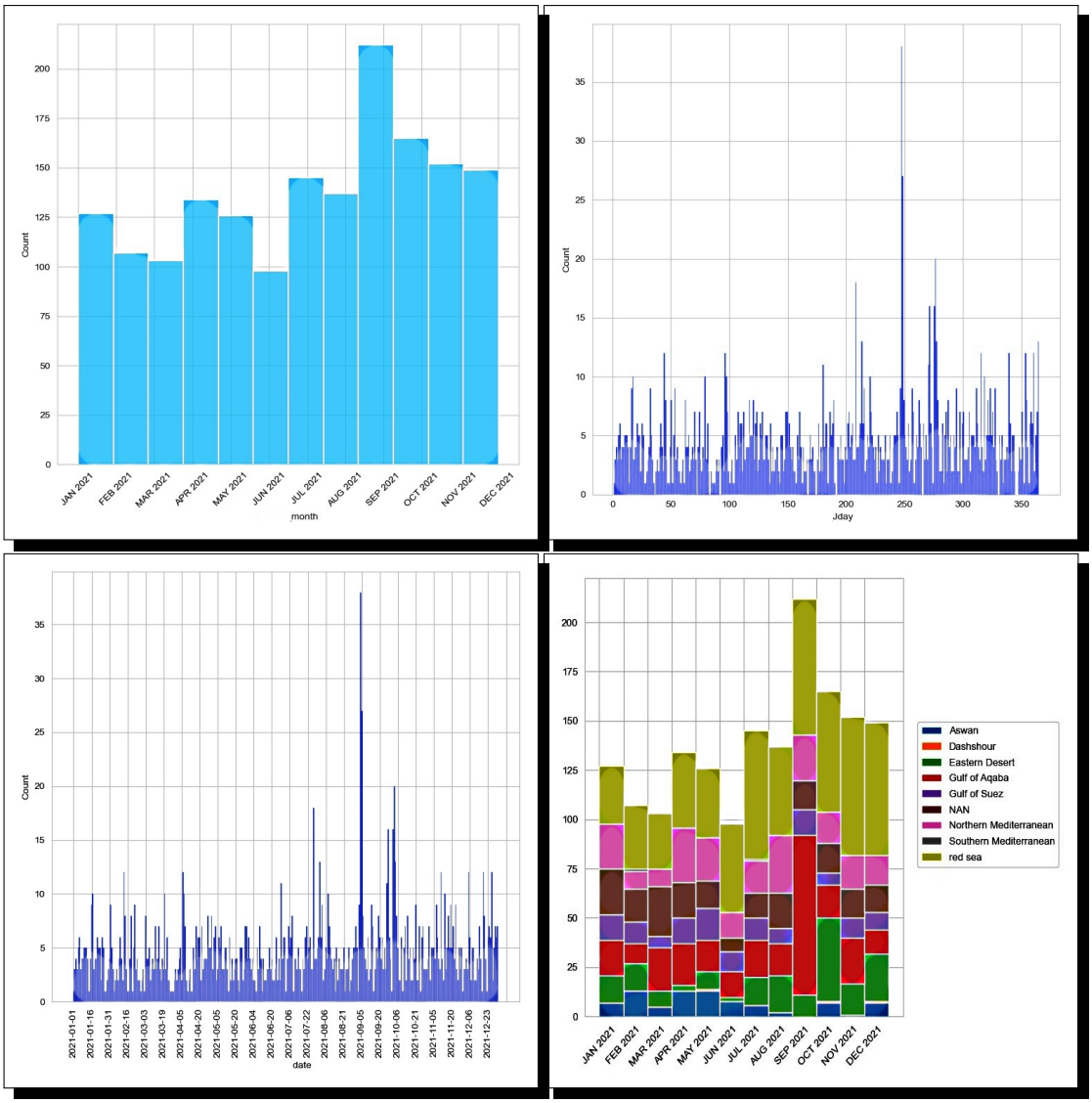

Figure 4.6. *Temporal distribution reported seismicity by the ENSN stations.*

complete detection of events, that is, no events are missed.

M_C was estimated from the deviation of the earthquake frequency-magnitude distribution from the Gutenberg–Richter law. The Bulletin with events bigger than the defined M_C is assumed to be complete. The magnitudes of completeness of the ENSN Bulletin for this Summary period is shown in Figure 4.7. Distribution of reported seismic activity by ENSN stations in terms of magnitude and depth is shown in Figure 4.8.

4.3. *Focal Mechanism Examples*

P-wave first motion is the simplest method to determine the fault plane solution. This method depends on the azimuth and distance from the hypocenter.

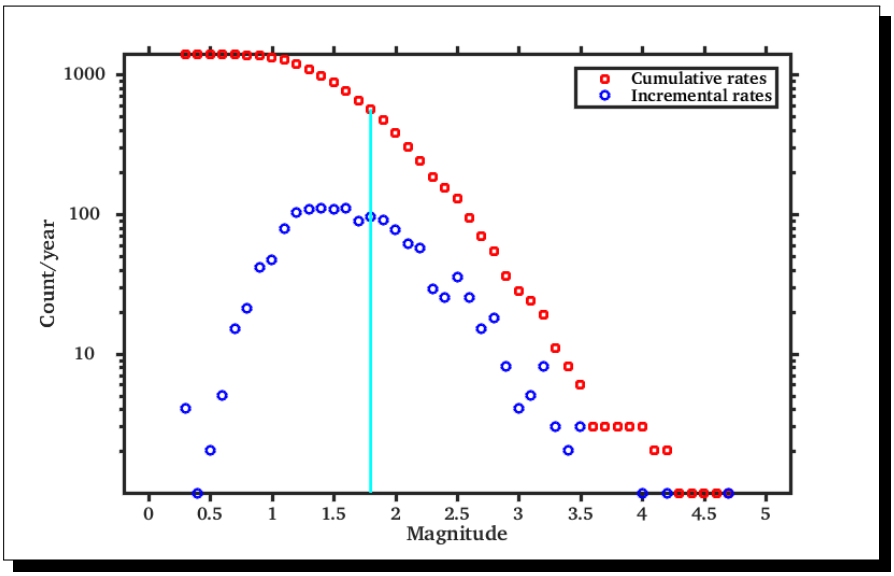

Figure 4.7. *Magnitude of completeness deduced from the cumulative plot of local earthquakes in 2021 for all events in the ENSN Bulletin.*

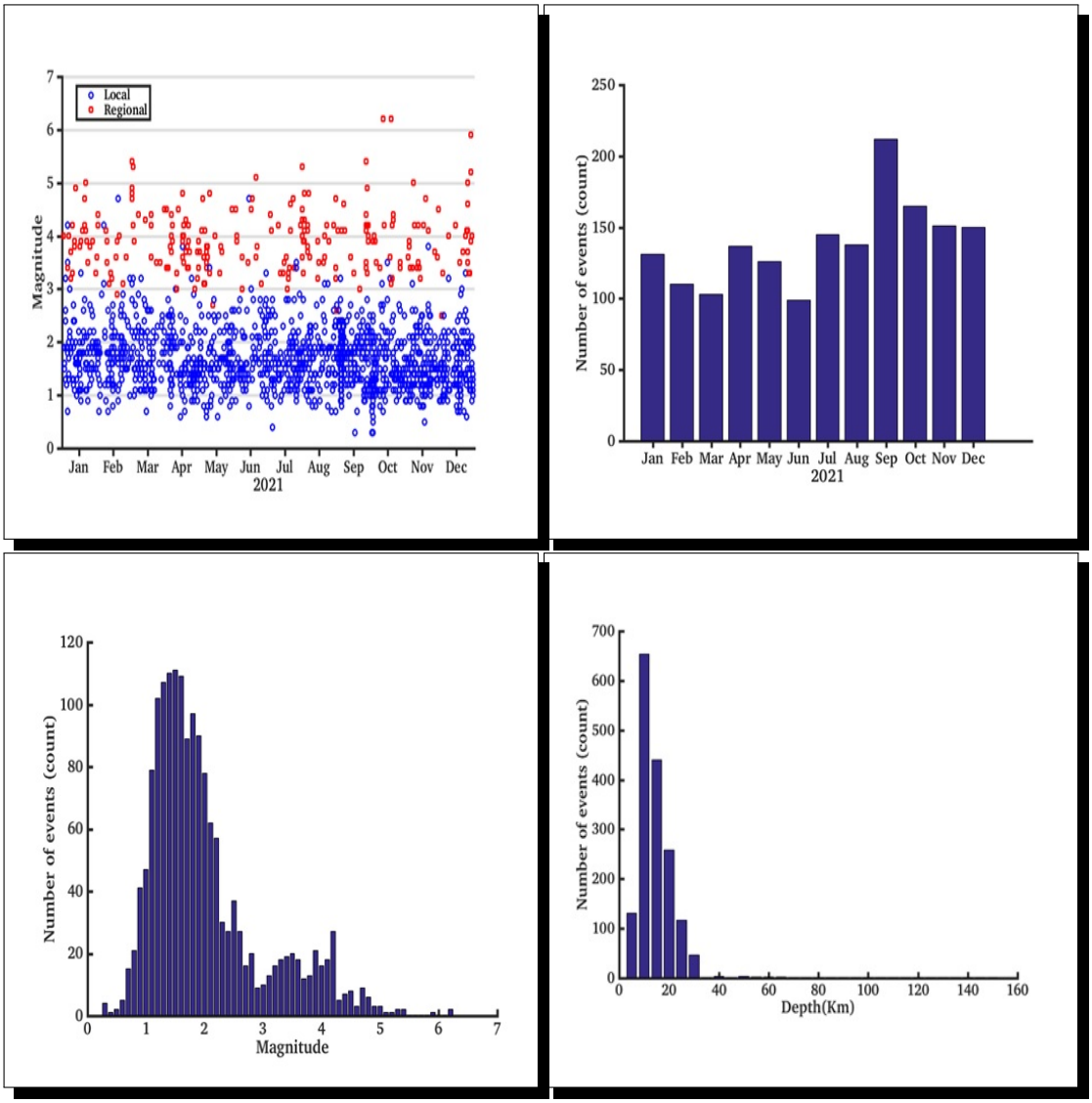

Figure 4.8. *Activity counts and distribution reported seismicity by the ENSN stations for 2021.*

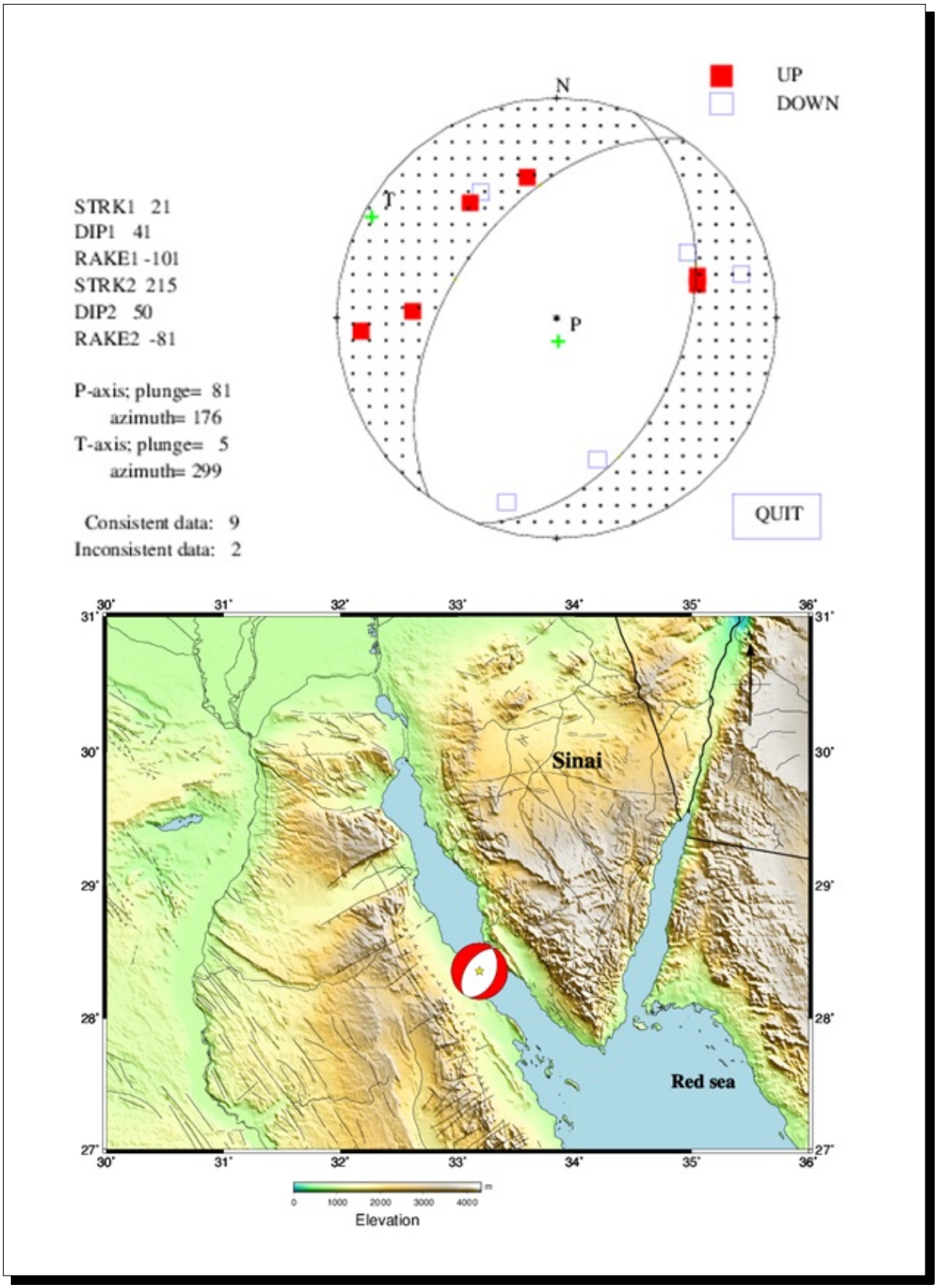

Figure 4.9. *Fault plane solution for 27, July 2021, an earthquake (3.52, Ml) occurred in the Gulf of Suez.*

The polarity of the first P-wave arrival varies between seismic stations in different directions from an earthquake.

The Red Sea is an active seismic zone in Egypt, and its activity may be attributed to the divergent plate motion between the Arabian plate and African plate. On July 27, 2021, at 14:39:13 (GMT) an earthquake of ML 3.52 Ml and occurred at the south Gulf of Suez, Egypt. The quake has been small felt in Egypt while no casualties were reported. The instrumental epicenter is located at Long: 33.187E, Lat: 28.355N). Fault plane solution reflects normal faulting mechanisms with minor strike-slip component and their nodal planes trending parallel to the main trend of the Red Sea Rift (Figure 4.9).

It is obvious that the tension forces trending NW-SE and compressional forces trending NE-SW which are in a good agreement with opening of the Red Sea. On contrary, the Northern Egyptian continental margin is characterized by moderate seismic activity.

Another event occurred south east Crete, On December 29, 2021, a moderate (Ml= 5.86) earthquake occurred approximately 309 km northwest of Alexandria (lat: 34.63N, Long:25.26E). Approximately, at the same location On May 28, 1998, a moderate (Mb = 5.5) earthquake occurred (27.64_E and 31.45_N). Fault plane solution reflects Reverse faulting mechanisms (Figure 4.10).

4.4. *Regional Moment Tensors (RMTs)*

Bulletin HYDRA software program implemented in ENSN calculates Regional Moment Tensors (RMTs) inversion automatically. Implemented approach solves for the source depth, moment magnitude, strike, dip, and rake angles of a shear-dislocation source via a time-domain inversion scheme. Figure 4.11 shows some examples of the moment tensor solutions for felt earthquakes in and around Egypt using HYDRA automatic RMT solution.

4.5. *Significant Events*

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides or

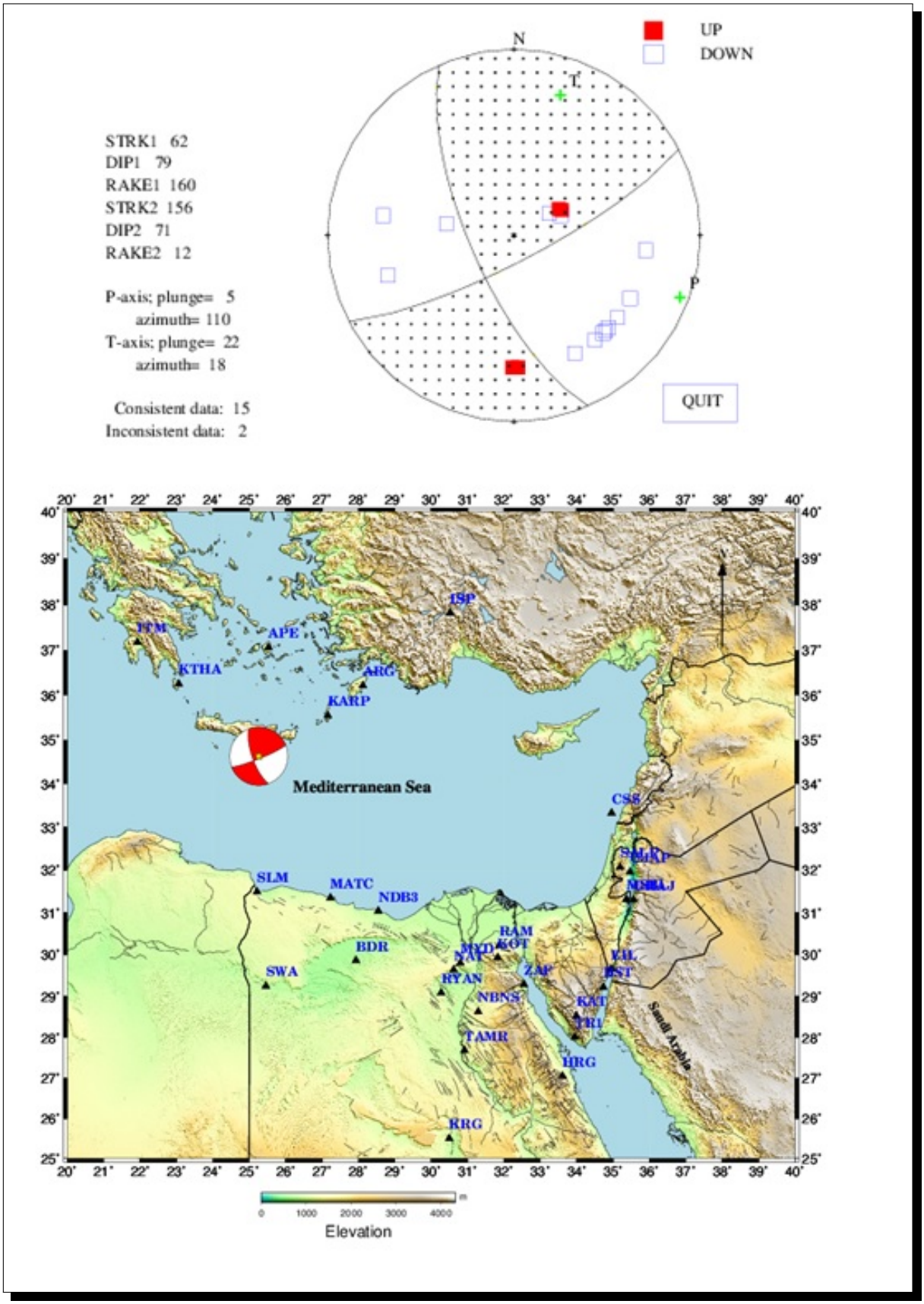

Figure 4.10. *fault plane solution for 29, December 2021, an earthquake (5.86 Ml) occurred in the south East Crete Island.*

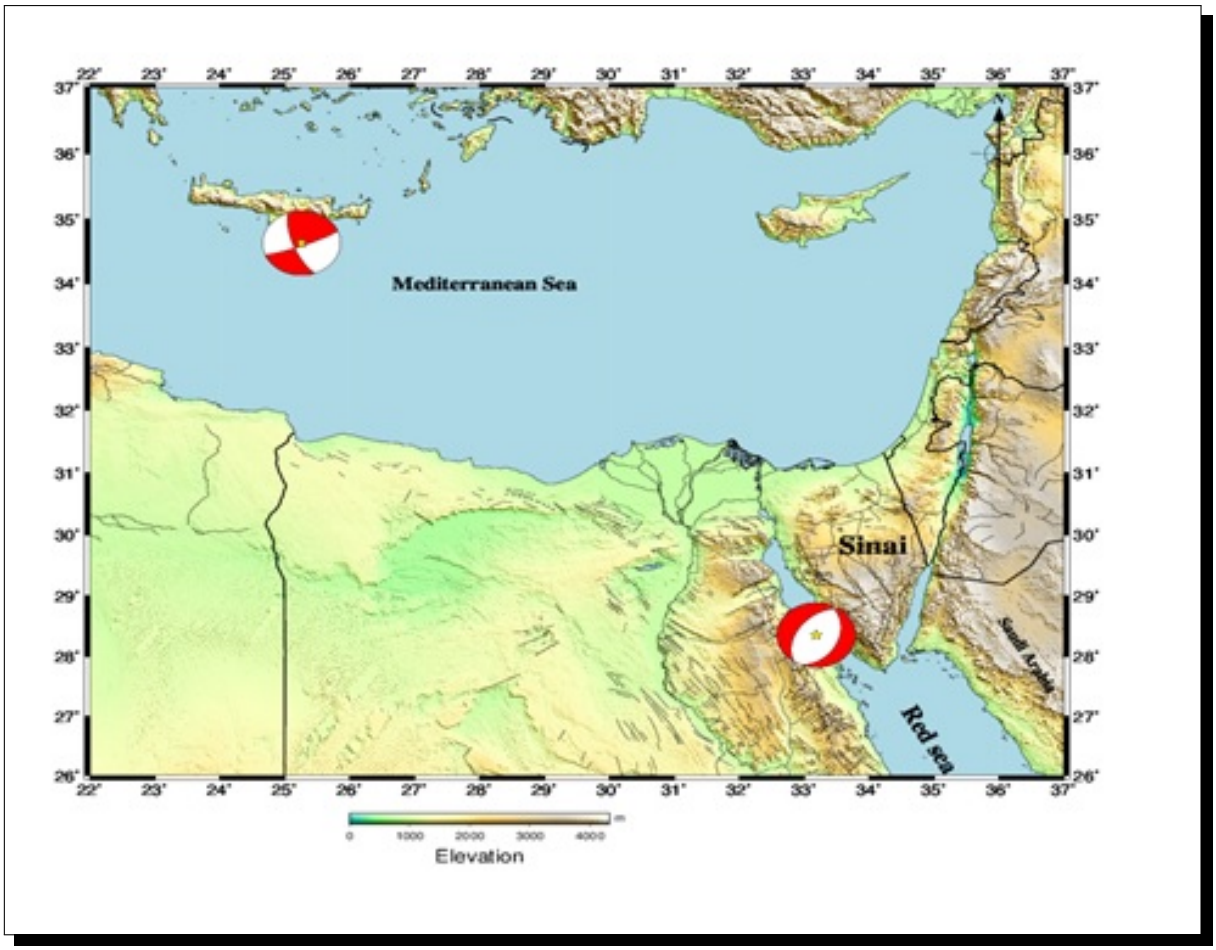

Figure 4.11. *Moment tensor solutions for felt earthquakes in and around Egypt using HYDRA*

the collapse of caverns. Earthquakes can affect hundreds of thousands of square miles; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses the ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture or collapse.

Felt throughout Crete and on many other Greek Islands but no reports of damage or casualties have been received. Also felt in mainland Greece, Turkey, Libya, Egypt and Cyprus.

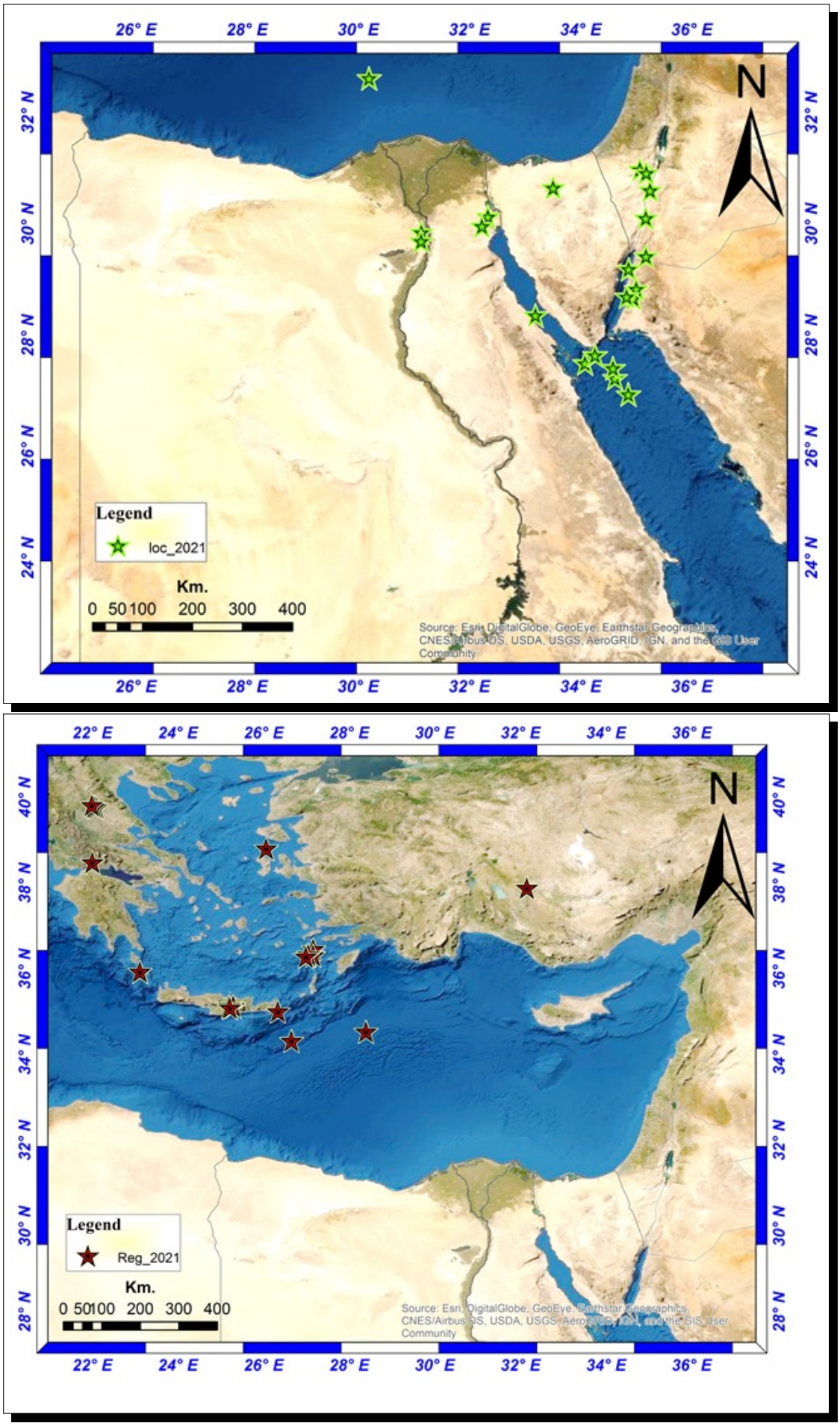

Figure 4.12. *Significant local and regional seismic events reported by ENSN during 2021.*

Chapter

5 Notable Events List

The following is a list of notable earthquakes recorded by the Egyptain National Seismic Network (*ENSN*) with local magnitude ($M_L \geq 3.0$).

For the complete list of recorded earthquakes, researchers and any other interested parties are strongly advised to contact Egyptian National Seismic Network (*ENSN*) laboratory.

Table 5.1. *List of notable earthquakes recorded by the Egyptain National Seismic Network (ENSN) with local magnitude ($M_L \geq 3.0$).*

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	1	3	13	15	30.84	27.23	34.62	15.10	3.20
2021	1	5	2	47	45.07	27.51	34.04	16.12	3.49
2021	1	7	23	56	12.52	23.08	37.45	9.50	3.04
2021	1	17	7	51	0.39	22.71	31.59	3.08	3.30
2021	2	6	16	14	49.88	22.18	34.64	19.72	4.25
2021	2	19	8	40	40.50	22.89	28.64	8.16	4.65
2021	3	3	12	26	19.20	26.94	34.87	10.00	3.08
2021	3	4	18	19	13.90	29.85	31.14	4.64	3.17
2021	3	11	2	12	14.31	22.78	31.54	1.48	3.20
2021	4	11	1	55	41.48	29.19	34.87	5.80	3.05
2021	4	25	19	49	22.56	21.89	37.98	14.89	3.21
2021	5	11	12	50	44.21	30.98	35.07	7.70	3.42
2021	6	17	21	56	38.02	27.41	34.59	14.72	3.02
2021	6	30	6	11	21.01	29.69	31.14	25.01	3.28
2021	7	27	8	24	42.97	28.36	33.19	22.26	3.43
2021	7	27	14	39	13.74	27.64	34.26	19.08	3.52
2021	8	21	19	30	4.22	28.66	34.95	3.54	3.31
2021	8	24	7	42	55.08	29.92	32.34	0.00	3.10

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	9	4	18	11	56.72	28.83	35.01	11.88	3.21
2021	10	11	20	24	10.34	30.65	33.51	1.44	3.12
2021	10	16	17	47	58.25	24.20	36.18	11.57	3.51
2021	10	18	8	45	5.87	28.69	34.83	19.06	3.23
2021	11	7	10	54	38.32	29.45	35.13	14.94	3.07
2021	12	9	17	31	24.29	34.89	23.50	27.34	3.98
2021	12	9	19	24	38.08	30.13	32.34	5.80	3.24
2021	12	21	9	6	24.38	29.96	32.22	7.47	3.03
2021	12	24	16	15	40.33	28.72	34.79	14.15	3.23
2021	1	1	16	36	18.93	35.77	28.06	15.11	3.97
2021	1	5	9	24	26.28	20.04	39.69	10.02	4.19
2021	1	5	16	47	39.67	34.46	25.53	15.76	3.37
2021	1	6	21	30	1.07	36.06	27.39	24.58	3.95
2021	1	8	1	33	31.99	38.23	28.98	15.93	3.73
2021	1	8	1	46	50.58	34.90	23.21	13.71	3.24
2021	1	9	2	52	19.36	36.81	31.07	21.16	3.29
2021	1	9	4	33	54.48	35.73	26.51	15.25	4.17
2021	1	11	1	34	32.36	35.60	26.44	10.30	3.80
2021	1	11	20	39	4.51	35.57	26.70	25.27	3.91
2021	1	12	22	9	57.90	38.43	22.25	18.99	4.91
2021	1	16	8	48	19.62	34.12	26.03	25.46	3.71
2021	1	17	11	22	39.76	34.87	24.59	17.56	3.91
2021	1	18	4	23	15.61	35.63	26.42	27.54	4.11
2021	1	20	20	35	37.18	35.96	28.21	7.00	4.21
2021	1	20	23	37	57.17	37.68	26.77	2.91	4.70
2021	1	21	12	28	34.23	36.48	28.24	9.11	4.10

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	1	21	14	27	5.72	35.03	33.52	50.04	4.95
2021	1	22	6	57	27.09	35.51	26.68	0.02	3.93
2021	1	23	10	59	56.52	35.92	28.46	17.46	3.53
2021	1	25	23	54	45.39	35.85	22.28	12.97	3.24
2021	1	27	16	12	57.46	35.03	26.53	75.45	4.00
2021	1	30	15	12	38.26	34.40	26.59	15.68	3.28
2021	1	31	14	20	12.57	35.25	27.57	21.07	3.61
2021	2	1	5	46	55.17	38.62	26.14	5.78	4.43
2021	2	1	6	0	10.00	38.69	26.14	29.77	4.23
2021	2	6	21	14	13.90	30.60	35.25	13.01	3.08
2021	2	8	1	25	18.74	36.12	25.08	152.25	4.14
2021	2	9	7	30	36.36	37.69	26.43	10.00	3.94
2021	2	9	11	3	15.65	32.62	30.20	31.73	3.52
2021	2	11	23	59	0.41	34.02	25.82	145.18	3.06
2021	2	12	1	53	8.00	36.15	26.19	142.68	3.57
2021	2	13	4	42	27.80	34.26	26.55	32.21	3.22
2021	2	17	21	13	12.71	34.19	26.29	12.54	3.62
2021	2	18	3	4	34.95	38.07	23.47	18.88	3.91
2021	2	20	17	0	46.36	35.76	28.07	21.70	3.90
2021	2	23	19	14	4.47	34.11	26.08	21.37	3.10
2021	2	26	15	46	46.06	34.29	26.08	10.00	3.57
2021	3	3	10	16	30.25	38.33	22.89	24.16	5.40
2021	3	3	10	34	10.68	39.40	22.05	16.86	4.65
2021	3	3	11	45	48.57	39.35	22.02	21.26	4.81
2021	3	3	18	24	8.61	39.37	21.89	5.27	4.87
2021	3	4	9	36	19.27	39.45	21.87	10.01	4.16

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	3	4	18	38	20.44	39.45	22.00	10.02	5.29
2021	3	5	0	45	20.02	34.34	26.84	18.28	3.87
2021	3	9	4	30	34.40	34.20	26.17	31.18	4.38
2021	3	15	1	55	47.75	37.13	28.87	11.71	4.34
2021	3	20	3	9	6.43	35.35	27.33	16.44	3.62
2021	3	20	22	50	38.61	35.21	27.64	10.53	4.40
2021	3	20	23	3	29.72	35.07	27.59	3.57	4.18
2021	3	25	17	32	52.96	34.50	25.62	30.66	3.51
2021	3	28	23	26	12.11	35.79	27.62	11.68	3.51
2021	4	1	12	33	36.89	36.31	26.82	108.91	4.46
2021	4	3	6	10	11.18	35.01	22.88	11.64	4.50
2021	4	3	17	58	51.32	34.26	25.05	10.98	3.39
2021	4	4	11	18	18.66	34.08	26.25	2.80	3.44
2021	4	6	8	8	34.54	34.52	33.68	29.49	3.77
2021	4	7	1	32	24.11	33.01	27.73	22.42	4.43
2021	4	7	7	8	19.41	36.33	27.21	21.43	3.96
2021	4	7	21	54	57.68	36.38	27.11	15.28	3.66
2021	4	8	0	33	48.87	36.39	27.13	11.66	4.15
2021	4	8	15	23	6.76	36.42	27.16	12.65	3.88
2021	4	12	17	14	52.81	34.19	26.21	13.20	3.05
2021	4	12	20	53	37.44	32.72	22.96	22.82	3.30
2021	4	13	20	28	3.62	36.49	27.22	10.96	4.77
2021	4	17	11	59	27.51	31.61	21.02	20.25	3.80
2021	4	17	17	8	3.97	36.30	27.26	26.25	4.54
2021	4	17	19	8	33.11	35.85	27.47	31.05	3.56
2021	4	17	20	57	14.73	36.24	27.26	10.92	3.91

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	4	17	22	36	2.25	35.95	27.43	31.77	3.95
2021	4	18	3	24	57.65	36.42	27.19	30.48	3.95
2021	4	18	16	26	26.94	36.33	27.15	4.90	4.17
2021	4	18	19	19	37.31	36.61	27.00	29.54	3.53
2021	4	20	5	9	54.78	36.28	27.20	21.79	4.27
2021	4	20	8	21	56.47	36.51	25.55	10.60	3.87
2021	4	21	5	46	42.50	36.39	26.90	21.33	3.79
2021	4	21	22	39	27.58	34.57	25.34	15.28	3.40
2021	4	22	0	6	15.39	36.30	27.19	3.28	3.73
2021	4	22	0	6	17.25	36.30	27.19	26.04	3.90
2021	4	22	19	49	58.56	36.39	27.22	14.85	4.20
2021	4	22	21	48	49.74	34.39	23.33	14.27	3.41
2021	4	23	15	4	25.68	35.38	27.60	19.55	3.73
2021	4	28	2	39	2.53	32.61	25.73	7.41	3.03
2021	4	30	5	19	8.62	34.87	26.39	3.44	3.22
2021	4	30	7	52	19.64	36.62	31.73	22.53	3.68
2021	5	1	9	43	23.52	34.81	23.35	24.52	3.87
2021	5	1	14	15	4.24	36.35	26.83	102.40	3.39
2021	5	2	9	16	21.03	36.55	22.91	8.95	3.66
2021	5	4	15	2	3.31	34.12	25.89	10.01	4.08
2021	5	5	23	40	32.49	36.19	27.71	10.20	4.73
2021	5	6	9	31	49.41	33.99	25.85	5.05	3.62
2021	5	6	16	48	39.97	35.58	26.52	25.17	3.09
2021	5	6	21	44	43.48	34.05	25.73	6.76	3.09
2021	5	7	3	8	9.77	37.55	19.70	29.34	4.13
2021	5	7	15	0	30.99	34.04	25.66	8.49	3.12

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	5	8	10	18	23.08	37.83	21.72	13.07	3.71
2021	5	8	11	41	45.63	36.48	27.29	25.91	3.80
2021	5	8	14	23	21.55	35.63	28.40	6.39	3.48
2021	5	8	21	40	11.75	35.73	23.27	49.40	3.41
2021	5	9	17	17	6.06	36.86	30.99	10.72	3.83
2021	5	9	21	44	33.51	36.36	28.32	35.03	3.65
2021	5	11	18	51	1.75	35.79	25.76	11.81	3.26
2021	5	11	21	31	3.00	40.79	21.12	29.95	4.26
2021	5	16	0	16	30.10	34.58	25.09	13.48	4.00
2021	5	20	1	31	8.54	35.23	26.55	25.15	3.31
2021	5	21	22	23	31.45	36.31	27.16	24.95	3.80
2021	5	22	22	51	11.18	33.97	25.80	5.89	3.69
2021	5	31	6	23	37.97	35.02	32.58	10.33	4.51
2021	6	3	15	6	9.66	38.01	22.07	9.62	4.54
2021	6	4	1	5	27.65	35.14	25.47	12.66	4.22
2021	6	4	20	23	7.98	36.59	27.20	31.99	4.03
2021	6	9	2	36	30.90	35.15	25.62	25.63	3.62
2021	6	9	4	46	13.98	34.40	26.26	14.93	3.59
2021	6	14	19	1	18.65	34.61	25.81	11.87	3.50
2021	6	17	0	35	12.69	35.40	24.80	20.67	4.45
2021	6	17	16	58	3.61	30.92	35.17	5.52	3.02
2021	6	18	16	51	24.51	35.53	28.22	10.85	4.67
2021	6	21	6	23	1.03	36.34	21.70	15.55	3.65
2021	6	21	22	14	14.97	36.36	27.17	27.07	5.13
2021	6	22	15	44	27.46	36.41	27.10	20.00	3.84
2021	6	26	7	23	37.14	34.42	26.90	23.94	3.06

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Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	7	4	17	30	9.03	33.66	28.58	30.58	4.43
2021	7	5	20	40	29.66	34.98	25.10	9.12	4.07
2021	7	11	0	0	17.81	38.38	23.31	16.79	4.17
2021	7	13	10	17	17.99	35.98	29.75	16.90	3.30
2021	7	15	19	25	12.88	34.12	25.86	28.94	3.33
2021	7	16	2	9	11.53	37.65	19.83	11.43	3.51
2021	7	16	17	17	17.53	36.31	27.13	22.45	3.45
2021	7	18	4	56	54.58	35.20	25.13	10.14	3.65
2021	7	19	21	4	12.89	36.18	30.68	20.23	3.57
2021	7	20	4	50	10.95	36.41	27.26	21.80	3.29
2021	7	20	6	14	57.34	36.55	27.19	16.51	3.17
2021	7	21	15	11	28.41	34.21	26.19	21.25	3.37
2021	7	22	14	16	26.12	36.35	27.10	10.66	4.61
2021	7	22	16	49	30.96	40.58	23.47	4.99	4.14
2021	7	24	2	7	37.51	35.07	25.24	13.84	4.72
2021	7	25	20	55	15.83	36.87	35.55	20.01	3.23
2021	7	31	19	57	54.35	36.23	27.08	0.08	4.47
2021	7	31	23	25	42.05	36.36	27.09	9.09	4.16
2021	8	1	4	31	28.65	36.30	27.04	16.75	5.30
2021	8	1	5	12	35.18	36.36	27.06	8.38	4.30
2021	8	1	8	37	33.59	36.27	27.06	12.07	4.01
2021	8	1	9	14	28.85	36.21	27.04	9.64	4.47
2021	8	1	16	3	51.30	36.31	27.14	23.54	4.04
2021	8	1	17	44	26.98	36.28	27.14	23.44	3.74
2021	8	2	22	11	13.29	36.35	27.09	7.65	3.34
2021	8	2	23	56	18.65	36.31	27.00	8.95	3.87

Continued on next page

Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	8	3	12	38	20.13	36.30	27.20	66.30	4.84
2021	8	3	17	39	59.58	36.23	27.09	14.47	3.94
2021	8	3	19	53	14.75	36.31	27.01	6.47	4.30
2021	8	3	22	50	45.29	36.22	27.12	25.12	4.06
2021	8	3	23	49	27.89	36.31	27.09	18.74	4.81
2021	8	6	10	52	42.91	36.11	27.05	28.41	4.17
2021	8	6	10	58	15.70	36.30	27.10	23.88	3.71
2021	8	6	16	1	11.76	36.37	27.08	22.53	3.75
2021	8	6	20	41	58.42	36.32	27.13	7.33	4.10
2021	8	7	1	39	44.68	36.28	27.11	10.76	4.81
2021	8	8	9	13	9.45	35.82	28.54	20.93	3.48
2021	8	15	11	58	30.21	36.40	27.20	21.79	3.20
2021	8	15	14	34	20.43	36.30	27.14	21.64	3.87
2021	8	16	5	31	39.64	37.37	22.11	3.54	3.52
2021	8	20	11	45	9.76	36.41	27.24	22.04	3.45
2021	8	21	0	47	59.20	34.48	25.36	14.67	3.58
2021	8	21	13	21	22.20	36.32	27.06	12.40	4.16
2021	8	23	7	19	31.94	34.14	26.32	3.07	4.25
2021	8	25	5	0	0.07	35.08	23.12	2.70	3.97
2021	8	29	21	7	41.40	37.11	25.23	10.06	4.16
2021	8	31	9	18	49.71	34.80	32.48	9.93	3.19
2021	8	31	11	4	28.40	38.97	30.16	14.89	4.65
2021	8	31	18	32	15.43	36.18	28.10	60.34	3.35
2021	9	2	21	12	53.31	36.41	27.08	7.06	4.10
2021	9	5	21	27	52.58	35.91	27.62	9.35	4.12
2021	9	7	11	14	58.62	36.01	31.00	8.55	4.56

Continued on next page

Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	9	8	1	40	3.06	36.37	27.26	6.54	4.12
2021	9	13	8	1	11.41	35.08	26.79	22.51	3.63
2021	9	16	1	8	20.04	34.91	32.00	2.66	3.30
2021	9	21	0	5	48.21	33.78	28.49	31.03	3.01
2021	9	27	6	17	20.57	35.12	25.20	10.38	5.38
2021	9	27	6	37	43.76	35.12	25.21	5.75	4.16
2021	9	27	7	30	46.21	35.12	25.24	12.37	4.24
2021	9	27	8	22	0.05	35.16	25.26	21.06	4.06
2021	9	27	11	2	26.71	35.09	25.23	14.04	4.42
2021	9	27	12	31	48.56	35.28	25.25	4.68	3.35
2021	9	27	18	15	45.85	35.07	25.17	21.67	3.55
2021	9	27	20	10	1.67	35.07	25.19	16.11	4.09
2021	9	27	21	37	10.66	35.25	25.26	2.14	4.12
2021	9	28	4	48	10.18	35.09	25.22	20.40	5.13
2021	9	28	6	1	5.99	36.28	28.50	57.52	4.16
2021	9	28	12	9	52.06	35.28	25.22	2.15	3.53
2021	9	28	15	13	16.11	35.23	25.18	6.42	4.18
2021	9	29	11	54	49.15	35.11	25.24	7.28	3.94
2021	9	29	22	22	16.62	36.43	27.21	3.98	4.22
2021	9	29	23	27	39.90	36.45	27.16	20.74	3.95
2021	10	3	7	15	7.71	37.48	30.18	2.05	3.92
2021	10	4	14	3	23.95	36.45	27.14	9.24	3.97
2021	10	5	7	54	11.06	36.16	27.07	0.95	3.93
2021	10	6	7	13	40.95	35.51	26.52	28.30	3.52
2021	10	9	9	15	16.32	34.77	23.65	31.50	3.40
2021	10	12	9	24	4.49	34.94	26.43	9.48	6.23

Continued on next page

Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	10	13	18	22	53.14	35.79	21.70	74.07	4.16
2021	10	18	2	27	44.36	34.94	28.95	7.66	3.56
2021	10	19	5	32	29.55	34.59	28.57	31.56	6.22
2021	10	19	6	50	17.95	34.33	28.46	29.81	3.14
2021	10	20	2	44	5.73	35.09	25.22	14.75	4.22
2021	10	20	4	52	19.56	35.80	29.71	12.44	3.19
2021	10	21	8	12	58.39	35.08	25.17	26.77	4.28
2021	10	21	9	38	38.35	35.04	25.20	5.87	4.39
2021	10	27	4	53	4.26	34.72	32.77	11.27	3.46
2021	10	27	13	43	26.10	34.80	32.84	12.63	3.42
2021	11	3	15	9	44.50	35.27	23.22	15.13	3.63
2021	11	4	10	53	9.03	34.43	28.44	14.55	3.91
2021	11	4	21	17	12.11	35.40	27.27	65.45	3.81
2021	11	5	4	28	12.72	34.39	26.61	8.74	3.65
2021	11	7	2	17	55.64	35.11	25.25	24.82	3.41
2021	11	8	17	43	23.55	37.88	32.11	20.03	4.98
2021	11	9	9	12	26.45	36.33	22.94	20.21	4.16
2021	11	11	23	32	8.96	34.22	33.60	3.04	3.40
2021	11	12	3	45	58.33	35.19	23.26	88.08	4.17
2021	11	12	14	26	15.33	34.72	33.16	6.47	3.54
2021	11	13	7	53	43.89	35.76	31.22	7.67	3.43
2021	11	14	20	35	7.09	36.10	27.76	7.09	3.22
2021	11	17	18	30	1.71	34.35	26.74	24.21	4.24
2021	11	19	13	27	6.99	37.60	19.93	10.29	4.69
2021	11	21	20	35	43.97	35.96	30.95	15.59	4.12
2021	11	21	23	49	28.79	20.86	38.21	14.70	3.76

Continued on next page

Table 5.1 – continued from previous page

Yr.	Mon.	Dy.	Hr.	Min.	Sec.	Lat.	Long.	Dep.	Mag.
2021	11	27	5	14	9.67	34.06	26.27	12.67	3.66
2021	11	29	1	36	38.88	34.36	26.98	13.35	3.60
2021	11	30	4	0	40.81	37.61	26.09	7.44	4.50
2021	12	4	2	39	26.27	35.29	23.19	48.87	3.30
2021	12	15	3	43	28.61	34.32	26.65	9.59	4.25
2021	12	19	7	23	38.92	34.71	26.64	15.40	3.54
2021	12	22	11	21	18.26	34.68	24.08	10.34	3.69
2021	12	24	1	57	34.61	30.82	27.17	0.04	3.50
2021	12	25	12	19	42.79	36.43	27.18	27.59	4.09
2021	12	26	15	15	10.12	35.14	26.93	3.40	4.64
2021	12	26	18	59	1.99	35.11	27.15	1.17	5.02
2021	12	26	22	2	20.59	35.08	27.04	7.54	4.07
2021	12	26	22	15	49.25	35.08	26.96	4.06	3.50
2021	12	26	22	46	50.88	35.14	26.97	13.65	3.69
2021	12	27	23	15	33.89	35.07	26.83	0.17	3.29
2021	12	28	21	29	17.41	35.06	26.90	0.04	3.33
2021	12	29	5	8	7.18	34.64	25.26	22.31	5.86
2021	12	29	16	47	6.56	34.66	25.34	27.44	5.23
2021	12	29	23	6	39.77	35.11	25.31	8.53	3.91
2021	12	30	21	55	4.80	34.80	23.70	60.02	3.99

مشروع مراقبة المحاجر

أصبح البحث العلمي التطبيقي ركيزة ونقطة انطلاق للتطور الصناعي والتقدم الاقتصادي في جميع البلدان حيث يساهم في حل المشكلات التي تواجهها المؤسسات والصناعة. بدلاً من ذلك، أصبح نشاطًا اقتصاديًا، ويلعب دورًا مهماً وحيوياً في تقدم ونمو الصناعة والإقتصاد. وإذا فرضنا أن البحث العلمي بالتعاون مع الصناعات المختلفة مهم للدول المتقدمة. في هذه الحالة، يكون الأمر أكثر أهمية وإلحاحًا بالنسبة للبلدان والمؤسسات النامية، حيث يتم استخدام الخطط الموضوعة على أسس سليمة ومتينة، لتجنب الأخطاء، ودفع الخسائر، وتحسين الأداء، وزيادة العوائد.

ومن هذا المنطلق، فإن التخطيط السليم للصناعات المختلفة التي تستخدم التفجيرات للحصول على خامات المحاجر مثل (الاسمنت، الذهب، البازلت، الدولوميت) من حيث اختيار مواقعها والتحكم الدقيق فيها وما قد تسببه من إزعاج للمواطنين نتيجة التفجيرات التي تُجرى للحصول على المواد الخام وكذلك الحفاظ على البيئة، فقد آلت إلى المعهد القومي للبحوث الفلكية والجيوفيزيقية مراقبة التفجيرات التي تُجرى بمحاجر شركات الأسمنت. نظراً لما يحتويه المعهد من أجهزة ومحطات لرصد أي هزات طبيعية أو صناعية داخل القطر المصري وخارجه. بذل فريق العمل خلال العام ٢٠٢١ الكثير من الجهود رغم الظروف العالمية الاقتصادية في توسيع الخدمة لتشمل الصناعات الأخرى بجانب الأسمنت مثل محاجر الذهب والدولوميت.

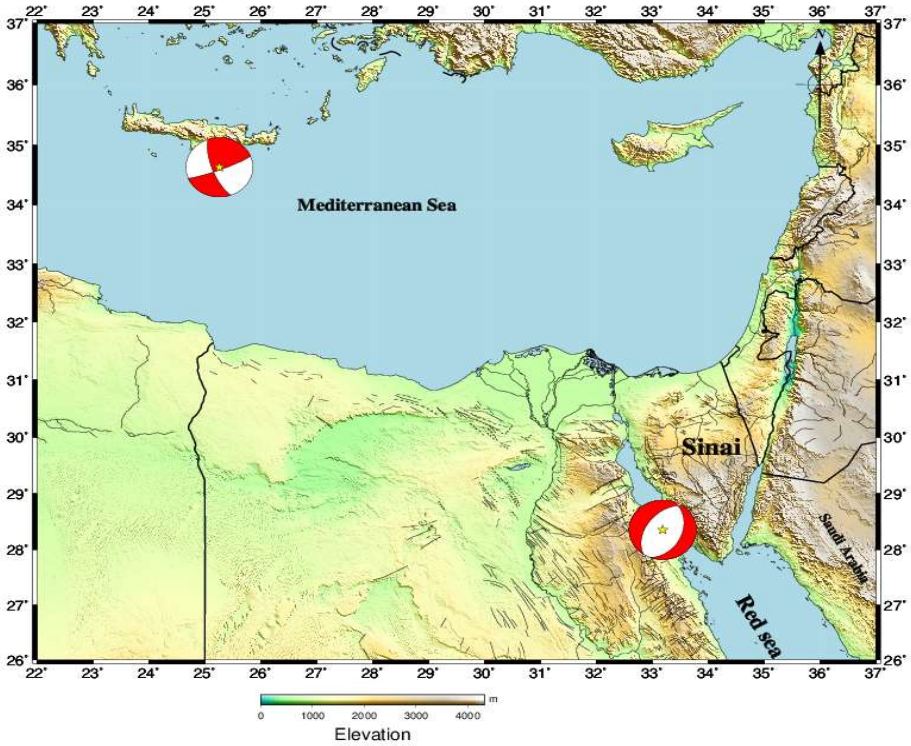
شمال شرق مرسى مطروح، تم الاحساس بهذا الزلزال من قبل سكان مدينة القاهرة وبعض المدن الأخرى.

مشروع مراقبة الزلازل والهزات الارضية حول حرم الموقع النووي بالضبعة المزمع إنشائه

إن الهدف الرئيسي لمشروع الضبعة هو مراقبة النشاط الزلزالي حول حرم موقع محطة الطاقة النووية المستقبلية. يتم حالياً رصد الزلازل بشكل مستمر لموقع الضبعة والمناطق المحيطة به من قبل شبكة الزلازل المحلية بالضبعة (DLSN) والشبكة القومية المصرية لرصد الزلازل (ENSN).

إن التطوير المستمر لمحطات الرصد وكذلك التحديث المستمر لطرق الرصد والتحليل للبيانات المسجلة، أدى الى زيادة قدرة الشبكة المحلية المصرية بالضبعة على رصد وتُوقِيع الهزات الزلزالية الصغيرة، سواء كانت طبيعية أو اصطناعية بقوة ٠,٥ بمقياس القدر الزلزالي بدائرة نصف قطرها ٥٠ كم حول الحرم النووي.

تم نقل بيانات المحطات الزلزالية العاملة بشبكة الضبعة القومية المحلية عبر الاتصالات اللاسلكية إلى وحدة التسجيل الموجودة في موقع الضبعة خلال الفترة الزمنية ٢٠٠٥ إلى ٢٠١٠. منذ عام ٢٠١٣ تم تطوير نظام الرصد الآلي عبر الإنترنت عن الحالة الفنية للمحطات لضمان الاستجابة السريعة لأي عيوب تحدث في النظام.



شكل ١٥: ميكانيكية الحركة في مكامن الزلازل الكبيرة داخل مصر وما حولها

الزلازل التي تم الإحساس بها خلال عام ٢٠٢١ في مصر:

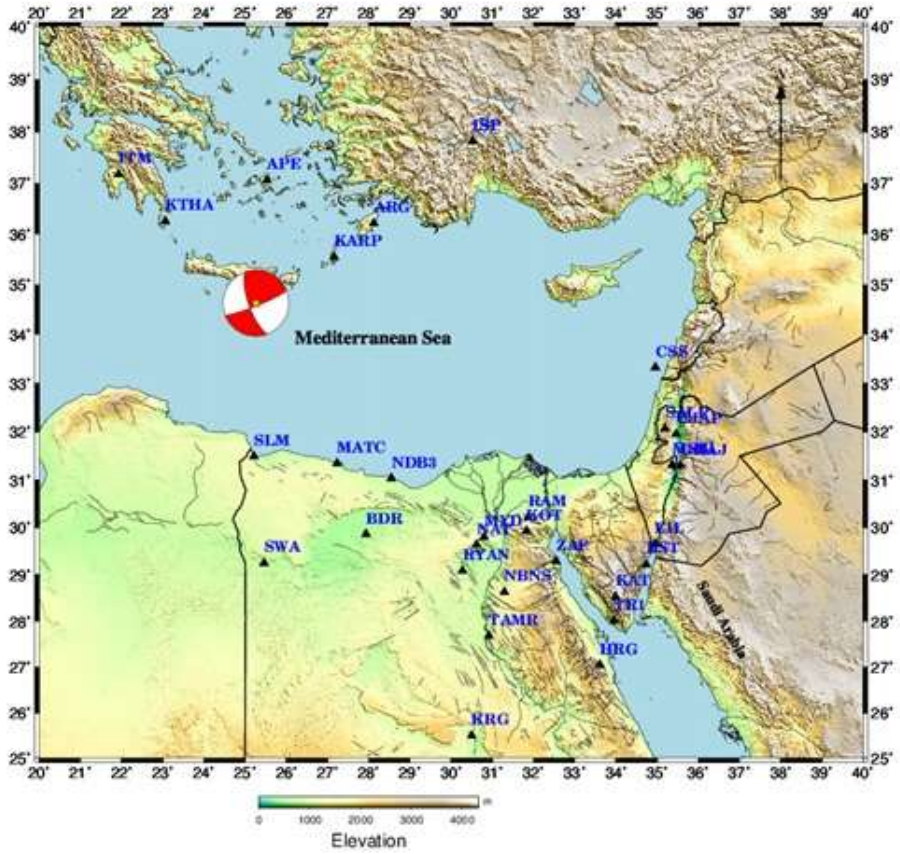
يوضح الشكل رقم ١٥ ميكانيكية الحركة في مكامن الزلازل وأهم الزلازل التي حدثت خلال عام ٢٠٢١م .
ومن أهم الزلازل التي حدثت خلال عام ٢٠٢١ م وشعر بها المواطنون هي:

*** ٢٧ يوليو ٢٠٢١، حدث زلزال بقوة (M_L= ٣,٥٢) في خليج السويس.**

*** ٢٩ ديسمبر ٢٠٢١ حدث زلزال بقوة (M_L= ٥,٨٦) جنوب شرق جزيرة كريت على بعد ٦٠٠ كم**

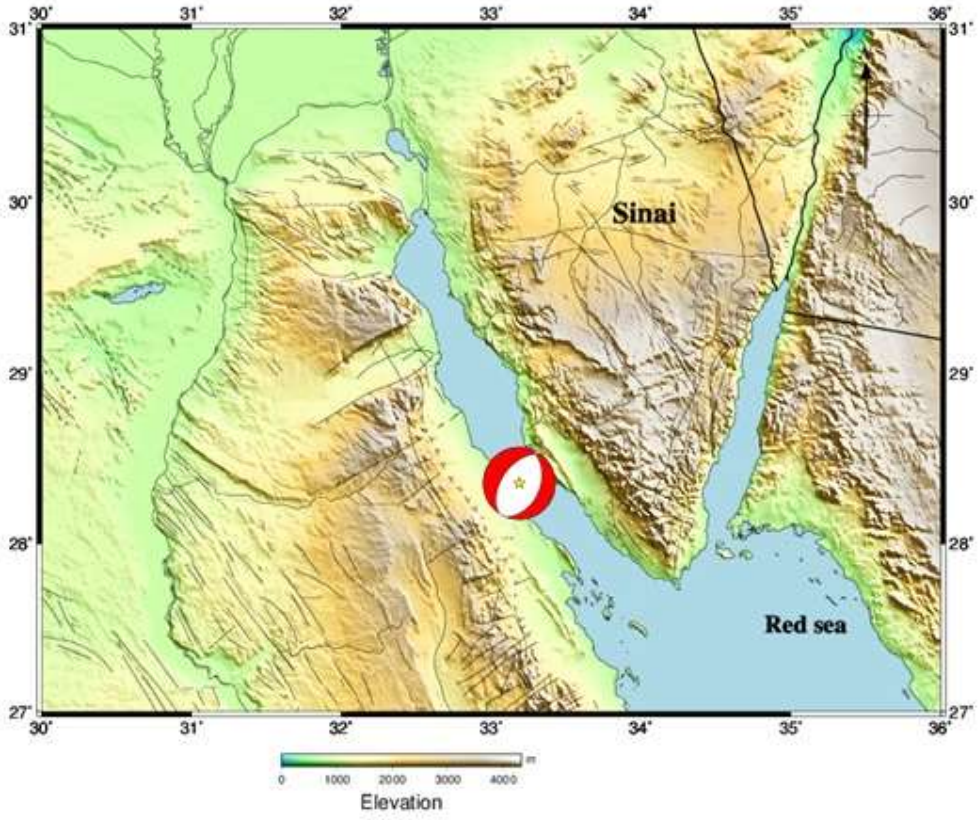
٢- زلزال كريت

وعلى العكس في ذلك تتميز الحافة القارية في شمال مصر بالنشاط الزلزالي المعتدل كما فى الشكل نفسه. حيث انه في ٢٩ ديسمبر ٢٠٢١ في تمام الساعة ٠٥:٠٨:٠٧ (بتوقيت جرينتش) حدث زلزال قوته (٥,٨٦ درجة على مقيس ريختر) في جنوب شرق جزيرة كريت على بعد ٦٠٠ كم شمال شرق مرسى مطروح شكل (١٤). ويقع مركز الزلزال عند ٣٤,٦٣ شمالاً و٢٥,٢٦ شرقاً، وقد شعر السكان بهذا الزلزال بينما لم ترد أنباء عن وقوع أي خسائر ويوضح الشكل رقم (١٥) ميكانيكية الحركة لهذه الهزة وقد يتأثر شمال مصر ببعض الزلازل متوسطة الحجم.

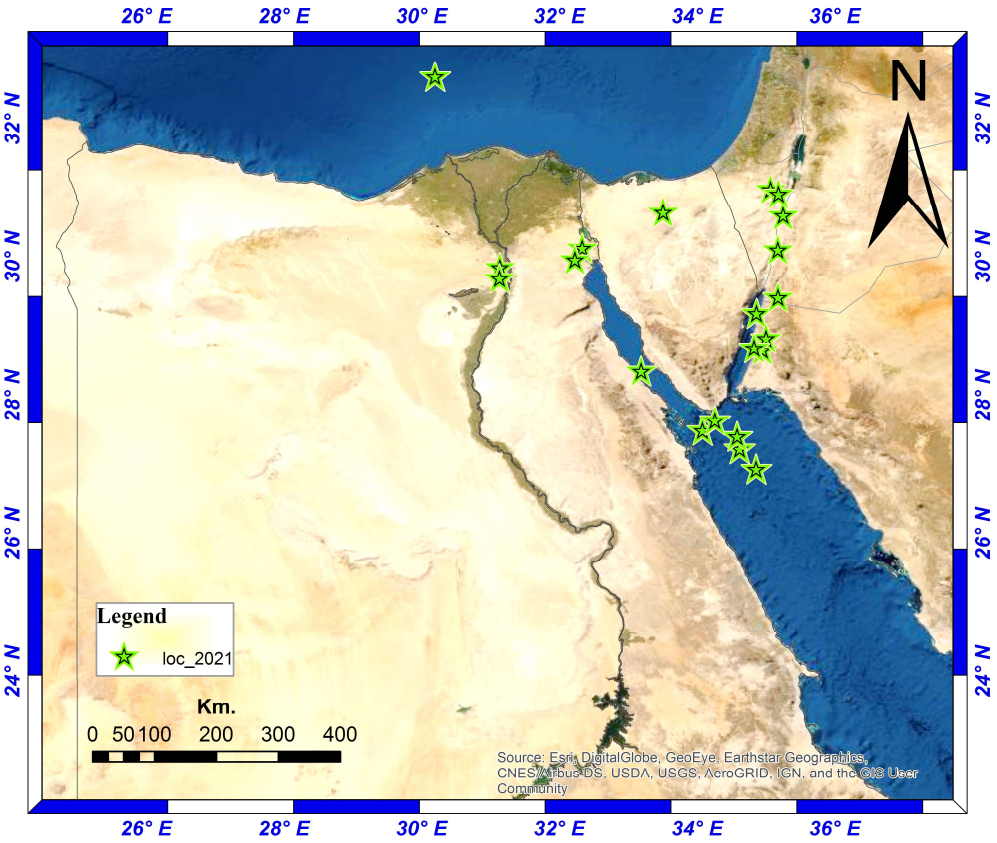


شكل رقم ١٤: يوضح نوع الصدع المسبب للزلزال (صدع طبيعي رأسي مع نسبة صغيرة لإزاحة جانبية أفقية)، والذي حدث يوم ٢٩ ديسمبر ٢٠٢١ م في البحر المتوسط، جنوب شرق جزيرة كريت وبلغت قوته ٥,٤ على مقياس ريختر

ميكانيكية الحركة لهذه الهزة والتي تشير إلى أن الصدع المسبب لهذه الهزة عبارة عن صدع طبيعي رأسي مع نسبة صغيرة لإزاحة جانبية أفقية تتفق بالتوازي مع الاتجاه الرأسي لصدع البحر الأحمر. ومن الواضح أن قوى الشد تأخذ اتجاه شمال غرب – جنوب شرق وقوى الضغط تأخذ اتجاه شمال شرق- جنوب غرب وهي تتفق مع القوى العاملة والمؤثرة في انفتاح البحر الأحمر.



شكل رقم ١٣: يوضح نوع الصدع المسبب للزلزال (صدع طبيعي رأسي مع نسبة صغيرة لإزاحة جانبية أفقية) والذي حدث يوم ٢٧ يوليو ٢٠٢١م في خليج السويس وبلغت قوته ٣.٥٢.

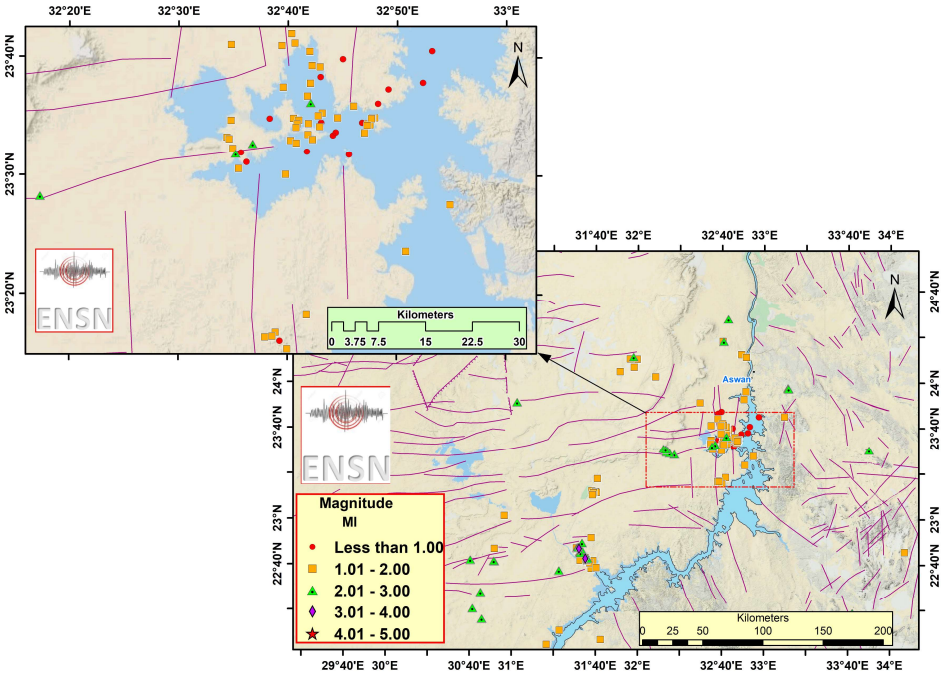


شكل رقم ١٢: تسجيلات محطات العجلة الزلزالية لعام ٢٠٢١ م لبعض الزلازل المحسوسة.

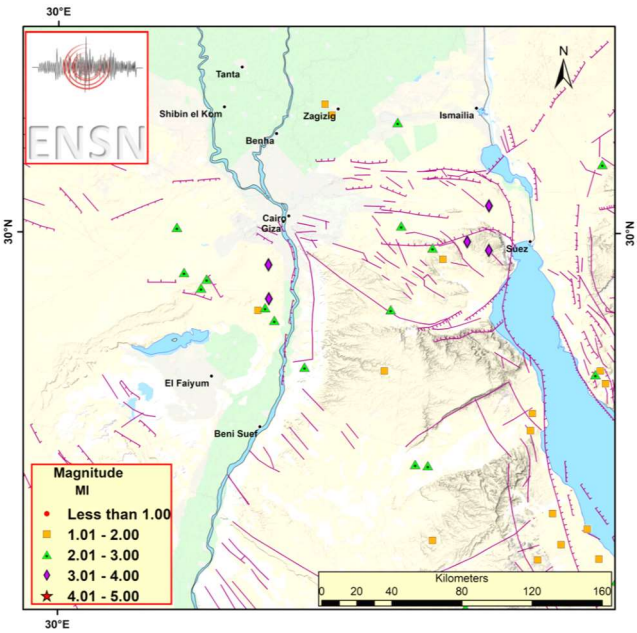
أمثلة لبعض الزلازل المسجلة خلال عام ٢٠٢١

١- زلزال البحر الأحمر

يعتبر البحر الأحمر من أهم المناطق النشطة زلزالياً في مصر. حيث يعزى هذا النشاط الزلزالي إلى حركة الصفيحة المتباينة بين الصفيحة العربية والصفيحة الإفريقية. في ٢٧ يوليو ٢٠٢١ في تمام الساعة ١٣:٣٩:١٤ (بتوقيت جرينتش) حدث زلزال قوته (٣,٥٢ درجة على مقيس ريختر) في خليج السويس شكل (١٣)، وقد شعر السكان بهذا الزلزال بينما لم ترد أنباء عن وقوع أي خسائر. ويقع مركز الزلزال عند ٢٧,٦٤ شمالاً و٣٤,٢٦ شرقاً ويوضح الشكل رقم (١٥)

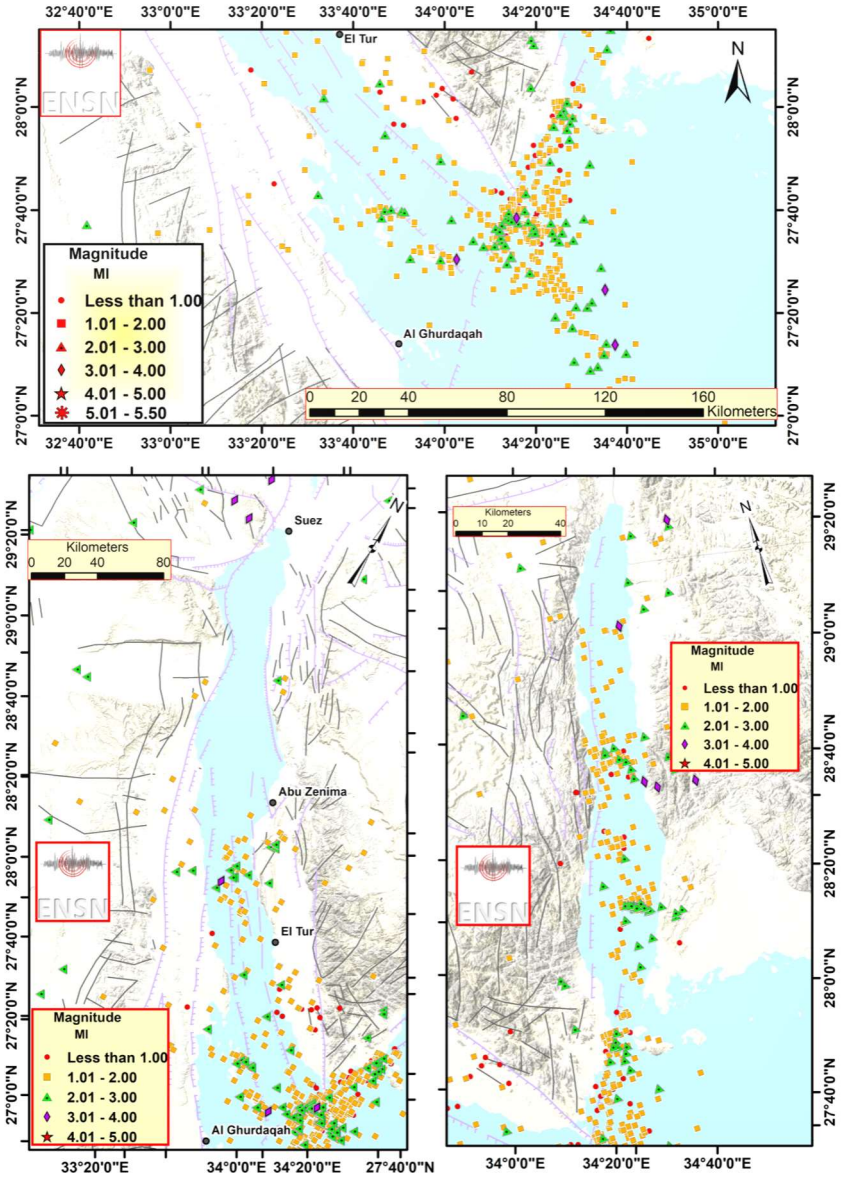


شكل رقم ١٠: النشاط الزلزالي المحلي داخل جمهورية مصر العربية والمسجل خلال عام ٢٠٢١ م بمنطقة أسوان وبحيرة السد العالي.



شكل رقم ١١: النشاط الزلزالي المحلي داخل جمهورية مصر العربية والمسجل خلال عام ٢٠٢١ م، القاهرة - السويس

كما تحدث زلازل قليلة جنبا إلى جنب مع جنوب الأردن، شمال السودان، البحر الأحمر، وعلى طول نظام صدع البحر الميت وتسجيل تفجير لبنان المؤسف الشهير الذي حدث في مرفأ بيروت في شهر أغسطس. ويمثل الشكل رقم ١٢ تسجيلات محطات العجلة الزلزالية لعام ٢٠٢١ م لبعض الزلازل المحسوسة.

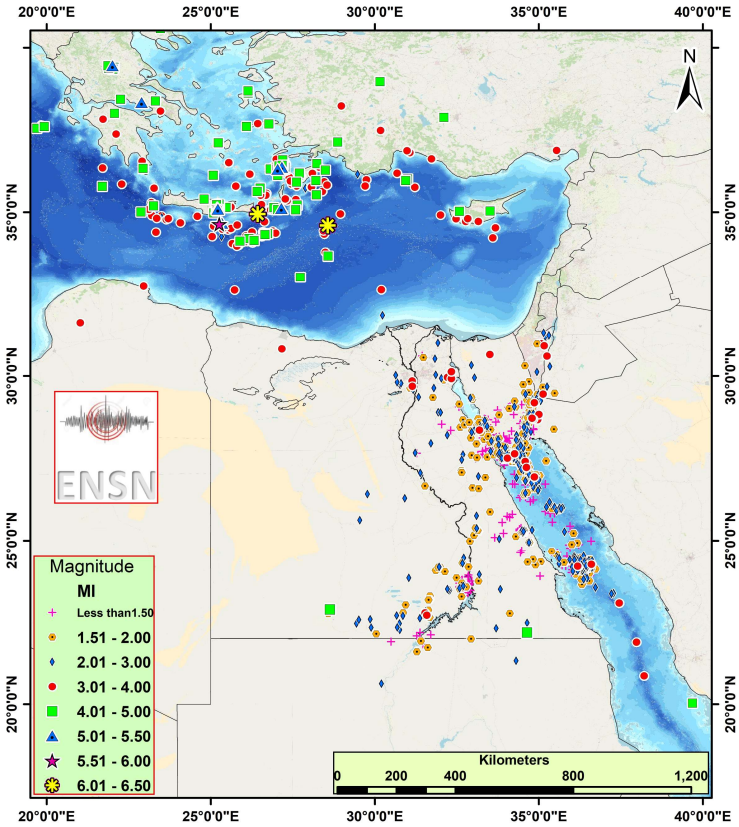


شكل رقم ٩: النشاط الزلزالي المحلي خلال عام ٢٠٢١م في خليج السويس وخليج العقبة وشمال البحر الأحمر

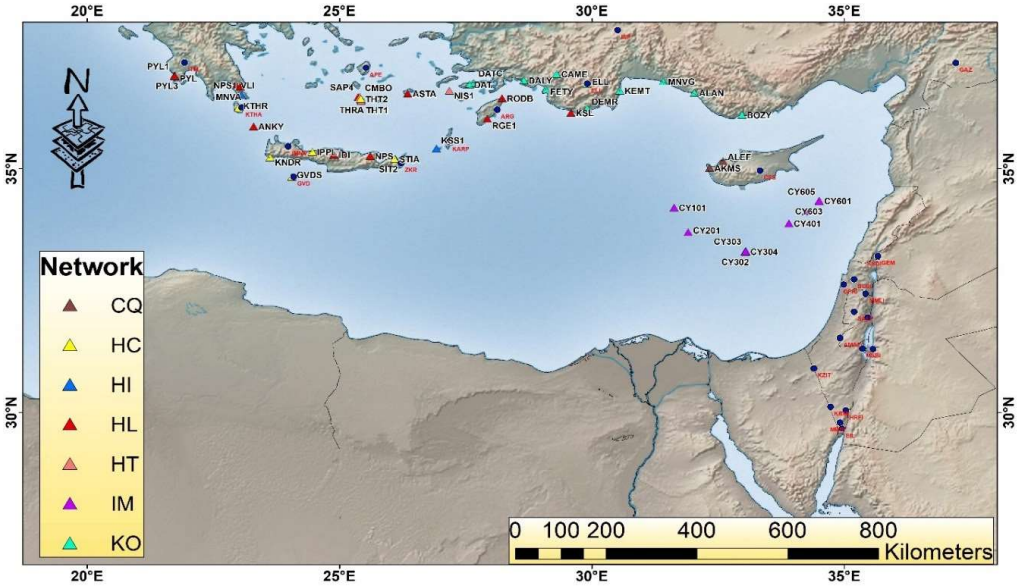
ملخص النشاط الزلزالي خلال ٢٠٢١

يتضح من خرائط النشاط الزلزالي وجود زيادة نسبية في معدل النشاط الزلزالي خلال عام ٢٠٢١ م في مصر وما حولها (الشكل ٨). علماً بأن تلك الأنشطة الزلزالية المحلية تتوافق مع المناطق الزلزالية النشطة المحددة سابقاً خلال السنوات السابقة. وتوضح الاشكال (٩،١٠،١١) تكبيرًا (zoom in) لبعض المناطق الزلزالية المختارة في مصر للفوالق السطحية.

كما يوضح الشكل رقم ٨ الأنشطة الزلزالية الإقليمية ممثلة في مجموعة من النشاط الزلزالي إلى الجزء الجنوبي من الأقواس اليونانية والقبرصية. ويمتد النشاط الزلزالي شمالاً إلى الجزء الجنوبي من اليونان وتركيا.

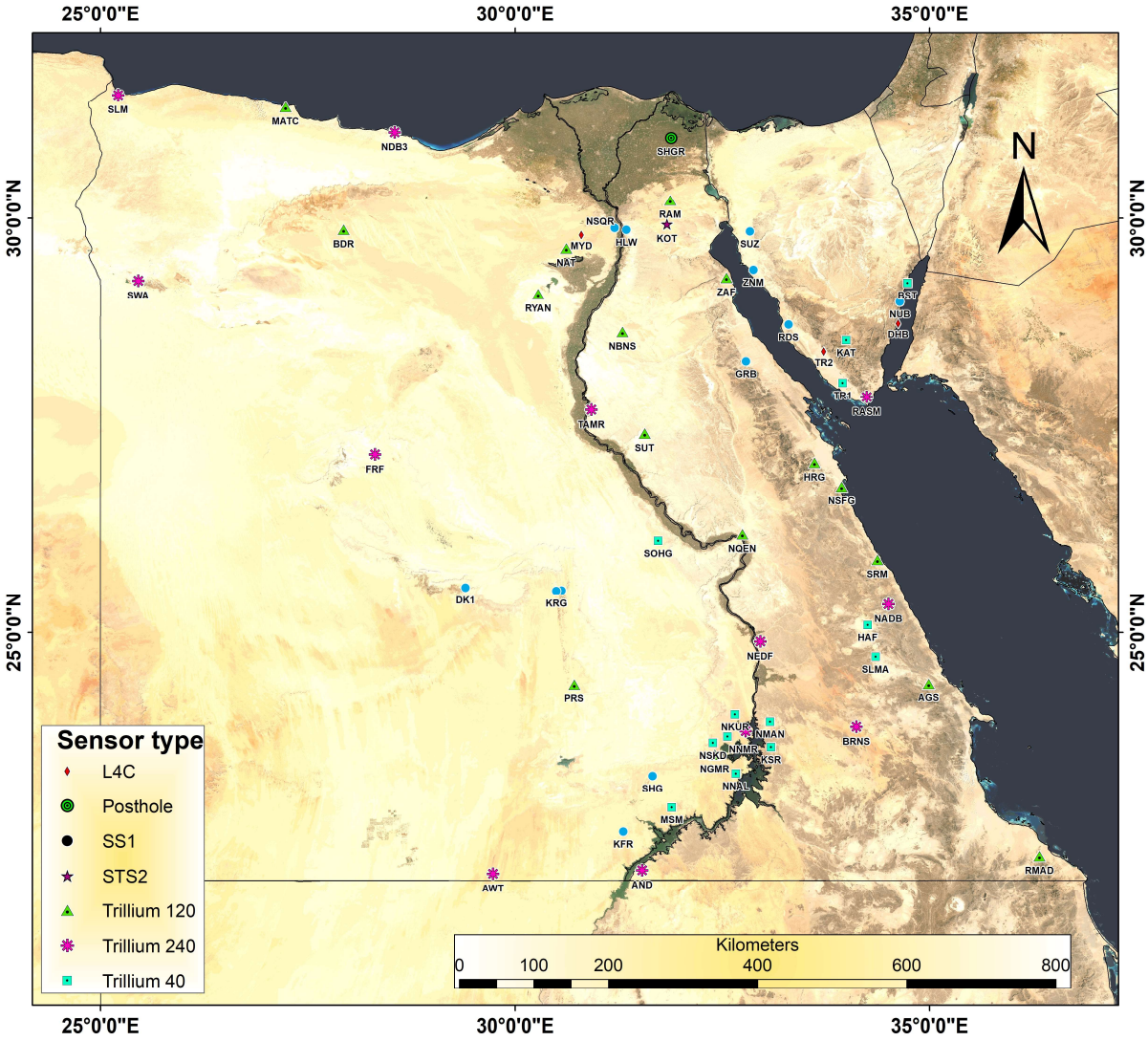


شكل رقم ٨: النشاط الزلزالي الإقليمي والمحلي المسجل بأجهزة عجلة التسارع الأرضية خلال عام ٢٠٢١



شكل رقم ٦: مواقع محطات الزلازل الدولية التي تستخدم في تحديد معاملات الزلازل بدقة أكبر جنبا الى جنب مع المحطات المصرية الاخرى.

شكل رقم ٧: توزيع أجهزة قياس العجلة الزلزالية



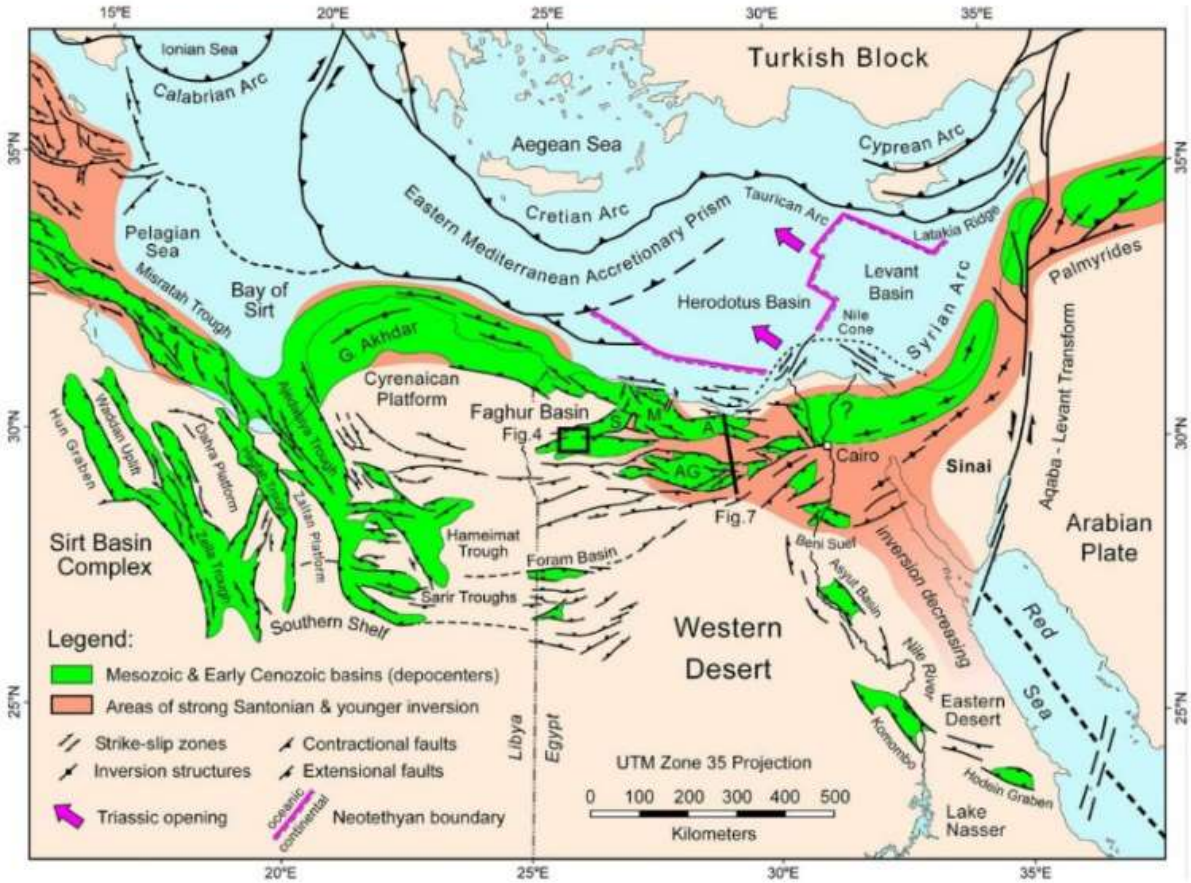
شكل رقم ٥: توزيع محطات الزلازل بالشبكة القومية المصرية لرصد الزلازل بأنواعها المختلفة.

الشبكة القومية المصرية للزلازل

في ١٢ أكتوبر١٩٩٢ ، حدث زلزال بقوة (٥,٩) في جنوب غرب القاهرة، وقد تسبب هذا الزلزال في وفاة ٥٦١ شخصاً وإصابة ٩٨٣٢ آخرين، وتسبب في خسائر تقدر بأكثر من ٣٥ مليون دولار أمريكي. ونتيجة لهذا الضرر، دعمت الحكومة المصرية المعهد القومي للبحوث الفلكية والجيوفيزيقية وكلفته بإنشاء وتركيب الشبكة المصرية القومية لرصد الزلازل، وتتكون من محطات قياس الزلازل العادية بأنواعها الى جانب محطات قياس عجلة التسارع الأرضية لقياس الزلازل القوية، ويتم استقبال البيانات بالمركز الرئيسي للرصد الزلزالي في حلوان، بالإضافة إلى خمسة مراكز فرعية في كل من الغردقة وبرج العرب ومرسى علم وأسوان والخارجة. يوضح (الشكل ٥) توزيع محطات الزلازل بالشبكة القومية المصرية لرصد الزلازل بأنواعها المختلفة وتستعين الشبكة القومية ببعض محطات الرصد الدولية (شكل ٦) لتعيين حساب معاملات الزلازل بشكل أدق خصوصاً عند حصول زلازل خارج نطاق مواقع الشبكة القومية المصرية لرصد الزلازل، (الشكل ٧) يوضح أجهزة قياس عجلة العجلة الزلزالية، ويتم اختيار هذه المواقع لتغطية المصادر الزلزالية المعروفة قدر الإمكان .كما أن هذا التوزيع يشمل بعض المناطق التي بها زلازل تاريخية معروفة مسبقاً.

في جنوب مصر من العصر الجوراسي إلى أواخر العصر الطباشيري أو أوائل العصر الحديث. زاد النشاط التكتوني والصهاري مرة أخرى في نهاية العصر الطباشيري كما هو مبين في الشكل (٤) والذي يدعم الملاحظات الجيولوجية التي تمت في جنوب مصر من الأصل التكتوني لوادي النيل.

كما تأثرت مصر بانفتاح البحر الأحمر(نظام منتصف المحيطات) وفرعيه (خليج السويس) ونظام تحويل (خليج العقبة - البحر الميت) وبالتالي، فإن الحركة الزلزالية ترجع إلى التفاعل بين الصفائح الثلاث لأوراسيا وأفريقيا والصفيحة العربية، وبالتالي، يمكن استنتاج أنه على الرغم من أن الزلازل المدمرة حدثت بشكل غير منتظم، إلا أنه لا يمكن تجاهل عواقبها الخطيرة.



شكل رقم ٤: يوضح الوضع التكتوني (التراكيب الجيولوجية) لمصر

الوضع التكتوني (التراكيب الجيولوجية) في جمهورية مصر العربية:

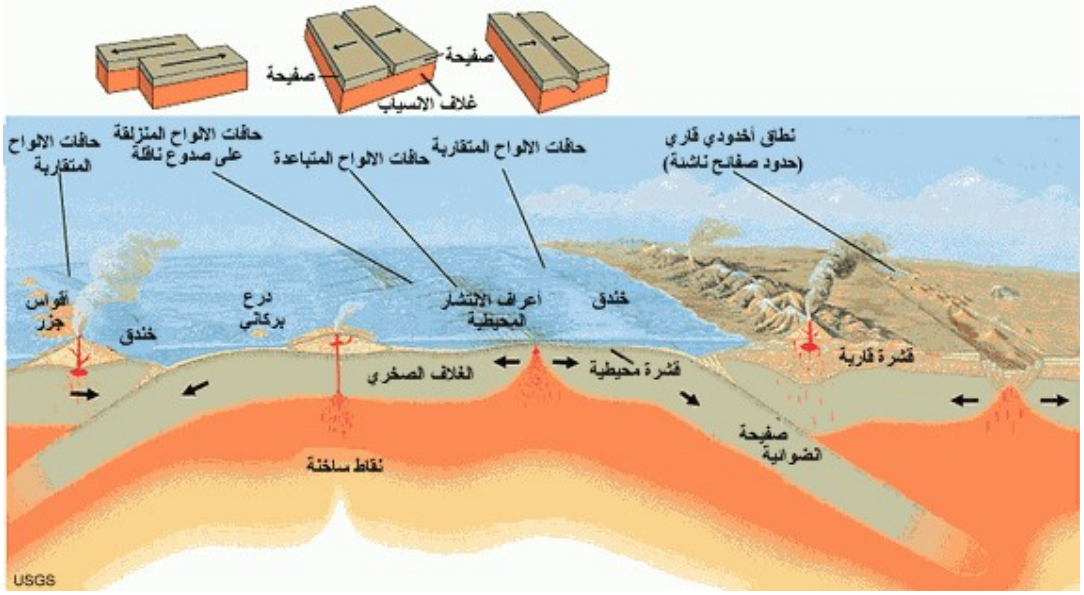
تعتبر الزلازل أحد الظواهر الأكثر تأثيراً من ظواهر المخاطر الطبيعية، حيث إن لها آثار على الحياة الطبيعية والبشرية، كما أن تقييم المخاطر الزلزالية في أي منطقة يلعب دوراً هاماً في التقليل من آثارها.

تعتبر الزلازل ظاهرة جيوديناميكية، والنشاط الزلزالي الحالي والظواهر الجيوديناميكية الأخرى المتعلقة به (مثل تشوه وتمزق القشرة الأرضية، والبراكين، والظواهر الحرارية الأرضية، والسمات الطبوغرافية، وما إلى ذلك) هي نتائج لعملية جيولوجية حديثة نسبياً، والتي تسمى عادة، المناطق التكتونية النشطة.

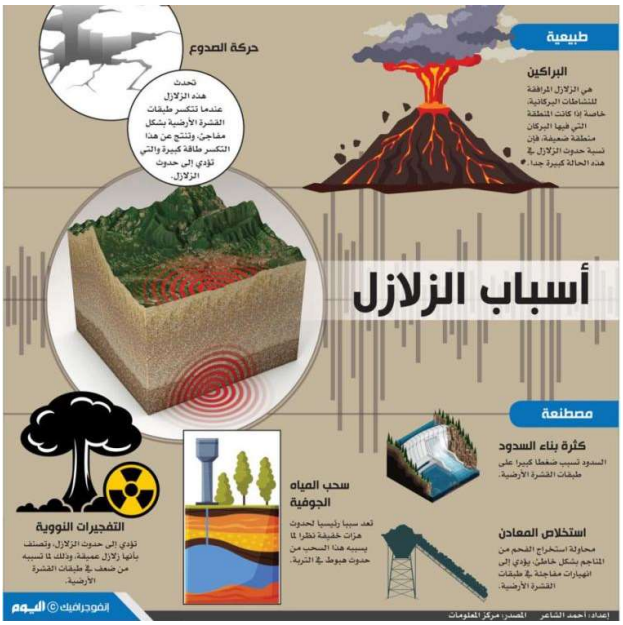
ويمكن وصف الإطار التكتوني العام لمصر، بأنها تتكون من ثلاث وحدات تتحكم في التاريخ الرسوبي والتركيبي لمصر، وهي الكتلة العربية النوبية، الرصيف (الجرف) المستقر، والرصيف(الجرف) غير المستقر. يغطي الجرف المستقر جزءًا كبيراً من مصر حيث يتمثل في المحيط الكتلي العربي النوبي. وهو يعكس الاستقرار التكتوني النسبي نحو الجنوب، ينتمي جزء كبير من شمال مصر إلى الجرف غير المستقر والذي يعاني من تشوهات صخرية شديدة. وفى الحدود الشمالية تقع مصر بالقرب من أحد أنظمة الكسر القارية وهو القوس الهليني (القوس اليوناني) عند حدود التقارب بين صفحتين كبيرتين من صفائح الليثوسفير (أوراسيا وأفريقيا) .

يوجد أربعة أنظمة من الصدوع التي تتجه في عدة زوايا هي ٥٥، ٧٠، ٨٠، ١٥٠ درجة من الشمال والتي تمثل مناطق الكسر الرئيسية الإقليمية والعابرة للقارات .والتي نشأت خلال مختلف حقبة التركيب القشري. تم التحكم عموما في تشوه حقبة الفانيروزويك داخل اللوح والعمليات ذات الصلة من التآكل والتعرية والترسيب من الاتجاهات والتراكيب الجيولوجية التي تم تنشيطها في كثير من الأحيان جنباً إلى جنب مع أنظمة الصدوع القائمة، استمر النشاط البركاني والتكتوني في مصر حتى نهاية عصر الباليوزويك في العصر الترياسي ومن ثم تم ترسيب أكثر من كيلومتر من طبقات الحجر الرملي النوبي

- استخلاص المعادن يؤدى إلى انهيارات في طبقات القشرة الأرضية.

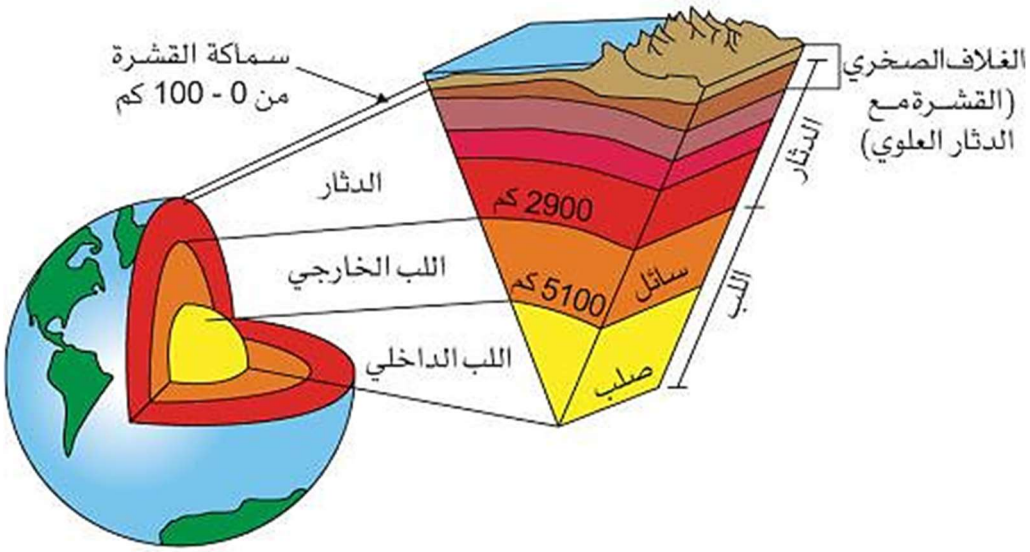


شكل رقم ٢ تحرك ألواح الطبقات الأرضية العليا الصلبة (الليثوسفير) وتغورها في بعض الأحيان وتبدأ بالتحرك حسب اتجاه حركة طبقة الوشاح (الدثار) العلوية.



شكل رقم ٣: تصدعات القشرة الأرضية هي أغلب ما يسبب الزلازل.

الأرضية تتشقق طبقات الأرض العليا الصلبة الى وحدات صخرية كبيرة (الليثوسفير) وتبدأ بالتحرك حسب اتجاه طبقة الوشاح وقد تغور أجزاء من القشرة الأرضية الصخرية تحت بعض (ظاهرة الاندثار القاري) (شكل ٢).



شكل رقم ١: التركيب الداخلي للأرض

إذا رجعنا اسباب وقوع الزلازل فإننا نجدها تنحصر فيما يلي:

- تصدعات قشرية عندما تحدث الزلازل في القشرة الأرضية فجأة (شكل ٣) مما يسبب إهتزازت في الأرض.
- نشاط زلزالي مرافق للنشاطات البركانية.
- نشاط زلزالي متولد عن وجود بحيرات صناعية.
- الضغوط العالية في باطن الأرض والتي تؤثر في المناطق الطبيعية نتيجة كثرة بناء السدود.
- انهيار الكهوف الجوفية العظمى وسقوطها الذي قد يبلغ مدن بأكملها.
- سحب المياه الجوفية والذي قد يولد زلازل صغيرة (مستحدثة).
- التفجيرات النووية تؤدى أيضاً إلى حدوث زلازل.

مقدمة:

الزلازل جزء من حياة الأرض وجزء مأساوي من تاريخ البشر، حيث لا يمر عام إلا ونسمع بحدوث عشرات الزلازل. إن أهم ما يميز بنية الأرض الباطنية هو تباين خصائصها الفيزيائية والكيميائية وظهور الطبقات الصخرية والمعدنية المختلفة بدءاً من مركز الأرض وحتى سطحها الخارجي، ولقد تم الاعتماد على معرفة مكونات وخصائص باطن الأرض على الطرق والوسائل الجيوفيزيقية خاصة الامواج الاهتزازية التي تطلقها الزلازل من الهزات الأرضية الطبيعية أو التفجيرات الصناعية والنووية.

وقد لوحظ تباين سرعة الأمواج الاهتزازية (السيزمية) الطولية والعرضية بالكرة الأرضية وذلك طبقا لتباين طبيعة المواد التي تكونها وحسب درجة صلابتها وليونتها ومن الدراسات العلمية تم التعرف على طبقات الأرض المختلفة، وقد لوحظ وجود اختلافات كبيرة في طبيعة هذه الطبقات كيمائياً وفيزيائياً ومعدنياً، وقد ساعدت هذه الاختلافات على زيادة التفاعلات الباطنية التي انعكست بقوة على كل أنحاء الارض. وعليه تم التعرف على ثلاث طبقات رئيسية تنفصل عن بعضها البعض بسطوح انفصالية وانتقالية تتغير عندها سرعة الأمواج الاهتزازية بصورة واضحة مما يشير إلى الانتقال من وسط فيزيائي إلى أخر وتتكون الأرض من ثلاث طبقات رئيسية (موضحة في شكل ١) وهى:-

أ. **القشرة الأرضية:** والتي يبلغ سمكها (٣٠-٤٠ كم) في المناطق السهلية وتصل الى عمق حوالي ٥٠ كم في المناطق الجبلية وتصل الى عمق حوالي ٨٠ كم تحت السلاسل الجبلية العملاقة مثل جبال الهيمالايا.

ب. **الوشاح أو الستار أو الدثار:** والذي ينقسم إلى جزء علوي يصل عمقه إلى حوالي ١٠٠٠ كم والجزء السفل يصل عمقه إلى حوالي ٢٩٠٠ كم.

ت. **النواة:** ويصل عمق الجزء العلوي منها إلى ٥١٢٠ كم، ثم النواه الداخلية حتى مركز الأرض على عمق حوالي ٦٣٧٠ كم. ونتيجة للتحركات المستمرة في هذه الطبقات وتحرك طبقة القشرة

كلمة رئيس المعهد

إن تسجيل الزلازل بمصر بدأ باستخدام الأجهزة المعيارية منذ عام ١٨٩٩م. تم لاحقاً استبدال أجهزة قياس الزلازل ميلن شاو (Milnshaw) وجاليتزن (Galitzen) وسبرنجنزر (Sprengnether) بالتكنولوجيا الرقمية. وفي عام ١٩٦٢ ، استقبلت حلوان محطة رصد زلازل كجزء من شبكة قياس الزلازل المعيارية العالمية (WWSSN). ولا تزال هذه المحطة تعمل حتى يومنا هذا. ومع بداية عام ١٩٧٢م تم تركيب أربع محطات قياسية في حلوان، وأسوان، وأبو سمبل، ومطروح. كانت إحداهم يابانية الصنع قصيرة المدى، بينما باقي المحطات روسية الصنع متوسطة المدى.

دعمت الحكومة المصرية المعهد القومي للبحوث الفلكية والجيوفيزيقية (NRIAG) لإنشاء الشبكة القومية المصرية للزلازل (ENSN) وذلك بعد حدوث زلزال ١٢ أكتوبر ١٩٩٢ في منطقة دهشور، على بعد ٣٥ كيلومترًا جنوب غرب القاهرة. قام المعهد القومي للبحوث الفلكية والجيوفيزيقية (NRIAG) بتحديث تقنية اتصالات نقل البيانات من خطوط الهاتف إلى الأقمار الصناعية والنظام العلمي للاتصالات المتنقلة (GSM) لتحسين كفاءة ومهام الشبكة القومية المصرية للزلازل (ENSN).

بحلول منتصف عام ٢٠٠٣ تم تركيب المحطات الحقلية لرصد الزلازل في جميع أنحاء مصر، كما تم أيضاً بناء وتجهيز خمسة مراكز فرعية. علاوة على ذلك، تم إنشاء مركز بيانات الحد من الكوارث الزلزالية (EDRDC)، بدعم تكنولوجيا نظم المعلومات الجغرافية. و بناء علي النشاط الزلزالي الذي تم تسجيله في البحر المتوسط و كذلك البحر الأحمر، تم استحداث عدد من المحطات لتضاف الي الشبكة القومية للزلازل. تعد نشرة الزلازل المصرية (الكتالوج) والتي تشمل الزلازل المسجلة في مصر والمناطق المحيطة بها في عام ٢٠٢١ كأحد مخرجات العناصر الأساسية لتقارير الشبكة القومية المصرية للزلازل (ENSN). حيث تستخدم هذه المخرجات في تقييم المخاطر الزلزالية.

أ.د. جاد القاضي

رئيس المعهد القومي للبحوث الفلكية والجيوفيزيقية

جمهورية مصر العربية
وزارة التعليم العالي والبحث العلمي
المعهد القومي للبحوث الفلكية والجيوفيزيقية
الشبكة القومية للزلازل

النشرة الدورية السنوية للزلازل
جمهورية مصر العربية
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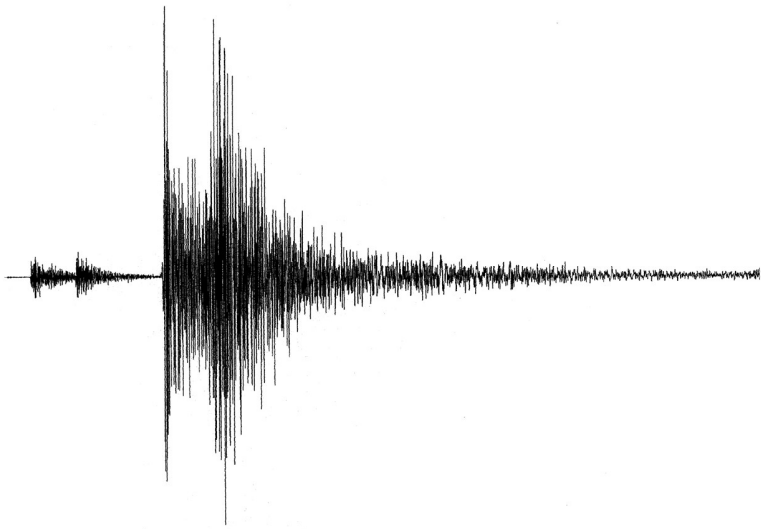

عدد يناير ٢٠٢٢

القاهرة - مصر