

MONITORING OF CRUSTAL MOVEMENTS IN EGYPT USING GPS TECHNIQUE

By

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TECTONICS

TOPICS TO BE FOCUSED

SEISMICITY

GPS OBSERVATIONS

CONCLUSIONS &
RECOMMENDATIONS

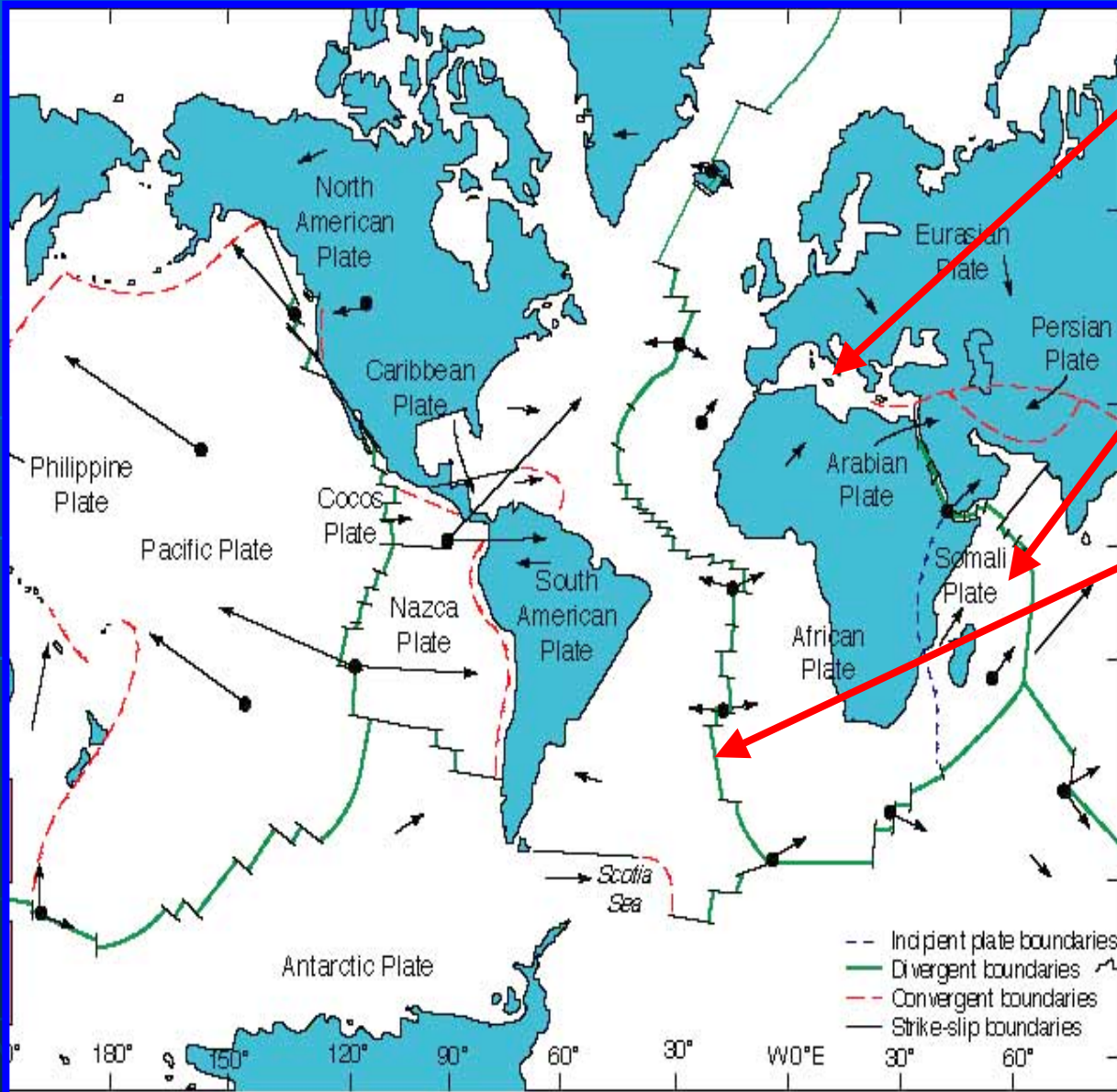
Global Tectonic Setting

■ Major tectonic elements:

- Africa moves north relative to Eurasia (name of the combined Europe and Asian tectonic plates) at ~ 10 mm/yr.
- To the west the mid-Atlantic ridge is opening at rate of ~ 20 mm/yr.
- To the east the rapidly move Indian Plate is converging on the Eurasian Plate at ~ 45 mm/yr.
- To the north east the Arabian plate is converging on Eurasia at ~ 25 mm/yr.
- The eastern part of Africa is being rifted by the East African Rift.

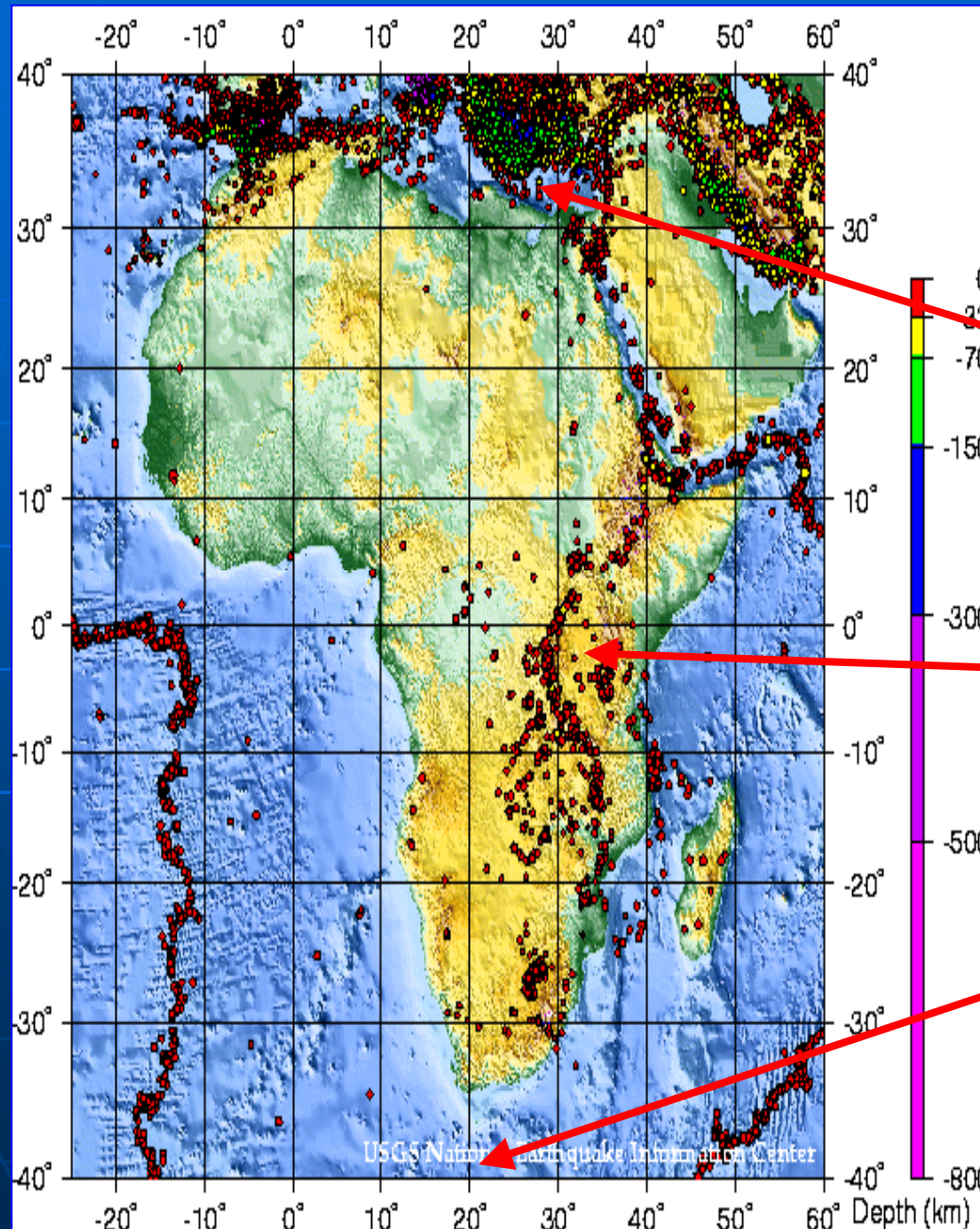
■ Consequences of these motions are earthquakes and volcanoes. $10 \text{ mm/yr} = 1 \text{ meter of motion in } 100 \text{ years.}$

Global Plate motions



- Convergence of Africa and Eurasian Plate
- Proposed Somalia Plate
- Spreading of mid-Atlantic Ridge

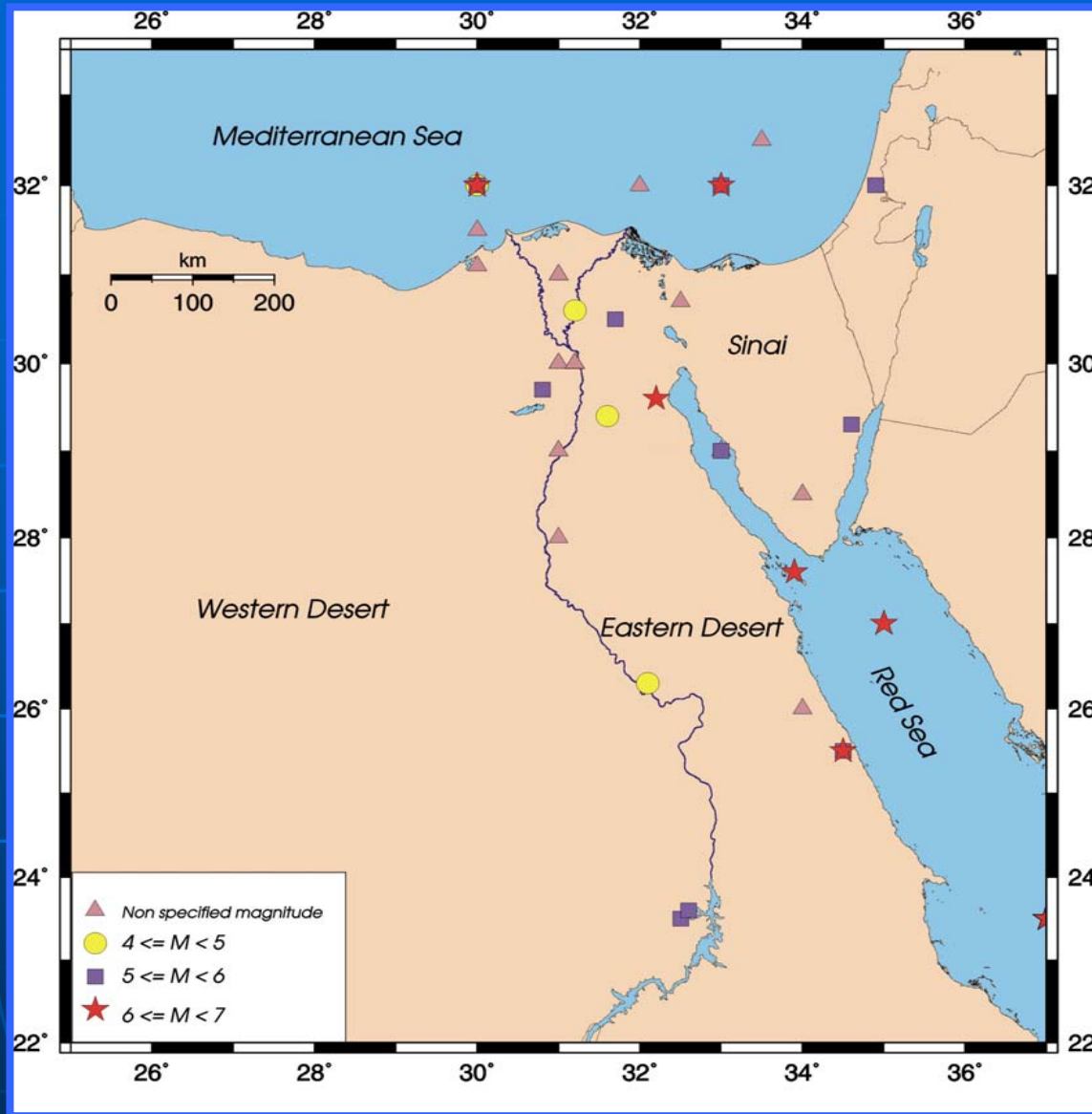
Earthquakes 1977-1997



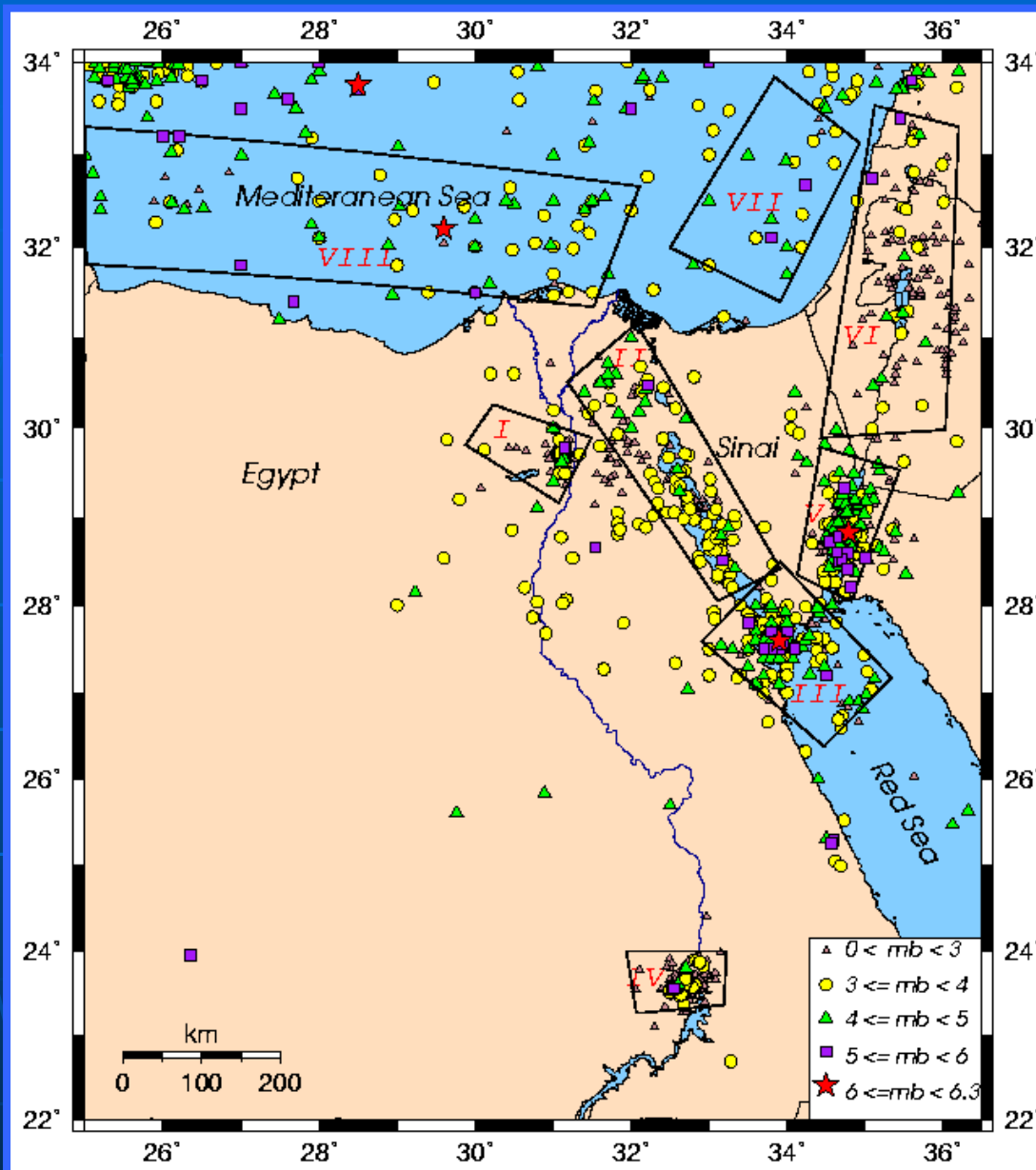
- North African events are collision events

- Events in East Africa Are associated with rifting

- Southern boundary of rift system not distinct



Historical earthquakes in Egypt from 2200BC to 1900AD(Polrer and Taher, 1980; Mamoun et al., 1984; Ambraseys, et al.,1994).

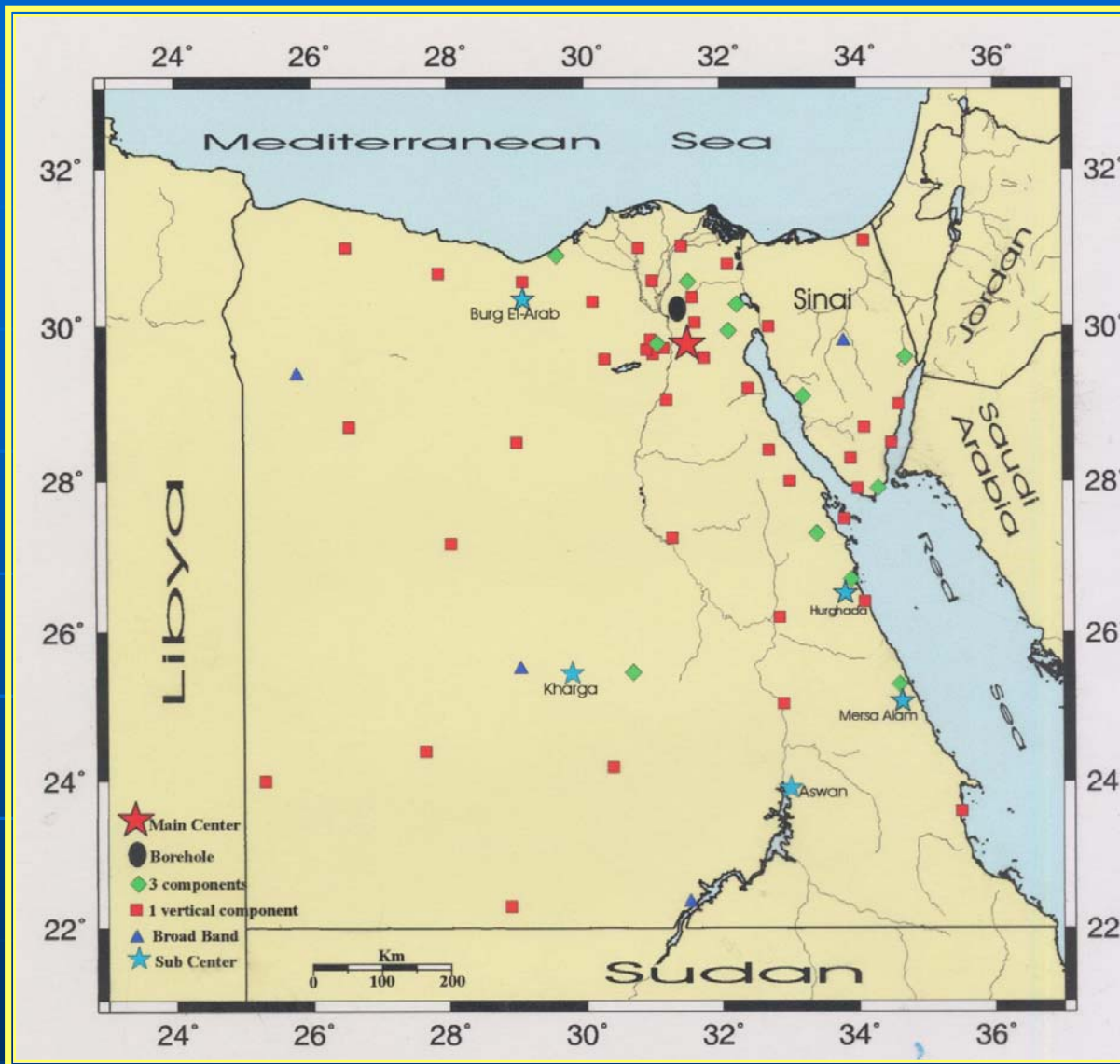


Seismic activity of Egypt from 1900 to July 1997 based on data from NRIAG with the proposed seismic active zones.

The Egyptian National Seismic Network Stations (ENSN)

➤ The Network consists of:

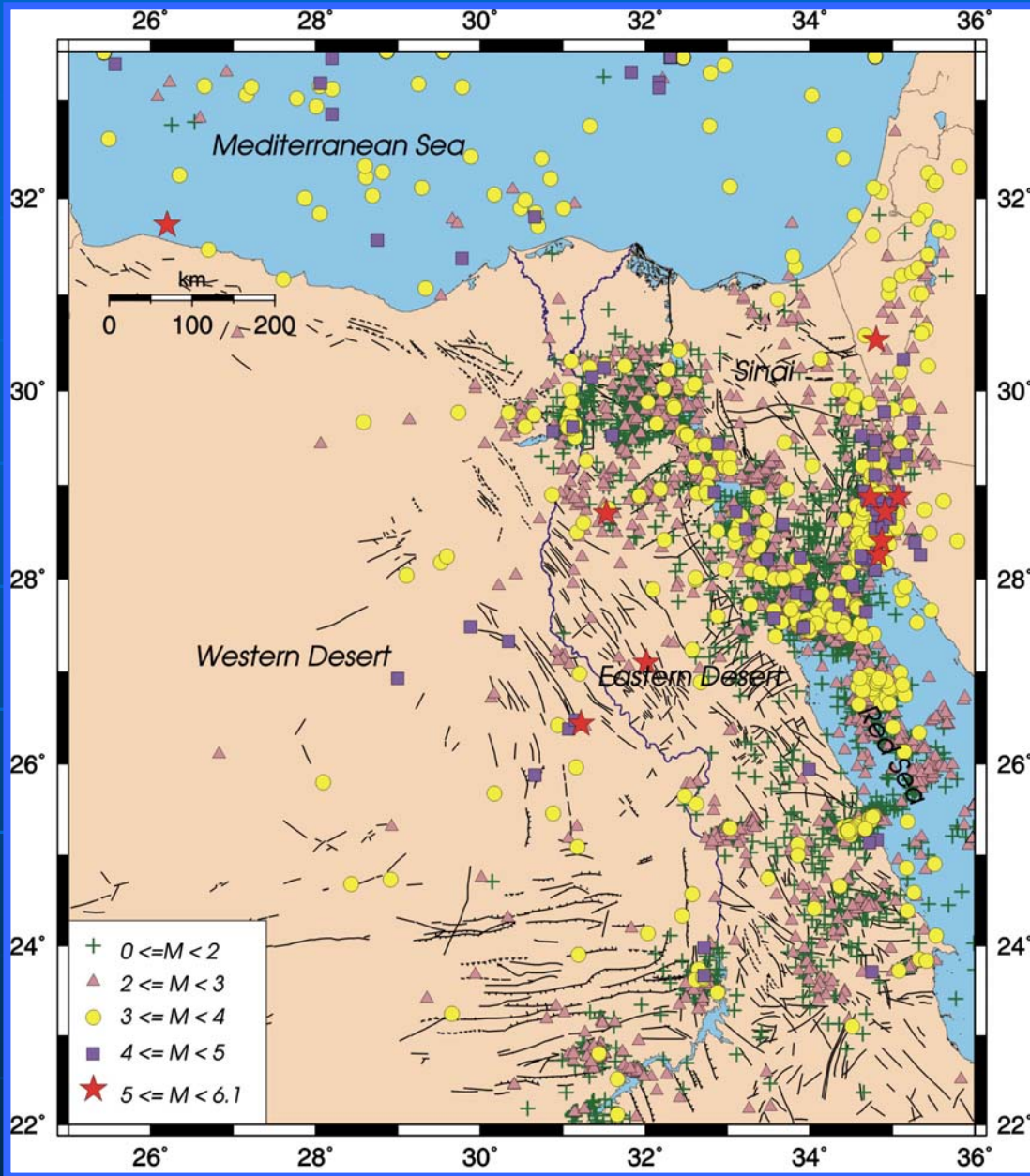
- 64 Short Period Stations SS-1.
 - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second
- 4 Very Broad Band stations STS-2.
 - Natural Frequency .008 Hz, Sampling rate = 100 Sample per Second
- Broad Band Station SJ13 at High Dam (Aswan).
 - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second
- 24 Portable Stations LC4.
 - Natural Frequency 1 Hz, Sampling rate = 100 Sample per Second



Geographical distribution of ENSN stations that transmit their data to Helwan main center



The Egyptian National Seismic Network (ENSN)



**Local earthquakes recorded by ENSN
from Aug. 1997 to Dec. 2003.**

The Egyptian National GPS Network

➤ The GPS Network Stations are classified into:

● Permanent GPS Network:

- 1 Network Consists of 9 Stations.

● Survey Mode Networks.

- 4 Networks:

➔ **Aswan Network:** Consists of 11 Stations,

➔ **Sinai Network** : Consists of 11 Stations,

➔ **Greater Cairo Network** : Consists of 11 Stations,

➔ **Middle Part of Egypt Network:** Consists of 10 Stations.



Distribution of permanent and survey mode GPS station

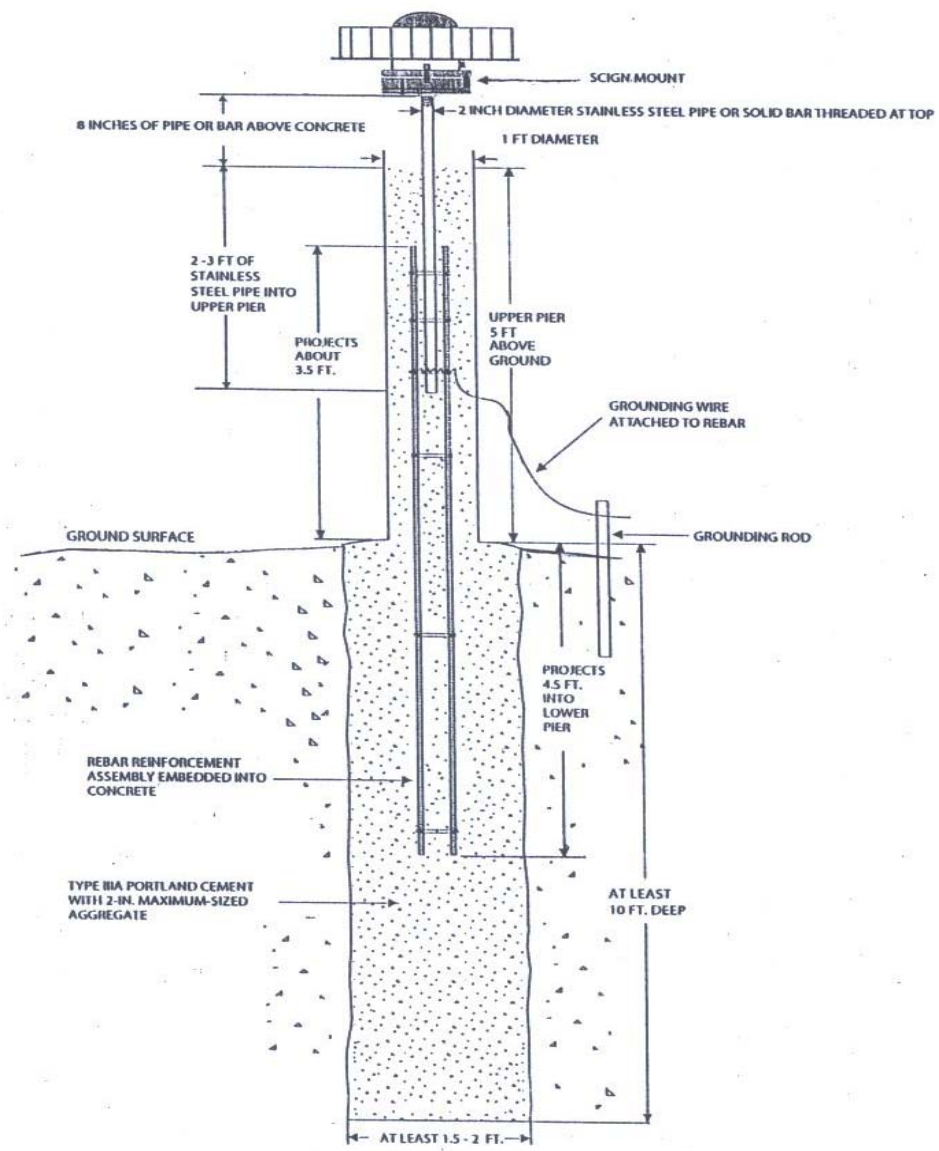
Instrumentation Facilities

➤ ~~Geomatics~~ Horizontal Geodetic Instruments

- ➔ • 20 Trimble Receivers 4000 SSI
- ➔ • 2 Total Stations TC 1100L
- ➔ • 4 Trimble RTK 4800
- ➔ • 2 Kern (GK2-A)
- ➔ • 4 Trimble RTK 5700
- ➔ • 1 Leica (NA3003)
- ➔ • A Permanent GPS Station of choke ring antenna connected with TurboRogue Receiver

➤ Gravity Instruments

- ➔ • LaCoste & Romberg- model G of Trimble 5700 CORS Connected with Zephyr
- ➔ • LaCoste & Romberg- model D



Monumentation of the GPS Station



Survey Mode GPS Station: Antenna Connected with Trimble Receiver

GPS Applications

➤ There are several uses to GPS in different fields such as:

 The Coast Guard

 Offshore Exploration

 Natural Resource Management

 Navigation

 Transportation and Fleet Management

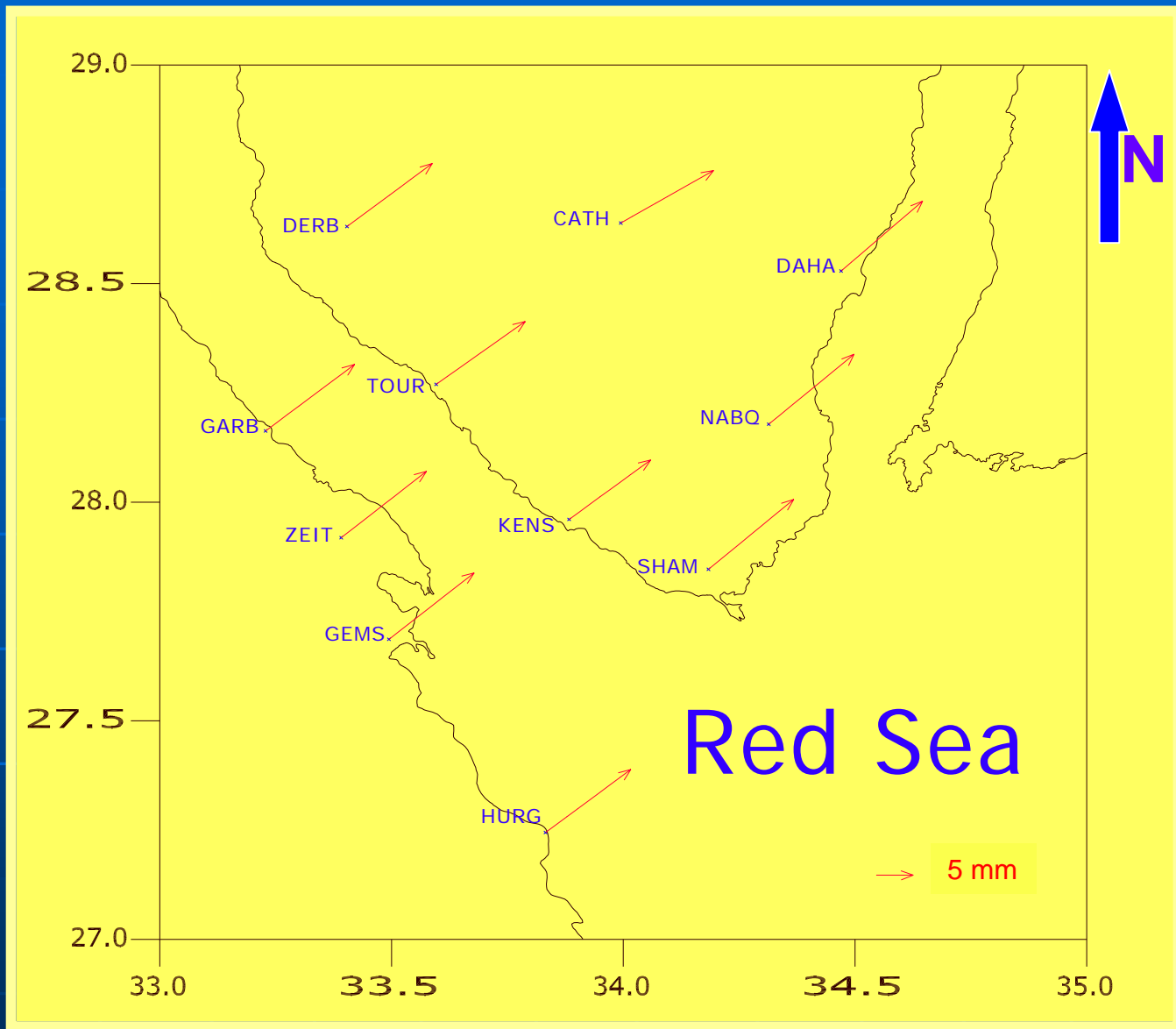
 Agriculture

 Crustal Deformation Studies

Crustal Deformation Studies

The following steps have been followed for monitoring movements in Egypt:

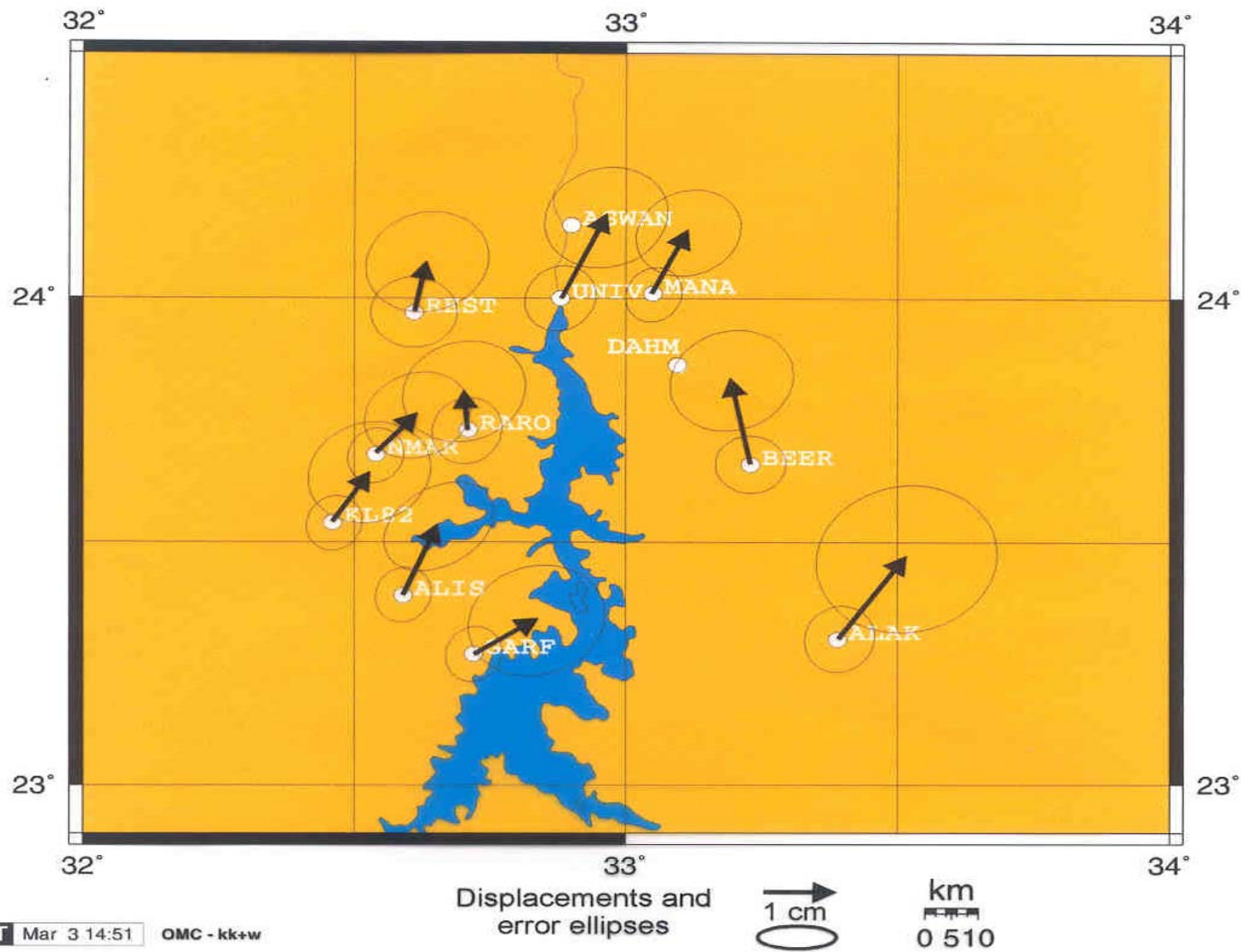
- Design and establishment of GPS network.
- Carrying out the repeated measurements.
- Final analysis of repeated measurements using the scientific software (e.g. Bernese V4.2 & 5.0; GAMIT).



Total horizontal velocities of Sinai network with ITRF2000 reference stations from 1997 to 2003.

Station velocities in mm/6yr of Sinai network from 1997 to 2003 relative to IGS permanent station (black) using ITRF2000 velocities and Nuvel -1A.

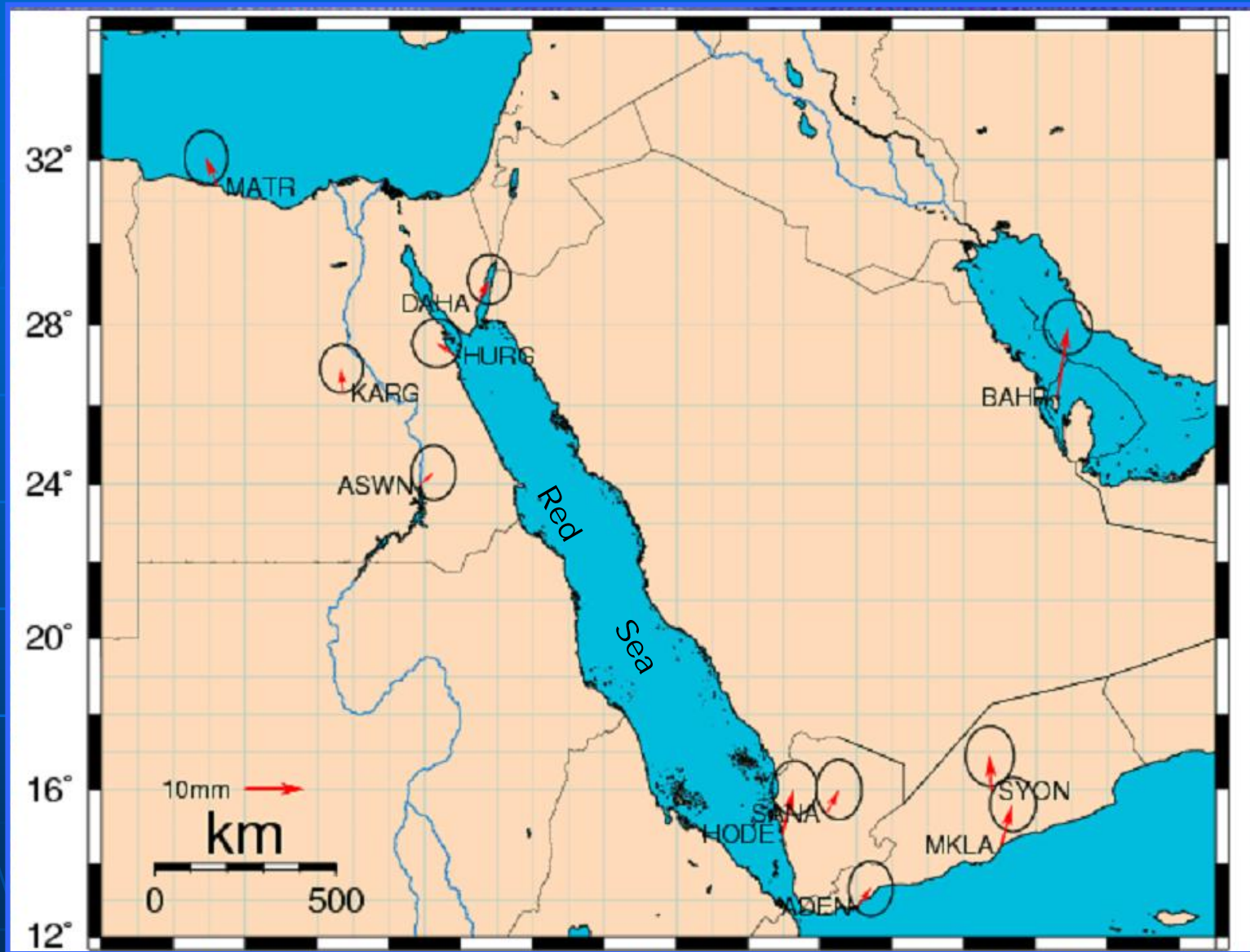
Station ID	Campaign year						Geographic coordinate		ITRF2000 velocity		Nuvel velocity			
	97	97	98	98	99	00	02	03	Lat(°)	Long(°)	V _N (mm/6y)	V _E (mm/6y)	V _N (mm/6y)	V _E (mm/6y)
Nabq							28.178	34.314	28.639	34.00	20±0.2	25±0.2	19.5	25.1
Daha Nico							28.529	34.470	35.141	33.396	20±0.1	22±0.2	19.5	25.1
Derb Sham							28.630	33.404	27.846	34.184	18±0.3	23±0.1	19.6	24.9
Garb							28.163	33.228			19±0.2	24±0.1	19.6	24.9
Sofi							42.556	23.395			ITRF2000			
Gems							27.686	33.494			19±0.1	23±0.1	19.6	25.0
Tour Hurg							28.269	33.596			18±0.3	24±0.2	19.6	24.9
							27.267	33.869			18±0.2	23±0.0	19.6	25.1
Zeck Kens							43.788	41.565			ITRF2000			
							27.960	33.883			17±0.1	22±0.3	19.6	25.0
Zeit Mate							27.919	33.392			19±0.2	23±0.0	19.6	24.9
							40.649	16.704			ITRF2000			



Displacement vectors in Aswan network for the period from 1997- 2000



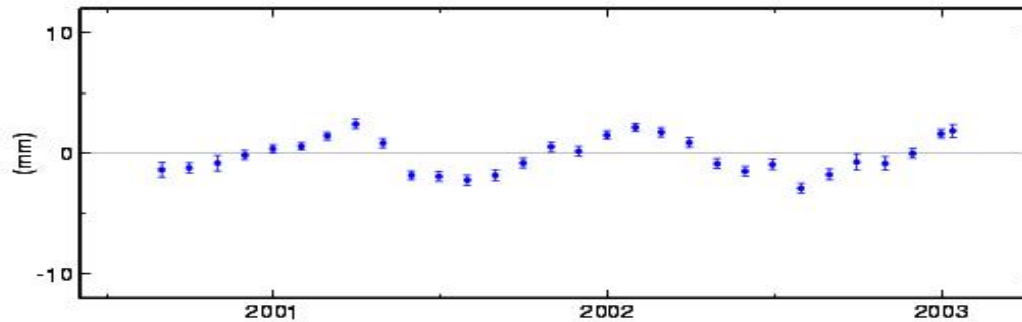
Distribution of GPS geodetic station between Egypt and Yemen.



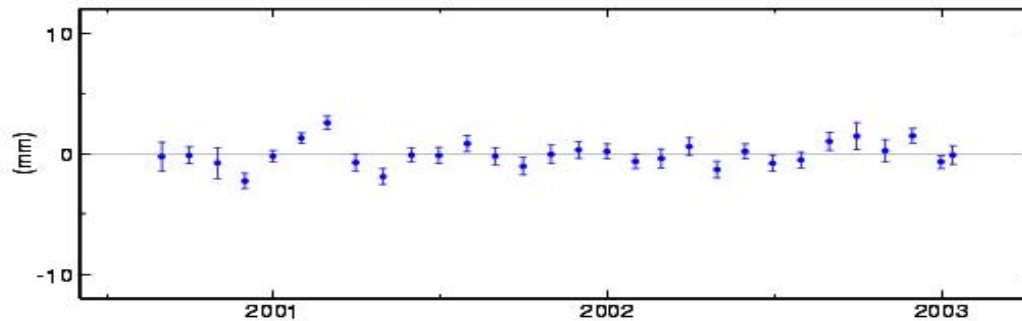
Displacement vectors in Egypt –Yemen network for the period from 2000 to 2003

PHLW

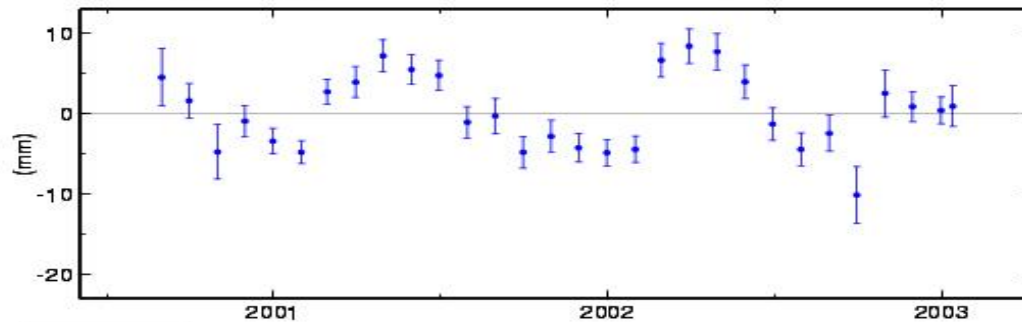
PHLW North Offset 3324172.018 m
rate(mm/yr)= 5.38 ± 0.11 nrms= 3.67 wrms= 1.5 mm # 30



PHLW East Offset 3025858.465 m
rate(mm/yr)= -4.33 ± 0.17 nrms= 1.65 wrms= 1.1 mm # 30



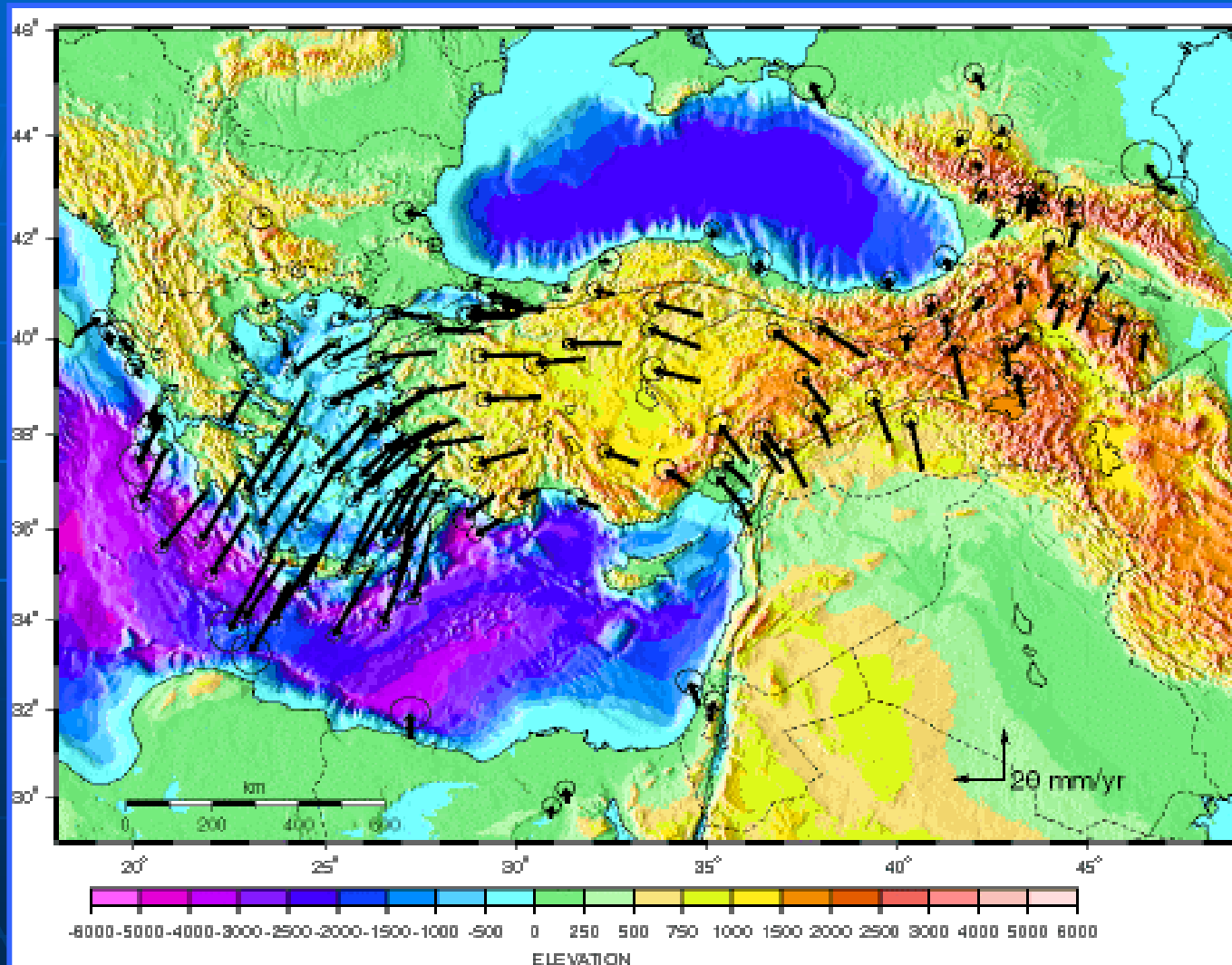
PHLW Up Offset 148.629 m
rate(mm/yr)= -0.81 ± 0.53 nrms= 2.26 wrms= 4.5 mm # 30

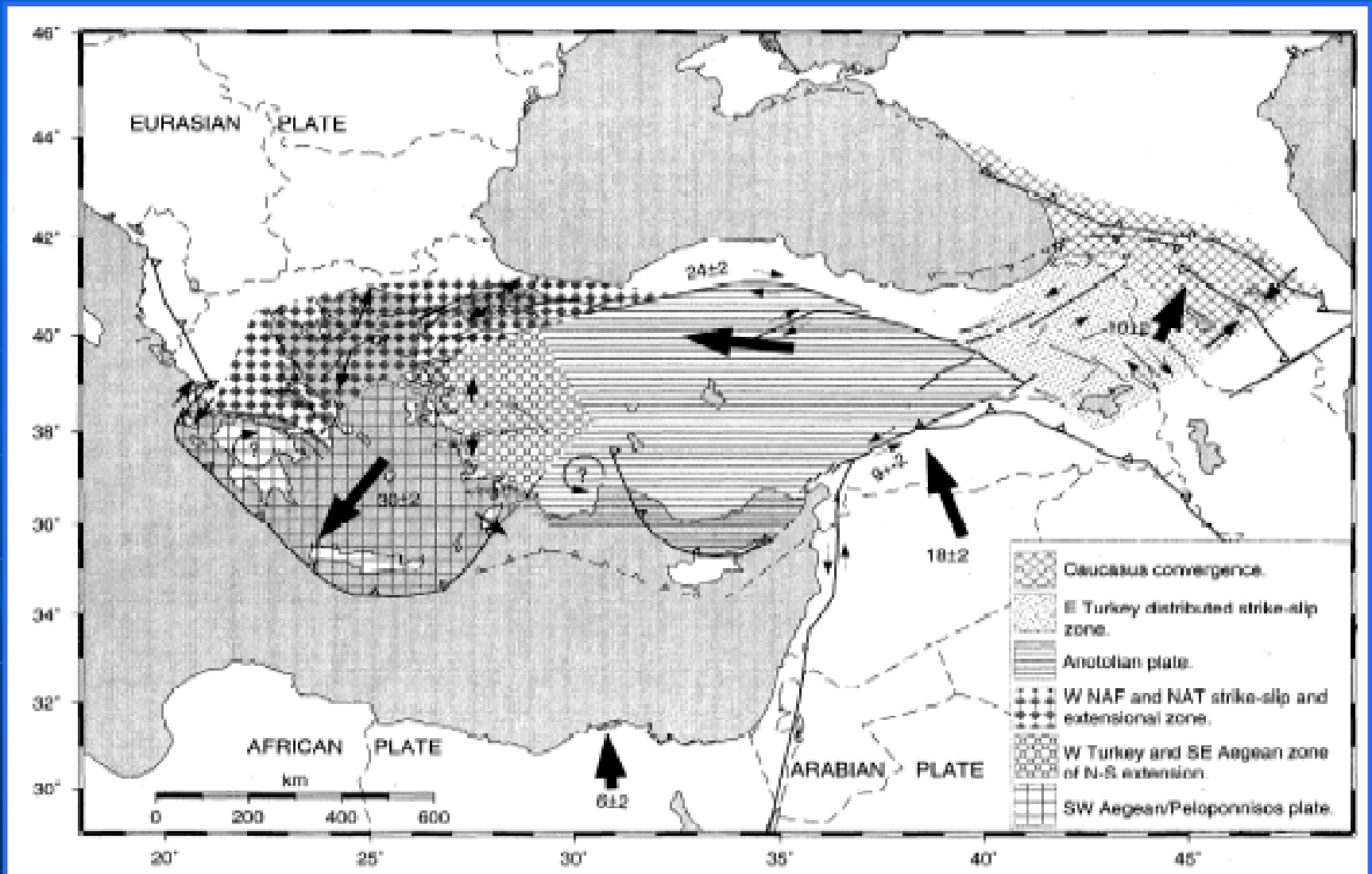


Some details of Northern Collision

**Measured GPS
Motions in
Turkey and
Greece**

**Continuously
operating GPS
systems allow
these types of
dense networks**





Generalized Regional Motions Model of the Eastern Mediterranean Region

CONCLUSIONS

3 A generalized model of the regional plate motions in the eastern Mediterranean has been deduced from the first time since 1994 till now to cover different regional networks (e.g. Sinai, Aswan, Greater Cairo and Middle Part of Egypt).

4 Adjustment and analysis of the repeated GPS campaigns from the different networks revealed significant motions.

RECOMMENDATIONS

2

It should be emphasized that all concerned authorities, research institutes and universities covering many parts of Egypt and the neighboring sea and the Gulf of Aden should cooperate in a program of studying the crustal movements using GPS technique to evaluate the seismicity and earthquake hazards in these regions.

THANK YOU