MONITORING CRUSTAL DEFORMATION IN EGYPT USING GPS TECHNIQUE IN ITRF REFERENCE FRAME

By

Dr. Salah M. Mahmoud

Professor, Head Department of Geodynamics
**National Research Institute of
Astronomy and Geophysics (NRIAG)
Helwan, Cairo, Egypt**

FIG Working Week & GSDI-8

16 – 21 April, 2005 Cairo, EGYPT

TECTONICS

SEISMICITY

TOPICS TO BE FOCUSED

GPS OBSERVATIONS

CONCLUTIONS & RECOMMENDATIONS
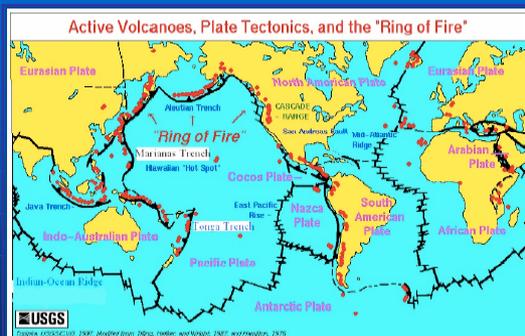

Major Plate Features of the Earth.


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 Red Sea and the East African Rift.

- **Consequences of these motions are earthquakes and volcanoes. 10 mm/yr=1 meter of motion in 100 years.**


Global Plate motions
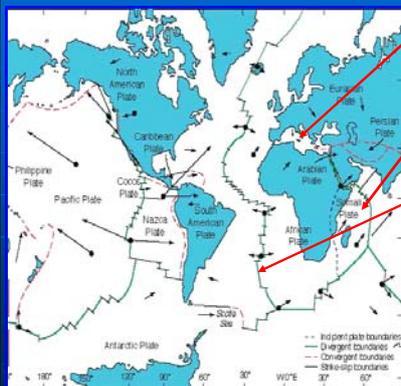
- Convergence of Africa and Eurasian Plate

- Proposed Somalia Plate

- Spreading of mid-Atlantic Ridge

Earthquakes 1977-1997
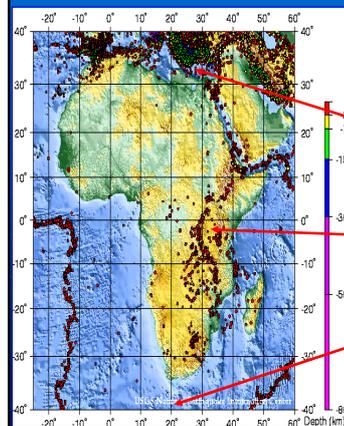
- North African events are collision events

- Events in East Africa Are associated with rifting

- Southern boundary of rift system not distinct

Distribution of earthquakes epicenters as recorded by IDC for the period from 2000 to 2003.

Historical earthquakes in Egypt from 2200BC to 1900AD(Poirer 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.
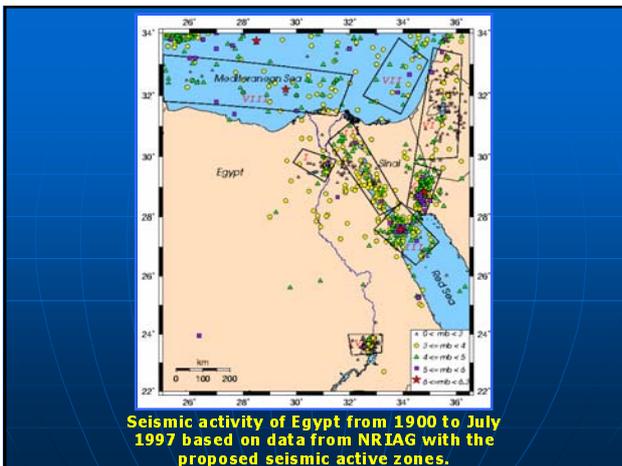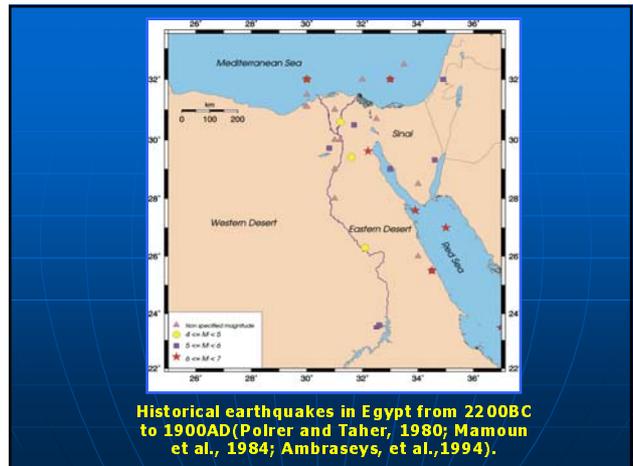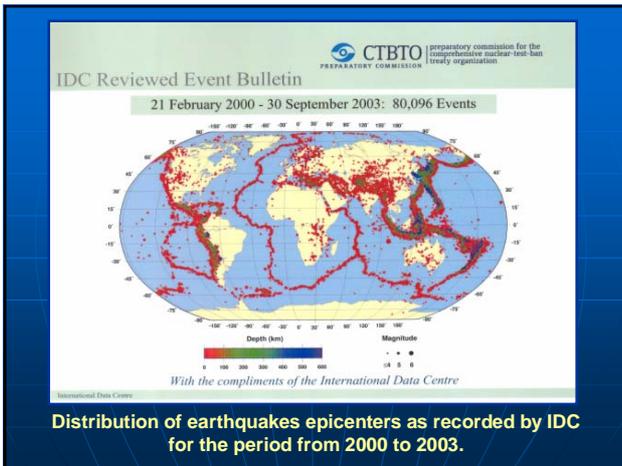
The Egyptian National Seismic Network Stations (ENSN)

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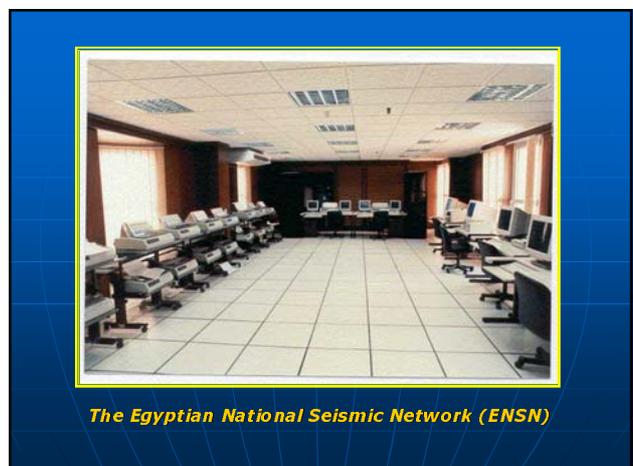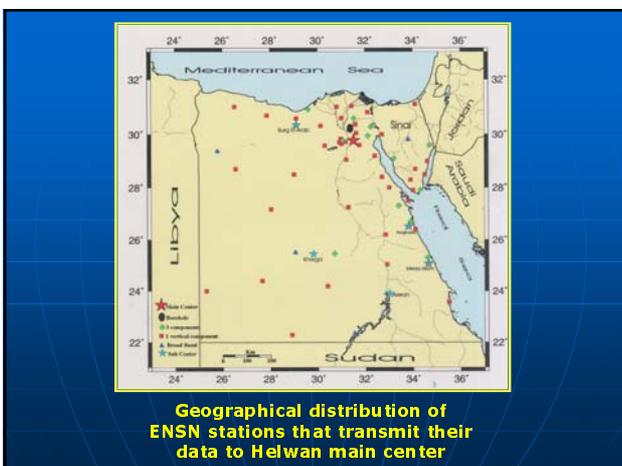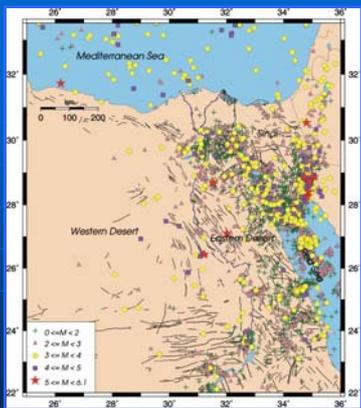
Local earthquakes recorded by ENSN from Aug. 1997 to Dec. 2003.

The High Dam, ASWAN
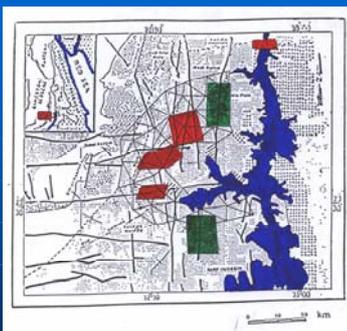
Local Geodetic Networks Around Active Faults in Lake Nasser Region

1983

Kalabsha Network
Aswan, 1984-1994
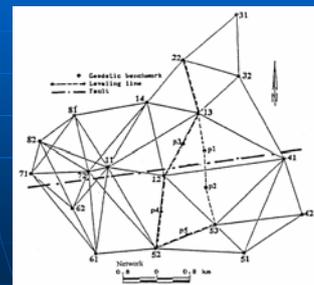
Seiyal Network
Aswan, 1986-1994
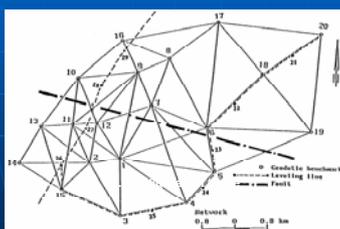
The Egyptian National GPS Network

➤ **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

Monumentation of the GPS Station
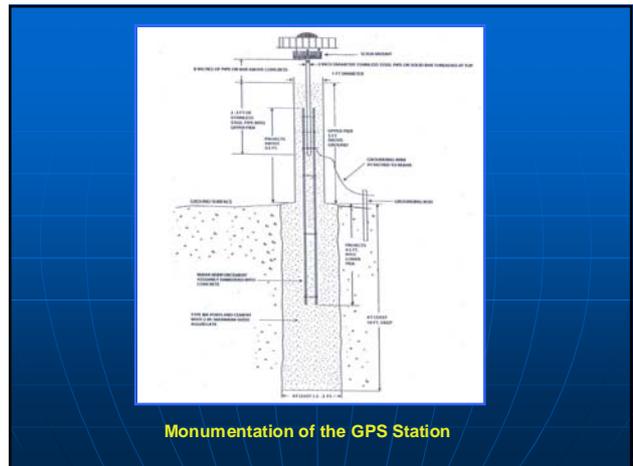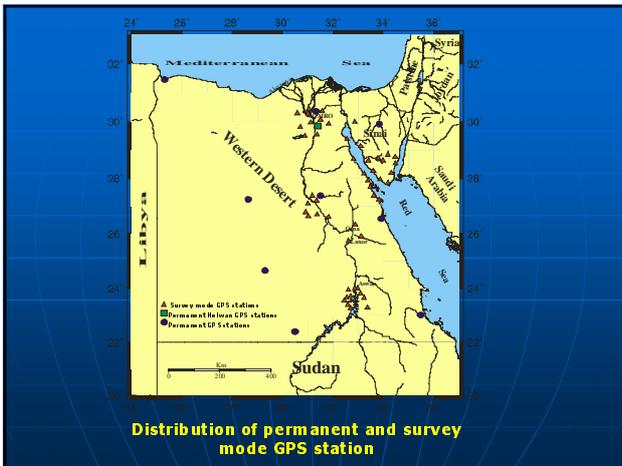
Instrumentation Facilities

➤ **GPS, Vertical and 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**

- • 9 Permanent GPS Receivers of Trimble 5700 CORS Connected with Zephyr Antenna
- • Lacoste & Romberg- model D

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 at NRIAG for monitoring crustal deformation 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).

Seismicity
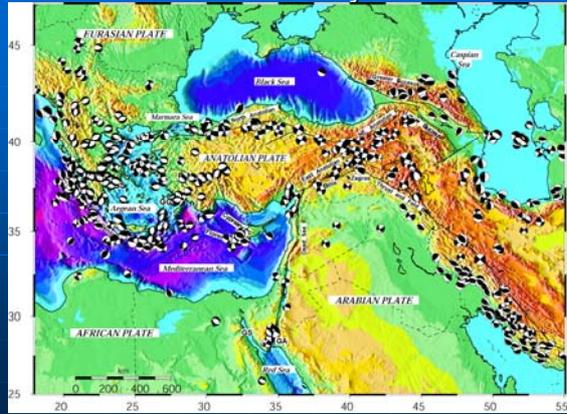
GPS Velocity Field
Global CGPS 1992-2000, regional SGPS 1988-2000
McClusky et. al., **2000, JGR**
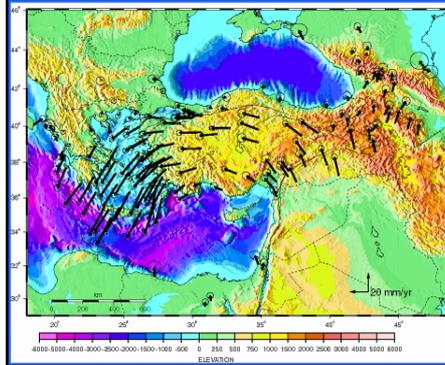
Continuously operating GPS systems allow these types of dense networks

GPS Velocity Field
Global CGPS 1992-2003, regional SGPS 1988-2002
McClusky et. al., 2003, JGI
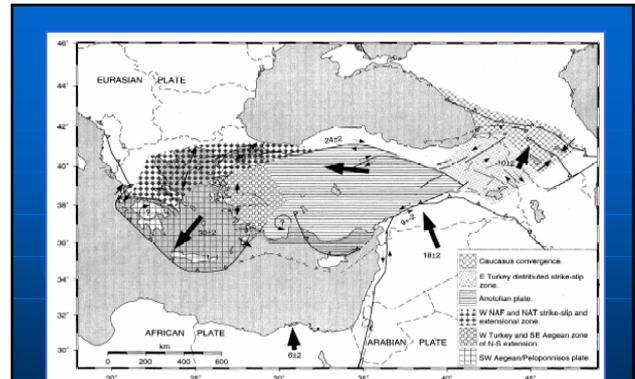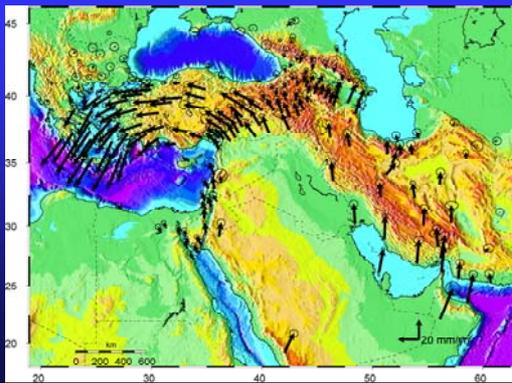
Generalized Regional Motions Model of the Eastern Mediterranean Region
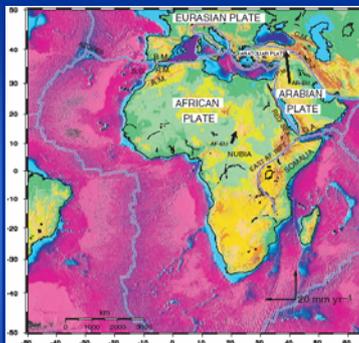
NUVEL-1A motion of Arabia and Nubian (African) relative to Eurasia. (After DeMets et al.,1994).

Sinai Area

5

Slide 1

Sinai velocity field
1997-2003

w.r.t. Nubia **w.r.t. Arabia**

Slide 2

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

Slide 3
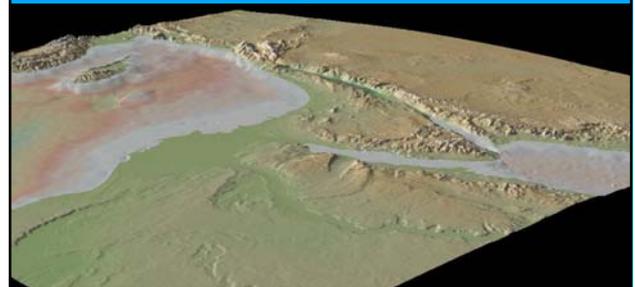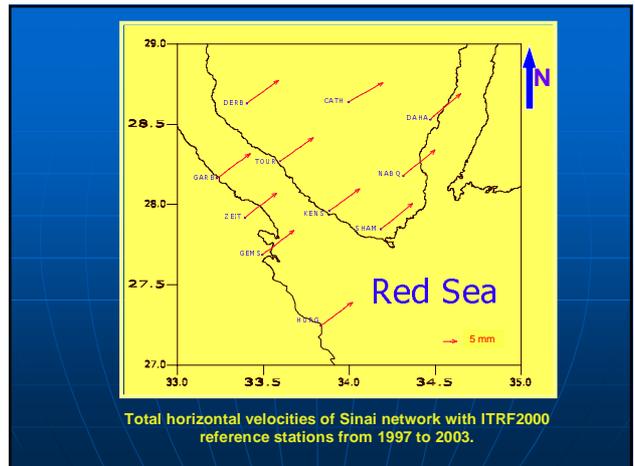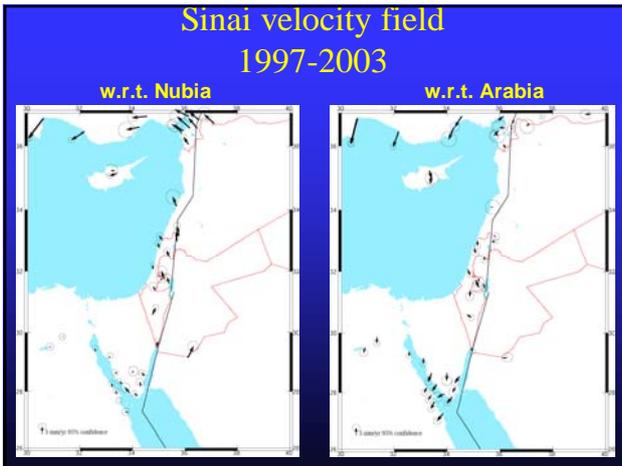
Station velocities in mm/6yr of Sinai network from 1997 to 2003 relative to IGS permanent station (black) using ITRF2000 velocities and Nuvel -1A.

Station ID	Campaign year							Geographic coordinate		ITRF2000 velocity		Nuvel velocity	
	97	98	99	00	02	03		Lat(°)	Long(°)	V_N (mm/6y)	V_E (mm/6y)	V_N (mm/6y)	V_E (mm/6y)
Cath Nabq								28.178 28.639	34.315 34.00	20±0.2	23±0.2	19.5	25.0
Daha Nico								29.52 35.141	34.470 33.396	20±0.1	22±0.2 ITRF2000	19.5	25.1
Derb Sham								28.630 27.846	33.404 34.184	18±0.3 20±0.1	23±0.1 23±0.1	19.6 19.5	24.9 25.1
Garb								28.163	33.228	19±0.2	24±0.1	19.6	24.9
Sofi Gems								42.556 27.686	23.395 33.494	19±0.1	ITRF2000 23±0.1	19.6	25.0
Tour Hurg								28.269 27.267	33.596 33.869	18±0.3 18±0.2	24±0.2 23±0.0	19.6 19.6	24.9 25.1
Zeck Kens								43.788 27.960	41.565 33.883	17±0.1	ITRF2000 22±0.3	19.6	25.0
Zeit Hate								27.919 40.649	33.392 16.704	19±0.2	23±0.0 ITRF2000	19.6	24.9

Slide 4

Velocity Field for Greater Cairo Region

1997-2002

Slide 5

Displacement vectors in Aswan network for the period from 1997- 2002

Slide 6

PHLW

Distribution of GPS geodetic station between Egypt and Yemen.
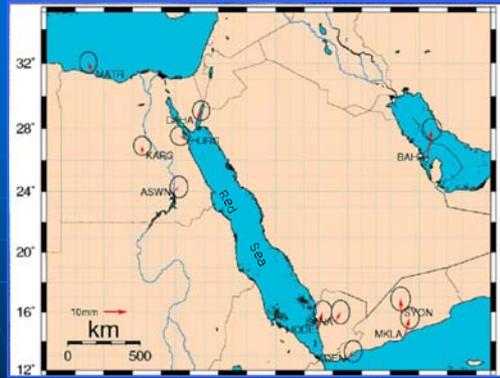
Displacement vectors in Egypt –Yemen network for the period from 2000 to 2003

CONCLUSIONS

3 A generalized model of the regional plate motions in the eastern Mediterranean has been deduced.

GPS observations in Egypt were applied for the first time since 1994 till now to cover different regional networks (e.g. Sinai, Aswan, Greater Cairo and Middle Part of Egypt).

4 Combination of GPS results together with oriented GPS campaigns from the different networks prevailed significant motions.

Adjustment and analysis of the recent GPS campaigns could be used as disaster management tools.

RECOMMENDATIONS

2 It should be emphasized that all concerned authorities, research centers and Universities in the countries surrounding the Red Sea and the Gulf of Aqaba to cooperate in the program for studying crustal deformation using GPS technique to evaluate the seismicity and earthquake hazards in these regions.

Increasing GPS geodetic networks covering many parts of Egypt and the neighbor countries for studying crustal deformation in these regions is of great importance.

THANK YOU