The Seismic Activity and Seismic Monitoring of Cyprus

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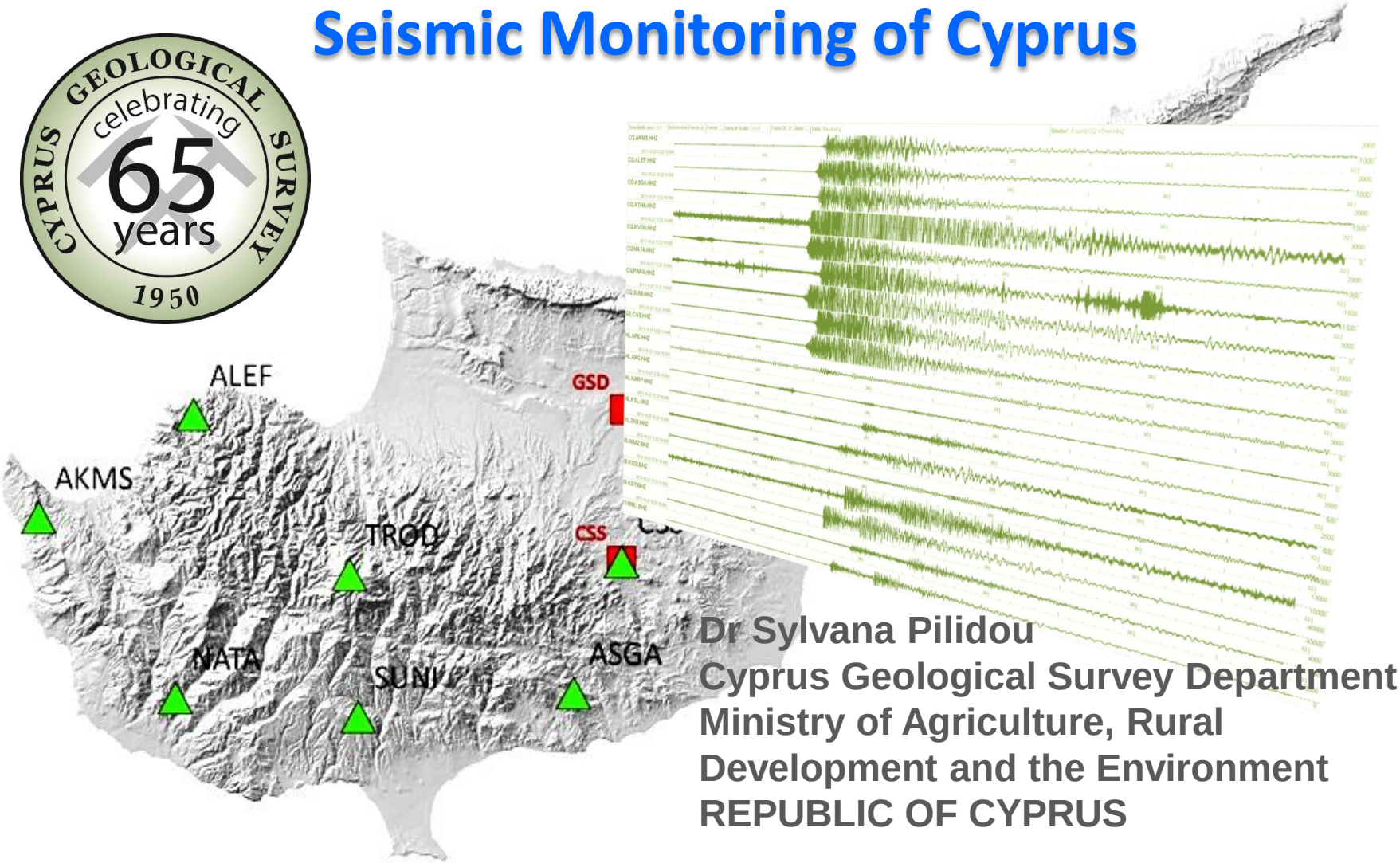
on behalf of Dr Sylvana Pilidou of the Cyprus Geological Survey Department

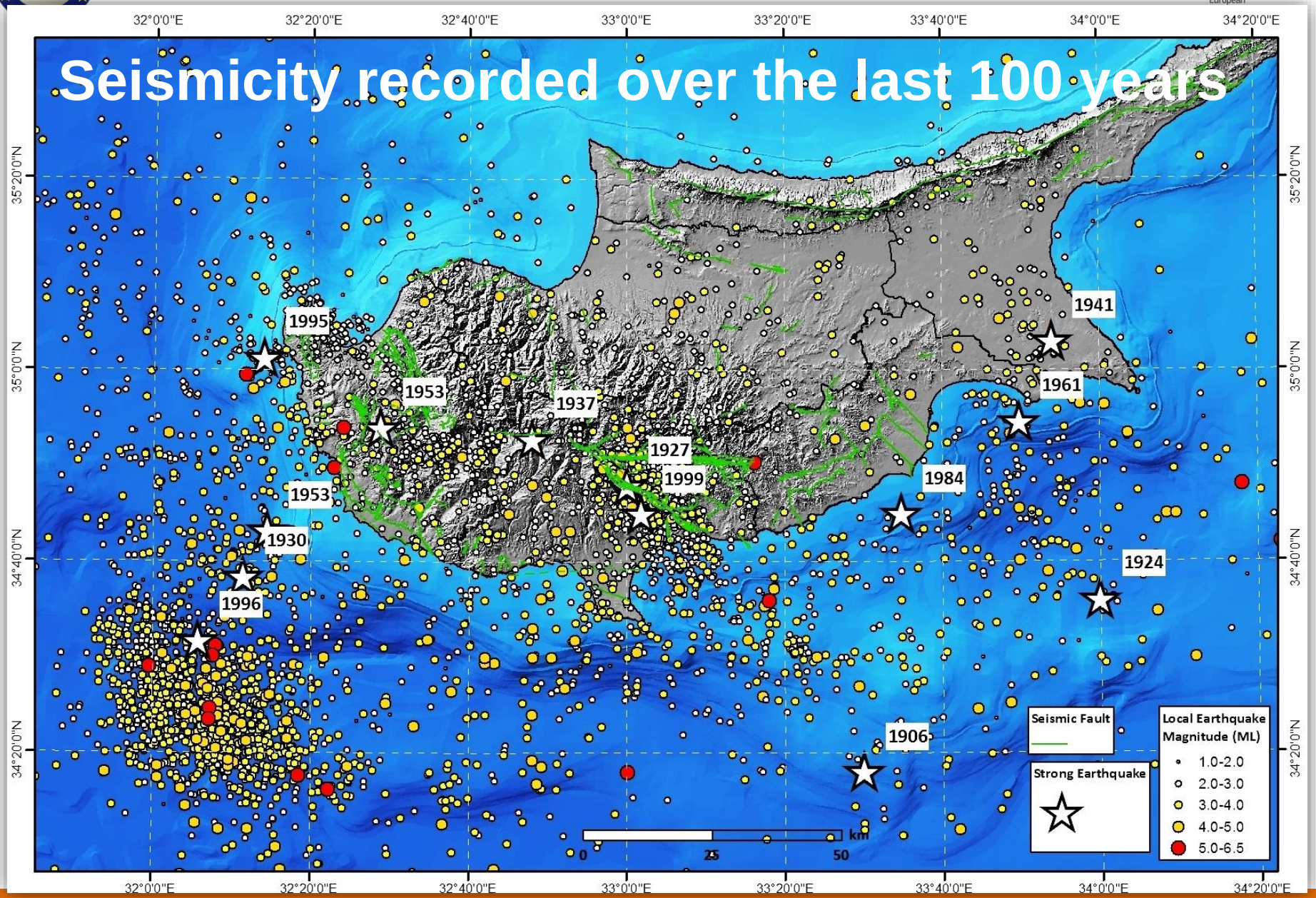
European Commission

Project co-funded by the EU Humanitarian Aid and Civil Protection

The Seismic Activity and Seismic Monitoring of Cyprus



Dr Sylvana Pilidou
Cyprus Geological Survey Department
Ministry of Agriculture, Rural Development and the Environment
REPUBLIC OF CYPRUS


Seismicity recorded over the last 100 years
32°0'0"E
32°20'0"E
32°40'0"E
33°0'0"E
33°20'0"E
33°40'0"E
34°0'0"E
34°20'0"E
35°20'0"N
35°0'0"N
34°40'0"N
34°20'0"N
1995
1953
1937
1927
1999
1953
1930
1996
1941
1961
1984
1924
1906
Seismic Fault
Strong Earthquake
Local Earthquake Magnitude (ML)
1.0-2.0
2.0-3.0
3.0-4.0
4.0-5.0
5.0-6.5
0
25
50
km

Why should we monitor the seismicity of Cyprus?

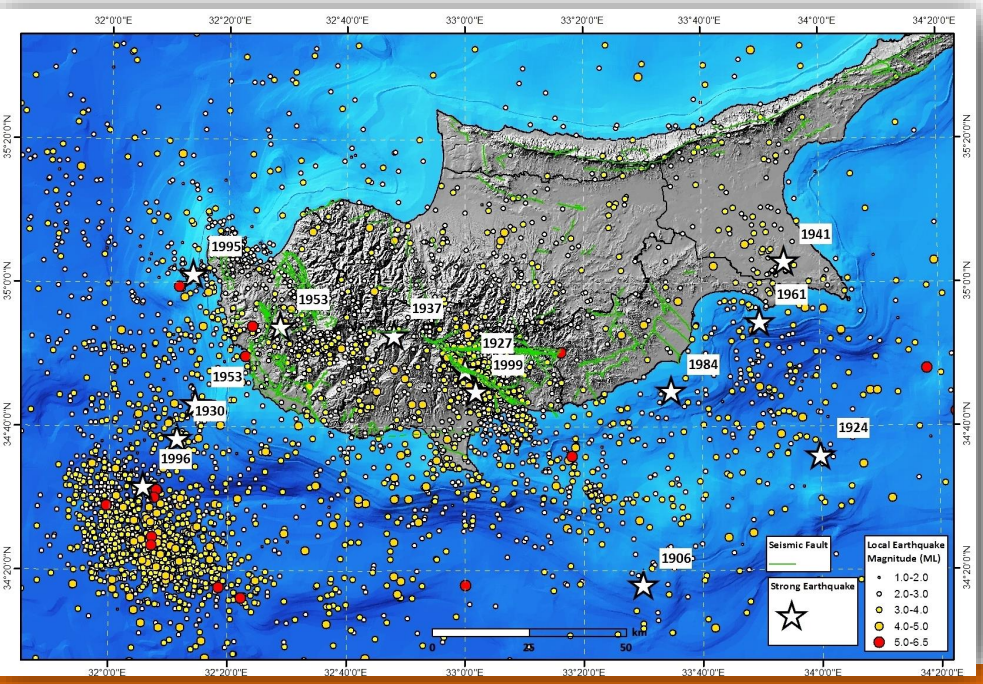
We can save lives

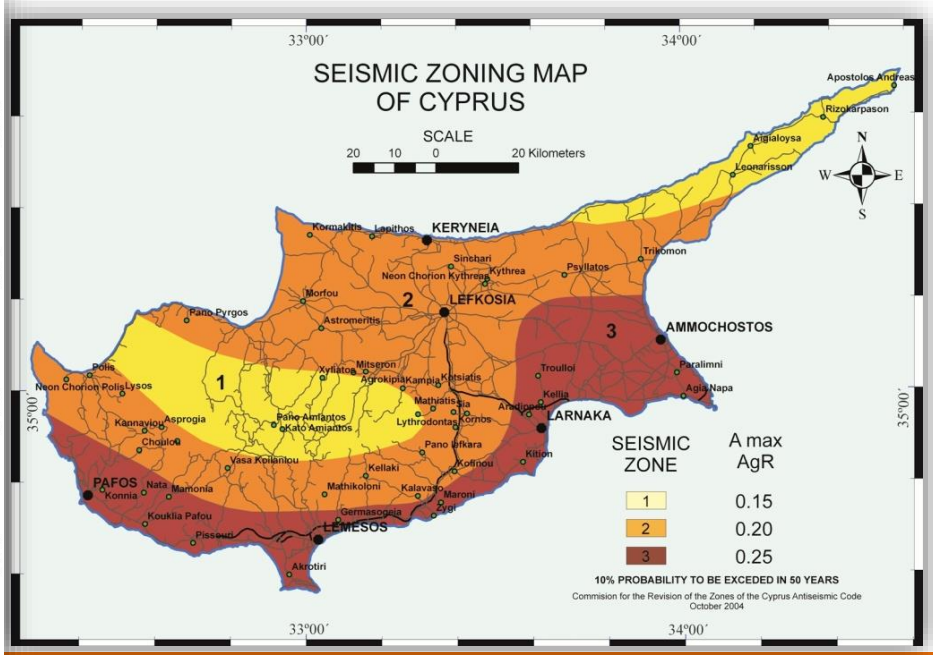
Predicting earthquakes?

NO

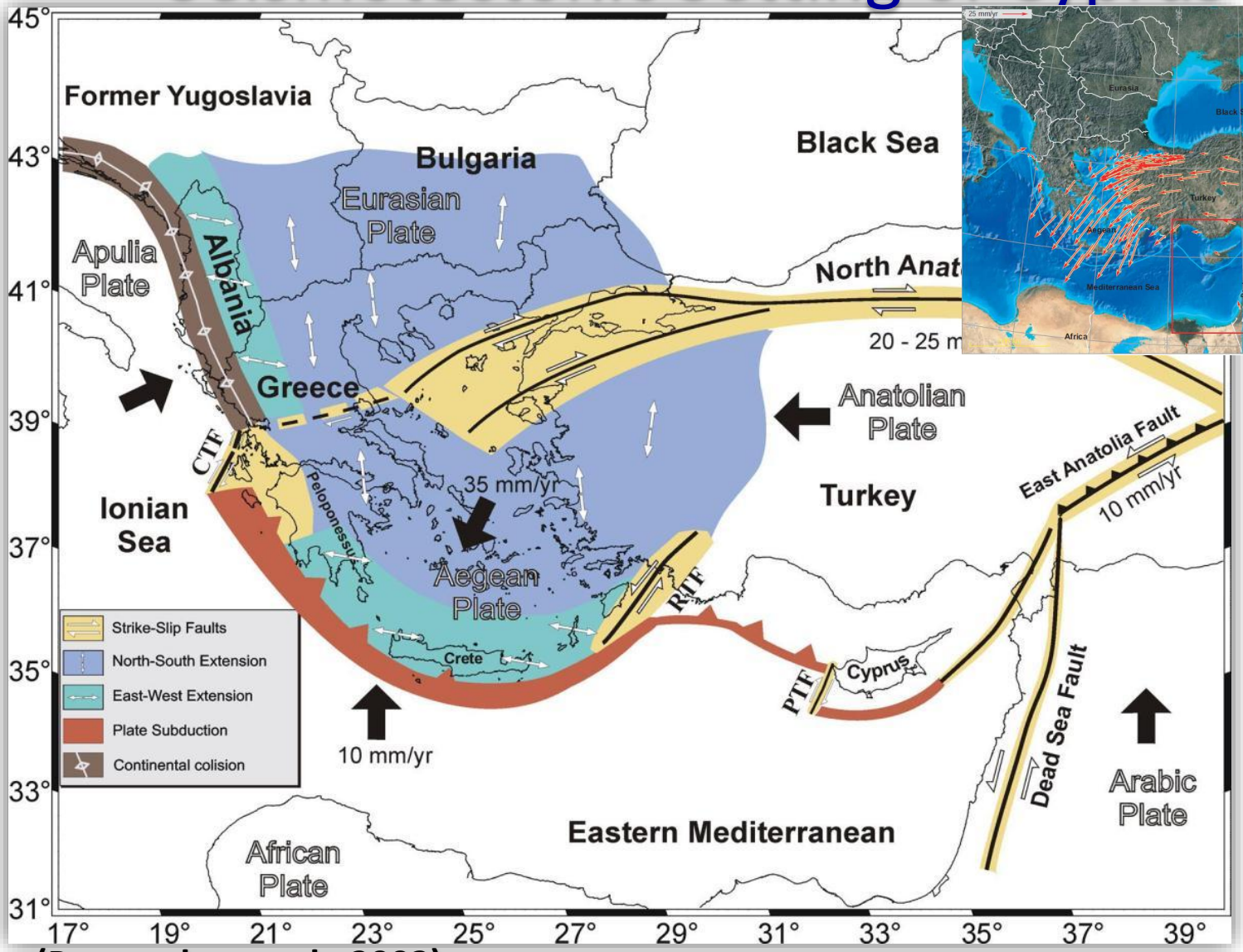
Improving/updating the anti-seismic measures?

YES



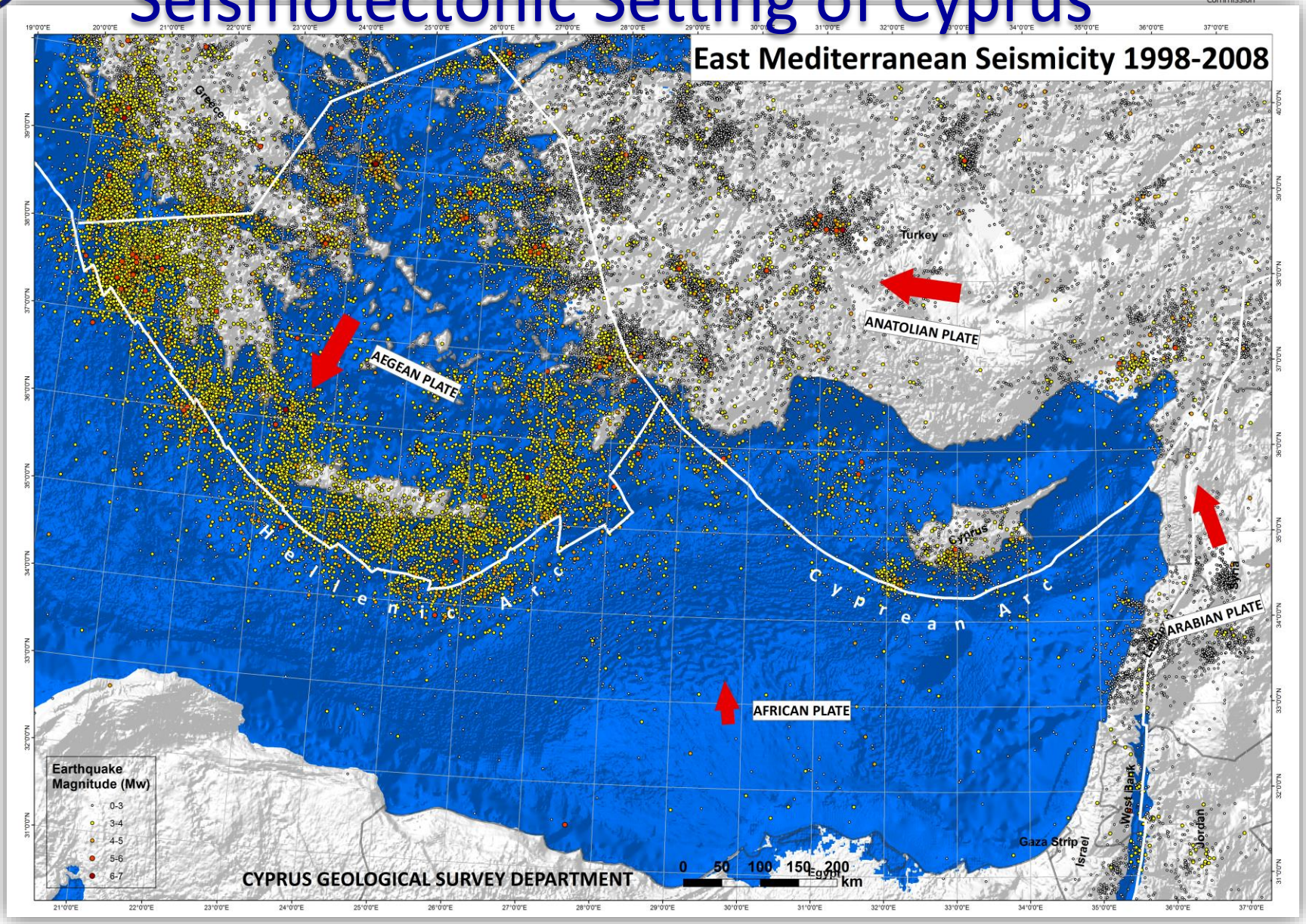


Seismotectonic Setting of Cyprus

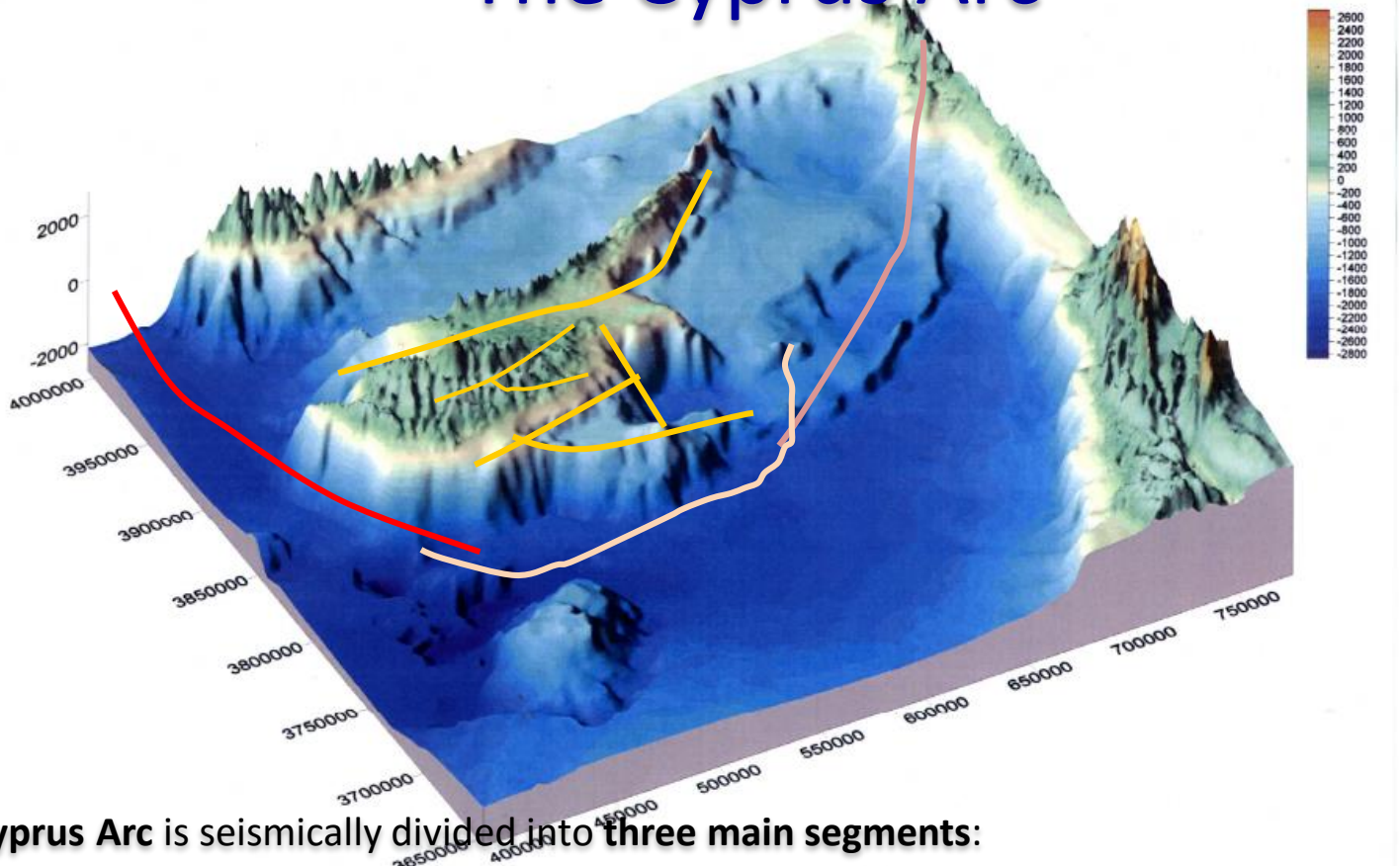


(Papazachos et al., 2003)

Seismotectonic Setting of Cyprus

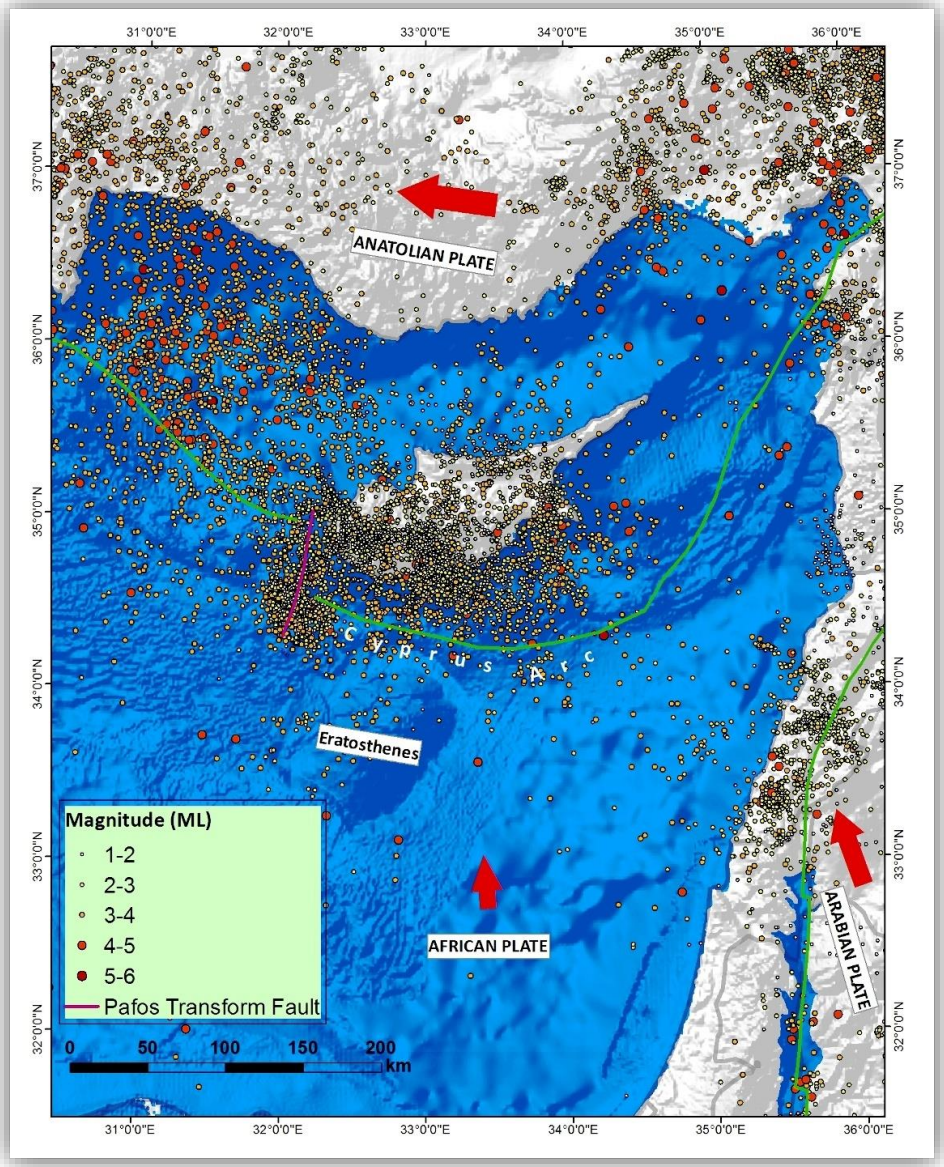


The Cyprus Arc



The **Cyprus Arc** is seismically divided into **three main segments**:

1. The **western part**, which extends from the Antalya gulf (where it joins the Hellenic Arc) to the west of Cyprus.
2. The **central part**, which extends between the south-west coast of Cyprus to the south-east (north of Eratosthenes seamount all along.
3. The **eastern part**, which extends further north-eastwards ending at the Africa-Anatolia-Arabia triple junction.



The Cyprus Arc

The **western part** exhibits high seismic activity with medium depth (up to 135 km) earthquakes near the Antalya gulf (active subduction?).

The **central part** also exhibits high seismic activity with both shallow and medium depth earthquakes (Eratosthenes Seamount Collission?).

The **eastern part** is an area of low seismic activity and the absence of medium depth earthquakes (locked subduction?).

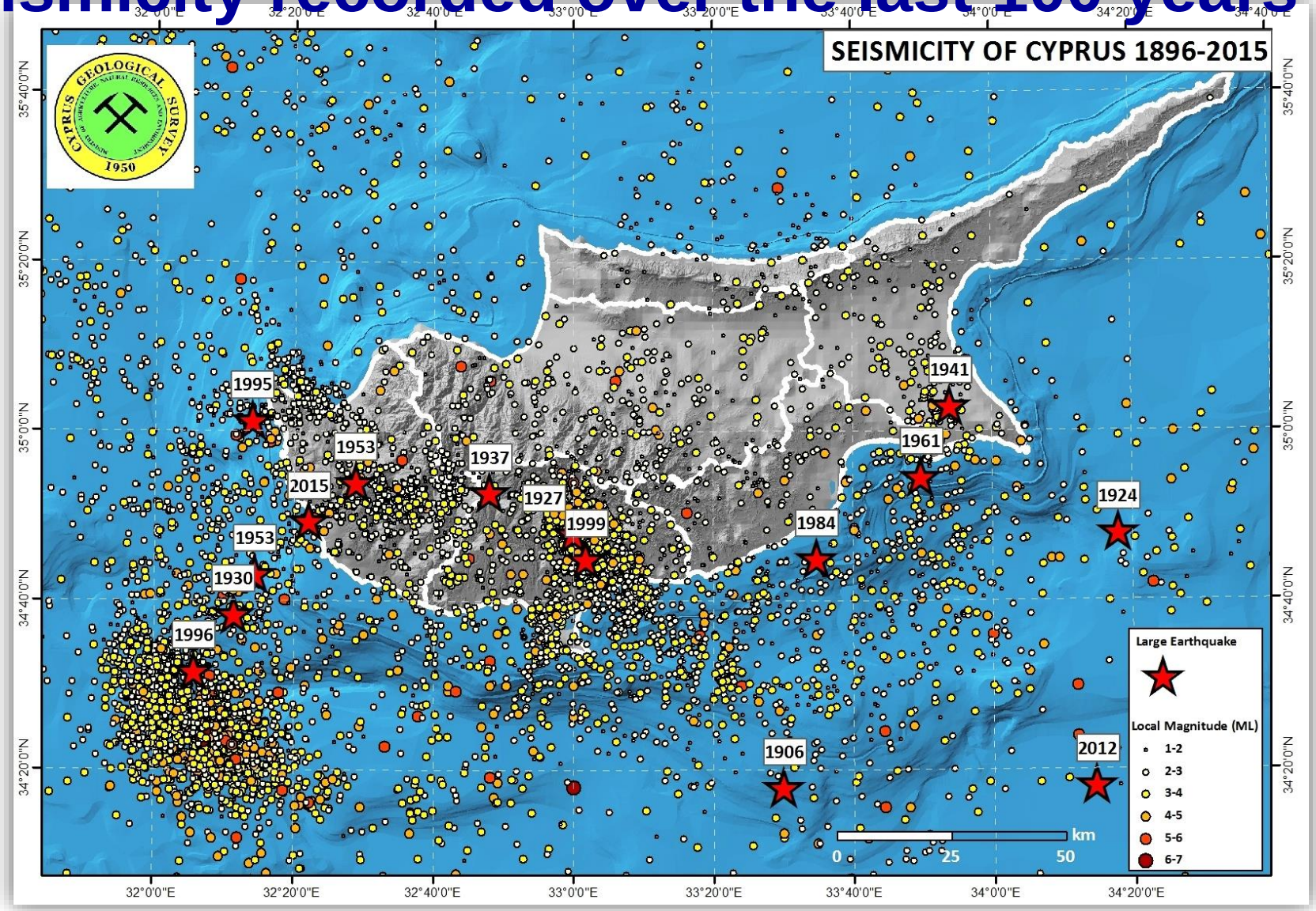
GTR/CYP/0905-170 September 2005 p. 236

Maximum earthquake sizes estimated for the main Quaternary faults and fault systems (relation of Wells and Coppersmith, 1994) | PART 7 - FIGURE 1

Active faults of Cyprus

Date: 15-09-2005 | Author: Anna FIORAVANTI File: figure_max.mxd | Source: GEOTER, 2005

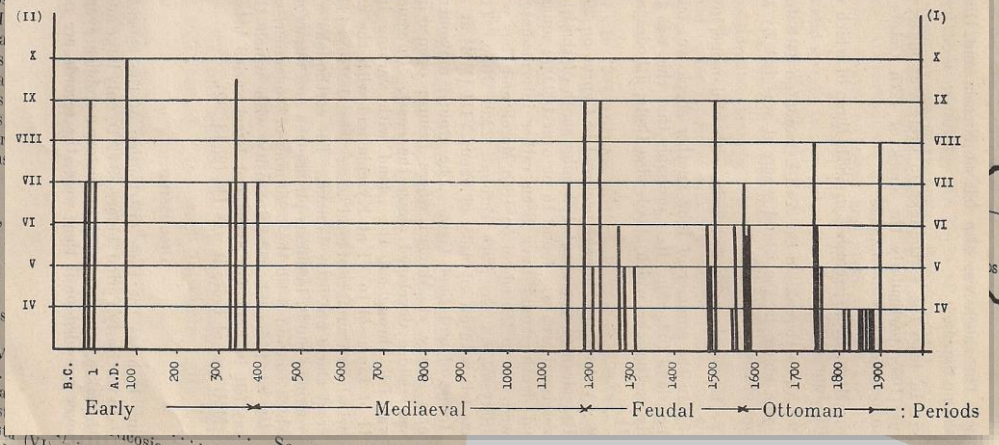
Seismicity recorded over the last 100 years



Historically

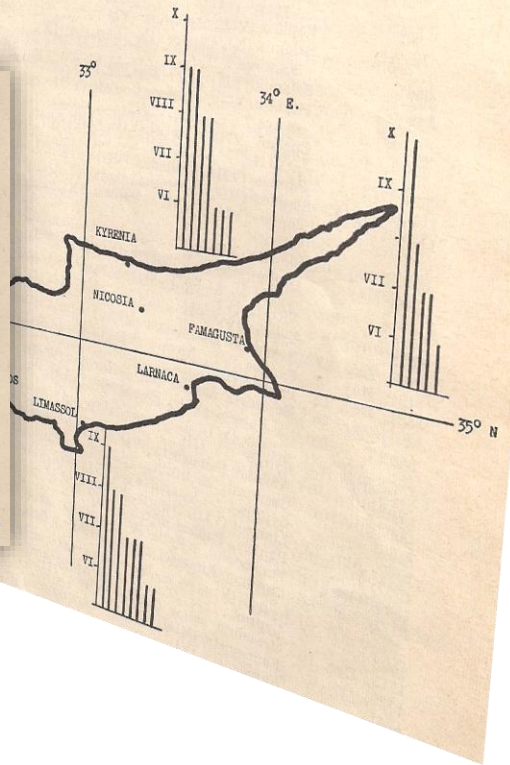
Year	Place-Intensity	Epicentre
1495 ? BC	Paphos (?)	?
180 ?	Cyprus	West of Cyprus ?
92	Cyprus, Syrian coast	West of Cyprus ?
69	Famagusta, Syrian towns	Syria
26	Paphos (VII), Egypt (IV)	SW of Paphos
15	Paphos (IX), Curium (IX) other towns in Cyprus (VIII)	SW of Paphos
6 ?	Paphos (VII), Amathus (VI)	36°N - 28°E ?
76 AD	Salamis (X), Paphos (IX), Larnaka (IX), s.s.wave ?	SE of Cyprus
332	Salamis (VII)	East of Cyprus
342	Paphos (X—), southwest coasts (VIII+), wave ?	Southwest coast
367	Curium (VII), Akrotiri (VII), south coasts (VIII)	W. and S. of C.
394	Paphos (VII ?), Salamis (VII)	East of Cyprus
1144, May 19	Paphos (VII ?), regional shock	?
1183	Paphos (VIII), NNE of Paphos (IV)	
1202-3	Cyprus	
1222, May	Paphos	
	(VII	
1267	Nicosia	
1268	Cyprus	
1303, Aug. 7	Nicosia	
1481, May 3	Paphos	
1481, Dec. 18	Paphos	
1491, Apr. 25	Messaor	
	Limas	
	phos	
1542, Dec. 12	Cyprus	
1546	Nicosia,	
1547	Cyprus	
1566	Cyprus	
1567, Apr. 25	Limasol	
1567, Dec.	Paphos,	
1569, Oct. 13	Famagus	
1577, Jan. 28	Curium,	
	mis (V	
1583	Cyprus	
1718, Dec. 10	Messaoria	
1735, Dec.	Famagust	
1741	Famagust	
1756, Jan. 17	Nicosia, Messaoria valley (V)	local ?

EARTHQUAKE INTENSITIES FELT IN CYPRUS



Year	Place-Intensity	Epicentre
1810, Feb. 16	Cyprus (III-V)	35½N - 25°E
1822, Sep. 5	Famagusta, Larnaka (IV)	Israel-Syria
1837, Jan. 1	Cyprus	Israel
	Limassol (III-V)	Southeast of C.
1838	Nicosia, Dali, Hierokipos (IV)	36°N - 36°E ?
1845, Feb. 21	Cyprus (III-IV)	35½N - 26°E
1856, Oct. 12	Cyprus (III-IV)	?
1861, Jun.	Cyprus (III-IV)	34°N - 37°E
1870, Jun. 24	Cyprus (III-IV), Limassol (IV)	?
1882	Cyprus (III-IV)	36°N - 26°E
1887, Jul. 17	Akrotiri (VIII), Limassol (VII—), Kyrinia (V)	34°N - 33°E
1896, Jun. 29		

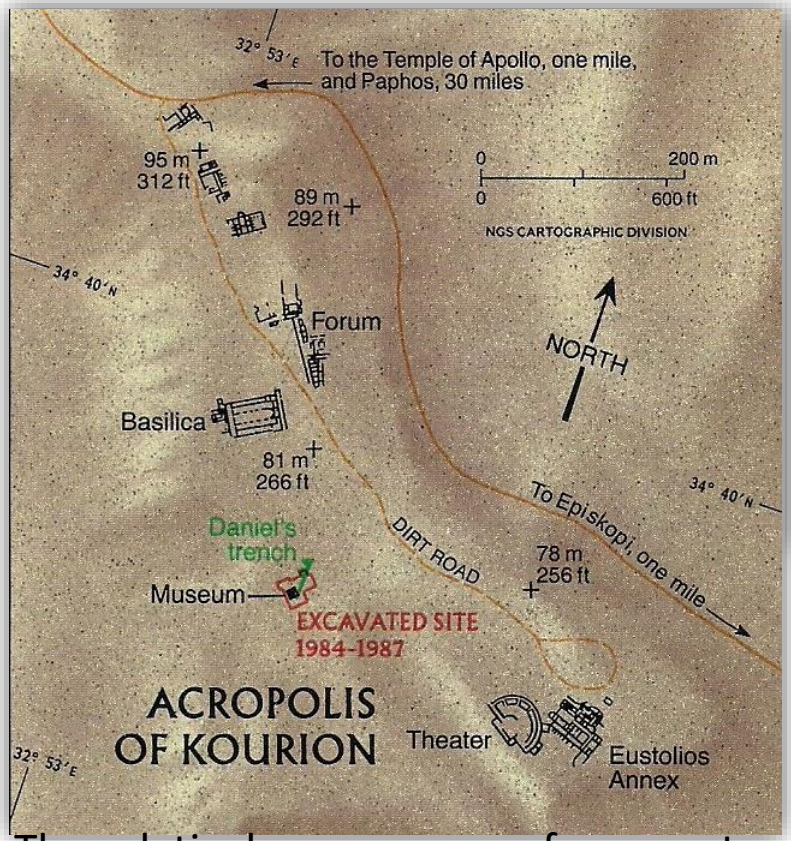
INTENSITY DISTRIBUTION IN CYPRUS (100 B.C. - 1900 A.D.)

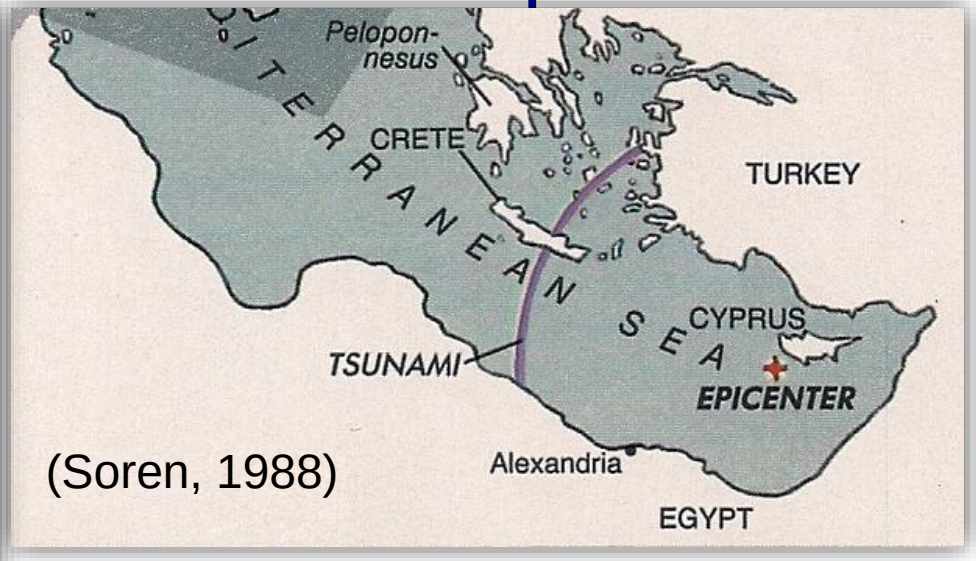


Historic Earthquakes of Cyprus

Date	Place – Intensity	Epicentre
26 BC	Pafos (VII), Egypt (IV)	South-west of Cyprus
15 BC	Pafos (IX), Kourion (IX) and other towns in Cyprus (VIII)	South-west of Pafos
76 AD	Salamis (X), Pafos (IX), Larnaca (IX)	South-east of Cyprus
332-333 AD	Salamis (VII)	East of Cyprus
342 AD	Pafos (X)	South-west coast of Cyprus
365 AD	**Kourion (VII), Akrotiri (VII), south coasts of Cyprus (VIII)**	**South-West of Cyprus**
394 AD	Pafos (VII), Salamis (VII)	East of Cyprus
1144	Pafos (VII)	West of Cyprus
1183	Pafos (VIII)	Near Pafos
1202-1203	Cyprus (VI)	South-West of Cyprus
3 May 1222	Pafos (IX), Lemesos (VIII)	South-West of Cyprus
7-8 Aug. 1303	Nicosia (V), Lemesos (V)	South of Cyprus
3 May 1481	Pafos (VI), Nicosia (VI)	West of Cyprus
25 Apr. 1491	Mesaoria Valley (IX), Nicosia (VIII), Lemesos (VII)	Cyprus
12 Dec. 1542	Cyprus (IV-III)	North-West of
1546	Nicosia, Famagusta (VI)	Cyprus
25 Apr. 1567	Lemesos (VII), Nicosia, Famagusta (V)	South of Cyprus
28 Jan. 1577	Kourion (VI), Nicosia, Salamis (V)	South of Cyprus
10 Dec. 1735	Famagusta (VIII)	Near Famagusta
1741	Famagusta (VI)	Near Famagusta
29 June 1896	Akrotiri (VIII), Lemesos (VII)	190km south of Cyprus

The A.D. 365 Kourion Earthquake





The relatively numerous references to earthquakes in a time which is otherwise characterized by a paucity of historical records, strengthens the case for a period of high seismic activity.

On July 21, AD 365, just after dawn, a cataclysmic event had struck the eastern Mediterranean.

Originating under the seafloor, the earthquake shook the entire region and was accompanied by the largest known tsunami, which strokes the coastal areas of Egypt and eastern Greece. As a result, 50,000 people lost their lives in Alexandria.

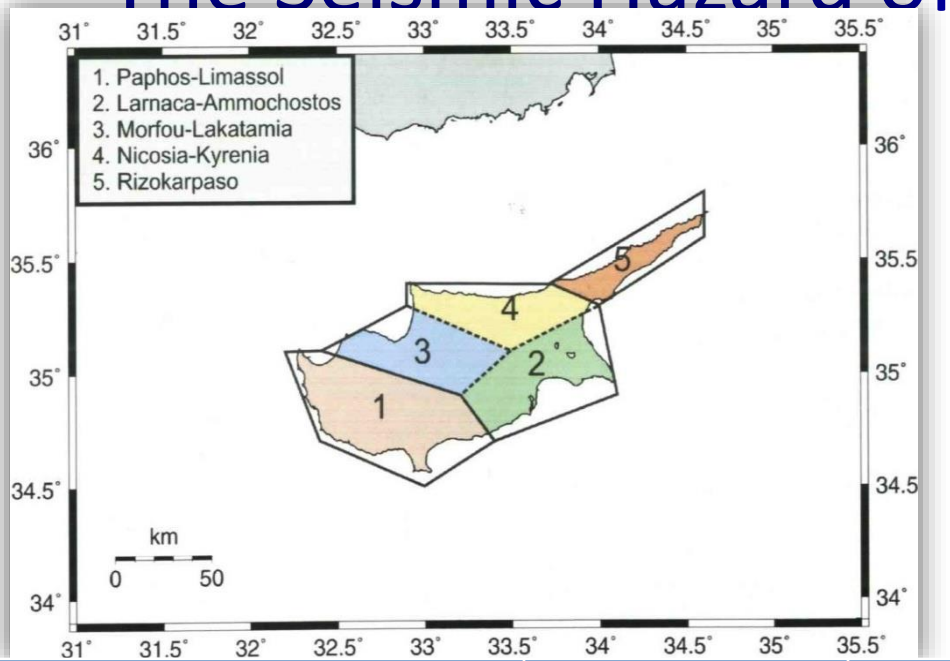
The A.D. 365 Kourion Earthquake

The A.D. 365 Kourion Earthquake

A FAMILY'S LAST MOMENTS

They were in the bedroom. A young mother of 19 still clutched her one-and-a-half-year-old baby to her breast. The child, its teeth still coming in, grasped its mother's elbow. Over them lay a man of about 28, presumably the father, who had tried to shield the pair from a deadly rain of limestone building blocks. The woman, whose neck had been snapped, had a bone hair-pin on her skull. The man wore a ring inscribed with the first two letters of "Christ" in Greek. Bald skeletons now, displayed at the Local Archeological Museum of Kourion in Episkopi village, had been a family of three, clinging together for life as their home crumbled in an earthquake that leveled Kourion 16 centuries ago.

The Seismic Hazard of Cyprus (Papazachos et. al, 2013)



Magnitude	Return Period (in years)	Number of earthquakes in 100 years
≥7.0	153	0.7
≥6.5	52	2
≥6.0	17	6
≥5.5	6	17
≥5.0	2	50

Zone	T_{VII} (years)	Probability ($P_{50/VII}$)
1. Pafos-Lemesos	59	0.57
2. Larnaca-Ammochostos	135	0.31
3. Morfou-Lakatamia	132	0.32
4. Lefkosia-Kerynia	145	0.29
5. Rizokarpaso	832	0.06

The Tsunami Hazard of Cyprus

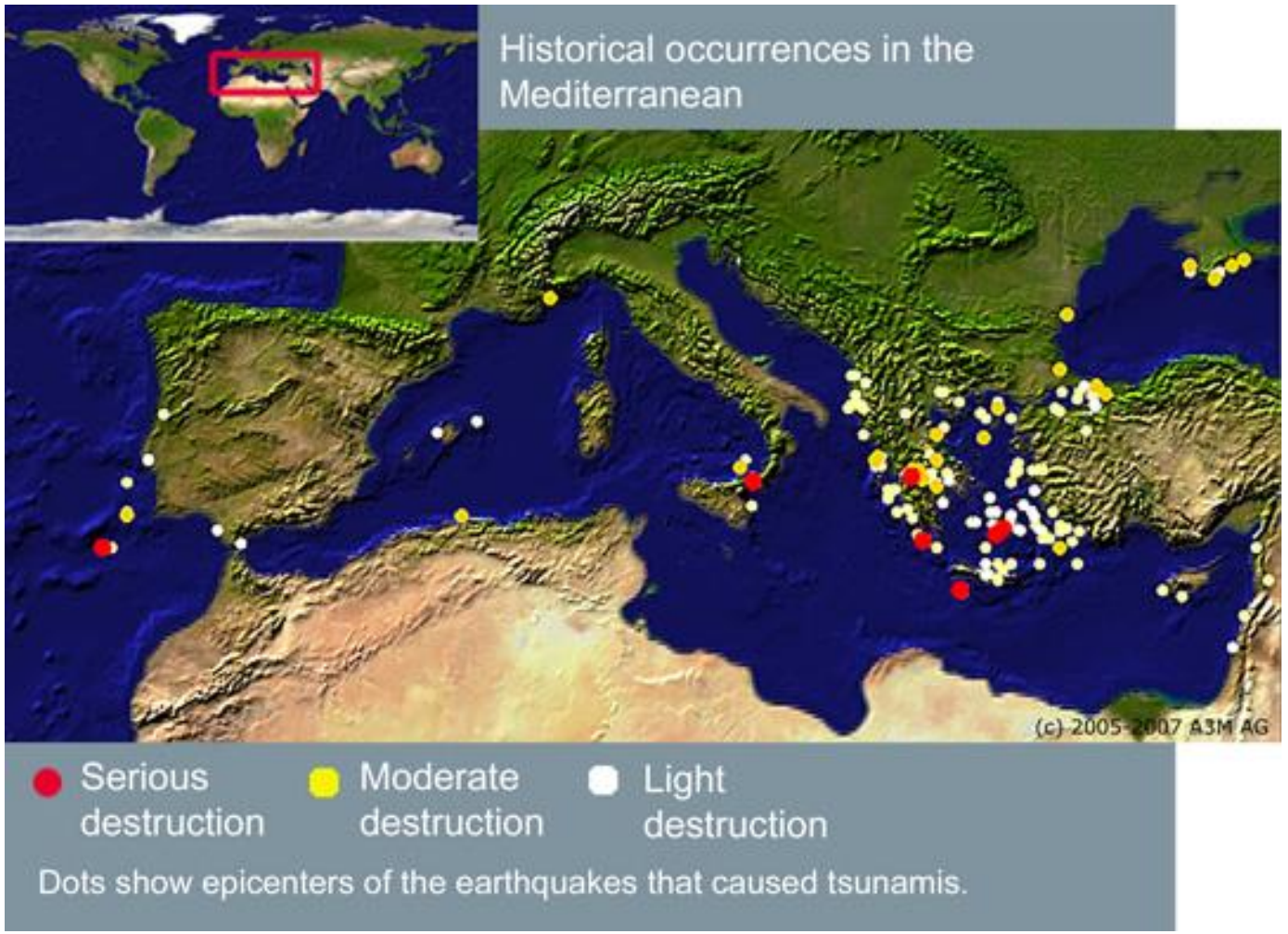
(Fokaefs & Papadopoulos, 2007)

- Mediterranean Sea experiences 10% of global tsunami activity

- Cyprus at lowest risk compared to Levantine Coast or Greece.

- BUT Catastrophic destructive tsunamis documented through history by

  - Direct Observations,
  - Archaeological Evidence
  - Geomorphological Evidence.



The Tsunami Hazard of Cyprus

(Fokaefs & Papadopoulos, 2007)

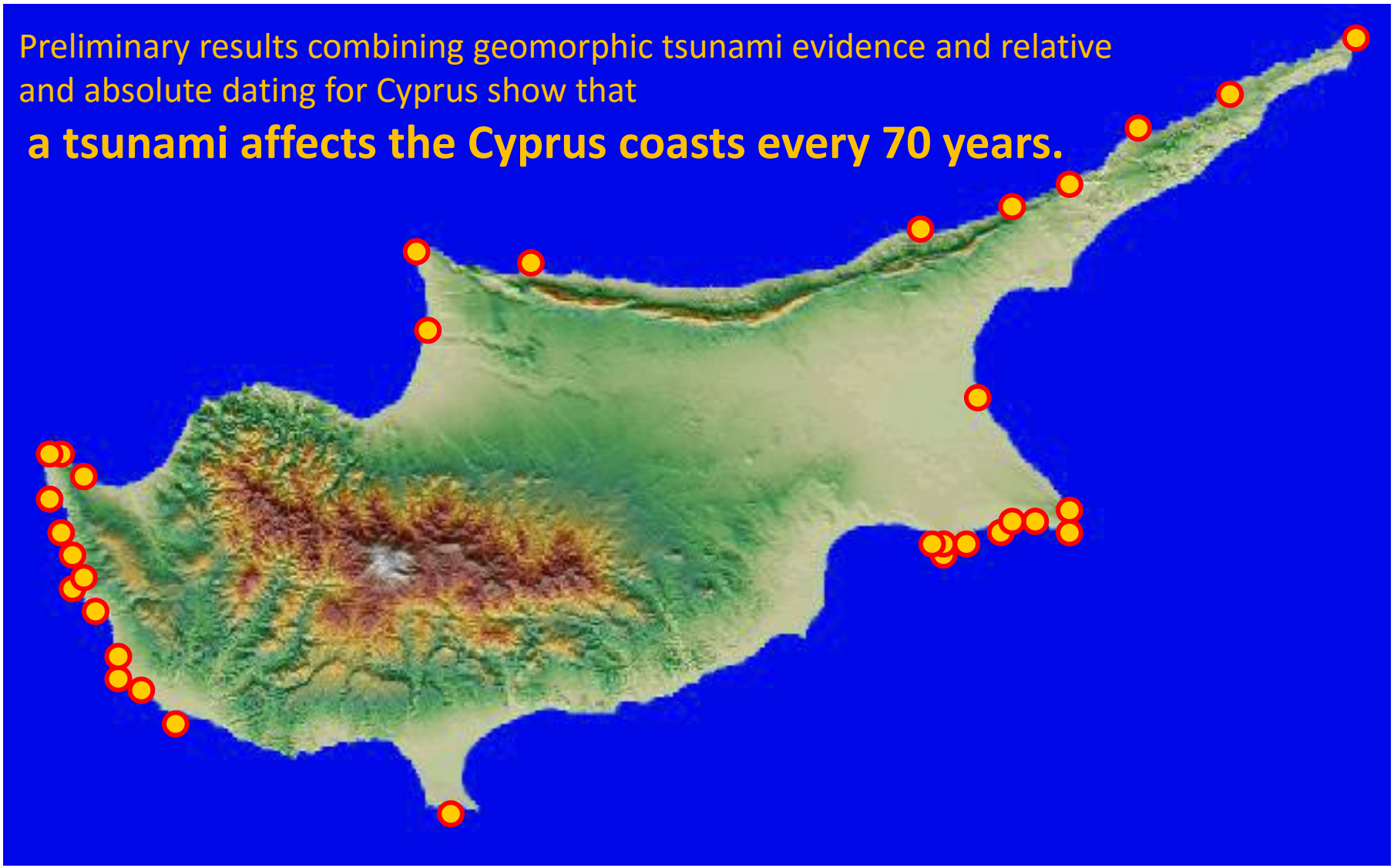
Tsunami Intensity	Wave Height (m)	Return Period (in years)
Moderate	> 0.5	30
Strong	> 1	120
Very Strong	> 4	375

Date	Source of tsunami	Area Affected	Description
1202	**Possibly landslide near the Levantine coast due to a strong earthquake in the area of Israel, Syria and Cyprus.**	**Levantine coast and Cyprus.**	**The sea between C… mountainous waves piled up throwing ships up onto the land. Eastern parts of the island were flooded.**
1222	**Strong submarine earthquake south of Pafos.**	**Cyprus.**	**One of the most destructive events reported in historical catalogues. Earthquake desctruction and destructive tsunami flooding in Pafos and Lemesos. The castle of Pafos collapsed and the harbour was left without water.**
1303	**Strong earthquake in Hellenic Arc between Crete and Rhodes.**	**From Crete to Levantine coasts.**	**One of the largest and best documented seismic events in the history of the Mediterranean area. Destructive tsunami in Crete. Damaging sea-wave in Rhodes. Tsunami reported to be seen at SW Turkey, Egypt, Cyprus and Palestine.**
1953	**Strong double earthquake south-west of Cyprus.**	**Cyprus.**	**Small tsunami along the coast of Pafos which caused no damage.**

Geomorphological Evidence of Palaeo-tsunamis in Cyprus (Noller et al., 2005, 2011)

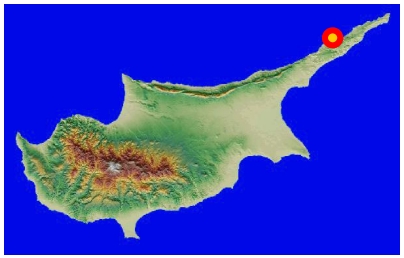
Preliminary results combining geomorphic tsunami evidence and relative and absolute dating for Cyprus show that

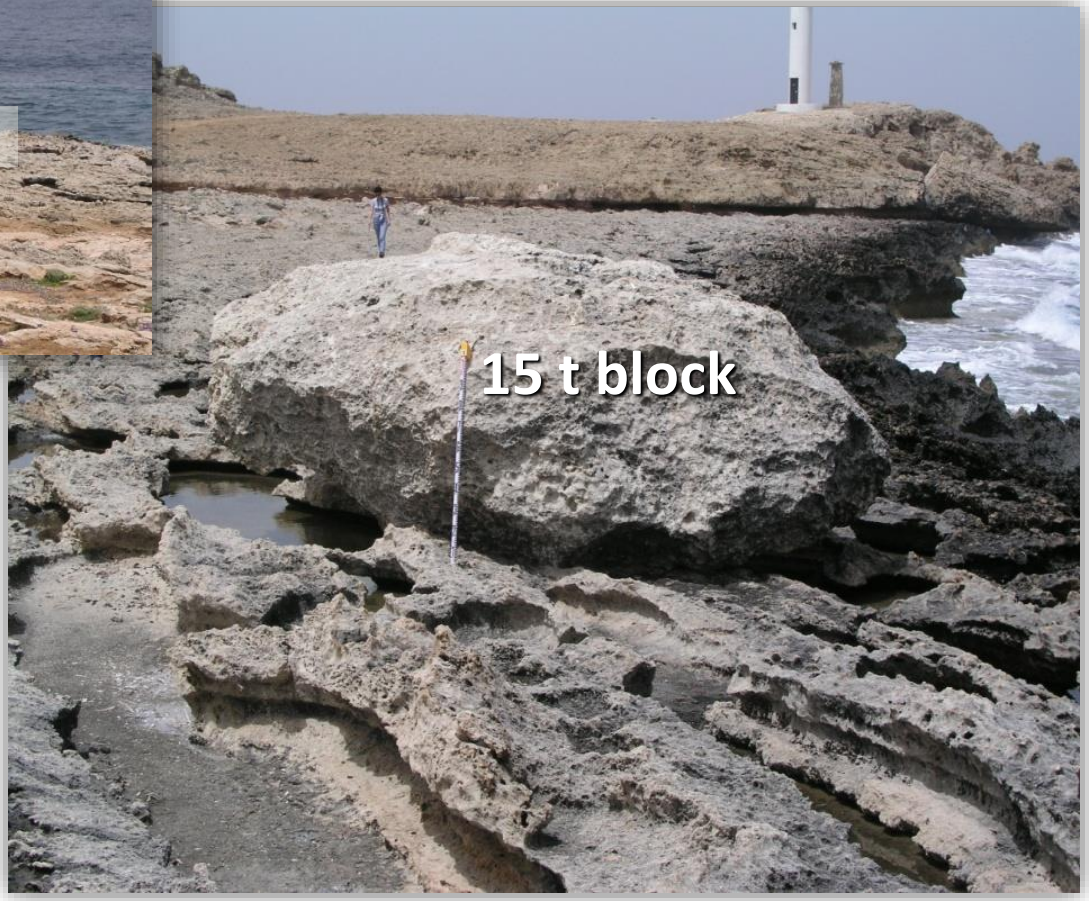
a tsunami affects the Cyprus coasts every 70 years.



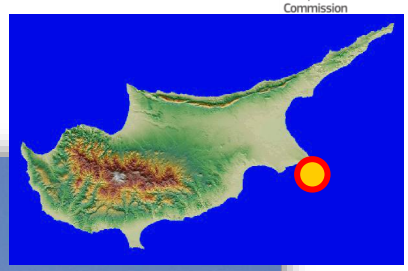
Kormakiti Cape

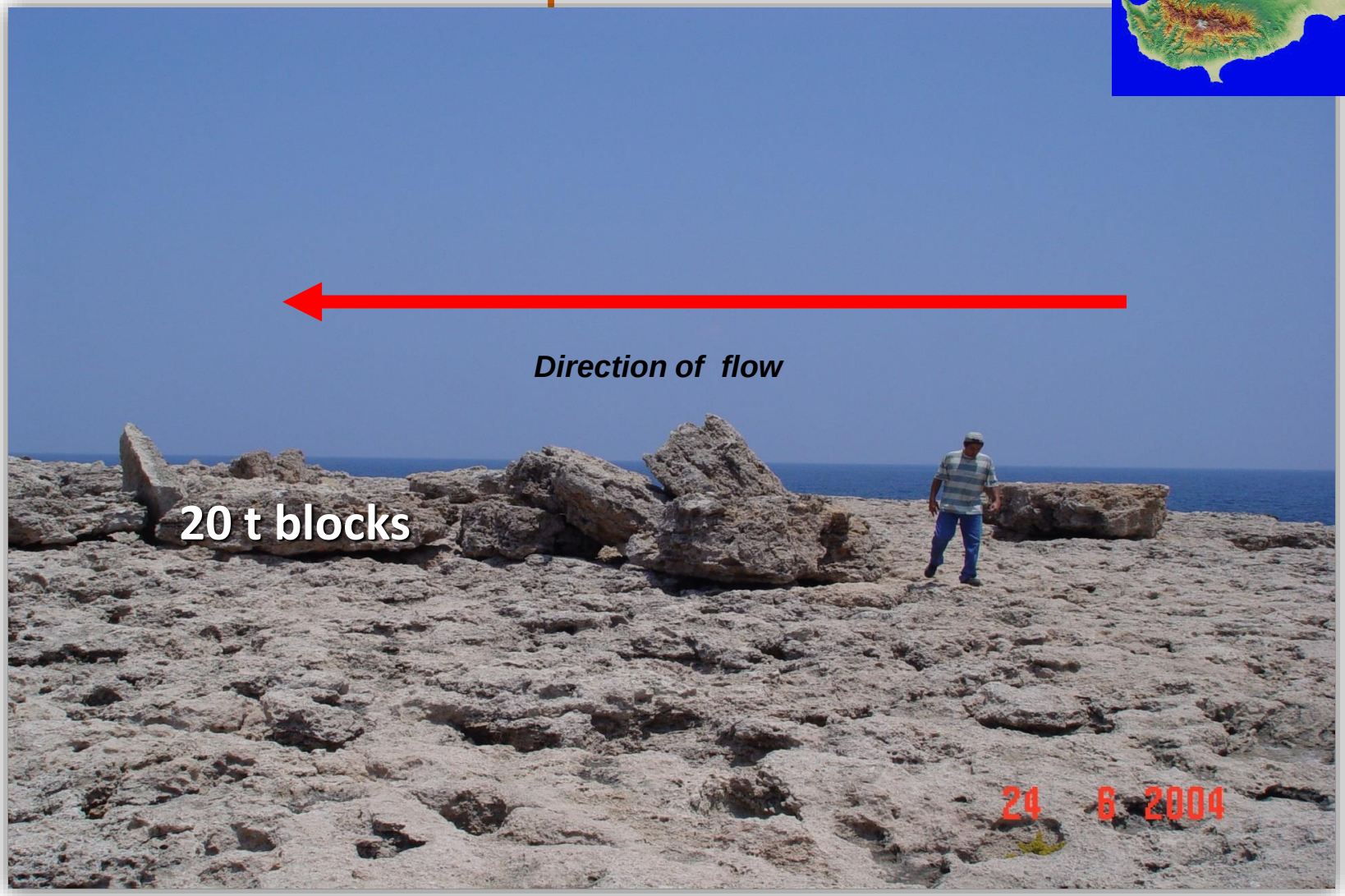
Cape Plakoti, Karpasia



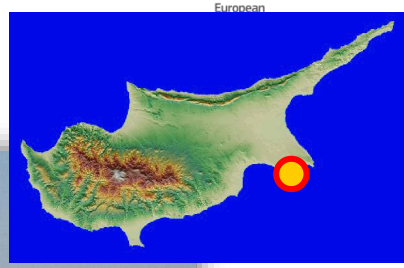


Cape Greco

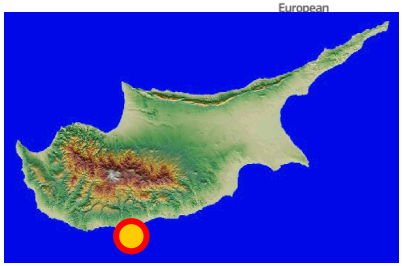


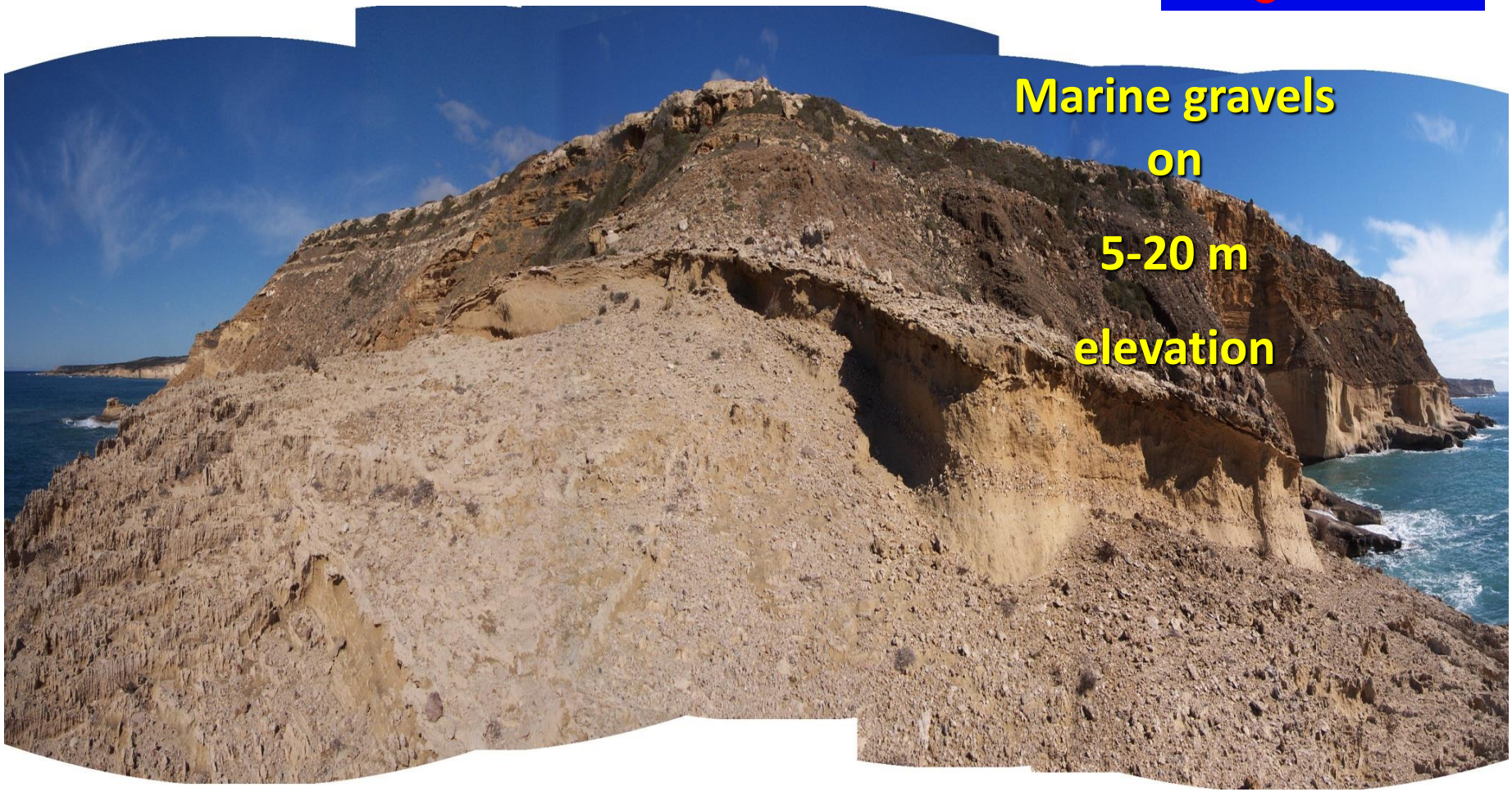


Agia Napa

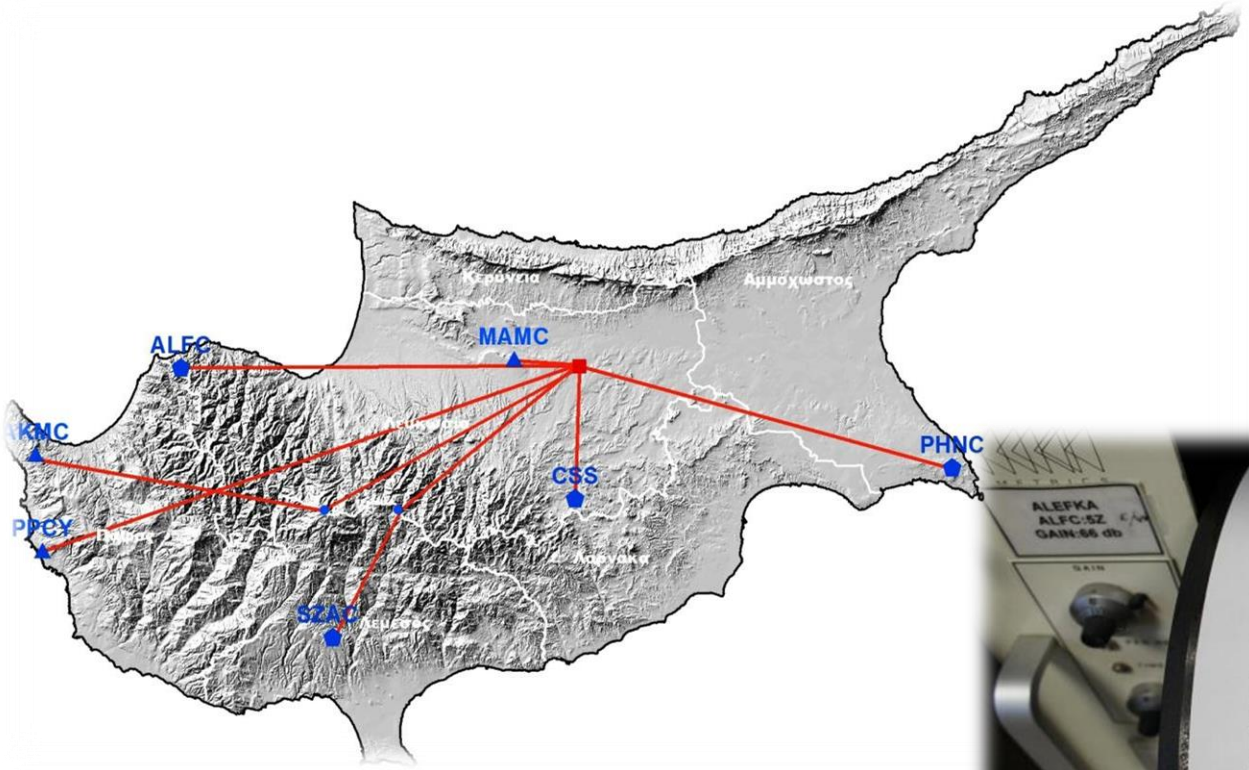


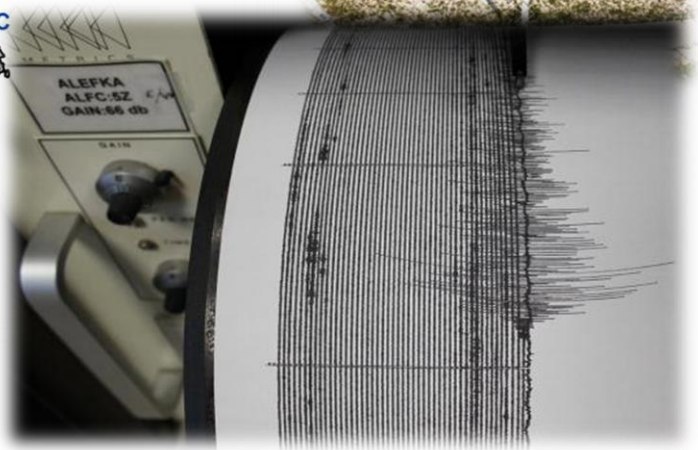
Akrotiri





The first Seismological Network of Cyprus (1984-1997-2013)

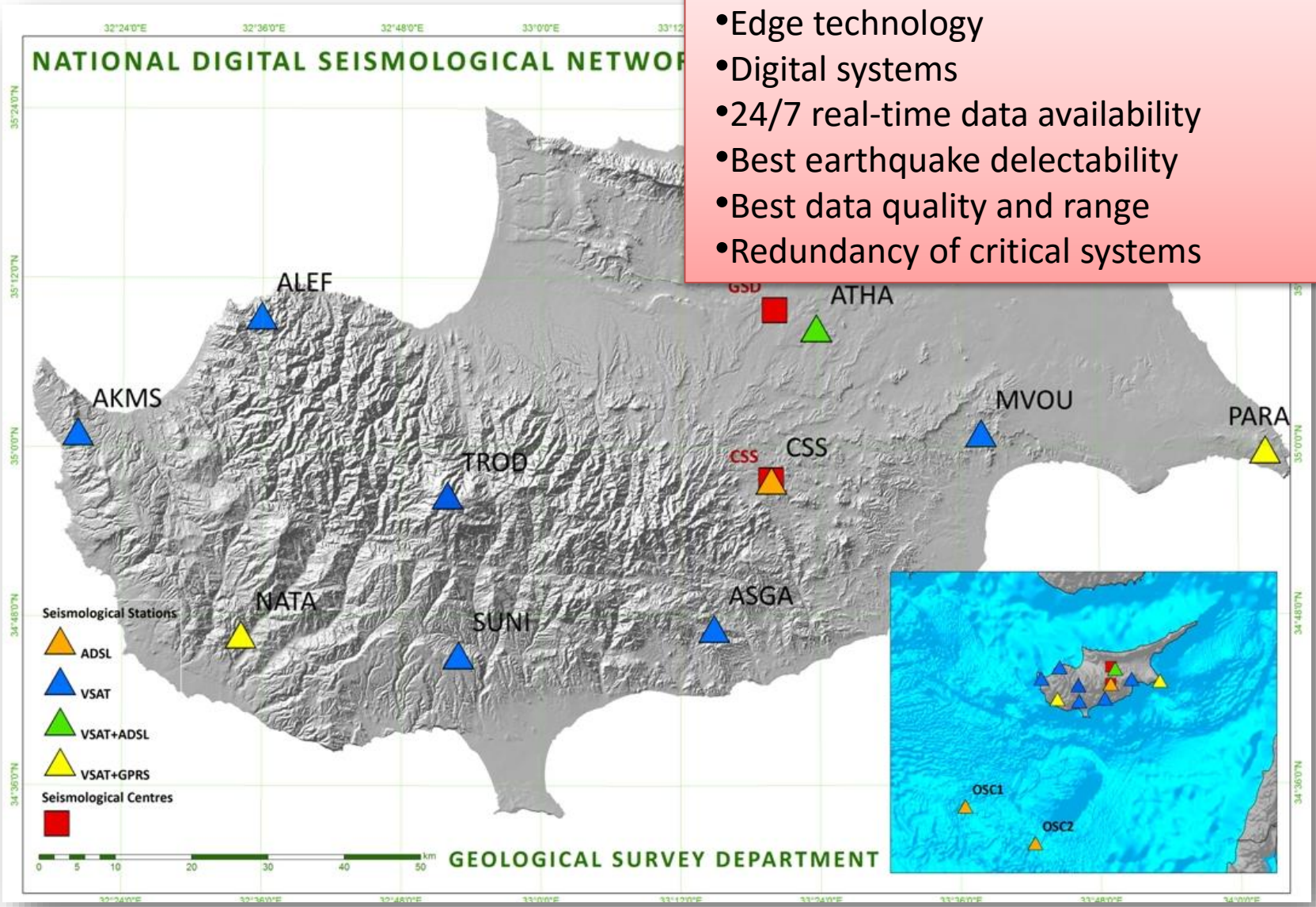




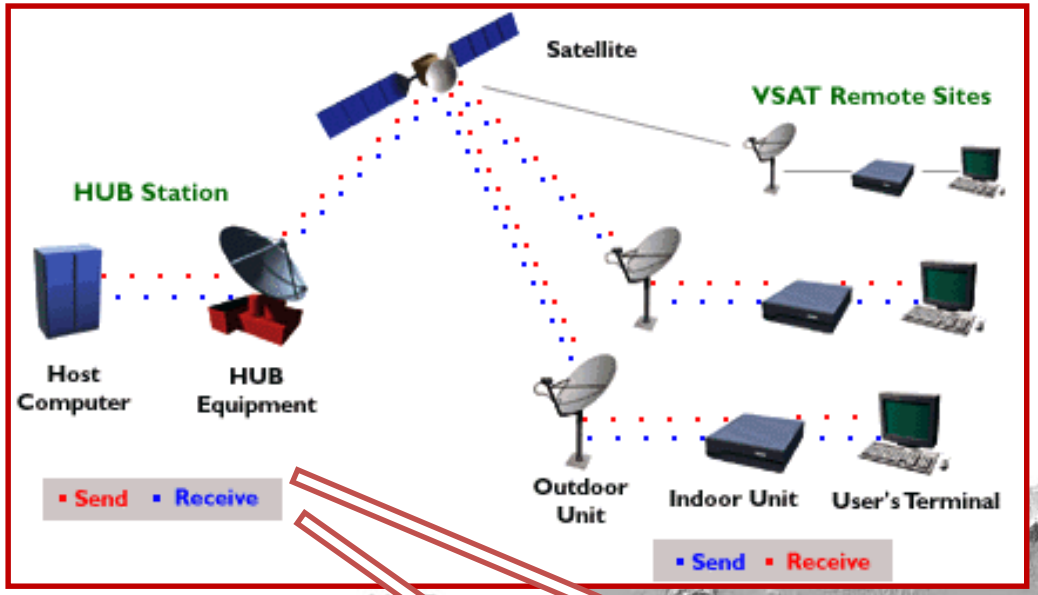
2008: URGENT NEED FOR UPGRADE DUE TO OLD TECHNOLOGY

The new digital seismic network of Cyprus (2011-2014)

- Edge technology
- Digital systems
- 24/7 real-time data availability
- Best earthquake delectability
- Best data quality and range
- Redundancy of critical systems



Main Telecommunications Network: Private VSAT



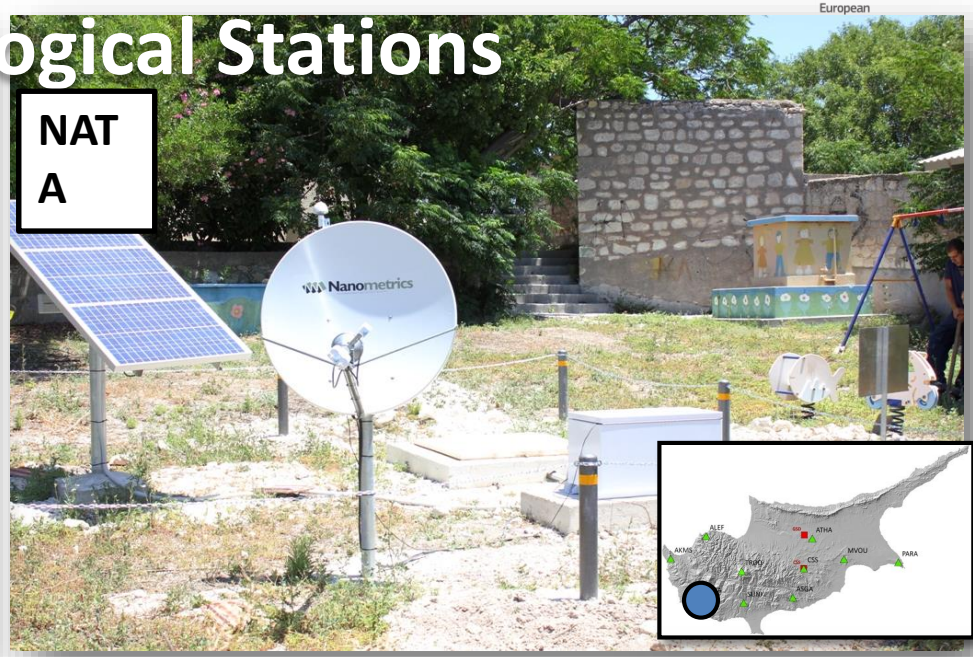
- Autonomous under GSD control
- 2-way communications
- Dual streaming at 2 centres

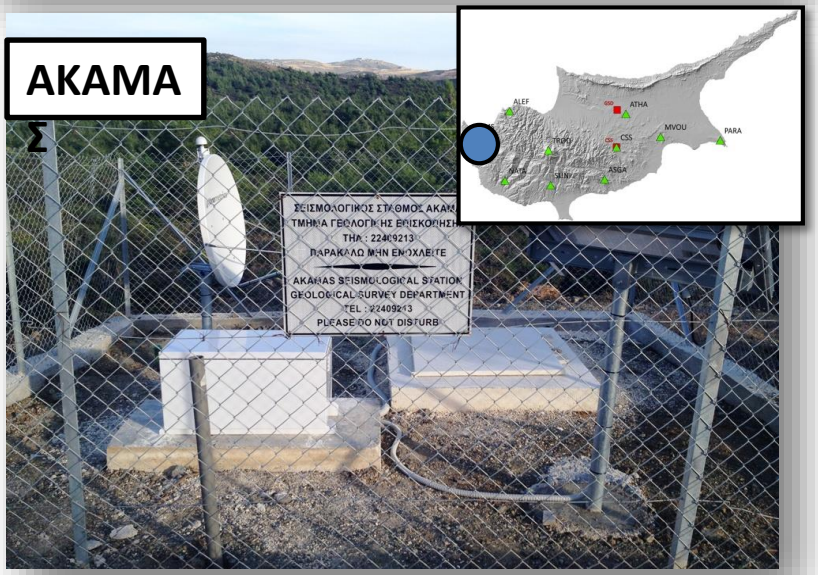
- Use of geophysics - specialized satellite (more upload than download!)

- A backup ADSL/GPRS telecommunication network is also in operation.

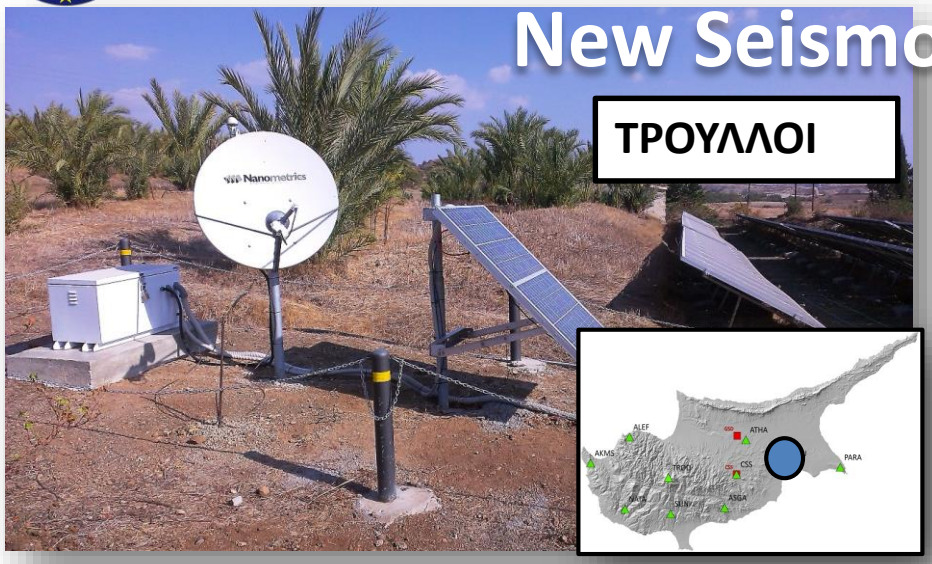
The Athalassa Seismological Station (prototype)

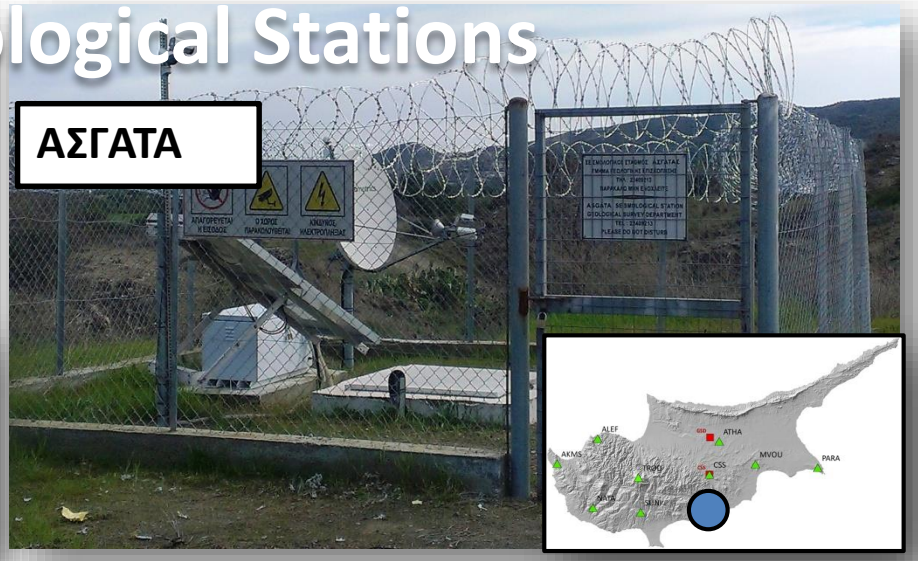
New Seismological Stations

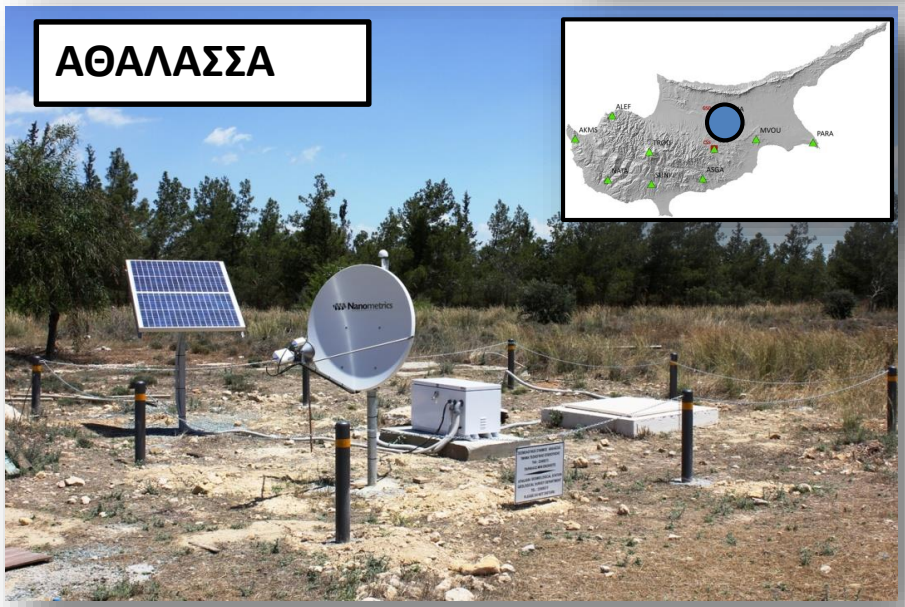


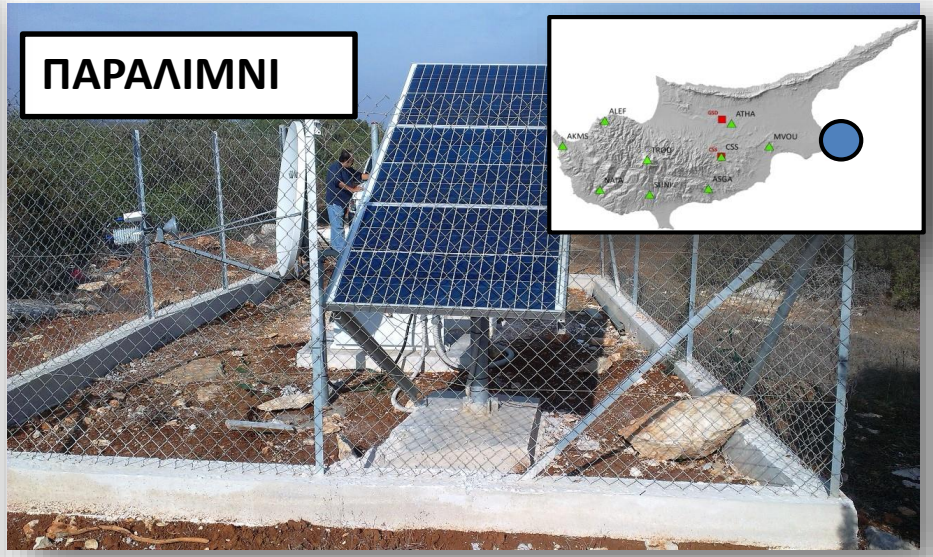


New Seismological Stations

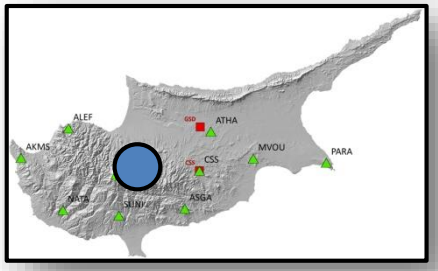








Our current project…New Station at Troodos

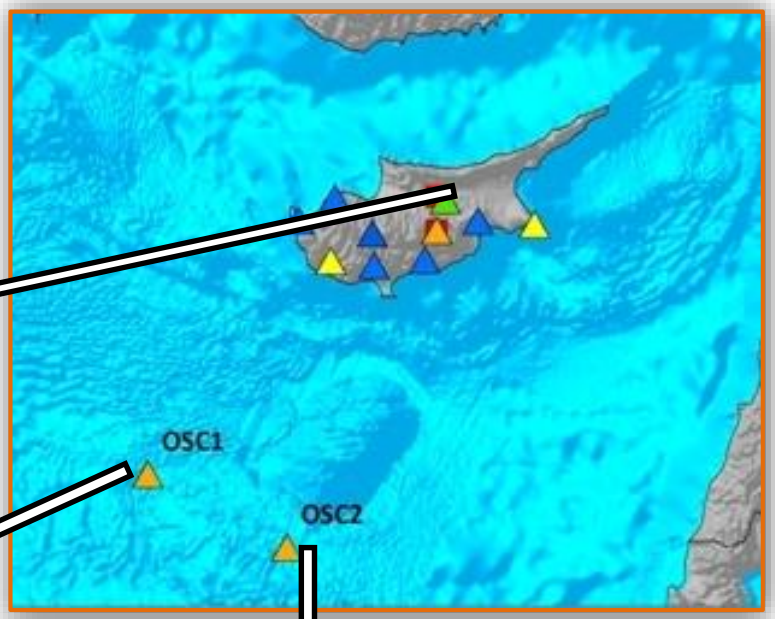


Local seismological stations connected to the new network

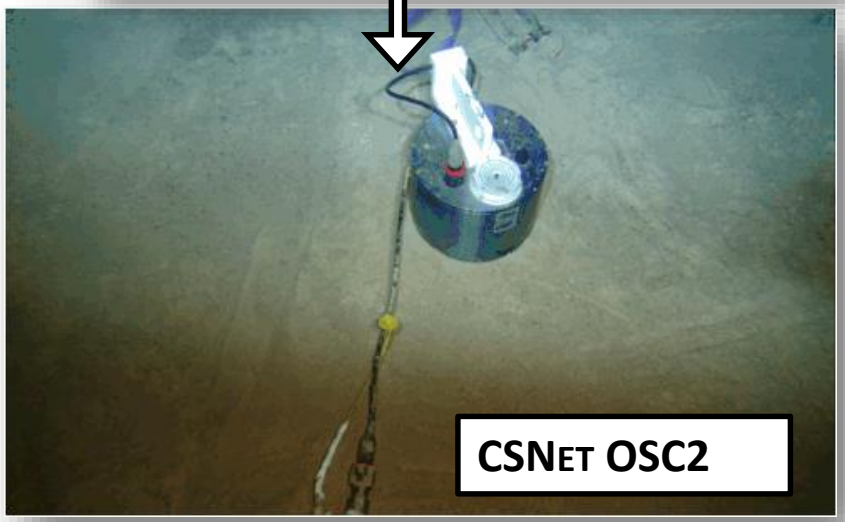
GEOFON

CSS

Total = 11 seismological stations



CSNET OSC1



CSNET OSC2

Other regional and global stations connected…

15 Regional Stations

CYPRUS IS INCLUDED FOR THE FIRST TIME ON THE FDSN MAP!

35 Global Stations

THE NEW SEISMOLOGICAL CENTRE OF LEFKOSIA (2013)

THE NEW SEISMOLOGICAL CENTRE OF LEFKOSIA (2013)

SUPPORTS

Real-time continuous data acquisition from local and other networks

Data Storage

Data Realtime Redistribution

Data pre-processing

Data automatic processing

Data manual processing at different levels

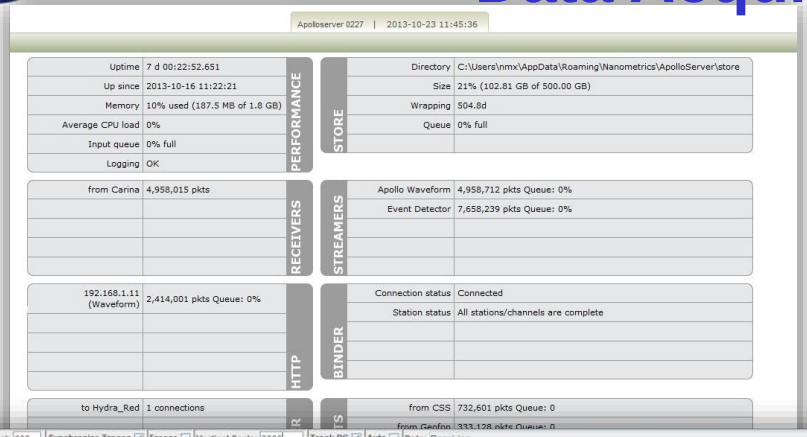
•Remote

BACKUP SEISMOLOGICAL CENTRE – MATHIATIS (2014)

- Earthquake-proof building
- Independent operation from main SC
- Supports all main operations

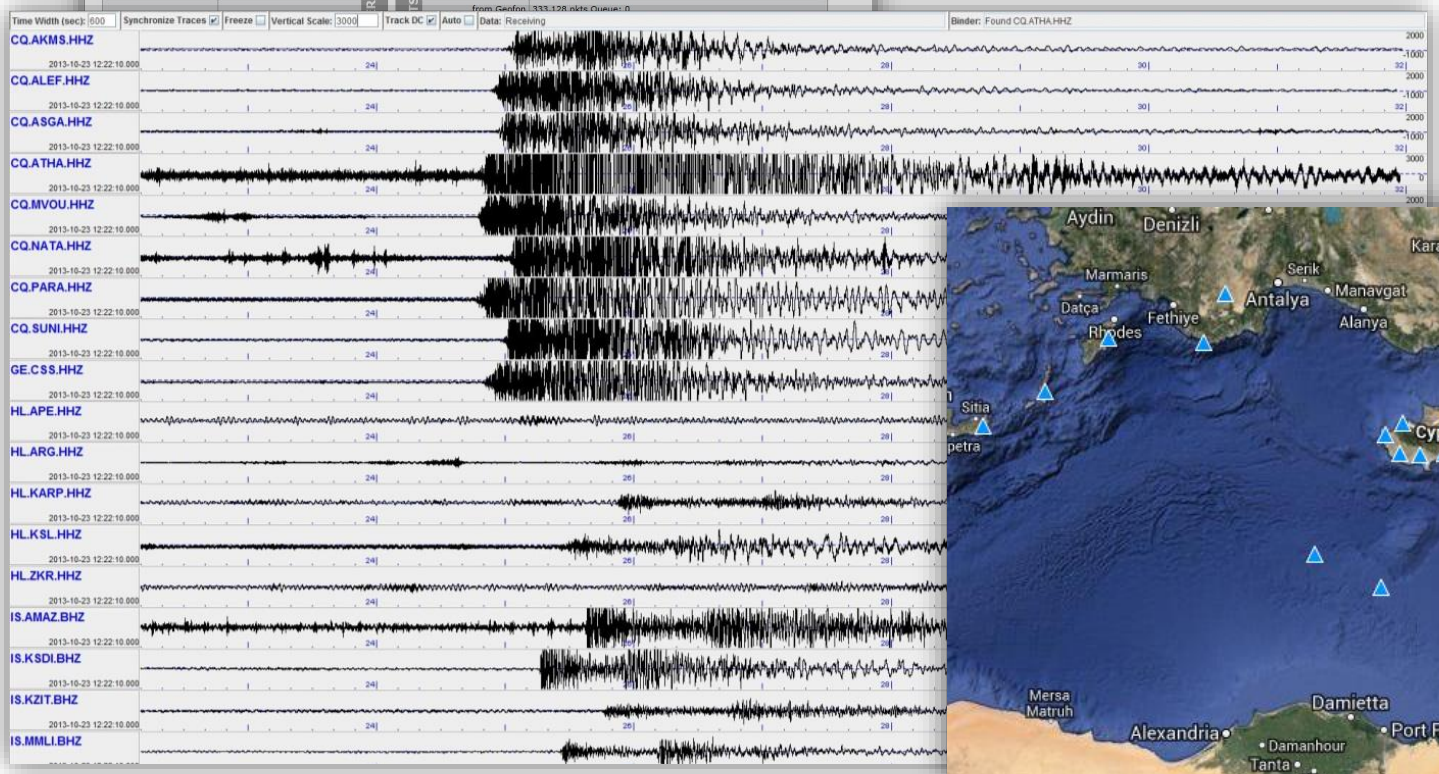
- Unmanned
- Securely networked with main SC
- Webcam
- Backup Webserver

Data Acquisition System

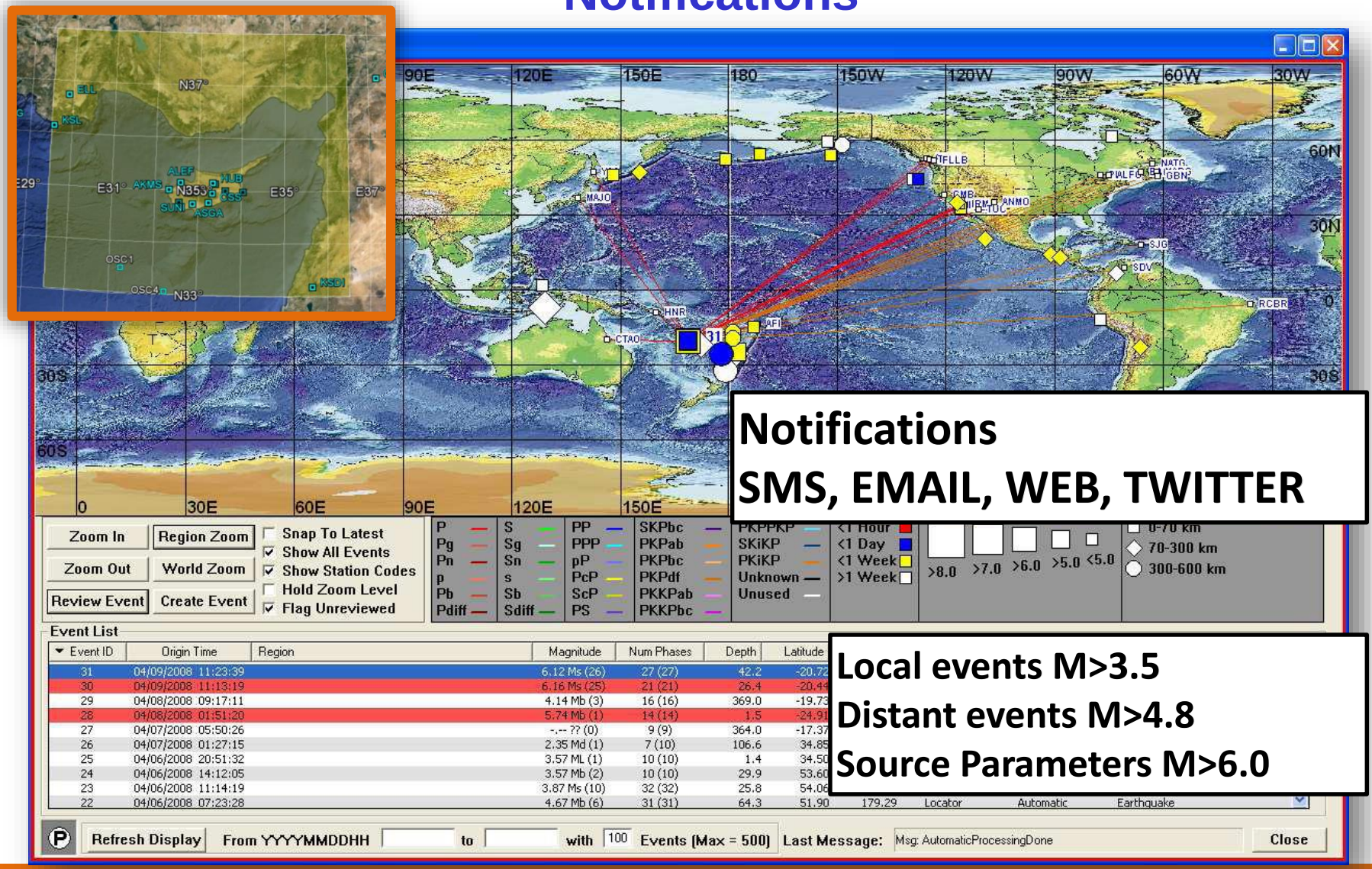


- Data acquisition
- Data storage
- Data redistribution

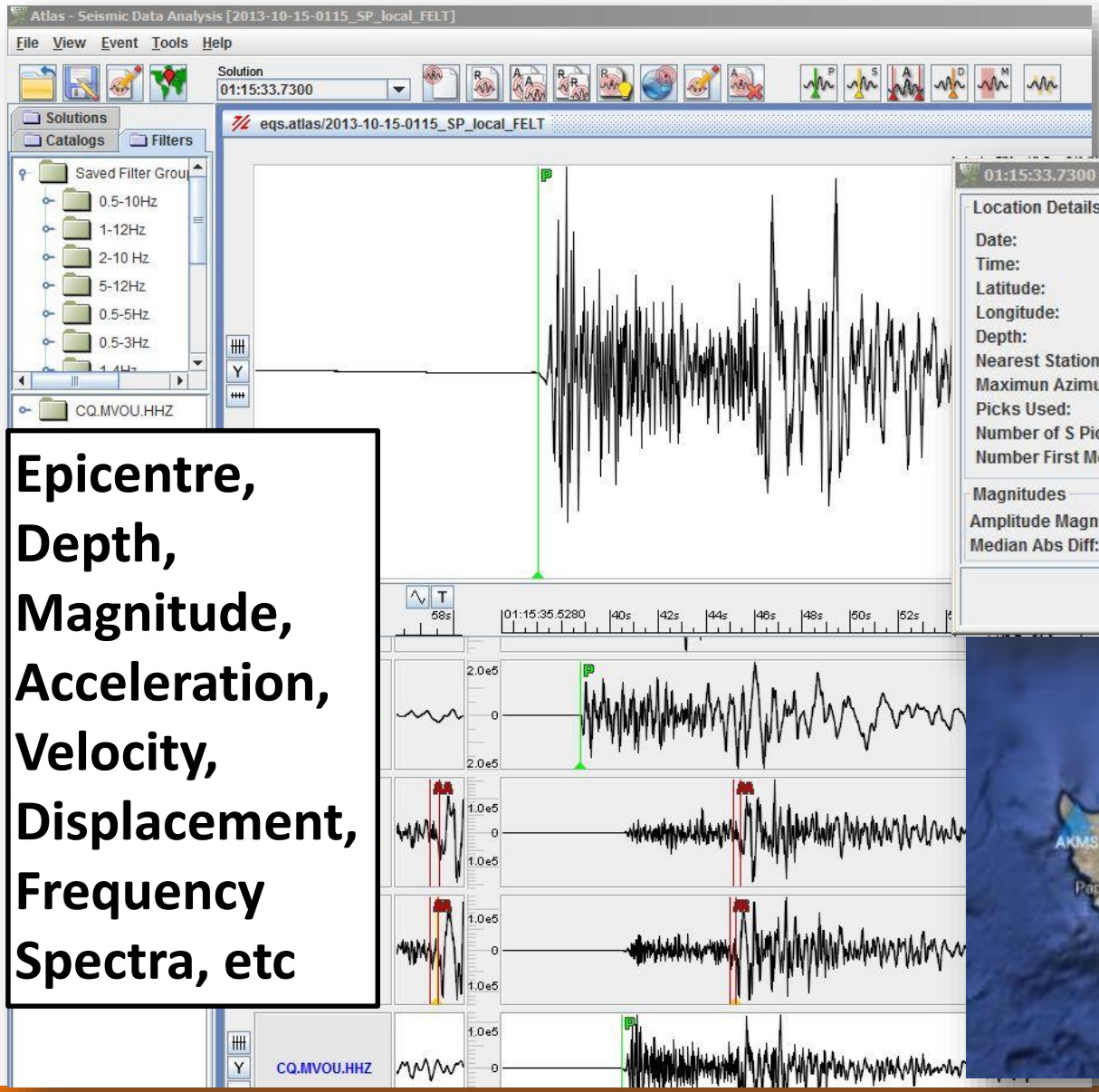
IN REAL TIME!

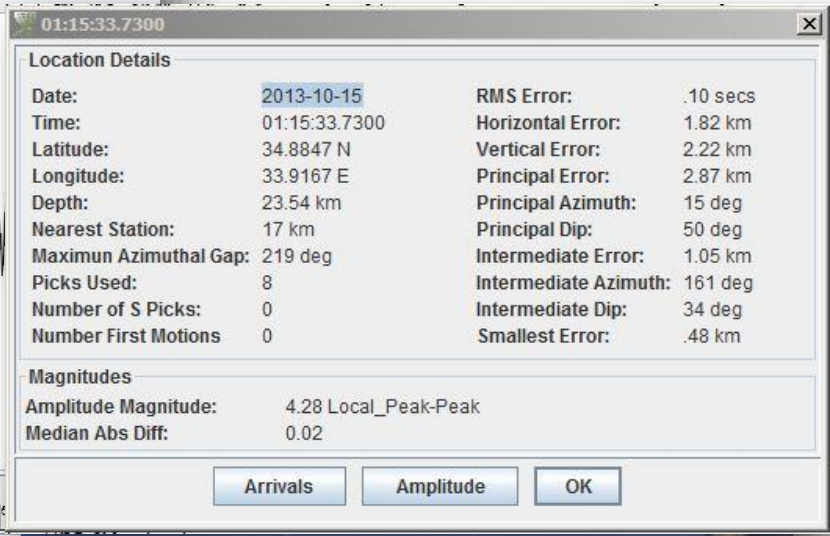


Automatic Data Processing & Notifications



Manual Data Processing





Epicentre, Depth, Magnitude, Acceleration, Velocity, Displacement, Frequency Spectra, etc

Network Monitoring and Management

- SOH of equipment
- Telecommunications status/config
- Instrument configurations

Network Performance

Earthquakes detected per year

>750 local (> 0.8ML)

> 600 regional (> 3.0ML)

> 600 distant (> 4.8ML)

Local

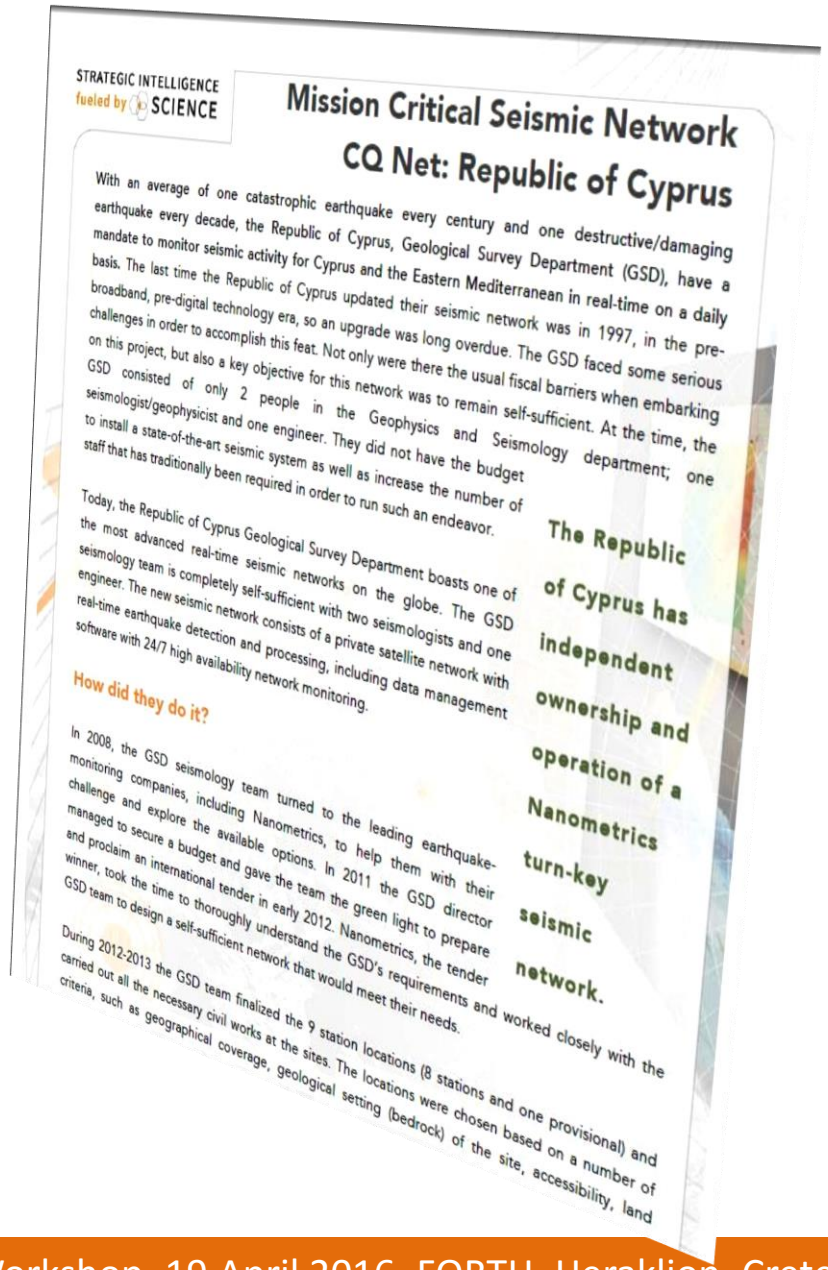
Felt earthquake, 4.1ML, 15/10/2013

Regional

5.5ML, Greece 07/08/2013

Distant

7.7ML , Pakistan, 24/09/2013



STRATEGIC INTELLIGENCE fueled by SCIENCE

Mission Critical Seismic Network

CQ Net: Republic of Cyprus

With an average of one catastrophic earthquake every century and one destructive/damaging earthquake every decade, the Republic of Cyprus, Geological Survey Department (GSD), have a mandate to monitor seismic activity for Cyprus and the Eastern Mediterranean in real-time on a daily basis. The last time the Republic of Cyprus updated their seismic network was in 1997, in the pre-broadband, pre-digital technology era, so an upgrade was long overdue. The GSD faced some serious challenges in order to accomplish this feat. Not only were there the usual fiscal barriers when embarking on this project, but also a key objective for this network was to remain self-sufficient. At the time, the GSD consisted of only 2 people in the Geophysics and Seismology department; one seismologist/geophysicist and one engineer. They did not have the budget to install a state-of-the-art seismic system as well as increase the number of staff that has traditionally been required in order to run such an endeavor.

Today, the Republic of Cyprus Geological Survey Department boasts one of the most advanced real-time seismic networks on the globe. The GSD seismology team is completely self-sufficient with two seismologists and one engineer. The new seismic network consists of a private satellite network with real-time earthquake detection and processing, including data management software with 24/7 high availability network monitoring.

The Republic of Cyprus has independent ownership and operation of a Nanometrics turn-key seismic network.

How did they do it?

In 2008, the GSD seismology team turned to the leading earthquake-monitoring companies, including Nanometrics, to help them with their challenge and explore the available options. In 2011 the GSD director managed to secure a budget and gave the team the green light to prepare and proclaim an international tender in early 2012. Nanometrics, the tender winner, took the time to thoroughly understand the GSD's requirements and worked closely with the GSD team to design a self-sufficient network that would meet their needs.

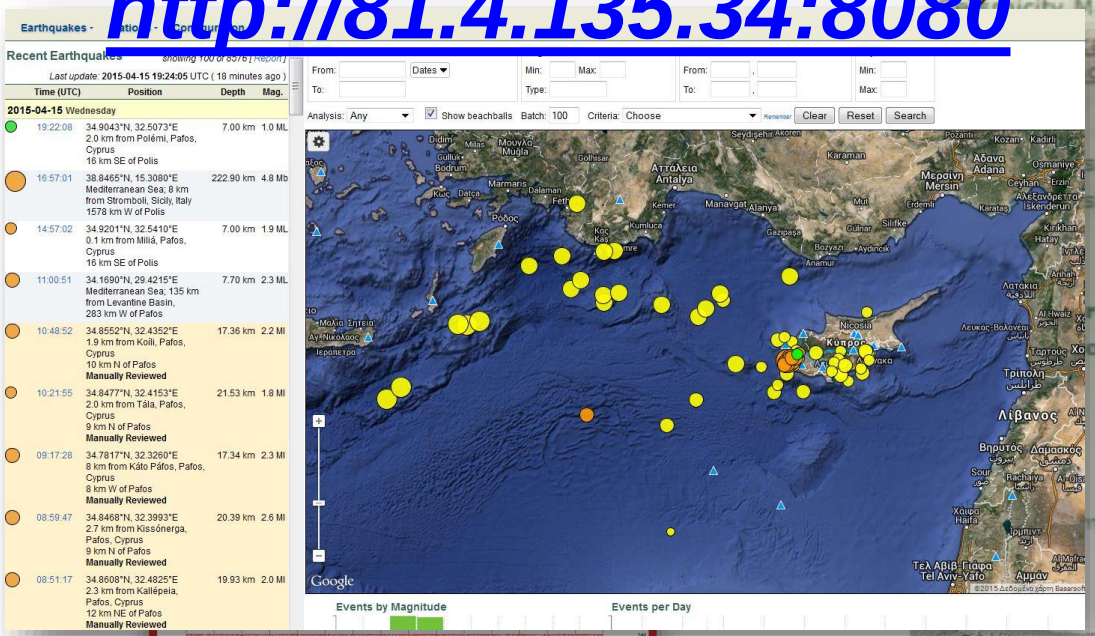
During 2012-2013 the GSD team finalized the 9 station locations (8 stations and one provisional) and carried out all the necessary civil works at the sites. The locations were chosen based on a number of criteria, such as geographical coverage, geological setting (bedrock) of the site, accessibility, land

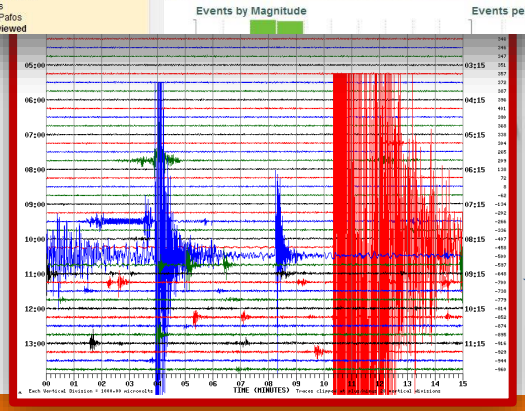
The New Seismological Network of Cyprus becomes known worldwide!!!

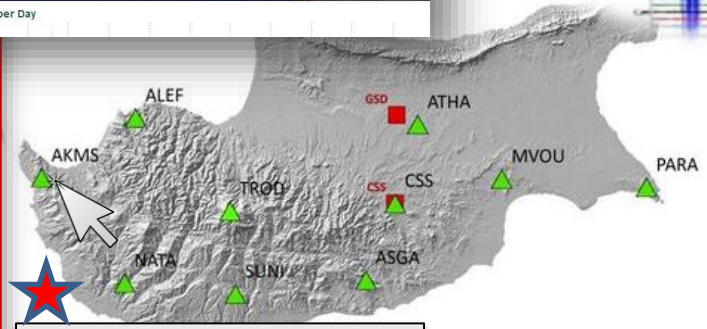
Our New Website

http://www.moa.gov.cy/gsd

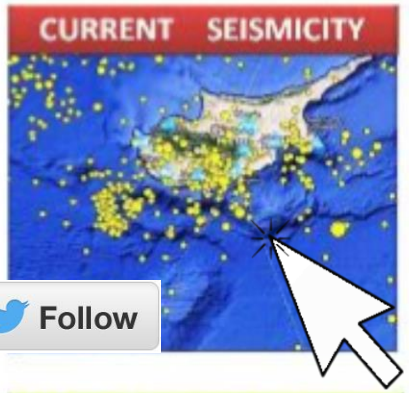
http://81.4.135.34:8080



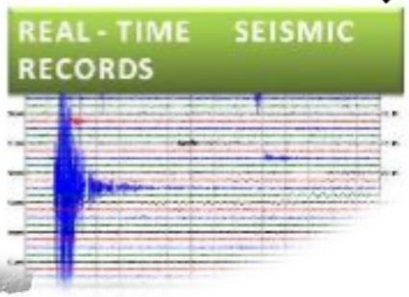




M=5.6, 15/04/2015



Follow



Thank you for your attention!