MINISTERIO DE DEFENSA

REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA
EN SAN FERNANDO

BOLETIN ROA
No. 3/2006

"Earthquake monitoring and Earthquake Risk in WEstern Mediterranean (EERWEM)" Workshop

Abstracts book

csem emsc

Orfeus

Organized by:

Real Instituto y Observatorio de la Armada en San Fernando (ROA)
European Mediterranean Seismological Centre (CSEM-EMSC)
and
Observatories and Research Facilities for European Seismology (ORFEUS)

San Fernando, Cadiz, Spain.
13-16 June 2006

Foto Portada:
Fachada Edificio Principal del Real Instituto y Observatorio de la Armada. (Siglo XVIII).

MINISTERIO DE DEFENSA

REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA
EN SAN FERNANDO

BOLETIN ROA
No. 3/2006

"Earthquake monitoring and Earthquake Risk in WEstern Mediterranean (EERWEM)" Workshop

Abstracts book

Organized by:

Real Instituto y Observatorio de la Armada en San Fernando (ROA)
European Mediterranean Seismological Centre (CSEM-EMSC)
and
Observatories and Research Facilities for European Seismology (ORFEUS)

San Fernando, Cadiz, Spain.
13-16 June 2006

Edita:

MINISTERIO
DE DEFENSA

SECRETARIA
GENERAL
TECNICA

Imprime: Real Instituto y Observatorio de la Armada
San Fernando (Cádiz). Junio 2006
Depósito Legal: CA 469-78
ISSN 1131-5040
NIPO 076-06-053-2

The edition of this volume has been coordinated by:

Dr. José Martín Davila
ROA Geophysical Department

Dr. Antonio Pazos García
ROA Geophysical Department

Dr. Rémy Bossu
CSEM Staff

Dr. Torild van Eck
ORFEUS Staff

The Organization of the workshop "Earthquake monitoring and earthquake risk in Western Mediterranean" (EERWEM workshop) has been mainly funded by European Commission project INCO-CT2005-015107-EERWEM and partially by the Spanish Science and Education Ministry (MEC) under the Project REN2003-05178-C03-02 and the Complementary Action "EERWEM workshop" (ACO 0601018).

FOREWORD

The foundation of the Royal Naval Institute and Observatory in San Fernando (ROA) by mid 18th century, was an initiative of Jorge Juan, Captain of the Company of Midshipmen, after his participation, together with Bouguer, La Condamine and Godin, well known members of the Paris Science Academy, in the scientific campaign carried out between 1735 and 1744 at Peru to determine the physical shape of the Earth by measuring the length of one degree of meridian. He propose to build an observatory in the "Castle of the Villa" in Cadiz city, which was the Headquarters of the Naval Academy of Midshipmen, with the intention of providing the knowledge of Astronomy to the future naval officers. By the end of 18 th century, all Naval facilities moved from Cadiz city to San Fernando, and, finally, on 1798 the Royal Naval Observatory was also moved to San Fernando, to its present headquarters. Nowadays ROA is divided in four departments: Astronomy, Astronomical Ephemerids, Geophysics and Time.

Geophysical activities have a long tradition at ROA, coming from the end of XIX th century (1879) when the first Spanish geomagnetic station, a variographs ADIE type, was installed at ROA enclosure. Regarding to Seismology, on 1898 a Milne horizontal pendulum, first Spanish seismological station, was installed on a pier located at ROA main building. Since then, different type of equipment has been installed: Graiño horizontal seismographs (1912), manufactured at ROA based on Mainka design, Alfani (1933) pendulums, Spregnether (1966), and Spregnether 5100 V/H series (1976), which are still working.

Nowadays ROA main seismological activities are carried out both by deploying permanent and temporal seismological nets and also by marine refraction/wide angle reflection surveys. Within the former, both a short period and also a broad band seismological nets have been deployed in collaboration with other Institutes, to study the seismic activity associated to the Eurasia – Africa plates collision at the Ibero-Maghrebian region. More details about these nets can be found inside this abstracts volume. Within the later activities, different on land and marine surveys have been carried out by ROA since 1975, usually in collaboration with other Institutions, at different regions, from Spanish area to Antarctica.

As a summary, Seismology is a well established research line at this Naval Observatory, and this research has also run in close collaboration with other scientific Institutions. I hope this workshop, oriented to get a better knowledge of the seismicity and seismic risk at Western Mediterranean area, allows to strengthen the collaboration among institutes working at this area.

Finally, I want to thank to all participants, specially to the invited speakers, their participation and contributions.

San Fernando, June 13th, 2006

Juan C. Coma Samartín
ROA Director

INDEX

CHNet 2006: Status Report of the Swiss Seismological Service

Manfred Baer, Domenico Giardini
Swiss Seismological Service
ETH Hönggerberg
CH-8093 Zürich

baer@seismo.ifg.ethz.ch
http://www.seismo.ethz.ch

Introduction

The Swiss Seismological Service (SED) monitors the seismicity within Switzerland and, for strong earthquakes, world wide with the aim of:

- recording all felt events within Switzerland, which means that the detection threshold is well below the perceptibility threshold,
- archiving all the seismic signals and event parameters on a long term base,
- disseminating information about strong earthquakes to Swiss authorities and the Swiss disaster relief unit,
- disseminating information on felt earthquakes to the public and media,
- providing the all seismological data to the scientific research community,
- developing new methods for detection, characterization and mapping of earthquakes and their effects on ground shaking.

Seismic Networks

The monitoring system consists of the digital high gain seismic network (SDSNet), the strong motion network (SSMNet) and the portable instruments for aftershock measurements.

SDSNet

Presently there are 27 broad band stations equipped with STS2 sensors and 8 short period stations with LE3D5 sensors installed (Fig. 1). Five of the broad band stations are installed at large dam sites. One of the stations is part of the global monitoring network of the CTBTO. Furthermore, 12 of the broad band sites are equipped with an additional ES-T strong motion sensor (see table Station list). The seismic signals are digitized on Nanometrics digitizers, either HRD24 or Trident (see table of station list), at 120 samples per seconds which permits to use the full frequency response of the STS-2 sensors. The digitizers are equipped with a local solid state data buffer of about one hour to cover for short interruptions on the communication lines. The data are transmitted on the intranet of the Swiss federal government to two redundant acquisition systems (DAS) from where the signals and state of health information is transferred to the data processing computer (DPS) at the data centre of the SED. At the data centre there are currently the wave forms of two Austrian and five Italian stations integrated in real time processing for more reliable determination of the epicentre parameters for near border earthquakes. On the DAS event detection is performed by coincidence criteria of the single station STA/LTA detection.

Upon declaring an event, a 100 second time window is transferred to the DPS where an automatic phase picking an location procedures are run. In addition to the event data, the continuous signals are archived at the data centre of the SED. Currently the yearly data volume arises to about 700 Gbyte and goes back to 1999.

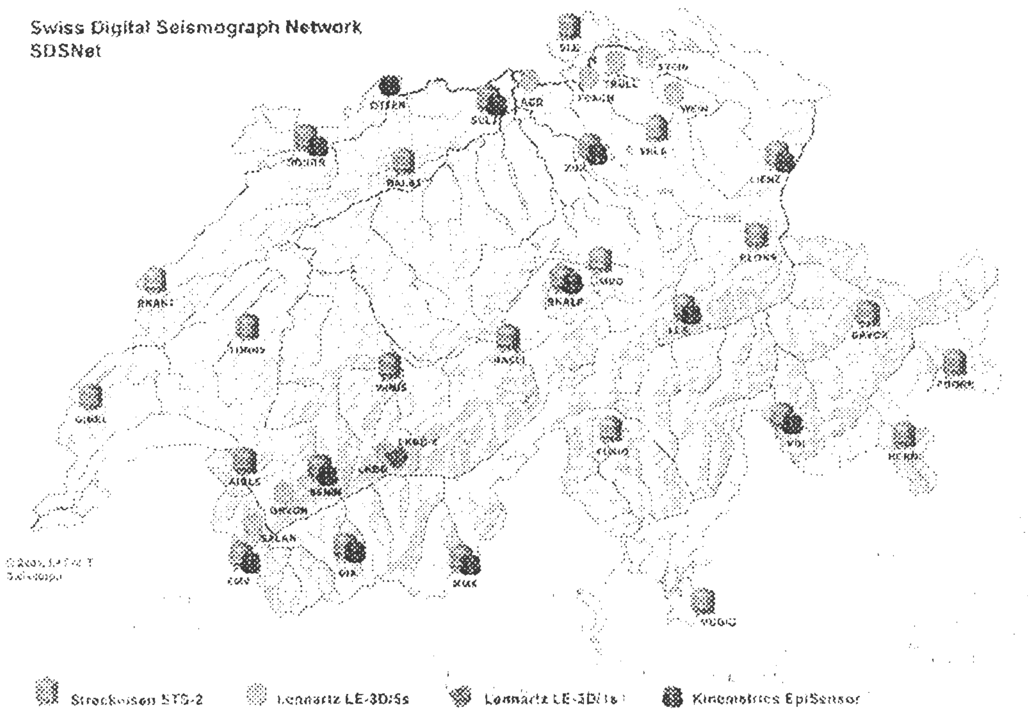


Fig 1: Station map of the Swiss Digital Seismic Network

SSMNet

In addition to the highly sensitive SDSNet the SED is operating a strong motion network of 65 free field stations and 30 stations installed at the major Swiss dams.

These majority of strong motion stations are not continuously recording. The detected events are transferred to the SED by dial up and integrated into the wave form archive of the SDSNet. The SED is about to replace the 15 year old equipment with continuous data transmission to DPS. Eleven stations are already transmitting online at 250 Hz.

Data Access and Data Exchange

All data, waveform and earthquake parameters, can be requested from the database of the SED by means of AutoDRM. The data format supported is GSE2.x or IMS1.0. For some selected stations, the wave forms are available through SeedLink. However, all connections to the server need to be registered in the firewall. Currently the following institutions retrieve real time data from the SED: ORFEUS data centre, the Austrian NDC ZAMG, the Geophysical Institute in Prague, the INGV in Rome and the IRIS data centre.

Station List

Name	Latitude	Longitude	Elev	Sensor	Digitizer/sps
ACB	47.58755	8.25434	470	LE3D5	Trident, 120Hz
AIGLE	46.34280	6.95470	800	STS-2	HRD24, 120Hz
BALST	47.33578	7.69498	910	STS-2	HRD24, 120Hz
BERNI	46.41340	10.02310	2310	STS-2	HRD24, 120Hz
BNALP	46.87190	8.42610	1540	STS-2/ES-T	HRD24, 120Hz
BOURR	47.39500	7.23130	860	STS-2/ES-T	HRD24, 120Hz
BRANT	46.93806	6.47294	1145	STS-2	Trident, 120Hz
DAVOX	46.78056	9.87966	1830	STS-2	Trident, 120Hz
DIX	46.08130	7.40910	2410	STS-2/ES-T	HRD24, 120Hz
EMV	46.06440	6.89970	2210	STS-2/ES-T	HRD24, 120Hz
FLACH	47.57197	8.56763	370	LE3D5	Trident, 120Hz
FUORN	46.62022	10.26352	2330	STS-2	HRD24, 120Hz
FUSIO	46.45490	8.66310	1480	STS-2/ES-T	HRD24, 120Hz
GIMEL	46.53480	6.26590	1130	STS-2	HRD24, 120Hz
GRYON	46.25053	7.11106	1300	LE3D5	HRD24, 120Hz
HASLI	46.75680	8.15110	1280	STS-2	HRD24, 120Hz
LIENZ	47.29460	9.49270	1608	STS-2/ES-T	Trident, 120Hz
LKBD	46.38830	7.62810	1550	LE3D5	HRD24, 120Hz
LLS	46.84830	9.00930	1740	STS-2/ES-T	HRD24, 120Hz
MMK	46.05190	7.96510	2210	STS-2/ES-T	HRD24, 120Hz
MUGIO	45.92186	9.04160	830	STS-2	HRD24, 120Hz
MUO	46.96910	8.63820	1920	STS-2	HRD24, 120Hz
PLONS	47.04921	9.38070	1020	STS-2	HRD24, 120Hz
SALAN	46.14410	6.97300	1885	LE3D5	HRD24, 120Hz
SENIN	46.36335	7.29930	2035	STS-2/ES-T	HRD24, 120Hz
SLE	47.76450	8.49236	590	STS-2	HRD24, 120Hz
STEIN	47.66974	8.86899	540	LE3D5	Trident, 120Hz
SULZ	47.52880	8.11280	670	STS-2/ES-T	Trident, 120Hz
TORNY	46.77365	6.95862	760	STS-2	HRD24, 120Hz
TRULL	47.64870	8.68161	525	LE3D5	Trident, 120Hz
VDL	46.48450	9.45080	1930	STS-2/ES-T	HRD24, 120Hz
WEIN	47.52873	8.98586	555	LE3D5	Trident, 120Hz
WILA	47.41465	8.90753	910	STS-2	HRD24, 120Hz
WIMIS	46.66630	7.62520	770	STS-2	HRD24, 120Hz
ZUR	47.37050	8.58200	615	STS-2/ES-T	Trident, 120Hz
Austrian Stations:					
DAVA	47.2867	9.8803	1602	STS-2	80Hz
WTTA	47.2638	11.6363	1764	STS-2	100Hz
Italian Stations:					
BOB	44.76792	9.44782	910	TRILL	100Hz
DOI	44.50415	7.24665	1039	TRILL	100Hz
MABI	46.0549	10.5140	1853	TRILL	100Hz
MDI	45.7697	9.7160	954	TRILL	100Hz
MONC	45.0739	7.9271	480	TRILL	100Hz

SEISMICITY AND EARTHQUAKE RISK IN PORTUGAL

M. Bezzeghoud, J. F. Borges, B. Caldeira, R. Grandin
Centro de Geofísica de Évora, Universidade de Évora, Colégio Luis Verney, Rua Romão Ramalho, 59, 7002-554 Évora, Portugal
mourad@uevora.pt /Fax: +351 266 745 394

Abstract: The workshop "Earthquake monitoring and Earthquake Risk in WEstern Mediterranean" (EERWEM) will summarize the current knowledge, on-going projects and research plans with regard to seismic activity and risk in the region. This work is organized in two topics: i) presentation of our current research on seismic activity and earthquake risk in the Western Mediterranean region, particularly in Portugal and ii) a short training course about seismic data processing and waveform analysis. Some applications based on broad band teleseismic wave form will be presented using software currently available on the internet sites.
Ongoing research projects within the group will be presented and discussed. Some preliminary results will be shown, in particular for the following research topics: i) Seismic Tomography of the Continental Lithosphere of Algarve (Portugal); ii) Finite seismic source modelization and strong motion prediction in Portugal and iii) the University of EVOra (UEVO) Broad Band seismic station (STS2) and upcoming temporary broad band network.

Introduction

The interaction between Iberia and Africa results in a complex region located in the western part of the Eurasian-African plate boundary. This region corresponds to the transition from an oceanic boundary (between the Azores and the Gorringe Bank), to a continental boundary where Iberia and Africa meet (Borges et al., 2001; Buforn et al, 2004). Portuguese mainland is characterised by a low instrumental seismicity, with a large scattering (Fig. 1). The largest instrumental earthquake occurred in 1969 (Mw~7.3), but since then, only two earthquakes have reached a magnitude of 5 or more (2003/07/29, Mw=5.4 and 2004/12/13, Mw=5.4). These earthquakes all struck the region located between the Horseshoe Abyssal Plain and Cabo Sao Vicente. Most major submarine canyons are aligned with NE-SW trending faults onland. These faults have been reactivated since Miocene, and historical records of large earthquakes show that they are still active today. Indeed, large earthquakes have occurred in the past, but since the main seismogenic centres are located offshore, their epicentral locations are very uncertain. The largest earthquake ever reported in Europe occurred in the region, in 1755 (Mw~8.5), and was accompagned by a massive tsunami. For this event, at least four different seismogenic origins are currently supported by various authors (Moreira, 1985; Buforn et al., 1988; Baptista et al., 1998; Zitellini et al., 2001; Gutscher et al., 2002; Terrinha, 2003; Villanova et al., 2003).
This work is planned on two topics: i) presentation of our current research on seismic activity and earthquake risk in the Western Mediterranean region, focused particularly on Portugal and ii) a short training course about seismic data processing and waveform analysis will be done. Some applications based on broad band teleseismic wave form will be presented using body wave analysis software currently available on the internet sites.

Three research projects in progress, which may be the link for future collaboration between the CGE team and some associated partners of the EERWEM project, will be presented and discussed. Preliminary results will be shown, in particular for the following research works: i) Seismic Tomography of the Continental Lithosphere of the Algarve (Portugal); ii) Finite seismic source modelization and strong motion prediction in Portugal and iii) The University of EVOra (UEVO) Broad Band Station and the future perspectives.

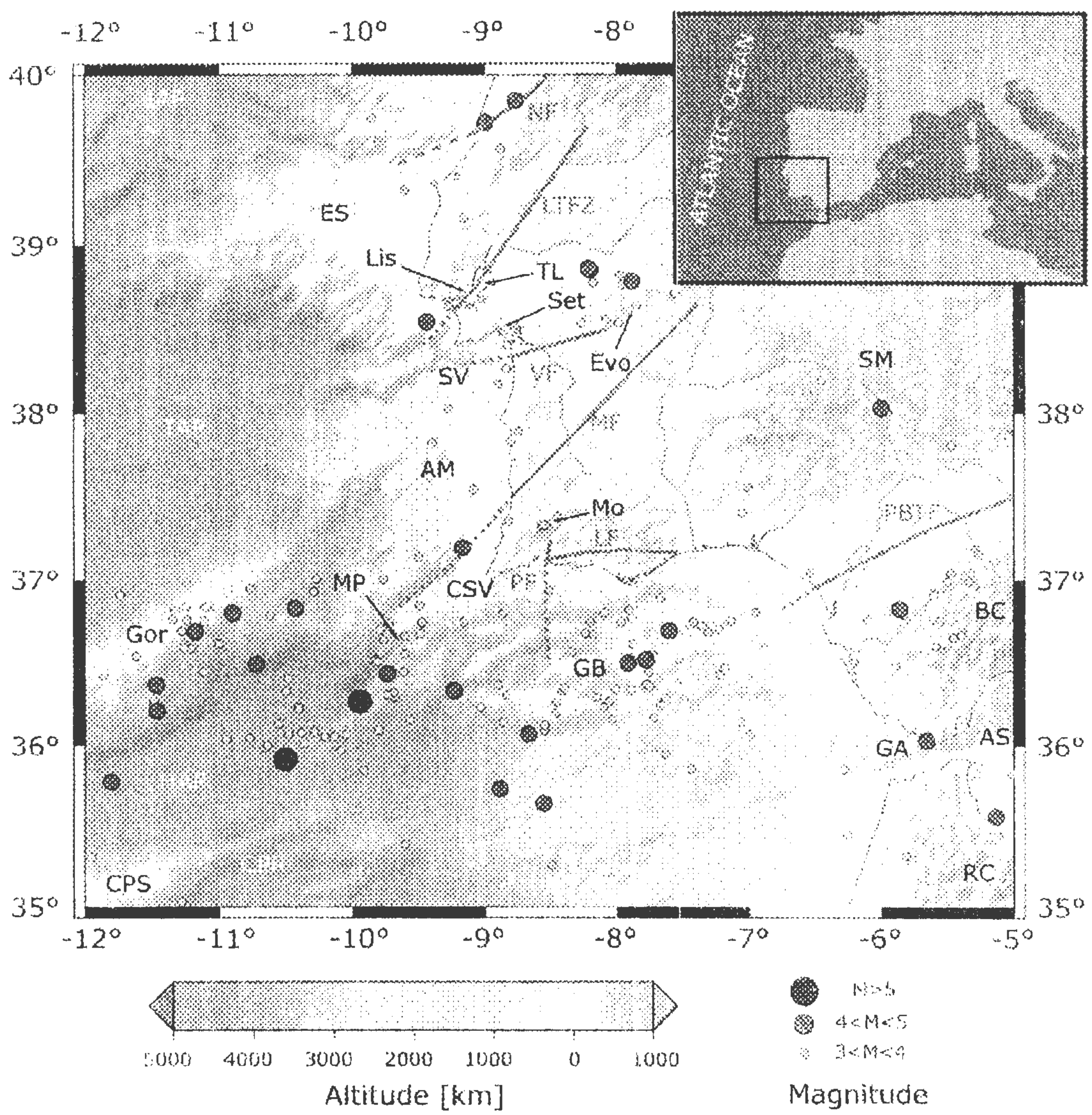


Figure 1 - Bathymetric map of the area of study (British Oceanic Data Centre, 2003), with the location of earthquakes epicenters (data provided by the Instituto de Meteorologia, Lisbon) that occurred between January 1995 and December 2005 (see Carrilho, 2005). Major accident affecting the crust, and their inferred prolongation into the ocean are also shown. AM= Alentejo Margin; AS= Alboran Sea; BC= Betic Cordillera; CPR= Coral Path Ridge; CPS=Coral Path Seamount; CSV= Cabo São Vicente; ES= Estremadura Spur; Evo= Évora city; GA= Gibraltar Arc; GB= Guadalquivir Bank; Gor= Gorringe Bank Seamount; HAP= Horseshoe Abyssal Plain; IAP= Iberian Abyssal Plain; Lis= Lisbon city; LF= Loulé Fault; LTFZ= Lower Tagus Fault Zone; MF=Messajena Fault; Mo= Monchique range; MP= Marquês de Pombal; NF= Nazaré Fault; PBTF= Pre-Betics Thrust Front; PF= Portimão Fault; RC= Rif Cordillera; Set= Setúbal city; SM= Serra Morena; SV= Sado Valley; TAP= Tagus Abyssal Plain; VF= Vilariça Fault.

Seismic tomography in the Algarve region

Portable seismic network consisting of 30 short-period stations, including a subnet of 7 telemetred stations was installed for the first time, in January 2006, in the Algarve region (Monchique-Portimão and Loulé-Faro) (Fig. 2). This network will be operating for a period of 6 month (until June 2006) or more. This seismic experiment is coordinated by the "Centro de Geofisica de Évora" (University of Évora, Portugal) with the collaboration of the "Institut de Physique du Globe de Strasbourg" (France), the "Instituto de Meteorologia (Lisboa, Portugal)" and the "Centro de Geofisica da Universidade de Lisboa" (University of Lisbon, Portugal). The telemetred network stations are installed in the same local as the "Transfrontiere" telemetred network of the "Instituto de Meteorologia" (Lisbon, Portugal) which was in activity for the period 1999-2003. These data together with those recorded by the network in activity will constitute a seismic data base for the regions of Monchique-Portimão and Loulé-Faro. Using the TomoDD programme (Zhang and Thurber, 2003) with this data base we project to determine a high resolution 3-D velocity model in these regions. The area is of interest for a tomography study for several reasons: the crustal thickness and the velocity structure is poorly determined in this area. Improvement of the 1D and 3D velocity structure and the earthquake hypocenters may help to reveal details about geological structures, seismic active faults, and focal mechanisms. This information may be useful to provide a key in order to constrain the updip limit of the seismogenic zone in view to determine the earthquake source areas and active fault zones of the regions. The results will contribute yet again to a better control of the seismic risk assessment of the region under study. Local seismic events were recorded during the three last months at short and regional distances. Some preliminary results about the local seismicity will be presented.

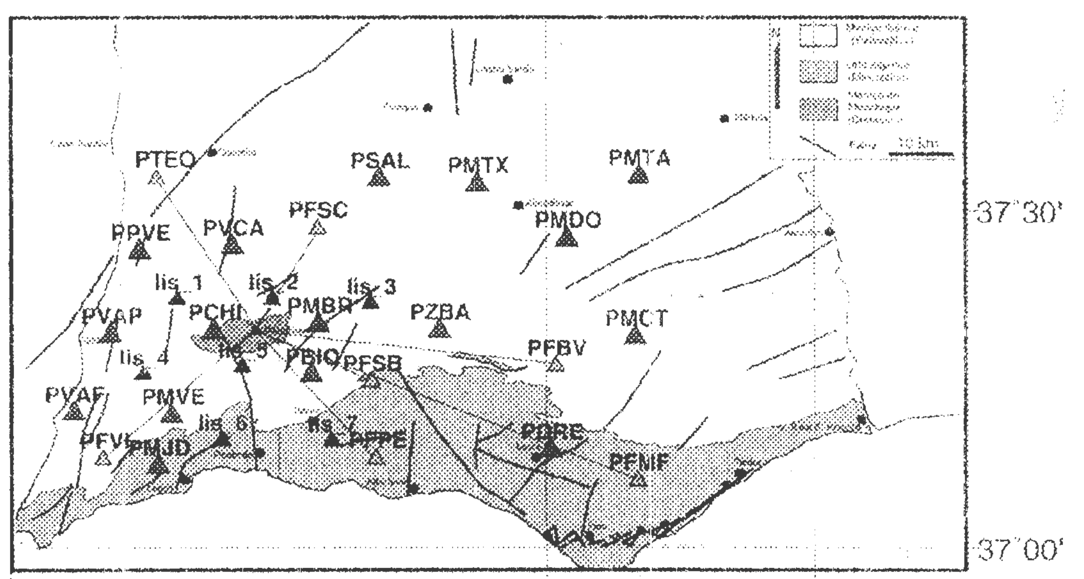


Figure 2 - Seismic network and simplified geologic scheme of the Algarve region (adapted from the Geologic map of Portugal to scale 1/500,000. SGP, 1992). The station codes beginning by the letter P are of the responsibility of the CGE (University of Évora) and EOST (University of Strasbourg), the station codes indicated by "Lis" are of the responsibility of the CGUL (University of Lisbon). Telemetred stations are linked by a solid line.

New 3D crustal model and Ground Motion in SW Iberia due to the adjacent oceanic earthquakes

Based on available geophysical data and geological evidences, we will present a 3D velocity model of the upper mantle, crust, and sedimentary cover, for south Portugal and the adjacent Atlantic area. The model is constrained thanks to data available from recent instrumental earthquakes. Using data provided by wide-angle refraction/reflection profiles (e.g. Matias, 1996; Afilhado et al., 1999), we elaborated a 3D velocity model of the shallow lithosphere (depth < 35km) in SW Iberia and its adjacent Atlantic area. This model intends to integrate the effects of the large variations of crustal thickness across the ocean/continent transition (OCT), as well as the complexity of major basins structures. Thanks to a finite-difference seismic wave propagation code, we simulated the occurrence of two recent earthquakes of particular interest, located in the Horseshoe Abyssal Plain, 250 km SW Cabo São Vincente. First, the July 29th, 2003 earthquake (M_w=5.4) was implemented, and we were able to compare Fourier amplitude spectra of recorded and synthetic ground-motion velocity at 5 sites in continental Portugal, at large distance from the source (243km<d<353km), on different geological settings. In the frequency range considered (0.3Hz<f<0.7Hz), predicted and observed spectral amplitude are in very good agreement for 2 stations, and for the 3 other stations, the ratio of synthetic and real spectral amplitude remains inferior to 4.

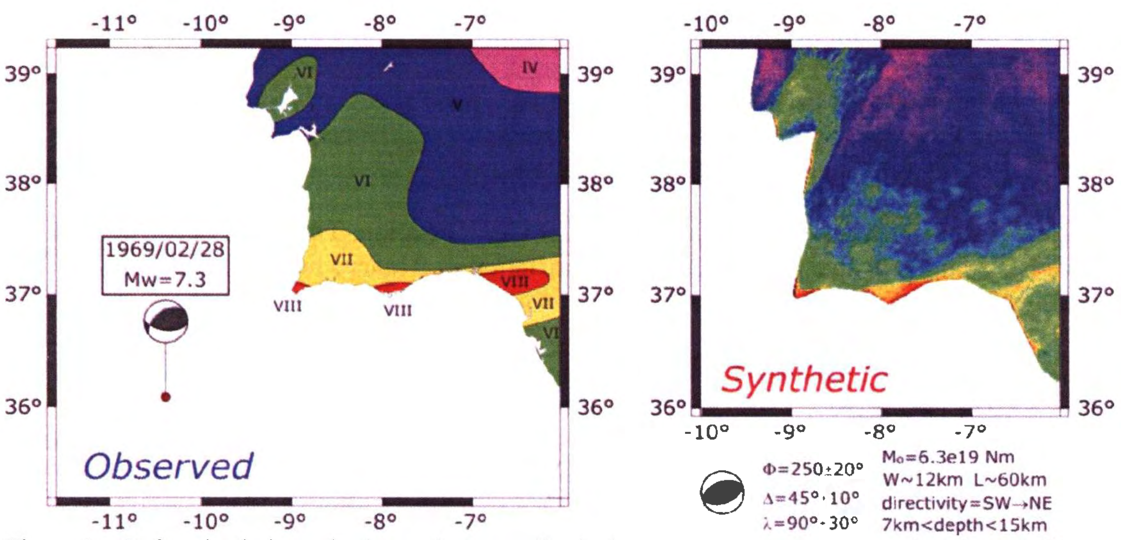


Figure 3 – Left, seismic intensity in southwestern Iberia due to the February 1969 earthquake (modified from Paula and Oliveira, 1996; Martinez-Solares, 1979). Right, synthetic seismic intensity map (see text for details). Both site effects and directivity may explain the difference in estimated intensity between the Tagus and the Guadalquivir basins, and the particular "L" shaped pattern. The best fitting focal mechanism is also shown.

This overestimation of spectral amplitude can be reduced by implementing seismic attenuation in the numerical model. Secondly, in the case of the February 28th, 1969 earthquake (M_w=7.3), we were able to compute seismic intensity maps based on an empirical relation between peak ground velocity (PGV) and seismic intensity (Fig. 3). By fixing a particular set of source parameters (seismic moment, coseismic displacement direction, fault area), and varying other source parameters (dip, rake, strike, rupture directivity) within uncertainty ranges proposed by several authors, we compared synthetic and observed intensity map. A rupture direction towards NE may explain the high level of ground shaking in the Guadalquivir basin, and a particular set of source parameters reproduces well the observed seismic intensity pattern in the whole region. In this work, we study two earthquakes that struck the Horseshoe Abyssal plain, focusing on the influence of source parameters on the synthetic ground motion pattern, and we show that, when a certain set of source parameters are constrained, it is possible to reproduce the observed seismic intensity distribution by varying the source parameters that most strongly control this distribution, namely the fault strike and rupture directivity. We are able now to test several possibilities, and to compare synthetic ground motion obtained onshore with historical evaluations of seismic intensity. Directivity of the source, as well as site effects, may explain the particular distribution of strong ground motion observations (Grandin et al., 2006; Fig. 3).

The University of ÉVOra (UEVO) Broad Band Station and the future perspectives
Seismology is one of the targets of the "Centro de Geofísica de Évora" (Centre of Geophysic of Évora, CGE). Nowadays, a permanent Broad Band (BB) station (UEVO) has been installed in Mitra (12 km away from the city of Évora) and is integrated in the Western Mediterranean network (WM) in collaboration with the "Real Observatorio de la Armada" (ROA, Real Spanish Navy Observatory) and "Universidad Complutense de Madrid" (UCM). This station is equipped with an STS2 seismometer and SeisComp PCs, software originally developed for the GEOFON network, in connection with Earth data PS6-24 digitizer with three converters. UEVO station transmit the data in quasi real-time from Mitra to Évora and to San Fernando. The information and coordinates of the UEVO station are listed in the following table:

Network	Station code	Station Name	Latitude	Latitude	Elevation (m)
WM	UEVO	Universidade de Évora	-8.01674	38.52940	232.0

Figure 4 shows recent earthquake recorded at UEVO station. Temporal network with five BB stations is also planed and will be installed in Algarve region (South of Portugal) during 2006.

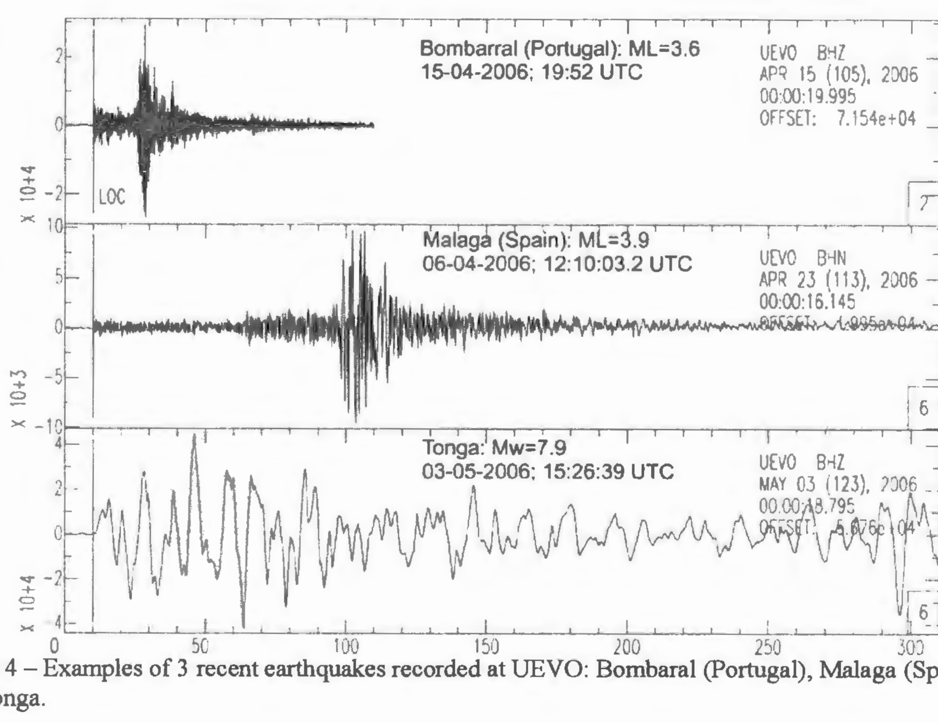


Figure 4 – Examples of 3 recent earthquakes recorded at UEVO: Bombaral (Portugal), Malaga (Spain) and Tonga.

Conclusion

We recognized that if we are to make progress, then the identification of specific actions that we could achieve would solidify our investigation on seismicity and earthquake risk. The relationship between European institutions, particularly from Portugal, Spain and France with Maghrebian institutions from Morocco, Algeria and Tunisia is essential to better understand the seismic activity and estimate the seismic hazard in the Western Mediterranean region, particularly in the Ibero-Magrebian area. The projects, described in this paper, will give new insights on seismic risk in SW Iberia, and will help identify regions that are most exposed to strong ground motion in association with acknowledged fault rupture scenarios, in particular for the great "Lisbon" earthquake, in November 1st, 1755 (M_w~8.5), in order to discriminate between possible source the one that fits best the observed intensity pattern.

There are numerous Institutions in Western Mediterranean region with a common interest in seismicity and earthquake risk. In aggregate, they comprise a large resource of scientific and engineering expertise. Furthermore, the basic messages that these institutions seek to communicate regarding earthquake impacts and risk mitigation are similar. Nevertheless, the community is consistently surprised by the effects of earthquakes and does not realize that there are effective actions that could be implemented to save lives and reduce social economic impacts in future events.

Acknowledgments

The teleseimsic body wave data used in the present study are from the IRIS-DMC. This work was supported by FCT Projects POCI/CTE-GIN/55994/2004, POCTI/CTE-GIN/59750/2004 and CGE/FCT/SEISMOLITOS project.

References

Afilhado A., D. Vales, A. Hirn, A. González, L. Matias and L. Mendes-Victor (1999), Contribution for the monitoring of the SW Portuguese margin: crustal thinning along IAM5, poster presented at the 22nd IUGG assembly, Birmingham, UK, 18-30 July.

Borges J. F., A. J. S. Fitas, M. Bezzeghoud, and P. Teves-Costa (2001), Seismotectonics of Portugal and its adjacent Atlantic area, Tectonophysics, 337, 373-387.

Buforn E., M. Bezzeghoud, A. Udias and C. Pro (2004). Seismic source in the Iberian-African plate boundary and their tectonic implications. *Pageoph*, 161, 3, 623 – 646.

Buforn, E., Udías, A. and Colombás, M.A. (1988). Seismicity, source mechanisms and seismotectonics of the Azores-Gibraltar plate boundary. Tectonophysics, 152, 89-118

British Oceanic Data Centre (2003), Centenary edition of the GEBCO digital atlas, www.bodc.ac.uk.

Carrilho J. (2005), Estudo da sismicidade da Zona Sudoeste de Portugal Continental, M. S. thesis, 172 pp., Univ. of Lisboa.

Grandin R., J. F. Borges, B. Caldeira, M. Bezzeghoud, F. Carrilho and C. S. Oliveira (2006). "Strong Ground Motion in SW Iberia due to adjacent oceanic earthquakes", European Geosciences Union General Assembly, poster available for download at www.cge.uevora.pt

Gutscher M. A., J. Malod, J. P. Rehault, I. Contrucci, F. Klingelhoefer, L. Mendes-Victor and W. Spackman (2002). Evidence for active subduction beneath Gibraltar, Geology, 30, 1071-1074.

Matias L. M. (1996), A sismologia experimental na modelação da estrutura da crusta em Portugal continental, Ph.D. thesis, Univ. of Lisboa. 398 pp.,

Terrinha, P. A.G., (1997). Structural geology and tectonic evolution of the Algarve basin, South Portugal. *PhD thesis*, Royal School of Mines, Imperial College. London, 423 pp.

Vilanova S. P., C. F. Nunes and J. F. B. D. Fonseca (2003), Lisbon 1755: A case of trigerred onshore rupture?, Bull. Seism. Soc. Am., 93, 2056-2068.

Zhang H. and C. H. Thurber (2003). Double-Difference Tomography: The Method and Its Application to the Hayward Fault, Califórnia, Bulletin of the Seismological Society of America; October 2003; v. 93; no. 5; p. 1875-1889; DOI: 10.1785/0120020190

Zitellini N., L. Mendes-Victor, D. Córdoba, J. Dañobeitia, R. Nicolich, G. Pellis, A. Ribeiro, R. Sartori, L. Torelli, R. Bartolomé, G. Bortoluzzi, A. Calafato, F. Carrilho, L. Casoni, F. Chierici, C. Corela, A. Correggiari, B. Della Vedova, E. Gràcia, P. Jornet, M. Landuzzi, M. Ligi, A. Magagnoli, G. Marozzi, L. M. Matias, D. Penitenti, P. Rodriguez, M. Rovere, P. Terrinha, L. Vigliotti and A. Zahinos Ruiz (2001), Source of the 1755 Lisbon earthquake and tsunami investigated, EOS Trans. Amer. Geophys. U., 82, 285.

Technicalities of the EMSC activities:

R. Bossu, G. Mazet-Roux and S. Godey

The EMSC provides two main services to the community: a) Real time earthquake information and alert system; b) Euro-Med bulletin. Real time information are provided on the web site for approximately 12,000 worldwide events a year, while the alert system concerns only potentially damaging earthquakes with their manually determined characteristics being disseminated by fax, emails and SMS within 30-40 minutes of the event's occurrence. The Euro-Med bulletin reports all manually reviewed arrival times and earthquake location for the Euro-Med region and it is set to be published with a target delay of 3 to 6 months.

All these services are composite services which result from the integration of data provided by the network operators and aiming at providing homogeneous information at Euro-Med scale and facilitating data access for the seismological community. They are also based on the assumption that the best and most reliable earthquake information for a given country is the one provided by the local or national networks. Alongside homogeneous information, the other benefits are rapid and automatic access to data in a single format, and association of all phases related to the same event.

Data exchanges operated by EMSC involve about 80 different networks and close to 2,000 stations worldwide. They largely rely on automatic processing which implies the definition and the use of standards and procedures. The technical aspects will be presented such as the international station and network coding system, the use of the autoDRM for automatic data access, the main steps of the phase association, the use of emails and in the near future XML to implement data exchanges.

European projects practicalities

R. Bossu (EMSC) and T. Van Eck (ORFEUS)

The European Union mainly funds Research and Development through what is called the Framework Programme (FP).The FP is proposed by the European Commission and adopted by Council and the European Parliament following a co-decision procedure. FPs have been implemented since 1984 and cover a period of five years with the last year of one FP and the first year of the following FP overlapping. The current FP is FP6, which will be running up to the end of 2006. The maximum overall amount for Community financial participation in the EC Seventh Framework Programme (FP7) should be EUR 72 726 million for the period 2007 – 2013.

The purpose of this presentation is not to fully present the FP7 which could be the subject of another workshop on its own. Nevertheless, FP projects probably represent the main funding opportunity for international cooperation, especially for cooperation between European institutes and institutes from Northern Africa and/or the Middle East. EERWEM itself is funded through the FP6. Unfortunately, the experience shows that it is very difficult for new comers to make a valid proposal to the Commission due to a lack of understanding of the rules and the practicalities of this process. Therefore, the presentation aims at easing the participation of Northern African institutes in future European projects by presenting key aspects and practicalities faced during the submission of a proposal to the European Commission. Pragmatic questions will be answered such as "I have an interesting project, can it be funded by the European Commission?", "Which partners can participate to the proposal?", "What are the financial rules and the eligible costs and activities?" etc.

We hope that by explaining the whole proposal submission process, we will be in a position to fully exploit FP funding opportunities for Mediterranean countries in the future.

REACTIVATION OF THE IBERO-MAGREBIAN REGION?. THE AL HOCIEMA (FEBRUARY 24, 2004, MW=6.2) AND BULLAS (JANUARY 29, 2005, MW=) EARTHQUAKES.

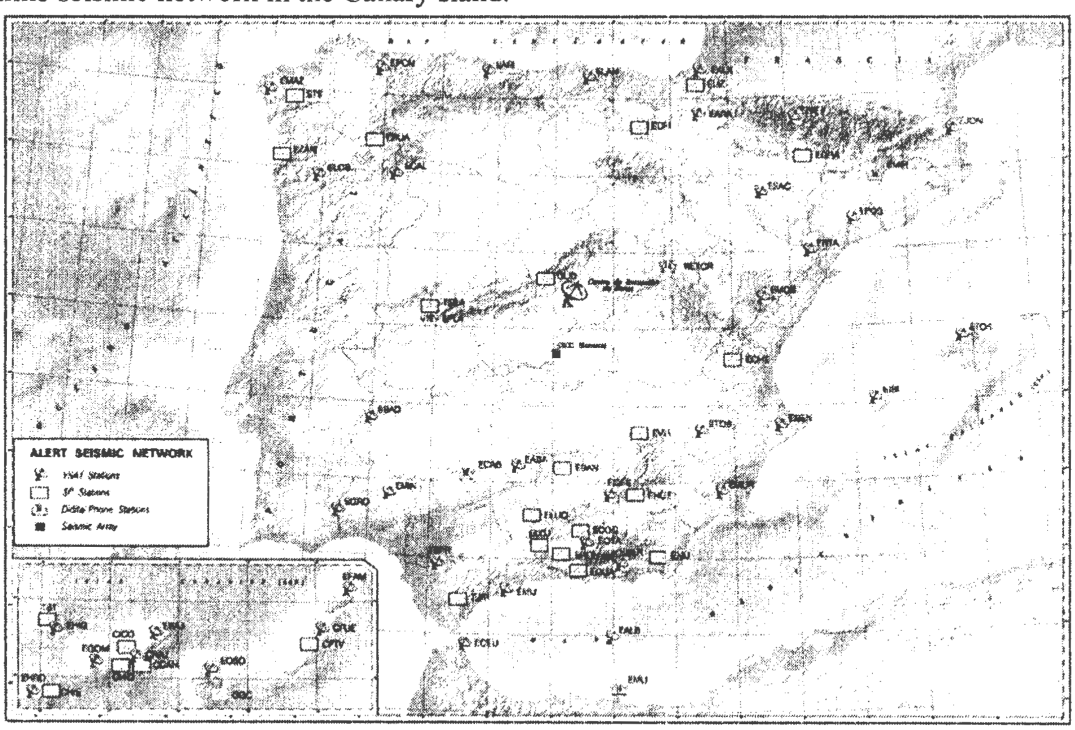
E. Buforn
Dtp. de Geofisica y Meteorología. Facultad de CC. Fisicas. Universidad Complutense, Madrid, Spain.
ebufornp@fis.ucm.es /Fax: 913944398

Seismicity of the Ibero-Maghrebian region is a consequence of the plate boundary between Eurasia and Africa and it presents different characteristics along the boundary. The Gulf of Cadiz (west) and Algeria (east) have large level of seismicity, with the occurrence of large earthquakes as the March 15, 1964 (Ms=6.5), February 28, 1969 (Ms=8.1), October 10, 1980 (Ms=7.1) or May 23, 2003 (Mw=7.1). The central part, Betics, Alboran Sea and northern Morocco, are characterized by a continuous occurrence of moderate shallow earthquakes, with the large shocks separated by long time intervals. However in the last years, this central part has experienced a increase of the seismicity, with the occurrence of earthquakes that have caused important damages. On February 24, 2004, the Al Hoceima region (northern Morocco) was shaken by an earthquake (Mw=6.2 which caused more than 600 victims, large number of injured and important economic losses at the region. The earthquake was followed by a series of aftershocks during more than two months, three of them with magnitudes Mw equal or greater than 5.0. Focal mechanism of this earthquake obtained from body wave inversion show strike-slip faulting, with planes trending on WNW-ESE and NNE-SSW direction. From the slip inversion and directivity function of Rayleigh wave, rupture and velocity plane have been estimated. The Murcia region (SE Spain) is another part of the Ibero-Maghrebian region where the seismicity level has increased in the last years. On January 29, 2005 a moderate shock (Mw=5.0) caused important economic losses near the Bullas city. Previously on February 1999 and August 2002, two moderate shocks occurred at the same region, causing, the 1999 event, losses estimated in more than 54 million of euros. Focal mechanisms of 2002 and 2005 earthquakes show strike-slip faulting, and the 1999 shock thrusting motion. These differences on the obtained solutions are consequence of the complexity of the Betics region.

THE SPANISH NATIONAL SEISMIC NETWORK. PRESENT-DAY STATUS.

E. Carreño (1), R. Antón (1)
(1) Instituto Geográfico Nacional. Spain.
echerrero@fomento.es /Fax: +34-91-599758
ranton@fomento.es /Fax: +34-91-599758

The present configuration of the National Seismic Network in Spain consists of 67 seismic digital stations in real time, 111 accelerometers for dial-up interrogation and also, 19 portable stations and one mobile station for real time connection. The main goal is the robustness of the network, mixing VSAT stations and telephone ones. This type of configuration began in 1999. The 24 hours attention and the current software for hypocentral computation allow for obtaining an excellent solution for earthquakes with magnitude greater than 3.0 for the Iberian peninsula and surrounding areas. This solution is obtained three minutes after the earthquake origin time. For the rest of the events it takes around eleven minutes. In the last year, 3.637 regional events have been located by the network. For the volcanic monitoring is being established an special real time seismic network in the Canary Island.



Spanish seismic network. Real time seismic stations with velocity records.

Spanish seismic network. Seismic stations with acceleration records.

MODSISNAC – MODERNIZATION OF THE PORTUGUESE NATIONAL SEISMIC NETWORK

F. Carrilho (1), M.L. Senos (2), P.M. Alves (1), D. Vales (1), J.A. Pena (1)
(1) Instituto de Meteorologia, I.P., Rua C ao aeroporto, 1749-077 Lisboa.
(2) Instituto de Meteorologia, I.P., Delegação Regional dos Açores, Rua Mãe de Deus, Ponta Delgada.
fernando.carrilho@meteo.pt /Fax: +351-218 491 565

Instituto de Meteorologia, I.P. (IM) runs the national seismic network and is the responsible for the seismic monitoring on Portugal Mainland, Azores and Madeira archipelagos. Portugal mainland territory is located close to the border between the Eurasian and African plates. The interaction between these plates is the main cause for a significant seismic activity in the area, where occurred several catastrophic earthquakes which were originated on continental tectonic structures, such as the 1909 Benavente event, and on submarine structures, as the great 1755 "Lisbon" earthquake. Madeira Islands are located in the African plate, far from the Azores - Gibraltar fracture zone, presenting a very low level of seismicity. The Azores archipelago is located near the triple junction between the American, African and Eurasian plates, and has a high seismicity rate with several damaging earthquakes.
The actual seismic network, mostly constituted by instrumentation from several technologies, presents several weaknesses, such as limited bandwidth associated to the short-period and enhanced short-period sensors, insufficient dynamic range (96 to 120 dB), non capacity to record strong motions in near field and non generalization of real-time data transmission.
To upgrade the seismic network, a new project has started in 2006. The idea is to perform major improvements in the present network, introducing significant enhancements in the remote stations, and adopting real-time transmission of signals and real-time processing capability. These improvements will permit: quality data acquisition in highly sensitive stations which are also equipped with strong-motion sensors, higher quality digital transmission, real time monitoring at the Operational Center, automatic signal detection, automatic association of detections and event location, development of a rapid earthquake information system for Civilian Protection authorities and other emergency purposes, automatic archive of recorded data, development of high-level products (bulletins, shake maps, etc.), and also the distribution of data for scientific research purposes.
The network development will consist in the installation of 20 new stations, equipped with high dynamic range and high-resolution 6 component digitizers, low-noise broadband sensors and strong-motions, that will transmit real-time data via dedicated VSAT links to OC. At this Centre, data will be automatically processed allowing quick hypocenter determination, which, after being validated by on duty seismologists, will permit the rapid dissemination of earthquake messages, mostly to the Civilian Protection authorities. This network will also, in the future, be integrated within a tsunami detection and warning system – NEAREST project – for the Cadiz Gulf and Portuguese western coastal areas.

PRESENTATION OF THE CGS'S ACCELEROGRAPHS AND SEISMOGRAPHS NETWORKS

M. Chikh (1), N. Laouami (1), N. Slimani (1) and Y. Bouhadad (1).
(1) Centre national de recherche appliquée en génie parasismique (CGS) Algeria
Chmoad2001@hotmail.com / fax: +213-21-495-536

The national centre of applied research in earthquake engineering (CGS) is monitoring and developing the national accelerograph network in order to constitute a strong motion data bank necessary for seismic hazard assessment and seismic code regulation. Three steps can be mentioned concerning the national accelerograph network development: (i) The first 90 analog station (SMA-1) were installed after the El Asnam earthquake 1980 followed by acquisition of 80 (SMA-1) analog and 40 (SSA-1) digital accelerographs mainly installed in free field and some of them on building or dams. Finally, 125 Etna digital accelerographs are acquired and being installed. Since 1985, this network records most of moderate to strong earthquakes.

Recently, the CGS acquired a seismological networks constituted by five (05) broadband stations composed of a Streckeisen STS-2 sensor, a Quanterra Q330 digitizer and a Baler recorder, which are not yet installed ; and ten short period stations which are composed by a Lennartz LE-3Dlite sensor and a K2 digitizer-recorder. This later has been used during the Zemmouri 2003 and Laalam 2006 earthquakes to record after shocks.

We are planning to install the broadband stations and collaborate with international institutions.

Some preliminary attempt to sea floor observation : the Ligurian Sea project

Anne Deschamps.

Dans le bassin Méditerranéen de nombreuses métropoles sont directement au bord de mer. L'aléa sismique est contrôlé non seulement par la sismicité à terre mais aussi par la sismicité en mer, plus difficile à caractériser. Les outils d'imagerie des fonds marins sont performants et rendent l'exploration géophysique possible à des coûts raisonnables. L'analyse fine de la sismicité passe par des observations de longue durée sur le fond marin par des OBS (Ocean Bottom Seismometers) qui sont de plus en plus courantes avec un coût encore largement supérieur au coût de telles observations à terre. Mais la surveillance sismique, c'est à dire avec un instrument qui transmette des données en temps quasi réel est encore un défi technologique. Des expériences sont en cours ou prévues dans plusieurs pays comme le Japon, les Etats Unis, le Canada ... qui utilisent soit des câbles en fond de mer directement reliés à la côte, soit des câbles vers une bouée en surface. Les données collectées sont aussi confrontées au développement de la méthodologie de bonne installation d'un capteur en fond de l'eau assurant le couplage avec le sol et la compréhension du bruit relié au mouvement de houle. On montrera quelques exemple d'enregistrements large bande d'OBS et du capteur sismologique très longue période installé le long des côtes françaises et relié par câble à internet

Libyan Digital Seismological Network as a first seismological database for Libya

A. Elmelade,
abmiladi@yahoo.com
LCRSSS; Tripoli - Libya
Fax. 218214909053

ABSTRACT

No seismological stations in operation in Libya before March 2000, when the efforts of Libyan Center for Remote Sensing and Space Science reached to the cooperative program between the center and the Swiss Institute of Geophysics (ETH), by implementing two temporary three component very broadband stations, one in the West of Libya near Gharyan City and the other in the East near Al Marj City, monitoring locally these two regions of Libya and regional and distant seismic activity. The only two operating stations will not cover local seismicity in different parts of Libya, and will lack the accuracy, any way some local, regional and distant events were collected.
LCRSSS with cooperation of UNESCO, started the executive program of the LDSN, by selecting the proper remote sites for stations, the civil works for the fifteen stations sites was then achieved.
In September 2000, ten three components broadband seismological station was installed in different parts of Libya, followed by two more broadband and three very broadband seismological stations installed in the mid 2005.
A total of fifteen seismological stations are installed in the more active regions in all over the country.
Three sensors are very broadband STS2 type, and twelve sensors are broadband TRILLUM type. Data transmission is via Satellite communication, transmission links allow data flow in both directions – from the remote stations to the main center and vice versa, to allow remote access of data acquisition parameters of remote stations. Power at remote sites is provided by solar panels.
More details about LDSN, will be given in the workshop.

A BROAD BAND, PERMANENT OBS INSTALLED OFFSHORE TARRAGONA (NE SPAIN)

T. Frontera (1), J.A. Jara (2), X. Goula (1), A. Ugalde (3), C. Olivera (1)
(1) Institut Cartogràfic de Catalunya (Barcelona) tfrontera@icc.es (2) RSE S.A. Aplicaciones Territoriales (Barcelona) (3) Observatori de l'Ebre (Roquetes, Tarragona)

SUMMARY
The Institut *Cartogràfic de Catalunya* (ICC) and the *Observatori de l'Ebre*, in collaboration with the Spanish oil company *Repsol Investigaciones Petrolíferas*, are carrying out a project with the aim of improving the knowledge of the seismicity and seismic risk in the Tarragona region (north-eastern Spain). Within this framework, in August 2005 a permanent ocean bottom seismometer (OBS) was installed inside the security perimeter of the Casablanca oil platform, which is located 40km offshore Tarragona. The OBS station has a three component broad band sensor and a differential pressure gauge (DPG). They were submerged at about 400m to the SW of the oil platform and were deposited at about 150m depth. Data are digitized on-site and are transmitted through a submarine cable to the platform, where they are recorded. A continuous mode and almost real time VSAT satellite data transmission from the platform to the data center at the ICC is expected for 2006. This step will imply the total integration of the OBS station into the ICC seismic network. Since the OBS is operative, some local as well as distant seismic events have been recorded. A seismic noise study from the OBS recordings shows a quite noisy behaviour. The causes are being analyzed. A DPG signal analysis is also being performed.

INTRODUCTION
On August, 12th 2005 a permanent Ocean Bottom Seismometer (OBS) and a differential pressure sensor (DPG) were installed near the Casablanca oil platform, at about 40km from the coast of Tarragona (figure 1). The project has the goal of improving the area's seismicity understanding, which is densely populated and industrially very active.

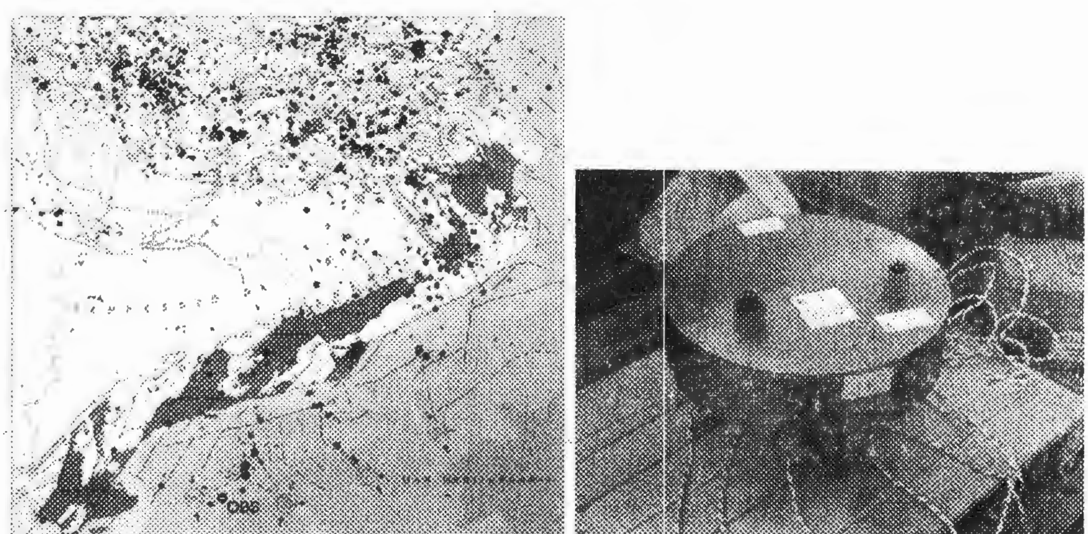


Figure 1: Left: OBS before its installation. Right: OBS location on the *Mapa de Sismicitat de Catalunya 1977-1997* (ICC, 1999).

The project, which is pioneer in Spain, is being carried out by the *Institut Cartogràfic de Catalunya* (ICC) and the *Observatori de l'Ebre* with the collaboration of *Repsol Investigaciones Petrolíferas S.A.* and it is being financed by the *Ministerio de Educación y Ciencia* (CASABLANCA REN2003-06577), FEDER funding and the ICC.

INSTRUMENTAL SPECIFICATIONS

- CMG-3T (Güralp Systems): flat instrument velocity response from 50 Hz to 120 sec.
- DMA24 digitizer in the cylinder top.
- The horizontal sensor has the capability of levelling in between ±10 degrees.
- The casing of the sensor is manufactured with titanium (grade 5) with double "O" rings.
- Differential pressure sensor (DPG).

INSTALLATION PROCESS

The installation operations began on August 9th at the commercial harbour of Sant Carles de la Ràpita, where the material preparation started on board of the ship Boluda Abrego, from which the maneuvers were done.

The OBS was loaded onto the ship, which sailed to the immersion point, where was submerged and deposited on the seabed (figure 2). In order to control the process, a submarine robot sent images that were watched from the ship. Additionally, an uninterrupted signal analysis was made. The OBS was installed at about 400 m SW from the platform, in the security area of the Casablanca field, and at a depth of about 150 m (figure 2).

Figure 2. Left: OBS' immersion. Right: Submarine robot image from the OBS and the pressure sensor deposited on the seabed.

Once the sensor was installed, the ship sailed to the platform, launching the cables with adequate ballasts, so that they stay buried in the sea bottom (figure 3).

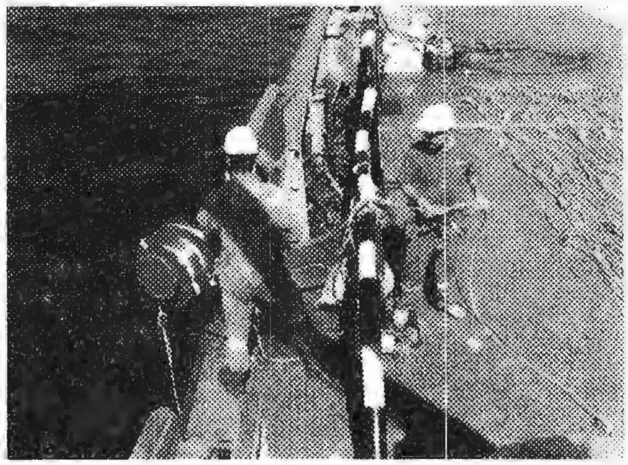


Figure 3: Cables' launching once jointed with ballasts.

At the platform, the connections to the equipment to store the seismic data were made. The submarine cables that were closest to the platform were stuck to its structure in order to reduce the signal noise.

FIRST RESULTS

As an example, some seismic events recorded on the vertical component are shown: Japan earthquake on August, 16th 2005. Mw=7.2 (figure 4).

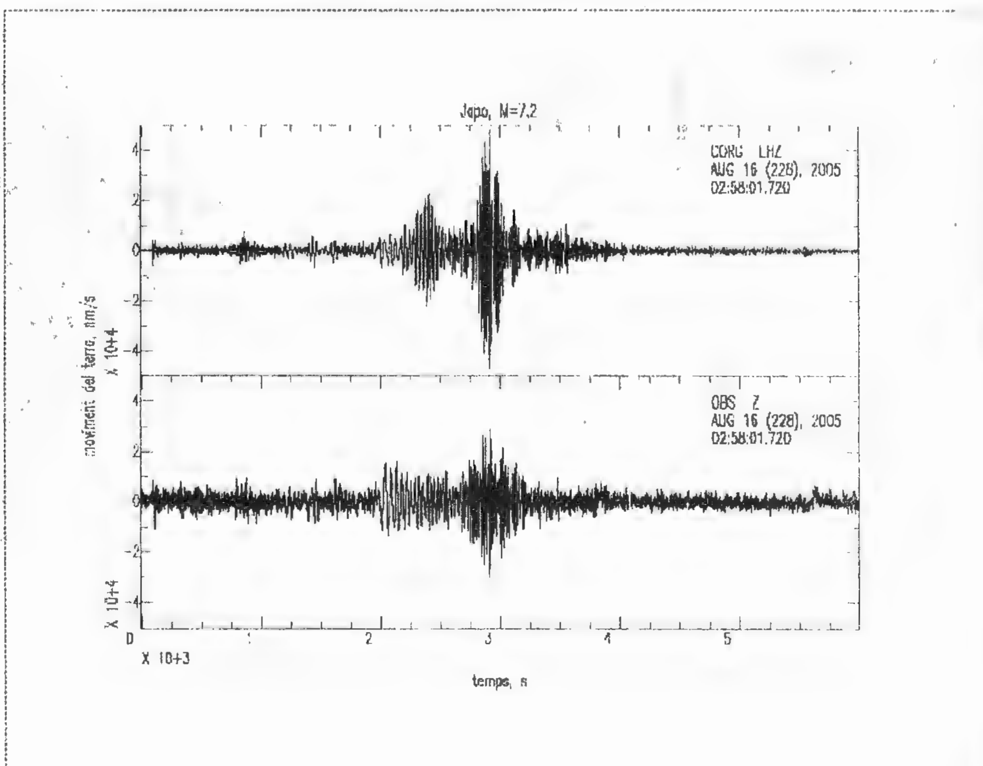


Figure 4: Non-filtered vertical records from the OBS (bottom) and CORG terrestrial station (top). One hour and forty minutes at one sample/second are represented.

Local event offshore Tarragona on August, 22nd 2005. M=1.4 (figure 5).

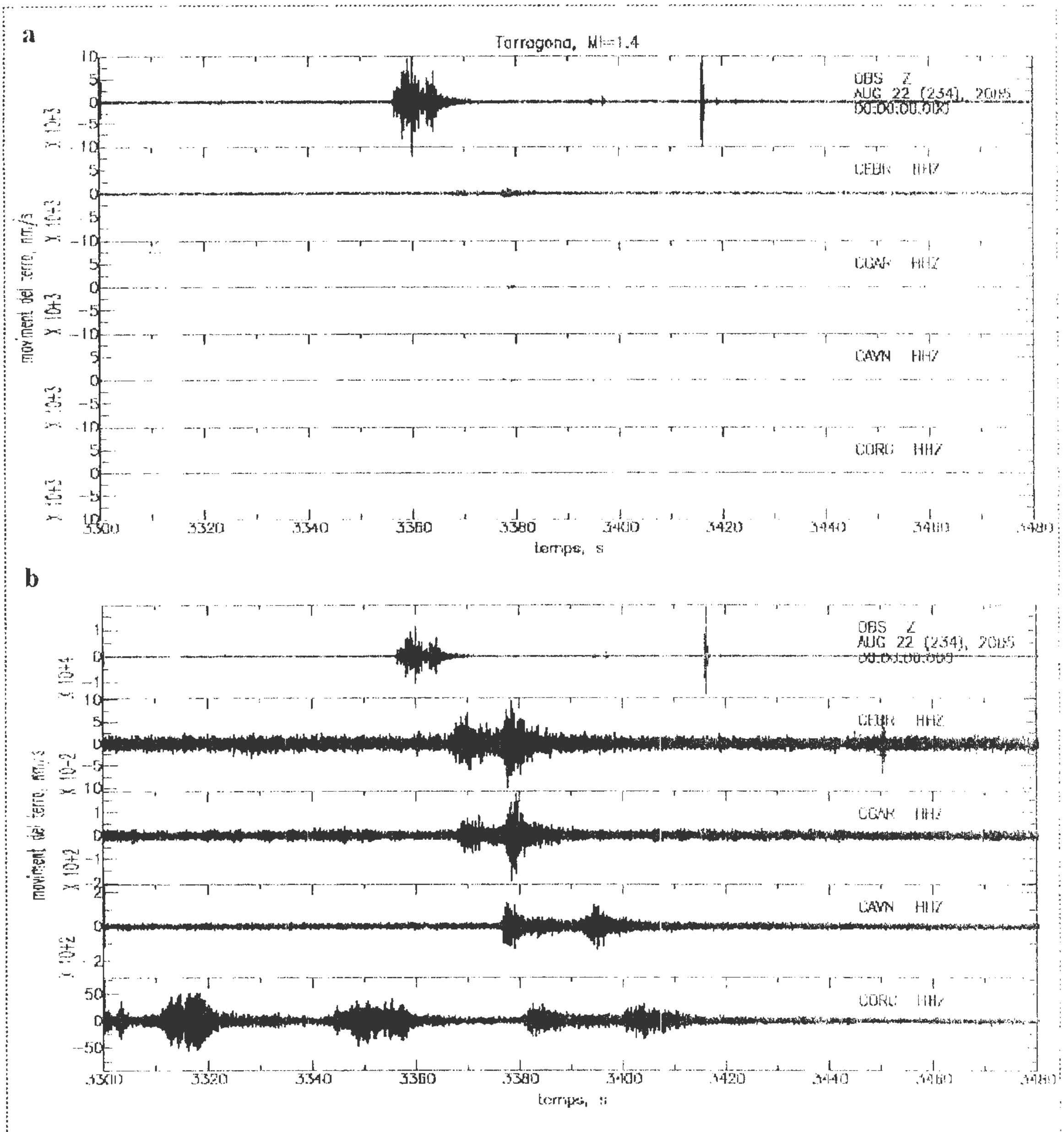


Figure 5: High pass (1Hz) filtered vertical records from the OBS (top) and some terrestrial stations. Three minutes at 100 samples/second are represented. a: All records are plotted at the same scale. b: Records are scaled at its own maximum amplitude.

PRELIMINARY NOISE ANALYSIS

The acceleration power spectral density (psd) of the OBS vertical component was computed for 5 minute periods at 3:00h, 9:00h, 15:00h and 21:00h every day between August, 14th and October, 16th 2005. The same study for the horizontal components has also been done, but the time period for which data are available is much shorter, because these sensors have had many tilt problems. There is not any significant difference between the psd at the different moments of the day, so only results at 3:00h are shown.

The average curves show a high noisy behaviour in relation to the Peterson models (1993) and to the Catalonia network terrestrial stations (figure 6). The main difference observed is the noise between 0.2Hz and 3Hz. The causes are being analyzed.

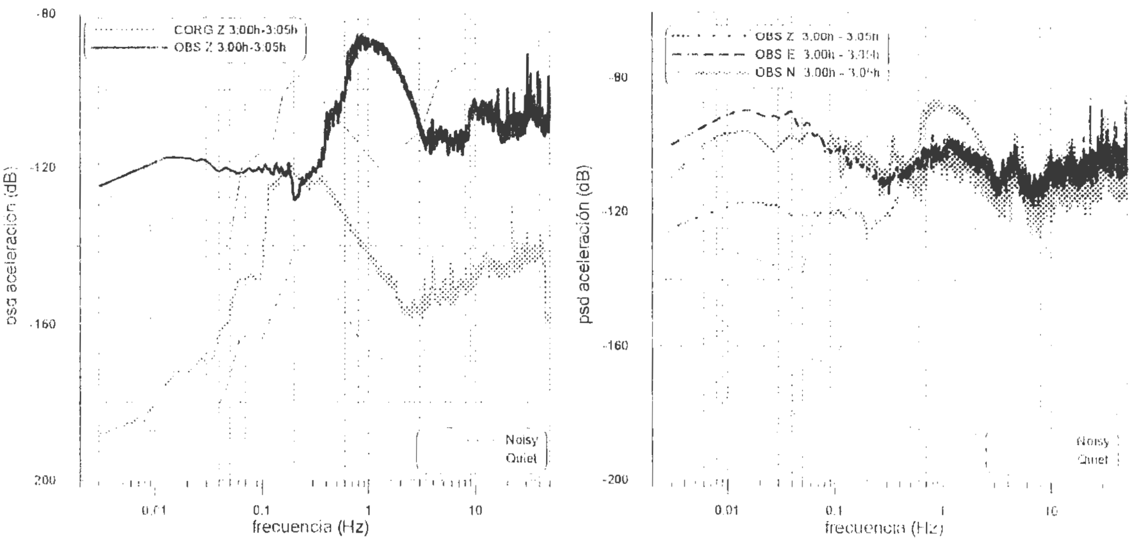


Figure 6. Left: Mean of the acceleration psd for the OBS and CORG terrestrial station vertical components.The Peterson psd curves (1993), noisy and quiet, are also shown. Right: Acceleration psd averages for the three OBS components, together with the Peterson models (1993)

A similar psd study for the differential pressure gauge (DPG) has been done for the same period as the vertical OBS component. Figure 7 shows this result together with the OBS vertical component acceleration psd. The DPG has been calibrated for frequencies between 0.05Hz and 5Hz.

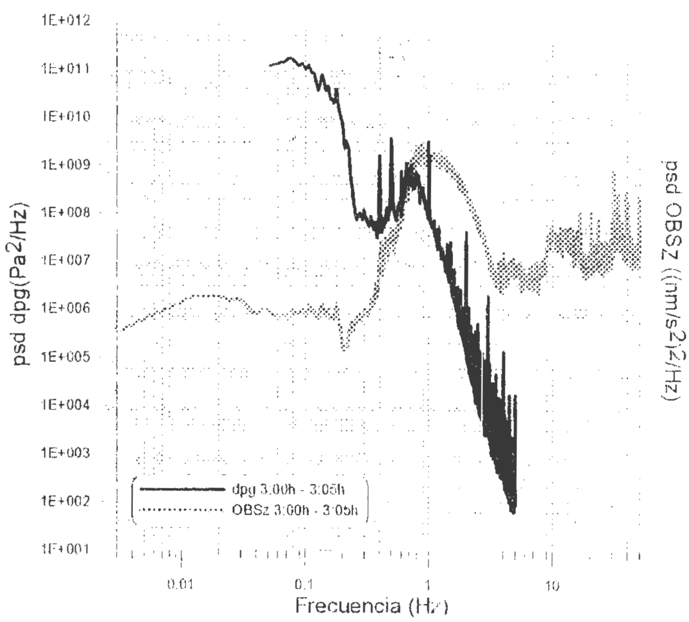


Figure 7: Mean of DPG psd together with the acceleration psd for the OBS vertical component.

CONCLUSIONS AND FUTURE GOALS

OBS integration to the Catalonia seismic network is expected. Data will be transmitted via satellite from the platform to the ICC seismic data reception center to be processed together with the terrestrial station data.

The OBS is very noisy between 0.2Hz and 3Hz. A site effect study will be performed in order to explain this behaviour.

For OBS vertical component low frequencies, DPG data will be used to reduce noise due to ground deformation under long-period ocean-wave loading and OBS horizontal data will be used to correct current and tilt effects (Webb and Crawford, 1999; Crawford and Webb, 2000).

Once the noise study has been carried out, an earthquake signal analysis will be performed.

The ANTARES project (Deschamps et al., 2005; Deschamps et al., 2006) in the Ligurian Sea includes a similar OBS and DPG instrumentation as in ours, but the site conditions are quite different. A joint analysis from data and technical aspects from both projects is in mind.

ACKNOWLEDGEMENTS

We are grateful to many people, who have made possible the OBS installation and the first record analysis:

- Jaume Miranda, Antoni Roca, Jorge Fleta, Teresa Susagna, Sara Figueras and Josep Manel Rebled, from the Institut Geològic de Catalunya.
- Miquel Torta , from the Ebre Observatory.
- Martin Rowe and Andy Smith, from Güralp S.L
- The Boluda Abrego crew and its captains Manolo and Paco.
- The Sumergia divers and their heads Ramón Alía and Antonio Valverde.
- Enrique García, Òscar Serra, Amancio Villaverde, Agustín Plaza and Fernando Arnau, from Repsol Investigaciones Petrolíferas S.A.
- The Casablanca platform workers and their head Pedro Zulueta.
- Antonio Pazos, from the Real Instituto y Observatorio de la Armada de San Fernando.
- Toni Marcè, from RSE S.A. Aplicaciones Territoriales.

REFERENCES

Crawford, W.C. and S.C. Webb (2000). Identifying and removing tilt noise from low-frequency (<0.1 Hz) seafloor vertical seimic data, *Bull. Seis. Soc. Am., 90(4)*, 952-963.

Deschamps, A., Y. Hello, M. Dugué, V. Bertin and A.Le Van Suu (2005). Antares: a seismological broad-band sensor at 2500m in Mediterranean Sea, *Geophysical Research Abstracts, Vol. 7*, 03705, SRef-ID:1607-7962/gra/EGU05-A-03705, European Geosciences Union.

Deschamps, A., Y. Hello, V. Bertin and A.Le Van Suu (2006). Analyse of seismological broad-band observation at 2400m on sea floor in Metiterranean Sea, *Geophysical Research Abstracts, Vol. 8*, 09197, SRef-ID:1607-7962/gra/EGU06-A-09197, European Geosciences Union.

Institut Cartogràfic de Catalunya (1999). "Mapa de sismicitat de Catalunya 1977-1997". *Institut Cartogràfic de Catalunya*, Barcelona.

Peterson, J. (1993). Observation and modeling of seismic background noise, *U.S. Geol. Surv. Tech. Rept.*, 93-322, 1-95.

Webb, S.C. and W.C. Crawford (1999). Long-period seafloor seismology and deformation under ocean waves, *Bull. Seis. Soc. Am. 89(6)*, 1535-1542.

Seismicity Monitoring, Wied Dalam Broadband Station, MALTA

Pauline Galea, Physics Dept., University of Malta

ABSTRACT

The Physics Department, University of Malta, operates one three-component digital broadband station WDD, which forms part of MedNet, as well as being a real-time contributor to the VEBSN (ORFEUS). The Maltese islands lie in the low/moderate seismicity region of the Sicily Channel, characterized by a diffuse crustal seismicity of magnitudes peaking around 3.0 – 3.5, and an apparent upper limit of around 4.8. within a radius of about 100km round the islands. Felt ground shaking on the islands in the historical past has been due to large magnitude events in Sicily and Southern Greece as well as to this offshore seismicity, presenting a low-moderate seismic hazard to the islands. Very high building and population density, together with the lack of an enforced building code, however, results in risk estimates that cannot be neglected.

Offshore seismicity is associated mostly with submarine faults bounding the grabens of the Sicily Channel rift system and related transform fault zones. This system, active since the Pliocene, represents a NE-SW extensional regime and results in three main NW-SE trending grabens, bounded by normal faults, and several volcanic centres. An amount of smaller magnitude seismicity recorded on WDD is not, or very poorly, recorded elesewhere, and therefore cannot be directly located by conventional methods. Larger magnitude events, however are recorded on Sicily and Tunisian stations, and possibly also on part of the Libyan network, offering the possibility of much improved, routine epicenter location for the Sicily Channel. A small real-time regional network for this region would be ideal, and could also provide source mechanism information necessary for elucidating the still uncertain neo-tectonics of the area.

The French Accelerometric Network (RAP): current state in 2006.

Philippe Guéguen[1,2], Bruno Feignier[3], Fabrice Cotton[1], Catherine Berge-Thierry[4], Pascal Dominique[5], Annie Souriau[6] and Clotaire Michel[1]

[1] Laboratoire de Géophysique Interne et Tectonophysique, University of Grenoble
[2] Laboratoire Central des Ponts-et-Chaussées, Paris
[3] Laboratoire de Détection Géophysique, CEA, Bruyères-le-Châtel
[4] Institut de Radio-Protection et de Sureté Nucléaire, Fontenay-aux-Roses
[5] BRGM, Orléans
[6] Observatoire Midi-Pyrénées, University of Toulouse

Contact: pgueg@obs.ujf-grenoble.fr

Abstract. France is a country of moderate seismicity but, due to dense urbanized and industrial areas, the seismic risk is significant. Furthermore, recent developments in numerical and semi-empirical methods request a good knowledge of several parameters. The mission of the French accelerometric network programme (RAP, Réseau Accelerometrique Permanent) is to expand and modernize significantly the acquisition and application of French accelerometric data (both strong and weak motion) in order to improve earthquake related research and public safety from earthquakes. This network is the result of co-operative efforts including academic institutions (INSU-CNRS, Universities of Grenoble, Nice, Strasbourg, Toulouse, IPG Paris) and several state agencies (BRGM, CEA, IRSN, LCPC). Since 1995, around 120 stations have been installed in some seismic areas of France. This network also includes specific research actions (site effects, building monitoring, deep borehole...). Other French accelerometric stations devoted to strong motion recording are also associated to the network. All data are archived and freely distributed in a database center, data being available in SAC, ASCII and SEED format. Some RAP's recordings are given as example, corresponding to the Vallorcines (Ml=4.9, September 08, 2005) earthquake.

1. Introduction

Since the report established in 1989 by Bard et al. (1989), written at the Ministry of Environment request, and the recommendation made by the Parliamentary Office for the evaluation of the Scientific and Technological Choices in 1995 (Kert report) on the natural hazard which recommended the absolute necessity to have a strong motion network in France, the French Accelerometric Network (Réseau Accélérométrique Permanent, RAP) has been created. The deployment in the French territory of the first accelerometric stations started then, trying to cover all of the potentially active zones. Contrary to a traditional seismological network, the objective of the RAP was to install strong motion stations where the stakes were clearly identified in order to answer scientific problems relating to seismic hazard and vulnerability. After a first experimental operation launched in 1995, coordinated by Denis Hatzfeld (LGIT-CNRS), entrusted to Geoscience-Azur (University of Nice-Sophia Antipolis) and to the LGIT (University Joseph Fourier of Grenoble), and designed in order to test its technical and operational feasibility, a Scientific Interest Group (GIS-RAP) was created

in 2000 to bring together around the same network all the scientific and operational actors implied in the comprehension and the monitoring of the seismic hazard and vulnerability in France. The main role of the GIS-RAP and of its scientific board is to decide and to plan the instrumentation policy, coherently with the scientific objectives fixed from the beginning.
While in 1995 the first four stations were installed in the Alps, in 2000 the scientific board started to plan the extension of the RAP. That resulted in the development of the Provence and Eastern Pyrenees (managed by the BRGM), the Rhine (managed by IPG-Strasbourg), the Western Pyrenees (managed by OMP-Toulouse) and the French West Indies (managed by IPG-Paris) networks. Moreover, as mentioned since the first discussion in 1995, a special objective of the RAP is to homogenize and to distribute all the accelerometer data collected and available on the French territory. This paper is the opportunity to present the current state of the RAP in 2006, concerning the instrumentation policy, the evolutions of the RAP database and some major observations on significant earthquakes which occurred recently.

2. Instrumentation

With the support of its guardianships and its members, the GIS-RAP's instrumentation policy has been extended to the whole French territory. New stations have been installed, mainly in the central region (RAP-OPGC), in the Western part of France (RAP-LDG and RAP-UBO) and also in the French overseas region (Nouvelle-Calédonie in the Pacifi Ocean and Mayotte in Indian Ocean...). In 2006, there are now 120 stations installed (Fig. 1). Networks associated with the RAP are also implicated to supplement this instrumentation, e. g. in the area close to the Durance active fault (IRSN network), in areas characterized by a lack of instrumentation (e.g., by the CEA/LDG in the Jura region) and especially in the French West Indies islands of Guadeloupe (by the BRGM) and Martinique thanks to the network of the General Council with which an agreement was signed in 2002 (Fig. 1).

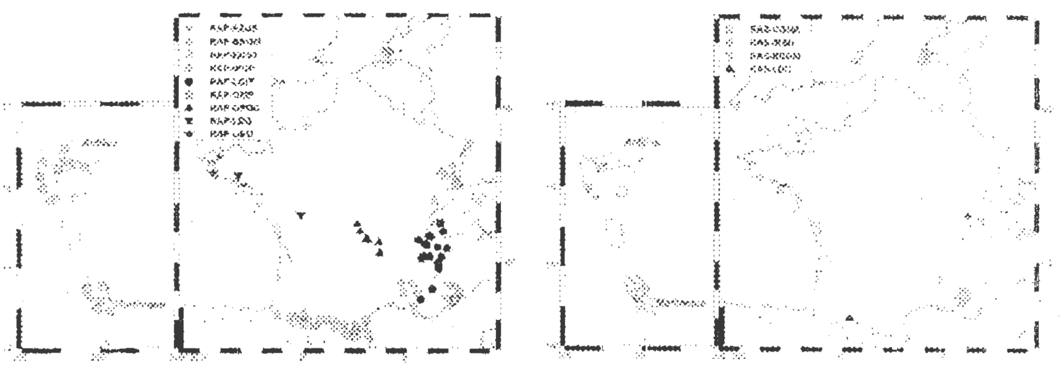


Figure 1: Localization of the RAP stations (left) and the associated networks (right) in France and in the French West Indies islands.

Since the beginning of the GIS-RAP, the scientific board has proposed technical evolutions in order to maintain the network on its higher level and it has initiated scientific actions. The main scientific objectives concern the knowledge of source effects and seismic motion, the propagation and attenuation phenomena, the analysis of site effects and the experimental assessment of vulnerability.

Moreover, the RAP can rely on marked operations for which specific instrumentations have been designed in order to reveal special phenomena. Among these marked operations, two of them are focused on site effects in Grenoble (Northern part of the Alps) and in Nice (Southern part of France), one concerns the monitoring of a deep borehole and of a building located in Grenoble's basin and the last is devoted to the liquefaction effect in the French West Indies.

3. The Online Database

All the data are collected and distributed by the online database (http://www-rap.obs.ujf-grenoble.fr) managed by the LGIT. The homogeneity and the quality of the data stored in the database allow to give the values of the peak ground acceleration recorded in case of strong events and to analyze the observations later. These two levels of work correspond to the scientific and operational objectives of the RAP.

Since 1995, 8770 seismic events have been recorded by at least one station of the RAP or associated networks (Fig. 2). The deployment of new stations allowed the increase, with a significant degree, of the number of recorded earthquakes. These events correspond to 19159 recordings available on the online access database of the RAP (Fig. 2). The great sensitivity of the stations allows the detection of low-to-moderate earthquakes (Ml<2) and, simultaneously, their great dynamics allows the recording of the ground motion produced by events of stronger magnitudes (Ml>5) without overflow. The maximal PGA found in the database reaches 0.7g: this value was recorded in the French West Indies and corresponds to the Ml=5.4 (February 14, 2005) aftershock of the Saintes earthquake main shock (21/11/2004, Ml=6.3), at 7 km from the epicenter. Since 2000, the number of strong motion recordings available in the database has increased significantly due to the experimental policy planed for the French West Indies by the scientific board of the GIS-RAP. Even if Fig. 3 highlights the most active zones of inland areas of France, there is no doubt that the majority of the events are located near Martinique and Guadeloupe islands, two of the most active regions, for which the same French seismic regulation has to be considered.

In complement of the online tools, which make it possible for the scientists to recover accelerometer data, the online database has been updated since 2004 thanks to a geographical interactive tool. This online Geographical Information System (GIS) allows for each event or set of events the screen location of the epicentre, the screen view of the PGA values and a quick preliminary analysis of the data (Fig. 4).

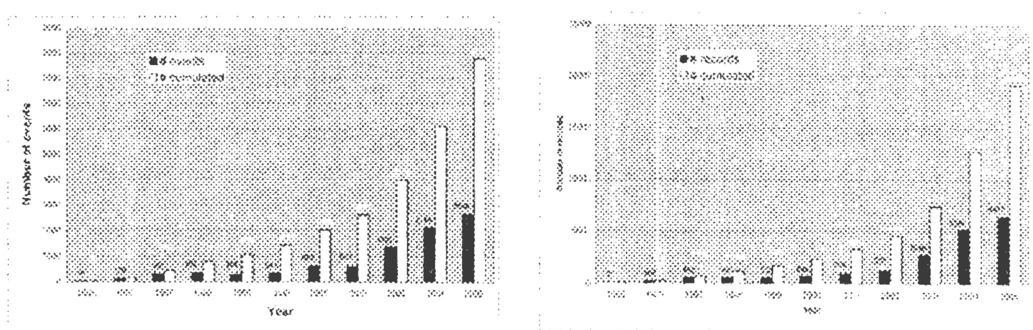


Figure 2: Number of events (left) and recordings (right) per year and cumulated since 1995 available on the online RAP database.

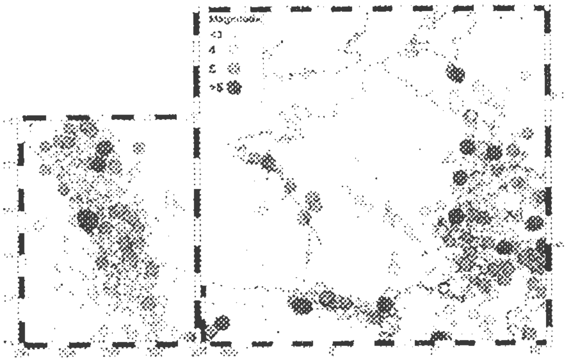


Figure 3: Localization of the events recorded by at least one station of the RAP or associated networks.

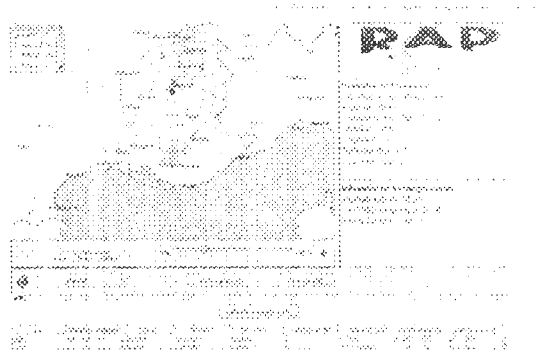


Figure 4: Set of screens displayed by the online GIS linked to the RAP database.

4. Example of the Vallorcine (Northern part of the Alps) September 08, 2005 earthquake (Ml=4.9, RéNaSS).

On September 08, 2005, a Ml=4.9 earthquake (source: RéNaSS) occurred in the Vallorcines urban area, close to Chamonix (Northern Alps). This event was strongly felt by the inhabitants of the Rhone-Alps region and in particular in Savoie and Haute-Savoie regions, without causing significant damages. The hypocenter of the earthquake was located near the Montets mountain pass, at 5km depth (source: RéNaSS). In the past, this area underwent an historical earthquake in 1905, with magnitude estimated around 5-6 which caused much damage in the area of Chamonix.

Thirty three stations of the RAP recorded this event, with a maximum PGA of 0.295m/s2 observed at the OGSI station, located 28km away from the epicenter. The attenuation of the PGA with the distance shows a fast decrease at long distance (Fig. 5). It is interesting to note that compared to the empirical attenuation relations of the seismic motion generally used in Europe for this magnitude, the predictions of the acceleration values generally over-estimate the ground motion. In general, these "European" relations are established on the basis of strong motion collected in Europe or in seismic regions characterized by stronger seismicity levels than in France and for an other type of magnitude (Ms instead of Ml). These observations are fundamental for the prediction of the seismic motion, e.g. in the choice of the empirical attenuation model which must be taken for probabilistic hazard assessment, bases of the seismic French (and European) regulation.

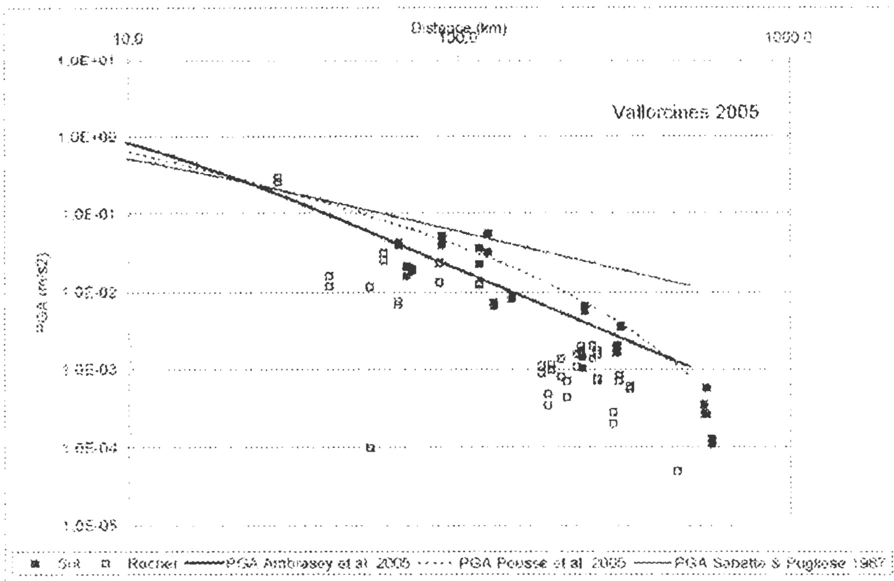


Figure 5: Attenuation of the seismic motion (acceleration PGA) with the distance for the Vallorcines earthquake (08/09/2005) recorded by the RAP stations located on rock or sediments and comparison with the "standard" European attenuation empirical models relations (after Guéguen et al., 2005).

Since the beginning of the RAP, these systematic observations have allowed to initiate many research tasks in France. The PhD thesis of S. Drouet (OMP, Toulouse), co-supported by the Ministery of Ecology and the CNRS, discussed what the empirical models of attenuation (and the methods used for the magnitude conversions associated to these models) are, having the better fit for the "strong motion" data (ML > 4.5) recorded for the last years in the Pyrenees region. Many discussions have been carried on the use of the data obtained from weak motion (M<5) in order to predict the seismic motion generated by strong events (M>5). Scherbaum et al. (2004) suggested that the adjustment to the European geological and tectonic conditions of the models developed for regions with strong seismicity rate (e.g., California, Japan) is preferable to the extrapolation of the empirical attenuation models resulting from weak motion. Several recent results also suggested the increase of stress drop with magnitude that may influence the empirical models. Moreover, recent studies (e.g., Pousse et al., 2005) indicate that the attenuation of the seismic motion with the distance is also dependent on the magnitude. Nevertheless, the data of weak motion, like those collected by the RAP, make it possible to specify the regional and local anomalies. In addition, Drouet et al. (2005) showed that the analysis of the weak motion is essential in the process of selection and adjustment of the models for the prediction of strong motions.

Simultaneously, the 13-storey City-hall building of Grenoble, monitored by the RAP, showed significant internal displacements. Occupants evacuated spontaneously the structure, the strongest motion being felt beyond the third story. The acceleration recorded at the basement stayed lower than the acceleration value given by the French seismic code: 0.02 m/s2 and 0.01m/s2 were observed in the longitudinal (North) and transverse (East) directions, respectively (Fig 6). Nevertheless, the Vallorcines earthquake produced significant levels of deformation, especially beyond the third level. The model used is based on the modal analysis extracted from ambient vibration recordings that enabled us to define an equivalent linear and elastic model. This model is validated by comparing the computed and observed motion at the building top for the same input time history of ground motion. The deformation partly explains the feeling of the occupants. Based on this procedure, it is thus possible to compute the maximal deformation for scenario earthquakes. Using the threshold integrity concept (Hans et al., 2005), information on the end-state of the structure can be obtained.

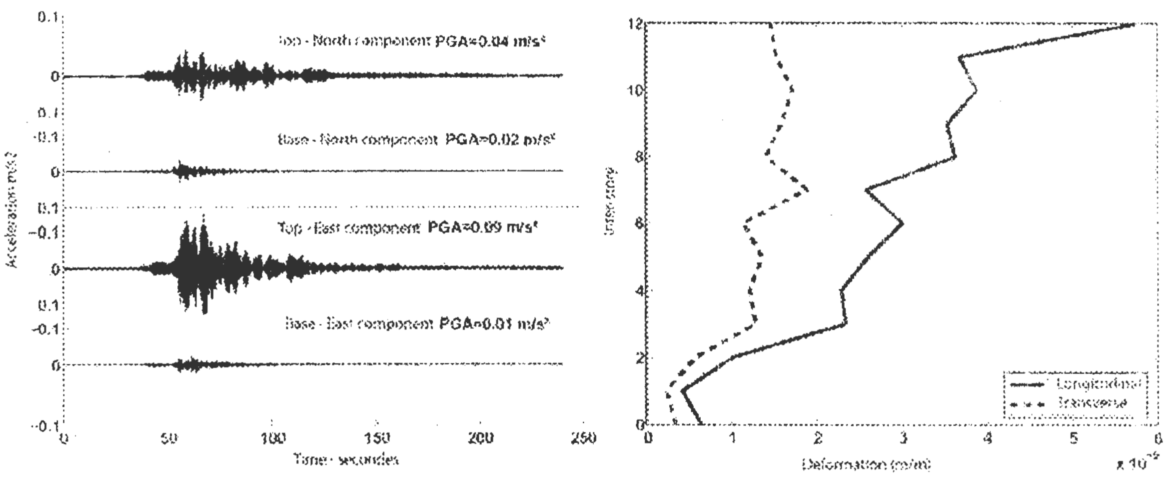


Figure 6: Motion produced by the Vallorcine earthquake (08/09/2005) recorded at the base and the top of the City-hall of Grenoble, experimental building of the RAP (left) and the induced inter-storey drift modeled in the building (right) (after Guéguen et al., 2005).

5. Conclusions

The RAP has now arrived to maturity and its online database, fortified by its 20000 recordings, brings essential information to the comprehension and the knowledge of the seismic hazard and vulnerability in France. The first studies undertaken on the data show that the use of low-to-moderate seismic motion gives relevant information for the prediction of strong ground motion, which is the base of the seismic hazard assessment. This is particularly confirmed by the increasing number of scientific papers and PhD thesis using these data. The online access to common waveforms encourages and facilitates the research tasks. Because of the available common and unique database, active synergies between the partners exist illustrated by the technical and scientific meeting of the RAP organized every two years by the scientific board. This meeting gives the opportunity to see emerging new scientific problems and the end-users of the data can express the technical or/and scientific evolutions needed to increase the quality of their analysis. These discussions can direct the updating of the stations and the policy of the scientific board.

The key points for the years to come are related (1) to the description of the geotechnical site conditions of the stations in order to better constrain the empirical model, (2) to calculate for each recording a set of parameters describing the ground motion (e.g., PSA, PSV, Arias intensity...) and (3) to complete and update the catalogue with information describing the event (e.g., Mw, focal mechanism…). These goals will be pursued particularly in the framework of the NERIES European project in which the RAP is identified as an active member in order to constitute exchange tools for accelerometric waveforms and parameters at the European scale.

Acknowledgements
The RAP is supported by the French Ministry of Ecology and Sustainable Development and by the Institut National des Sciences de l'Univers (INSU-CNRS) The partners and/or the local networks of the GIS-RAP are the BRGM (RAP-BRGM), the Universities of Grenoble (RAP-LGIT), Nice (Geoscience Azur, RAP-AZUR), Toulouse (RAP-OMP), Strasbourg (RAP-EOST), Paris (RAP-IPGP), Clermont-Ferrand (RAP-OPGC) and Brest (RAP-UBO), the CEA-LDG (RAP-LDG), the IRSN, the CNRS, the LCPC and the General council of Martinique.

References

Bard, P.Y., P. Mouroux, J.P. Méneroud. **1989**. Propositions pour un réseau accélérométrique permanent en France, *rapport 89 SGN 478 GEG, Secrétariat d'état à l'environnement et à la prévention des risques technologiques et naturels majeurs*, mai 1989, 31 pages.

Drouet, S., A. Souriau and F. Cotton. **2005**. Attenuation, seismic moment and site effects for weak motion events. Application to the Pyrenees. Bull. Seism. Soc. Am., Bull. Seismol. Soc. Am. 95, 1731-1748.

Guéguen, P., E. Chaljub, B. Delouis, P. Giroux, S. Hatton, C. Michel, S. Nechtschein, C. Péquegnat et J . Revilla. **2005**. Le séisme du 08 septembre 2005, Vallorcines, Haute-Savoie, *Note d'information du RAP*, http://www-rap.obs.ujf-grenoble.fr, novembre 2005.

Pousse, G., F. Cotton and F. Bonilla. **2005**. Do weak motion models predict strong ground motion? Results from the Kiknet records analysis, EGU, Vienna.

Scherbaum, F., F. Cotton and P. Smit. **2004**. On the Use of Response Spectral-Reference Data for the Selection and Ranking of Ground-Motion Models for Seismic-Hazard Analysis in Regions of Moderate Seismicity: The Case of Rock Motion. Bull Seism. Soc Am, 94(6): 2164-2185.

Hans, S., C. Boutin, E. Ibraim, and P. Roussillon. **2005**. In Situ experiments and seismic analysis of existing buildings - Part I: Experimental investigations. Earthquake Engineering and Structural Dynamics, 34.

GEOFON AND ITS ROLE IN EARTHQUAKE MONITORING

W. Hanka
Geoforschungszentrum Potsdam. Germany
hanka@gfz-potsdam.de /Fax: +49-331-288-1277

Introduction

The original scope of the GEOFON Program of GFZ (http://geofon.gfz-potsdam.de) is to collect and distribute worldwide high quality seismological data for all kinds of scientific studies (Hanka and Kind, 1994). It consists of three components, the global permanent broadband seismological network, a varying number of mobile network deployments and the GEOFON Data Center (now called GFZ Seismological Data Center). Unlike e.g. IRIS, as an initiative with a similar scope, GEOFON has to act on a much lower level what its resources are concerned and tries to achieve its goals using simple, inexpensive but innovative technical solutions and with intensive cooperation on all levels. This concept has been extremly successful over the past decade and many networks and data centers in Europe and worldwide have adopted it. Therefore GEOFON today acts more than a support center and networking, integration and capacity building institution for many networks and data centers rather than a just conventional seismic network and data center on its own.

GEOFON plays also a leading role in near real-time data collection and processing of broadband seismological data both on a European and global scale. Its SeedLink IP data transmission protocol as part of the GEOFON SeisComP data acquisition and processing software package has become a de-facto global standard adopted as a manufacturer independent real-time data exchange protocol by international organizations and major projects, supported by all major commercial suppliers of seismological equipment. The GFZ Seismological Data Center acquires presently near real-time data from more than 300 globally distributed stations from GEOFON stations and partner networks (GEOFON Extended Virtual Network – GEVN), most of them in Europe (derived from the Virtual European Broadband Seismic Network – VEBSN, Van Eck et al., 2004) and SE Asia. Using these real-time data feeds, automatic processes for data quality checks, event detection, localization and source quantification are applied and the resulting rapid but nevertheless highly reliable earthquake information is automatically published in the Internet and alerts are distributed by email and SMS messages to a wide spread user community.

For most of its partner networks, the GFZ Data Center not only acquires near real-time data streams for earthquake monitoring purposes, but also archives it together with the GEOFON data and the data sets from numerous temporary network deployments in the GFZ long-term Seismological Data Archive and re-distributes it to the user community. All data from permanent and temporary networks is in principle immediately and automatically jointly available to anybody, both as real-time feeds and from the data repository. However, temporary network data have normally a time period of exclusive usage of the project consortium (2-3 years). Some data of GEOFON partner networks is presently also not available to the public.

After the Tsunami tragedy in the Indian Ocean, GEOFON was selected to implement the seismological component of the German contribution to the future Indian Ocean

Tsunami Early Warning System (GITEWS). This nomination has to be regarded as a direct result of the great success of the GEOFON strategy being achieved in the past decade.

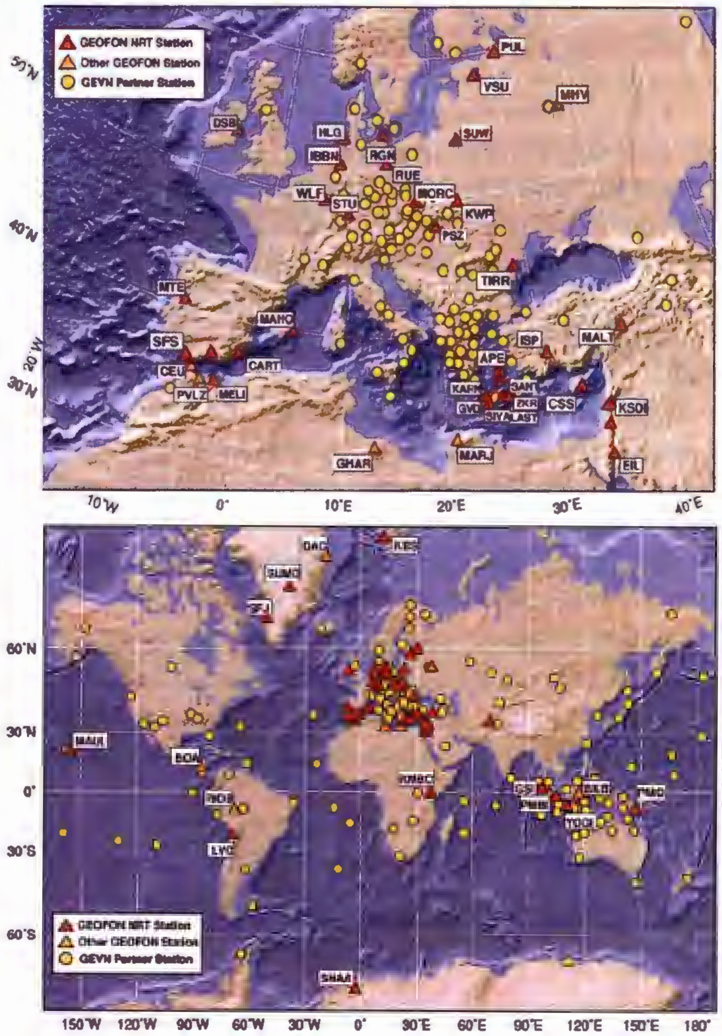


Figure 1. Overview of station distribution of the permanent GEOFON network and the GEVN partner networks in EuroMed area and globally.

The permanent GEOFON Network

The permanent GEOFON network (FDSN network code GE), presently consisting of 54 stations in all continents, became a multinational initiative. A number of institutions from different countries joint the GFZ efforts to set up a permanent seismological broadband network in Europe and the Mediterranean as well as to fill gaps in the global broadband network. Cooperations on different levels with similar programs like IRIS, MedNet, Pacific21 and individual national networks and geophysical institutes in many countries led to the fact that the GEOFON network has been growing much faster than expected. GEOFON stations are normally equipped with Streckeisen STS-2 VBB seismometer with a special shielding (Hanka, 2000) and adequate "true" 24-bit digitizers, which allow the recording of all relevant seismic signals from high frequency local events to the earth tides with sufficient dynamic range. In several "global" sites STS-1 seismometers are used. In older GEOFON stations Quanterra Q380 or Q4120 datalogger are still used , while in newer or upgraded stations Earth Data PS6-24 digitizers are installed. In the new satellite based Indian Ocean GEOFON sub network Q330 digitzers are used. These stations are also equipped with additional strong motion sensors.

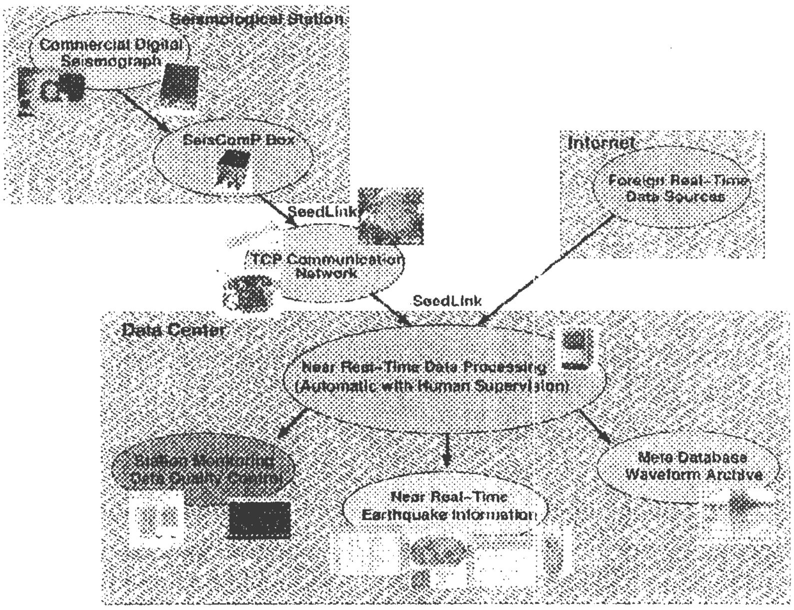


Figure 2: The Seismological Communication Processor (SeisComP) concept.

The Seismological Communication Processor

The core of the GEOFON network is the Seismological Communication Processor (SeisComP) system (Fig. 2). It is a concept for a manufacturer independent networked seismographic system, originally developed for the GEOFON network (Hanka et al., 2003) and further extended within the MEREDIAN project (van Eck et al., 2004) which became meanwhile a de-facto standard in Europe and worldwide. Its task is seven-folded: data acquisition, data recording and real-time communication on the station side, monitoring and controlling, automatic (near-)real-time data processing (quality control, event detection and location), data archival and data distribution on the data center side. SeedLink, the data acquisition and transmission part of the SeisComP software package makes it easy to deal with heterogeneous commercial hardware. SeedLink supports many different commercial and non-commercial data logger and digitizers, data formats and transfer protocols and provides unified appearance for heterogeneous hardware, formats and protocols within seismological networks. For this, all GEOFON stations are equipped with a so-called SeisComP box, a GFZ developed PC/104 based station and communication processor running the SeisComP software under Linux operating system. Although a standard office PC would in principle do the job as well, the SeisComP boxes have certain advantages (small size, low (12 VDC battery) power consumption, ruggedized field design, sophisticated environmental shielding).

Most (47) GEOFON stations are directly or indirectly connected to the GEOFON Data Center in Potsdam by SeedLink, mostly by Internet. For this, local Internet service providers or local or regional SeisComP data collection centers at partner institutions with Internet access are used. Different means are used to bridge the "last mile" from the remote seismic vault to the Internet access point. These can be radio, WLAN or satellite links as well as dedicated or dial-up telephone or IDSN lines. Using SeedLink, it is possible to transfer the complete data sets from the remote stations in (near) real-time to the GEOFON Data Center.

Many seismological networks in Europe and worldwide have adopted the GEOFON concept of establishing state-of-the-art high quality real-time broadband seismic networks at low costs. In many countries the existing old short period network were transformed into modern broadband networks after a single GEOFON station has been installed as nucleus and the required know-how has been transfered. Also the EC project MEREDIAN, carried out under the coordination of ORFEUS, had a substantial impact namely in distributing SeisComP as the European standard system for real-time data exchange amoung data centers. The major achievement of MEREDIAN, the Virtual European Broadband Seismic Network (VEBSN), consists mainly of a set of SeedLink servers at each contributing data center, offering real-time data access to all or a selected sub-set of stations available at the centers. SeedLink therefore supplies a real-time data exchange mechanism among data centers and makes it easy to establish cross-border virtual networks. In the US, the IRIS DMC has adopted SeedLink for distributing its real-time data streams (including those from the FDSN stations and USArray) to the users. In Central America, South and East Africa (including AfricaArray initiative), Japan, Australia, New Zealand and recently South East Asia, many networks are meanwhile using SeisComP and offer real-time data via SeedLink for exchange. Even if in some cases commercial data acquisition software is used, SeedLink provides a unique opportunity to link commercial networks to those from different manufacturers and to the SeisComP and Earthworm community. Alltogether, there are presently presumably between 1500 and 2000 stations worldwide in principle available via SeedLink.

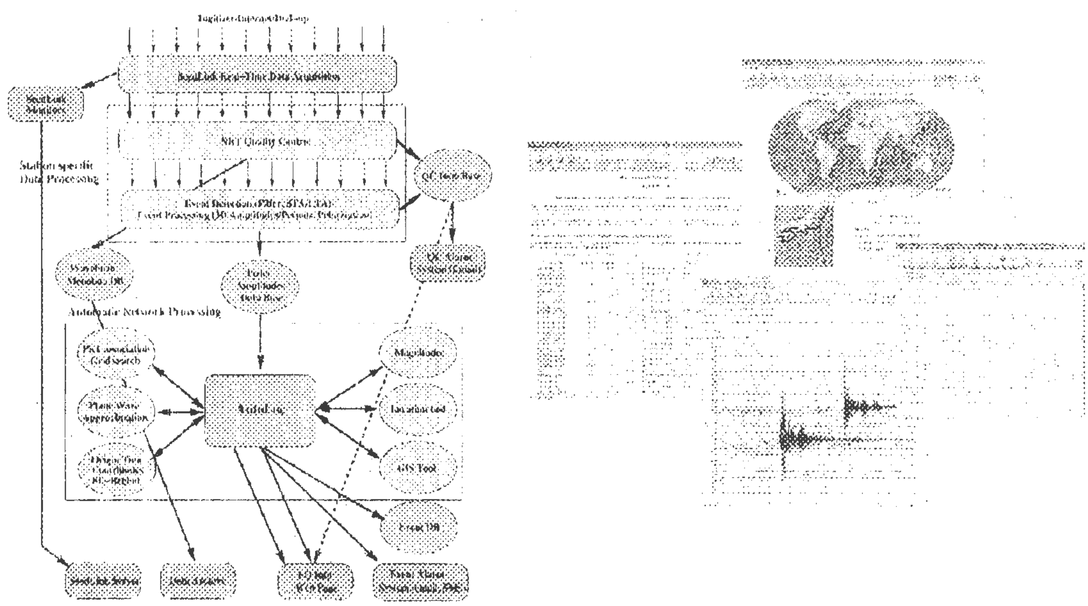


Figure 3. Data and information flow within the GEVN real-time data processing system and resulting Internet products.

The GEOFON Extended Virtual Network (GEVN) Earthquake Information System

Using these resources, real-time data streams from more than 250 foreign stations are presently acquired at the GFZ Seismological Data Center in parallel to those of the GEOFON itself forming the so-called GEOFON Extended Virtual Network (GEVN). Many stations are from GEOFON partner networks (mainly in Europe), where usually backup archiving at the GFZ Seismological Data Archive is the major issue. But also many additional global stations (namely from IRIS) and many stations from countries in the Indian Ocean area are used for global and regional earthquake monitoring purposes.

The near real-time data processing and its results is illustrated in Fig. 3. After performing quality control, the incoming single data traces are checked for seismic signals by automatic detectors and a variety of post detection algorithms. The individual event triggers are then associated to event related groups with a grid search method. Additional post-detection parameters like polarization angles, spectral characteristics and duration are determined to better classify questionable arrivals and to distinguish overlapping pick groups from parallel occuring events at different locations within the network. The precise hypocenter for the successfully associated and pre-located pick ensembles is finally determined by standard location programs (e.g. LocSAT). The obtained information is immediately distributed to registered users by email and SMS services and published on the GEOFON Internet page both in the "Seismic Monitor" (http://www.gfz-potsdam.de/geofon/seismon/globmon.html) and the online automatic bulletin (http://geofon.gfz-potsdam.de/db/eqinfo.php). A separate web page is generated for each event, where the arrival times and magnitudes for all stations are listed. All event pages are accessible from the Automatic Bulletin page. In the "Global Seismic Monitor" the epicenters of all larger earthquakes of the last two weeks are marked. The epicenter of the last bigger earthquake is blinking red. "Live" seismograms visualize recent earthquake activity at individual stations to the public (http://www.gfz-potsdam.de/geofon/gfn_liveseis.html). This system provides presently one of the fastest source of publicly available basic earthquake information on global and regional scale.

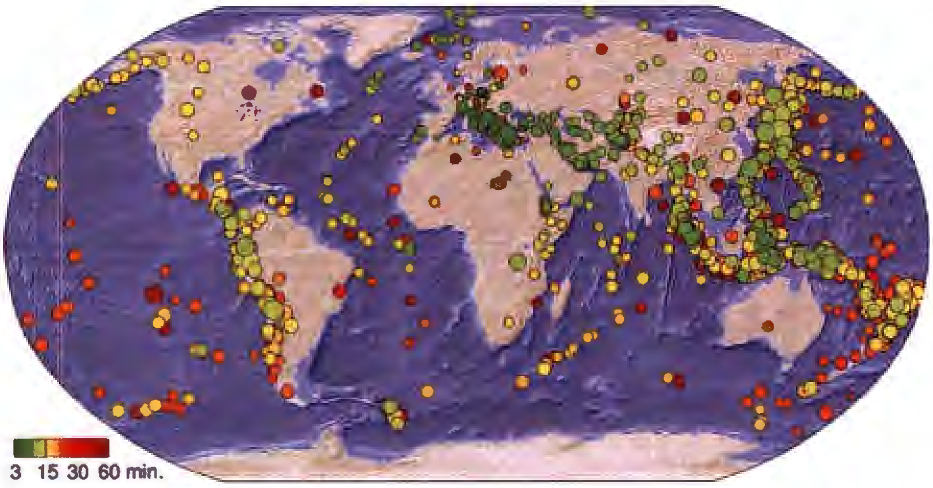


Figure 4: Global alert publication delay times of the GEVN Earthquake Information System in dependence of the geographical region.

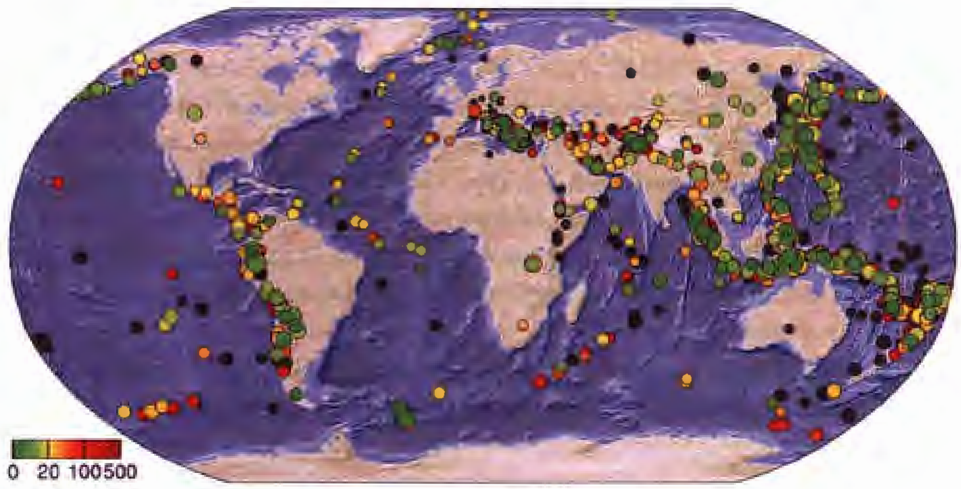


Figure 5: Global location accuracy (in km) for the GEVN Earthquake Information System in dependence of the geographical region and in comparison with NEIC.

In Fig. 4 the alert delay times are shown in dependence of the geographical region while in Fig. 5 the location performance of the system is illustrated in comparison to NEIC solutions. In both categories the system shows a very good performance for most parts of the world. The black dots in Fig. 5 indicate events not listed by NEIC. Some of them maybe not real events, but many of them are surely valid additional earthquakes locations.

The GFZ Seismological Data Center

The GFZ Seismological Data Center provides three basic services: the GEVN Earthquake Information Service, the GEVN SeedLink real-time data feed servic and the GFZ Seismological Archive. The two later ones are carried out in the ORFEUS distributed data center framework being presently setup within the NERIES EC project. In the GEVN SeedLink online data pool (near) real-time data from presently almost 30 worldwide partner networks are acquired parallel to the GEOFON network with in total more than 300 stations. In return, most of these partner networks obtain real-time GEOFON or other GEVN data feeds for their needs. Most of these data feeds are also available for other users. Therefore usually more than 40 institutions worldwide acquire GEOFON and other data in near real-time from the public GEVN SeedLink server (geofon.gfz-potsdam.de:18000).

The GFZ Seismological Data Archive holds all continuous data from the permanent GEOFON network as well as the data from most of the GEVN partner networks, for which it also serves as long-term backup data archive. However, the major part of the archive holdings (presently about 8 TB, the largest data archive in Europe) is data obtained from mobile seismic experiments with the GFZ instrument pool. Data from temporary networks is usually restricted to the project consortium for 2-3 years before it gets released for public use. Although most data sets are derived from broad band stations, also a substantial amount of short period data is archived as well as some strong motion and OBS data. All data is online available on large RAID disk arrays. Backup files of all data are in addition also stored online in a mirrored RAID system and offline in a large tape robot system in the GFZ Central

Computer Department. The data retrieval system is automatic, but queued. Request times therefore depend on the number of parallel requests. All data sets are accessible jointly in a unified way by a prototype web request formulation tool (http://www.gfz-potsdam.de/cgi-bin/geofon/request?mode=nform&nettype=perm) or by breq_fast email requests (breq_fast@gfz-potsdam.de). Within the NERIES project, GEOFON is responsible for the implementation of the European Integrated Data Archive (EIDA) as a de-centralized archival system which is more suitable for the situation in Europe than a centralized approach as e.g. at the IRIS DMC.

GEOFON and the Indian Ocean Tsunami Warning System

After the Sumatra earthquake on December 26 2004, the GEVN real-time processing system published the first reliable automatic solution 12 minutes after the rupture had started. At that time, the GEVN was still concentrated on the EuroMed area with no stations in the Indian Ocean area and the response time and location accuracy was not comparable to today. But nevertheless, the GEVN alert was most likely globally the first alert publicly available on the Internet, even 2 minutes before the first bulletin message of the Pacific Tsunami Warning Center was issued. 14 stations belonging to the IRIS, Kandilli (Turkey), NOA (Greece) and NEIP (Romania) and GEOFON networks contributed to this very first solution. However, the derived mb magnitude value of 7.0 underestimated the total size of the quake drastically (as happened at all other automatic systems as well). Therefore it was not suitable for tsunami warning. Nevertheless, the public interest in the GEVN earthquake monitoring system in the follow-up of the tsunami tragedy raised in Germany the idea of selecting GEOFON to establish the seismological component of the proposed German contribution to the Indian ocean Tsunami Early Warning System (GITEWS). This success is a direct result of the achievements in real-time data exchange within MEREDIAN, ORFEUS and FDSN the merits belong to the whole community.

Basis of the seismological component of the Indian Ocean TEWS should be a intensive cooperation among the countries in the area and the donor countries. All available resources should be combined and all recorded data should be shared in real-time. Negotiations in this direction are underway both on bilateral level and within the UNESCO IOC/IOTWS framework. GITEWS/GEOFON plays a major role in this. A number of new high quality broadband stations are already installed and more will follow in the next future. Within the German contribution to the IOTWS, up to 40 new GEOFON type stations with satellite communication are planned, of which more than half will be located in Indonesia. In addition, the planned coastal stations for water level and deformation monitoring (consisting of tide gauges and GPS) will be equipped with seismic strong motion sensors to minimize the time before the first seismic sensor detects a disastrous earthquake. In addition to the land based monitoring system, broadband ocean bottom sensors in connection with the sea floor pressure gauges are installed, which will be capable of transmitting selected data windows on internal or remote trigger. All data will be transmitted in real-time to the GITEWS control center in Jakarta and to GFZ. Other partner centers in the region will also obtain the data.

References

Buforn, E, A. Udias, J. Martin Dávila, W. Hanka and A. Pazos, 2002. Broad band stations network UCM/ROA/GFZ in South Spain and Northern Africa. *Seism. Res. Lett., Vol. 73, No. 2, 183 – 186.*

Hanka, W., 2000. Parameters which influence the very long-period performance of a seismological station: examples from the GEOFON network. *In: (P. Bormann and E. Bergman, editors) New Manual of Seismological Observatory Practise.*

Hanka, W., A. Heinloo and K.-H. Jäckel, 2003. Networked Seismographs: GEOFON Real-Time Data Distribution, *In: Proceedings of OHP/ION symposium "Long-Term Observations in the Oceans: Current Status and Perspectives for the Future", January 21 - 27, 2001, Workshop Report, 58 – 62.*

Hanka, W. , R. Kind, 1994. The GEOFON Program. *Annali di Geofisica, Vol. XXXVII, N5, Sept. 1060-1065.*

Van Eck, T., C. Trabant, B. Dost, W. Hanka, D. Giardini, 2004. Setting up a virtual Broadband Seismograph Network Across Europe. *EOS, Transactions, AGU, Vol. 85, No. 13, 125 – 129.*

ON LAND BROAD BAND "WESTERN MEDITERRANEAN" AND OCEAN BOTTOM "FOMAR" SEISMIC NETWORKS.

J. Martin Davila (1), A. Pazos (1), E. Buforn (2), A. Udias (2), W. Hanka (3), M. Benzzeghoud (4), M. Harnafi (5), A. Nadji (6), J. Prián (1), J. Quijano (1), J. A. Peña (1), J. Gallego (1) and G. Muñoz-Delgado (1)

(1) Real Instituto y Observatorio de la Armada, San Fernando, Spain. (mdavila@roa.es and pazos@roa.es)
(2) Departamento de Geofísica y Meteorología, Universidad Complutense, Madrid, Spain (ebufornp@fis.ucm.es)
(3) GeoforschungsZentrum, Potsdam, Germany. (hanka@gfz-potsdam.de)
(4) Physics Dpt., Universidad de Evora, Evora, Portugal (mourad@uevora.pt)
(5)Institut Scientifique, Université Mohammed V Agdal Rabat, Morroco (harnafi@israbat.ac.ma)
(6) Université d'Oran – Es Sénia, Oran, Algeria (amansour.l@yohoo.fr)

1. INTRODUCTION

The "Ibero-Maghrebian" region is a part of the Eurasia-Africa plate boundary, comprising the Southern part of the Iberian Peninsula, the Northwestern part of Africa, the Gulf of Cadiz and the Alboran sea. Its main geological settings are: The Iberian Massif, the Moroccan Meseta and Hauts Plateaux, forelands of the Betic, Rift and Tell mountain belts, and the Atlas cordillera (Buforn et al, 1995). The area is crossed by several main faults: Plasencia-Alentejo and Cadiz-Alicante (SW and S Iberian Peninsula), Trans Agadir-Nekor fault system (NW Africa) which links to Carboneras-Palomares (E Iberian Peninsula) across the Alboran Sea. The geodynamic behaviour of this zone shows a convergence between Iberia and Africa, with compression stresses in a NNW-SSE direction, with a differential motion at Alboran area. The Nuvel-1 plate motion model (Demets et al 1994) predicts for the area a continued NW-SE convergence of Eurasia and Africa at a rate of several mm/year.

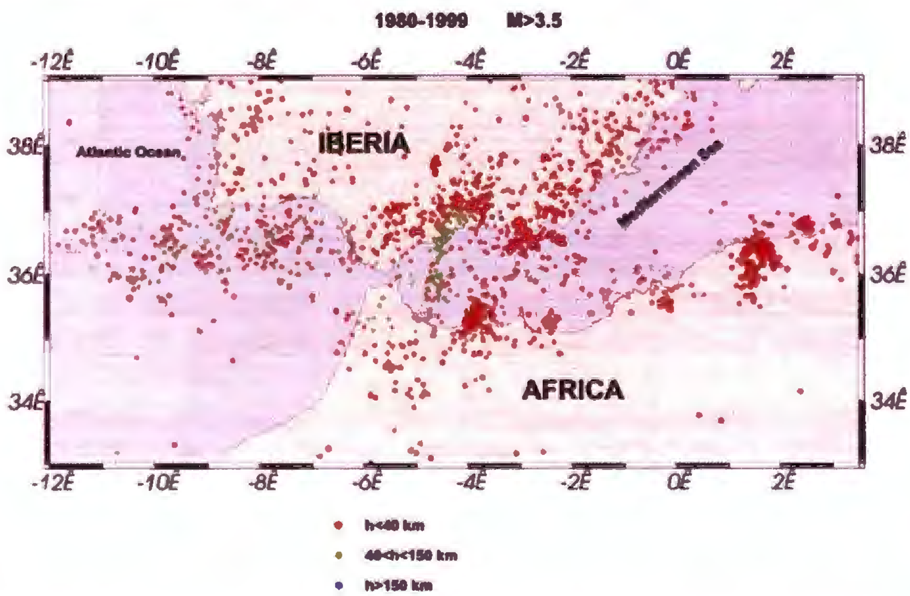


Figure 1: Distribution of earthquake epicenters on the Ibero-Maghrebian region, from IGN and ROA data files (1980-1999; mb ≥ 3.5).

The whole zone constitute a broad deformation area, without a well defined plate boundary line, with a moderate seismic activity of low to moderate magnitude and shallow depth earthquakes (h< 30 km). Nevertheless, big events are well documented: Lisbon (1755, I_0= X) and Gulf of Cadiz (1964, Ms= 6.4 and 1969, Ms= 8.1) on the West part, and Orán (1790, 1887, I_0= X), Asnam (1980, Ms= 7.1) and, more recently Bourmedes (2003, Mw= 7.1) on the East part, are good examples. Some then have produced tsunamis: Lisbon, Gulf of Cadiz and Bourmedes, among others. An intermediate seismic activity is also clearly registered from Gulf of Cadiz to the East (30<h<150 km), specially at 4° W, where a group of epicenters are clearly aligned on a N/S line, from Granada Basin to Moroccan coasts (figure 1). On the other hand, very deep earthquakes have also been registered at Granada basin (1954, M= 7.0).

To study the seismicity associated to this complex area, the Royal Naval Institute and Observatory in San Fernando (ROA) has deployed, since 1898, when a Milne type pendulum was installed at San Femando, different type of seismic stations. Nowadays ROA has three types of stations: Short and Long period (ROA) and Broad Band (deployed in collaboration with other institutions).

2. ROA LP SEISMIC STATION AND SP SEISMIC NET

Short Period net (SFS network) has been deployed from 1986 on in the vicinities of Gibraltar Strait (Martin Davila et al, 2001), in collaboration with Spanish IGN and SECEGSA state company. These are nine one/three components analog stations linked to ROA headquarters via radio UHF/VHF (figure 2). These stations are being upgraded, extending the sensor response up to 20 seconds (Pazos et al., 2005), and converting them to digital recording

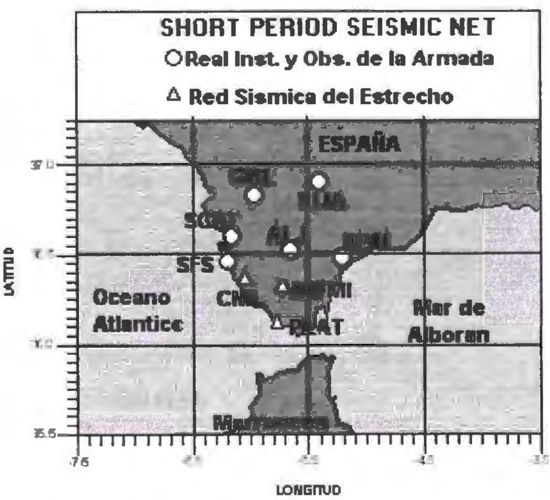


Figure 2: ROA Short Period seismic network.

On the other hand, since 1976 a three components Spregnether 5100 type Long period station, is installed on a pier located in a ROA tunnel.

3. "WESTERN MEDITERRANEAN" (WM) BROAD BAND SEISMIC NET

From 1996 on, ROA and the University Complutense of Madrid (UCM), together with the GeoforschungZentrum of Potsdam (GFZ), have deployed a broad band seismic net with stations located at Southern Spain and Spanish possessions located Northern Africa, mainly surrounding the Alboran sea. This net has been named as "Western Mediterranean net" (WM FDSN code) (Buforn et al., 2002), and, at present is formed by eight stations (figure 3) located at: San Fernando (SFS), Málaga (MALA) and Cartagena (CART) at Iberian peninsula, Mahón (MAHO) at Minorca island, and three more stations at Melilla (MELI), Peñón de Vélez-Gomera (PVLZ), and Ceuta (CEU), all them located Northern Africa. Most them are collocated with permanent geodetic GPS stations (Gárate et al, 2004). Evora University (Portugal) has contributed to the network with one station (UEVO) and it is planned that Institut Scientifique of Rabat (Université Mohammed V; Morocco) and Université d'Oran (Algeria) will associate to WM net new BB seismic stations.

WM network stations include the following instrumentation: Streckeisen STS-2 sensor, a high resolution data acquisition system Quanterra or Earth Data digitizer, a Seiscomp process system, based on an embedded PC with Linux operating system (Heinloo, 2004). SFS, MALA, CART, MAHO, MELI and UEVO data are available in real time trough telephone modem or/and Internet, and PVLZ and CEU data are downloaded periodically.

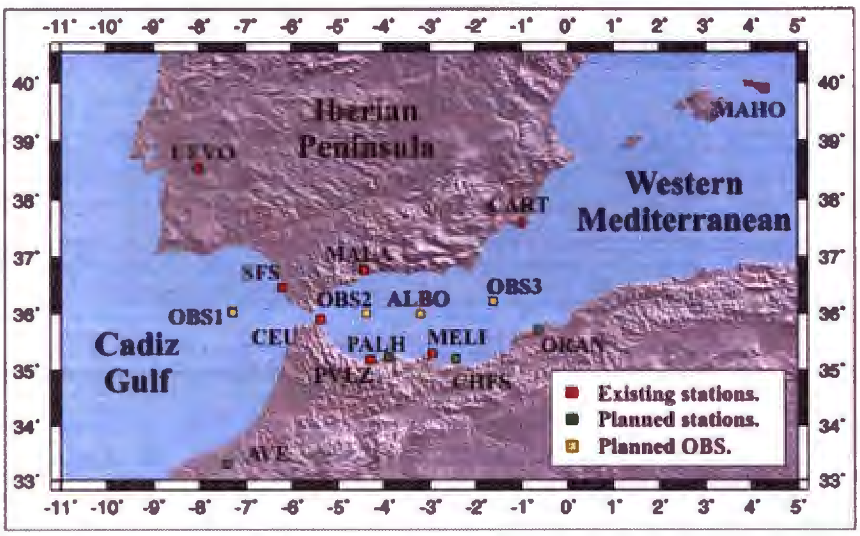


Figure 3: Western Mediterranean (WM) BB seismic network and next future OBS FOMAR network.

4. "FOMAR" OCEAN BOTTOM (OBS) SEISMIC NETWORK

Most of the seismic activity on figure 1 is located at marine areas. This situation, together with the low magnitude of the majority of events in the Ibero-Maghrebian region (Martin Davila and Pazos, 2003), the absence of BB seismic stations at some areas and the poor geographic azimuthal coverage, clearly indicates the necessity to deploy Ocean Bottom Seismometers (OBS) in the region, in order to acquire high quality seismic data which allow to study those earthquakes with marine epicentres. To remedy this situation ROA and UCM proposed two complementary initiatives to the Spanish Ministry of Education and Science (MEC) to acquire and deploy several OBS's in the Alboran sea and Gulf of Cadiz (Figure 3). These OBS will constitute the so called FOMAR network, (FOndo MARino: Ocean bottom). Both proposals have been approved recently by the Spanish Research Council (Ministerio de Educación y Ciencia) through the projects: RIOA05-23-002 (OBS Alboran) and CGL2005-24194-E (Red FOMAR). Under OBS ALBORAN project a permanent OBS will be deployed in the vicinities of Alborán island, linked to it via microwaves or underwater cable (to be decided after the seismic noise tests), in order to have the data available in real time. Under RED FOMAR project a semi-permanent deployment (figure 4) of three OBS will be carried out for, at least, a three year's period. Once finished, it will be decided to transform some them into permanent devices. Both deployments will be carried out with the support of the Spanish Navy, Institution to which ROA belongs, and will complement WM BB net. It's planned to start this deployment within 2006.

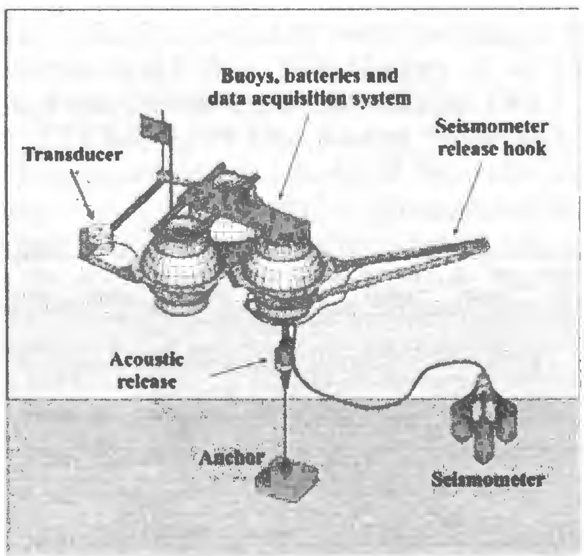


Figure 4: A temporary OBS deployment scheme (from Guralp Systems web page).

5. CONCLUSIONS

In order to study the seismicity associated to the Eurasia-Africa plate boundary at the Ibero-Maghrebiam region, ROA in collaboration with UCM and GFZ has deployed a Broad Band seismic (Western Mediterranean; WM) network, with stations installed at Southern Spain and Northern Africa region. University of Evora has installed also a BB station which has been associated to WM net, and it's planned that in the next future both the Université Mohammed V and the Université d'Oran will also associate stations to WM net.

In order to complement WM net, an Ocean Bottom OBS deployment at Gulf of Cadiz and Alboran sea (FOMAR net), including a permanent and three semi-permanent OBS is planned to be carried out starting on 2006.

6. ACKNOWLEDGEMENTS

This work has been partly funded by the Spanish Ministry of Education and Science (MEC) through the project REN2003-05178-C03-01/02 (ERSE), and through the above mentioned projects: RIOA05-23-002 (OBS ALBORAN), and CGL2005-24194-E (RED FOMAR).

7. BIBLIOGRAPHY

Buforn, E., Sanz de Galdeano, C. and Udias, A., 1995. Seismotectonics of the Ibero-Maghrebian region. Tectonophysics, 248: 247-261.

Buforn, E.; Udías, A.; Matín Davila, J.; Hanka, W.; and Pazos, A. (2002), Broadband station network ROA/UCM/GFZ in south Spain and northern Africa, Seismological Research Letters, 73, 2, 173-176

Demets, C., Gordon, R.G., Argus, D.F. and Stein, S., 1994: Effect of recent revisions to geomagnetic reversal time scale on estimate current plate motion. Geophys. Res. Lett., 21: 2191-2194.

Gárate, J.; Martín Davila, J.; y Berrocoso, M. (2004), Series temporales para las estaciones GPS del Observatorio de la Armada en San Fernando, Resúmenes, 4ª Asamblea Hispano-Portuguesa de Geodesia y Geofísica, Figueira da Foz, Portugal, 501-502.

Martín Davila, J., Gárate, J., Pazos, A., Udías, A., Berrocoso, M., Hanka, W., Buforn, E., Pérez, P., Prián, J., Quijano, J., Peña, J. A., Gallego, J., Muñoz- Delgado, G., Van der Lee, S. (2001): The Royal Naval Observatory in San Fernando (ROA) Seismic (SP, LP, VBB) and Geodetic (GPS) nets deployed South Spain- North Africa Region. In "Workshop on the Geodynamics of the Western Part of Eurasia - Africa Plate Boundary (Azores-Tunisia)".ROA Bulletin 03/2001.

Martín Davila, J and Pazos, A. (2003): Sismicidad del Golfo de Cádiz y zonas adyacentes. In: Sismicidad de la Península Ibérica. Física de la Tierra, 213-229.

Pazos,A.; Alguacil, G.; and Davila, J.M. (2005), A simple technique to extend the bandwidth of electromagnetic sensors, Bulletin of the Seismological Society of America, 95, 5, 1940-1946.

Seismic Monitoring Network

Abstract

By
Nacer Jabour and Youssef Timoulali

In the mid of the past century, four seismic stations were in operation in *Morocco (Ibn Rochd, Ifrane, Rabat Zair and Rabat ville). Later on, the moroccan network comprised 15 analog and autonomous seismic stations, run by the Départment* de Physique du Globe in Rabat.

In 1985, a new telemetred seismic network was set up by the Laboratoire de Géophysique of the National Scientific and Technical Research Center to provide near real time seismic data.

This seismic network is composed of several units:

- An acquisition system with A/D converter;
- An analog recording system on drums;
- 29 short period seismic sensors from which one of three components;
- 2 VBB stations in Midelt (CTBTO) and Rabat (MEDNET);
- 24 accelerographs from which two interconnected networks;
- 7 repeaters;
- 31 radio links UHF/VHF;
- 7 dedicated phone lines;
- 8 portable seismic stations from which 2 digital stations.

The installed seismographs are from Kinemetrics, SS1 sensors of short period type (1 Hz). These stations are essentially of vertical components. The recording is of high gain, 16 bit, 50 sps, the archiving in CDF (Common Data Format), the records analysis can be carried with SWS or other softwares.

Actually the network performance averages 50%, this low performance is due to the lack of spare parts. Some of the spare parts are actually not produced by the manufacturer.

The installed accelerographs are from Kinemetrics, SSA 1 model and SIG SM 1 model with digital recording. The accelerographs have a programmable threshold triggering with 1 g as a full scale, a natural frequency of 50 Hz and a 70% damping.

The data acquisition is done with a sampling frequency of 200 sps per channel and can be reduced by decimation. The three channels are (L,V,T). The resolution is 12 bits (dynamics of 72 db). The accelerographs can be operated with three modes: data acquisition. parametering and diagnosis.

The digital recording is done by triggering with the help of a detection programme based on the calculus of the mobile averages STA, LTA. The data storage is done by memory cards 512 Kb, approximately 20 minutes of continious recording of three channels with 200 sps per channel in compressed data mode.

The electricity supply, 12 VDC, is provided by internal batteries of lead dioxyde maintened in charge by 24 VAC (220/24 VAC transformer), the use of external batteries is also possible.

These accelerographs contain a RS232 outlet and can be connected to a computer, either directly or through a modem.

For the moment data transfer is done only from the VBB station (Med Net network) in Rabat to Roma via internet.

The VBB station in Midelt (part of the CTBTO network) started to send signals to Vienna, transmission for Rabat has some technical problems.

A seismic bullettin and a seismic catalogue are produced each month by the Institut National de Géophysique but these products are not widely distributed.

The Institut National de Géophysique is in the beginning process of implementing a new digital short period seismic network. Because of budget constrains, the project can take two to three years to be achieved.

Half of the stations are out of order or have bad performance. New digital stations will be installed in the future, new sites will be selected according to the transmission technique that will be implemented.

Table : Seismic stations and instrumentation

Code	Regist. at WDC (0)	Lat. (N)	Long. (E)	Elev. (m)	Station type (1)	Sensor type (2)	Recording equipment (3)	Data Transfer (4)	Recording (5)
	Y/N				3C LP	Kirnos	Drum recorder		A - C
					3C SP	LE-3D	MARS-88/MC		D - F
MDL	Y	32.817	355.386		3C BB	STS-2		RT sat.	D - C
RBA	Y	33.990	353.142	50	3C BB	STS-2		RT wire	D - C
ZER	Y	34.091	354.530	1118	1C SP	SS-1	Drum recorder	RT	D - F
RSA	Y	34.877	354.172	609	1C SP	SS-1	Drum recorder	RT	D - E
RTC	Y	33.990	353.142	50	1C SP	SS-1	Drum recorder	RT	D - E
TSY	Y	35.373	354.030		1C SP	SS-1	Drum recorder	RT	D - E
DKH	Y	35.488	354.637	1237	1C SP	SS-1	Drum recorder	RT	D - E
CPS	Y	35.791	354.090	326	1C SP	SS-1	Drum recorder	RT	D - E
BMD	Y	35.780	354.301	396	1C SP	SS-1	Drum recorder	RT	D - F
BIT	Y	35.648	354.271	60	1C SP	SS-1	Drum recorder	RT	D - F
DAL	N	35.900	354.519		1C SP	SS-1	Drum recorder	RT	D - E
TZC	Y	32.148	353.510	1700	1C SP	SS-1	Drum recorder	RT	D - F
TIS	Y	31.892	353.446	1687	1C SP	SS-1	Drum recorder	RT	D - E
KIB	Y	32.576	353.961		1C SP	SS-1	Drum recorder	RT	D - E
KHF	Y	32.983	354.293	1060	1C SP	SS-1	Drum recorder	RT	D - E
MIF	Y	33.409	354.771	2070	1C SP	SS-1	Drum recorder	RT	D - E
CIA	Y	31.565	351.241	437	1C SP	SS-1	Drum recorder	RT	D - E
OUK	Y	31.209	352.132	2720	1C SP	SS-1	Drum recorder	RT	D - E
JHA	Y	31.736	350.546	725	1C SP	SS-1	Drum recorder	RT	D - F
SOI	Y	31.169	350.383	900	1C SP	SS-1	Drum recorder	RT	D - E
BAM	Y	30.666	350.834		1C SP	SS-1	Drum recorder	RT	D - F
YBT	Y	29.848	350.515	140	1C SP	SS-1	Drum recorder	RT	D - E
CZD	Y	33.033	354.957	2356	3C SP	SS-1	Drum recorder	RT	D - E
TZK	Y	34.089	355.816	1980	1C SP	SS-1	Drum recorder	RT	D - E
TGT	Y	34.070	354.945	820	1C SP	SS-1	Drum recorder	RT	D - F
TNG	Y	31.416	354.444		1C SP	SS-1	Drum recorder	RT	D - E
ZAI	Y	34.970	357.254	750	1C SP	SS-1	Drum recorder	RT	D - F
BMK	Y	34.679	357.066	350	1C SP	SS-1	Drum recorder	RT	D - E
TOU	Y	34.962	356.246	1126	1C SP	SS-1	Drum recorder	RT	D - E
PAL	N	35.225	356.058	412	1C SP	SS-1	Drum recorder	RT	D - E
JBB	Y	35.013	355.802	1230	1C SP	SS-1	Drum recorder	RT	D - E
CGR	N	30.630	350.12		1C SP	SS-1	Drum recorder	RT	D - E
DKD	N	30.360	350.854		1C SP	SS-1	Drum recorder	RT	D - E
AOF	N	30.440	350.440		1C SP	SS-1	Drum recorder	RT	D - E
AFS	N	30.420	350.500		1C SP	SS-1	Drum recorder	RT	D - E
TNF	Y	32.530	354.681	2250	1C SP	SS-1	Drum recorder	RT	D - E
ZFT	Y	32.034	355.648	1800	1C SP	SS-1	Drum recorder	RT	D - E

(0) Y: Station code is registered at the World Data Centre (USGS/ISC)

(1) 1C – one component vertical seismometer; 3C – three component seismometer
SP – short period seismometer; BB – broad band seismometer; LP – long period seismometer

(2) e.g.,
STS-2 - Streckeisen broad band seismometer
LE-3D – Lennartz three directional 1Hz geophone
SS-1 – Kinemetrics 1Hz seismometer
Kirnos – 12 s long period seismometer

(3) e.g.,
MARS-88 – product of Lennartz electronic
SSR-1 and K2 – product of Kinemetrics Inc.
Drum recorder

(4) Transfer to the processing centre: R T: Real Time, RT wire, RT radio link, RT satellite

Dial-up; On site; A analogue; D - Digital

(5) A – analogue; D – digital; C – continuous recording; E – event recording

The personel is composed of 13 researchers from different fields and 12 technicians. Beside the seismic monitoring the Institut National de Géophysique carries site studies for large projects as dams where the majority of the strong motion instruments have been installed.

Nacer JABOUR,
Seismic monitoring service.
Institut National de Géophysique
CNRST, 52, bd Omar Ibn Khattab.BP 8027 – 10.102 Agdal.
Rabat. MOROCCO.
Tel: +212 37 77 86 74
Fax: + 212 37 77 86 78
Email: jabour@cnr.ac.ma

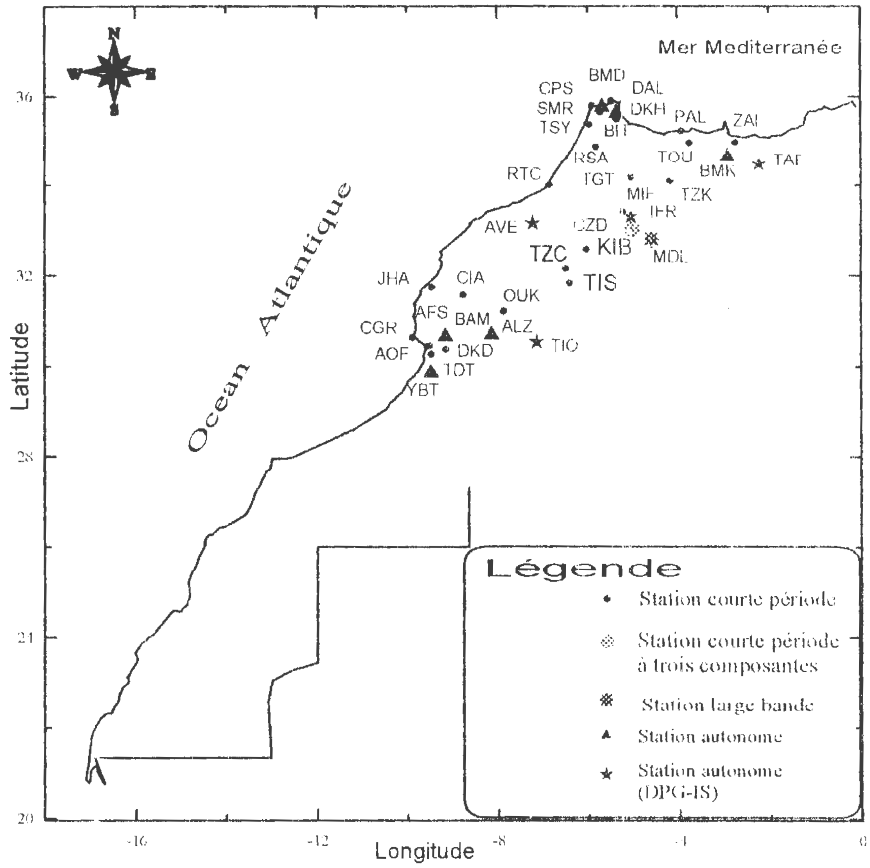


Fig 1:Moroccan seismic network

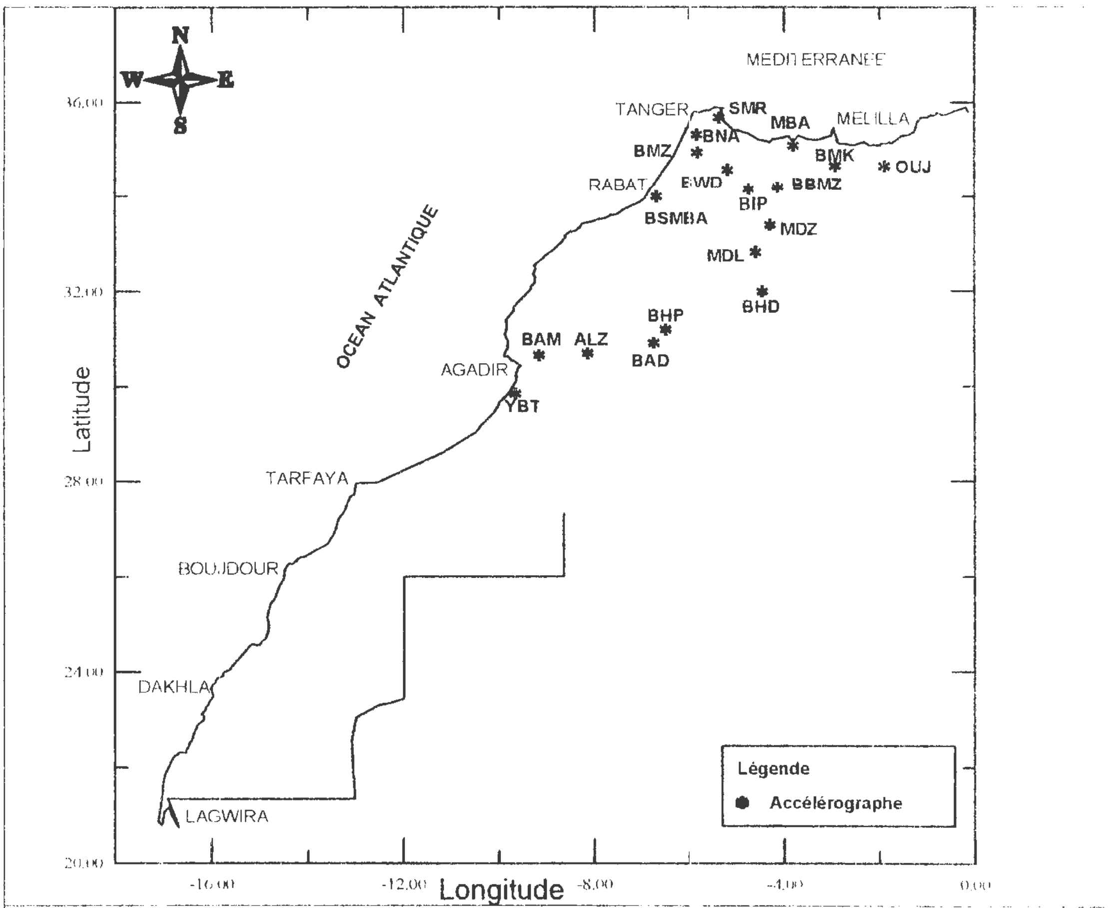


Fig 2:Moroccan accelerograph network

The 2004 Al Hoceima Earthquake : Seismotectonic and Seismic Risk Implications

ABSTRACT

By
Nacer Jabour and Youssef Timoulali

The on going study of the 2004 Al Hoceima Earthquake has brought new ideas to explain both the historical seismicity and the seismic behaviour of this Mediterranean tectonic province. According to the historical seismic catalogues many events in the past centuries took place in this part of northern Morocco in the way that we are observing instrumentally.

The occurrence of this major earthquake, Mw=6.4, ten years after the 1994 earthquake, Mw=6.0, has also significantly updated our knowledge about the seismic hazard in this region.

The traditional houses experienced more damage as this type of constructions has shown a high degree of vulnerability, partial or total collapse was observed even outside the epicentral area. An earthquake of this size may have an effective duration of shaking that weakened the old built structures.

The first analysis of the strong motion records obtained from the main shock, Amax=0.24g, has shown a clear site effect, an amplification is probably due to both the instrument shelter and the local topography. The ground strong motion recorded is a little bit higher than value given by the Moroccan building code RPS 2000 in Al Hoceima seismic zone.

In the city of Al Hoceima, located on a hard rock massif, very few buildings experienced slight damage. Southward from the epicentre, in the city of Imzouren, many new houses were heavily damaged especially those built on recent sediments. Other constructions were damaged merely because of the soft story effect.

Hundreds of land slides were triggered within a radius of 20 km from the epicenter. Rock falls were also extensively observed attesting the high degree of ground instability in the region of Al Hoceima.

The series of aftershocks that followed the 2004 seismic event covered a wide area around the epicentre with relatively less seismic shocks in the area struck by the 1994 event. The first aftershocks are in majority grouped near the Ajdir fault that has a north-south direction which is in agreement with the published focal mechanisms and the macro seismic surveys. The occurrence of great number of off-fault aftershocks shows also the intense fracturation and the heterogeneity of the geological structures.

A unilateral rupture to the SSW can be hold as a general pattern of this earthquake. The segmentation of the fault that did not break the surface that suggests a complex left lateral faulting can also fit with the general pattern already observed in some micro seismic surveys.

Finally, the 2004 seismic event can be regarded as an intermediate phase in a long sequence of earthquakes that their eastward migration may reach gradually the eastern side of the Nekor basin where other faults may be dislocated. The Trougout fault, within this scenario, can be seen as a future source candidate. This fault, which is likely more coherent, has an off-shore extention as mentioned in other studies, the total length of this structure may reach 40 km hence containing a potential of a magnitude 7 earthquake.

E mail: jabour@cnrst.ma

References:

El Mrabet T., Jabour N. ; (1997), ''Historical Seismicity of Al-Hoceima Region'' Journal of the European Soceity XXII General Assembly, Vienna, Austria, April, 1997.

Calvert A., Gomez F, Seber D, Barazangi M., Jabour N., Iben Brahim A., and Denmati A. ; (1997) : An Integrated Geophysical Investigation of Recent Seismicity in the Al-Hoceima Region of North Morocco., Bullletin of the Seismological Soceity of America, vol.87, N°3, pp.637-651, June 1997.

Calvert A., Sandvol E., Seber D., Barazangi M., Mourabit T., Mourabit T, Vidal F., Alguacil G. Jabour N. ; (1998) ; Velocity Tomography Constraints on Geodynamics Models for the Alboran Region of the Western Mediterranean., Submitted for Spring 1998 AGU Meeting in Boston.

Ait Brahim Lahcen, Nakhcha Chafik, Tadili Benaissa, El Mrabet A., Jabour Nacer. (2004). Structural analysis and interpretation of the surface deformations of the February 24th , Al Hoceima earthquake. csem-emsc NewsLetter; N°21.

Jabour, N., Kasmi, M., Menzhi, M., Birouk, A., Hni, L., Hahou, Y., Timoulali, Y., Bedrane, S (2004): "*The Février 24th, 2004 Al Hoceima earthquake*", Newsletter of European-Mediterranean Seismological Centre, N° 21, ISSN: 1607-1980.

Z. Cakir, M. M. Meghraoui, A. Akoglu, N. Jabour, S. Belabbes, L. Ait-Brahim, (2005) : Surface deformation associated with the Al Hoceima (Morocco) earthquake (Mw 6.4, 24/02/2004) deduced from InSAR: implications for the active tectonics along North Africa. Submitted to Geophysical Research Abstracts.

Abdelali F., Vernant P., McClusky S., Reilinger R., Gomez F., Ben Sari D., Mourabit T., Feigl K., Baraazangi M., (2006): Active Tectonics of the western Mediterranean: Geodetic evidence for roll back of a delaminated subcintinental lithosphere slab beneath th Rif Mountains, Morocco. Submitted toJournal :GEOL: Geology.

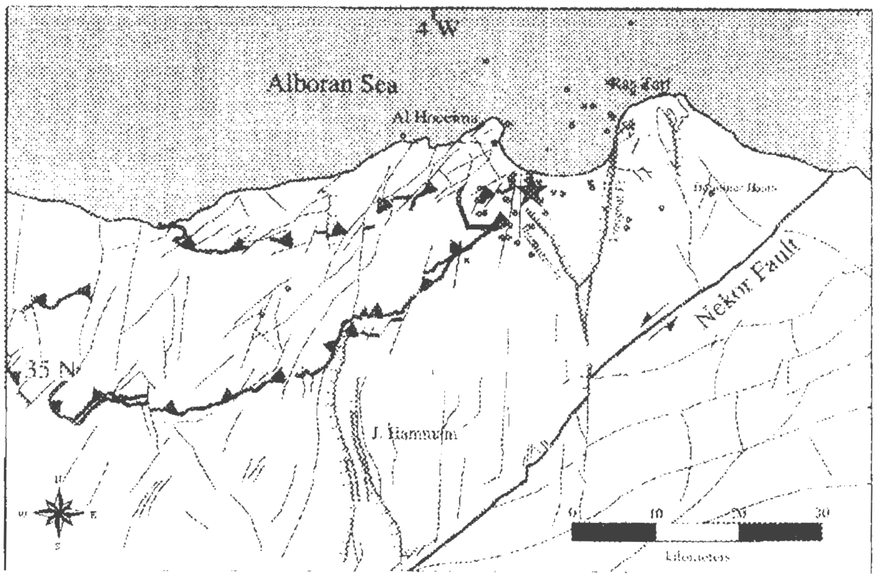


Fig 1: One hour of aftershocks activity, M>3, with major faults mapped. February, 2004 main shock is represented with a star.

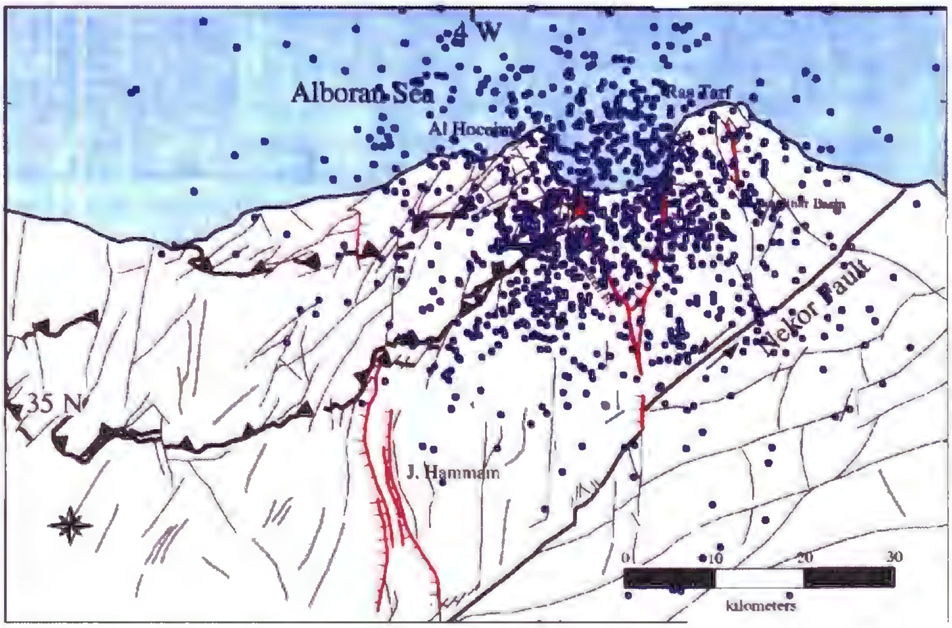


Fig 2: One year of aftershock activity with major faults mapped, February, 2004 main shock is represented with a star.

MEDNET ACTIVITIES AND PLANS

SALVATORE MAZZA, M. OLIVIERI, A. MANDIELLO, P.CASALE
Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata, 605, 00143 Roma, Italy

Abstract. The Mediterrean Network (MedNet) presently comprises 22 operating broadband seismic stations installed and maintained in cooperation with 13 geophysical institutions in Italy and in most of the countries facing the Mediterranean Sea. All the stations are equipped with Quanterra digitizers and Streckeisen sensors, mostly STS2 with a few STS1.

Aim of the network is to contribute to monitoring of one of the most active seismic regions of the World in terms of providing high quality real-time broadband data to the seismological community. TCP connections provide real-time data collection over the whole network. This important technological upgrade allows a prompt contribution to the seismic monitoring of Italy and of most countries bordering the Mediterranean Sea, since data are exchanged in real-time with other seismological observatories. SeedLink protocol has been adopted for transmission.

As for data archiving and distribution, continuous data streams are stored at the MedNet Data Center and are directly available at users' request by the standard AutoDRM and NetDC protocols (in GSE and SEED formats respectively). Station metadata and continuous waveforms are archived in a MySQL database on RAID systems and backed up on DLT tapes. Presently, fully automatic network functions include: daily monitoring of state of health; triggered retrieval of event waveforms (with magnitude- and region- specific selection criteria), local and surface wave magnitude determination, and update of web pages (http://mednet.ingv.it) for events and station information. Rapid semiautomatic moment tensor solutions are calculated by means of a modified Harvard technique, which lowers the Mw threshold down to 4.5 for regional events in those areas with proper station coverage.

The seismic network of Tunisia

Attafi Khereddine (1), Moncef Rajhi (1)
(1) Institut National de la Météorologie, Tunisia.
attafi@meteo.tn /Fax: (216) 71 772 609

The seismicity of Tunisia has remained not well understood during the last decades. One of the major lacks in seismological data could be explained by the inexistence of seismic network for monitoring local earthquakes. Three major periods could characterize the evolution of seismic instrumentation history in Tunisia: Until 1922, during which seismic events were reported in several and different manuscripts. The period till 1976, where data were recorded by a MAINKA mechanical seismometer and from 1976 up to now, a period during which the Tunisian seismic network has been largely upgraded with three stages of development. The first stage started with the installation of three telemetred analogic stations around the capital Tunis. The second stage started in 1989, and then, fourteen analogic seismological stations were installed to cover the major active regions of the territory. This network has been installed in the frame of the project PAMERAR for seismic risk reduction and finally, the third stage, with the increasing of the number of seismological stations by the installation of five digital instruments to cover the central part of Tunisia and realized in the frame of the cooperation between INM (Tunisia) and JICA (Japan).

Data exchange with other seismological agencies was not fully developed. The rising of new needs, opportunities for new collaboration to monitor seismicity in the neighboring areas with the purpose of the reduction of earthquake losses and the use of technology older than 1970 leaded to think toward a new system for seismic alert at the scale of the national level in on hand, and to satisfy requirement for data exchange in real time by providing earthquake parameters to other agencies, in the other hand. A new protocol of cooperation between INM (Tunisia) and Monaco (France) is signed to undergo the progress of the technology in the field of seismology by sharing the how know. The main purpose is the initiation of the renovation of the existing seismic network for monitoring local seismicity and the transition to the digital world. The new infrastructure could facilitate a best contribution and a deep collaboration in data exchange with other agencies and to participate in other fields in the seismic risk and seismic hazard.

In this paper, the seismic network is detailed from remote station with the main components to the national center where data are collected and archived. Two kinds of equipment constitute the network: Analogic and digital components.

Seismological Observations at the Scientific Institute-Morocco

Abdelkrim RIMI, Benaïssa TADILI, Mimoun HARNAFI & Ahmed EL HASSANI.

Department of Earth's Physics
Scientific Institute
Ibn Battouta Avenue, B.P. 703 Rabat
10106 Morocco

Abstract
Because of the privileged geographical position of Morocco, its seismic activity has been of first-rate importance in the geodynamical studies and the assessment the seismic risk over the Ibero-Maghrebian region as well.

HISTORIC INSIGHT

Since 1933 the attributions as research in seismology of the Section of Earth's Physics and Meteorology (S.P.G.M.) of Scientific Institute (I.S.C.) were fixed.
In 1937, the first seismological station in Morocco was installed at Ibn Rochd observatory of (Averroès). In the middle of the Seventies, deep seismic soundings and studies of microsismicity began. In 1981, the number of the stations of the national seismological network passed from two in 1964 to fourteen. It was regarded as the 1st in the Arab world and the 2nd in Africa.

MAIN ACTIVITIES

1) Observatory work

a) Design and maintenance of the seismological network for the monitoring of the seismic activity over the territory.
b) Data-gathering provided by the seismological network, their interpretation and diffusion of the results in the form of catalogues, bulletins and seismicity maps. However the diffusion of seismological information in the form of weekly, monthly and annual paper bulletins has been stopped since 1990, but the data has been sent regularly to the CSEM.
c) Field intervention, in the event of major earthquake, for the recording of the aftershocks and the macroseismic investigation;

2) Research Activities

Seismic risk assessment: the research tasks undertaken by the researchers of the DPG relate to seismology, seismic zoning and signal processing. Some lie within the scope of conventions with public, semi-public or private organizations; others are led in collaboration with Moroccan and foreign university institutions.

3) Earthquakes Databases

The macroseismic seismological data (since 1913) and instrumental (since 1937) constitute an inheritance of constant increase. These databases are of capital importance for the research tasks in seismology and seismic hazard.

HUMAN RESOURCES

The present day staff of DPG is composed of 7 researchers, and 8 technicians of which 4 work at the observatories.

DIFFICULTIES

Since 1984, real difficulties of the Earth's Physics Department started.
1-the geophysical data being very expensive, the majority of research work were made within the framework of international co-operations (in the seventies and eighties) deep seismic refraction profiles across the Atlas and Rif (French, Spanish and German co-operation)
2- as for as the equipment, we cannot get the spare parts for the (MEQ 800) portable seismic stations, therefore it has been very difficult to intervene after an earthquake to record the aftershocks
3-three new digital seismic stations are acquired and just two installed at Averroes and Ifrane observatories but that Tiouine is still not installed because that observatory is not yet connected to the national electrical network.
4- Tough the good quality of the Aouint Torkoz (AINTZ) observatory in southern Morocco (see location in the figure 1), we had stopped it because it is very far from Rabat.
6- We have a real need of observatory technicians: only one at the Tiouine observatory, and one at the Ifrane observatory

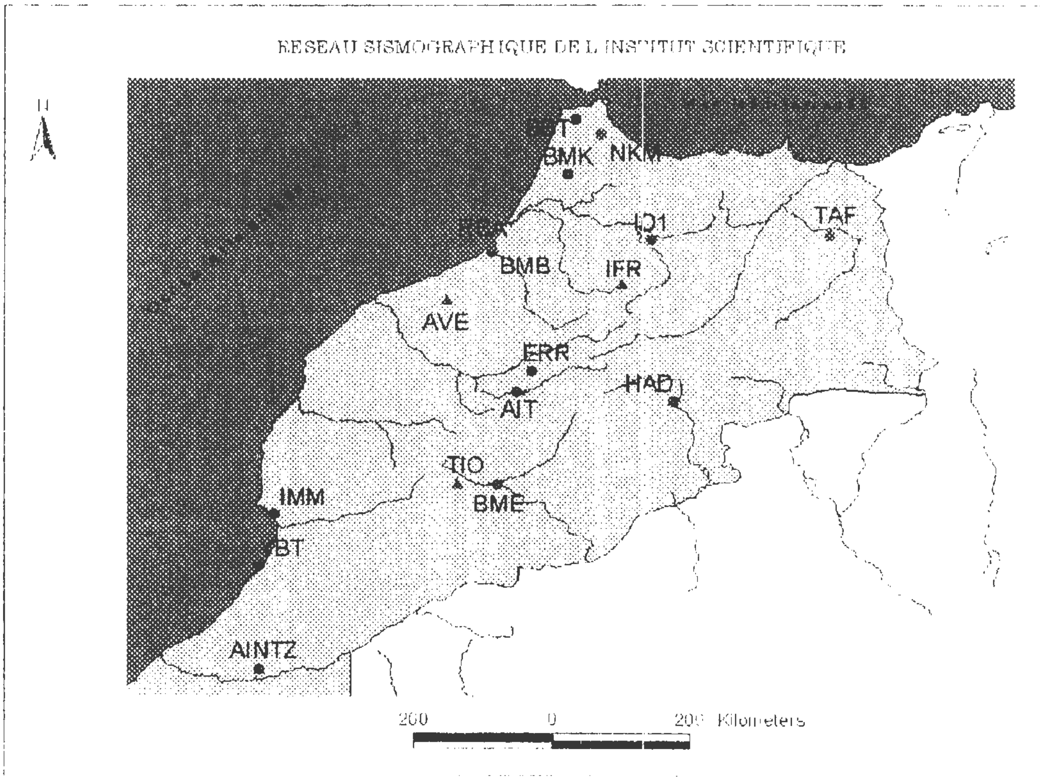


Figure 1: Seismological Network in northern Morocco, green circle inndicates station still operating while red circle indicates stopped station, green triangles are oobservatories of the Scientific Institute. The dates in the left square correspond to the starting of the stations recording.

FUTUR PLANS

1- Giving back to Averroes observatory its previous fame by the installation of a Broad Band seismological station, connecting it to the worldwide seismological network (Internet), and developing geomagnetic observations just renewed three years ago.
2- Developing the seismological network by the installation of Broad Band seismological stations thanks to international co-operations and accelerometers already ordered for studying ground movements.
3- Connecting Tiouine observatory to the electric network.
4- Reinstalling the seismological station in the Aouint Torkoz
5- Carrying on a good cooperation with Moroccan institutions to exchange seismological data (Universities and CNRST). The successful recent reoccupation of the HAD station (figure 1) using a digital station of Faculty of Sciences and Techniques of Errachidia is a good example.
6- Studies of microseismic zoning, Application and update of the paraseismic construction code.
7- The Moroccan earthquakes file, stopped in 1985, is to be updated; some studies are on going to homogenize such a file with those of neighbouring regions.

REAL-TIME REGIONAL ALERT SYSTEM BASED ON VSAT PLATFORMS IN CATALONIA (SPAIN)

A.Roca (1), X. Goula (1), C. Olivera(1), T. Susagna(1), S. Figueras(1), J. Irizarry(1) and N. Romeu(2)

(1)Institut Geològic de Catalunya, Barcelona, Spain.(2)RSE, Aplicaciones Territoriales SA, Barcelona, Spain.
colivera@icc.es

ABSTRACT

The emergency plans include various levels of intervention depending on the severity of the event in order to have ready the adequate amount of resources. The early warnings based on rapid detection provided by seismic networks activate the emergency plans, when needed.
A real time system based on a VSAT seismic network has been developed and is now operational in Catalonia (Spain). The system generates a SMS message informing of the location and magnitude of the earthquake event. The automatic generation of a seismic risk scenario based on vulnerability assessment methodologies, using GIS techniques has already been developed and now is being implemented and tested.

INTRODUCTION

The main objective for simulating damage scenarios is to have, in case of earthquake, a quick evaluation of the possible intensities felt in each municipality of the region, the possible number of people that could have felt the earthquake with several intensities and the affected area for each intensity. If the earthquake has an intensity high enough to produce damages, the method gives an estimation of building damages to, human casualties and economic losses.
This damage scenarios simulation becomes an useful, simple and quick tool for civil protection for the preparation and activation of the emergency plans. A Geographical Information System (GIS) is used to visualize the results together with different information layers.
These scenarios give a first forecast, in conjunction with a VSAT based real time seismological network, immediately after occurring an earthquake.
This presentation has been prepared for the EERWEM Meeting on June, 2006 in San Fernando (Spain). It constitutes a synthesis of different contributions presented at Lisbon (Goula et al., 2005) and San Francisco (Roca et al., 2006) for the anniversaries of the Lisbon, 1755 and the California, 1906 earthquakes. It presents the new developments for real time seismology and earthquake risk based on the VSAT regional seismic network of Catalonia (Spain).

VSAT SEISMIC NETWORK

In 1996 a new concept of seismic network was designed and planned in order to fulfil two main objectives:

i) to provide rapid information for Civil Defense services and society in general and
ii) to obtain systematically high quality data for the scientific community.

It is planned to create robust, high performance field infrastructures and install up to 20 stations equipped with three component broadband sensors and a high dynamic range. The stations are based on VSAT platforms sending continuous almost real time seismic data via satellite to the Hub at the processing center of the Institut Cartogràfic de Catalunya (ICC).
Data are continuously stored and processed with an automatic location system. After validation by seismologists information is disseminated via Internet.
A detailed description of the network can be found in Goula et al. (2001).
At the present time (May, 2006), 10 fields stations are operative, with STS-2 and Guralp CMG-3T sensors together with the reception and processing center (See Figure 1). One OBS station (#20) is also operative in front of the Tarragona Coast, not yet branched to the VSAT network (Frontera et al., 2006). Five more stations (# 11 to 15 in Figure 1) are under construction. One more station is planned in Andorra ((# 16) in Figure 1) and three more stations are under construction (# 17 to 19 in Figure 1), in the South of France (Interreg III a, ISARD Project). They will be equipped with Kinemetrics accelerometer episensors. All the stations will be operational at the end of 2006.

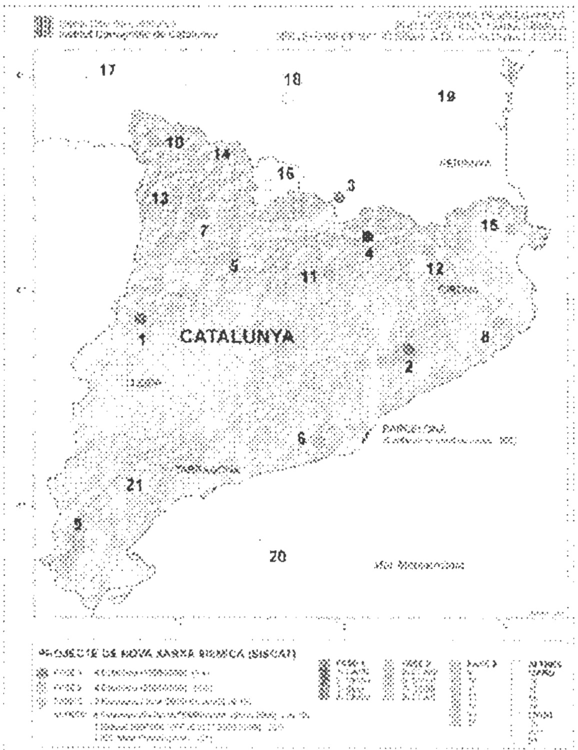


Fig. 1. Map of situation of BroadBand stations of the VSAT Network

A view of Bruguera Station in the Pyrenees (# 4 in Figure 1) with the seismometer vault, the instrumental house, the solar cells and the VSAT antenna is shown in Figure 2. All stations are provided with high performance electrical and environmental protections.
Data transmission from field stations to the central HUB placed at the ICC facilities in Barcelona is continuous and in quasi real-time, via the satellite HISPASAT- 1D and using VSAT (*Very Small Aperture Terminal*) platforms. A scheme of data transmission is joint in Figure 3 and a view of the reception antenna is shown in figure 4.

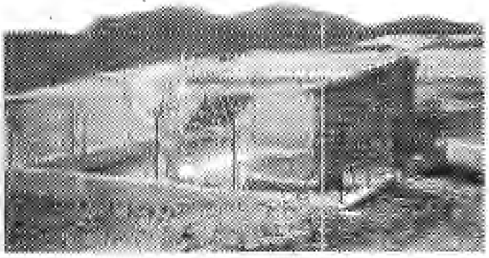


Fig. 2. View of VSAT- Bruguera Station

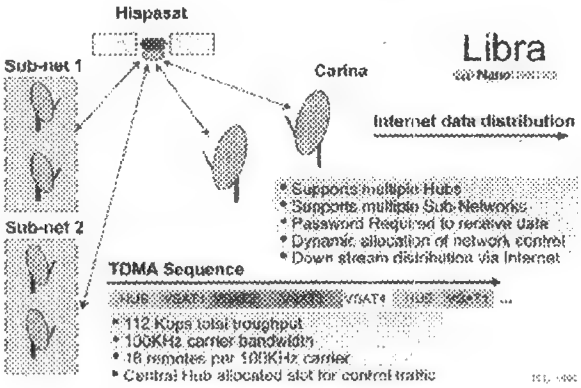


Fig. 3. Scheme of seismic data transmission

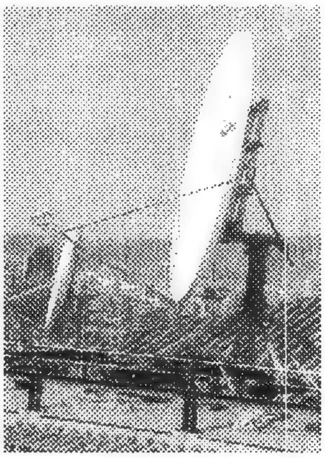


Fig. 4. View of the reception antenna installed in the ICC building

Real Time Alert System

At the central site, an acquisition computer stores the seismic data into ringbuffers with a capacity of 16 days of data using NAQS Server software. NAQS Server software is a primary software element for data acquisition and seismic data handling.
At present, seismic data and triggers are automatically processed by a Data Analysis Computer, which performs the automatic event detection, and determinates the hypocenter and the magnitude of the earthquake. A complete documentation of the event location is automatically generated.
This automatic process will be substituted by an Earthworm based system (USGS, 2005), developed by RSE S.A. (Romeu et al., 2006), in order to generate triggers, to detect events, and to determinate location and magnitudes of events quickly with great accuracy.
When an event occurs and it is located the alert system sends an SMS message to a distribution list (Figure 5). According with the configuration parameters the distribution list can be different depending of the event characteristics. Alert system reports when one message is delivered and when it is stored at the Message Service Center. The latent period of the alert message is between 2 and 3 minutes since the event detection. The information sent in the alert message is:

–Header
–Origin time (UTC)
–Magnitude (ML)
–Hypocenter location (lat, long, depth)
–Location error (RMS)
–Number of stations witch have detected it
–Nearest station which has detected it
–Distance between the epicenter and the nearest station (Km)
-Level of Emergency depending on the magnitude and location.

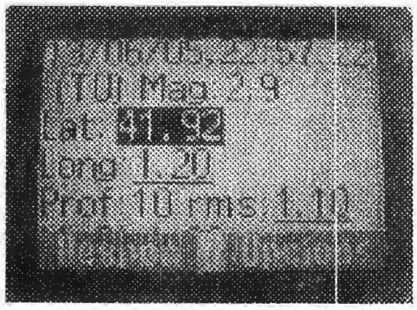


Fig. 5: View of the SMS message

Damage scenario mapping

A methodology has been proposed to generate damage scenarios that give an estimation of the possible effects of a given earthquake for the preparation of emergencies. The method can also be used to give a first damage estimation, immediately after the occurrence of an earthquake.
Another application of the methodology is the zonation of the territory in order to establish the criteria for activation of different levels of the earthquake emergency plan according to the severity of the estimated consequences of the events.

The methodology consists of three steps:
1) Estimation of epicentral intensity.
Once the epicenter depth and magnitude of the earthquake has been determined by the Real Time Alert System, it is possible to estimate the epicentral intensity from a correlation between magnitudes and intensities felt by the population.
2) Intensity attributed to each municipality.
It is necessary to adopt a law of attenuation of the intensity versus the distance. The relationship used for Catalonia has been fitted to the intensity data points contained in the database of felt earthquakes.
3) Estimation of building damage, assessment of the human casualties and evaluation of economic losses. In the case of intensities greater than V these computations are carried out following the methodology developed by Susagna et al. (2006) and Roca et al. (2006). The number of uninhabitable buildings, the number of homeless, and the damages to the people are also computed. Data on building occupancy (inhabitants / building) for each municipality and average surface of the houses are used. The economic losses produced by the damage to the buildings are estimated and, finally, are expressed in terms of the Gross National Product (GNP). The surface that could be covered by debris is also estimated.
A Geographical Information System (GIS) was used to develop an application - *ESCENARIS V1.00* (RSE, 2003) - to visualize the results together with different information layers. An example of a scenario map and list of municipalities is shown in Figure 6.

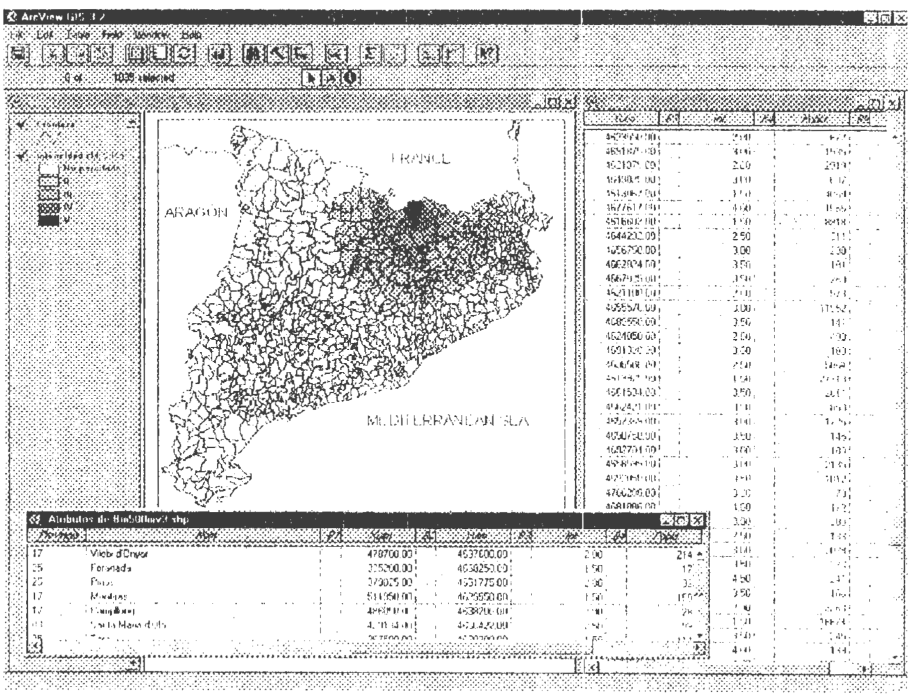


Fig. 6. Example of a scenario map with the list of municipalities for an earthquake of M=4.0 in the Pyrenees

This procedure is now being implemented in connection with the real-time VSAT transmissions based seismic network of the ICC to provide the Civil Protection authority with fast and complete information to activate adequate levels of the Seismic Activation Plan.

REFERENCES

Goula, X., Jara, J.A., Susagna, T. and Roca, A. (2001). A new Broad-Band Seismic Network with satellite Transmission in Catalonia (Spain). In: Observatories and Research Facilities for European Seismology, ORFEUS Newsletter, vol.3, nº1.

Goula, X., Susagna, T., Irizarry, J. and Romeu. N (2005).Generation of automatic seismic risk scenarios in Catalonia. *250 th Anniversary of the 1755 Lisbon earthquake*. Lisbon, 1-4 November, 2005.

Frontera, T., Jara, J.A., Goula, X., Ugalde, A. and Olivera, C. (2006). Instalación y primeros resultados de un sismómetro de fondo marino, permanente, en la zona costera de Tarragona. 5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica, Sevilla, Febrero 2006.

RSE, (2003). *Manual d'utilització del programa de càlcul i representació d'escenaris de danys*, Internal Report, Institut Cartogràfic de Catalunya, Barcelona, 56 p.

Roca, A., Goula, X., Susagna, T., Chávez, J., González M. and Reinoso, E. (2006). A simplified method for vulnerability assessment of dwelling buildings and estimation of damage scenarios in Catalonia, *Bulletin of Earthquake Engineering*. (in press).

Roca, A., Susagna, T., Goula, X., Romeu, N., Irizarry, J., Olivera, C., Figueras, S., Fleta, J. and Gasulla, N. (2006). A Contribution to Seismic Prevention in Catalonia (Spain) 100 *th Anniversary Earthquake Conference Commemorating the 1906 San Francisco Earthquake. San Francisco*, 18 - 22 April 2006, California.

Romeu, N., Jara, J. A., Goula, X., Susagna, T., Figueras, S., Olivera, C. and Roca, A. (2006). Sistema Automático de Información Sísmica, 5ª Asamblea Hispano Portuguesa de Geodesia y Geofísica, Sevilla, Febrero 2006.

Susagna, T., Goula, X., Roca, A., Pujades, L., Gasulla, N. and Palma, J.J.(2006). Loss scenarios for regional emergency plans: application to Catalonia, Spain. In: C. S. Oliveira, A. Roca and X. Goula, (Editors). *Assessing and Managing Earthquake Risk, pp 463 - 478*, Springer.

USGS (2005). Earthworm Documentation Release 6.2, in http://folkworm.ceri. memphis.edu / ew-doc/.

The Unesco Tsunami Warning and Mitigation System.

F. Schindelé
CEA-DASE, National representative of France and Past Chairman of ICG/PTWS

The Intergovernmental Oceanographic Commission of Unesco is mandated to co-ordinate the implementation of the Tsunami waming systems in the main different basins that have been impacted by tsunamis, the Pacific Ocean, the Indian Ocean, the Caribbean region and the Mediterranean and North-East Atlantic and connected seas.

The Pacific Tsunami Waming System PTWS is an international programme for coordination of tsunami waming and mitigation activities in the Pacific. Administratively, participating nations are organized under the IOC as the ICG/PTWS with the ITIC acting as the PTWS Secretariat and the PTWC acting as the operational headquarters for tsunami waming. Among the most important activities of the PTWS is the detection and location of major earthquakes in the Pacific region, the determination of whether they have generated tsunamis, and the provision of timely and effective tsunami information and wamings to coastal communities in the Pacific to minimize the hazards of tsunamis, especially to human life and welfare. To achieve this objective requires the national participation and contribution of many seismic, sea level, communication, and dissemination facilities throughout the Pacific Region.

The experience in the Pacific is shared in all the other regions to implement the tsunami waming systems in the three other regions. The contribution and sharing of seismic data from the seismic network is one of the backbone of the system.

LOCAL EARTHQUAKE TOMOGRAPHY FOR UNDERSTANDING COMPLEX EARTHQUAKE ACTIVITY IN AL HOCEIMA REGION (NORTHERN MOROCCO)

Y. Timoulali (1), N. Jabour, (1), M. Menzhi (1), R. Merrouch (1), Y. Hahou (1)
(1) Centre National pour la Recherche Scientifique et Technique
timoulali@cnrst.ma/ Fax 2123778678

The occurrence of the magnitude 6.4 northern Morocco earthquake, followed by several aftershocks has offered an excellent opportunity for investigating the local velocity structure using the techniques of local earthquake tomography.
The seismic tomography is used in order to understand the complex earthquake activity in northern Morocco (figure1). First, we found the minimal 1-D velocity model and, then, we used simultaneous relocations of hypocenters (figure 2a,b) and, finally, we determined a detailed three-dimensional P wave velocity structure of the crust beneath Al Hoceima region (figure 3). The tomography inversion is perfomed along with resolution criterea, two candidate statistcs are used to assess parameter resolution; spread function of the averaging vector and derivative weight sum.
The result of local earthquake tomography indicates significant P velocity anomalies in this region. A significant low P velocity at 5 Km depth in the Nekor fault region and also in the western side of Al Hoceima city. The low P velocity can be interpreted as a fault gouge.
A high P velocity at 15 Km depth in the Nekor fault region and at the north-western part of the Nekor fault regiion is also observed. The high velocity indicates that the Nekor fault may be active at this depth even it did not show a detectable seismic activity in recent times.
Many tomographic anomalies are observed elsewhere but it is difficult to correlate them with particular geological features. More seismic stations are in this case necessary to improve the tomographic study especially in central Rif region .
Finally the tomography analysis in the Al Hoceima region shows the geodynamic process linked to the Africa-Eurasia plate boundary. However, GPS survey is necessary to determine the plates boundary precisely.

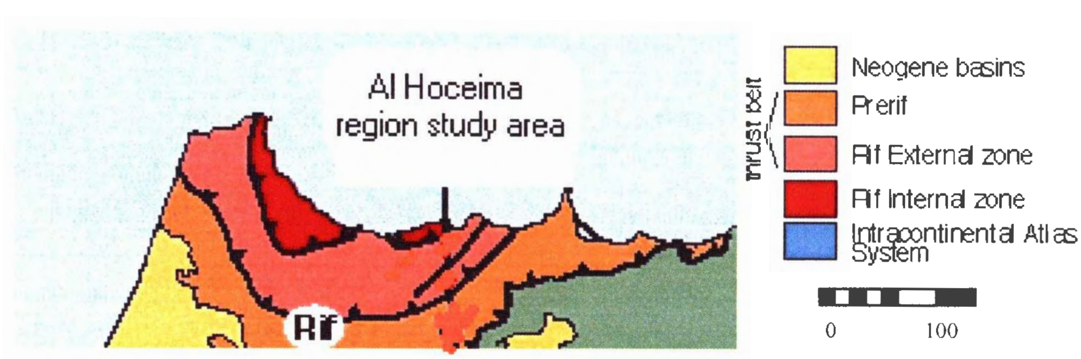


Figure 1. Map showing north Morocco and Al Hoceima Region study Area

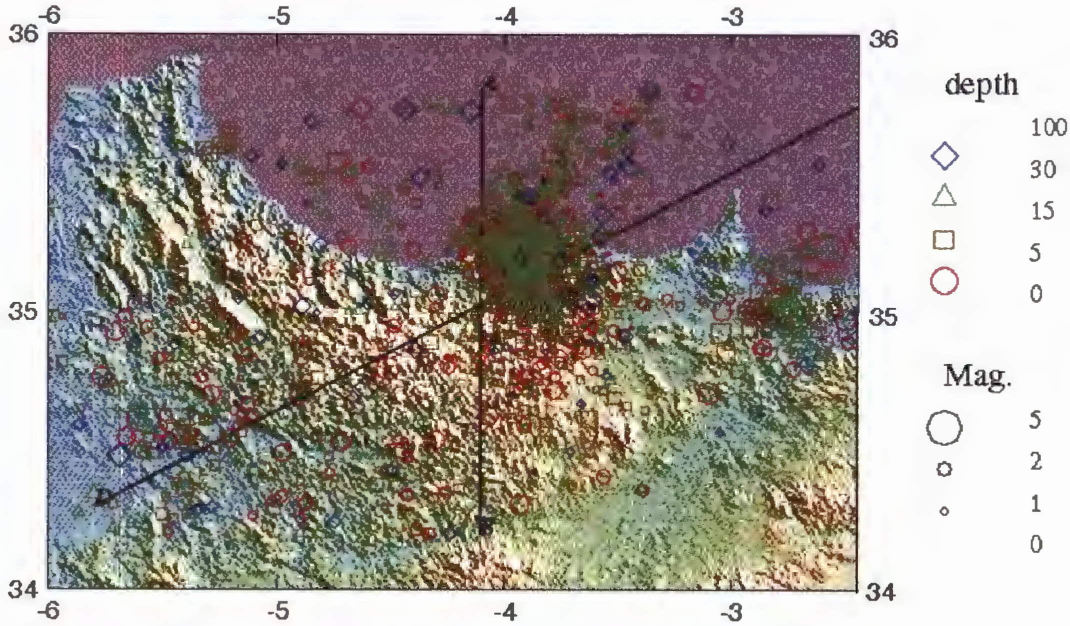


Figure 2 a: Initial epicentral location from 1988/12/01 to 2006/4/9

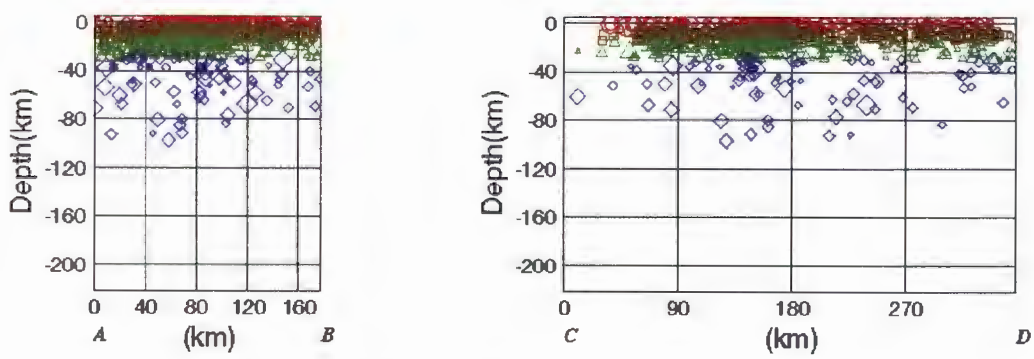


Figure 2 b: Initial hypocentral location from 1988/12/01 to 2006/4/9

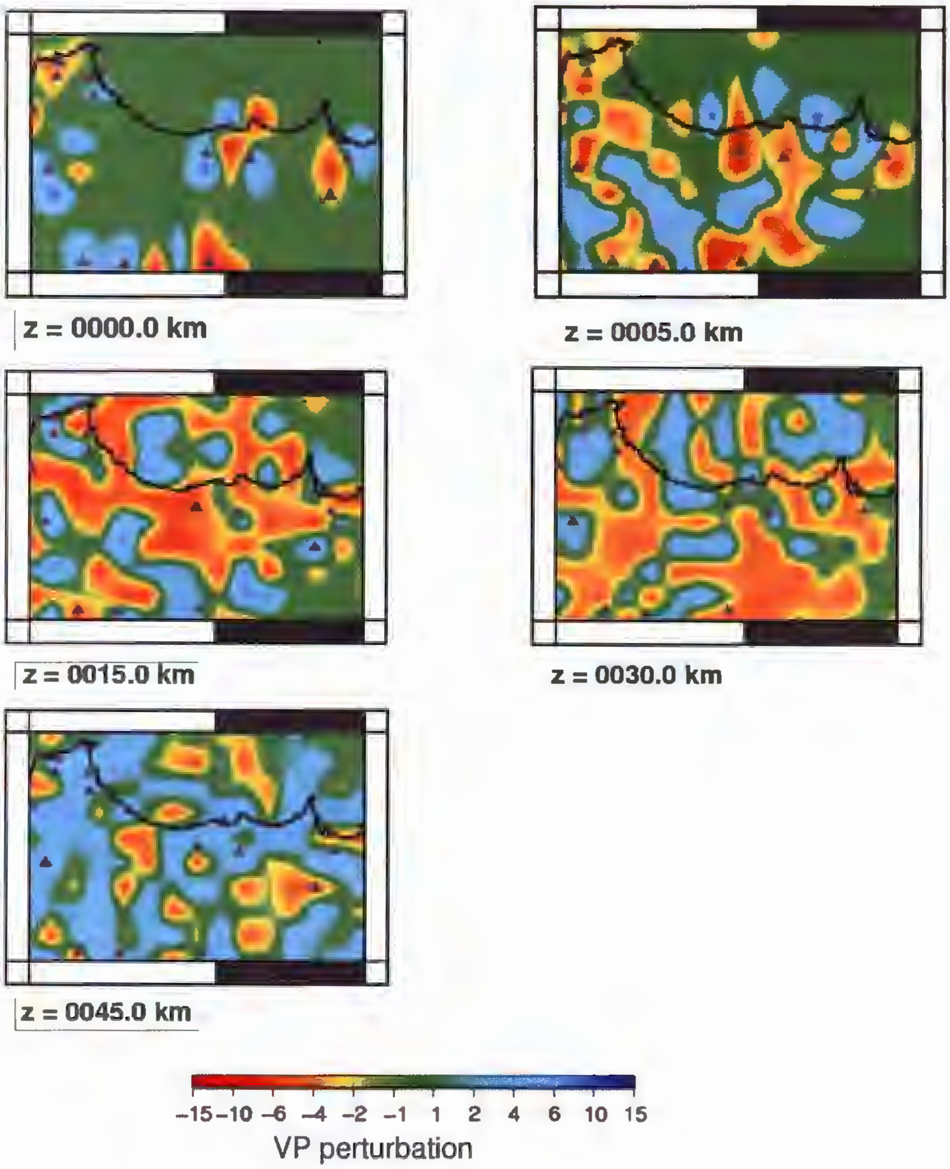


Figure 3: Vp perturbation relative to 1-D model

References

- Eberhart-Phillips, D. (1993), " Local earthquake tomography: earthquake source regions" in Seismic tomography: theory and practice, ed. Iyer, H.M., and K. Hirahara, Chpman and Hall, London, pp. 613-643.
- Kissling, E., W.L. Ellsworth, D. Eberhart-Phillips, and U. Kradolfer (1994), " Initial reference models in local earthquake tomography" J. Geophys. Res. 99, 19635-19646.
- Thurber, C. H. (1983), " Earthquake locations and three-dimensional crustal structure in the Coyote Lake area, central California" J. Geophys. Res. 88, 8226-8236.
- Barry, R. , Lienert (1994) " A computer program for locating earthquake locally, regionally and globally " Hawaii institute for geophysics / SOEST.
- Um, J. ,and C. Thurber (1987) " A fast algorithm for two-point seismic ray tracing" Bull. Seism. Soc. Am. 77, 972-986

SEISMICITY AND SEISMOTECTONICS OF THE AZORES-TUNISIA REGION

Agustín Udías
Dpto de Geofisica y Meteorología, Universidad Complutense, Madrid
audiasva@fis.ucm.es /Fax:913934398

The Azores-Tunisia region is formed by the most western part of the boundary between the lithospheric plates of Eurasia and Africa, which extends from Azores to the Caucasus. This region serves as a link between the tectonics of the Atlantic and the Mediterranean. From Azores Islands to near the Strait of Gibraltar earthquakes are shallow and located at a narrow band with large earthquakes with strike-slip and reverse faulting at its central and eastern part. To the east, earthquakes are spread over a wider region on southern Spain and northern Morocco, Algeria and Tunisia. In this part, related with the Betic-Rif arc and the Alboran sea, intermediate and deep earthquakes are present. The dynamics of the region is related to the opening of the Atlantic and the closing of the Mediterranean. The pole of rotation of the relative motion of Africa is located near the Canary Islands producing extensions at the Azores, strike-slip motion at the center of the Azores-Gibraltar fault and horizontal compressions in NW-SE direction from near the cape San Vicente to Tunisia. A complex interaction exists between the Iberian Peninsula and northern Morocco with an extensional center at the Alboran Sea.

ORFEUS, EMSC and NERIES: The challenge of coordinating the European- Mediterranean earthquake data exchange infrastructure.

Torild van Eck (ORFEUS), Remy Bossu (EMSC) and Domenico Giardini (ORFEUS)

ORFEUS (Observatories and Research Facilities for EUropean Seismology; www.orfeus-eu.org) and the EMSC (European Mediterranean Seismological Center www.emsc-csem.org) are the two organizations that coordinate currently the data exchange on a European level. We will shortly present the organizations, its structure and its relations within a global perspective.

NERIES (NEtwork of Research Institutes for Earthquake Seismology) is a new EC project, more specifically an Integrated Infrastructure Initiative (I3) project coordinated by ORFEUS in close collaboration with the EMSC. Its objective is to significantly upgrade the European data exchange infrastructure meeting the current and future requirements of the scientific community and general society. We will present the practical aspects of current and planned work on some relevant activities, like real-time data exchange, data archiving, web services and workshops. The NERIES project offers opportunities for a broad audience of earth scientists and observatories: workshops and meetings will generally be open, specific research grants are available for EU researchers, researchers and observatories are invited to collaborate with the different NERIES activities and all software developments within the project will become publicly available. In the presentation we will address the practicalities involved.

Both ORFEUS and the EMSC are keen to coordinate NERIES activities with other European scale projects. We will present a short overview of these projects and the current and planned fields of collaboration. The EERWEM project, although small, is one of these projects.

INITIATIVES FOR THE STUDY OF THE SEISMICITY AND VELOCITY STRUCTURE IN SOUTHERN IBERIA AND NORTHWEST AFRICA: PICASSO

A. Villaseñor[1], J. Gallart[1], and the PICASSO Working Group
[1]Institute of Earth Sciences "Jaume Almera"-CSIC, c/Lluís Solé i Sabarís s/n, 08028 Barcelona, Spain.
antonio@ija.csic.es / Fax: +34-93-4110012

Abstract
PICASSO (Program to Investigate the Cause of the Alboran-AtlaS System convective Overturn) is the first of a number of emergent research initiatives to explore the three-dimensional structure and evolution of the Europe-Mediterranean region. The goal of PICASSO is to understand the lithospheric processes that resulted in the present day geodynamic scenario in the Southern Iberian Peninsula and Northern Africa regions through the imaging of the three-dimensional internal structure of the crust and lithosphere, with special emphasis in the geometry of the upper mantle. The area is specially controversial as different data sources and interpretations provide different geodynamic models that resulted in the present day tectonic scenario. The proposed geodynamic processes include: orogenic collapse, slab break-off, mantle delamination, and active subduction.

PICASSO is an international research program to carry out multiscale and multidisciplinary experiments, although the main component will be the deployment of a dense temporary seismic network in Southern Spain and Portugal and Northern Morocco. The deployment of this network will allow to improve the seismic monitoring and earthquake location in regions such as the Gulf of Cadiz and Alboran Sea, which are not sufficiently covered by existing permanent networks. The waveform data acquired in this experiment, together with data from permanent networks in the region will be used to carry out studies of Earth structure, including: local and teleseismic travel time tomography, surface wave tomography using dispersion measurements and ambient noise, receiver functions, SKS splitting, etc.

In anticipation of PICASSO and to make use of waveform data from existing networks, we have started a project to determine teleseismic P-wave arrival times for stations in the Iberian Peninsula using waveform similarity. The compilation of the data needed for this study has required the time-consuming task of formulating separate requests to the different networks operating in the region, before a complete waveform dataset could be assembled. Preliminary results show that the obtained teleseismic arrival times significantly improve the ones obtained by individual networks. In addition, we have obtained arrival times for stations that routinely did not report pick data for distant earthquakes. This an other studies of seismicity and Earth structure would greatly benefit from integrated waveform data archives through data centers (ORFEUS) and research infrastructures (NERIES).

1. Introduction

A number of research initiatives in the field of the Geosciences are currently being developed and submitted to European and National Science Foundations. In these initiatives, that are multi-disciplinary in nature, Seismology plays a major role, particularly the deployment of dense networks of broadband instruments, following the example of the US-funded initiative USArray, which is part of the EarthScope program (http://www.earthscope.org/). In this communication, we describe briefly some of the major initiatives at the European level, with particular emphasis of those that refer to the Europe-Africa plate boundary zone in the western Mediterranean. Similarly to the US example, a large-scale program, TOPO-EUROPE, includes an important seismic component: EUROARRAY. The pilot deployment of this network would take place in southern Iberia-northern Morocco, an experiment named PICASSO. Other initiatives, such as a research project involving the entire peninsular Spain (TOPO-IBERIA) and a smaller deployment in southern Iberia-northern Morocco are also discussed.

2. Research initiatives

2.1. TOPO-EUROPE and EUROARRAY

The TOPO-EUROPE proposal has been submitted to the European Science Foundation as a potential EUROCORES program.

TOPO-EUROPE is concerned with the science of coupled Solid-Earth - surface processes of continental Europe. In addition to addressing world-class scientific issues within Earth-System science, TOPO-EUROPE will have considerable societal relevance, because topography directly affects humanity as a result of secular landscape changes and its inherent effects on geohazards and environmental change. Participants in TOPO-EUROPE plan to investigate the 4-D evolution of the topography of the European continent and adjacent parts of North Africa, Asia and the Middle East. This requires an integrative multidisciplinary approach connecting research in the sub-disciplines of geomorphology, geology, geophysics, geodesy, remote sensing and various branches of geotechnology. Advantage will be taken of existing and planned European research facilities and extensive European know-how. New satellite-based techniques will supply ultra-high resolution information on temporal and spatial variations of surface topography, whereas EUROARRAY multi-sensor (GPS, magnetotelluric and seismic) instruments deployed throughout Europe will provide fundamental new details on surface deformation and the electrical and seismic structure of the Solid Earth. Results of applying these novel monitoring, deep probing and associated imaging techniques will be linked to a major program aimed at developing high-resolution reconstruction and modelling methods that will help to understand the interplay of phenomena controlling continental topography, in order to assess related natural hazards and the vulnerability of intensified land use. Europe is unique in that it hosts excellent natural laboratories to study and resolve first-order problems in continental topography. Several sites, each with its own specific characteristics and problems, will be selected. Combined, they address the general issue of topography evolution. The importance of lithosphere-scale processes controlling topography development has only recently been recognized. Therefore, major scientific breakthroughs can be expected in the coming years.

A significant component of TOPO-EUROPE is the EUROARRAY deployment. New global seismic models of the Earth will be based on seismological data from existing global networks which are to be further intensified in the coming decade (FDSN, IRIS, GEOFON, EarthScope). Data from temporary geophysical network deployments are needed to fill in gaps in the key regions. Through the multi-faceted EUROARRAY (EUROARRAY will be the European counterpart of the USARRAY component of the recently funded EarthScope program in the US. Both programs will have open data policies, thus providing new possibilities for the solid-Earth sciences on a global scale.) measuring and monitoring component of TOPO-EUROPE, surface deformation and Solid-Earth geophysical data will be acquired across Europe. Eventually, a spatially uniform and dense network (60 km spacing) of co-located GPS, magnetotelluric and seismic instruments will complement existing European instrumentation for a wide variety of scientific purposes. In addition, a dense roving network of co-located geophysical instruments will focus on specific targets of surface deformation and subsurface structure. This initiative will promote organizational and scientific collaboration across Europe for the benefit of the growing multidisciplinary Solid-Earth science community, exploiting the latest in high-technology European infrastructure and aiming at an open data policy (new for Europe). The anticipated

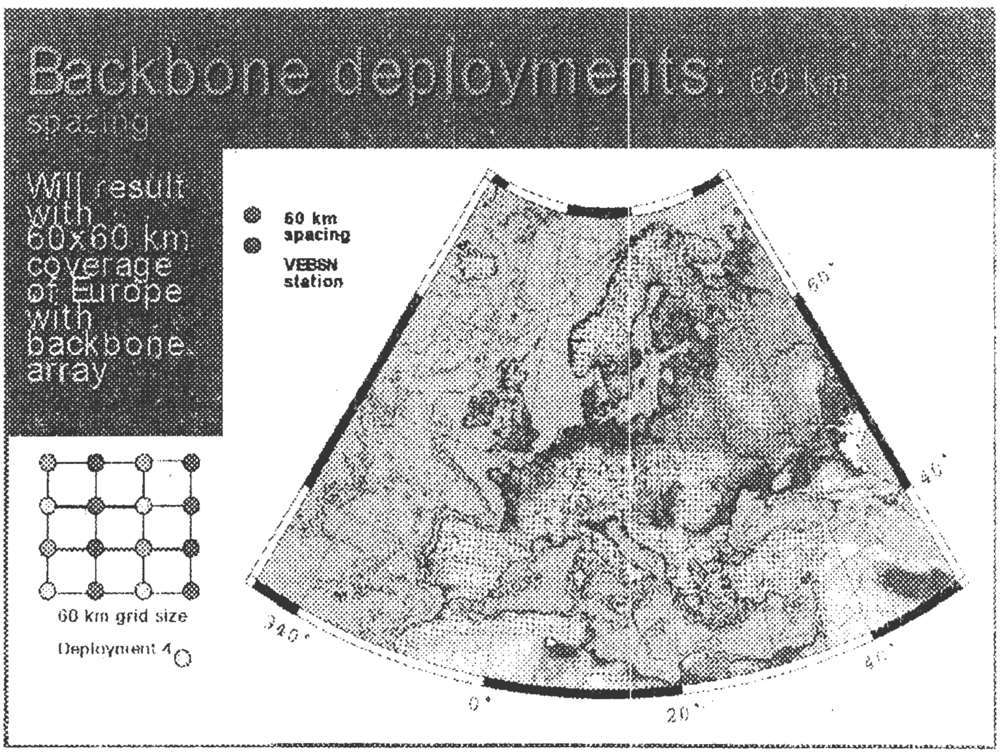


Figure 1. Backbone deployment of EUROARRAY. A final station coverage of 60 × 60 km will be achieved by 4 consecutive deployments indicated by colors in the in the lower left grid

boost in quality, quantity and availability of data achieved through EUROARRAY will promote strong technological and methodological innovation, allowing Europe to maintain its leading role in international Solid-Earth sciences. Undoubtedly, the EUROARRAY data will facilitate the development of new generations of surface deformation models and 3-D electromagnetic and seismic images of the subsurface. Early outputs will probably include comprehensive high-resolution seismic and electrical models of the Solid-Earth beneath Europe, including much better estimates of absolute seismic velocities and electrical resistivities. The historically unprecedented density of the international seismic network which now exists, together with the development of new seismic techniques (especially the use of smaller seismic phases, so far largely disregarded), will also reveal details of the Earth's internal structure unknown to date: (a) Detailed crustal structure determination underneath each station will supplement existing models; (b) Thickness of the transition zone will be determined more accurately on a global scale; (c) The lithosphere-asthenosphere boundary, large shear zones will be traced with new techniques; (d) The study of seismic anisotropy will facilitate the determination of asthenospheric flow directions, which will supplement GPS observations.

2.2. TOPO-IBERIA

The TOPO-IBERIA proposal has been submitted in April 2006 to the Spanish Ministry of Education and Science (MEC), as a potential Consolider-Ingenio project (a new category of large-scale projects introduced by the MEC).

TOPO-IBERIA is a proposal that involves more than 100 PhD researchers from 10 different groups. It corresponds to the willingness and interest of the Spanish scientific community to establish an integrated framework to develop multidisciplinary geo-scientific studies in our country. The 'micro-continent' formed by the Iberian Peninsula and its margins constitutes a most suitable natural laboratory, well identified by the international scientific community, to develop innovative, frontier research on its topography and 4-D evolution. The objective of TOPO-IBERIA is to understand the interaction between deep, surface and atmospheric processes, by integrating research on geology, geophysics, geodesy and geo-technology. The knowledge on the relief changes and its causes is of great social impact concerning the climate change and the evaluation of natural resources and hazards. Three major domains of research have been identified: the southern and northern borders of the Iberian plate (the Betic-Rif system and the Pyrenean-Cantabrian system) and its central core (Meseta and Central-Iberian systems). It is intended to build up a comprehensive, multidisciplinary base of data and results to tackle the key existing questions by developing novel interpretation strategies. A major aim of this program is to significantly increase the high-quality information available, by deploying a technological observatory platform, IberArray, of high resolution multisampling. With this program, our community could join the leading edge of international research, marked by similar initiatives, such as TopoEurope/EuroArray in Europe or the ongoing US program EarthScope.

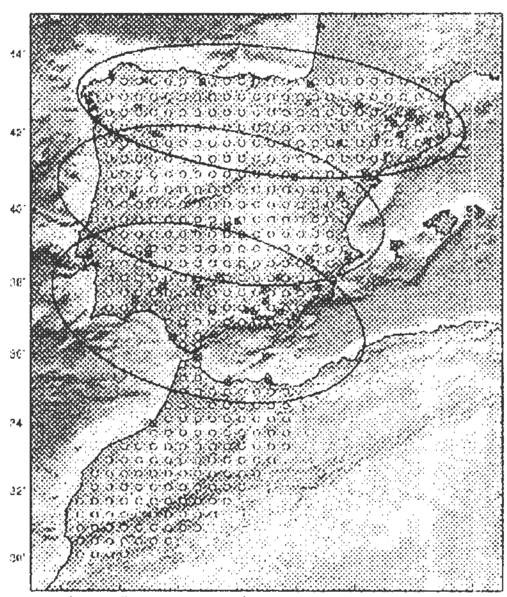


Figure 2.. Backbone deployment of IBER-ARRAY, with a station coverage of 50 × 50 km, showing the 3 study regions described in the proposal.

2.3. PICASSO

PICASSO is a multi-disciplinary Initiative to explore the 3-dimensional structure and evolution of the Betics-Alboran-Atlas in order to develop understanding of the lithospheric processes that resulted in the present day geodynamic scenario. This is an international research program to carry out a multi-scale, multi-seismic experiment in the area which includes: Atlas, Alboran, and southern Iberia.

The motivation is to study the lithospheric processes that are affecting the area, if there is a place in the world were delamination is an active process, this is probably it. The most resolutive way to address the proposed topic is a multidisciplinary research program that includes structural geology, geodynamic modeling, magnetotellurics, gravity and multi-scale, multi-seismic experiments. These acquisition experiments would be addressed to constrain the crustal and upper mantle structure.

The main objective is to determine the 3-dimensional internal structure of the crust and the lithosphere, with special emphasis in the geometry of the upper mantle in order to image the lithospheric processes that are taking place. The area is specially controversial as different data sources and interpretations provide different geodynamic models that resulted in the present day tectonic scenario. The geodynamic processes suggested include: orogenic collapse, slab break-off, mantle delamination, and active subduction.

3. Early results: Teleseismic arrival times

In anticipation of PICASSO and other initiatives that involve the deployment of large-scale temporary seismic networks, it has been recognized that the existing permanent networks are underutilized for many of the studies proposed in these initiatives. This often the result of the difficult access to the data from the different networks. Recent developments in European data centers (ORFEUS, EMSC-CSEM) and new research infrastructures (NERIES) are starting to facilitate data access, but the compilation of the data needed for some seismic studies still require the time-consuming task of formulating separate requests to the different networks operating in the region, before a complete waveform dataset could be assembled.

As a pilot study in the area of interest of initiatives such as TOPO-IBERIA and PICASSO, we have started to determine teleseismic P-wave arrival times in existing digital stations in the Iberian Peninsula that belong to permanent monitoring networks for earthquakes occurred during 2004, using an adaptive stacking method that makes use of waveform similarity between close stations. This method provides relative P-wave arrival times with an accuracy better than 0.2 seconds on average. In addition we obtain absolute arrival times by phase picking on the waveform stacks.

The spatial distribution of teleseismic travel time residuals with respect to a reference 1D model (ak135) for single earthquakes provides a first order approximation to the distribution of seismic velocities beneath the Iberian Peninsula, but can also be used to identify station timing problems, polarity reversals, and location errors. The average values of teleseismic station residuals also provide a robust estimate of the Earth structure beneath the station, and can be used as a station correction for accurate earthquake location.

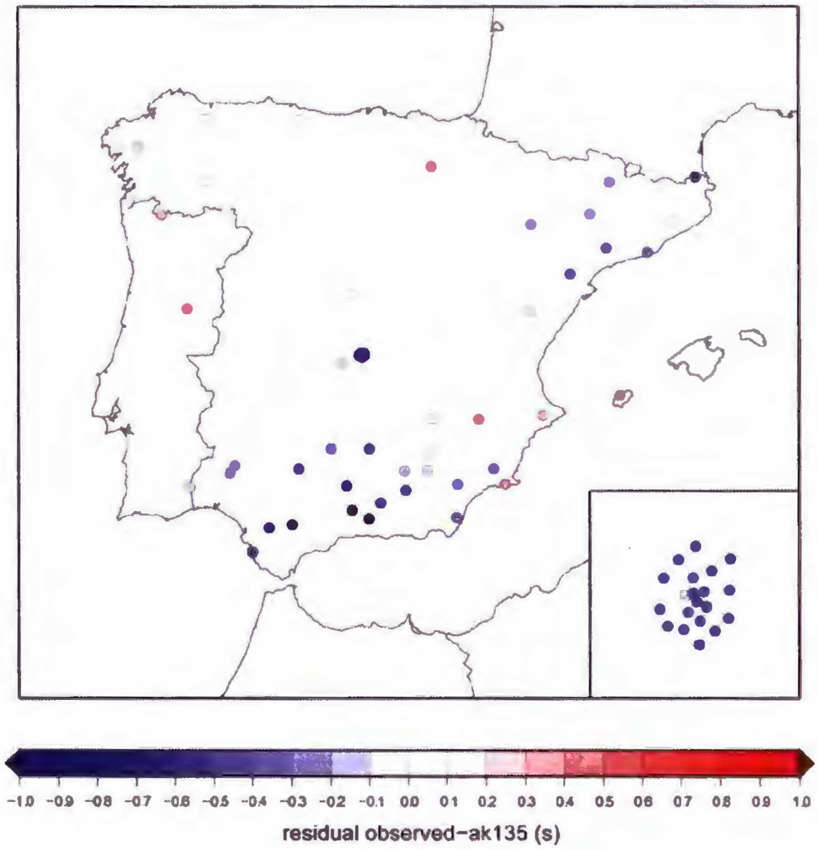


Figure 3. Teleseismic travel time residuals with respect to ak135 for stations in the Iberian Peninsula belonging to different networks, for an earthquake in Tibet.

The main purpose of obtaining this new arrival time dataset is to improve tomographic models of the upper mantle beneath the Iberian Peninsula and Western Mediterranean region. Current models are based on arrival time data from the bulletins of the International Seismological Centre (ISC), which are known to be very heterogeneous in quality, and to contain a significant number of outliers. Therefore, this new dataset, obtained in an homogeneous, consistent fashion should result in improved models of Earth structure.

EARTHQUAKE MONITORING IN ALGERIA, THE ALGERIAN EXPERIENCE

A.K.Yelles-Chaouche, H.Djellit and S. Haned
CRAAG Route de l'Observatoire B.P. 63 Bouzareah Algiers

Algerian seismic activity began to be recorded in1910, when the first station was installed in Algiers (Bouzareah). Later on, number of the stations increased step by step by addition of several stations at Oued Fodda (1935) followed by stations of Tlemcen, Relizane(1955) Setif(1958). At that time these stations were equipped by photometric or magnetic record systems.
After the occurrence of the El Asnam earthquake (October, 1980), it appeared urgent to modernise the algerian network. It was done by installation in 1990 of a telemetred network which allows to give in real time informations about the earthquakes.
Due to the location of the algerian seismicity, the network of 32 stations was installed in the northern region of Algeria. The network **(REALSAS)** is formed by three regional networks, each one formed by a three component regional station and seven secondary vertical station.
Because the need to complete the coverage of the network , it was decided recently to open new local stations near towns of Guelma Batna, Tiaret or Tlemcen.
Very soon, the CRAAG will reinforce his network by the addition of 50 new digital stations. Among them, fifteen will be broadband stations. These stations will be mainly installed in the regions which are not covered by the actual network. Some of them in the Tell region, the others in the High Plateau, the Saharan Atlas and the Saharan platform.
This new network will allow to improve the seismic monitoring and the seismic hazard assessment of Algeria. The network will permit to the CRAAG to contribute more efficiency in the seismic monitoring of the Mediterranean region.

THE BOUMERDES EARTHQUAKE (ALGERIA) OF MAY 21 th, 2003, Mw :6.8: A STRONG SEISMIC EVENT IN CENTRAL ALGERIA

A.K. Yelles-Chaouche [1], H. Djellit [1], J. Devrchère [2], K. Lammali [1], A. Kherroubi [1], H. Beldjoudi [1] and S. Haned [1]

[1] Centre de Recherche en Astronomie Astrophysique et Géophysique, Route de l'Observatoire, B.P. 63 Bouzareah Algiers, Algeria
[2] Université de Bretagne Occidentale-Brest, Place Nicolas Copernic UBO-29280 Plouzanne, France

The Boumerdes-Algiers earthquake of magnitude Mw :6.8 is the most important seismic event which hit the Algiers region since centuries. The main schock, with a depth of 7 Km, was located 7 Km north of the village of Zemmouri (50 Km east of Algiers, CRAAG location). It happened in a region characterized previously by a low seismic activity. According to the focal mechanism solution provided by the NEIC and the ETH seismological centers the earthquake is associated with a reverse fault. The earthquake with a seismic moment of 3.8 10 26 dyne.cm, killed 2267 persons and caused important damage in the epicentral area of Intensity X located between Dellys and Algiers. In this region, site effects as liquefaction, minor landslides have been observed.
From a synthesis of several data collected (Maradja survey, geodetic and seismological data), we can assume that the earthquake was triggered by an unknown offshore fault, the Zemmouri fault, located around 15 Km from the coastline along the slope of the algerian margin. This NE-SW oriented fault with a fault plane dipping 42 ° towards the south extents over 50 Km along the margin, between Dellys and Ain Taya.
Geological investigations along the coastline revealed in the epicentral area surface breaks with two major orientations (N 50° along the Zemmouri bay and 120 ° near the Corso village) affecting the quaternary geological formations. The earthquake generated along the coast an average uplift of the about 50 cm which is linked with the Tellian chain built.
Offshore, the earthquake triggered a small tsunami which affected mainly the Balearic islands coast.

The seismological network of Tunisia

ATTAFI Khereddine (1), RAJHI Moncef (1)
Institut National de la Météorologie, Tunisie
attafi@meteo..tn

1. Introduction

In 1922, a mechanical seismograph was installed in Tunis to monitor seismic activity around the town. This Mainka seismograph has been used during many years and recorded several events.

In 1970, an earthquake, of magnitude 5.6 on the Richter scale, strikes the area of Tunis, damaging many buildings and injuring many people. This quake gave raise to the thinking of monitoring seismicity, at least in Tunis region, where are centralized the major activity, infrastructure and the population of the country.

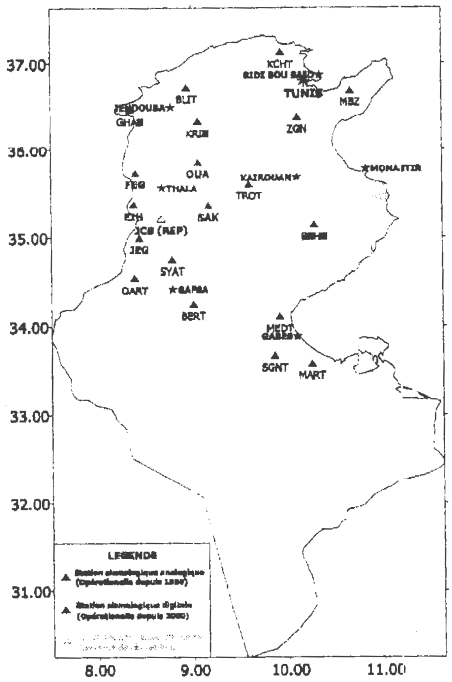
Indeed, the first analogic seismic network was installed around Tunis in July 1976. This network comprised three field remote seismic telemetred stations: Kechabta (KCHT), Zaghouan (ZGN) and Menzel Bou Zelfa (MBZ) and transmitted their data to a subcenter which was installed in Sidi Bou Saïd in Tunis and using UHF radio link. At this receiving center, a Long Period (LP) seismometer has operated until 1989 and has recorded, also, events located at different distances.

After the destructive earthquake happened in El Asnam (Algeria), a project for the reduction of earthquake losses has been launched. This project, titled PAMERAR, subscribed as UNESCO PROJECT 705TUN40 and funded by the Kuwaiti bank (FADES) constituted the frame of the extension and the development of the actual mixed analogic and digital physical seismic network in Tunisia.

During 2000, in the frame of the cooperation between the Japanese International Cooperation Agency (Japan) and the Institut National de la Météorologie (Tunisia), a complete digital regional seismic network was installed in the central part of the country.

The main objective, of the installation and the development of these networks, was to provide seismic data for the following purposes:

- Monitoring seismic activity and identifying seismogenic sources,
- Scaling earthquakes either on the Richter scale or by establishing isoseimal maps for strong earthquakes,
- Studying and determining source mechanism,
- Providing data for seismic hazard assessment,
- Contribution for the assessment of the seismic risk,
- Contribution for the elaboration of the seismic code,
- And providing data for researcher in seismology and engineering seismology.



RESEAU SISMOLOGIQUE TELEMETRE DE LA TUNISIE

Fig. 1: Geographical distribution of seismic stations. Blue triangles: analogic seismic stations; Green triangles: planned analogic seismic stations; Purple triangles: digital seismic stations; red stars: Receiving centers.

Station name	Station code	Components	Coordinates						Altitude (m)	Fréquence [MHz]
			Latitude			Longitude				
			°	'		°	'			
Trozza	TROT	EW, NS , UD	35	33.70	N	9	36.01	E	900	403.225
Bou Thadi	BTH	UD	35	7.83	N	10	16.84	E	178	403.025
Berda	BERT	UD	34	14.45	N	9	.56	E	255	403.125
Sidi Aïch	SYAT	EW, NS , UD	34	44.59	N	8	47.46	E	526	403.025
Moularès	OART	UD	34	31.90	N	8	23.80	E	484	403.225
Ghardimaou	GHAT	UD	36	27.45	N	8	21.59	E	296	403.125
Le Krib	KRIT	UD	36	19.60	N	9	3.79	E	786	403.025
Menzel Bou Zelfa	MBZ	UD	36	40.80	N	10	40.20	E	220	403.025
Zaghouan	ZGN	UD	36	22.38	N	10	6.58	E	748	403.225
Kechabta	KCHT	UD	37	6.60	N	9	56.40	E	420	403.125
Balta	BLIT	UD	36	42.78	N	8	57.17	E	565	403.225
Sidi Gnaou	SGNT	UD	33	39.46	N	9	51.61	E	767	403.125
El Meda	MEDT	UD	34	5.86	N	9	54.93	E	139	403.225
Mareth	MART	UD	33	34.34	N	10	14.99	E	140	403.025
Jebel Goubel	JEG	EW, NS , UD	34	59.31	N	8	26.82	E	943	408.100
Ouled Ayar	OUA	EW, NS , UD	35	50.44	N	9	3.97	E	1271	403.250
Sidi Abdelkader	SAK	UD	35	21.01	N	9	10.31	E	1015	403.350
Fedj Ghchioua	FEG	UD	35	43.53	N	8	24.58	E	1047	403.450
El Hazza	EIH	UD	35	21.54	N	8	23.48	E	1155	403.150
Jebel Chaambi	JCB	REPEATER	35	12.28	N	8	40.67	E	1544	Rx 408.100/Tx 403.05

Table 1: The seismic stations of the network of Tunisia.

2. Description of the seismic network

These main objectives, as described in the introduction, have imposed the choice of sensors for equipping the Tunisian seismic network. All the sensors housed in each field analogic stations are short period seismometers; model L-4C from Mark Products with 1 Hz of frequency and ~0.7 of critical damping. All the instruments, from the field package to the main center are from Sprengnether (USA).

The remaining sensors installed for each complete digital seismic station and covering the central part of the country are also short period with 1 Hz frequency; model JC-V100-3D seismometers or JC-V100-1V-SI seismometers from MARKRAND (Japan). Each kind of sensors is with transducer moving coil. Field seismic stations and the recording center are completely digital and manufactured by Markrand (Japan).

The installation of the whole seismic network (Fig. 1) has followed the principal rules and guidelines recommended in literature (Willmore, 1979; Trnkoczy and Živčić, 1992, Uhrhammer et al., 1998) and manuals:

- Site selection (Fig. 2) and evaluation of the background noise,
- Construction of necessary shelters (Fig. 3) to house the electronic components of the field seismic stations,
- And data transmission.

Field measurements of the site effects, in term of noise, on each selected site showed amplitudes in the range of 10 µKine to 25 mKine. Detectability of events at each seismic field station and then recording representative seismic waveforms, either in the regional subcenter or in the main center, depends on measured amplitudes of the seismic noise. Following the empirical formula:

$$0.85\,M - 2.5 = \log A + 1.7 \log r$$

where:

M is the magnitude of the detected seismic event
A is the amplitude in cm/s of the recorded noise
r is the distance between the seismic station and the event source

the system could record events ranged between magnitudes of 0.46, at very quite sites (~10 µKine), to 2.10 at sites with typical level of noise (~20 mKine) on the Richter scale, at the average distance of 50 Km from the source.

2.1 Field packages

Two kinds of field packages are discussed below and composing the existing network. The first one is analogic and functioning since 1989. The second is the digital system installed recently, in 2000. Basically the two types of field packages are widely different and performance of each system to reply to the essential needs, in one hand, and to the main objectives, in the other hand are in the advantage of the complete digital seismic system.

2.1.1 The analogic seismic stations

The field analogic package (Fig. 4) contains a seismometer, amplifier, voltage (VCO) controlled oscillator, automatic calibration unit, power supply, a transmitter and an antenna. For three-component seismic station, a multiplexer is introduced (Fig. 4) beside the VCO. The signal, coming from the seismometer, is amplified through the amplifier (AS110) a device that accepts signals from the microvolt to the millivolt range and has a frequency passband of **0.1 to 30** Hz with a 12-dB/octave roll-off. At this step, the noise could be controlled; by switching the guessed values of attenuation for fixed low and/or high pass filters selectable form out to 30 Hz. The attenuation is adjustable in 6 dB steps from 66 to 108 dB. The output analogic signal goes then to the VCO (TC10), a unit equipped with a center frequency, for modulation. This VCO modulates the frequency which is ranged as follows: 680, 1020, 1380, 1700, 2040, 2380 and 2720 Hz and the output signal, comes to the transmitter operating in the band of radio UHF from 403,025 to 403,450 MHz. This scheme corresponds to a seismic analogic station with one component seismometer. If the station is equipped with three-component seismometer, the output seismic signal from the VCO goes to the multiplexer before transmitting to the subcenter.

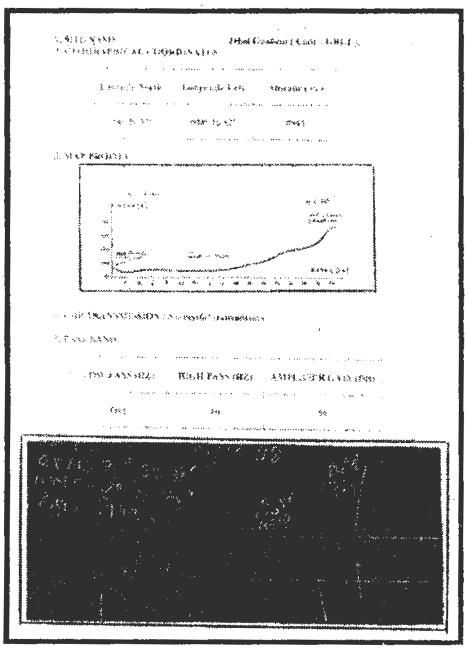


Fig. 2: Site selection. A sample of data sheet indicating the main operations carried for the selection of the site for the seismic station.

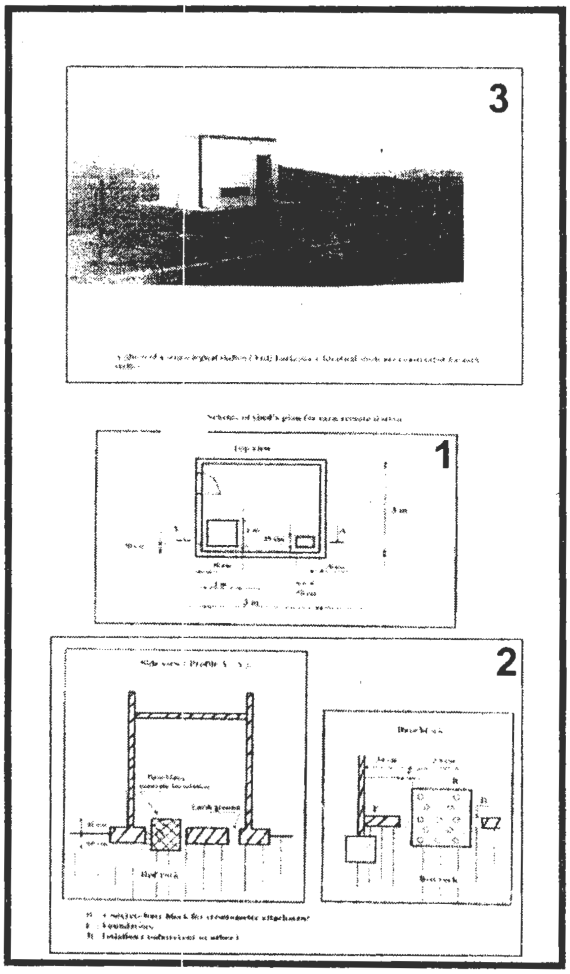


Fig. 3: Scheme showing shelter for housing seismic equipment. The base block in concrete is efficient in minimizing background noise and protecting seismometer for chemical corrosion of the medium.

2.1.2 The analogic seismic stations

The field analogic package (Fig. 4) contains a seismometer, amplifier, voltage (VCO) controlled oscillator, automatic calibration unit, power supply, a transmitter and an antenna. For three-component seismic station, a multiplexer is introduced (Fig. 4) beside the VCO. The signal, coming from the seismometer, is amplified through the amplifier (AS110) a device that accepts signals from the microvolt to the millivolt range and has a frequency passband of **0.1 to 30** Hz with a 12-dB/octave roll-off. At this step, the noise could be controlled; by switching the guessed values of attenuation for fixed low and/or high pass filters selectable form out to 30 Hz. The attenuation is adjustable in 6 dB steps from 66 to 108 dB. The output analogic signal goes then to the VCO (TC10), a unit equipped with a

center frequency, for modulation. This VCO modulates the frequency which is ranged as follows: 680, 1020, 1380, 1700, 2040, 2380 and 2720 Hz and the output signal, comes to the transmitter operating in the band of radio UHF from 403,025 to 403,450 MHz. This scheme corresponds to a seismic analogic station with one component seismometer. If the station is equipped with three-component seismometer, the output seismic signal from the VCO goes to the multiplexer before transmitting to the subcenter.

Each remote analogic station contains a calibration unit. A daily calibration sequence, with about 14.5 sec, is generated and recorded in the receiving center. A pulse is then observed at each recording system and serves for controlling the health of the seismometers.

A power supply unit containing, two solar panels, a charger for controlling voltage and two batteries with 120 AH (DC 12 V), power the entire field package and insure the energizing the seismic station in the field.

2.1.3 The digital seismic stations

The field package is shown in fig. 5. It contains a seismometer, a GPS antenna for receiving time, a power supply, an UHF antenna and the main unit called MULTIFUNCTIONAL TRANSMITTER MARK9800-TX GF3. The package contains also a sensor for temperature control and two fans: One of them functions when the temperature, in the housing box, is up 30°C and the second, a fan for emergency, works once the temperature is above 55°C. Basically, the multifunctional transmitter is composed of two main units:

- The data acquisition unit
- The radio-modem unit.

2.1.3.1 The data acquisition unit

The seismic signal recorded by the seismometer is input to the preamplifier board. Indeed, the signal is amplified by the amplifier with a gain of 20 dB and then output to the butter-worth type anti-alias filter with a cut-off frequency of 25 Hz, at which gain is –3 dB and a slope of –18 dB/octave. The filtered signal is sent to a multiplexer in the analogic to digital board through the buffer amplifier. The multiplexed signal is digitized by a successive approximation method type 16 bit AD converter with a sampling rate of 100 samples per second. The digitized data is stored in the FIFO memory on the AD board and transmitted to the CPU board memory with a rate of 100 cycles/sec. The timing of data processing at the AD board is controlled from the host CPU board through STD-bus.

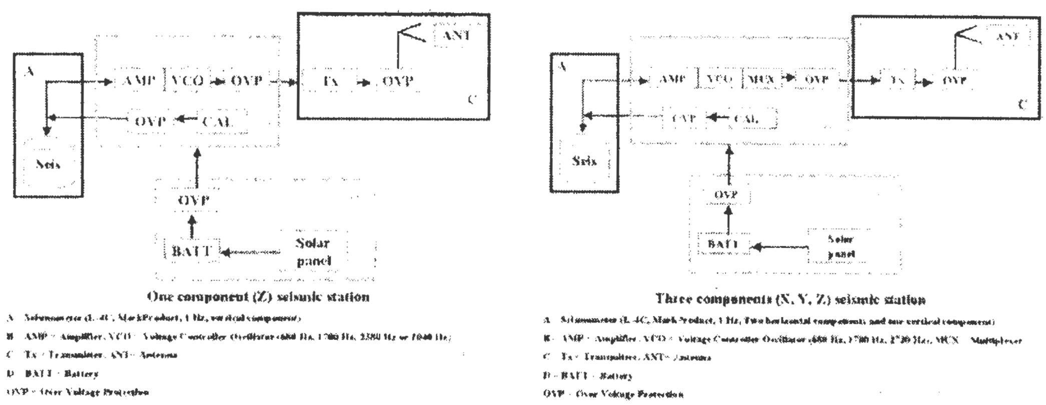


Fig. 4: Main components of an analogic seismic station. In the left, a general scheme, of one component seismic station. To the right a three component seismic station.

The signal from the GPS is also processed at this board. In fact, the GPS board is equipped with a GPS engine, an internal clock, an interface with I/O driver and a control CPU. Once three or more satellites provide the time information to the GPS antenna; the GPS-driver calculates the time and sends it to the control CPU through the serial RS232C with a transmission speed of 4800 bps.

The control CPU synchronizes the internal clock to the GPS time sent from the GPS engine. The tome information of the internal clock is continuously output to the bus buffer by the control of the CPU on the GPS board.

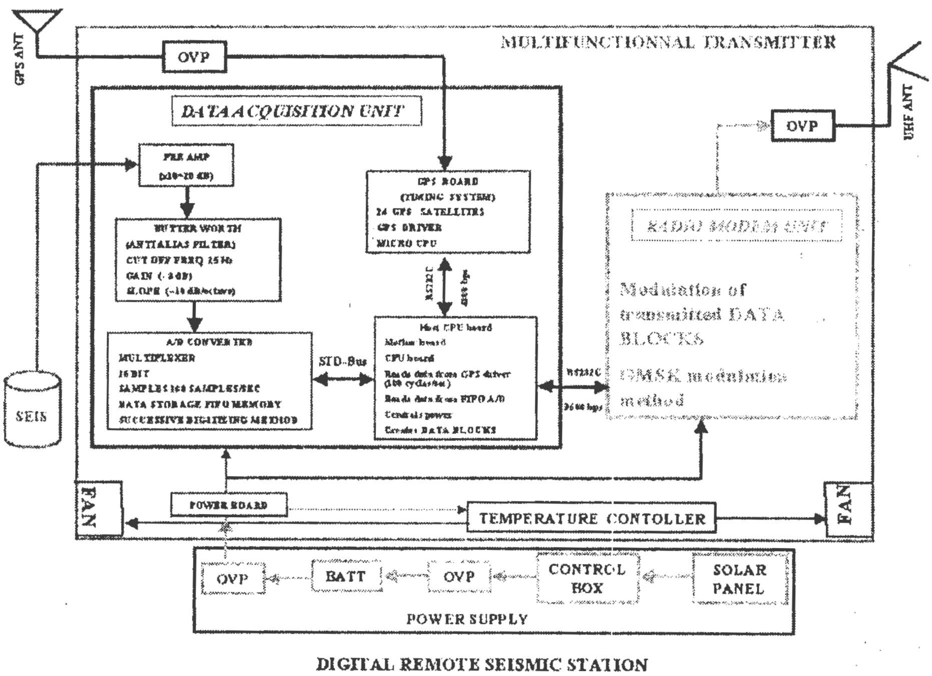


Fig. 5: Scheme of a digital seismic station. Drawing of the multifunctional transmitter with its basic units and the power supply.

The host CPU board in the data acquisition unit reads the digitized seismic signal stored in the FIFO memory on the AD board and the time information data stored in the driver on the GPS driver on the GPS board with an average speed of 100 cycles/sec, and then creates data blocks composed of the digitized seismic data and the time information data with the specified format. These data blocks are output to the serial RS232C port with a transmission speed of 9600 bps.

2.1.3.2 The radio-modem unit

The radio-modem unit comes without detailed description. This unit is manufactured by DATA RADIO, INC. from Canada. It receives the data blocks from the data acquisition unit through the serial RS232C interface. Then these data blocks are converted for its convenience and then modulated with the GMSK (Gaussian Modulation Shift Key) modulation method. After processing, the carrier frequency is multiplied so that it comes to 403 MHz or 408 MHz bands depending on the programmed parameters and the radio signal is generated as the output of the multifunctional transmitter by the final power amplifier. The radio signal, then, is output to the transmitter and sent from the Tx antenna through the lightning surge suppressor to the receiving center installed in Thala station.

2.1.4 The repeater station

Because of the impossibility to transmit seismic signal directly from the field station, at Jebel Goubel (JEG), to the regional receiving subcenter, the Thala station, due the existence of the highest mountain in Tunisia, Jebel Chaambi, a repeater station (JCB) is included in this regional network to relay (Fig. 6) the digital seismic field station, Jebel Goubel (JEG), to the digital receiving subcenter, the Thala station.

The incoming signal, from the observatory station of Jebel Goubel (JEG) to the Rx antenna with 408.100 MHz carrier frequencies, is input into the Mobile Duplexer for high pass unit, which is housed in the box of the repeater system (T-BASE system). This Mobile Duplexer acts as a mechanical notch-filter allowing the isolation of the receiving and the transmitting frequencies. The output signal is then output to the antenna input connector of the receiver unit: The radio modem T-96S. Through a local control bus line, the receiver unit is connected to another radio modem T-96S serving as a transmitter unit and to diagnostics simplexer working as an interface unit. From a 15-pin/D-sub type connector, the receiver unit sends not only the RS232C equivalent transmitted data signal from JEG with a speed of 9600 bps but also, the RS232C, controls the signal. This data transmission from the receiver to the transmitter is done through the control of the interface unit. While the observation station JEG is transmitting continuously the seismic signal, the receiver unit detects it and generates the DCD control signal. The interface unit (diagnostics simplexer) detects the incoming signal from the receiver unit and generates the RTS control signal to the transmitter unit, which comes into "transmitting mode". The transmitter unit outputs the radio signal with a frequency carrier of 403.050 MHz that is input for low pass in the Mobile Duplexer before sending it to the receiver center through the Tx antenna.

A power supply unit containing, two solar panels, a charger for controlling voltage and two batteries with 120 AH (DC 12 V), power the entire field package and insure the energizing of the seismic station in the field. Inside the housing box, an electronic board is designed to control de distribution of the power for the different units above described.

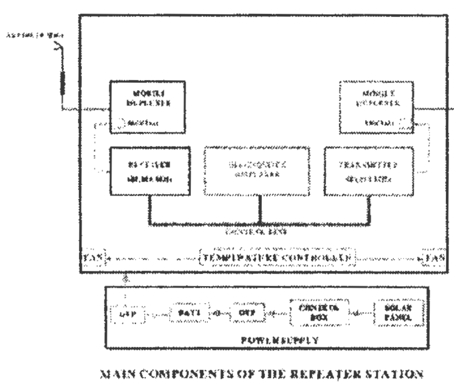


Fig. 6: Basic components of the repeater station.

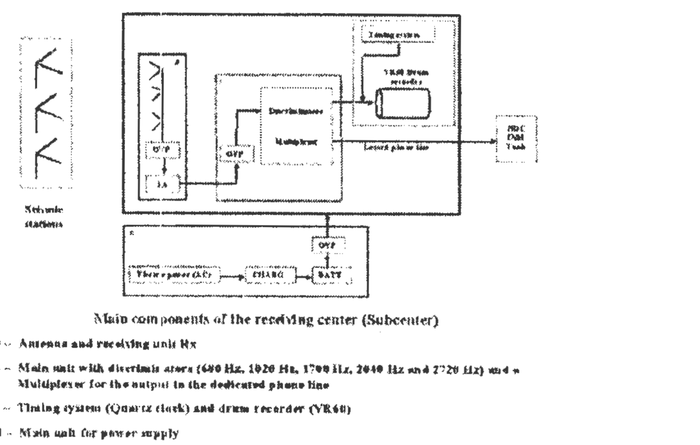


Fig. 7: Main components of the analogic receiver center.

2.2 The receiving regional centers

The Tunisian seismic network configuration (Fig. 1) includes to types of field seismic stations as shown above: Complete analogic seismic stations and a complete digital ones with a repeater station.

Accordingly, two kinds of receiving centers are designed. Each three neighbor analogic seismic stations transmit their recorded seismic signals to an analogic receiving center. The total number of seismic stations is fourteen linked through UHF radio link to five subcenters as presented in table 1.

The digital receiving center is installed in Thala meteorological station and receives seismic signals from five sites distributed around this center no so far, from the receiving center, than fifty kilometers of distances. Coordinates and other parameters of each station are presented in table 1, too.

2.2.1 The analogic receiving subcenters

Five subcenters compose the analogic seismic network. They constitute five nodes where seismic signals are received and then transmitted to the main center, to Tunis, in real time and continuous data flow, through five dedicated phone lines (300Hz to 3000 Hz).

The incoming signals from the field seismic stations (Fig. 7) are received through the three Rx antenna and come to the corresponding receivers. From each receiver, outgoing signal are sent for input into the discriminators and then output to the VR60 drum recorder, and sent too, for input into a multiplexer with three entries and one output to the phone line.

The timing system is composed by a quartz clock and integrated in the VR60 drum recorder. The system is controlled and corrected if a wide drift of time is noticed.

The phone line working in the range from 300 Hz to 3000 Hz is maintained by the PTT company and tests for assessing the gain for each modulated frequency is realized through this line. In table 1 are shown determined values at each analogic seismic station.

2.2.2 The digital receiving subcenter

Signals coming from the five digital seismic stations (Fig. 8) are received at Thala subcenter through the multi-band antenna (403 to 420 MHz). These signals are output to the mobile duplexer unit acting as a mechanical band-pass filter. The filtered signals are then sent to the radio frequency band amplifier and then five signals with the carrier frequencies, used at each remote station, are amplified so that they have adequate amplitude level and output separately to the distributor. This distributor has eight buffers for eight channel outputs. These buffers have the same size for the frequency band. The system uses channels 1 to 5 related to the carrier frequencies sent by each receiver. The interface RS232C serial port is accessed on the 15-pin/D-sub type connector with a speed of 9600 bps and used to send data to the data-buffering unit. The DCD signal for the five-receiver signals control is done independently and the transmitted data include the seismic signal and the GPS information. The data-buffering unit contains a CPU controller board and a motherboard that are controlled over the STD-bus. The buffer controls the access time for the PC to receive the 9600 bps Rx signals that are continuously transmitted from five receiver units. The algorithm to control the data access with the PC is programmed in an EP-ROM on the CPU board.

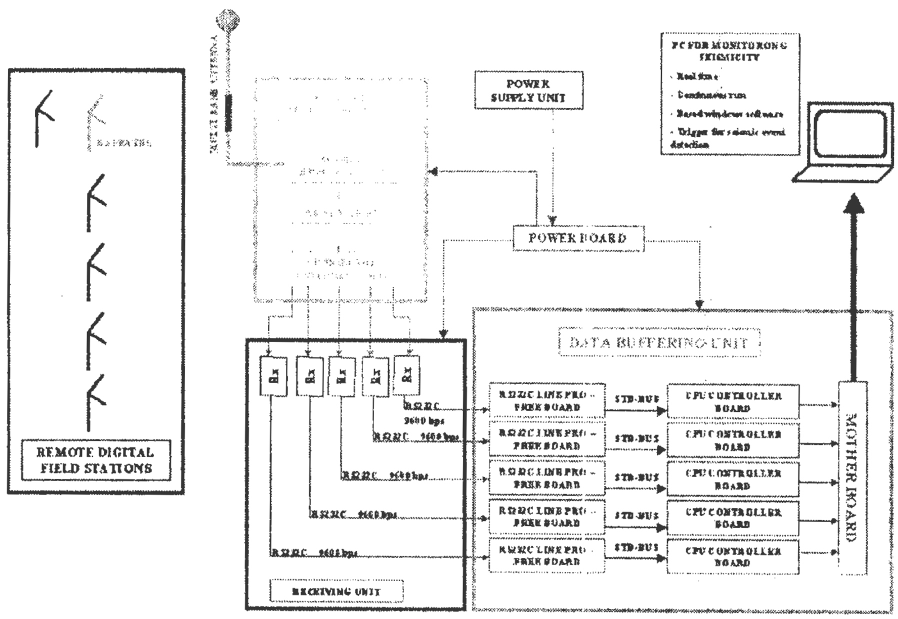
The power supply is composed of an AC power voltage translator, an UPS and a DC ± 12V.

Event detection and recording are based on trigger level. The seismicity is monitored in real time and continuously and traces are displayed by windows based software provided by Markrand (Japan).

2.3 The main center: the national data center (NDC)

Basically, the NDC is composed of two systems:

The first system is receiving data from the five analogic nodes (Fig. 9) described above and using five dedicated phone lines for data flow and transmission and working continuously and in real time. The incoming signals are input to discriminators and then, with the integrated base time, they are output to VR60 drum recorders. The system is equipped with GPS timing system to correct time due to the drift of the quartz clock used here as base time system. Simultaneously, through BNC connectors and an interface for output to PC of 15-pin/D-sub type, 15 channels are digitized using A/D converter 12 bit type, installed inside a PC dedicated, only, for data acquisition. The time here is recorded through one channel and displayed with the seismic traces. The software used here, are MS-DOS based operating system and provided by IASPEI. This PC is on line and monitor seismicity in real time. Events are recorded on the basis of STA/LTA ratio. It is connected to another PC for data retrieve and post processing of recorded waveforms using also the IASPEI package.



SUB-CENTRE : DATA RECORDING STATION

Fig. 8: General scheme of the digital receiving center. Basic elements are the receiver multicoupler unit, the receiving unit and the data buffering unit. Events are recorded on PC on the basis of trigger level defined as STA/LTA ratio.

The second system is receiving data from the digital network (Fig. 10) installed in Thala meteorological station. A digital phone line with up to 64 kbps speed links two modems for data transmission. At each end, two routers with TCP/IP addresses are installed. Actually, the WinVNC software (Freeware) developed by James Weatherall (2002) and downloadable from the site www.realvnc.com is used to monitor in near real time the seismicity in the central part of the country. Allowing the direct access to the PC and the installed software, the setting parameters and the control of recorded events are done at the NDC through the main PC of post processing.

3. Conclusion

In This paper, the seismological network of Tunisia has been presented on the point of technical view. Basic components have been detailed for both the analogic instruments used at the seismic observatory operating system in Tunis at the INM and the digital seismic units installed in the central part of the territory. Gathering data must reply to the basic parameters: The total gain and the delay group. The main purpose of the installation of the network was also discussed. Managing seismic risk and evaluation of the seismic hazard is not a stand alone fields and require data. The main data are seismic source parameters which are acquired by a seismic network that should be installed in the state of the art. The main compromises are the existence of facilities and a site with a low background noise. Comparative elements for each main component among the data transmission show the hard task to establish an efficient seismic network.

Basically, the network of Tunisia operates two ways:

- The analogic part of the hole of the seismic network is operating in real time.
- The digital system, installed in the central part of the territory, could be considered as a near real time seismic system.

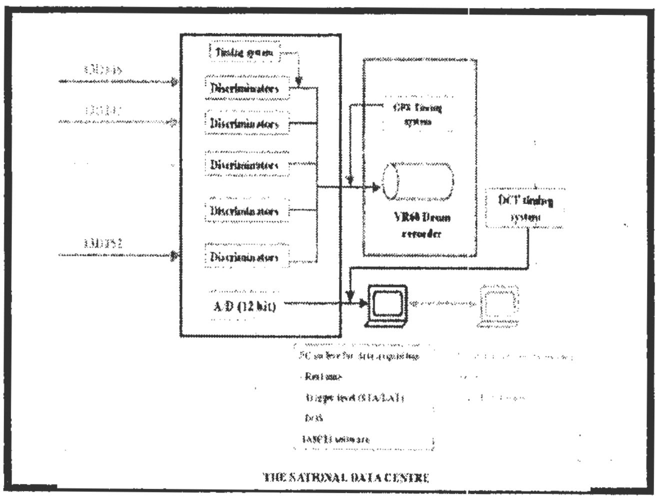


Fig. 9: The NDC. Real time monitoring system. Five dedicated phone lines are connected to discriminators for receiving continuously the data flow from the five analogic nodes. Outputs are sent to the VR60 drum recorders. Simultaneously, digital record is realized on the on line PC.

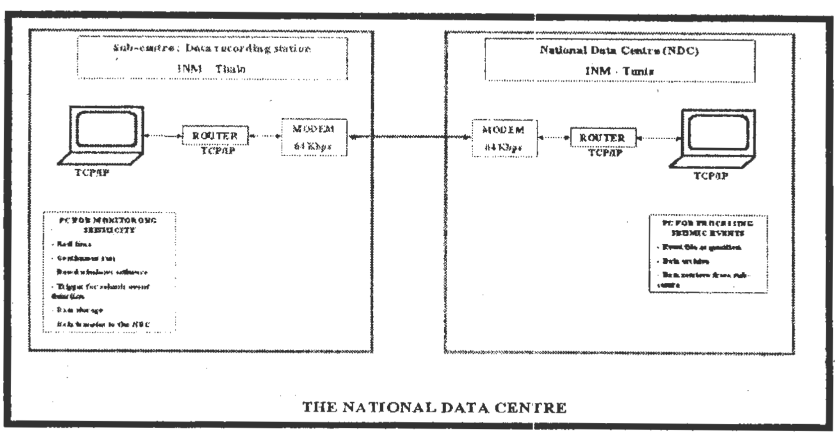


Fig. 10: The NDC. Near real time monitoring system. Using VNC software, the based acquisition PC at the subcenter is controlled and the setting of parameters are done at the NDC.

References

Bormann, P., Wylegalla, K., Strauch, W., and Baumbach, M. (1992). Potsdam seismological station network: processing facilities, noise conditions, detection threshold and localization accuracy. Phys. Earth Planet. Int., **69**, 311-321.

Havskov, J., and Ottemller, L. (1999 a). SeisNet: A general purpose virtual seismic network. Seism. Res. Lett., 70, 522-528.

Havskov, J., and Ottemller, L. (1999 b). Electronic Seismologist - SeisAn Earthquake Analysis Software. Seism. Res. Lett., **70**, 532-534.

Lee, W. H. K., and Steward, S. W. (1981). Principles and applications of micro-earthquake networks, Advances in Geophysics, Supplement 2, Academic Press, New York.

Scherbaum, F., and Johnson, J. (1992). Programmable Interactive Toolbox for Seismological Analysis (PITSA). IASPEI Software Library Volume 5, Seismological Society of America, El Cerrito.

Scherbaum, F. (1996). Of poles and zeros; Fundamentals of Digital Seismometry, Kluwer Academic Publisher, Boston, 256 pp.

Scherbaum, F. (2001). Of poles and zeros: Fundamentals of digital seismology. Modern Approaches in Geophysics Kluwer Academic Publishers, 2nd edition, 265 pp. (including an CD-ROM by Schmidtke, E., and Scherbaum, F. with examples written in Java).

Scherbaum, F. (2002). Analysis of digital earthquake signals. In: Lee et al. (2002), Part A, 349-355.

Trnkoczy, A. (1998). Guidelines for civil engineering works at remote seismic stations. Application Note 42, Kinemetrics Inc., 222 Vista Av., Pasadena, Ca. 91107.

Trnkoczy, A., and Živčić, M. (1992). Design of Local Seismic Network for Nuclear Power Plant Krsko, Cahiers du Centre Europeen de Geodynamique et de Seismologie, Luxembourg, **5**, 31-41.

Uhrhammer, R. A. (1980). Analysis of small seismographic station networks. Bull. Seism. Soc. Am., 70, 1369-1379.

Uhrhammer, R. A., Karavas, W., and Romanovicz, B. (1998). Broadband Seismic Station Installation Guidelines, Seism. Res. Lett., **69**, 15-26.

Willmore, P. L. (1959). The application of the Maxwell impedance bridge to the calibration of electromagnetic seismographs, Bull. Seism. Soc. Am., **49**, 99-114.

Willmore, P. L. (Ed.) (1979). Manual of Seismological Observatory Practice. World Data Center A for Solid Earth Geophysics, Report **SE-20**, September 1979, Boulder, Colorado, 165 pp.

MINISTERIO
DE DEFENSA

PUBLICACIONES
Pd
DE DEFENSA