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The IBERARRAY broadband seismic network: A new tool to investigate the deep structure beneath Iberia

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Introduction

The development of the Earth Sciences in Spain has recently been improved by the approval of the large scale "TopoIberia" research project, funded by the Spanish Ministry of Science and Education under the 'CONSOLIDER-INGENIO 2010" programme of excellence. This project provides an integrated framework for multidisciplinary geoscientific studies in Iberia and gathers about 125 PhD researchers from 10 different groups and institutions. It can be regarded as the Spanish branch of the European-scale "TopoEurope" initiative, accepted by the European Science Foundation as an Eurocores theme, and focussed on understanding the interaction between deep, superficial and atmospheric processes that control the topography of continental Europe and its margins by integrating research on geology, geophysics, geodesy and geotechnology.

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. 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 new, comprehensive, multidisciplinary base of data and results to tackle the key existing questions by developing novel interpretation strategies.

A major aim of the TopoIberia project is to significantly increase the high-quality information available, by deploying a technological observatory platform, named IberArray and focused in the acquisition of new seismic, GPS and magnetotelluric data. In this contribution we aim to report on the characteristics, objectives and current status of the seismological component of this platform.

The IberArray seismic network

Following the spirit of the USArray from Earthscope, the IberArray seismic design includes the deployment of a dense array of new generation dataloggers equipped with broadband seismometers in an approximately 60x60 km grid. This network will cover Iberia and North Morocco in three successive footprints, each lasting for about 18 months. The equipment consists of Nanometrics Taurus dataloggers and Trillium 120s seismometers.
Some of the nodes of the theoretical network are covered by permanent stations of the national broadband network (IGN) or other networks operating in the region (IAG-UGR, ROA). Data from those stations will also be integrated into the IberArray database.

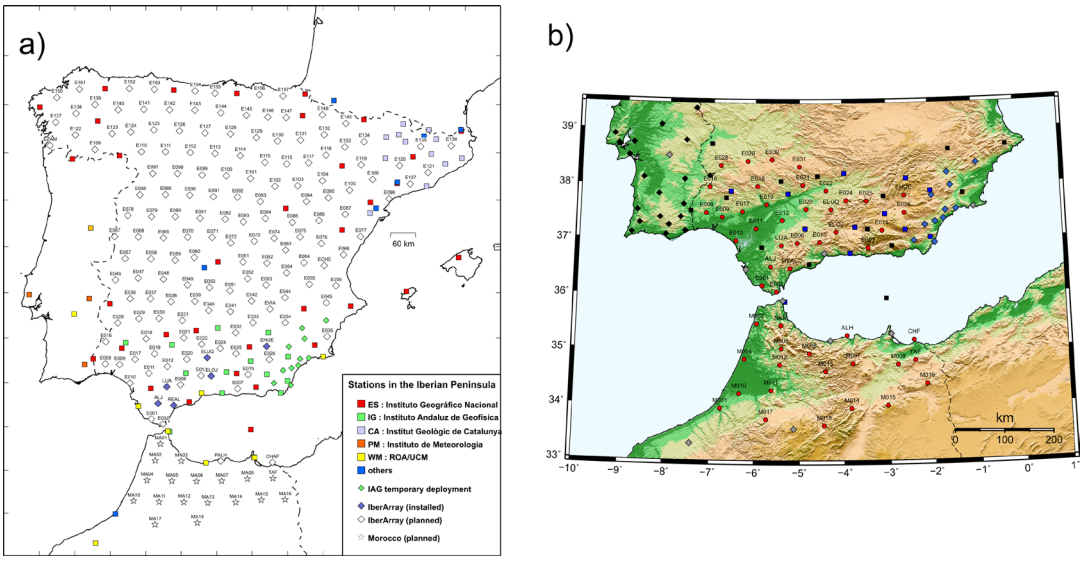

Figure 1. *- a) Complete deployment schedule (3 stages) of the IberArray seismic network. BB stations from permanent and semi-permanent networks covering IberArray nodes are included. b) Detailed map of the first footprint, deployed during 2007 in southern Iberia and northern Morocco.*

The first leg covers the southern part of Iberia (35 stations) and northern Morocco (20 stations). The network over Iberia was implemented mostly during summer 2007, with about 30 stations operational by late September 2007. The deployment was completed during November 2007 by the installation of the stations in North Morocco. In some cases, we have used sites of the short period permanent network, but in most cases the installation was performed in the open, with the seismometer buried, or in the basements in unused buildings with a reasonable security level. In all cases special care has been taken to ensure the best possible stability and thermal insulation of the instruments.

The IberArray Processing and Quality Control Center

Even if the instrumentation is capable of real time streaming of continuous data, in this first

leg such telemetry is not implemented, mainly to avoid problems associated with increased power consummation, GPRS coverage etc… Therefore, the maintenance of the network is assured by field teams that visit the stations, recover the recorded hard disks and send data and metadata to a central IberArray processing and quality control center (IPQCC), located in Barcelona (http://xeon.ija.csic.es/IberArray). These maintenance visits have a maximum interval of about three months.

Once in the IPQCC, a protocol has been designed to ensure reliable manipulation and storage of the data. Firstly, the raw data, about 2 Gb per day, is collected and stored in a backup device. Then the data is decompressed and converted to the standard mini-SEED format and the corresponding response files are computed.

The quality control of the data is performed in two steps. Firstly, the state of health parameters (batteries charge, thermal insulation, time adjustments, geophone leveling, etc.) are systematically inspected to look for anomalies that require attention. Secondly, the continuous seismic data is checked by visual inspection of the waveforms and analyzed in the frequency domain using the PQLX software (http://www.orfeus-eu.org/Organization/Newsletter/vol8no1/PQLX/PQLX.htm). This package calculates the power spectral density (PSD) of the continuous data for each station in 1-hour long intervals and then performs a statistical analysis to generate the corresponding probability density function (PDF). This procedure allows evaluation of the mean noise level for each station at different frequency ranges and the identification of temporal variations in the background noise. All the information retrieved in the IPQCC is disseminated between the research teams using a dedicated website, where each station of the network has a specific webpage.

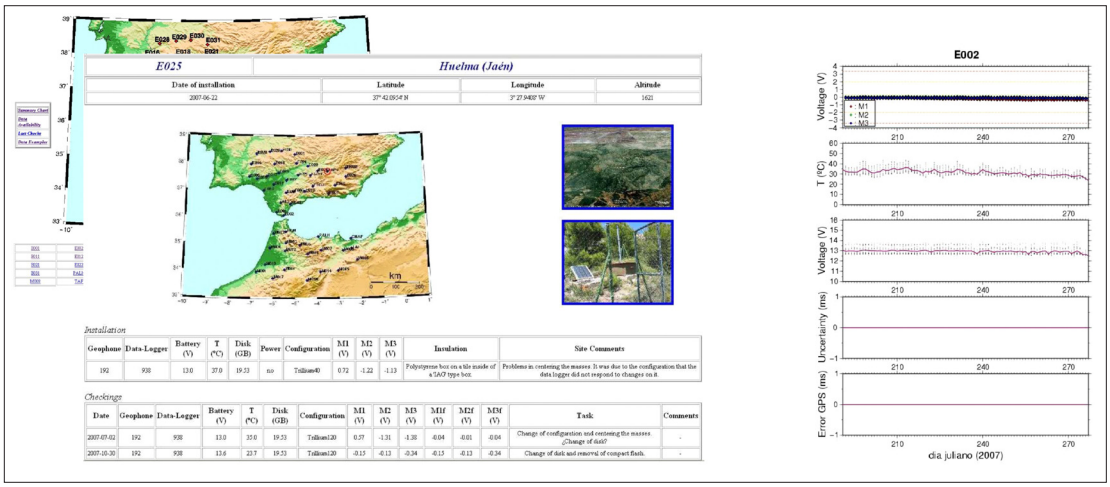

Figure 2. *- Metadata information online server screendump. Each station has a www page where all the related information is reported, including graphics of temperature, voltage and mass centering variations.*

Finally, the data are organized in mini-SEED files (one per station, component and day) and transferred to the FTP server together with the corresponding response files. A duplicate data center has been established to ensure the integrity of the data set. The members of the project can access the data through both data centers using a Continuous Waveform Buffer (CWB) repository (ftp://hazards.cr.usgs.gov/CWBQuery) or by a direct ftp connection.

In a second stage, the IPQCC will systematically extract from the raw data set the events detected by permanent networks. For teleseismic events we use the USGS/NEIC catalog, while for the local and regional events, the reference catalog is the one provided by the Spanish IGN. For the local and regional events, we have implemented a procedure that recovers the complete IGN catalog, including phase picks, then exports it to SEISAN format and extracts the associated waveforms for each station of the IberArray network. Therefore, once the phases have been picked, each event can be located using the previous picks from the permanent networks as well.

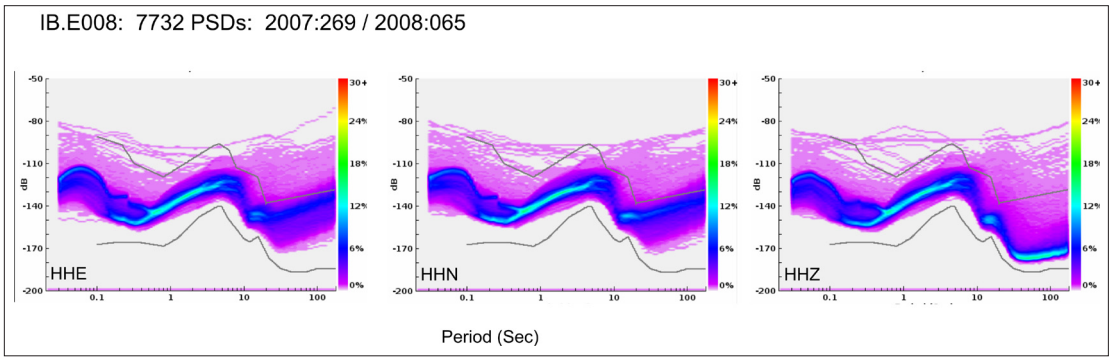

Figure 3. *- Example of the spectral analysis using PQLX systematically performed for each station to evaluate the noise level at different frequency ranges.*

Discussion

The seismic database obtained from the IberArray seismic network will provide a large waveform and catalogue database with unprecedented resolution for this region. Earthquake data at local, regional and teleseismic scales will be analyzed using different methodologies. The first expected result will be a significant increase in the accuracy of the location of regional seismicity and the determination of focal mechanisms, particularly in the Alboran Sea and northern Morocco, where the azimuthal gap will be significantly smaller than the one achieved by permanent networks. Further improvements in characterization of seismogenetic zones will arise from the use of advanced location techniques, such as 3D velocity models and double differences, grid search and maximum intersection methods.

A special emphasis will be attributed to seismic tomographic techniques, using travel times and waveforms of P and S arrivals, surface waves and ambient noise. The rather small

distance between the nodes of the network will improve the resolution of the previous tomographic studies over the region, filling the gaps not resolved by the permanent seismic networks. Surface waves, will also be used in a tomographic scheme to obtain S-wave velocity models with a good resolution in the shallow parts of the models. A third methodological development will be the use of background noise (of environmental origin) to obtain maps of short period (5-20 s) group velocities to provide well resolved S-wave velocity models of the shallow subsurface in all areas, regardless of local seismic activity.

In addition, receiver functions (RF) studies of the broadband data acquired by the IberArray network will provide images of lateral variations of the 410 and 660 discontinuities under the Iberian Peninsula, hence complementing the models obtained by tomographic techniques. At lithospheric scale, the RF data will also provide good quality 2D high resolution sections of the deep lithosphere beneath the Iberian Peninsula.

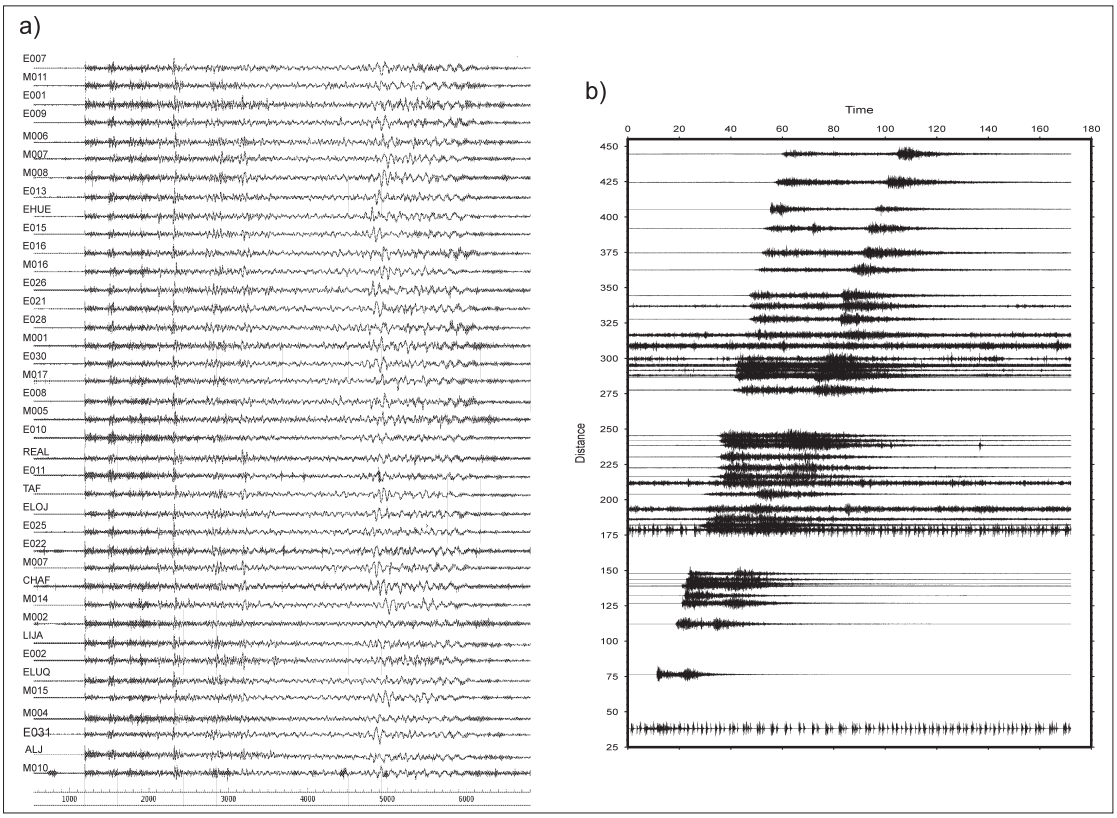

Figure 4. *- First insights in the data. a) Teleseismic event in the Tonga Islands region (09/12/2007 07:28:20.82 Lat: -25.996, Lon: -177.514, Z: 152 km, Mw 7.8, Dist: 165º), b) Regional event in northern Morocco (Tamassint) relocated using Iberarray network, providing an azimuthal gap of 60º (21/01/2008 02:24:03.8 Lat: 35.076, Lon: -3.953)*

Finally, we intend to investigate the presence and properties of seismic anisotropy beneath Iberia using high quality SKS, SKKS and PKS waves. We expect that the acquired data will allow detailed investigation of the possible presence of multiple anisotropic layers, as already suggested in some previous studies.

Acknowledgments

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