# Mapping active faults in the Murcia region, Spain by Nanoseismic Monitoring


University of Stuttgart

**Martin Häge, Manfred Joswig**

Institut for Geophysics, University Stuttgart, Richard-Wagner-Straße 44, 70184 Stuttgart, Germany
Martin.Haege@geophys.uni-stuttgart.de



ESC XXIX General Assembly
Potsdam, September 12-17, 2004



## Abstract

The Seismic Navigating System (SNS) has made it possible to detect very small earthquakes in various places with relative ease. The SNS consists of four seismometers which are of two types; a three-component as well as three one-component seismometers respectively. High resolution of microseismic events is attained by utilizing small aperture of 200m. This method was employed in the Province of Murcia, Spain to register the microseismicity with the aim of mapping active faults. The result revealed a registration of $M_L$=-1 in 10km and $M_L$=-2 in 2,5km distances. The number of estimated events for $M_L$=-1 in 10km distance from the local bulletin correlated nicely with the number of the measured events.


## 1.Tectonic and geological setting

The study area is located in the southeast of Spain, 50km west of Alicante (Fig. 1). The area lies between the Prebetic and the Internal Betic in the Subbetic Zone which is part of the Betic Cordillera. The Subbetic Zone consists of Mesozoic and Tertiary sediments. The Betic Cordillera is situated in the north of the Africa-Eurasia plate boundary. This boundary is defined by a high seismicity which is distributed over a zone of several hundreds of kilometers (CALVERT et al. 2000). The thickness of the crust beneath the Betic is 25-39km (BANDA et al. 1993). Because the seismicity has a very diffuse depth distribution, the lithospheric structure beneath the region is complicated.

As seen in Fig.1, the seismicity results in a number of faults. The active fault CF (Crevillente Fault Zone) strikes southern in the area under investigation.
A geological map of a part of the study area is shown in Fig. 2. The measurement location of Burete lies in the quadrant H5 with cretaceous limestone as geological unit.

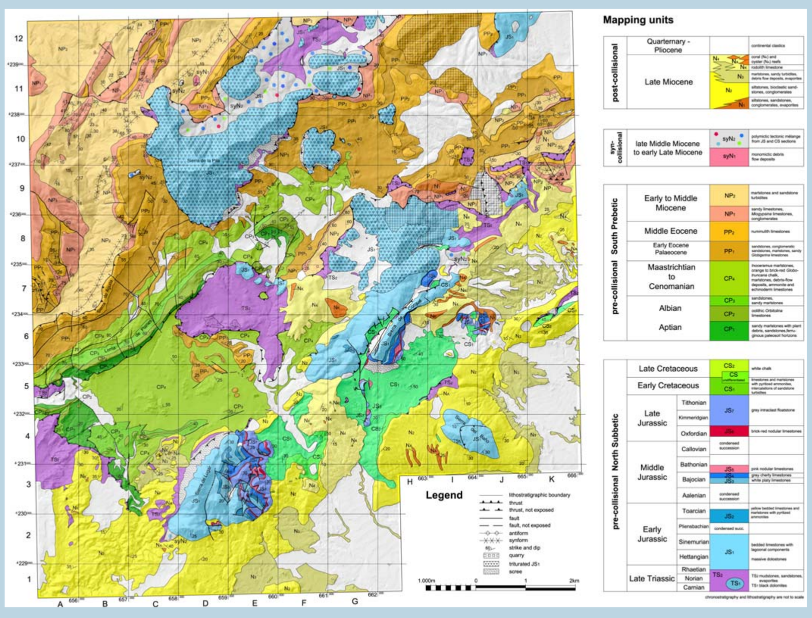


*Fig. 2: Geological map of the area under investigation (from PELZ et al. 2002)*

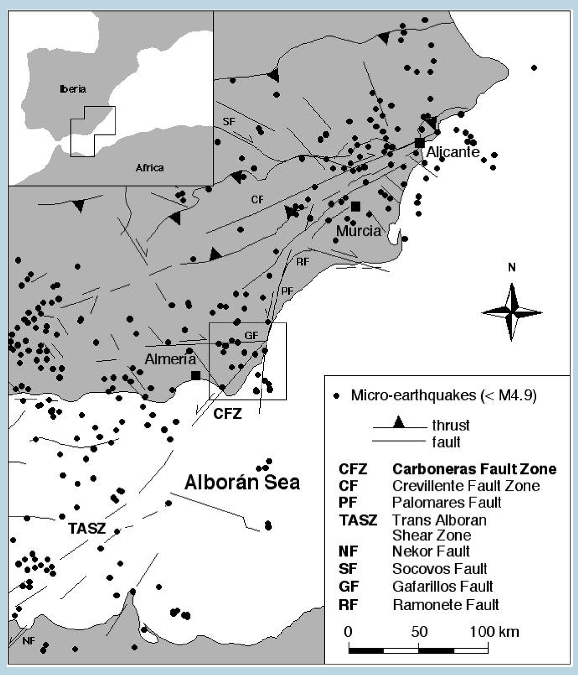


*Fig. 1: Tectonic map of the area under investigation (from REICHERTER et al. 2001)*

## 2. Bulletin estimation

In Fig. 3, earthquakes from 1984-2003 are plotted 60km within the study area Capres. The distribution of the earthquakes is very homogenous and there is no visible clustering. As later shown in Fig. 7, we detected earthquakes with $M_L$=-1 in 10km distance. For this reason, we analyzed the earthquakes 10km around Capres. The measurements were respectively undertaken in Capres and at a location near Burete. Both places were away from civil infrastructure and big streets.
Since it has been earlier stressed that there was no clustering of the earthquakes, an assumption is hereby made that the earthquake activities in Capres and at the location near Burete are the same. Hence, the two data were combined.

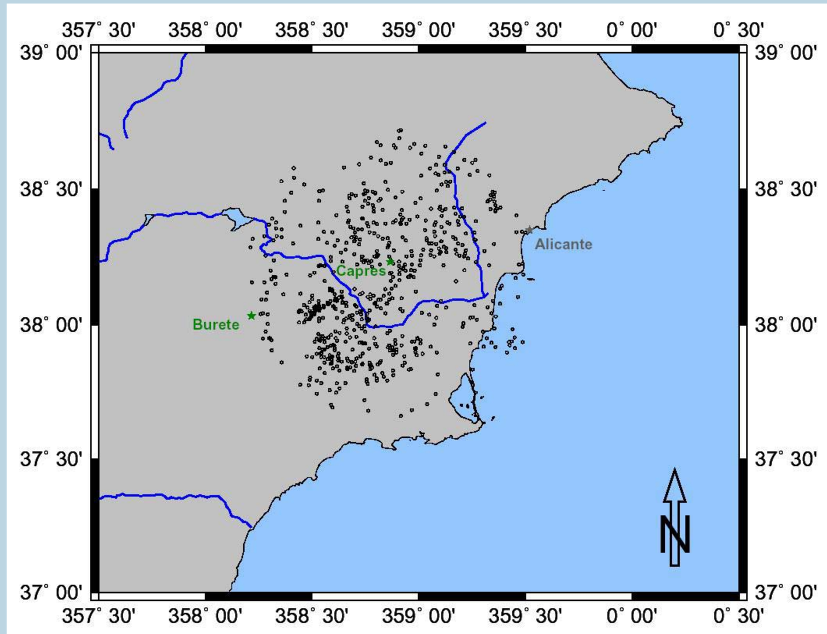


*Fig.3: Epicentral distribution of earthquakes from 1984-2003 60km around Capres*

To get an estimation of how many earthquakes with magnitude $M_L$=-1 are anticipated, we undertook some calculations on the magnitude-frequency graph for the events in the area 10km around Capres as illustrated in Fig. 4 with red curve. For the statistical evaluation of the b value, these 37 events were too sparse and therefore exact valuation were not possible. Hence, assumption of a constant b value over the area around 60km of Capres was made. In order to estimate the expected events with $M_L$=-1, a best fit straight line was drawn through the red graph with the same slope as the magnitude-frequency curve of the events of 60km around Capres.

Reading from Fig. 4, the frequency number for earthquakes with $M_L$=-1 is 10^3,7 which corresponds to 5012 events per year. Consequently, this invariably means we have 14 events in one day. Judging from this, we can expect to have a total of 14 earthquakes with a minimum Magnitude of -1 in one day.

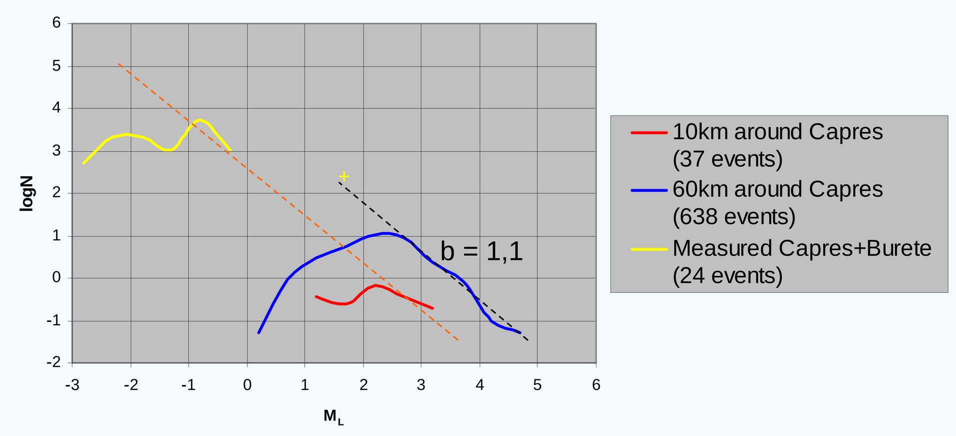


*Fig. 4: Distribution of the number of events versus magnitude per year from regional bulletin (20 years) and Nanoseismic Monitoring (2 nights)*

## 3. Measure conditions

Fig. 5 gives an illustration of the local noise situation in different nights. *Capres** is an example that shows noise as the limiting factor for the sensitivity of the system. *Capres** could not be taken for statistical evaluation because the noise level was too high. During this day, it was very windy and stormy. This is clearly evident in the microseismicity of the sea on the seismogram and can be located to the northeast with the array method. This example shows that there is a need for very low background noise for Nanoseismic Monitoring. The data which were taken for the statistical evaluation are Capres and Burete. One could easily see better conditions; that is a lower noise at Burete. This reflects the higher sensitivity of the measurement in Fig. 7.

An example of an event is depicted in Fig. 6. This is an earthquake with a $M_L$=-1,7 in 2km distance. The station in the north was mounted on a gypsum formation while the other stations were on sediment. Hence, the amplitudes of the SNN (marked red) are attenuated and do not underlay reverberations.

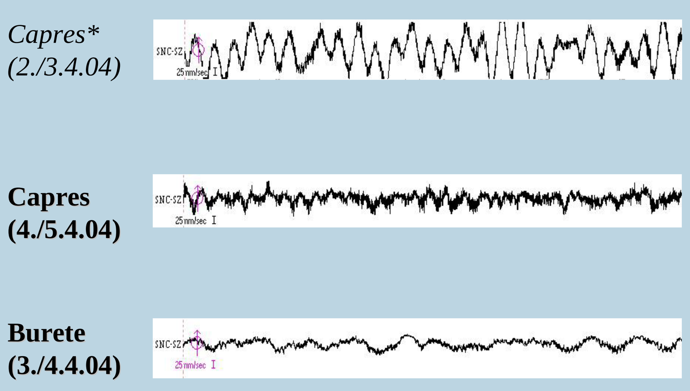


*Fig. 5: Noise samples (20sec, night time) of the measuring places*

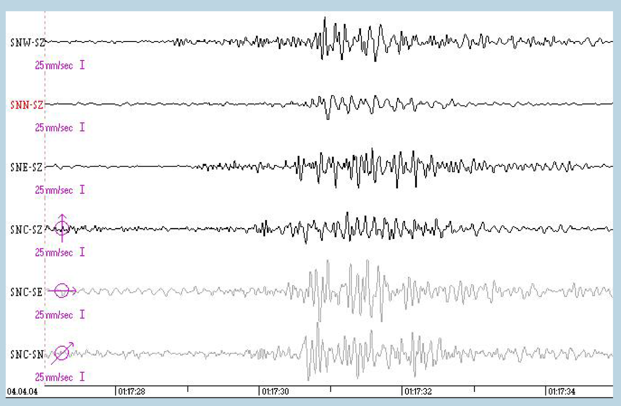

*Fig. 6: Example of an earthquake with a $M_L$=-1,7 in 2km distance. The first three traces present the small array and the fourth to sixth traces the central three component seismometer*

## 4. Measured events

The following pictures show the results of the measurements. Fig. 7 is a plot of the magnitudes versus distances of all detected events (number: 24). As earlier mentioned in paragraph three, the noise conditions at Burete was minimal better compared with Capres. The distance correction curve for $M_L$ is plotted and one could see that the sensitivity of the SNS averages $M_L$=-1 in 10km and $M_L$=-2 in 2,5km distances in the region under investigation. The sum of the registered earthquakes with a $M_L \geqslant$ -1 is 13 and these 13 events were measured in two nights during a 17- hour period. This suggests that the theoretical amount of events on one day is 18.

Considering the high uncertainties in the statistical estimation, this result fits very well with the expected 14 events in paragraph two. This is also shown in the magnitude-frequency distribution of Fig. 4 (measured events in yellow) in comparison to the bulletin calculated graphs. Throughout the measurements of two days, the data acquired were very low and the statistical observation is inconsistent. The implication of this is that a small variation in the data causes significant changes in the curve appearance. However, the nice correlation of the yellow curve with the estimated best fit straight line is clearly seen.

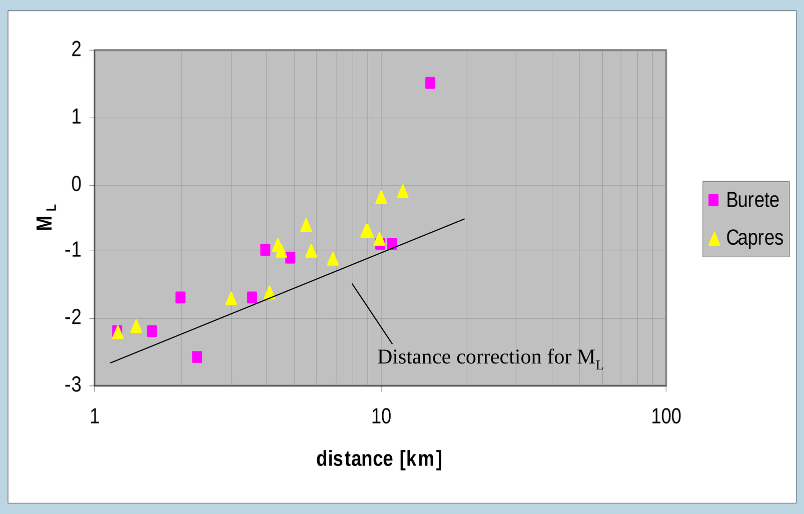


*Fig. 7: Distance correction for $M_L$*

Of the 24 detected events, only 13 events could be located. In some parts, the events were too weak to be picked exactly on the p and s onset; under this situation, only the magnitude could be determined with the maximum amplitude and the $t_s$-$t_p$ time. The located events are shown in Fig. 8 in orange colour. The events detected at the Capres area are scattered irregularly while at the Burete area, a cluster is visible from a measurement taken within a period of only one night.

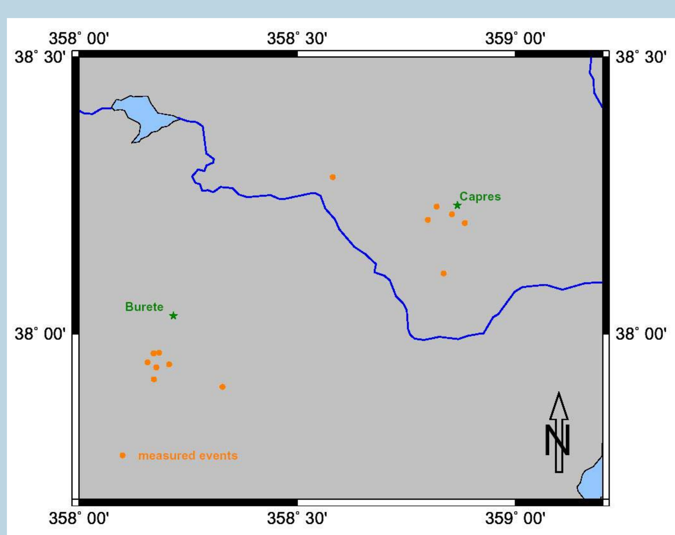


*Fig. 8: Map with measured earthquakes around Capres and Burete (orange dots)*


## 5. References

Banda, E., Gallart, J., García-Dueñas, V., Dañobeitia J.J. & J. Makris (1993). Lateral variation of the crust in the Iberian peninsula: new evidence from the Betic Cordillera, *Tectonophysics*, Vol **221**, 53-66.

CALVERT, A., SANDVOL, E., SEBER, D., BARAZANGI, M., ROECKER, S., MOURABIT, T., VIDAL, F., ALGUACIL, G. & N. JABOUR (2000). Geodynamic evolution of the lithosphere and upper mantle beneath the Alboran region of the western Mediterranean: Constraints from travel time tomography, *J. Geophys. Res.*, Vol **105**, No B5, 10871-10898.

Pelz, K. & H. Seyfried (2002). Improving palaeogeographic concepts through Structural Modelling: Balanced Cross-Sections from the Eastern Part of the Betic Cordillera (Province of Murcia), *poster AGU*, Nizza.

Reicherter, K. & S. Reiss (2001). The Carboneras Fault Zone (southeastern Spain) revisited with Ground Penetrating Radar - Quaternary structural styles from high-resolution images, *Geologie en Mijnbow/Netherlands J. Earth Sci.*, **80** (3-4), 11-20.


## Conclusions

With the Nanoseismic Monitoring, it is possible to detect very weak earthquakes which occur in the vicinity of the system. In this study, we measured 24 earthquakes during a 17-hour period at night and localized 13 events. As clearly demonstrated in this presentation, there exists a high potential to map active faults with microseismic events. For further investigations, it is planned to measure at different sites with the aim of gathering more information about the fault mechanism of very small earthquakes with special attention to site effects (geology) on shallow earthquakes.