

Present deformation and seismic potentiality in the Eastern Pyrenees

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Introduction

Although the current seismicity of the Eastern Pyrenees is moderate, a destructive seismic crisis took place in the Middle Ages (1427-1428) (Banda and Correig, 1984; Olivera et al., 1999), which seems to indicate that periods of low seismic activity are interrupted by destructive earthquakes, probably with long repetition intervals. In fact, there is not enough historical information to estimate the duration of this interval and the use of an interdisciplinary approach- geology, seismology and geodesy- is necessary to assess the present distribution of the tectonic deformation, which is at the origin of destructive earthquakes.

Present tectonic deformations

The study of the distribution of current tectonic deformations originated by the regional stress field is very important in investigating which are the most likely areas of future destructive earthquakes. Analysis of historical and instrumental seismicity data, together with research into the deformations that have affected recent geological formations (Plio-quadernary), enables an initial qualitative approximation of recent tectonic deformations to be made.

Field studies carried out have permitted the analysis of large number of evidences of recent deformations (affecting formations of post-Miocene age), from one side to the other of the mountain range axis (Philip et al., 1991; Fleta et al., 1996). All of these observations suggest the presence of faults with recent activity, liable to be able to concentrate nowadays the regional tectonic deformations. Recent field investigations indicate the presence of morphological evidences and geophysical anomalies in the Bas Valley, but not shallow enough to prove the existence of surface faulting produced by Paleoseismic events (Fleta et al., 2001).

Seismicity

Seismic information based on seismograph readings is available for the eastern Pyrenees, in a very imprecise way, from the start of the century through to the 1970s. The recent development of the seismic network of Catalonia, carried out by the Servei Geològic de Catalunya (SGC), and in particular of the seismic network of the eastern Pyrenees, in collaboration with the Observatoire Midi-Pyrénées (OMP) of the Toulouse, has permitted the detection and location of earthquakes, including even those of small magnitude, which define with precision the areas of current fragility. The distribution of epicentres corresponding to the period 1977-1996 (Fig.1)(ICC, 1999) shows a marked concentration of seismic events of small magnitude at the two extremes of the NW-SE direction fault system -the system in which the areas of damage of the two 1427 earthquakes is concentrated- and very little activity on these faults.

In 1996 a new concept of seismic network was designed that plans to install up to 20 stations equipped with three component broadband sensors with high dynamic range (24 bits) with two main objectives: i) to provide rapid information in the event of a felt earthquake to Civil Defence services and society in general and ii) to obtain systematic quality data for the scientific community. The stations have VSAT antennae to send the seismic information via satellite in almost real time to the ICC, which have a HUB for reception purposes. Data are processed with an automatic location system and they are continuously stored. Data are disseminated through our Website (www.icc.es/sismes) among other means. Five stations are operative at the beginning of 2001 (ICC, 2001).

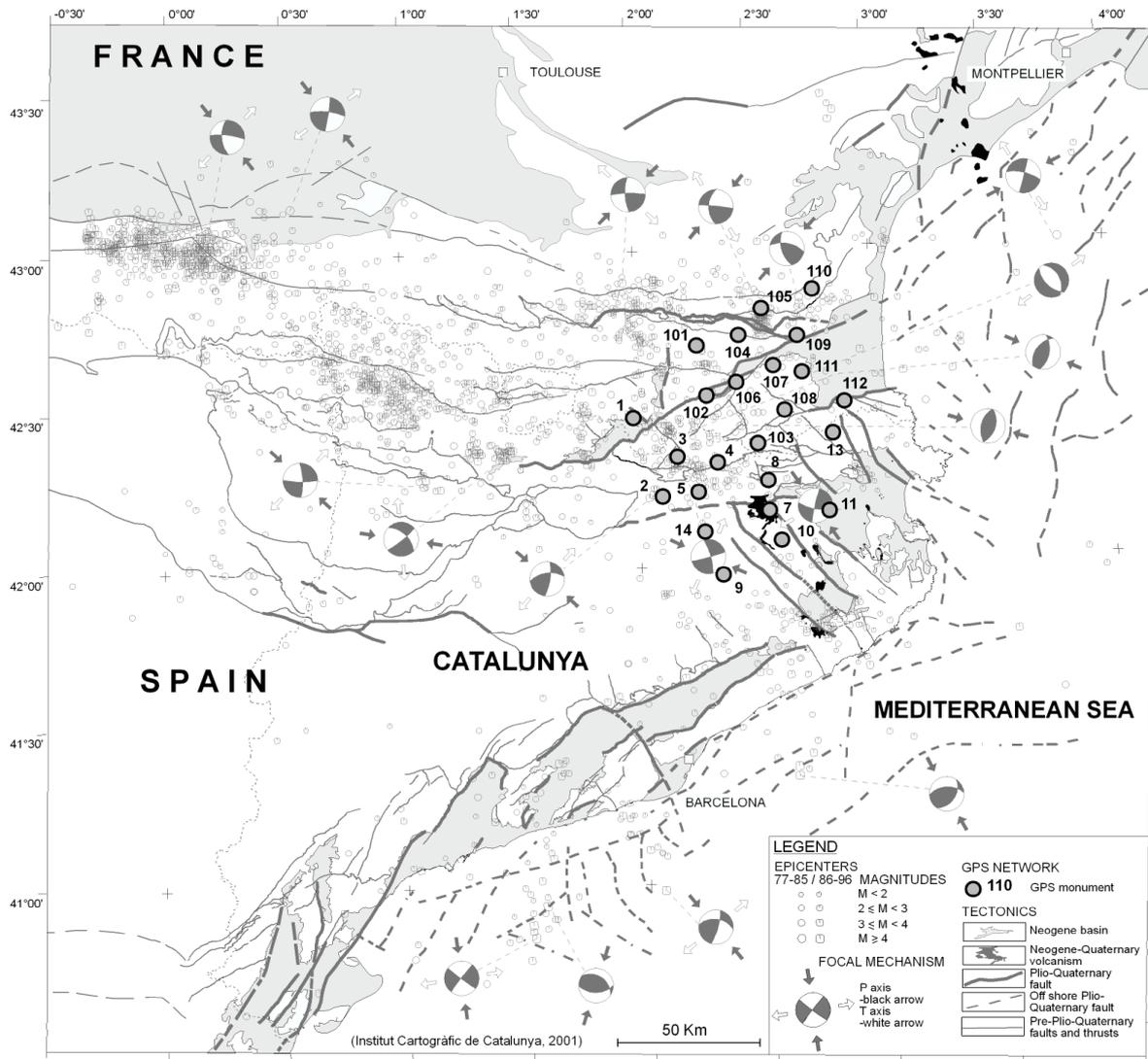


Fig 1. Seismicity 1977-1996 with focal mechanisms and PotSis GPS network on a structural background.

GPS measurements

In 1992 a network of 24 points was set up covering an area of 80 km x 100 km. The mean distance between neighbouring points is about 17 km and the maximum variation in altitude between two neighbouring points is 850 m. The maximum variation in altitude is 1280 m, which restricts the vertical accuracy of the network, but our main interest is to determine horizontal movements. The GPS network was established at both sides of the Eastern Pyrenees as an important part of the PotSis¹ project which is a long term multidisciplinary collaboration between Spanish and French teams to study the present-day tectonic deformations through seismic, neotectonic and geodetic measurements. The expected rate of deformation is of the order of 1 mm/yr. To measure such low rate, the network is periodically observed. The PotSis network has been observed in 1992, in 1994 and in 1999. All the descriptions about each campaign and their processing are shown in Tèrmens et al. (2000).

¹ The PotSis workgroup is composed by the Servei Geològic de Catalunya (ICC), GEOTER (Montpellier), Unitat de Geodèsia (ICC), GEOID (Montpellier), Institut de Protection et de Sùreté Nucléaire (Paris), Observatoire Midi-Pyrénées, Groupe de Recherche de Geodesie Spatiale (Toulouse), Université Scientifique et Technique du Languedoc (Montpellier), Universitat de Barcelona.

The evaluation of movements between PotSis'92 and PotSis'94 are shown in Talaya et al. (1999). The results suggested that the level of noise between surveys separated by two years is comparable to that between two sequential days of measurements recorded by a permanent station. First results of the evaluation of movements from PotSis'99 campaign compared to PotSis'94 show a complex pattern of the distribution of deformations, that can be related to the stress state pattern deduced from microtectonic and focal mechanisms data (Goula et al., 1999). Moreover, the ICC is deploying a permanent GPS network (CATNET), using real time transmission with VSAT stations, some of them installed at the same place than seismic stations (Talaya and Bosch, 1999). This network, together with French permanent stations, will enable us to monitor, in continuous way, the geodynamical processes of the NE part of Spain and Eastern Pyrenees.

References

- Banda, E. and Correig, A. 1984 1428 The catalan earthquake of February 2, 1428. *Engineering Geology*, 20, 89-97.
- Fleta, J., Grellet, B., Philip, H., Escuer, J.; Goula, X. i Bousquet, J.C., 1996. Les deformacions tectòniques en els materials plio-quaternaris de la depressió de Tortellà-Besalú. *Geologia de la conca lacustre de Banyoles-Besalú*, (Maroto, J. & Pallí, Ll. eds.), Quaderns, 17, C.E.C.B., Banyoles, pp. 99-112.
- Fleta, J., Santanach, P., Goula, X., Martínez, P., Grellet, B. and Masana, E., 2001. Geologic, geomorphologic and geophysical studies previous to a paleoseismological analysis of the Amer fault (NE Spain). *Netherlands Journal of Geosciences – Geologie en Mijnbouw* (accepted).
- Goula, X., Olivera, C., Fleta, J., Grellet, B., Lindo, R., Rivera, L.A., Cisternas, A. and Carbon, D., 1999. Present and recent stress regime in the eastern part of the Pyrenees. *Tectonophysics*, 308 (4): 487-502.
- ICC, 1999, Mapa de sismicitat 1977-1997 Escala 1: 400 000. Institut Cartogràfic de Catalunya. Generalitat de Catalunya.
- ICC, 2001. A New Broad-Band Seismic Network with satellite transmission in Catalonia (Spain) Orfeus Newsletter (submitted).
- Olivera, C., Redondo, E., Riera, A., Lambert, J. and Roca, A., 1999. Problems in assessing focal parameters to earthquake sequences from historical investigation: The 1427 earthquakes in Catalonia. *Procs. IX Asambleu Española de Geodesia y Geofísica, SIM2-07*, 8pp.
- Philip, H., Bousquet, J.C., Escuer, J., Fleta, J., Goula, X., Grellet, B., 1992. Présence de failles inverses d'âge quaternaire dans l'Est des Pyrénées: implications sismotectoniques. *Comptes Rendus de l'Académie des Sciences*, vol. 314, II, pp. 1239-1245. Paris.
- Talaya, J. and Bosch, E., 1999. CATNET, a permanent GPS Network with Real Time Capabilities. *ION GPS'99*, 13-18 Sept 1999. Nashville (USA).
- Talaya, J., Feigl, K., Térmens, A., Colomina, I., 1999. Practical Lessons from Analysis of a GPS Network Designed to Detect Movements of ≈ 1 mm/year in the Eastern Pyrenees. *Phys. Chem. Earth (A)*, vol. 24, N. 4, pp. 355-359.
- Térmens, A., Castellote, M., Soro, M., Fleta, J., Goula, X. and Talaya, J. (PotSis Group), 2000. PotSis'92, PotSis'94 and PotSis'99 GPS campaigns to improve the knowledge of seismic potentiality in the Eastern Pyrenees. *WEGENER X General Assembly*. 18-20 Sept. 2000, San Fernando (Spain).