GEOLOGICAL BASED SEISMIC MACROZONATION FOR PYRENEES

COLAS Bastien [1]; GARCÍA Iván [2], BUXÓ Pere [2], ROULLÉ Agathe [1] and GOULA Xavier [3]

(1) BRGM, Montpellier (France). b.colas@brgm.fr, a.roulle@brgm.fr
(2) GEOCAT Gestió de Projectes. S.A., Barcelona (Spain) igarcia@ggp.cat, pbuxo@ggp.cat
(3) Institut Geològic de Catalunya, Barcelona (Spain). xgoula@igc.cat

KEY WORDS: seismic hazard, site effects, shake-map, EC8, GIS mapping, Pyrenees.

INTRODUCTION

The Pyrenean Region is one of the highest seismic hazard areas in France and Spain. Many disastrous seismic events were related in past, e.g. the 1428 earthquake with an estimated epicentral intensity of IX in Catalogne, Spain. The recent seismicity is characterized by low-to-moderate magnitude events which can locally affect people located in urban areas as the 2006 Lourdes earthquake in France.

This study is part of the European project SISPYR, which aims at mitigating seismic risk in Pyrenees. Part of the work of this project consists in building an operating system able to produce real time Shake-Map for all Pyrenees. Actually, a reliable evaluation of ground motion shortly after a main earthquake is critical for an efficient organization of emergency services.

This system, based on the USGS ShakeMap tool (Wald *et al*., 2005), works as follows:

- acquisition of real strong motion data (PGA, PGV..) at bedrock condition
- acquisition of interpreted macroseismic data
- modelling strong motion parameters on the target area from a grid of regularly spaced stations
- ensuring consistency between measured and simulated data, bias correction
- taking account soil amplification
- producing maps

The paper presents the geological based method used for determination of site effects, necessary to take into account for local soil amplifications. This method follows the above steps:

- geological zonation according to geomechanical behaviour for basement and quaternary deposits for all Pyrenes
- definition of representative soil columns
- assignment of main soil classes from soil columns and EC8 building code
- mapping of soil classes on 500 m grid mesh
- attribuation of amplification coefficient from soil classes.

LITHOLOGICAL QUALIFICATION

For shake-map implementations, amplification factors are usually derived from Vs30 values (or classes) using, for example, Borcherdt (1994) method. The way we take is to consider the geological description attached to Vs30 classes as the proxy for evaluation of amplification factors.

We perform the geomechanical map of Pyrenees (or “site condition map”) from two geological maps describing Quaternary deposits and geological structure of Pyrenees at 1:400.000 scale (Courbouleix *et al*., 2008; Baudin *et al*., 2008). In the two maps, after analysing the materials, each geological unit is characterized by a qualitative soil class according to its genesis and its age. We define the following classification

- HR (hard rock) for Paleozoic, Mesozoic and Paleogene materials and volcanic rocks
- SR (soft rock) for Neogene deposits
- SRa (alterd rock) for altered granites
- SS (soft soil) for glacial, fluvial, alluvial and colluvial quaternary deposits
- VSS (very soft soil) for coastal, deltaic and swamp Holocene deposits

The result is a “2.5D” geomechanical classification map which represents a soil column zonation all over Pyrenees (Figure 1).

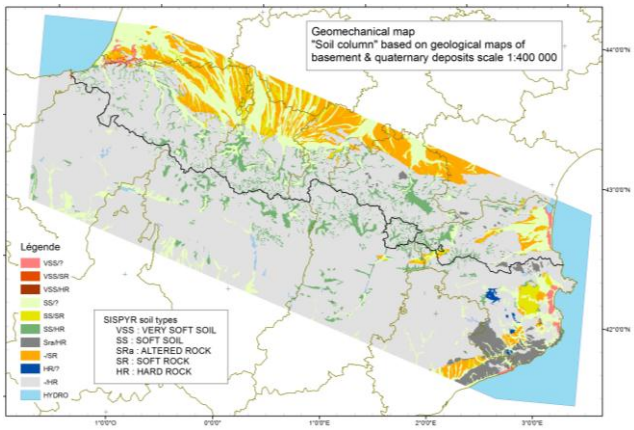

Figure 1 – 2.5 D Geomechanical map

GROUND TYPE ZONATION

To account for the influence of local soil conditions on seismic ground motion, EC8 building code defines 5 main soil classes (A, B, C, D, and E) based on lithological description of a soil column and on geotechnical or geophysical parameters (C_u, N_{SPT}, Vs_{30}). Following Convertito (2009) and from our experience of seismic microzonation in Pyrenees, we adapt this classification considering depths superior to 30 m. We modify the EC8 soil classes adding two classes B' and F corresponding respectively to deep tertiary basins lithologicaly described as soft rock (clays, marls) and deep soft or very soft quaternary deposits.

CHARACTERIZATION OF THE THICKNESS OF DEPOSITS

We use different approaches from both sides of the border to estimate thickness of superficial deposits:

- Deterministic approach in Spain
- Global GIS approach in France

In Spain, work is done at the polygon scale. Thickness is evaluated for each geological unit and for each location from bibliographic resources of different research groups and government agencies, supplemented with boreholes information. This work leads to a synthesis of Quaternary deposits and Neogene basins in the Iberian sector.

In France, the approach is based on the definition of the main geological domains of Pyrenees regarding of the depth of seismic basement. Information of classes of thickness of quaternary deposits is collected from the Pyrenean's quaternary map and from comparison of geological and quaternary map. Back analysis is built from boreholes database available in BRGM.

MODIFIED-EC8 MAP & SEISMIC LOCAL HAZARD

Finally, we assign the geomechanical classification defined in SISPyr project (A, B, B', C, D, E, F) to each polygon of both maps (Fr.Sp.), considering superficial geological formations and the vertical soil column concerned (Figure 2):

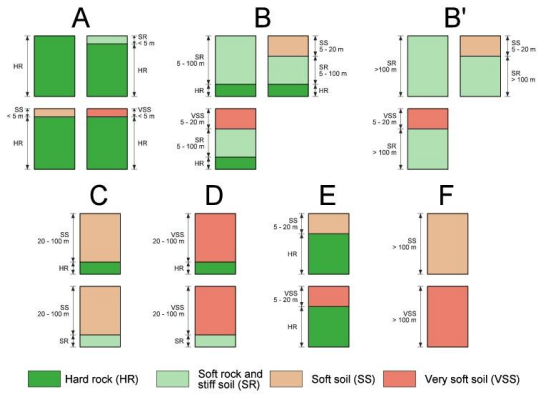

Figure 2 – SISPYR soil columns vs modified EC8 classes

A final step of validation and harmonization across the border leads to produce a final site condition map provided as a 500 m x 500 m grid for all Pyrenees (Figure 3):

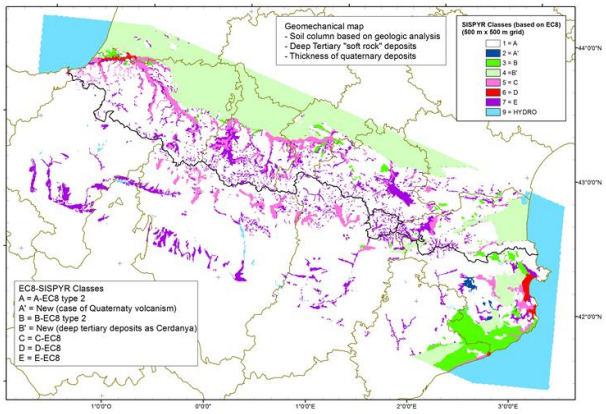

Figure 3 – Modified EC8 soil classes map

Finally, to evaluate site effects, we propose to calculate the values at the surface from the strong motion data at bedrock condition via a computed amplification coefficient. The computation is done at each node of grid of the mesh, for all Pyrenees, according specific assignation of a response spectrum and amplification factors for each modified-EC8 classes.

ACKNOWLEDGEMENTS

We are grateful to EU for supporting SISPYR (Spain–France–Andorra INTERREG IVA Project).

REFERENCES

BAUDIN. T., BARNOLAS. A., GIL. I., MARTIN-ALFAGEME. S. (2008) - Carte géologique des Pyrénées à 1/400 000 (Socle) BRGM - ITGE, Orléans : Editions BRGM.

BORCHERDT R.D (1994) – Estimates of site-dependent response spectra for design (methodology and justification). Earthquake Spectra, vol. 10, n° 4, p. 617-652.

CONVERTITO V., DE MATTEIS R., CANTORE L., ZOLLO A., IANNACCONE G. and CACCAVALE M. (2009) – Rapid estimation of ground-shaking maps for seismic emergency management in the Campania Region of southern Italy. Natural hazards, doi: 10.1007/s11069-009-9359-2

COURBOULEIX. S., BARNOLAS. A., CALVET. M., MARTIN-ALFAGEME. S. (2008) - Carte géologique du Quaternaire des Pyrénées à 1/400 000 BRGM - ITGE, Orléans : Editions BRGM.

WALD, D. J., WORDEN, B. C., QUITORIANO, V., and PANKOW, K. L. (2005) . ShakeMap Manual: Users Guide, Technical Manual, and Software Guide, USGS Techniques and Methods, 12-A1, 128 pp.