GEOLOGICAL AND LITHOLOGICAL CHARACTERIZATION FOR A SEISMIC ZONATION IN A BORDER REGION (CERDANYA, SPAIN-FRANCE)

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INTRODUCTION

One of the objectives of the Interreg IIIA ISARD project is to realize a seismic risk scenario in the Cerdanya area (a cross border valley between France and Spain). Beyond the necessity of taking into account the seismologic parameters of potential seismogenic sources and building vulnerability, seismic scenarios should also include the consequences of soil behaviour on ground motion. The present study aims at estimating the soil behaviour in case of seismic aggression. This has led to the realization of a cross border harmonized lithological map for the superficial formations, which has been the base for the Cerdanya seismic zonation regarding to the EC8 rules.

INPUT DATA – METHODOLOGY

An asymmetric NE-SW trending intra-mountainous Terciary basin, infill by up to 800 m of mainly unconsolidated Neogene sediments is the most striking geologic feature of the Cerdanya valley. The basin, developed along the Tet-Conflent fault, is bounded by a basement made up by consolidated sedimentary, igneous and metamorphic Paleozoic rocks.

Seven geologic maps at 1:50000 scale have been used for the lithological harmonization. Four maps from the French side (Llac *et al*., 1988; Besson *et al*., 1990; Autran *et al*. 2004), and three maps from the Spanish side (Cirés *et al*. 1994; Cirés *et al*. in edition; Losantos *et al*. in edition). Because of the differences in geologic information at both sides of the border, the lithological harmonization has separately been done for each side using a lithological typology created in the frame of the project (Fig. 1).

The final map contains 4716 polygons described by 22 lithological entities, (Table 1 and Fig. 2).

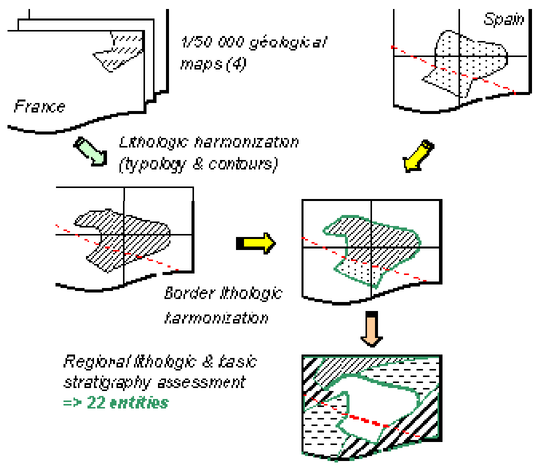

Figure 1 - Harmonization methodology.

	MAIN LITHOLOGY
QUATERNARY DEPOSITS	Q-FILLS
	Q-LANDSLIDE DEPOSITS
	Q-PEATS
	Q-COLLUVIONS
	Q-SCREES
	Q-SCREES & COLLUVIONS
	Q-ALLUVIAL CONES
	Q-DIAMICTONS
	Q-SILTS & CLAYS
	Q-SANDS & GRAVELS
NEGENE DEPOSITS	CLAYS & SANDSTONES OR CONGLOMERATES
	CLAYS
OTHERS	LIMESTONES & MARLS OR CLAYS
	ACID & BASIC ROCKS DYKES & VOLCANICS
	MARLS
	CONGLOMERATES
	GRANITIC ROCKS & SANDS (divided)
	GNEISSES & HORNFELSES
	LIMESTONES & MARBLES
	SANDSTONES & QUARTZITES
	SHALES
	SLATES & SCHISTS & SILTSTONES

Table 1 - Harmonized lithological typologies.

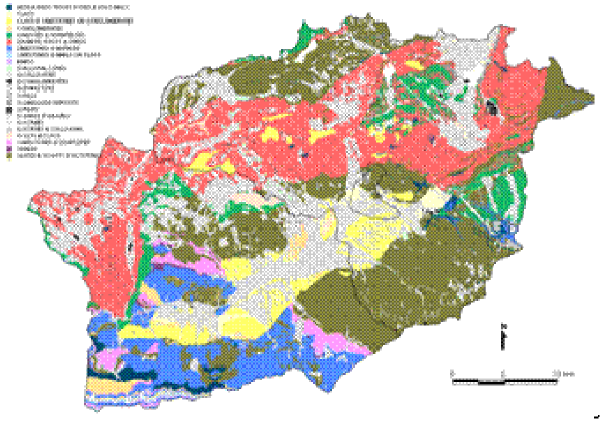

Figure 2 - Lithological harmonized map of Cerdanya valley for superficial formations.

GEOTECHNICAL ZONATION

The geotechnical zonation is based on a simplified litho-stratigraphic mapping including data of:

- Geophysical measurements (SASW and H/V); which give the resonance frequency of the site from H/V .
- Spectral ratio (Nakamura, 1989), a Vs profile from SASW measurements (Bitri et al., 1997) and an estimation of EC8 criteria Vs30 (the average share velocity for the first 30 meters of a soil column).
- Boreholes data from BRGM geologic database.
- A geological and geophysical synthesis of the Cerdanya Neogene basin.

In figure 3 the spectral ratios obtained applying Nakamura's method in one cross-section are presented. The dashed line follows the fundamental frequency drawing the bedrock geometry.

Considering the homogeneity of the Vs30 values on alluvial "sand & gravels deposits" and "diamictons – glacial deposits", the zonation of the Cerdanya valley could be simplified into 6 soil classes (fig. 4) identified as follows:

- Neogene basin deposits.
- Quaternary deposits inside the Neogene basin,
- Rock formations: mainly made up of Paleozoic rocks.
- Local deposits of Neogene formations overlaying the basement, out of the Miocene basin.
- Thin Quaternary deposits, out of the Miocene basin.
- Thick Quaternary deposits, out of the Miocene basin.

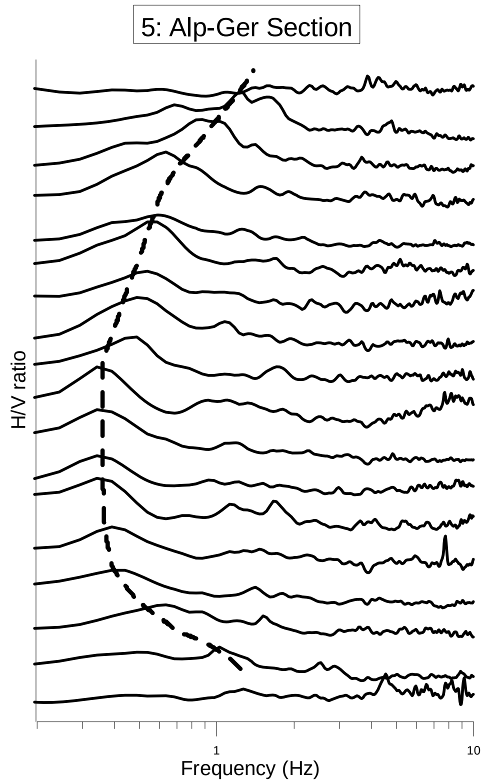

Figure 3 - Spectral ratios of the Alp-Ger profile, the dashed line indicates the fundamental frequencies.

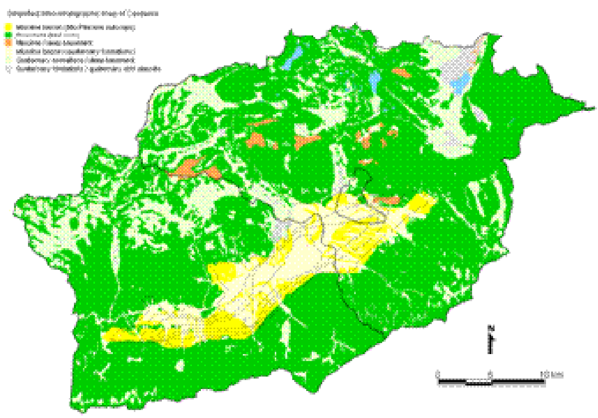

Figure 4 - Simplified litho-stratigraphical map of Cerdanya valley.

Considering each litho-stratigraphic entity and the corresponding values of Vs30 for the main deposits, some zones have been supposed to have the same behaviour in terms of seismic response and could have been merged. The final zonation consists in:

- 1. Rock formations and Quaternary deposits of less than 5 m depth.
- 2. Basin formations (Neogene deposits).

- 3.Quaternary deposits covering Neogene deposits.
- 4.Soft Quaternary deposits covering stiff Quaternary deposits.
- 5. Thin soft soils overlaying the basement (5 and 20 m depth).

The geotechnical zonation is shown in figure 5.

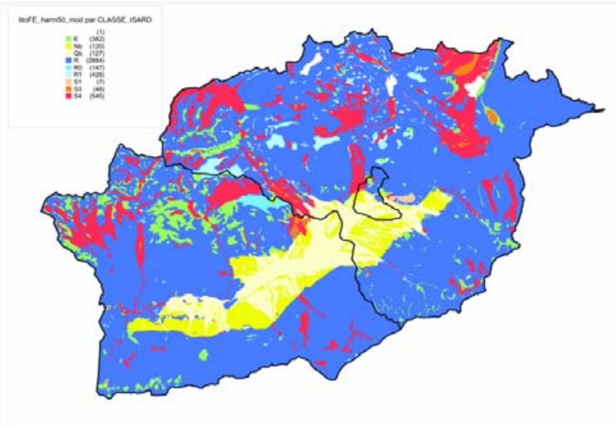

Figure 5 - geotechnical zonation map of Cerdanya valley.

Each geotechnical zone as been associated with an EC8 class as indicated in table 2:

	A Vs>800	B 360<Vs<800	C 180<Vs<360	D Vs<180	E (*)
1					
2					
3					
4					
5					

Table 2 - Determined soil classification in terms of EC8 soil classes (: A soil profile consisting of a surface alluvium layer with Vs_{30} values of class C or D and thickness varying between about 5 m and 20 m, underlain by stiffer material with Vs_{30}>800 m/s).*

SEISMIC ZONATION

In order to perform a complete seismic zonation of Cerdanya Valley, the seismic behaviour of each geotechnical zone showed in figure 5 must be characterized by a transfer function and intensity increment

For each zone, a representative soil column has been defined using geological, geotechnical and geophysical data (as shown in Fig. 9 for the Neogene basin). The transfer function and the intensity increment have been computed for each soil column applying a 1D equivalent linear model using Shake (Schnabel et al., 1972).

The computed seismic responses allowed us to perform a complete seismic zonation that will be used for seismic scenarios purposes (which are one of the final goal of the project) and for future seismic risk studies in the area.

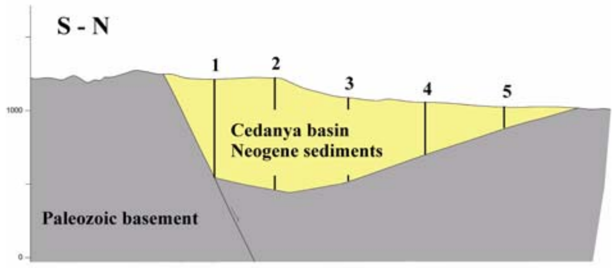

Figure 6 - Cerdanya basin geologic cross section (simplified from Cirés et al. (in edition) showing the location of the soil columns for the 1D numerical computations.

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