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Ground Zoning Map of the Piedmont Region (NW Italy): Methodology and Preliminary Results

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Abstract

This paper briefly describes the methodology and preliminary results of a study aimed at the realization of a Ground Zoning Map of the Piedmont region, characterized by low-to-moderate seismic hazard. In this study, two thematic maps were produced, namely a Lithotechnical map and a Ground Zoning Map of the Piedmont region at 1:250,000 scale. In the Lithotechnical map, the geological units were grouped, on the basis of their strength properties, grain-size, density and weathering of rocks, into 24 categories qualitatively characterized by a homogeneous seismic response. In the Ground Zoning Map, the regional territory was subdivided into three main sectors characterized by homogeneous mechanical behaviour during seismic shaking. These areas were further subdivided into several zones characterized by homogenous lithostratigraphy and/or geo-structural conditions. These maps should constitute the basis for the realization of an updated Vs_{30} map of the Piedmont region, which is currently lacking.

Introduction

The Piedmont region is characterized by a low magnitude seismicity (less than 5 on the Richter scale), mainly clustered in its western sector, alongside the western Alps and in its south-eastern sector alongside the Langhe sector (Perrone et al. 2013 and references therein). In the new seismic classification of Italy (President of the Council of Ministers' Ordinance n. 3274, 20th March 2003) a large part of Piedmont falls into Zones characterized by low and very low seismic hazard. The application of the "New Technical Standards for Constructions, 14th January 2008 Ministerial Decree" imposes the earthquake-resistant designs for structures, and the characterization of ground motions for the entire regional territory. These recommendations are based, following the Eurocode 8 directives (BS EN 1998-1:2004, 2004), on the definition of the Vs_{30} parameter. In this paper, the methodological approach and preliminary results of a study aimed at the realization of thematic maps for the seismic site characterization of the Piedmont region are described. These maps should constitute the basis for the realization of an updated Vs_{30} map of the Piedmont region, which is currently lacking.

Methodology

The paucity of Vs_{30} measurements does not allow direct characterization of the site amplification for the entire study area. Nevertheless, the wide availability of geological maps for the whole study area (Geological Map of Italy on a scale of 1:100,000), even if outdated (most of these maps date back to the first half of the last century), induced us to adopt a geologically-based strategy for the realization of the thematic maps described in the following. In this strategy, when Vs_{30} measurements are not sufficiently abundant or unavailable, surficial geological units are assigned a constant Vs_{30} value on the basis of representative values for a specific geological unit.

In order to update the information regarding this area, geological maps were integrated using GIS software, with the Italian Landslides Inventory (IFFI Project; only landslides wider than 500 m were considered) and with the Quaternary deposits mapped in the Geological Map of the Piedmont region on a scale of 1:250,000 (Piana et al. in press). A preliminary geological map on a scale of 1: 250,000 in shapefile format is required as a starting material for the realization of Vs_{30} maps (Wald et al. 2006), resulting from the integration of these different data. Proceeding from this map, two thematic maps, namely the "Lithotechnical Map" and the "Ground Zoning Map" were created.

In the Lithotechnical Map the geological units were grouped into different categories on the basis of their strength properties, grain-size, density and weathering of rocks. Each category is considered to be qualitatively characterized by a homogeneous mechanical response to seismic shaking.

The Ground Zoning Map (1:250,000 scale) was created (Figs. 1 and 2) starting from the previous one, in which the regional territory was subdivided into different sectors characterized by homogeneous mechanical behaviour during seismic shaking. These sectors were further subdivided into several zones characterized by a homogenous lithostratigraphy. A preliminary Vs_{30} value was assigned to each zone based on the Eurocode 8. Jv and GSI parameters were also assigned, on the basis of the literature, to characterize the fractured bedrock.

This map, despite having a completely different scale, was created using a procedure similar to that proposed for the first level of microzonation studies in Italy (Gruppo di lavoro MS 2008). This methodology has been chosen because, compared to the classical ones (Wills et al. 2000), allows to take into account a greater number of parameters for the characterization of seismic site response, such as: (i) the rock strength of the bedrock, (ii) the thickness of surficial deposits and (iii) the deep-seated gravitational slope deformations (DGSDs) and the fault zones, which cause a strong decrease of the rock mass quality. This allows a more accurate evaluation of the seismic site conditions. In addition, this methodology allows to immediately view, on a regional scale, the different areas qualitatively characterized by different seismic response. This second aspect can be useful both in the land use planning and in the civil protection perspective.

Lithotechnical and Ground Zoning Map

In the Lithotechnical Map the geological units were grouped into 24 different categories. Two main categories were identified, namely the Quaternary surficial deposits and the pre-Quaternary bedrock. The pre-Quaternary bedrock was further subdivided into (i) metamorphic and (ii) sedimentary consolidated bedrock. The DGSDs and the regional fault zones, responsible for the decrease of the rock mass quality were also considered.

In the Ground Zoning Map (Figs. 1 and 2), the regional territory was subdivided into Stable Areas, Stable Areas possibly affected by seismic amplification and Areas susceptible to instabilities, represented in blue, green and red tonalities respectively, on the basis of the lithological characteristics, rock fracturing and thickness of the surficial deposits (Gruppo di Lavoro 2008).

In the stable areas, corresponding to areas where poorly fractured bedrock crops out or is covered by a thin blanket of Quaternary deposits (less than 5 m), no seismic amplification phenomena are likely.

The stable areas possibly affected by seismic amplification phenomena correspond to areas where strongly fractured bedrock crops out, or is overlain by surficial deposits more than 5 m thick. In these areas, amplification phenomena during earthquake shaking could occur.

The areas susceptible to instabilities correspond to areas where permanent deformations, like landslides, could occur. These three categories were further subdivided into 36 different Zones, characterized by a roughly homogeneous stratigraphy for the first 30 m of depth, in which a homogeneous seismic response was expected. A stratigraphic column indicating the range of thickness of each lithotype and a qualitative estimation of its Vs value was also provided for each Zone. Moreover, Jv and GSI parameters were also qualitatively provided for the areas affected by DGSDs and/or fault zones.

In the stable areas, eight Zones were identified (Zones 1–8), where Vs_{30} values greater than 800 m/s were expected. These Zones were mostly widespread in the Western Alps, where poorly fractured metamorphic bedrock crops out and subordinately in the Langhe, Monferrato and Turin Hill, where coarse-grained sedimentary bedrock (conglomerates, breccias, sandstones) crops out.

In the stable areas that were likely to be affected by amplification phenomena, 25 Zones were classified (Zone 9–33), where Vs_{30} of 360–800 m/s were generally expected. These Zones, which were mostly widespread in the Po Plain, Langhe, Monferrato and Turin Hill, and subordinately in the Western Alps, include:

- areas where metamorphic bedrock, affected by DGSDs, crops out, or is overlapped by Quaternary deposits up to 30 m thick; widespread only in the Western Alps;
- fault zones;
- areas where fine-grained sedimentary bedrock (marls, clays, sands, chaotic complexes) crops out, widespread in the Langhe, Monferrato and Turin Hill;
- areas where sedimentary or metamorphic bedrock is overlapped by Quaternary deposits (loess deposits, block streams, glacial till, fluvial deposits, talus deposits) up to 30 m thick;
- areas where Quaternary deposits (fluvial and subordinately glacial and lacustrine deposits) are more than 30 m thick, mostly widespread in the Po Plain and in the main bottom valleys;
- areas where anthropic deposits, more than 30 m thick, are present.

In the stable areas susceptible to instabilities, three Zones were identified (Zones 34–36):

- landslide deposits, up to 30 m thick, that overlie metamorphic or sedimentary bedrock, possibly characterized by Vs values greater than 800 m/s;

• landslide deposits, up to 30 m thick, that overlap a bedrock affected by DGSDs, possibly characterized by Vs values of 360–800 m/s;
• a zone characterised by sinkholes.

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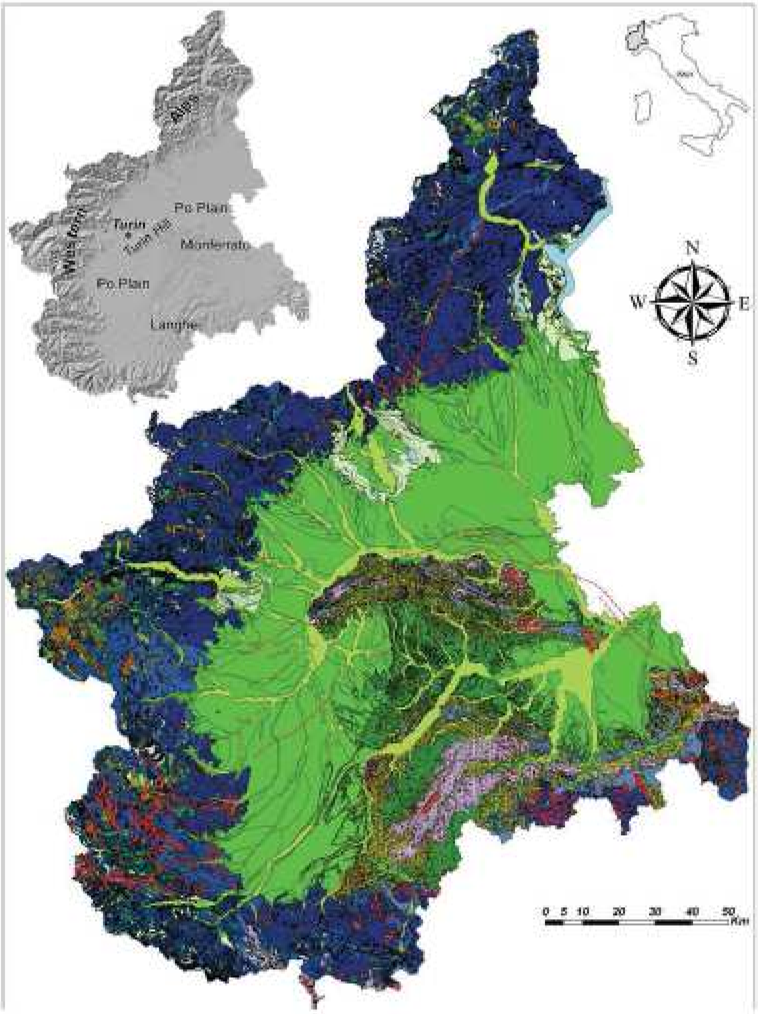

Fig. 1 Preliminary Ground Zoning Map of the Piedmont region. The legend of this map is illustrated in the Fig. 2

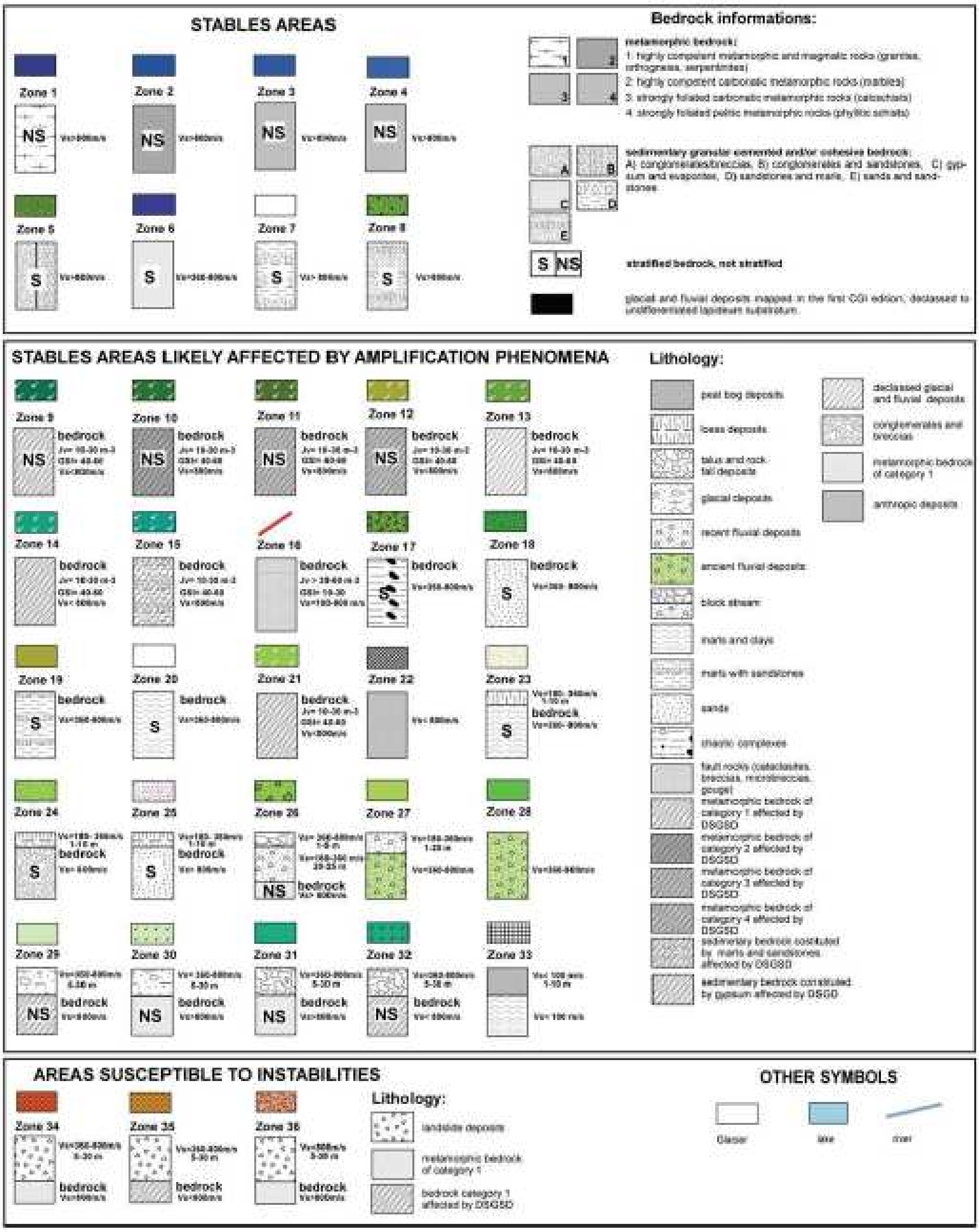

Fig. 2

Fig. 202.2 Legend of Fig. 202.1. In the legend a stratigraphic column has been assigned to each Zone. In the columns the thickness and the Vs values are shown for the different lithologies. The Jv and G.S.I. parameters were also indicated to characterize fractured bedrock (faults, DSGSDs)