NEW SEISMIC SOURCE ZONE MODEL FOR PORTUGAL AND AZORES FOR USE IN SHARE: METHODOLOGY AND PRELIMINAR RESULTS

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***Abstract**: The development of seismogenic source models is one of the first steps in seismic hazard assessment. In seismic hazard terminology, seismic source zones (SSZ) are polygons that delineate areas with homogeneous characteristics of seismicity. The importance of using knowledge on geology, seismicity and tectonics in the definition of source zones has been recognized for a long time. However, the definition of SSZ tends to be subjective and controversial. In the SHARE (Seismic Hazard Harmonization in Europe) FP7 project, seismic hazard will be assessed with a logic tree approach that allows for three types of branches for seismicity models: a) smoothed seismicity, b) SSZ, c) SSZ and faults. In this context, a large-scale zonation model for use in the smoothed seismicity branch, and a new consensus SSZ model for Portugal and Azores have been developed. The new models are being achieved with the participation of regional experts and external experts, according the SSHAC (1997) level-3 methodology.*

***Key words**: seismic-source-zones, seismic-hazard, SHARE.*

Project SHARE (Seismic Hazard Harmonization in Europe) of the 7th Framework Program of the European Commission aims to evaluate European seismic hazards using an integrated, standardized approach. Work Package 3 (WP3) specifically involves the identification and characterization of the earthquake sources to be used in the European source model. Towards this end, Task 3.2 is to compile a European database of active faults and seismogenic sources and Task 3.4 is to develop a seismic source zone model. To accomplish the objectives of project SHARE, Europe has been divided into seven regions, and Instituto Superior Tecnico (IST) has been tasked with integrating data from the Iberian Peninsula, Maghreb region and the Azores.

Project SHARE will utilize a level-3 SSHAC (1997) methodology, wherein various regional experts come together in a workshop setting to present the results of relevant research to integrators and external experts. Subsequently the data is evaluated by the integrators and expert panel, who determine how to integrate the various contributions using a logic tree approach.

In order to comply with the SSHAC (1997) level-3 methodology, a SHARE-IBERIA workshop was held in January 2010 in Olhão, Portugal, with the participation of a large number of regional experts. The discussions focused on the locations, geometries, segmentation behaviors, activity rates, and recurrence intervals of faults in Iberia and Azores, which are considered to be active in the current stress regime. The panel of external experts included Dr. Kuvvet Atakan (University of Bergen), Dr. Ivan Wong (URS Corporation), and Dr. Pilar Villamor (GNS, New Zealand). At this workshop, a first draft of a seismic source zone model for Portugal and Azores was developed. The model was further discussed in February 2010, during a meeting in Lisbon where a small group worked on a preliminary model that could be distributed and discussed by the regional community. The resulting first-iteration-model, together with a preliminary justification of the boundaries, was sent out for discussion to the regional experts and external experts. In June 2010 at the annual meeting of the SHARE project, the integrators presented the models and new input was received from the participants and task leaders. The second-iteration model, and the corresponding boundary justifications will be distributed for a second round of feedback from the regional and external experts.

In the SHARE project, the logic tree will allow three types of branches for seismicity models: a) smoothed seismicity models, b) seismic source zone models, and c) seismic source zone models and faults, as stated in the document "Specification of source models to be used in SHARE" by Sørensen, Grünthal, Pagani and Woessner. For the application of the smoothed seismicity approach it is necessary to define large-scale source zones**.** The large-scale zonation should be based on the geological architecture, and should also reflect large differences in earthquake source processes, catalogue completeness, and ground motion attenuation. The seismic source zones (SSZ), which are the subject of the present paper, are geographic polygons that delineate areas with homogeneous characteristics of seismicity. The characteristics of seismicity that must remain constant within a SSZ are the maximum magnitudes, the probability of activity or probability of existence, and the activity rates (although some variability in the activity rates can be allowed, depending on the methodology). The characteristics of the earthquake catalogues, in particular the detection threshold or completeness, should also be input for the SSZ model (Frankel et al., 1996).

Because delineating SSZ involves the use of a wide range of data (geological, geophysical and seismological) and scientific interpretations, zonation models tend to be subjective and controversial (e.g., Reiter, 1991). SSHAC (1997) provides guidelines for establishing seismic source zones for hazard assessment. They distinguish amongst four types of SSZ: A) area sources that encompass spatial clusters of seismicity; B) regional area sources; and C) background area sources. The main difference between type-B and type-C SSZ is the scale (tens of kilometers for regional area sources and hundreds of kilometers for background area sources).

For the type-A SSZ the most useful and credible data types are well-located instrumental seismicity and mapped faults in the vicinity of seismicity. Data types with moderate usefulness and credibility include historical or poorly located seismicity and structural features that are parallel to zones of seismicity. For type-B SSZ data usefulness/credibility is considered high for criteria that account for changes in the spatial distribution of seismicity and regions of genetically related tectonic history. Data pertaining to changes in structural styles and changes in crustal thickness or composition are considered to have moderate usefulness/credibility. Data types with low usefulness and credibility include variations in geophysical signature, regional stresses and regional physiography (surface landforms). For type-C background area sources, data on regional differences in structural styles, tectonic history, physiography, and geology are considered to have the most value in terms of usefulness and credibility, whereas data on changes in the character of seismicity provide a low level of usefulness and credibility for delineating zone boundaries.

Taking into account SHARES's goals and the data available in the Iberian region, the SSZ required can be classified as type-B, meaning that they should reflect first-level changes in the spatial distribution of seismicity and genetically related tectonic history, second-level changes in structural styles and in crustal thickness, and third-level changes in geophysical characteristics, regional stresses and physiography.

The application of the SSHAC (1997) guidelines for developing type-B SSZ is not straightforward and some SSZ are still under debate.

Some major outstanding issues identified at the June 2010 SHARE meeting in Rome regarding the first-iteration model presented here that will be addressed in the next iteration are 1) the extent of the zone that includes the Lower Tagus Valley, since that zone is particularly inhomogeneous with respect to the distribution of seismicity rates; 2) the need to accommodate a rupture length compatible with a M8.5 earthquake in the region SW of Iberia; and 3) the change in the completeness time periods of the historical seismicity record across the shoreline.

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References

SSHAC (1997) [Senior Seismic Hazard Analysis Committee, Budnitz, R.J., Chairman, G., Apostolakis, D.M., Boore, L.S., Cluff, K.J., Coppersmith, C.A., Cornell, & P.A. Morris] (1997) Recommendations for probabilistic seismic hazard analysis: Guidance on uncertainty and use of experts: Washington, D.C., U.S. Nuclear Regulatory Commission Report, NUREG/CR-6372.

Frankel, A., Mueller, C., Barnhard, T., Perkins, D Leyendecker, E., Dickman, N., Hanson, S., and Hopper, M. (1996). National Seismic Hazard Maps: Documentation, Open File Report 96-532, U.S. Geological Survey, USA.

Reiter, L. (1991) *Earthquake Hazard Analysis: Issues and Insights,* Columbia University Press, USA.