COMPILATION OF ACTIVE FAULT DATA IN PORTUGAL FOR USE IN SEISMIC HAZARD ANALYSIS

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SUMMARY

To estimate where future earthquakes are likely to occur, it is essential to combine information about past earthquakes with knowledge about the location and seismogenic properties of active faults. For this reason, robust probabilistic seismic hazard analysis (PSHA) integrates seismicity and active fault data. Existing seismic hazard assessments for Portugal rely exclusively on seismicity data and do not incorporate data on active faults. Project SHARE (Seismic Hazard Harmonization in Europe) is an EC-funded initiative (FP7) that aims to evaluate European seismic hazards using an integrated, standardized approach. In the context of SHARE, we are developing a fully-parameterized active fault database for Portugal that incorporates existing compilations, updated according to the most recent publications. The seismogenic source model derived for SHARE will be the first model for Portugal to include fault data and follow an internationally standardized approach. This model can be used to improve both seismic hazard and risk analyses and will be combined with the Spanish database for use in Iberian- and European-scale assessments.

1. INTRODUCTION

Active fault databases provide essential input data for robust probabilistic seismic hazard analyses (PSHA) that incorporate both seismicity and active fault data. Project SHARE is a regional program of the Global Earthquake Model (GEM) initiative, and represents a large collaborative effort to compile a seismic hazard model for the Euro-Mediterranean region to be used for PSHA. The SHARE seismic source model will use a logic tree approach to integrate data on active faults (herein termed “seismogenic sources” following SHARE terminology), seismicity data, and a seismic source zonation model. A major task within SHARE is the compilation of a European database of seismogenic sources; to accomplish this goal, the existing Italian Database of Individual Seismogenic Sources (DISS) ([1],[2]) is being expanded to include data from the Euro-Mediterranean region. This ambitious goal requires the integration of a large amount of data into a uniform framework, and requires the adoption of common methodologies and uniform standards for the definition and characterization of active seismogenic sources.

Project SHARE was designed to follow the SSHAC (Senior Seismic Hazard Analysis Committee) Level-3 strategy, wherein regional experts present their data to integrators and external experts in a workshop setting ([3]). The integrators and experts are responsible for evaluating the data and determining how to synthesize the various contributions into a logic tree. SSHAC recommendations describe a strict protocol for incorporating expert opinions and capturing uncertainties in PSHA ([3]); SSHAC Level-3 guidelines have been recently updated and revised based on lessons learned from a decade of implementing the original guidelines ([4]). A fundamental aspect of the SSHAC approach is the recognition that true consensus is not a realistic goal, and a more appropriate aim is for a PSHA source model "to represent the center, body, and range of technical interpretations" of the larger informed technical community ([3]).

2. PRELIMINARY SEISMOGENIC SOURCE DATABASE FOR PORTUGAL

Following the SSHAC methodology, a SHARE Iberian regional workshop was held in January 2010 in Olhão, Portugal. This productive meeting brought together researchers from throughout Portugal and Spain to present their research on active faulting in Iberia. At the Iberian regional meeting, the SHARE Iberian fault database was established as a broad, community effort, and researchers were invited to submit their data on seismogenic sources to the regional integrator for incorporation into the SHARE database. The task of compiling seismogenic source data for Portugal to integrate into the Iberian database has been significantly facilitated by the existence of the GIS Seismotectonic Database for Mainland Portugal ([5],[6]). Although this existing seismotectonic database is still in progress, and therefore incomplete, it has provided an excellent starting point for the compilation of seismogenic parameters for the sources in Portugal that will be used in the SHARE model.

The GIS Seismotectonic Database for Mainland Portugal contains relevant data for PSHA, though the focus is slightly different because the database was intended to be a repository of active fault data rather than a specific compilation of input data for a PSHA. In the current effort to compile a parameterized seismogenic source database for Portugal, faults in Portugal are characterized in terms of "composite seismogenic sources", following conventions established within the DISS database. Composite seismogenic sources (termed "seismogenic areas" in [1]; later renamed within the DISS database) are modeled with a complex geometry to capture both geological and geophysical data from large-scale tectonic features and localized geomorphic, geological, or geophysical evidence for active deformation ([1]). The composite seismogenic source framework for describing active faults was developed specifically for use in regional-scale PSHA applications ([1]).

The seismogenic source database for Portugal includes the following fields: source name, compiler name and affiliation, fault location (described as two or more pairs of geographic coordinates), segmentation data, minimum, maximum and preferred values for fault length, fault width, minimum and maximum rupture depth, strike, dip, rake, slip rate, and maximum magnitude; preferred values for recurrence interval, single event displacement, style of faulting, most recent earthquake, elapsed time since most recent earthquake, and penultimate earthquake; summaries, notes, links to relevant files, and an indication of the type of evidence that a certain fault exists, according to a specified "quality factor" scheme. For details on the definitions of all seismogenic parameters, see ([2]). The specification of minimum, maximum and preferred values for many of these parameters ensures that the database contains the appropriate epistemic uncertainty ranges to encompass these critical parameters. For consistency with the DISS database, each parameter has an associated code that indicates whether the value is based on 1) literature data, 2) original data, 3) empirical relationships, 4) analytical relationships, or 5) expert judgment ([2]).

The definition of an "active fault" can vary widely, for example, the Quaternary Fault and Fold Database of the United States includes faults that are considered to have been active during the Quaternary (the past 1,600,000 years) ([7]), whereas the Active Faults Database of New Zealand only includes faults that are known to be active in the Late Quaternary and younger ([8]). For practical purposes in PSHA applications, the appropriate definition of an active fault may be different for different tectonic regimes. Due to the slow slip rates in Portugal and the limited body of paleoseismic data, all faults in Portugal with a reasonable likelihood of being active and seismogenic within the current stress regime meet the criteria for inclusion in the SHARE Iberian seismogenic source database.

Whereas a protocol has not yet been established within project SHARE for handling the epistemic uncertainty that pertains to whether or not a specific fault source is active and capable of generating earthquakes, it has been recommended that the seismogenic source database should include a quantification of the likelihood of activity of each source. "Probability of Activity" [P(a)] is a system that has been used in PSHA studies to capture the epistemic uncertainty inherent in the judgment about whether or not a fault is active and seismogenic (e.g., [3]). In the implementation of this system, P(a) occupies the fault database as an independent field and provides a quantification of whether or not a fault is active; this uncertainty is then treated in a probabilitistic manner within the PSHA. Because of the slow slip rates in Portugal and throughout Iberia, there is a substantial amount of uncertainty regarding the Quaternary activity of many faults, and the implementation of a P(a) classification within the database allows for the inclusion of fault sources for which there is some, but no definitive data to indicate that they are active. The approach within the existing DISS database to these controversial sources is to label them as "debated seismogenic sources". However, a shortcoming of that approach is that the debated seismogenic sources are ultimately subject to a binary decision about whether or not they should be included in the source model. In order to accommodate a more robust representation of the potentially active faults in Portugal, the concept of debated seismogenic sources has been replaced with the P(a) scheme within the SHARE database; all faults with a P(a) <1 can be considered as debated sources, and the database can be filtered according to P(a) for use in the source model, as deemed appropriate.

To develop the database of seismogenic sources in Portugal, all regional experts were invited to act as (and be credited as) compilers of the seismogenic parameters. However, in order for the fault sources to be included in the SHARE hazard model, it was necessary for the integrators to make informed assumptions to complete the parameter table. These assumptions are preliminary, and will be updated on a case-by-case basis, as appropriate, with the introduction of additional credible data.

To date there are 32 composite seismogenic sources and 74 individual fault segments in the preliminary seismogenic source database for Portugal, which currently only includes sources on the mainland (Figure 1). The fault with the highest slip rate (≥0.4mm/yr) is the Manteigas-Vilariça-Bragança fault in northeastern Portugal ([9],[10],[11]). Most of the other faults in the database have substantially lower slip rates (preferred slip rate values between 0.01mm/yr and 0.1mm/yr), and are only expected to contribute to the seismic hazard at long return periods. In conjunction with the IBERFAULT meeting in October 2010, this preliminary database of seismogenic sources in Portugal will undergo a round of revision by regional and external experts in accordance with SSHAC methodology. At this point, the source model will be improved with a greater level of detail, and incorporated into the updated SHARE European fault database.

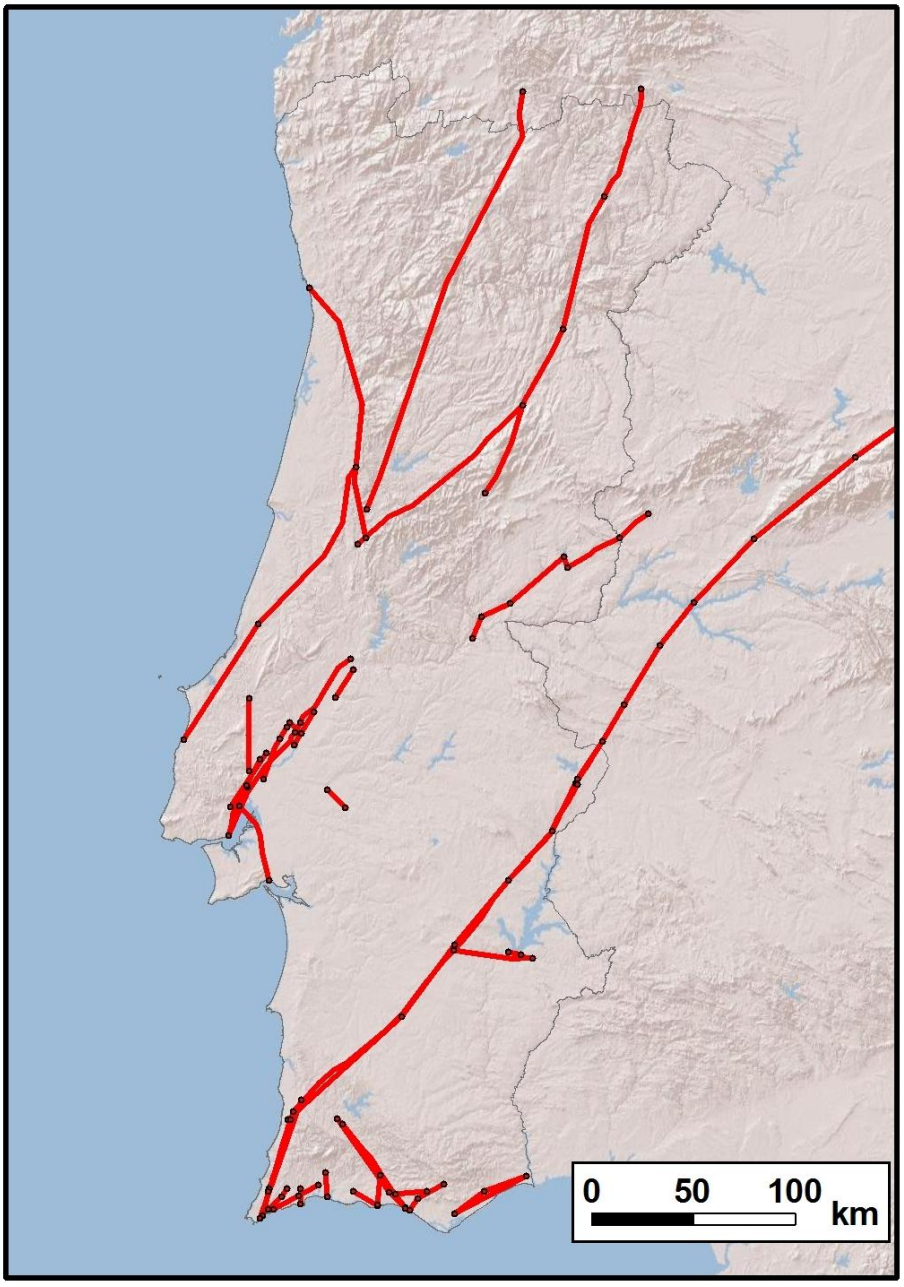

Figure 1. Map of mainland Portugal showing the surface traces of the composite seismogenic sources in Portugal that are included in the preliminary version of the SHARE Iberia fault database. Segment boundaries are indicated with black dots.

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