SEICHE - SEIsmicity of the plate interiors: Challenges for Hazard Evaluation

Executive Summary

The provision of security to the populations is at the heart of the social contract between a modern state and its citizens. Alongside with terrorism, crime or epidemics, earthquakes – particularly in countries with a geologic setting conducive to their occurrence - rank high in the list of threats met with an organized response, in view of their extremely disruptive effect upon the societies. Building codes are the most effective tool to mitigate earthquake risk: while designing a structure, the engineer must make sure that it can withstand a level of ground shaking that has a low – in the sense of socially acceptable – probability of being exceeded during the structure's lifetime. This can only be achieved after characterizing for a given site A) the process of earthquake occurrence within the relevant range of distances; B) the propagation of the seismic waves from the sources to the site; C) the level of ground shaking with a given probability of exceedence. This characterization is called **probabilistic seismic hazard assessment** (PSHA).

The seismicity of Portugal results from the convergence between Nubia and Iberia [1]. Despite its history (with earthquake disasters in 1344, 1356, 1722, 1755, 1858, 1909), for decades Portugal lagged behind in the application of the fast evolving PSHA techniques [2, 3]. This void was addressed at ICIST with a strategy that consisted of: A) launching research initiatives involving leading international experts; B) recruiting research students with high quantitative skills. As a result, a series of Ph.D. projects in seismology (at IST or away) built up the core of ICIST's seismology team from 2001 to 2007 [4, 5, 6, 7]. The year 2008 was a turning point for the team, in that A) the junior members begun attracting research funds as PI's in a sustained way; B) the team was invited to join international consortia (FP7 project MIAVITA, started in 2008; FP7 SHARE, started in 2009; FP7 EPOS, started in 2010).

Recent work of the team covered all the components of PSHA: historical [8, 9] and instrumental seismicity [10], palaeoseismology [11, 12], geomorphology [13], ground motion attenuation [14], instrumental source studies [15, 16], InSAR deformation monitoring [17] and PSHA proper [18, 19, 20]. This makes ICIST unique at national level in terms of installed capacity for seismic hazard studies. In the scope of FP7 project SHARE (Seismic Hazard Assessment for Europe), the PI coordinated fault source characterization in Iberia, and the team contributed also to improve the regional seismic catalogue and ground motion prediction equations.

Further progress requires re-thinking. Although the overall deformation budget is constrained by the rate of convergence between Nubia and Iberia of ~5mm/year [1], we ignore what percentage is taken up by faults away from the plate boundary. Besides, several assumptions of the technique are under increasing criticism in what concerns their validity in plate interiors [21]. Clustering of earthquakes in time and space became a widespread observation ~~in continental regions~~ [22], including Portugal [12]. Interaction between faults through stress transfer is now well understood [23], and was proposed for Portugal [8], and migration of earthquakes in space was documented [24; 25]. Space geodesy evidenced a continuum of fault behaviour from stick-slip to aseismic creep [26, 27, 28]. The locking depth of a fault was recognized as a key factor in hazard assessment [29].

The SEISHE project will seek answers to the following questions: A) which continental faults take up part of the convergence between Nubia and Iberia? B) How much does each fault contribute, and in what regime? Instead of the usual approach of modelling the regional deformation and checking predicted fault activity against (often unreliable) neotectonic data [30], we will start from the direct observation of the candidate continental faults over different time windows, thus producing key basic data not available currently:

- A systematic geomorphological investigation will identify the target structures;

- hypocentral relocation will clarify the association of seismicity to faults, and define locking depths;

- palaeoseismology will be used to study the long-term behaviour, including clustering;

- InSAR time-series of large image catalogues will be used to measure the average (aseismic) strain rate on each structure over the last decades.

Important outcomes of this analysis will be: a probability of activity for each fault; a robust estimate of the maximum magnitude for each fault, with associated return period; information on the current status of each fault (locked, creeping, loaded, in cluster, etc). These results will consolidate current PSHA for Portugal through a better understanding of the stress build up process, while paving the way for a new generation of hazard maps, and more effective risk mitigation.