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NEOTECTONICS STUDIES OF HAZARDOUS FAULTS IN THE CENTRAL ANDES: ISSUES AND CHALLENGES

Costa, Carlos H.

Departamento de Geología, Universidad Nacional de San Luis, Ejército de los Andes 950, Bloque II, 5700 San Luis, Argentina
costa@unsl.edu.ar

Abstract (Neotectonic and hazardous faults in the Central Andes: issues and challenges): *Neotectonic and paleoseismological studies constitute a basic requirement for seismic hazard assessment. At the Central Andes, as in many other regions, most seismic hazard assessments rely on the seismic catalog data. In other cases, neotectonic and paleoseismological data, when available, are often partly used or their results could be even misleading for users. This contribution aims to briefly address some current issues and challenges posed by the current state of the art and recent advances on the neotectonics of the Central Andes and adjacent regions, as regards to its contribution to seismic hazard analyses.*

Key words*: Central Andes, Neotectonics, Seismic hazard*

INTRODUCTION

It is widely accepted that geologic analysis of recent deformation is a necessary input data in seismic hazard assessment, allowing the recognition of pre-historic earthquakes that have deformed the earth surface. This approach allows sometimes to avoid the underestimation of the seismogenic potential posed by neotectonic structures. Such information is very relevant particularly at intraplate regions, where the seismogenic capability of fault sources is not well illuminated by current crustal seismicity, mostly because the return period for damaging earthquakes is beyond the short time spam covered by the historical and instrumental seismicity.

There is a general agreement to consider that in the Andean and sorrounding areas, the Quaternary period provides a conservative time framework to include structures that have produced earthquakes in the past and have the capability for generating damaging earthquakes in the future, thus posing a threat in terms of seismic hazard. (Costa et al. 2006; Multi Andean Project, 2009). Therefore, structures with evidences of Quaternary deformation (here also named as neotectonic structures) are considered potentially hazardous as for seismic hazard purposes. Hundreds of these structures have been inventoried along the Central Andes in South America, particularly during the last two decades (Audemard et al., 2000, Costa et al., 2000, Paris et al., 2000; Egüez et al., 2003; Lavenu et al.2000; Macharé et al., 2003; Saadi et al., 2002; PMA, 2009; Veloza et al., 2012). However, only a few of these structures have been studied under neotectonic or paleoseismic methods. Data compilation used for developing cartography and inventories with the available knowledge of Quaternary deformation, have relied on the existing information derived in many cases from regional geologic studies and/or general terrain analysis. Accordingly, their characterization as seismogenic sources under a suitable format for seismic hazard models is commonly inadequate or imply considerable epistemic uncertainties. Key data as for the Seismic Hazard Models requirements, such as slip rate and the 3D geometry of outcropping structures, are not available for the majority of them.

A significant amount of the inventoried Quaternary deformation along the Central Andes and sorrounding regions lie within the plate interior, where slip rates are considered to be lower than those characterizing major structures at the Northern Andes. Only a few of these faults have experienced historic primary surface ruptures onshore. Also, because a few of these structures have not yet been studied under paleoseismological techniques (i.e detailed trench logs, key horizons dating, etc), parameters that best capture the source capability and hazard are poorly constrained or unknown for most structures (i.e., slip rate, recurrence interval, and age of last movement).

The few known historic coseismic primary surface ruptures onshore, limit the comparison of basic parameters (surface rupture length, coseismic displacement) at the different Andean crustal settings with world-wide historical relationship.

In some areas, like at the Pampean flat-slab, (27°-33°S) the South American plate foreland has been involved in the Andean building orogenesis. As a result, a series of faulted blocks known as the Sierras Pampeanas have evolved during the Neogene and characterized by bounding reverse faults with Quaternary activity, even at distances up to 600 km away of the trench.

The Sierras Pampeanas have traditionally been considered as an area with a capability for large earthquakes considerably lower than the Andean belt. However, many earthquake-related evidences have been found along several neotectonic structures in this region during the last years. They include primary surface coseismic ruptures, large rock-avalanches and paleoliquefaction features. These phenomena have no historical analogs in the region, but they testify for the occurrence of large crustal earthquakes since the late Pleistocene.

Historical seismicity suggests that threshold magnitude for crustal earthquakes to produce surface rupture at the Andean front and these foreland regions is considered to be Ms > 7.0 (Costa, 2005). However, when estimating the Maximum Credible Earthquake (MCE) based on the most common empirical relationships used worldwide, such as rupture length, rupture area and coseismic slip, most results fall below such threshold magnitude.

The interpretations of this situation may range from: a. The basic data for estimating the MCE were wrong; b. New proxies for the Sierras Pampeanas region should be developed/adapted ; c. Both.

Although the "threshold earthquake" cannot be properly contrasted with historic data, it is considered that evidences of coseismic surface ruptures account for prehistoric crustal earthquakes with magnitudes larger than those recorded in the seismic catalog, so all these issues may lead to underestimates of seismic hazard in some regions.

In addition, fault hazard or seismogenic potential estimation solely based on proxies commonly used for plate boundary structures (such as age of last movement) may be inappropriate and even misleading for intraplate structures.

Consequently, many seismic hazard assessments usually do not consider neotectonic data, or do so partly. This situation often creates a gap in seismic hazard assessments, where geologic data are not well suited or not properly formatted for the SHA requirements and accordingly they are not suitably represented in the body of data.

For bridging this gap a close collaboration and teamwork development among earth scientists is fully necessary, where neotectonic practitioners could learn how to upgrade the existing data (even incorporating wide ranges of epistemic uncertainties) in order to make them to be considered as seismogenic sources. Training and experiences exchange among geologists is required in order to upgrade a classic map of neotectonic deformation into a 3D fault source.

Based on the current state of knowledge of Quaternary deformation in the Central Andes, this presentation aims to encourage discussions on the role of neotectonic data in seismic hazard assessment as well as on future research directions.

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