Estimation of the epicentral area of the 1912 Acambay earthquake (M 6.9, Mexico) determined from the earthquake archaeological effects (EAE) and the ESI07 macroseismic scale

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Earthquake Environmental Effects describe the geological features of an earthquake, including the surface faulting, ground cracks, soil liquefaction and landslides, among others. Historical large earthquakes could be classified according to the EEE macroseismic geological scale (ESI07), with the advantage that it is possible to compare different earthquakes which have occurred in different places and estimate the parameterization of their seismogenic sources. Hence, we have determined the ESI07 scale by the EEE description of the geological effects observed during the 1912 Acambay earthquake, which took place in the central basin of Mexico. Additionally, we have estimated the epicentral area of this earthquake, the total rupture length and the potential seismicity of the Acambay-Tixmadejé fault zone. Furthermore, we have estimated the earthquake archaeological effects (EAEs) of the oriented damage. To do this, we have modelled the S-wave travelling by assuming different epicentre locations at several active fault segments and thus, we have compared with the oriented damage mapped by Urbina and Camacho (1913) at different villages. Therefore, we propose a model of rupture of 1912 Acambay earthquake, releasing a M ≥ 7 earthquake and with the epicentre located at Tixmadejé. This rupture model implies earthquake directivity towards East and the S-wave travelling towards South. The total rupture length was estimated 33 km and the maximum coseismic offset 52 cm.

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1. Introduction

The tectonic framework of Mexico suggests that most of the earthquakes are related to the subduction trench of the Cocos Plate underneath the North America Plate (Pardo and Suárez, 1995). However, relevant paleoearthquakes estimated as intraplate faulting and with magnitude similar or larger than M6.9, struck the central part of Mexico (Suárez et al., 1994; Langridge et al., 2000; Garduño-Monroy et al., 2009; Rodríguez-Pascua et al., 2010; 2012a, Langridge et al., 2013; Ortuno et al., 2015). Therefore, the paleoseismological study of active faulting and lake systems as well (related to active faults), have become an essential tool to extend the seismic catalogue in the central part of Mexico and the Trans-Mexican Volcanic Belt (TMVB) over the historical record. The historical record of seismic events which have occurred in Mexico extends back to the XVIth century, whilst the seismic instrumental record beginning in 1910 (García-Acosta and Suárez-Reynoso, 1996).

The central part of the TMVB is featured by one of the most seismic active faults of Mexico: the E-W trending Morelia-Acambay Fault System (MAFS) (Suter et al., 1992, 2001; Suárez et al., 1994). The tectonic activity of this fault system determines the landscape (Ramírez-Herrera, 1998) and sedimentary evolution of several lacustrine basins in the surroundings, such as the Tierras Blancas Basin (TBB) (Rodríguez-Pascua et al., 2010). One of the most active faults of MAFS is the Acambay-Tixmadejé Fault (ATF), consisting of several E-W left lateral transpressive strike-slip active segments, located in the northern region of the area (Fig. 1), which exhibits geological evidence of recent seismic activity. Besides, the Quaternary fault activity has generated soft-sediment deformation

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structures: sand, silt and gravel dikes, pillows, mushrooms structures and decametric slumps disturbing the sedimentary infilling of the Tierras Blancas Basin in Acambay (Rodríguez-Pascua et al., 2010). From these seismites and their stratigraphic spatial correlation, the aforementioned authors have identified five moderate to strong paleoearthquakes affecting the basin (5.5 < M < 7). Moreover, the spatial distribution of the seismites affecting different detrital grain-size deposits (sand, silt and gravels), exhibits a spatial pattern according to the intensity of the seismic deformation.

The main goal of this study is to obtain the ESI07 macroseismic scale based on earthquake geological effects, from the original description by Urbina and Camacho (1913), which was carried out a few years after the Acambay earthquake of 1912 in central Mexico. The comprehensive and detailed description performed by Urbina and Camacho, represents an invaluable data source of no-subduction earthquake which took place in the central part of Mexico and that clearly improve the studies for the seismic hazard in the Transmexican Volcanic Belt.

1.1. The 1912 Acambay earthquake

The 1912 Acambay earthquake (Central Mexico) was one of the most destructive earthquakes of the XXth century. This earthquake was described by fieldwork (Urbina and Camacho, 1913) in a similar way that the 1906 San Francisco earthquake was (Lawson et al., 1906). On 1912, November 19th, a magnitude M6.9 earthquake hit the Mexican city of the Acambay and the surroundings small villages (13:55 UTC). This earthquake killed 140 people from the collapse of several buildings of the village. Urbina and Camacho (1913) carried out the scientific study of this devastating earthquake, located the epicentre with the techniques of those days and plotted the surface rupture caused by the main earthquake. Hence, they described the primary and secondary geological and environmental effects of this earthquake, and consequently, we have

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