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Assessing interaction of active extensional faults from structural and paleoseismological analysis: The Teruel and Concud faults (eastern Spain)

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ABSTRACT

The relationship of independence, interaction or linkage between two neighbouring intraplate active extensional faults, the Teruel and Concud faults, are investigated from structural and paleoseismological data, and the results are discussed to improve seismic hazard assessment for the region. This paper provides the structural and paleoseismological characterization of the almost unknown Teruel Fault from detailed mapping and trench analysis, and discusses its kinematic and dynamic relationships with the Concud Fault. Four individual events occurred between 76.0 ka and 9.2 ka BP have been recorded at two branches of the Teruel Fault. Unfortunately, these only represent a small fraction of its overall activity during such time lapse, and their time constraints do not allow correlating them with those at the Concud Fault. The Teruel and Concud faults are independent structures from the geometric and kinematic point of view, as evinced by their distinct (i) transport directions (N275°E and N220°E, respectively), and (ii) average coseismic displacements (0.5 m and 1.9 m, respectively). These displacements are consistent with their respective lengths (9.0 km and 14.2 km) and significantly smaller than those expected for a hypothetically joint Concud-Teruel, 23 km-long fault. However, their displacement gradients close to the relay zone indicate that both faults undergo dynamic interaction, thus suggesting a transient stage from independence to linkage. We hypothesize that slip on both structures occurred, at the scale of the seismic cycle, in a broadly alternating manner, which induced strain partitioning between them and allowed accommodating bulk biaxial extension in the region. Such deformation pattern would have increased the earthquake frequency with respect to the scenario of a hypothetically linked Concud-Teruel Fault, but diminished the potential seismic magnitude.

1. Introduction

In the last few decades, great efforts have been made to improve our understanding of the geometric interaction and linkage of segments of extensional fractures and normal faults showing overlapping or en-échelon arrays (e.g., Gibbs, 1984; Childs et al., 1995; Nicol et al., 1996; Ferrill et al., 1999; Peacock, 2002; Walsh et al., 2003; Fossen and Rotevatn, 2016). Recognition of linked en-échelon fault systems in the early stages of development is critical in seismic hazard assessment because seismic hazard analyses rely also on the ability to predict whether an earthquake will terminate at a fault tip or propagate onto adjacent faults (Ferrill et al., 1999; Wesnousky, 2008; Biasi and Wesnousky, 2016).

In moderately active intraplate areas, the historical seismic record is not long enough to include large earthquakes, owing to their large average recurrence intervals. Therefore, to reconstruct the true seismic history of faults, it is necessary to rely on paleoseismological studies (McCalpin, 1996; Caputo et al., 2008). Paleoseismology also provides additional information about fault kinematics: the pattern of incremental or 'infinitesimal' slip on individual faults, and hence the possibility of approaching the progressive bulk deformation of a tectonically active area.

This study assesses the state of geometric, kinematic and dynamic interaction of two neighbouring active faults, the Teruel and

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Concud faults, and discusses its influence on seismic hazard assessment for the region. These faults are located at the junction of the Teruel and Jiloca grabens (Fig. 1), which represent the largest Neogene-Quaternary extensional basins in the intraplate Iberian Chain (eastern Spain). The west-dipping Concud and Teruel faults strike NW-SE and N-S, respectively, and show a right-stepping arrangement with a 1.3 km-wide relay zone (Fig. 2a). The Concud Fault, the best documented active structure in the region, is expressed in the relief by a prominent scarp. It is located in the southern sector of the Jiloca Graben, and shows paleoseismological evidence of recurrent activity during Late Pleistocene (Lafuente, 2011; Lafuente et al., 2011a, 2014; Simón et al., 2012, 2016).

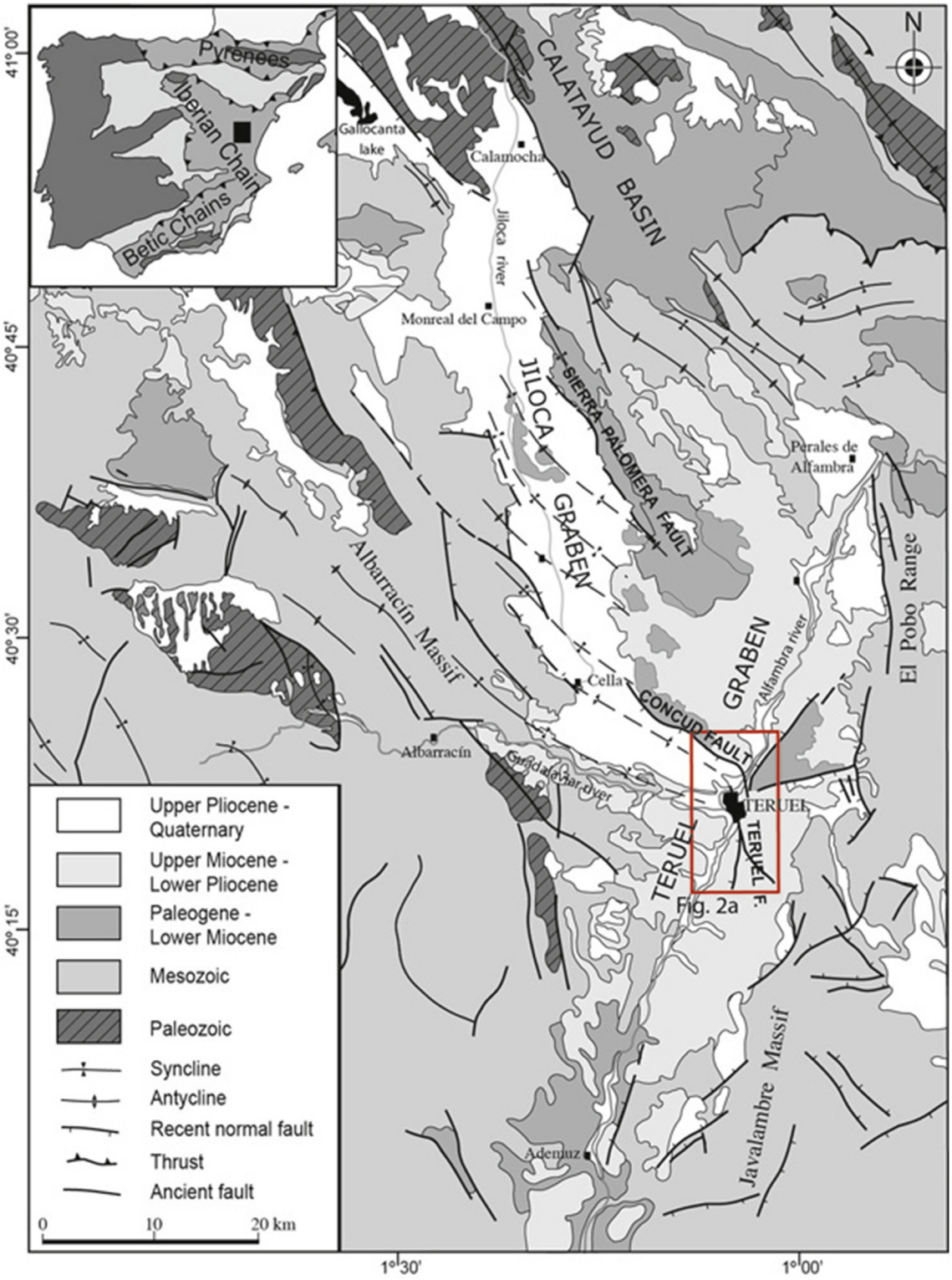

Fig. 1. Location of the Teruel Fault within the Teruel Graben system, eastern Spain. Inset: sketch of the main Alpine chains within the Iberian Peninsula.