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Active tectonics within the NW and SE extensions of the Pambak-Sevan-Syunik fault: Implications for the present geodynamics of Armenia

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ABSTRACT

This study analyzes the active tectonics within the northwestern and southeastern extensions of the Pambak-Sevan-Syunik fault (PSSF), a major right-lateral strike-slip fault cutting through Armenia. Quantifying the deformations in terms of geometry, kinematics, slip rates and earthquake activity, using cosmogenic ^{3}He, OSL/IRSL and radiocarbon dating techniques, reveal different behaviors between the two regions. Within the northwestern extension, in the region of Amasia, the PSSF bends to the west and splits into two main WNW–ESE trending reverse faults defining a compressional pop-up structure. We estimate an uplift rate and a shortening rate of 0.5 ± 0.1 mm/y and 1.4 ± 0.6 mm/y, respectively. This suggests that most of the ~2 mm/y right lateral movement of the PSSF seems to be absorbed within the Amasia pop-structure. Within the southeastern extension, the PSSF shows signs of dying out within the Tsghuk Volcano region at the southernmost tip of the Syunik graben. There, the tectonic activity is characterized by a very slow NS trending normal faulting associated with a slight right-lateral movement. Slip rates analyses (i.e. vertical slip rate, EW stretching rate at 90° to the fault, and right-lateral slip rate of ~0.2 mm/y, ~0.1 mm/y and ~0.05 mm/y, respectively) lead to the conclusion that the right lateral movement observed further north along the PSSF is mainly transferred within other active faults further west within the Karabagh (Hagari fault or other structures further northwestwards). Comparing our slip rates with those estimated from GPS data suggests that most of the deformation is localized and seismic, at least within the Tsghuk region. The geometrical and kinematic pattern observed within the two terminations of the PSSF suggests that the fault and its surrounding crustal blocks are presently rotating anticlockwise, as also observed within the GPS velocity field. This is consistent with the recent kinematic models proposed for the Caucasus-Kura-South Caspian region and brings a new insight into the present geodynamics of Armenia.

1. Introduction

Tectonic geomorphology and paleoseismology aim to highlight and characterize the behavior of active faults and the successive earthquakes that they generated. These characteristics (i.e. location, geometry, kinematics, slip rate, age, and magnitude of earthquakes) provide detailed assessments of the seismic hazards of the studied regions and a refined understanding of their kinematics and geodynamics. The Pambak-Sevan-Syunik fault (PSSF) is one of the major active structures of the Lesser Caucasus, and influences the entire geomorphology of Armenia (Philip et al., 2001). This outstanding feature is described as a ~500 km long fault, and would

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have been associated with many large earthquakes (Fig. 1). However, because previous morphotectonics and paleoseismological studies have characterized only the tectonic activity along the main segments of the fault, the activity within its northwestern and southeastern extensions remains poorly known.

In this paper, we present the results of a morphotectonic and paleoseismological study carried out at the NW and SE extensions of the PSSF, in the Amasia and Tsghuk regions of Armenia. This study analyzes how the right-lateral strike-slip deformation observed along the PSSF is transferred along its two terminations. This work synthetizes and completes the results presented by Ritz et al. (2013) and Mkrtchyan et al. (2014), and provides new insights into the present geodynamics of Armenia.

2. Tectonic setting

Armenia is located in the Lesser Caucasus, a region characterized by high volcanic plateaus situated in the middle of the collisional zone between the Arabian and Eurasian plates (Karapetyan et al., 2001; Philip et al., 2001) (Fig. 1a). Locked between the great Caucasus mountain range to the north, the Black Sea to the west, the South-Caspian Basin to the east, and the Arabian promontory to the south, Armenia and its surrounding territories have undergone intense continental deformations since the end of Oligocene and Miocene (e.g. Dewey et al., 1986; Avagyan et al., 2005; Sosson et al., 2010).

After the main Oligo-Miocene Arabia-Eurasia collisional period, within a general N–S compressional regime, the Armenian territory recorded differing spatial and temporal stress field variations (e.g. Avagyan et al., 2010). Fault slip data analyses (e.g. Ritz and Taboada, 1993) in Quaternary formations allowed determining a general strike-slip stress regime with the principal stress axe σ1 striking NS to NNE-SSW (Avagyan et al., 2010). Recent and active deformations are mainly characterized by strike-slip tectonics, associated locally with transpressional or transtensional components and can be described by four major coeval fault types: NW–SE trending dextral strike–slip faults; NE–SW trending sinistral strike–slip faults; E–W trending thrust faults, and N–S trending normal faults (Philip et al., 1989; Karakhanian and Balasanian, 1992; Karakhanian et al., 2004; Avagyan et al., 2005, 2010). The most important fault, the Pambak-Sevan-Syunik fault (PSSF) (Fig. 1a) corresponds to a 500 km NW–SE right-lateral strike-slip fault along which the present horizontal slip rate varies between 0.5 and 3 mm/y after geological studies (Avagyan, 2001; Philip et al., 2001), which is consistent with the 2 ± 1 mm/y estimated from GPS measurements (Karakhanian et al., 2013).

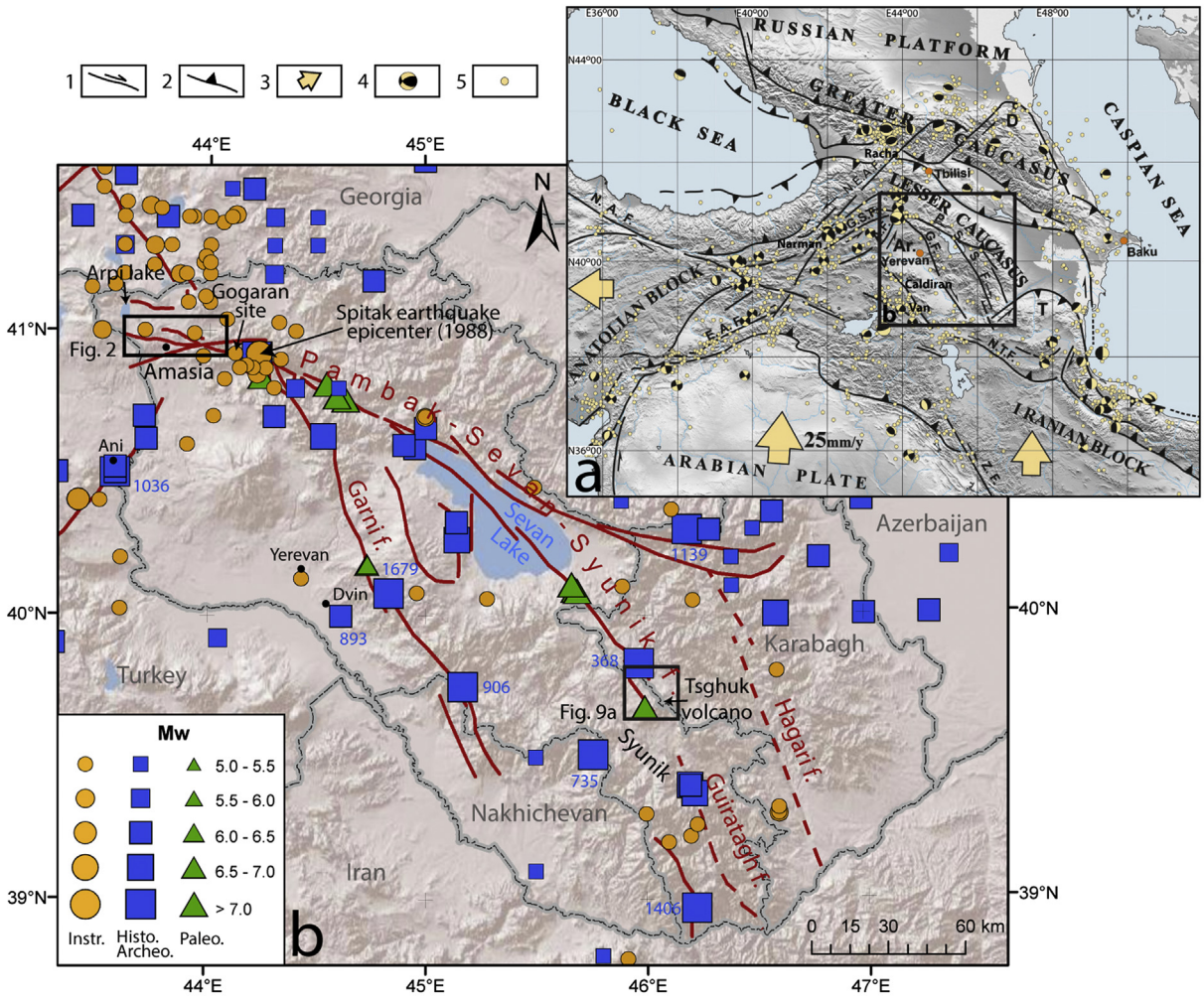

Fig. 1. a: Sketch map of the collision zone between northern Arabia and the Russian Platform (Eurasian Plate) (after Philip et al., 2001) 1: strike-slip faults, 2: reverse faults, 3: directions of block movements relative to the Eurasian Plate, 4: the main strong earthquake focal solutions, 5: moderate earthquakes. b: Map of active faults in Armenia with instrumental, historical-archeo- (with date of main events in blue), and paleo-seismicity ("NorAtom" Consortium Report, 2011). Black frames correspond to the 2 studied areas. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)