Geomorphology 270 (2016) 9–21

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Evaluation of the relative tectonic activity in the eastern Lake Van basin, East Turkey

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ARTICLE INFO

Article history:
Received 1 June 2015
Received in revised form 1 July 2016
Accepted 6 July 2016
Available online 6 July 2016

Keywords:
Geomorphic indices
Faults
Uplift rate
Lake Van basin

ABSTRACT

The eastern part of the Lake Van basin (Van region, Turkey) is controlled by reverse faults, such as the Gürpınar, Everek and Alaköy faults. These represent the major tectonic structures within the Van region and have caused many devastating earthquakes. Based on quantitative analyses, the Quaternary activity and topographic relief control of each of these faults was investigated. The Gürpınar, Everek and Alaköy faults are restricted to the southern slopes of the Güzelsu, Everek, and Karasu basins, respectively. Analyses of the mountain front sinuosity (S_{mf}) and valley floor width-to-height ratio (V_f) suggest high activity along the Gürpınar fault, the Everek fault, and the western part of the Alaköy fault. Furthermore, based on the integration between S_{mf} and V_f, the estimated uplift rates were observed to increase from north to south. The Gürpınar and Everek hanging-wall blocks are characterized by uplift rates of >0.5 mm yr^{-1}, whereas the Alaköy fault exhibited a rate of 0.05 to 0.5 mm yr^{-1}. These faults produce knickpoints or knickzones, complex basin hypsometric curves, and high values of the stream length–gradient index. Based on these geomorphic analyses, it was established that the tectonic activity of both the Gürpınar and Everek faults is greater than that of the Alaköy fault.

1. Introduction

Geomorphological and geological data are most commonly used for the comparison and determination of tectonic deformation rates within a region (Molin et al., 2004; Dumont et al., 2005; Necea et al., 2005). Furthermore, recent and current tectonic activities along fault lines produce notable effects on the geomorphological properties of the affected landscapes (Gordon, 1998; Giamboni et al., 2005). For example, in regions such as the eastern part of the Lake Van basin (Van region, E. Turkey), thrust systems and associated folds control the development and evolution of the alluvial and fluvial systems, which respond to tectonically induced local base-level variations, fault linkages, and spatio-temporal migration of folds (Ramsey et al., 2008; Pedrera et al., 2009; Giaconia et al., 2012). Tectonic uplift causes erosion that usually becomes the main driving factor behind channel incision, river deflection, headward erosion, and stream-head or -foot rejuvenation processes (Holbrook and Schumm, 1999; Snyder et al., 2000; Burbank and Anderson, 2001; Lavé and Avouac, 2001; Hilley and Arrowsmith, 2008).

Geomorphic analyses are useful for investigating the impact of tectonic activity on geomorphic processes and landscape development (Giaconia et al., 2012). Morphometric analyses are conducted using geomorphic indices that help in the assessment of the relative level of tectonic activity within an area and in the quantitative characterization of the geomorphic features of a landscape (Seeber and Gornitz, 1983; Brookfield, 1998; Keller and Pinter, 2002; Chen et al., 2003; Kobor and Roering, 2004). Geomorphic indices are commonly used to define the degree of regional tectonic activity because they allow for a rapid evaluation of extensive areas and help in the identification of the more dynamic segments of active faults (Strahler, 1952; Bull and McFadden, 1977; Keller et al., 2000; Azor et al., 2002; Keller and Pinter, 2002; Font et al., 2010).

The eastern part of the Lake Van basin is an important area of active tectonic structures in Eastern Anatolia (Fig. 1) where a number of devastating earthquakes have occurred throughout history to the present day, such as the Tabanlı (Van) earthquake on November 23, 2011. This region is controlled by three of the main active faults in eastern Turkey: the Alaköy, Everek and Gürpınar faults, from north to south. These faults are approximately parallel to each other and trend N90°–100°E. The Quaternary activity of these faults appears to have been thrust faulting; however, the Neogene activity of the Gürpınar fault was oblique-slip faulting.

The city of Van is located very close to the Gürpınar fault and lies on the northerly dipping hanging-wall block of this fault (Fig. 2). A devastating *Mw* 7.0 earthquake in this area occurred on an approximately E–W-trending active fault (Ambraseys and Jackson, 1998). It is believed that the earthquake caused approximately 2000 fatalities in the city of Van alone (Cuinet, 1892) and led to the collapse of many churches (40) and other buildings within the Van region (Ambraseys, 2009).

The Everek fault is located between the north of Van city to the west and Lake Erçek to the east (Fig. 2). The most recent destructive seismic event on this fault was the *Mw* 7.2 Tabanlı (Van) earthquake on October 23, 2011

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http://dx.doi.org/10.1016/j.geomorph.2016.07.009
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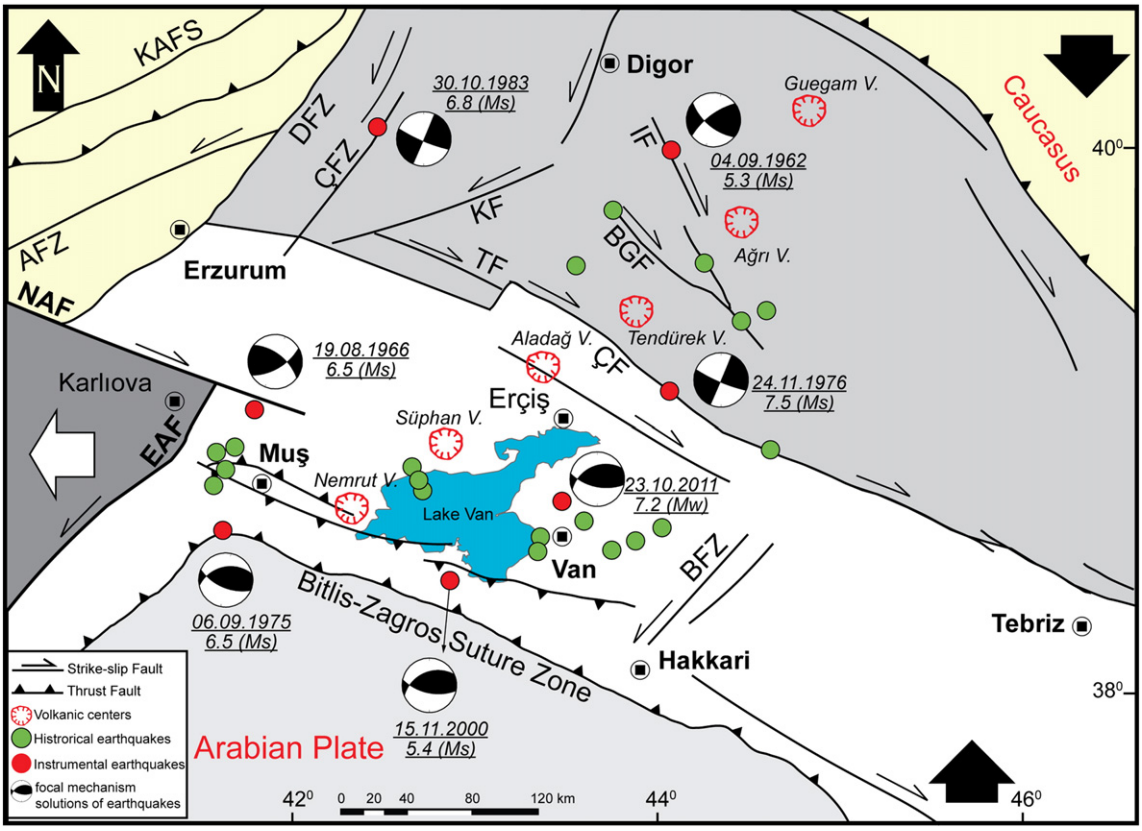

Fig. 1. The East Anatolian–Iranian plateau and its surroundings active tectonic setting. Block boundaries are from Reilinger et al. (2006) and Djomour et al., 2011; faults are from Koçyiğit et al. (2001).

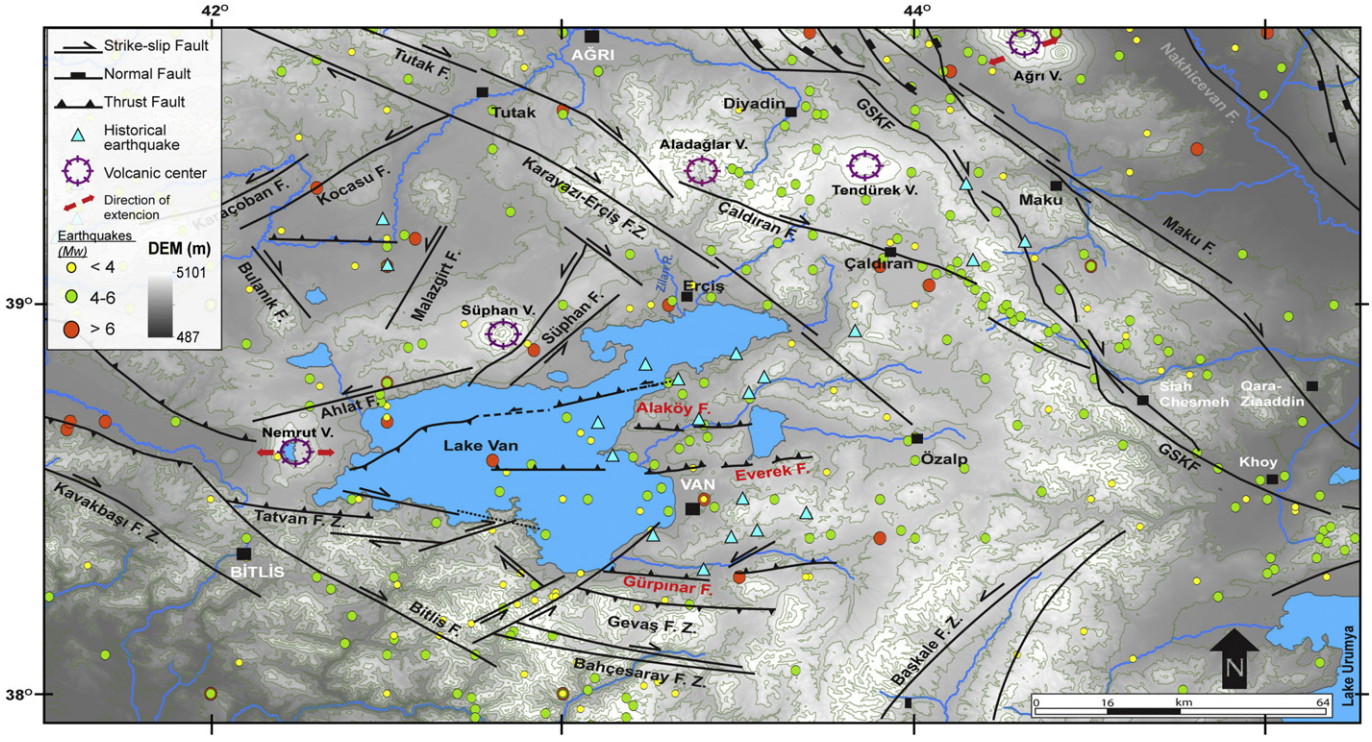

Fig. 2. Seismotectonic map of the Lake Van basin and its surroundings, modified from Koçyiğit et al. (2001) and Karakhanian et al. (2004). Seismicity data are from Ergin et al. (1967); Soysal et al. (1981); Ambraseys and Finkel (1995) and Tan et al. (2008).