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Investigation of site effect of Lake Van region (eastern Turkey) by using strong ground motion records

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ABSTRACT

The site effect plays a very important role in determining the structural damage that may occur in a possible major earthquake. In this study, seventy-nine strong ground-motion records (M > 4.5) from past earthquake events in the Lake Van region, recorded by 14 accelerometer stations located on dissimilar geological units, were analyzed for local soil properties using horizontal-to-vertical spectral ratio (EHVSR) method. In addition, EHVSR results were compared with Standard Spectral Ratio (SSR) results, which is another method used to determine soil amplification. The obtained predominant period, amplification factor, seismic vulnerability index (Kg) and bedrock depth values were examined. The EHVSR results show that the predominant frequencies of the sites and the amplification factor values were estimated as 0.58–5.77 Hz and 1.84–7.5, respectively. The seismic vulnerability index (Kg) values, which are crucial parameter in hazard assessment, change from 1.6 to 30. The bedrock depths range between 11 and 186 m for the study area. From the results of this study it is found that the damage may be high after a possible destructive earthquake in the study area where the predominant period, amplification, Kg values and bedrock depth are high.

1. Introduction

Eastern Turkey and its surrounding, called the Eastern Anatolian Plateau (EAP), have been shaped by the development of the continental collision (~11 million years ago) between the Eurasian and Arabian plates, and has affected the regional tectonic process. The active tectonics of the region have generally been affected by the active collision zone formed as a result of the ~15 mm/year movement of the Arabian Plate to the north and the ~5 mm/year movement of the Eurasian Plate to the south (Şengör et al., 2003; Reilinger et al., 2006). The EAP was formed by the effect of the collision that has continued since the Late Miocene, resulting in the shortening, thickening and uplift of the Eastern Anatolian crust (Şengör and Kidd, 1979; Şaroğlu and Yılmaz, 1986; Koçyiğit et al., 2001) (Fig. 1a). As a result of this compression deformation, the Anatolian Plate tends to rotate counterclockwise and escape to the west. In the Eastern Anatolia region, during the neotectonic period, due to the dominant north-south directional compressional tectonic regime, many northeast-southwest left lateral and northwest-southeast right lateral strike-slip, east-west trending thrust or reverse and normal faults or extensional fracture have developed (Şaroğlu and Yılmaz, 1986; Koçyiğit et al., 2001; Koçyiğit, 2013; Emre et al., 2013; Selçuk, 2016). Parallel to the compression direction, the N-S oriented extensional fractures controlled volcanic output. After continent-continent collision, crustal shortening developed in this period and the regional elevation increased (Şaroğlu and Yılmaz, 1986; Yılmaz et al., 1987; Şengör et al., 2003; Alkan and Bayrak, 2022). In addition, this continental collision is the reason for the formation of the Van Lake basin.

The Van Lake Basin is a dome-shaped basin formed as a result of the tectonic activity of normal, reverse and strike-slip faults in the Eastern Anatolian compression regime. This faulting causes hydrothermal activity, increased seismicity and regional volcanism (Toker et al., 2017a, 2017b). Thrust and strike-slip faults are the essential tectonic units in the basin, such as the Yeniköşk, Alaköy, Özalp, and Van thrust fault, Çolpan, Başkale, Gürpınar, Erciş–Kocapınar, and Çaldıran strike-slip fault zone (Koçyiğit et al., 2001; Koçyiğit, 2013; Utkucu, 2013; Akkaya, 2015; Akkaya et al., 2015; Toker et al., 2017a, 2017b; Sengul et al., 2019; Akkaya and Özvan, 2019). The Lake Van region has been exposed to many devastating earthquakes in historical and instrumental periods depends on the tectonic movement (Fig. 1b).

The most important of them are; 1111, 1646 and 1715 historical period Van region earthquakes, Baskale earthquake (M = 6.0) in 1908, Erciş earthquake (Ms = 5.9) in 1941, Çaldıran earthquake (Ms = 7.3) in 1976, the Van earthquake that occurred in 2011 (Mw = 7.1 and 5.6),

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