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The application of HVSR microtremor survey method in Yüksekova (Hakkari) region, Eastern Turkey

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A R T I C L E I N F O

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A B S T R A C T

The horizontal to vertical spectral ratios of microtremor (HVSR) analysis of Yüksekova and its surroundings is carried out using the results of field investigations, local soil conditions and seismotectonic features of the region. Soil-structure interaction is one of the most important reason for building damage ratio. The effects of soil conditions on probably damaged building units were determined, by conducting HVSR microtremor measurements.

In this study data collection is handled during 30 min using three component seismograph measurements at 40 points in the Yüksekova region. HVSR peak period map shows that the fundamental period range between 0.4 and 1.6 s in the soft sediments units. Rock sites of the northern coast of Yüksekova period range between 0.1 and 0.2 s. HVSR peak amplitude values are in the interval 1.5–6.0.

1. Introduction

Yüksekova (Hakkari) region, located in East Anatolian – Iranian plateau, has high seismicity risk because of its geological and tectonic characteristics and experienced many historical earthquakes. Yüksekova – Şemdinli Fault Zone (YSFZ) is one of the major fault zones in the study area because of the fact that it has a gap in the seismotectonic literature of Turkey (Demirtaş and Yılmaz, 1996). Earthquakes are known to be in the historical and instrumental period in the region. The study area and its surroundings are characterized by a strike-slip faulting that is dominant within neotectoinc regime and related structure (Koçyiğit, 2013). There are major structures in the region such as Yüksekova–Şemdinli Fault Zone (YSFZ), Başkale Fault (BF), Bitlis–Zagros Thrust Belt (BZTB) and Salmas (Iran) Fault Zone (SF) that can be specified as strike-slipe fault zones (Fig. 1). Most important earthquakes occured in the last century in this region are Başkale ($M = 6.0$; 1908), Salmas-Iranian ($M = 7.2$; 1930), Hakkari-Sütlüce (Mw = 5.9; January 25, 2005) and Yüksekova ($M = 5.2$; October 27, 2011) and Yüksekova settlement is adversely affected by these earthquakes. These earthquakes represent the seismic activity of the region and the related risks. Yüksekova town is settled on Quaternary deposits, mainly consisting of alluvial fan deposits including loosely-to-moderately cemented gravel, sand, silt and unconsolidated clay horizons. Besides, groundwater table is generally shallow-seated from place to place in the region. These facts contribute the earthquake sourced damage ratio in the region.

Parallel to the increasing population, the number of unplanned and uncontrolled buildings increase in Yüksekova town. This situation must necessitate suitable construction types. All these conditions such as poor construction quality and weak soil may increase the damage ratio in a porobable major earthquake occurence in Yüksekova. More severe earthquake damages are expected in the villages near to the faults because of the widespread settlement of unreinforced masonry and adobe buildings.

Within the scope of this study, the effect of soil condition was determined by conducting HVSR measurements in the study area. Data processing steps on the HVSR microtremor records taken from the region, HVSR peak frequencies/periods of the soil and HVSR peak amplitude values (amplification) were calculated. Because of the fact that the seismic activity of fault zones in Yüksekova region may trigger a major earthquake in the near future, the region may face with many casualities and economic losses due to local soil conditions of the urban area and low-quality construction practices in Yüksekova.

2. Geology of the region

The rock units in the study area are classified from Paleozoic to Quaternary units. The units in the region are a composition of the Hakkari nappes and the Bitlis–Pötürge–Malatya nappes of Cretaceous–Early Paleocene age and the Bitlis–Mordağ

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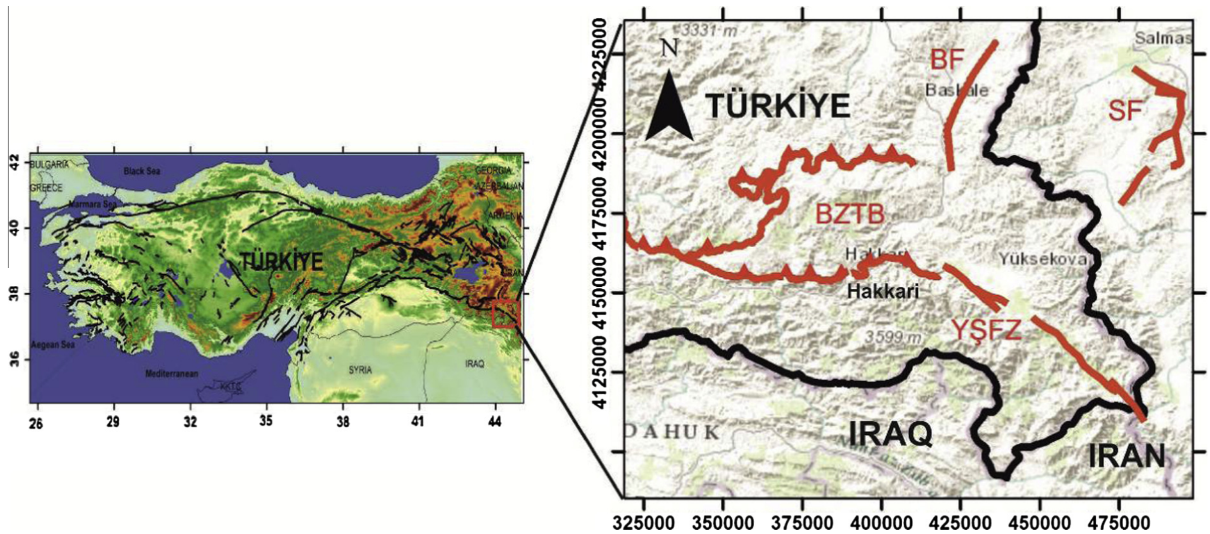

Fig. 1. Location map of study area and main fault zones (**BZTB:** Bitlis–Zagros Thrust Belt, **YŞFZ:** Yüksekova–Şemdinli Fault Zone, **BF:** Başkale Fault, **SF:** Salmas Fault).

metamorphic units of Paleozoic age and the Kırkgecit Formation of Oligo-Miocene age and Quternary units (Fig. 2).

Hakkari nappes: A thick mass is well-observed at the southern part of the study area. The Hakkari nappes have a gray to brown, thin to medium bedded sandstone, claystone and alternation of shale and limestone layers are observed as well, and this unit has been determined as Eocene–Oligocene aged by Yılmaz and Duran (1997).

Cretaceous–Early Paleocene aged tectonic slices which belong to Bitlis–Pötürge–Malatya nappes are located over the Hakkari nappes consist of spilitic basalts, tuff, limestone, conglomerate, shale ve flysch clastics. This unit is determined as Late Cretaceous–Paleocene in age by Şenel et al. (1984).

The Cretaceous units are overlain with allochthonous Bitlis and Mordağ metamorphic units as tectonic slice as well. In this study, these metamorphic units are so-called "Paleozoic units". Mordağ metamorphic unit consists of metasediments and metagabro, metadiabase, serpantinite and amphibolites. Precambrian aged Bitlis metamorphic units consist of augen gneiss, amphibolites, schist, marble rocks (Perinçek, 1990). These units are mapped around Yüksekova settlement in a wide range (Fig. 2).

The Allochthonous units are intensely deformed and overlain with an angular unconformity by the nearly flat-lying Paraallochthonous units. These range of Paleocene to early Miocene aged units -named as "Senozoic" in this study- consist of reddish conglomerate on lower layers, grayish–reddish sandstone, siltstone, claystone and fossiliferous limestone (Perinçek, 1990). This unit is the most widespread unit observed and located to the north and northeast of settlement of Yüksekova (Fig. 2).

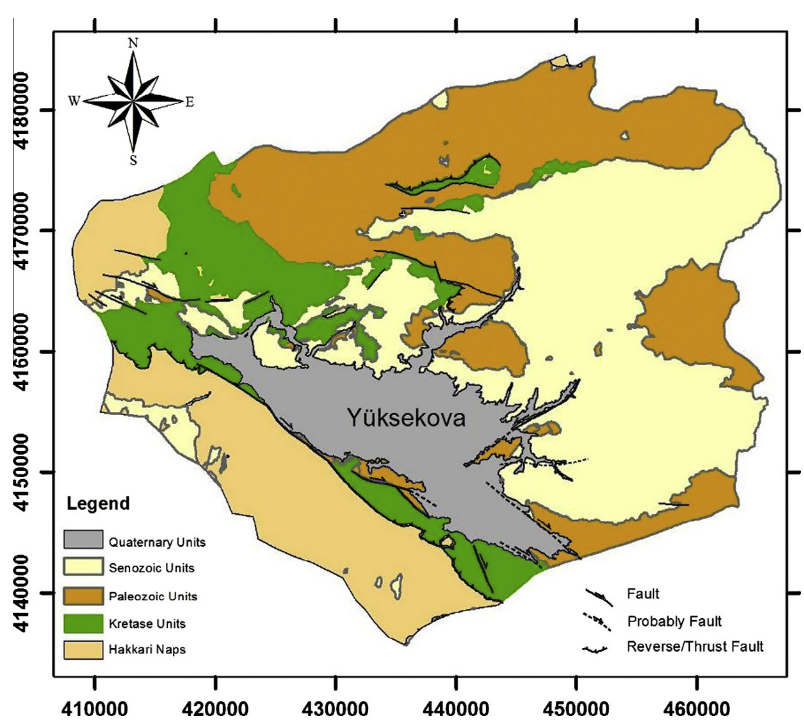

Fig. 2. Simplified geological map of the study area (Modified from MTA, 2002).