DETECTING ACTIVE FAULTS USING BY MORPHOTECTONIC FEATURES: BADINCA (ALASEHIR-TURKEY) CASE

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Abstract - The graben faults, form the Aegean Graben system, are able to produce a large number of destructive earthquakes not only in historic period but also in recent era. The ground ruptures of these faults might be covered by the Holocene sediments in time. Therefore, tracing them under the recent deposits might be difficult and required some techniques. This study has been focused on tracing an active segment of Alasehir fault using by some morphotectonic features. Many of the fault segments cannot easily be traced on the surface though they have produced catastrophic earthquakes.

Index Terms - Active fault, morphotectonic, surface rupture, graben, Alasehir, Manisa.

I. INTRODUCTION

The western Aegean region is dominated by grabens in N-S direction and (Buyuk Menderes Graben, Gediz-Alasehir Graben, Kucuk Menderes Graben) located in the D-B direction (Fig. 1). The NW-SE NE-SW directional grabens (eastern part of Gediz-Alasehir Graben, Denizli Graben, Dinar-Civril Graben) and NE-SW directional grabens (Baklan Graben, Acigol Graben, Burdur Graben) are located at the east of the Aegean region. The earthquake focal mechanisms of the regional earthquakes suggest that active extension is in N-S and NNE-SSW direction 1, 2] and it started 14 million years ago.

Detailed geological surveys [3, 4, 5, 6, 7, 8] as well as many tectonic and seismo-tectonic models have been proposed and discussed [9, 10, 11, 12, 13, 14, 15]. The stress in N-S direction on Western Anatolian block and the Aegean Sea has caused by the compression in western Anatolia due to the movement along the North Anatolian fault. On the other hand, Le Pichon and Angelier [16] and McKenzie [10] have argued that the tension is entirely related to Hellenic subduction. Kocyigit [4] suggests that these structures developed in the form of block-faulting in four different directions of extension of NW-SE, NW-SW, NW-G and NW-D directions. Sengör et al., [17] and Sengor [14] (1987) interpreted these different orientations in western Anatolia as "cross-graben". Jackson [18] tried to explain the deformation in the Aegean Sea by using the broken boards model, it is thought that this model explains the deformation before the rotational movement of the Anatolian block. Barka and Reilenger [19] have identified a Western Anatolian block limited to the Eskişehir fault and the Fethiye-Burdur fault by considering GPS and neotectonic data.

Edge faults of the grabens formed by the extension in Western Anatolia are also active and these faults produced destructive earthquakes in the historical and instrumental period. Active faults that cause earthquakes in the region are generally known. However, in some of these faults that have produced earthquakes and surface ruptures in the past, the traces on earth cannot be seen clearly. The traces of them may have disappeared and/or the Holocene sediments may cover them over time. In addition, the sedimentation rate of current sediments may be high in residential areas. It is crucial to know these lines before any construction.

It is possible to determine these buried fault lines by using the current morphotectonic data. In areas where these data are not available, some different methods can be employed.

In this study, a buried active fault in Alasehir region in Western Anatolia has been traced by morphotectonic features. The trenches were opened to verify the findings.

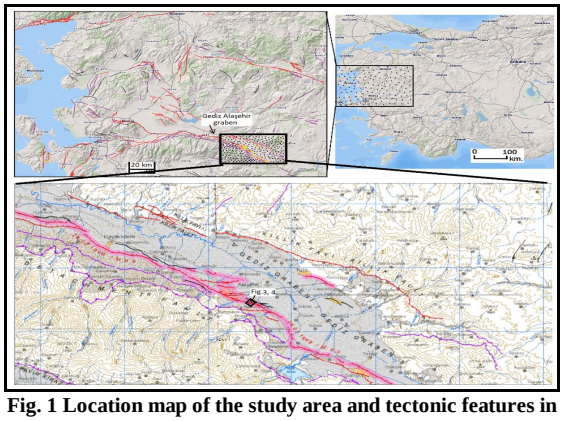


Fig. 1 Location map of the study area and tectonic features in SW Turkey.

II. SEISMICITY OF THE WESTERN ANATOLIA AND BADINCA REGION

Western Anatolia and Aegean Region have been a very active earthquake zone in historical and instrumental periods and they have become a very important natural phenomenon leaving traces in many civilizations in the region. The large earthquakes in

Western Anatolia have also generally formed surface rupture. The Cyprus-Hellenic arc, located at the southern parts of the zone, is a subduction zone and the faults in this zone especially around Cretan and Rhodes produce earthquakes M>6.0. The earthquakes in Burdur Fethiye fault zone within are NE-SW trending. A study conducted by using the seismic moments and focal mechanism solutions of the earthquakes has revealed that Southeastern Anatolia extends within north-south direction with the speed of 13.5 mm in a year and it gets thin with 0.5 mm/year [20]. This study suggests that the majority of the earthquakes in Western Anatolia occur in the fragile part of the crust at the uppest part with an area of 8-10 km and the crust has a more ductile structure at this depth. However, the earthquakes off coast of Rhodes and Antalya gulf could reach up to 200 km depths.

Sultandagi-Cay (Afyon) earthquakes happened in February 2002 in the eastern of Western Anatolia and 4 earthquakes and aftershocks whose magnitude is above 5.0 occurred. Three earthquakes M>5.0 recorded in July 2003 in Buldan zone. Three earthquakes similar in Buldan in August 2004 on Mugla-Gokova fault and two earthquakes M>5.9 happened on the Izmir-Seferihisar fault in October 2005. The earthquake activity (M=5.7 and 5.6) has continued about a month in those area. Cameli earthquake (M=5.0) occurred in November 2007. Bodrum, Ula and Ayvalik earthquakes in western and eastern side of Gokova fault, at offshore of the Aegean Sea have been recorded respectively in 2017.

The Badinca region (SE of Alasehir) is on the fault zone SW wing of the Alasehir (Gediz) graben. Gediz (Alaşehir) Graben is a depression area extending about 140 km in length, starting from Kemalpaşa in the west, extending approximately D-B up to Salihli and going eastward through Alasehir to Sarıgol in NW-SE direction. It is interesting to cross the direction of NW-SE between Salihli-Sarıgöl, which is about D-B. Gediz graben turns towards SE at the east of Salihli and gets narrow between Sarıgöl and Buldan (Fig. 1). The seismic activity between Sarıgöl and Buldan, which forms the southeastern edge of the Gediz graben, has increased again in the first quarter of 1997 especially near Buldan and nearby. Most of the faults around Sarıgöl, east of the Gediz Graben, are active and form surface ruptures [21, 22].

The fault bounds the SE of the graben is active and it starts from Armutlu in the west and extends to Ahmetli-Salihli-Alasehir-Sarıgol to the east. The fault, is about 110 km long, forms a boundary between young alluvium and older units. Sarıgöl and Buldan area, which forms the southeastern edge of the graben, have high seismic activity in the last century. Bozkurt and Sozbilir [23] emphasize that the factors controlling the southern wing of the Gediz graben are high-angle normal faults. They also observed numerous synthetic and antithetic structures that control the stepped morphology towards north. Researchers indicate that the oldest of these faults control the formation of the Plio-Quaternary units, and they are also actively controlling the development of the alluvial fans.

The latest earthquake in the study area was recorded on March 28, 1969 (Alasehir earthquake, M = 6.9) ant it has caused 36 km long deformation on the surface with loss of life and property. The quake has formed $K70^0$-80^0 W oriented surface fractures (Fig. 1) and 13 cm vertical strikes. Faulting is deep slip normal fault character, NE block is downed. Surface fractures developed in the form of depression of the alluviums on the skirts of the low peaks that constrain the valley [22]. Apart from this earthquake, on the same fault zone, the Salihli earthquake (M = 5.5) in 1965 and the Sart earthquake in 1595 were the major earthquakes.

The seismic activity in the western and middle regions of the graben is very low and the activity is concentrated on the eastern end of the graben as the records are examined in the study area. There are some deformations due to normal faulting in the vicinity of Sarıgol which is the eastern part of the graben. This indicates that graben formation continues in the east [24]. These findings and the impression are confirmed by the microseismic activity in 1997 at the southeastern end of the graben. After that the Buldan area and the Denizli graben cross. The seismic activity of the Denizli region is well known. Two large earthquakes M>6.0 between Buldan and Sarıgol were recorded in 2002. These findings suggest that there migth be a break in the area called Buldan ridge [25]. There are a large number of destructive historical earthquakes in the western part of the graben at BC 17, AC 40, 494, 1592, 1850, and 1862.

III. PALEOSEISMOLOGICAL STUDY

The Badinca region of Gediz (Alaşehir) graben especially the area located between 1969 earthquakes epicenters are examined. The studies implemented by Emre et al., [26] whose prepared the active earthquake fault map of Turkey and the others in Alasehir region are critical. The active faults, potential active faults, surface ruptures and inactive faults in the region generally extend in the direction of $K60^0$-70^0B. There are some studies about surface ruptures of 1969 earthquakes around Sarıgol [24]. However, most of these studies are small-scale and they have been made to determine the exact positions of the fault lines.

The position of fault at SW of the study area is $N77^0$W/ 66^0NE and a fault zone was observed on a road cut in the NW of the site (Fig. 2). Synthetic fractures were also observed in this zone parallel to the main fault line. There is not any evidence that the fault is crossing cut the recent sediments. However, geophysical study has detected an anomaly. Then a trench was dug on it and a fault of $K20^0$E/ 70^0SE was

detected (Fig. 3). This fault has been broken is a early N-NE grabenization phase and before the Gediz (Alasehir) graben. It is known that ND trending grabens like Gördes, Demirci and Selendi were formed before the main grabenization phase [27]. This fault has not shown a strike and covered by Quaternary sediments. Thus, it has not been considered as an active fault.

The fault in north is distinctive on the surface two between two active faults of the Badinca region. Along a straight line extending in the direction of N60^{0}W, the contacts of Neogene and Quaternary units are observed. Linearity in this locality is remarkable in the sudden change of the topographic features. In this region, the a cross-section has been taken by geophysical multi-electrode method, but no anomaly was observed. In addition, a trench was dug in this section but no trace of deformation was found in it. The sediments in the trench are rough-grained and poorly sorted young sediments. Sedimentary deposits come from a creek covered the trace of the fault. The absent of the fault deformation traces up to the three meters depth shows that the fault is deeper than that and the sedimentation rate there is too high. The geophysical data suggest that the sedimentary thickness of this area is around 15 m and it the fault continues under the sediment cover (Fig. 4).

IV. DISCUSSION AND RESULTS

Western Anatolia is one of the highest earthquake risk areas in Turkey. Generally, E-W directional grabens and normal faults forming these grabens are the most prominent tectonic structures of the region. The majority of these faults have produced destructive earthquakes in historical and instrumental periods and they still continue to produce them.The active faults which formed surface ruptures and destructive earthquakes in historical and instrumental periods can be determined by using the current morphotectonic data. In areas where these data are not available or are covered by Holocene sediments, geophysical studies can be performed. In this case, this method has been employed to trace a fault line in Alaşehir (Badinca) region in Western Anatolia. In order to determine the fault line, a NE trending anomaly belonging to the previous grabenization phase in the geophysical section was determined and a fault was detected by the paleoseismic study in the trench. The morphotectonic lineage on the surface of another fault in the same region is quite apparent. The geophysical data about this fault put forward that it continues under a cover of 10-15 m. Since the depth of the paleoseismic study depth was not more than 3 m, the findings of the fault were not observed. It turns out that the slip velocity of the fault is lower than the sedimentation rate.The precise determination of the fault lines in seismic areas is very important in microzoning studies for urban planning. The use of geophysical data in geophysical data as well as geologic-morphotectonic data are essential in determining the position of fault lines and possible bumper zones.

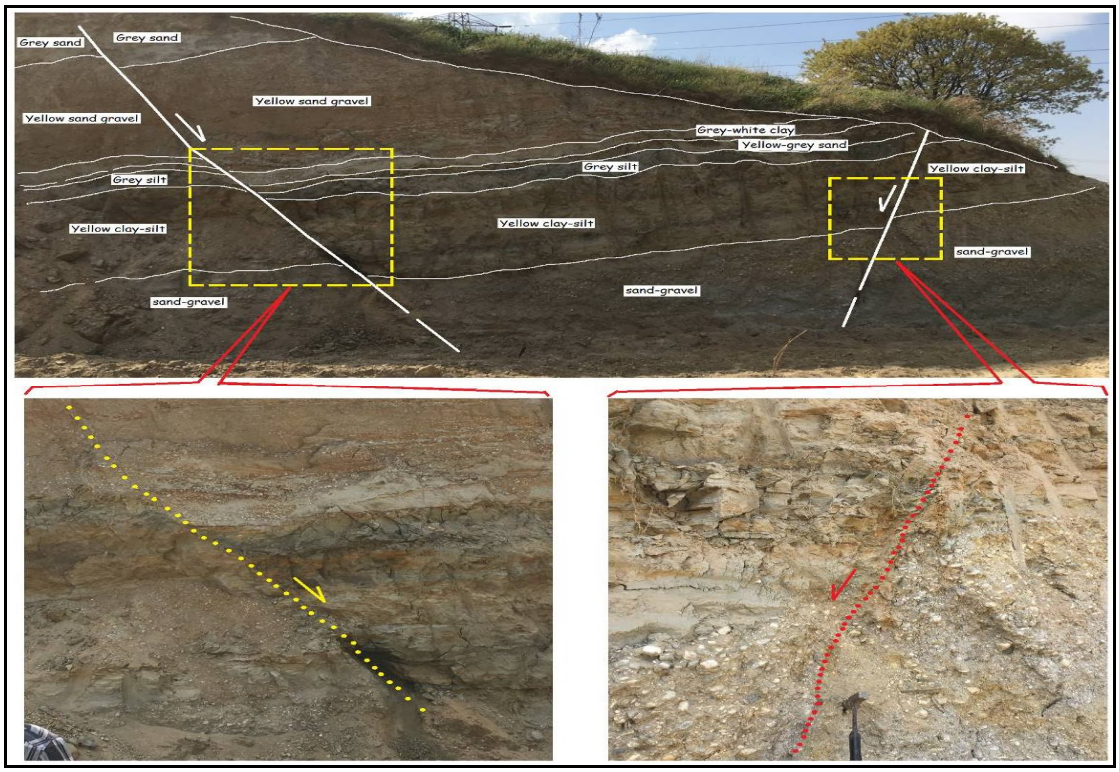


Fig. 2. General and detailed view of fault zone on a slope creep in NW Badinca (Alasehir) region (view towards west)

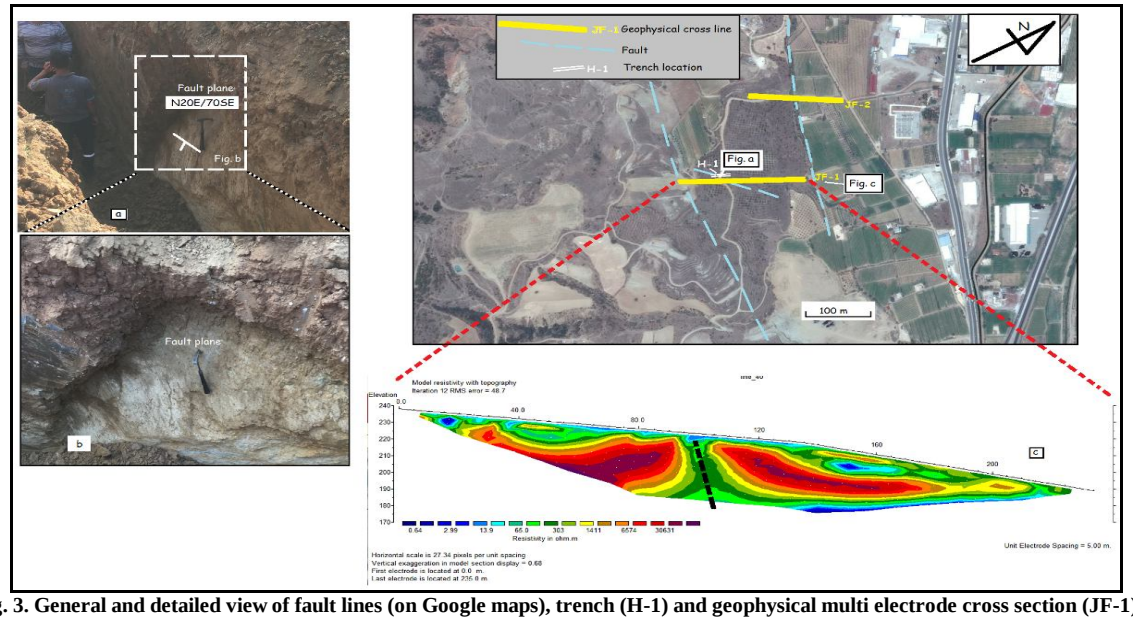


Fig. 3. General and detailed view of fault lines (on Google maps), trench (H-1) and geophysical multi electrode cross section (JF-1) in Badınca (Alaşehir) region.

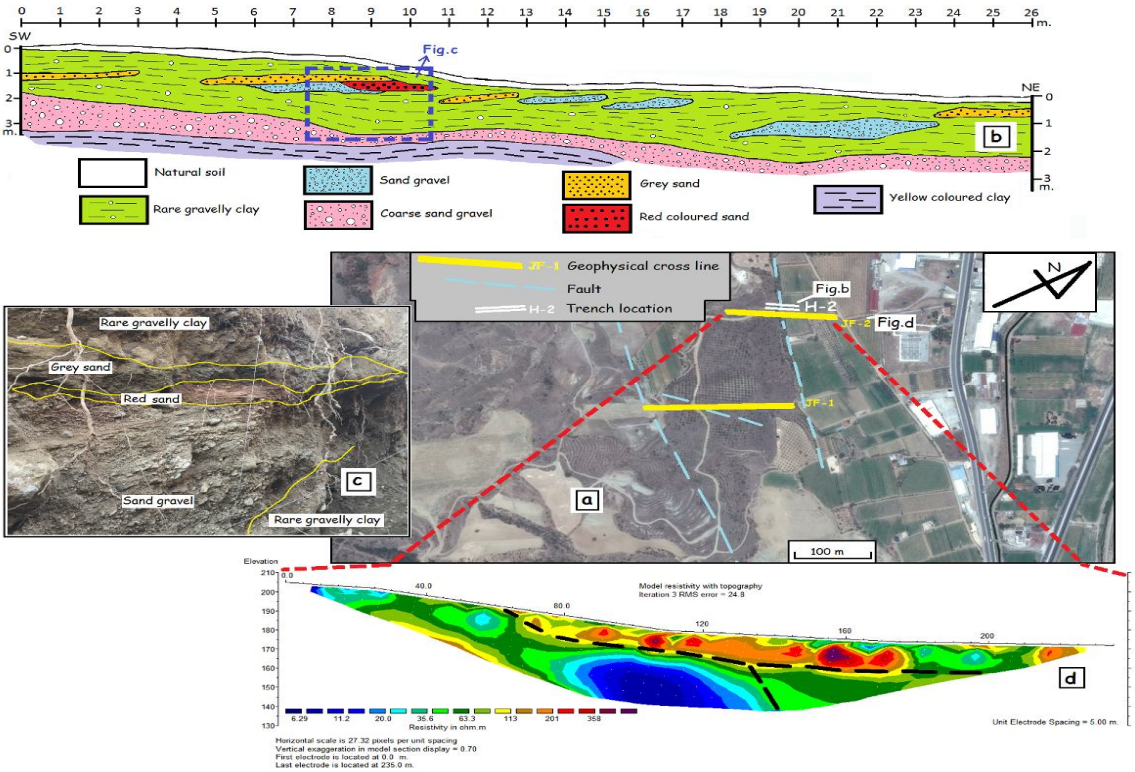


Fig. 4. Fault lines (on Google maps) (a), cross section of NW wall of the trench (H-2) (b), lithologies in the trench (c) and geophysical multi electrode cross section (JF-1) (d) in study area.

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