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ORIGINAL ARTICLE

Seismic record approach for the evaluation of natural hazards: a key study from SW Anatolia/ Turkey

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Abstract

Determination of the probability of occurrences and return periods of earthquakes are important issues in seismic hazard assessment and they are used in the evaluation of the natural hazards including liquefaction, slope failures, etc. Southwest (SW) Anatolian Region is well known with its seismic activity. This study aims to compare two areas with different faulting styles in terms of their seismic activities and the seismic hazard of two areas in SW Anatolia by evaluating the probability of occurrences, of earthquakes related with these fault mechanisms. Study area is divided into two groups as Muğla region and Fethiye–Burdur region due to differences in the fault types. Earthquakes follow Poisson distribution and magnitude–frequency relationships are the common methods in the probability calculations in earthquake engineering. Parameters "a" and "b" are important for these calculations. Calculations show that b parameters are low. Probability of occurrences of even high-magnitude earthquakes are in the range of a time interval important for human society. Our study areas cover both mountainous regions with high slope angles and coastal regions; therefore, earthquakes are likely to trigger both landslides and tsunamis in this region. So civil engineering structures in these regions must be designed properly and required precautions must be taken.

Keywords Probability · Return period · Seismicity · Magnitude–frequency relationship · Poisson method

Introduction

Active fault is defined as fault which has ruptured in the past 10,000 years. These faults are probable to generate earthquakes in the future (Keller and Pinter 2001). Strong ground motion is the single natural hazard related with these earthquakes and results in damages in structures, several secondary effects including slope failures, liquefactions and tsunamis which may result in casualties. So active faulting is in high importance for humanity. For this reason, it is important to know the seismicity of a region to fully evaluate the natural hazards (Slemmons and Depolo 1986).

This study aims to determine the probability of the occurrence of earthquakes in several timespans significant for human society by using statistical equations. SW Anatolian Region is controlled by different fault mechanisms including normal, strike-slip and thrust faults (Fig. 1). Gökova Fault Zone (GFZ), Muğla (MF) and Yatağan faults (YF) of Muğla-Yatağan Fault Zone (MYFZ), Milas–Ören Fault Zone (MOFZ) and Fethiye–Burdur zone (FBZ) which are shown in Fig. 1, are the major structures of the SW Anatolian Region. Tectonic geomorphology of Muğla-Yatağan Fault zone has been studied by Türe (2017). Muğla Yatağan Fault Zone is formed of two segments including Yatağan Fault (YF) and Muğla Fault (MF). Yatağan Fault dips NE with 85° and Muğla fault dips to SW with 55–80°. According to both morphological markers and fault geometry (Türe 2017) this fault zone is found to be active and probable to generate earthquakes up to Mw = 7.0. Moreover, South dipping Gökova Fault Zone is probable to generate earthquakes up to Mw = 7.2 by using the moment magnitude equations of Wells and Coppersmith (1994) as shown in Eq. 1. Here *a* and *b* are the regression coefficients and SRL means surface rupture length. Table 1 showing the moment magnitude scales of the faults in the Muğla region. These fault zones have

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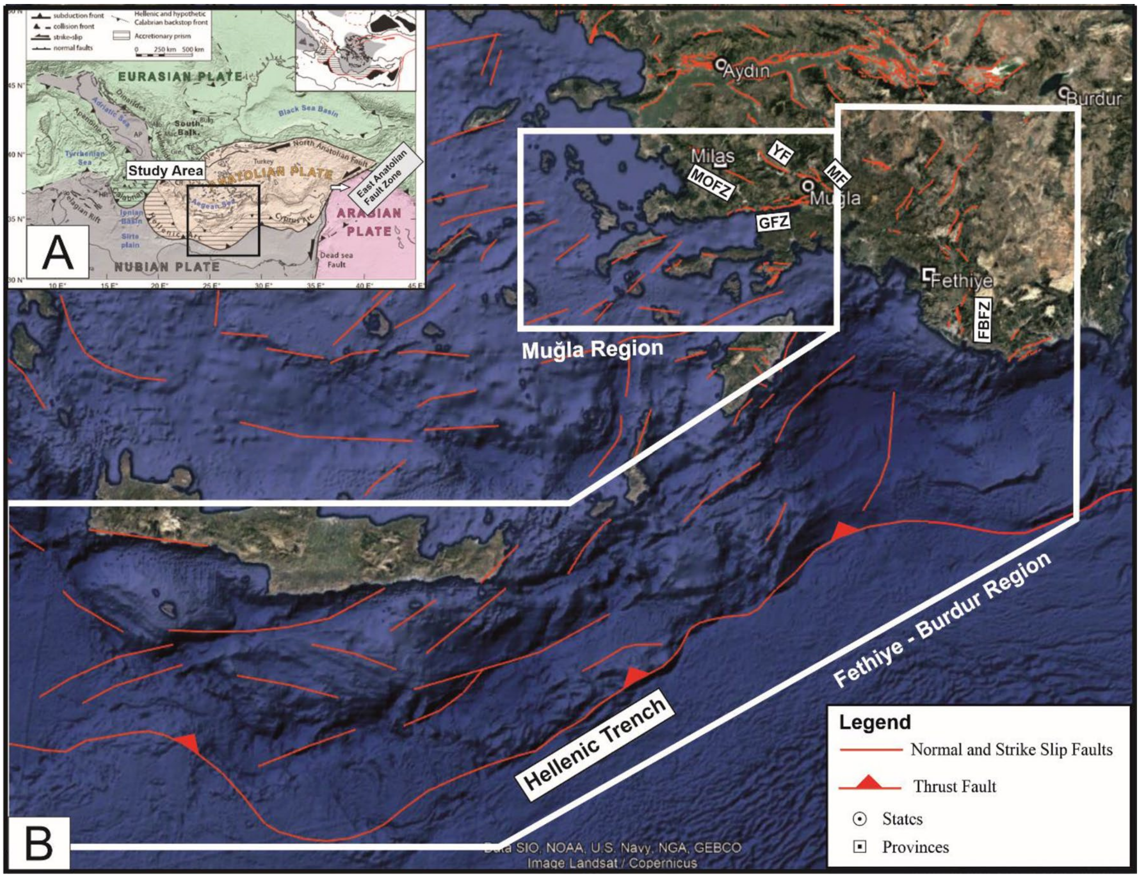


Fig. 1 Location and Tectonic map of study area above google earth image. Red lines represent active faults controlling the region and white boxes indicate the two regions with different fault styles used in the probability calculations. Fault data have been collected from active fault maps of General Directorate of Mineral Research and Exploration created by (Duman et al. 2011; Emre and Duman 2011; Emre et al. 2011a, b; Emre and Özalp 2011; Emre et al. 2011c, and d) and offshore faults have been modified from Pavlides et. al. (2008). Tectonic map of the Eastern Mediterranean region (Fig. 1a) has been modified from Chamot-Rooke et al. (2005) and (Pérouse et al. 2012)

Table 1 Table of moment magnitudes of different faults in the Muğla region according to the equations provided by Wells and Coppersmith (1994)

Fault	Fault type	M	a	b	SRL (km)
Milas FZ	SS	6.88	5.16	1.12	34
Milas S1	SS	6.17	5.16	1.12	8
Milas S2	SS	6.39	5.16	1.12	12.5
Milas S3	SS	6.44	5.16	1.12	14
Muğla-Yatağan Fault Zone	N	7.00	4.86	1.32	42
Yatağan Fault	N	6.50	4.86	1.32	17.5
Muğla Fault	N	6.71	4.86	1.32	25.2
Gökova Fault Zone	N	7.21	4.86	1.32	60

SS and N indicates strike-slip and normal faults, respectively. *a* and *b* are the regression coefficients and SRL means surface rupture length

generated earthquakes with magnitudes greater than 7.0 in the past. These earthquakes are listed in Table 2 and Fig. 2.

$$M_W = a + b \cdot \log(SRL) \quad (1)$$

According to the above information study area has been divided into two groups as Muğla region, considered as under the control of extensional tectonic regime, and Fethiye–Burdur region, under the control of compressional tectonic regime, in order to make comparison between normal fault dominated area and thrust fault-controlled area.

Materials and methods

SW Anatolian Region is composed of different types of faults, each controlling the tectonics of the area. This study aims to compare two zones with different earthquake style and the seismic hazard of these two regions in SW Anatolia by evaluating the probability of occurrences of earthquakes. Study area is divided into two groups as Muğla region and Fethiye–Burdur region (Fig. 3). Muğla Region is selected as a rectangular shape in the Western Section

Table 2 Table of the earthquakes with magnitudes greater than 7.0 between the years 1900 and 1963

Nr	Date (UTC)	Latitude	Longitude	Depth	Type	Mag	Source No 3	References Description 2	Place
1	25.04.1957 02:25	36.42	28.68	80	MS	7.1	3	Alsan et al. (1975)	Mediterranean
2	9.07.1956 03:11	36.69	25.92	10	MS	7.4	3	Alsan et al. (1975)	aegean sea
3	9.02.1948 12:58	35.41	27.20	30	MS	7.2	3	Alsan et al. (1975)	Mediterranean
4	25.02.1935 02:51	36.07	24.83	67	MS	7.1	1	Ayhan et al. (1981)	North of Crete Island- Aegean sea
5	30.08.1926 11:38	36.76	23.16	26	MS	7	1	Ayhan et al. (1981)	Aegean sea–Greece
6	26.06.1926 19:46	36.54	27.33	100	MS	7.7	1	Ayhan et al. (1981)	Datça–Aegean sea
7	3.10.1914 22:06	37.60	30.10	10	MS	7	9	Ambraseys-Jackson (1997)	Burdur
8	4.04.1911 15:43	36.50	25.50	140	MS	7.1	1	Ayhan et al. (1981)	Aegean sea
9	11.08.1903 04:32	36.00	23.00	80	MS	7.9	1	Ayhan et al. (1981)	Aegean sea

Reference list is provided by AFAD. (www.deprem.gov.tr). Details are not provided in the web site

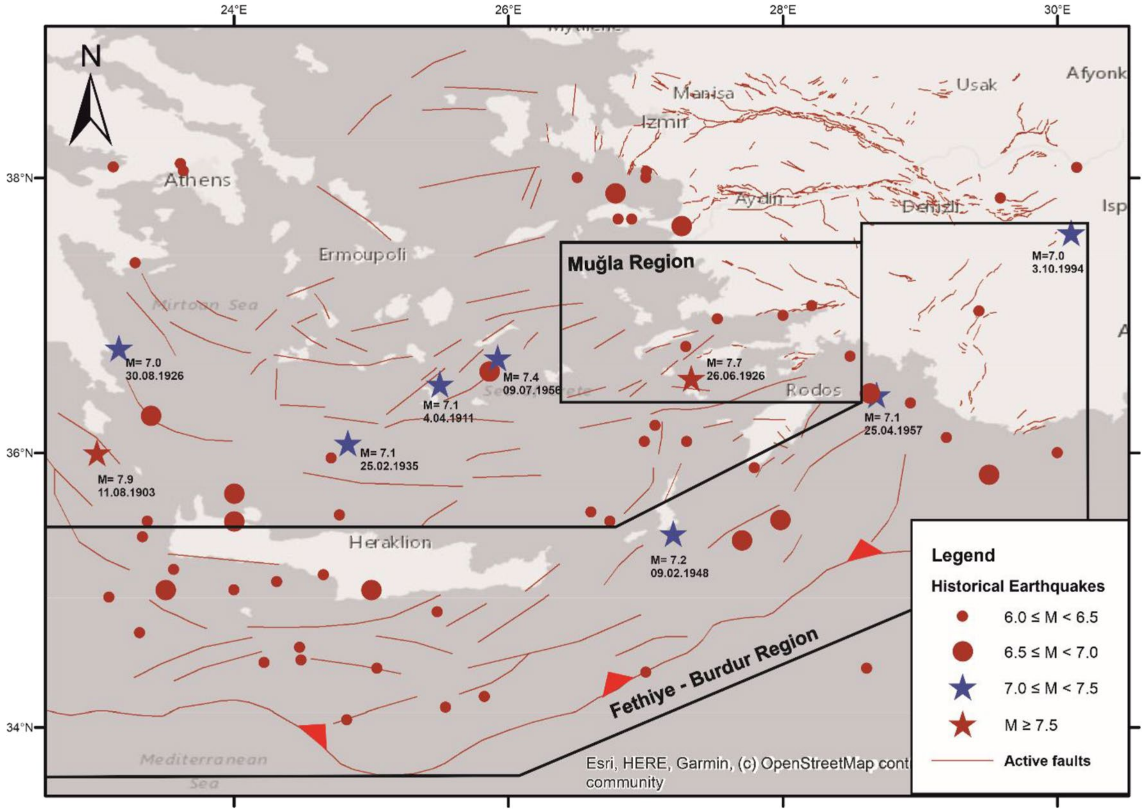
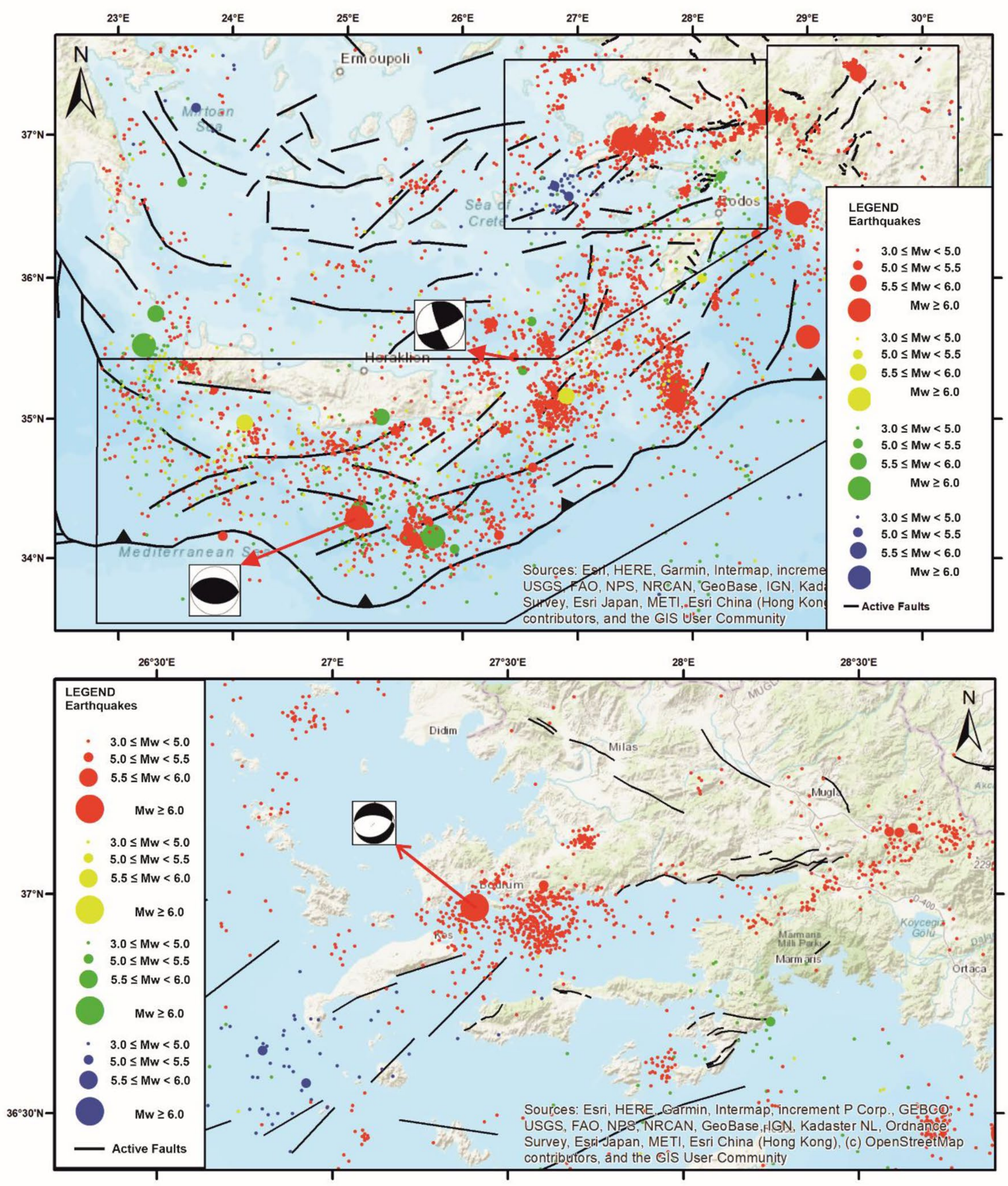


Fig. 2 Seismo-tectonic map of the study area showing the earthquakes in the region occurred between 1900 and 1960. Earthquake data obtained from (AFAD 2021) and references of the earthquakes with magnitudes greater than 7.0 are given in Table 2. Active faults are compiled and modified from (Duman et al. 2011; Emre and Duman 2011; Emre et al. 2011a, b; Emre and Özalp 2011; Emre et al. 2011c, and d) and Pavlides et al. (2008)

of SW Anatolia and main fault zones of this region are Muğla–Yatağan Normal Fault Zone, Milas–Ören Strike-Slip Fault Zone and Gökova Normal Fault Zone. Northern section of the Muğla region is bounded by Büyük Menderes Graben which is one of the other important areas in terms of seismic activity. Fethiye Burdur Region begins from Burdur in the North moves Southward through Fethiye and then follows Hellenic Trench through Rhodes according to the faults in the area. Fethiye-Burdur Region is bounded by Antalya from East and Isparta from North.



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Fig. 3 Seismo-tectonic map of the study area showing the earthquakes with magnitudes greater than Mw = 3.5 in the region that occurred between 1963 and 2021 have been plotted by using ArcMap. Figure in the bottom is the close view of the Muğla Region. Earthquake data obtained from Kandilli Observatory and Research Institute. Active faults are compiled from (Duman et al. 2011; Emre and Duman 2011; Emre et al. 2011a, b; Emre and Özalp 2011; Emre et al. 2011c, and d) and Pavlides et al. (2008). Colour coding indicates the depth variation and size scaling indicates the magnitudes. Red dots are the narrowest earthquakes and the blue ones are the deepest with depth intervals 0–25 m, 25–50 m, 50–100 m and deeper than 100 m from red to blue, respectively. Fault Plane solutions for three earthquakes are given in the figure (From deprem.gov.tr)

Fethiye–Burdur region is the continuation of Hellenic arc, which is a large subduction zone. These two zones are shown in the figures.

Seismic hazard potential analyses require the collection of data of earthquakes from pre-available catalogues. Earthquake data have been obtained from Kandilli Observatory and Earthquake Research Institute's (Bogazici University

(2021) Regional Earthquake-Tsunami Monitoring Center (http://www.koeri.boun.edu.tr/sismo/2/earthquake-catalog)) earthquake catalogue in this study. Earthquakes beginning from 1963 have been because data before 1963 are not instrumental records and may lead to mistakes during the collection of these information. Earthquake data composed of different magnitude scales including M_B, M_S, M_L, M_D and M_W. In order to maintain the uniformity in the analyses, these different magnitudes of earthquakes have been converted into a single type earthquake magnitude scale which is moment magnitude (M_W). Magnitude conversion equations used to convert these magnitude scales to Mw have been derived based on Linear Regression Analysis Method. An example of the conversion relationships has been studied by Scordilis (2006). Scatter graphs of different magnitude scales vs. moment magnitude are plotted (M_S-M_W, M_L-M_W, M_B-M_W, M_D-M_W graphs). Missing M_W values of the Earthquakes have been estimated by this method. This conversion has been made for each region separately (Fethiye–Burdur Region and Muğla Region) by using the SPSS software (Statistical Package for Social Sciences) (Fig. 4). Poisson method which assumes earthquakes follow Poisson distribution, which means earthquakes are independent of each other both in time and sources and it is impossible to occur 2 or more earthquakes at a single location at the same time, is one of the mostly used statistical method in the probability calculations (Gülkan and Gürpınar 1977; Özmen 2013). In order to ensure the independency condition for Poisson method, aftershocks have been eliminated from the earthquake catalogue by using Gardner–Knopoff (1974) method. They formulated the duration of aftershock in terms of magnitude of the largest event as in Eq. 2 and formulated the aftershock zone in terms of magnitude as in Eq. 3.

$$Log(T) = a1M + b1 \tag{2}$$

$$Log(L) = a2M + b2 \tag{3}$$

Moreover, they tabulated these magnitude values with length and duration (Table 3). ZMap (Wiemer 2001), a MATLAB tool for analyses of seismicity, has been used in order to decluster the aftershocks.

Figure 5 shows the testing of declustering method by giving the plots of cumulative number of earthquakes vs. time for each region**.** If declustering has worked well, this should show that the declustered catalog is a lot smoother than the full, unclustered catalog (Fig. 5). These lines curve upwards, showing that the number of earthquakes recorded has increased over time. This is to be expected, as more and more seismometers are deployed. Plots show more linear trending if cumulative number of events greater than magnitude of completeness (Mc) value vs years graph is plotted (Fig. 7).

Equation 4 is used to find the probabilities of the distribution of magnitudes. Gutenberg and Richter (1956) (GR Equation from now) correlate the magnitude to the number of events in his equation as follows:

$$\log(\mathrm{N}) = a - b \cdot (\mathrm{M}) \tag{4}$$

where a and b are parameters show variations according to the tectonism and so they are location dependent. Parameters "*a*" (annual mean seismic activity parameter) and "*b*" (Seismotectonic parameter) are related with seismic activity and tectonics of the study area, respectively. Earthquake catalog must be cleansed from the earthquakes with magnitudes lower than magnitude of completeness Mc value. Mc values are obtained via zmap by using maximum curvature method. Parameter "*a*" depends on the size of the study area and interest period. These parameters are obtained by using the maximum curvature method. Graph of cumulative events of events vs. magnitudes of events is plotted (Fig. 7). Probability calculations follow an order as follows: Eq. 5 is obtained, from the relationship between normal frequency and cumulative frequency. GR Equation may be modified and may be written exponentially as in Eq. 6, where $N(M)$ is the annual number of earthquakes. By dividing each side of the modified GR equation with the interest period (T_1) and by taking the logarithm of each side, Eq. 7. is obtained. Equation 8 is used to determine the annual mean occurrence numbers. In the equation M represents Moment Magnitude, and P represents Probability (Gençoğlu 1972; Tuksal 1976; Alptekin 1978; Sayıl and Osmanşahin 2008; Özmen 2013).

$$a^{'} = a - \log(b.Ln10) \tag{5}$$

$$N(M) = 10^{a-b.M} \tag{6}$$

$$\begin{gathered}
N(M)/T_1 = \left(10^{a-b\cdot M}\right)/\left(T_1\right) \\
\mathrm{Log}\left(N(M)/T_1\right) = a - bM - \log\left(T_1\right) \\
N\left(M > M_1\right) = (10^{a-b\cdot M-\log\left(T_1\right)}) \\
a1' = a' - \log\left(T_1\right) \\
N(M) = 10^{a1'-b\cdot M}
\end{gathered} \tag{7}$$

$$\mathrm{P} = 1 - \mathrm{e}^{-N(M)T} \tag{8}$$

Geology of the study area

Study area has undergone many complex geological and tectonic processes throughout the geological lifespan which has resulted in the occurrence of many different geological formations in the region from Precambrian to Holocene (Fig. 6). Lithological units that substance in Muğla region are composed of 2 groups as Basement Units and Tertiary

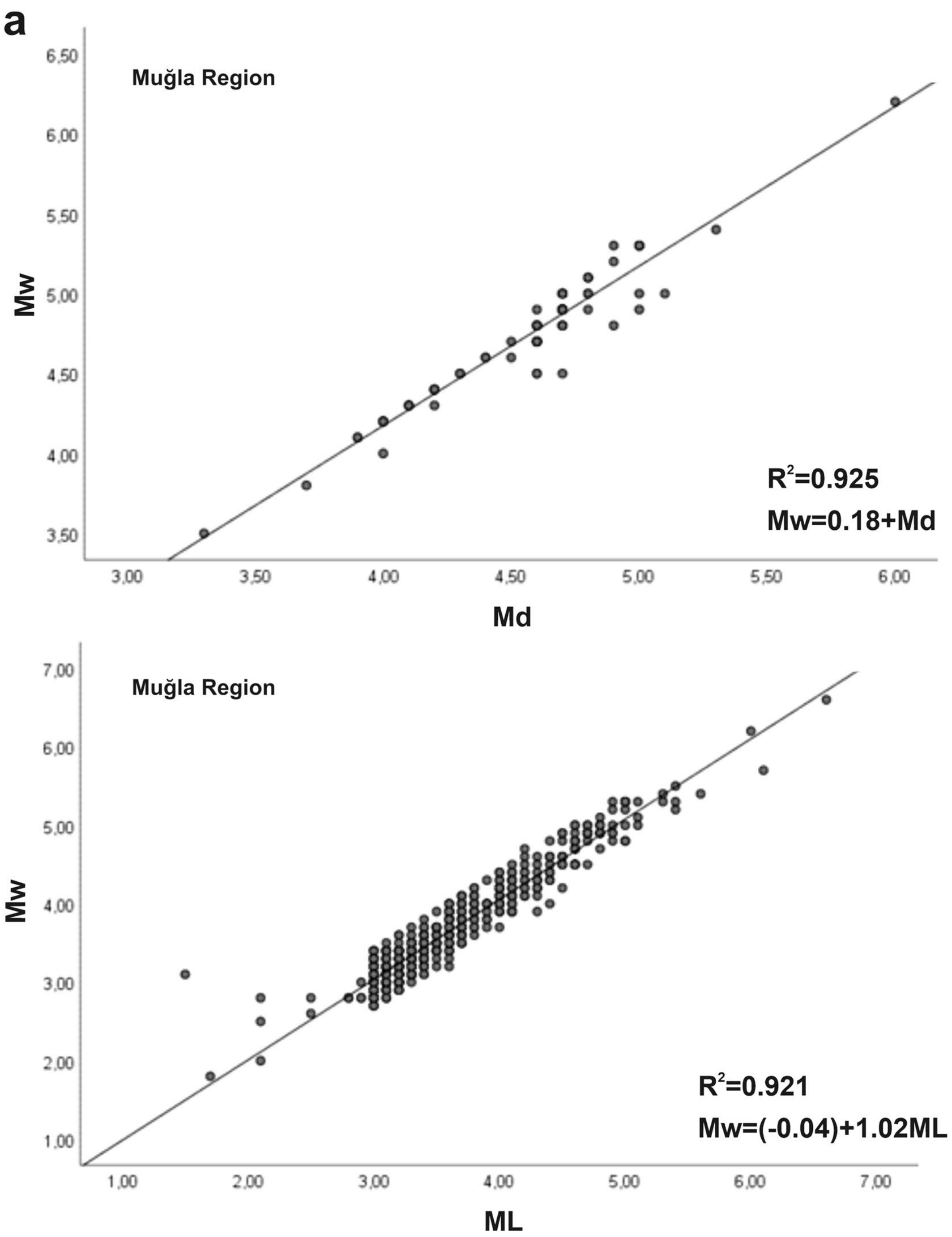


Fig. 4 **a** Regression analyses and magnitude conversion plots with the equations for the earthquakes. **b–d** Continuous, Regression analyses, and magnitude conversion plots with the equations for the earthquakes

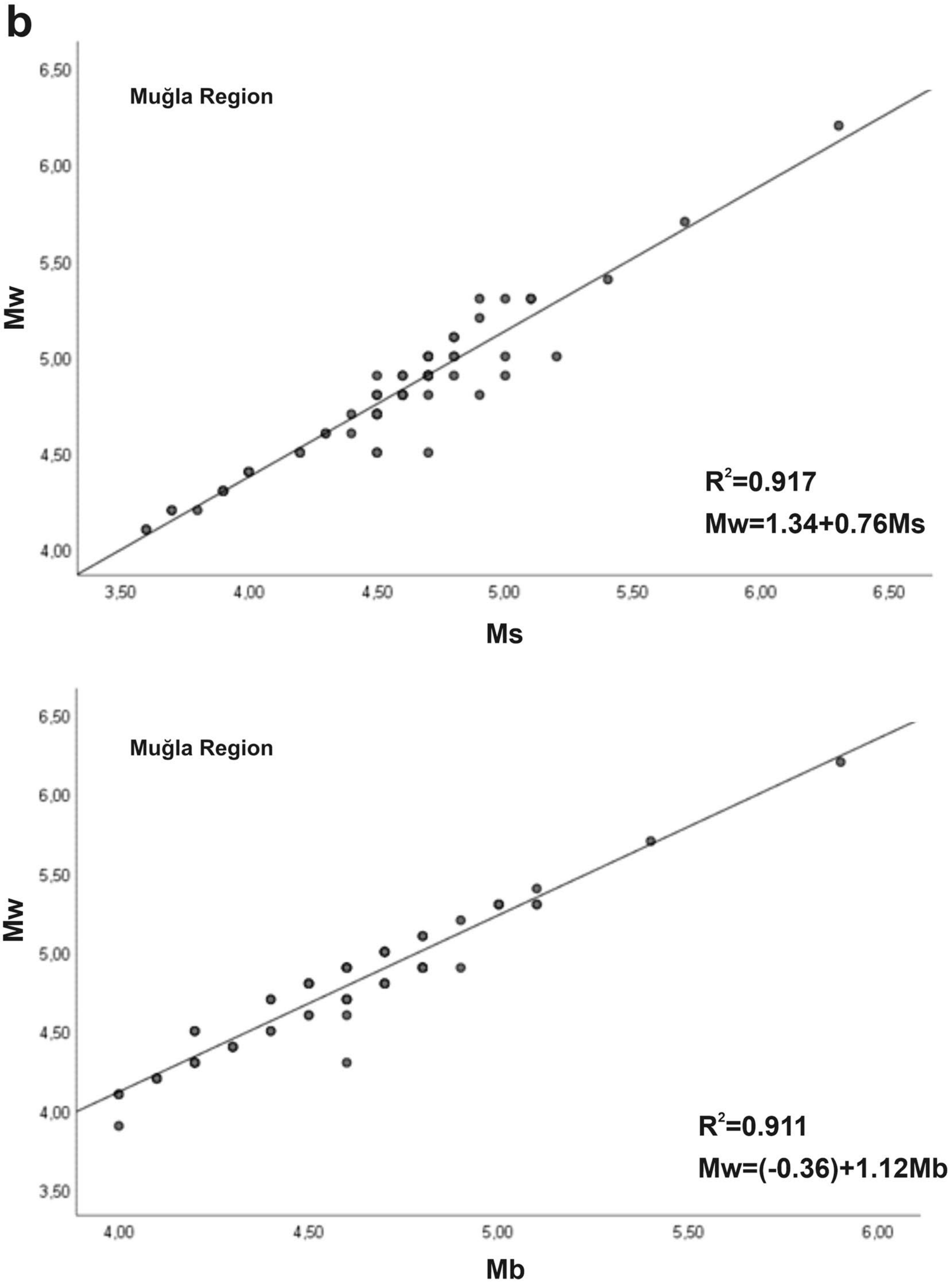


Fig. 4 (continued)

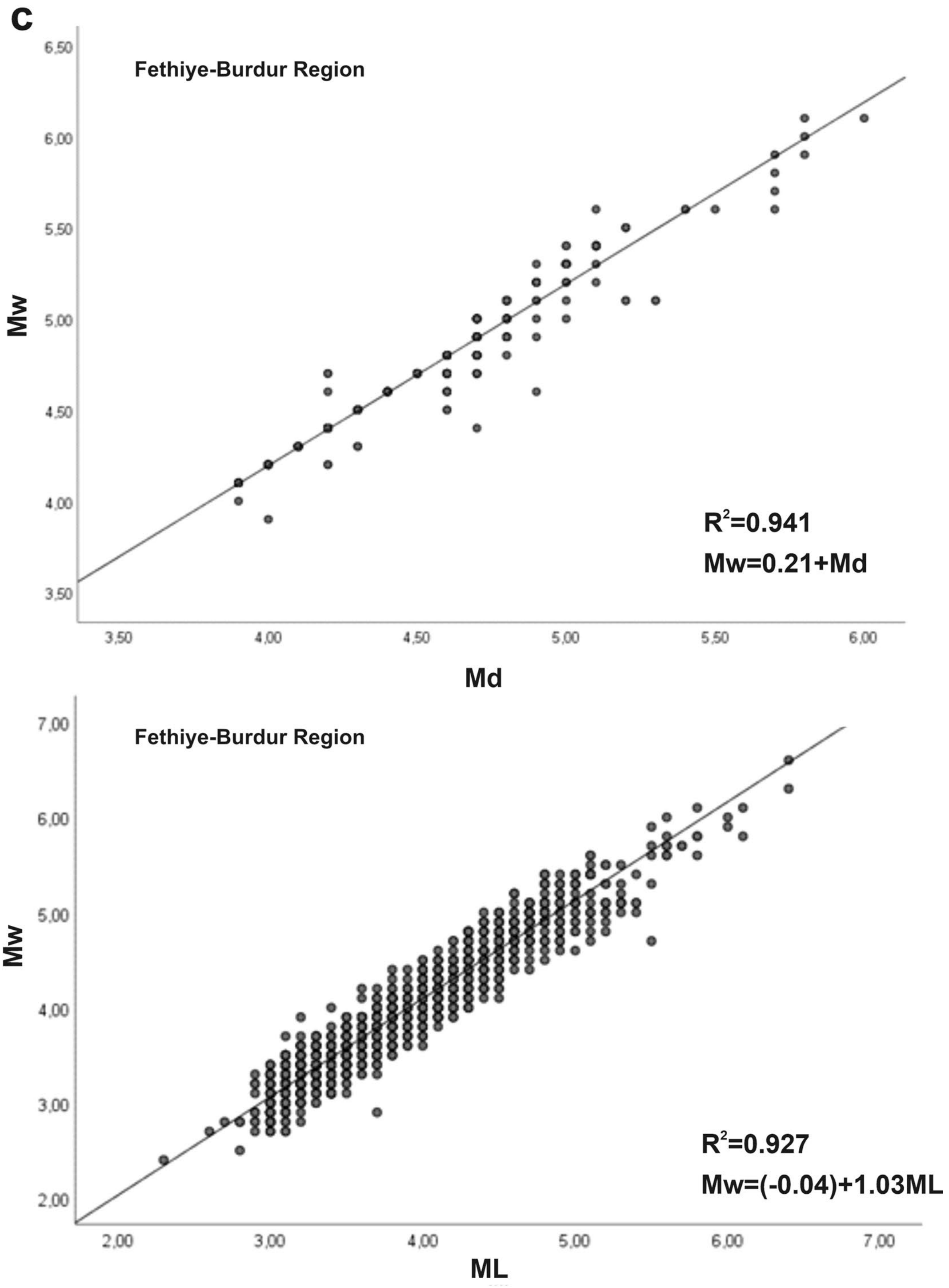


Fig. 4 (continued)

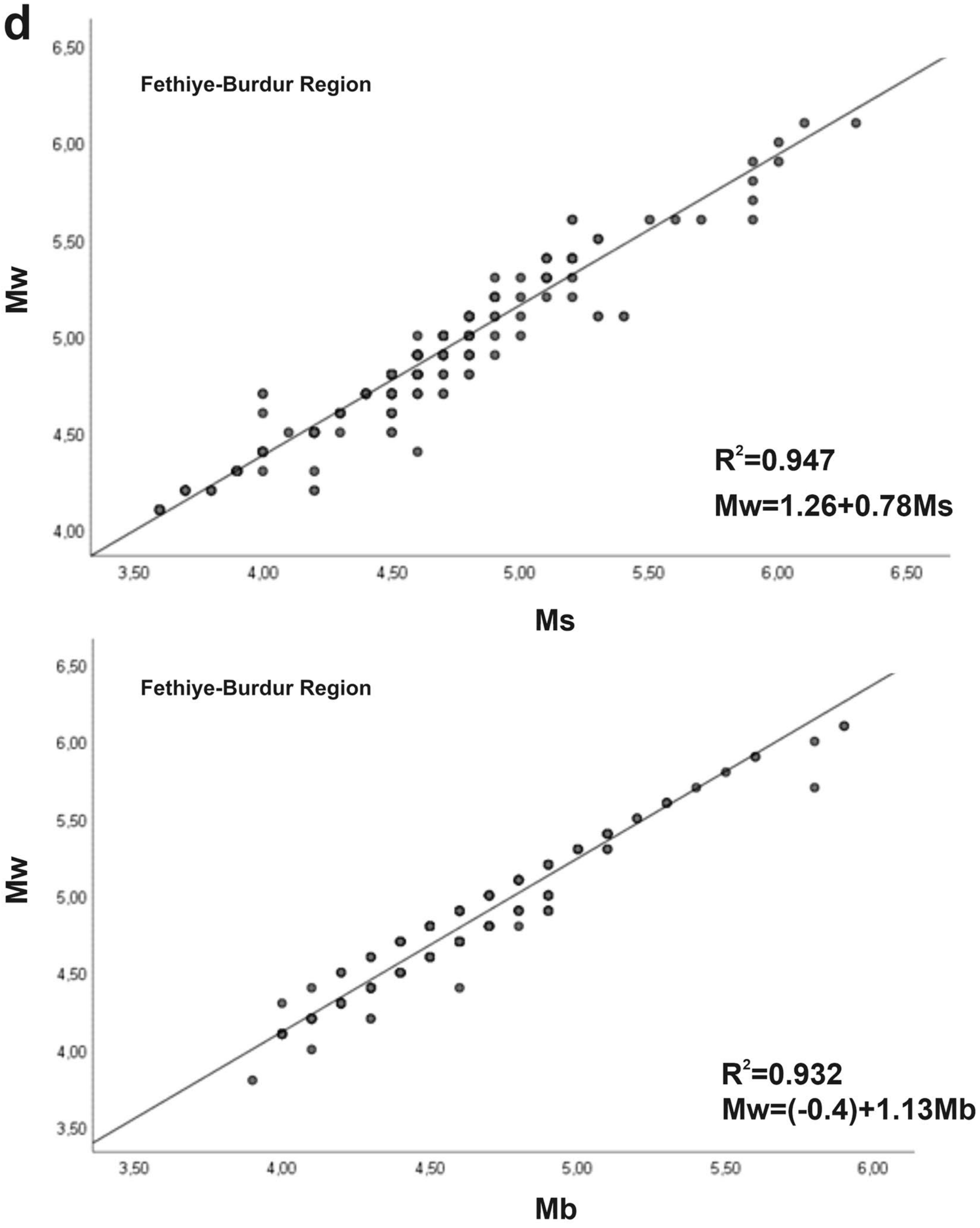


Fig. 4 (continued)

Units. Basement units comprise Beydağları Autocthonous, Southern-Çine Submassif of Menderes Massif and Lycian Nappes (Gül 2018 and references therein). All of these units show different engineering characteristics.

Çine Submassif covering the Northern part of the Muğla, comprises Pan-African metagranite core units (augen gneisses, mica gneisses and metagabbro) which are overlain by the Mesozoic and younger schists, phyllites, marbles, limestones and dolomites (Şengör et al. 1984; Özer et. al. 2001; Bozkurt 2001; Candan et al. 2001; Dora et al. 2001; Okay 2002; Whitney and Bozkurt 2002; Dora 2007; Gül 2018 and references therein). Lycian nappes contains Palaeozoic to Lower Miocene aged various types of sedimentary rocks bearing rocks and Jurassic-Cretaceous ophiolites and ophiolitic melanges bearing nappes between the Çine Submassif and the Beydağları Autochthone (Graciansky 1967, 1968; Brunn et al. 1971; Şengör and Yılmaz 1981; Şenel et al. 1989, 1994; Görür

Table 3 Aftershock identification windows (From Gardner and Knopoff 1974)

Magnitude	Length(km)	Time(days)
2.5	19.5	6
3.0	22.5	11.5
3.5	26	22
4.0	30	42
4.5	35	83
5.0	40	155
5.5	47	290
6.0	54	510
6.5	61	790
7.0	70	915
7.5	81	960
8.0	94	985

et al. 1995; Şenel 1997a, b, Collins and Robertson 1997, 1998, 1999; Şenel 2007; Okay et. al. 2001; Aldanmaz et al. 2009). The Beydağları autochthonous is composed of rudists, planktonic–foraminiferous half pelagic, massif limestones and Planktonic–foraminiferous units deposited in the transgressive environments (Sarı and Özer 2001, 2002; Sarı et al. 2004; Sarı 2006).

Tertiary units in the Muğla region covers vast areas. Bodrum–Milas region is characterized by Miocene and later volcanics and alluvial deposits that overlie the Palaeozoic to Pre-Miocene metamorphics, sedimentary rocks (Ercan et al. 1982, 1984a; Genç et al. 2001; Ulusoy et al. 2004; Karacık 2006). Quaternary volcanics and Pliocene sedimentary rocks unconformably overlie the Pre-Eocene rocks (Ercan et al. 1984b; Ersoy 1991; Dirik et al. 2003; Gençalioğlu- Kuşcu and Uslular 2018).

Muğla region hosts many rift and graben systems. These are Kale–Tavas Basin, Ören Basin, Gökova Graben and Yatağan Basin (Gürer and Yılmaz 2002; Gürer et al. 2013). The oldest basin in the region is E–W trending Kale–Tavas Basin (later and shorter basin called as the Gökova Graben) and it comprises Upper Oligocene to Lower Miocene rocks (Gürer and Yılmaz 2002). The youngest deposits of this basin are alluviums, alluvial fans and colluviums (Atalay 1980; Göktaş 1998; Gürer and Yılmaz 2002; Gürer et al. 2013). NW–SE oriented Muğla-Yatağan Graben and Milas–Ören Graben were filled by the lignite bearing lacustrine deposits and continental deposits including fluvial

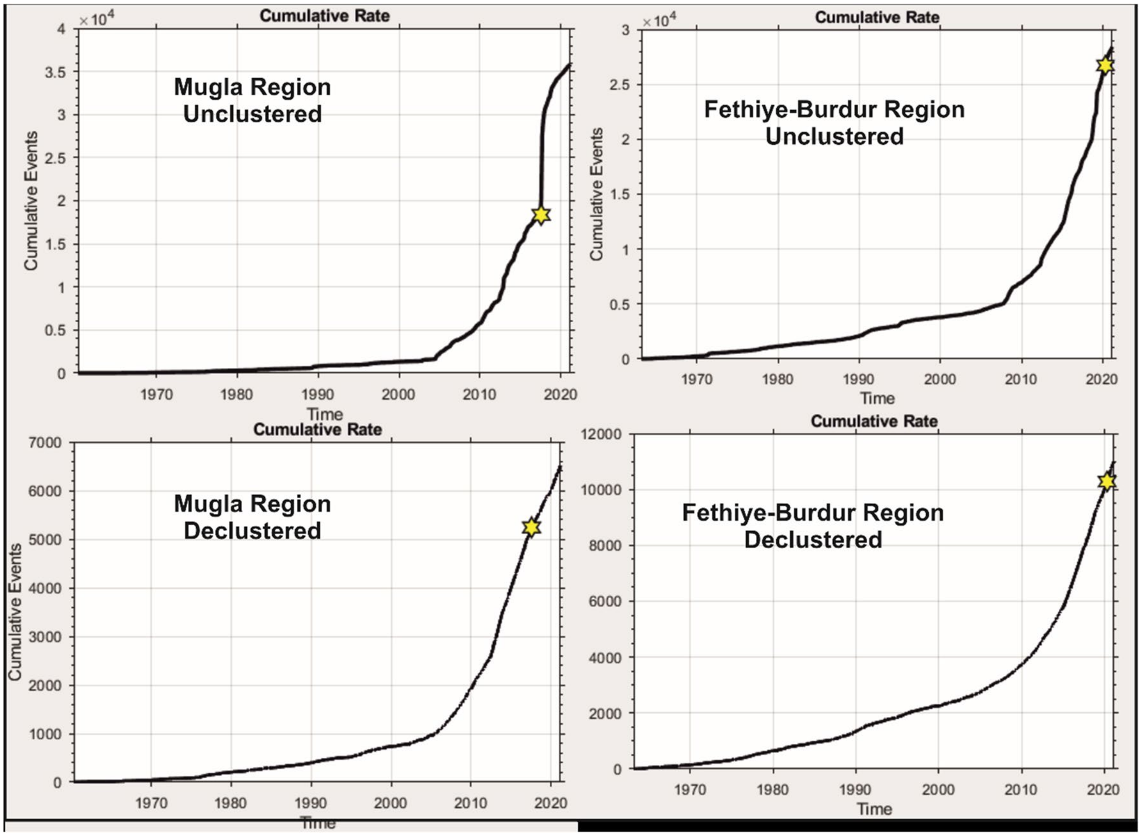


Fig. 5 Plots of cumulative number of earthquakes vs time for Muğla in the top and Fethiye–Burdur regions in the bottom. Yellow stars indicate the time of the largest events in the time interval

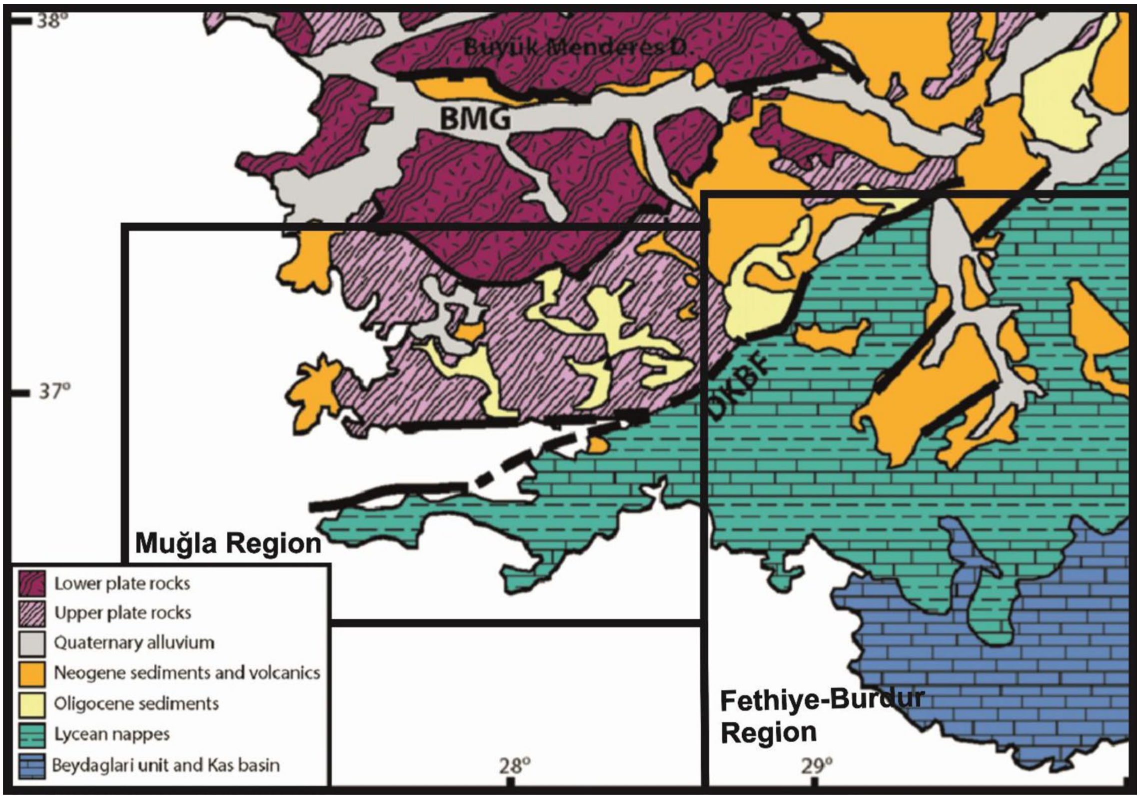


Fig. 6 Simplified geological map of the Western Anatolia. Crustal parts of the Muğla and Fethiye–Burdur regions are shown in black frames. BMG (Büyük Menderes Graben), DKBF (Datça–Kale Fault). Modified from (Kent et al. 2016)

clastics (Atalay 1980; Göktaş 1998; Gürer and Yılmaz 2002; Gürer et al. 2013; Gül et al. 2016).

Fethiye and surrounding region have been filled by the Pleistocene to recent old alluviums, younger alluvial deposits, colluviums, beach deposits (Ertunç et al. 2006; AFAD 2013). The Eşen Basin in SE of the Fethiye town contains post Miocene lacustrine and fluvial deposits including carbonates and clastic sediments (Alçiçek 2007).

Possible hazards due to earthquake in SW Anatolia

Several studies mentioned that the study area has been suffering from earthquakes since ancient times such as BC 227, BC 199–188, AD 142–144, 155, 1493, 1741, 1851, 1863, 1869 and past 120 years (Sezer 2003; Kalafat et al. 2005; Akyüz et al. 2016; Kılıç and Kalyoncuoğlu 2017; Sözbilir et al. 2017a, b).

Seismicity of the region was also responsible for the destruction of the ancient cities such as the Kibyra, Patara, (Yaltırak et al. 2015), Lagina and Stratonikeia (Karabacak 2016). 1957 Fethiye earthquake caused some property damage and loss of people's life (AFAD 2013).

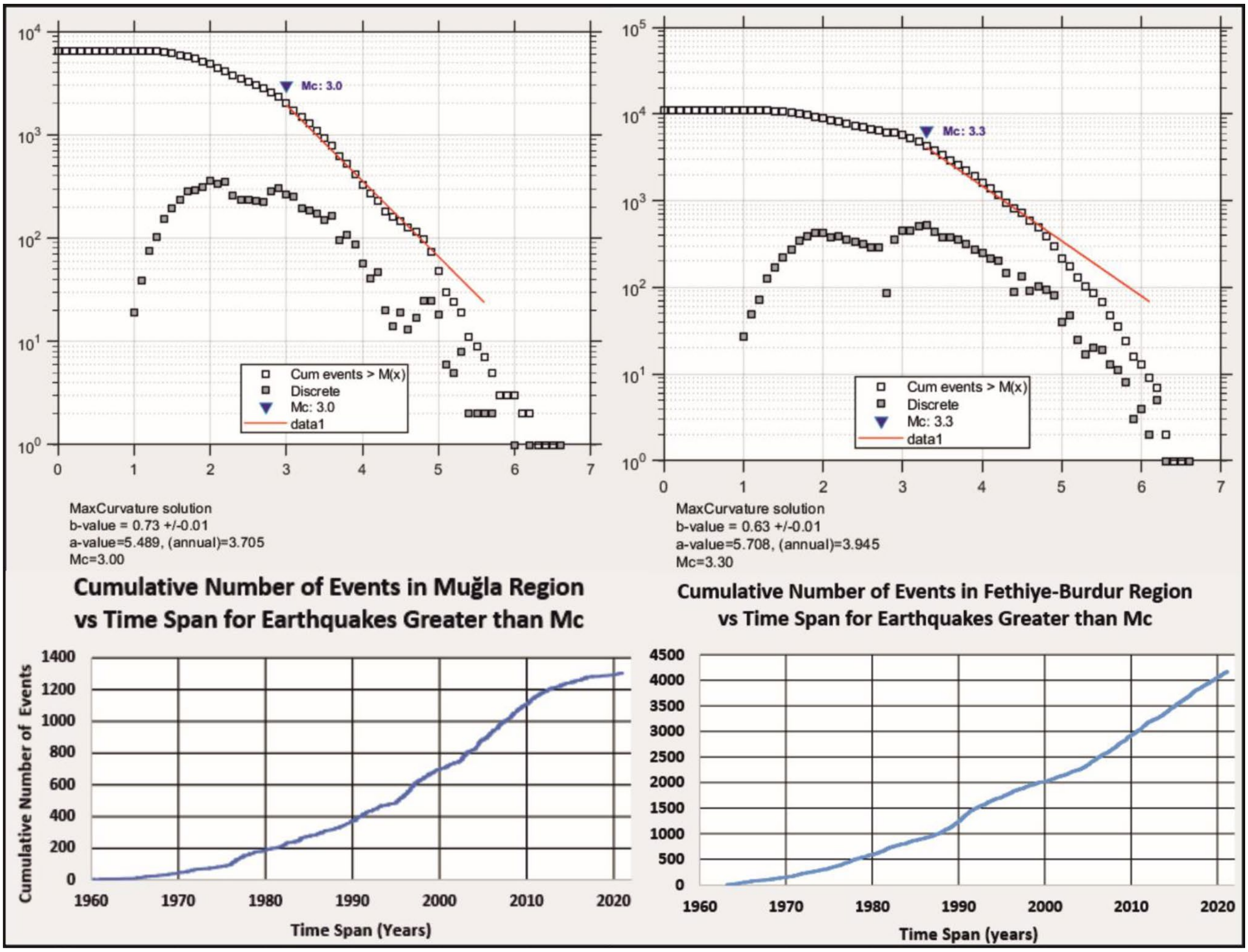
This seismicity also caused tsunami risk for Muğla coast that was responsible for the property damage and loss of people's life in ancient times (Altınok and Ersoy 2000; Altınok 2005; Papadopoulos et al. 2007). Tsunami after Kos 2017 Earthquake affected the Bodrum Town. Risk still continues (Yalçıner et al. 2017).

Moreover, Ertunç et al. (2006) described the possible liquefiable ground in Fethiye town centre. Similar ground can be observed in other settlement places of Muğla, built on the younger alluvial deposits.

Duman et al. (2009), AFAD (2013) and Orak et al. (2019) emphasized the recent mass movement including landslide, creep, earthflow (that threat the destruction of the main road between the Fethiye–Antalya) characteristics in east of the Fethiye town. AFAD (2013) also mentioned the possible rock fall risk of higher slope region around the Fethiye town. Gül et al. (2016) described the rock fall threat on top of the Asar Hill in Muğla city Centre.

Probability of occurrence calculations of earthquakes in Muğla and Fethiye– Burdur Fault Zone regions

SW Anatolian Region is known as an important area controlled by active faults that have caused many severe



Cumulative Number of Events in Muğla Region vs Time Span for Earthquakes Greater than Mc

Cumulative Number of Events in Fethiye-Burdur Region vs Time Span for Earthquakes Greater than Mc

Fig. 7 Magnitude of completeness values with a and b values of Muğla region in the left-hand side and Fethiye region in the right-hand side. These graphs are created by using the Zmap. Cumulative events larger than Mc value vs Time-span plots show more linear trends which means declustering is succesfull

earthquakes in the past and are also still able to generate many earthquakes in the future (Bozkurt, 2001). In this study seismicity of the SW Anatolia is discussed by comparing two zones of different earthquake style where thrust faults dominate in the surrounding of Fethiye and normal faults dominate in the surrounding of Muğla. Mc values and b parameters have been obtained by using Zmap which is a MATLAB tool used for seismicity analyses. Muğla region comprises many quarries and records with magnitudes lower than Mw = 3.0 which may be related with the blasting operations (Anonymous 2019). Mc values are 3.0 for Muğla region and 3.3 for Fethiye region; b values are low for both regions and indicate a considerably huge stress release (0.73 ± 0.01 and 0.63 ± 0.01 for Muğla region and Fethiye–Burdur region, respectively) (Fig. 7). The error values are so low and they do not influence the hazards in the region. Probability of occurrences of the earthquakes of two regions are shown in Table 4 and compared using graphs in Fig. 8. When it is assumed that a 100 years is approximately equal to a human lifetime, both regions are highly capable to generate earthquakes that are important in terms of human society with 100% probability of producing earthquakes with magnitudes greater than 6.0 in 100 years. However, when it is looked at the table, it is clear that probabilities of the given earthquake magnitudes are always larger in Fethiye–Burdur region. Moreover, Fethiye–Burdur region has also great importance in terms of earthquakes larger than Mw = 5.5 with probabilities higher than 50% probability of occurrence with respect to Muğla Region in the near future. According to these results it can be said that thrust fault-related earthquakes are much more hazardous than normal fault-related earthquakes in SW Turkey.

Possible hazards due to the earthquakes are given in the previous section. According to the results, even if Fethiye–Burdur region is much more probable to generate higher magnitudes of earthquakes than Muğla region, both of the regions must

Table 4 Probability of occurrence calculations of earthquakes with 0.5 unit increase in magnitude for Muğla and Fethiye–Burdur regions that show different fault mechanisms relative to each other

Region	M_W	N	Probability of occurrence of earthquakes with given magnitudes for some time intervals (%)						
			1 year	5 years	10 years	20 years	50 years	75 years	100 years
Muğla	4.5-4.9	91	77	100	100	100	100	100	100
	5.0-5.4	19	44	95	100	100	100	100	100
	5.5-5.9	4	8	33	55	80	98	100	100
	6.0-6.4	1	3	8	28	48	80	91	96
	6.5-6.9	1	2	8	15	28	55	70	80
Fethiye - Burdur	4.5-4.9	372	100	100	100	100	100	100	100
	5.0-5.4	119	93	100	100	100	100	100	100
	5.5-5.9	34	50	97	100	100	100	100	100
	6.0-6.4	9	18	64	87	98	100	100	100
	6.5-6.9	1	2	8	16	29	57	72	82

Yellow colour coded cells indicate the probabilities of occurrence of earthquakes with magnitudes of 5.5–5.9 and Blue colour coded cells indicate the probability of occurrence of earthquakes with magnitudes 6.0–6.4. There are a huge differences between two regions for these magnitude intervals in which the Fethiye–Burdur region has higher values

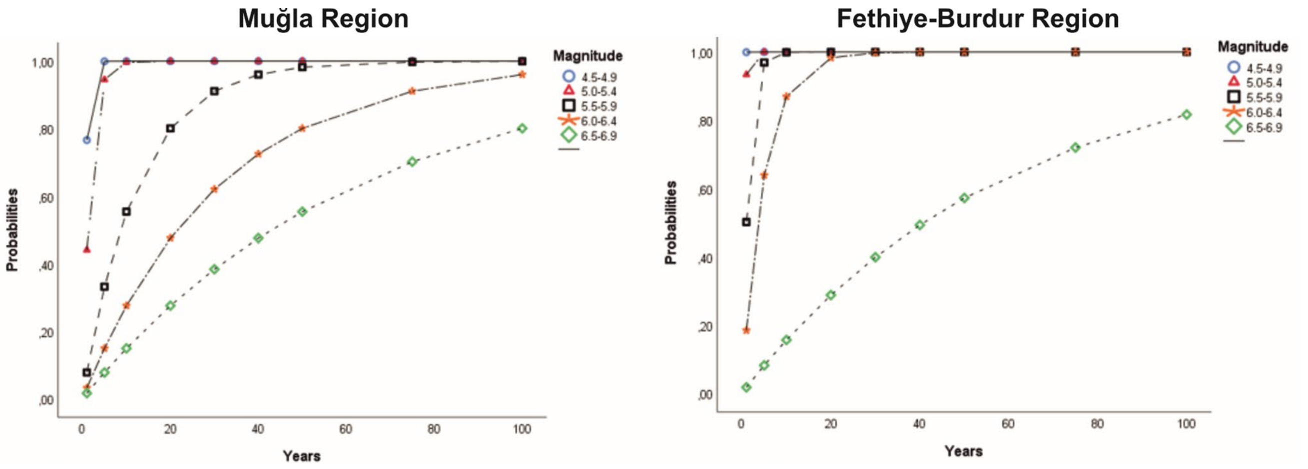


Fig. 8 Graphs comparing the probabilities of the occurrences of earthquakes for different magnitudes in different time spans. Probabilities of Muğla Region in the left-hand side and Fethiye-Burdur Region in the right-hand side are given in two separate graphs and probability of occurrences of different magnitudes are plotted with different colour codes. A huge increase in the probabilities of the earthquakes is observed in the Fethiye-Burdur Region with respect to Muğla Region for earthquakes with magnitudes between 5.5 and 6.5

take the precautions. 17 August 1999 Gölcük earthquake is an important clue that liquefaction is an important secondary effect of earthquake which is responsible for the destruction of engineering constructions and loss of life. Detailed analysis of liquefaction potential of the soils in both regions must be conducted as soon as possible in order decrease the liquefaction risks in these regions. Moreover, regions with high slope angles shown in the slope map with the faults controlling the regions in Fig. 9 are highly risky in any case of earthquake in these regions and sea sides of these regions are probable to face with tsunamis. Most of the fault-controlled regions show steep slopes according to the slope map especially Northeast of Ören/Muğla Northern margin of Muğla City center, Yakaköy region in the Eastern part of Fethiye. However, it is not constrained with these regions because there are lots of areas that may be affected from earthquakes resulted from faults that are far from the localities. So, these regions must take care of these hazards in order to prevent loss of life. Then necessary precaution measures including public education, relocation of settlements, early warning systems establishments, destruction of the risky buildings, reinforcements of old-important buildings-bridges, sea wall etc. must be done immediately.

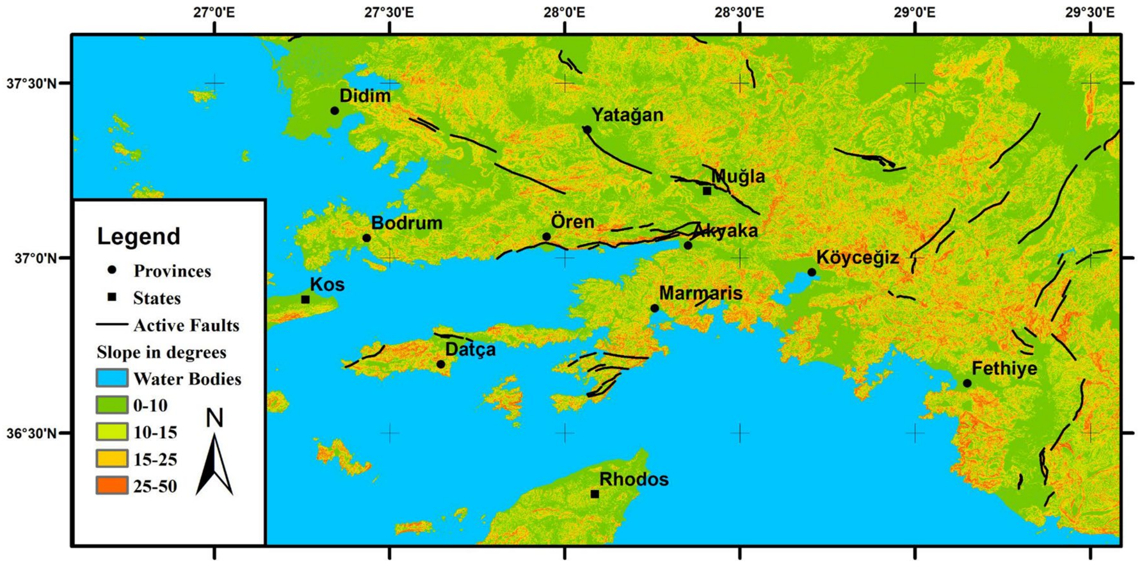


Fig. 9 Slope map of the Aegean Region created by ArcGIS software. Aegean Region is formed of many depressions and topographic highs because of the tectonic activity. This results in the formation of areas with wide range of elevations and so wide range of changes in slopes. As shown in the figure there are too many areas at the region whose slope is higher than 25 degrees. And these slope angles may reach up to 50 degrees in some localities

Conclusions

Tectonically different regimes have affected the SW Anatolia, especially Muğla and surroundings. Southern part of this region is under the effect of the mostly compressional regime via Helenic Trench (subduction zone) and its continuation on land is called as a Fethiye-Burdur Fault Zone. Northern part of the region is under the effect of the extensional regime via normal fault-strike slip faults. According to probability calculations, southern part is riskier than the northern region. Especially 5.0–6.4 Magnitude earthquake risks are significantly higher in 5 years' period in compressional regime area—Fethiye and surroundings. Similar to ancient time, earthquakes create big damage risk for recent settlements (such as Antalya city, Burdur city, Fethiye town, Ortaca town, Çameli town, etc., and Greek islands). Liquefaction, mass movement (landslide, creep etc.), rock fall, tsunami may also increase the threat level for this region.

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