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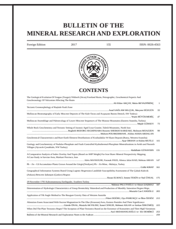
BULLETIN OF THE
MINERAL RESEARCH AND EXPLORATION

CONTENTS

29 NOVEMBER 1795 KAHRAMANMARAŞ EARTHQUAKE, SOUTHERN TURKEY

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Research Article

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ABSTRACT

Major tectonics on the Kahramanmaraş region are the northern strand of EAFZ (Sürgü fault zone, Çardak segment, Savrun segment and Toprakkale segment) and the southern strand of EAFZ (Gölbaşı segment, Amanos sgment), Engizek Fault Zone, Kahramanmaraş Fault Zone and The Narlı segment of DSFZ. An earthquake, occurred in Kahramanmaraş, 1795, is mentioned a manuscript named Divan-ı Hasmi which is found at Koyunoğlu Library in Konya. According to manuscript the Mercalli Intensity of the earthquake has calculated as eight and the magnitude is seven. The calculations made have strengthened the possibility of earthquake occurncy on the Gölbaşı segment of EAFZ.

1. Introduction

Kahramanmaraş city, which has an area of 14.346 km^2 and the population of 1.089.038 according to 2014 data, is the 11th biggest in population and the 18th largest city of Turkey (www.kahramanmaras.gov.tr). The northern parts of the city is rather mountainous. The landforms in Kahramanmaraş city where three different geographical regions approach to each other (the Mediterranean, the East Anatolian and the Southeast Anatolian regions) are generally formed by mountains which are the extensions of the Southeast Taurides and depression zones among them.

The manuscript, which has remained until today and is the subject of the study, was found among rare manuscripts in the library of the Konya Metropolitan Municipality. The manuscript takes place between the 138b and 143a foils of the Divan-ı Hasmi. In the Ottoman work of arts during that period, many manuscripts in different subjects were combined between the two covers, and the works called as “Divan” were formed. The name of the manuscript collected and written by Hafız Ahmet Nuri bin Hafız Halil is “Tarih-i Zelzele-i Mara’aş”. In the manuscript, the earthquake, which happened in 17 Cemaziye’l-Evvel 1210 according to the Islamic calendar, is mentioned and the information on the earthquake given by different people takes place. The information regarding the earthquake has drawn attention of Daş (2005) who studied in the Koyunoğlu Library. The transcription of the manuscript was made by the investigator and given to the author.

2. Regional Tectonic Setting

The Neotectonic period in Turkey began by the depletion of the E-W extending southern branch of the Neotethy’s Ocean in north of the African-Arabian plates along the Bitlis-Zagros Suture belt at the easternmost part and continent to continent collision between the Arabian and Anatolian plates at the end of Middle Miocene (11 million years ago) (Koçyiğit, 1984; Şengör and Yılmaz, 1981; Bozkurt, 2001). Following this collision, the East Anatolia was compressed and thickened. This thickening reached a level which cannot be compensated by the continental crust. This movement was then compensated by the formations of NAFZ and EAFZ, and it is the beginning of Neotectonic period in Turkey (Koçyiğit, 1984). This westward movement of Anatolia developed along the right lateral NAFZ and the left lateral EAFZ (Figure 1). As a result of the collision between the Eurasian and Arabian plates the Zagros Suture Belt was formed.

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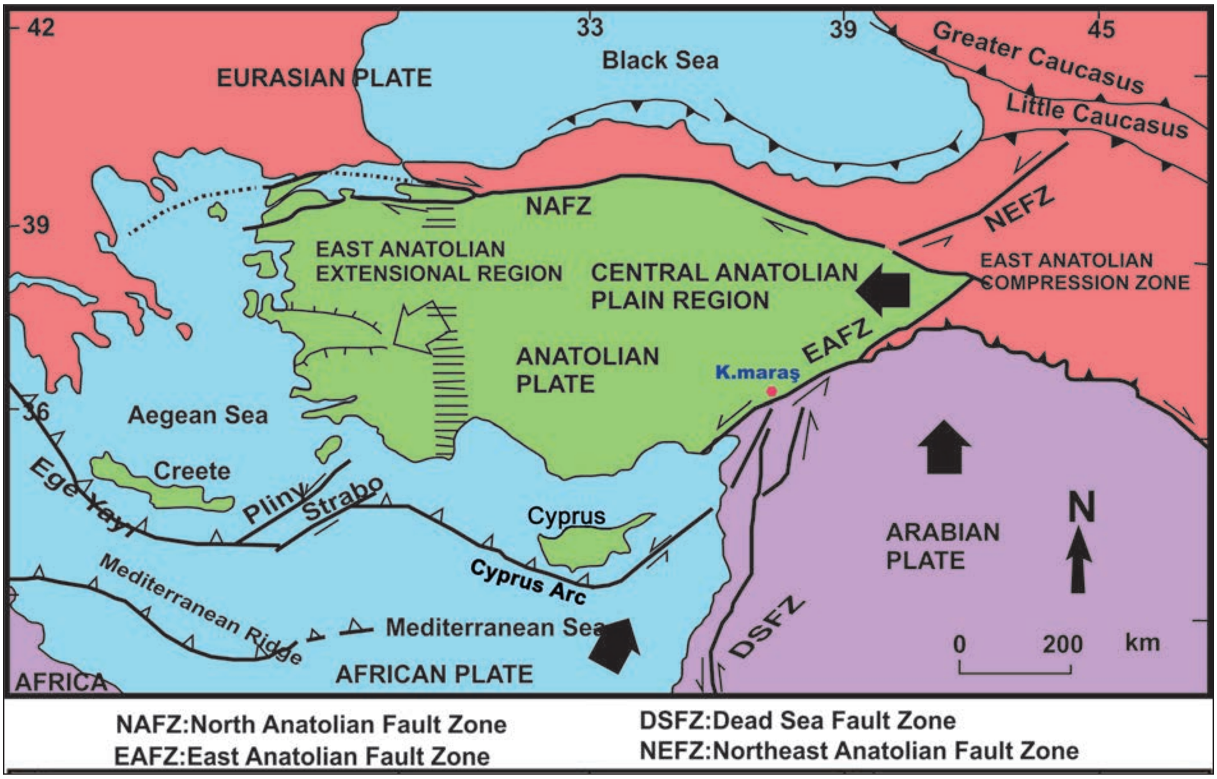

Figure 1- The tectonic setting of Turkey (modified from Bozkurt, 2001).

However, as a result of the subduction of the African plate beneath the Anatolian Block in west the Hellenic and Cyprus Arcs were formed (McKenzie, 1970 and 1972; Şengör and Yılmaz, 1981; Dewey et al., 1986).

The boundary between the Eurasian plate and the Anatolian block was distinguished by NAFZ; however, the boundary between the Arabian and African plates was detected by the DSFZ. The movement between Africa and Anatolia is compensated by Hellenic and Cyprus arcs. The convergence between Anatolia and Arabia is compensated by the left lateral strike slip movement that forms along the EAFZ (McKenzie, 1972; Harch et al., 1981; Şengör and Yılmaz, 1981; Şengör et al., 1985; Parlak, 2004).

There is a close relationship among the geographical, morphological and tectonic characteristics. Kahramanmaraş takes place on the suture belt where the Arabian and Anatolian plates collide; therefore, it has a very complicated geodynamic evolution. There are observed many rock assemblages and traces of deformation which formed in different environments within period ranging from Paleozoic to recent.

Kahramanmaraş and its surround is located in tectonically very complicated active region. It is stated that the junction point of faults, which form the tectonic framework in this region, is the region between Kahramanmaraş and Gölbaşı (Figure 2) (McKenzie, 1972; Dewey et al., 1973; Jackson and McKenzie, 1984; Şengör et al., 1985; Gülen et al., 1987; Karig and Kozlu, 1990; Kempler and Grafunkel, 1991; Chorowicz et al., 1994). This region, which is named as the Maraş triple junction, covers the northwestern corner of the Arabian plate and the Eurasian and African plates which synchronously deformed, and it consists of all characteristics that can be seen in a continental collision zone (Gülen et al., 1987; Westaway, 2003).

The continuation of the EAFZ after Kahramanmaraş is in debate. Some investigators emphasize that the fault zone after Kahramanmaraş continues towards Antakya and combines with the DSFZ (Allen, 1969; Arpat and Şaroğlu, 1975; Rotstein, 1984; Kelling et al., 1987; Şaroğlu et al., 1992*b*; Kiratzi, 1993; Rojay et al., 2000; Sezgin et al., 2002). However, the other investigators claim that the fault zone extends to Yumurtalık fault and Cyprus in southwest direction after Kahramanmaraş (McKenzie, 1972; Dewey et al., 1973; Jackson and McKenzie, 1984; Gülen et al., 1987;

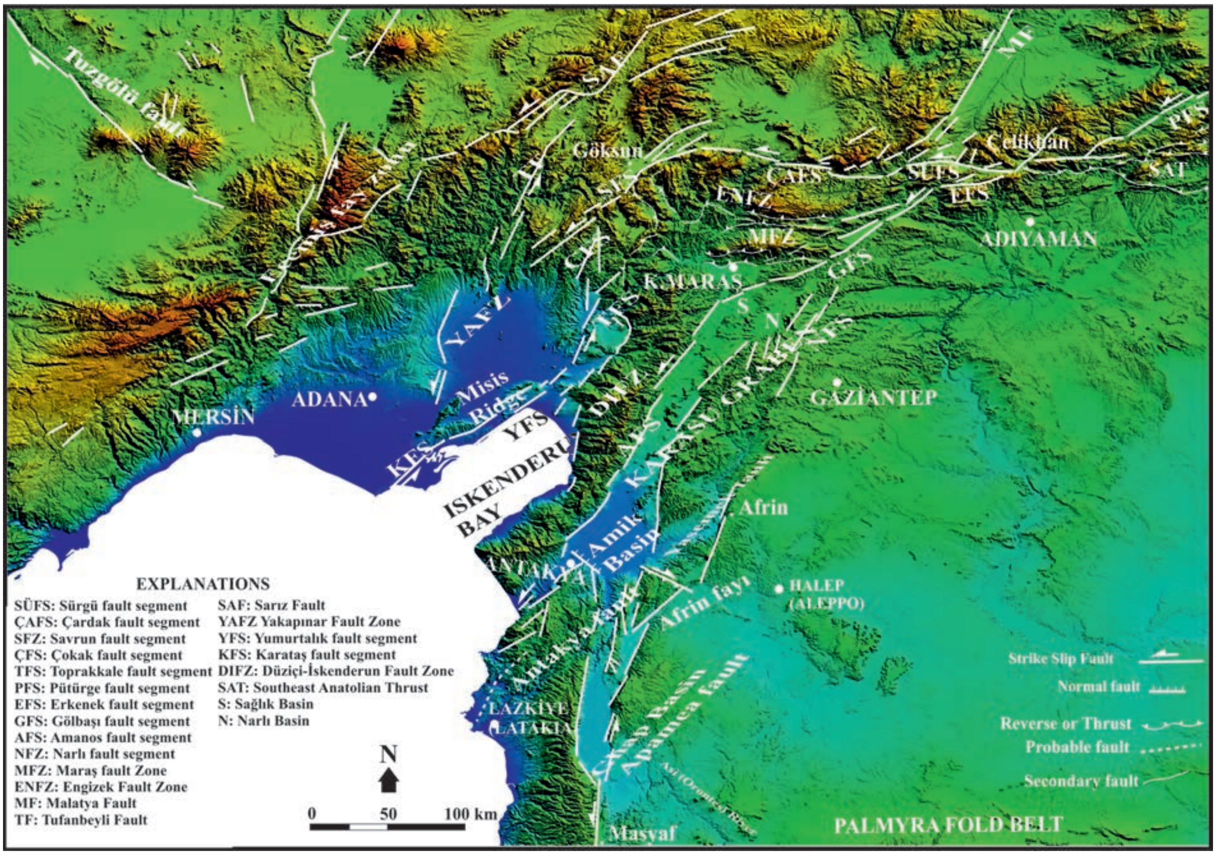

Figure 2- The tectonic map of Kahramanmaraş and its surround (modified from Emre and Duman, 2013).

Barka and Kadinsky-Cade, 1988; Karig and Kozlu, 1990; Kempler and Garfunkel, 1991; Westaway and Arger, 1996). Another group of researchers consider that the fault zone ends around Türkoğlu (Lovelock, 1984; Chorowicz et al., 1994). The EAFZ crosses the Aksu river in east of the Northern Amanos mountains and form the northern branch of the DSFZ. Some researchers state that there is such a fault, but it is not the segment of the EAFZ. They say that this section is the plate boundary between Anatolia and Africa (Muehlberger and Gordon, 1987).

Important tectonic structures located in Kahramanmaraş and its surround are the northern branch (Allen, 1969; Arpat and Şaroğlu, 1975; Herece, 2008; Duman and Emre, 2013; Robertson et al., 2013) (Sürgü segment, Çardak segment, Savrun segment, Çokak segment and Toprakkale segment) and the southern branch of the EAFZ (Gölbaşı segment and Amanos segment), the Engizek fault zone, Kahramanmaraş fault zone and Narlı segment of the DSFZ (Figure 2). It is also known that there have been numerous earthquakes in the region in the historical period along the faults and associated segments (Ergin, 1966; Soysal et al., 1981; Özmen, 1999).

The E-W extending fault, which separates from the Gölbaşı segment of the EAFZ, is named as the Sürgün fault (Ergin, 1966; Soysal et al., 1981; Özmen, 1999) and it is 75 km away from the city center. The Sürgün fault begins at the south of Çelikhan town and ends in the vicinity of Nurhak town. It is formed from three segments with lengths of 28, 25, and 11 km's and has a total length of 64 km (Duman and Emre, 2013; Emre et al., 2013; Menekşe, 2016). The fault, which extends in E-W direction, is named as the Çardak fault (Duman and Emre, 2013; Emre et al., 2013). It is formed by two segments with lengths of 34 and 50 km's (Duman and Emre, 2013; Emre et al., 2013; Menekşe, 2016) and approximately 55 km's away from the Kahramanmaraş city center. The Savrun fault (Kozlu, 1987; Perinçek and Kozlu, 1984; Robertson et al., 2004) begins at Göksun and ends around Sumbas. It is in NE-SW direction and has a total length of 63 km's (Duman and Emre, 2013; Emre et al., 2013; Menekşe, 2016). It is 63 km's away from the city center. The Çokak fault has a strike of N15E and a length of 25 km's. It is 53 km's away from Kahramanmaraş. The Toprakkale fault has a strike of N30-35E and a length of 52 km's (Duman and Emre, 2013). It has 90 km's distance from the city center.

The Gölbaşı segment is 90 km's long and formed by N55E extending many parallel faults (Figure 3). The segment becomes apparent at a point in near northeast of Harmanlı located in the Gölbaşı town of Adıyaman. The fault extends to Gölbaşı town as one branch, but it is divided into many branches in the vicinity of Gölbaşı (Çıplak, 2004). The approximate direction of the fault in this region is N60E. While the main branch runs towards Gölbaşı town starting from the west of Harmanlı, the Azaplı fault zone in north is observed which is formed by fault segments in similar directions (İmamoğlu, 1993).

The fault zone loses its appearance because of swampy areas and alluvial around Gölbaşı Lake. It again becomes distinctive in southwest of Gölbaşı town. The direction of the EAFZ is N50E here. The EAFZ is divided into branches starting from the south of the Azaplı Lake and extends towards the southern part of the İnekli Lake. The EAFZ continues along the Kısıklı Dere Valley in northeast of Sakarkaya with a strike of N55E. The EAFZ, which runs along the Koca Dere Valley, passes through the northern part of Tetirlik village and reaches Kartal village. It jumps to the left in east of Kartal village and forms a small sag pond then extends southward. The fault zone, which continues from the south of Kartal village to the southwest, passes through the Tevekkeli village and extends until the north of Türkoğlu town (Erkmen et al., 2009). The Gölbaşı segment is linear between Harmanlı-Sakarkaya, slightly concave between Sakarkaya-Elmalar towards north and convex between Elmalar-Türkoğlu towards south (Şaroğlu et al., 1987).

The Amanos segment of the EAFZ is composed of three sections as; Nurdağı, Hassa and Kırıkhan. These sections are 40, 45 and 35 km's long respectively with the total length of 120 km's (Duman and Emre, 2013). The distance of the nearest section of the Nurdağı segment to the Kahramanmaraş city center is 35 km's.

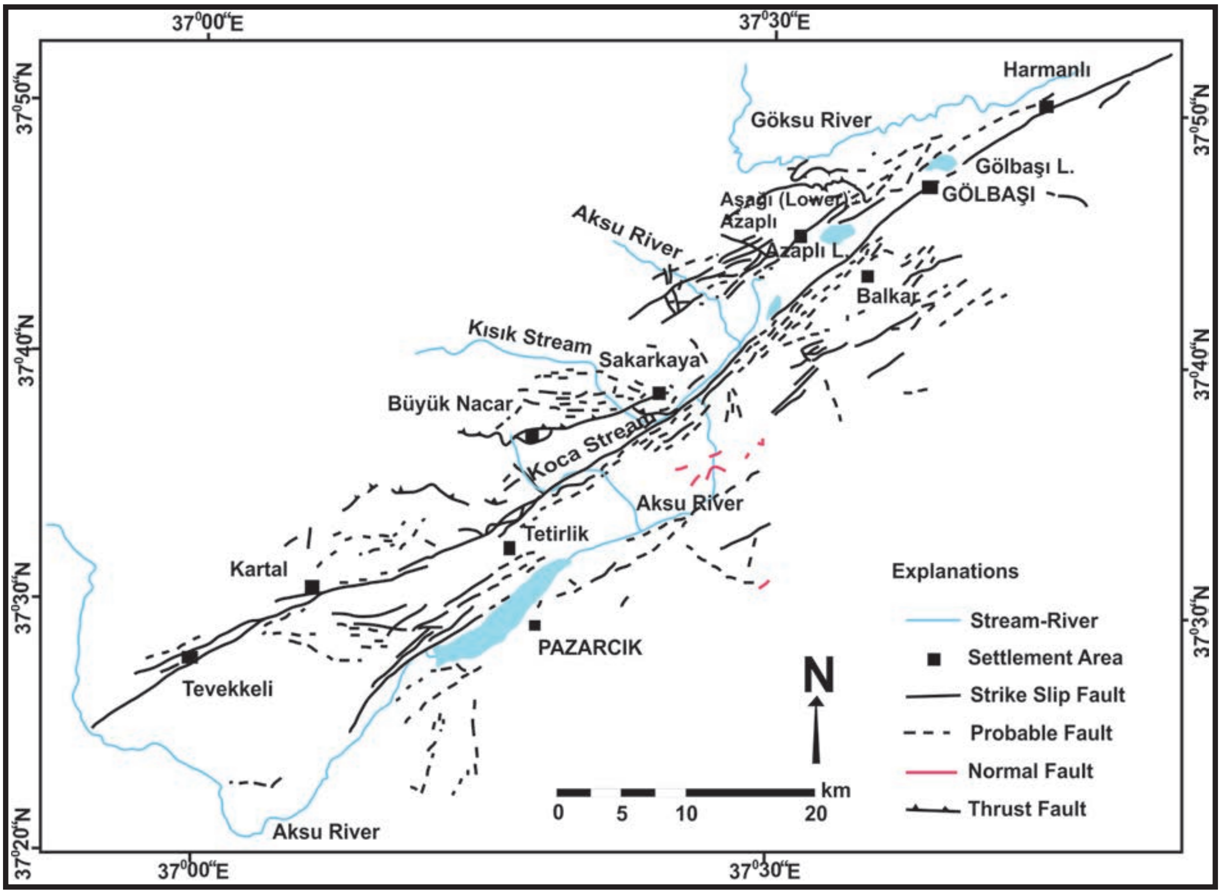

Figure 3- The tectonic map of Gölbaşı segment of the EAFZ (İmamoğlu, 1993; Erkman et al., 2009).

The Narlı segment of the DSFZ has a strike of N15-20E and is 35 km's long (Duman and Emre, 2013). It has a distance of 25 km's from the city center.

The Engizek thrust is formed by many large and small thrusts, and it is roughly in E-W direction. It begins at the northeast of Çağlayancerit town, passes through the northern part of the Menzelet Dam and extends until the west of Suçatı Dam (Emre et al., 2012*a*, *b*). It has an approximate length of 66 km's and is 30 km away from the city center.

The Kahramanmaraş fault zone is in E-W direction and begins from the vicinity of Sakarkaya in east of Kahramanmaraş. It passes through the southern part of Kahramanmaraş and extends until the Kılavuzlu Dam (Emre et al., 2012*a*, *b*). This thrust is 3 km's away from the city center.

3. The Evaluation of the Earthquake

Kahramanmaraş is one of the oldest cities of the Anatolia. In Kahramanmaraş; the Hittites, Assyrians, Macedonians and the Romans have reigned, respectively (Atalay, 1929). The oldest name of the Kahramanmaraş city is observed in the Assyrian written sources. According to these written sources the name of the city state was "Gurgum", and the capital city was "Markasi", the name of Kahramanmaraş in that period (Göl, 2006).

The city has taken the name of Mar'aş after the conquest of the Muslims. Mar'aş means the place of trembling in Arabic. This name was given as the area had turned into a swampy land because of rice cultivation and malaria has been extensively seen. When Maraş has been conquered by the Byzantines the name of the city has changed into "Marasaion". Then; the name of the city has changed into Maraş after the conquest of the Muslims. Although the name of the city has not been subjected to much changes, its location has continuously altered. The antic city, which had settled in southeast of the recent Kahramanmaraş, has been moved to the bank of Karasu in the Roman times. In the Middle age, first Reban then Altuntaş has become the city center. Due to the collapse of Altuntaş in an earthquake, the city center has moved to a place called "Kara Maraş" which is located in east of Kahramanmaraş in today. The Dulkadiroğulları have been the first to settle in today's city center (Göl, 2006).

Historical earthquakes that have occurred in the vicinity of Kahramanmaraş are given in different earthquake catalogues. Soysal et al. (1981) suggest the following earthquakes and associated magnitudes for the historical earthquakes in and around the study area as; the İslâhiye earthquake with magnitude of VII in 131 B.C., the İslâhiye and Maraş earthquakes with magnitude of VIII in A.D. 128, the Ceyhan, Antakya and Maraş earthquakes with magnitude of IX in A.D. 1114, the Maraş, Urfa and Harran earthquakes with magnitude of VIII in 1114 and the Elbistan and Maraş earthquakes with magnitude of VIII in 1544. However, Özmen (1999) proposes the İslâhiye earthquake with magnitude of VII in 131 B.C., the İslâhiye and Maraş earthquakes with magnitude of VIII in A.D. 128, the Maraş, Urfa and Harran earthquakes with magnitude of VII in 1114 November 29th, the Ceyhan, Antakya and Maraş earthquakes with magnitude of IX in 1114 August 10th, the Elbistan and Maraş earthquakes with magnitude of VIII in 1544 January 22nd for the earthquakes in and around the study area. In addition to the historical earthquake catalogues given above there is not mentioned about any earthquakes in Ergin (1966) and Ambraseys (1971), which occurred in Kahramanmaraş in 1210 (according to Islamic calendar), the topic of the study.

3.1. The Occurrence Date of Earthquake

The information below is given about the occurrence time, day and season of the earthquake in the manuscript (Figure 4) (Daş, 2005);

1st poetic; lines 7 and 8:

Ruz-i saat yedide, mah-ı Cemaziye'l–Ula (in November, at seven o'clock)

Maraş'ı yevm- sebte eyledi Allah lerzan (Allah flattened Maraş on Saturday)

2nd poetic; Lines 10 and 11:

On yedincisi Cemâziye'l-Evvel'inin yevm-i Sebt (On Saturday, November the 17th)

Rûz saat yedide oldı tezelzül âşikâr (It happened at 7 o'clock in the morning).

3rd poetic, lines 15 and16:

Mâh-ı Cemâziye'l-Evvel'inin on yedincisi (on the 17th day of November)

Sa'at yedide yevm-i Sebtde kıldı herkesi (It hit everyone at seven o'clock on Saturday)

4th poetic, lines 19, 20, 21 and 22:

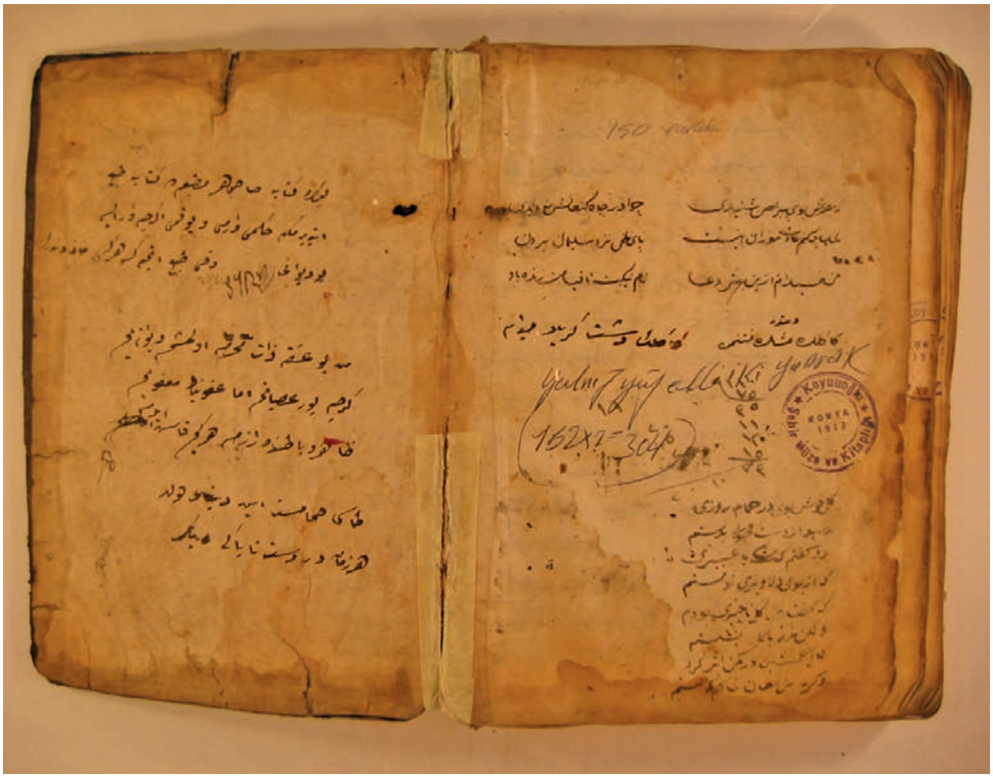

Figure 4- The identity of the manuscript (Daş, 2005).

Doğru çün Cemâziye'l-Evvel (In November)

On üçü kaldı hemân şöyle mesel, (Therefore, this parable remained)

Tut kulağına sözümü dinle işit, (Listen and hear my word carefully)

Öğle vakti idi çün yevm-i Sebt (It happened at noon of Saturday)

When the given information in poetical form are assessed, it is understood that the earthquake occurred in 1210 Cemaziye'l Evvel 17th (in Islamic calendar). The equivalents of the dates in Islamic calendar are given on table 1.

Table 1- The conversion of Islamic calendar into Gregorian calendar (http://www.ttk.gov.tr).

	Hijri	Gregorian	Rumi
Day	17	29	18
Month	Cemazeyilevvel	November	Teşrinisani
Year	1210	1795	1209
	Saturday	Sunday	

It is clearly seen that the season is winter and the earthquake occurred at seven o'clock on Saturday morning. On conversion process, the date is given as Sunday. However, the Saturday is absolutely emphasized in the manuscript. The "Sunday" on table 1 originates from conversion.

Estimation of Parameters Related to the Earthquake

Magnitude and Intensity of the Earthquake

Details stated in the manuscript related to the intensity of the earthquake are as follows;

1st poetic; lines 25, 26, 27, 28, 29 and 30:

Oldu virane cami u mescid şimdi, (Mosques and prayer rooms are ruined now)

Kalmadı dense seza bunda, dekakin ile han (There are not any shops and inns)

Münhedim oldı heman nice minare, mekteb (Several minarets and schools were blown up)

Okunur mu ola minba'd, ezn u Kuran (Will Ezan (call for pray) be read from the minaret anymore?)

Ak minare hele, ser çekmiş idi eflake (Ak minare would magnificently rise up to the sky before)

Her gören derdi anın kametini, serv-i revan (But today it is like a ruined cypress)

1st poetic; lines 37 and 38:

Kal’a-i Maraş’ı ser-tabe kadem kıldı harab, (Maraş castle is almost ruined)

Burcu baru komayup eyledi hâke yeksan (There is not any bastion in the castle and blown up)

2nd poetic; lines 14 and 15:

Nâ-bedîd oldu bir anda çok dekâkîn, buyût (Many shops were blown up)

Kalmadı Mar‘aş’ta her giz câmi u mescîd u menâr (There is not any mosque and praying room in Maraş)

2nd poetic; lines 18, 19, 20 and 21:

Her kesin virâne oldı menzil ü kâşânesi (Houses of citizens’ are ruined)

Kalmadı bir kimsede tamirine iktidâr (There is no possibility to repair these houses)

Kal’a-i Mar‘aş’da hergiz burc u bâru kalmayup, (There is not any bastion in Maraş castle, it has been ruined, fell down)

Münhedim olddukda, oldı ehl-i kal‘a hâksâr (Maraş castle has been ruined by Allah)

3rd poetic; lines 27, 28 and 29:

Ez cümle Ak Minâre ki, serv-i revân idi, (Everybody knew the magnificence of the Ak minare (like the cypress rising up to the sky)

Ecsâd-ı şehr-i Mar‘aş’a rûh-i revân idi (Maraş was a magnificent city)

Virân kıldı dest-i kazâ vü kader anı, (But, today it is ruined)

3rd poetic; lines 35 and 36:

Oldı derûn-i kal’ada nice hâneler harâb, (Many houses in the castle are ruined)

Üçyüz denildü hâne-i virân ale’l-hesâb (It was stated that three hundred houses had been ruined)

4th poetic; lines 29 and 30:

Şiddeti üç dakika oldu ammâ (It took three minutes)

Şehri baştanbaşa kıldı yağma (The city has entirely been ruined)

4th poetic; lines 33-34:

Kal‘asında dahi muhkem hâne (Even the house in the castle)

Kalmadı câna sezâ kâşâne (It is true to say that it is not available anymore)

4th poetic; lines 43-53:

Sorma ahvâl-ı perişân hisâr (If you ask about the castle; it is miserable)

Bir lağımla atılıp oldı ğubâr (It is as if it had been exploded by a tunnel and fallen down)

Kal‘a-i biçâre başdan başa (The whole castle is entirely ruinous)

Bir yumurta gibi çaldı taşa (It hit on the ground like hitting an egg on the ground)

Nice câmi ile minârelerin (Many mosques and minarets)

Sorma ahvâlin açar yaraların (Do not ask the general view and gash my wound)

Ağ Minâre idi makbul-i enâm (It was well known as the Ak minare)

Bir beyâz câmelü nâzik-endâm (It would rise up to the sky with a white figure)

Gör ne itdi ana da devrân (Watch! How it was pushed away)

Yıkılup hâke ile oldı yeksân (Knocked down and ruined)

Telef etdi nice câmi-i şerîf (Many mosques were knocked down)

In the manuscript, it is stated that shops and houses in the city were knocked down and ruined. Besides; it is mentioned that almost all mosques and praying rooms were collapsed, and the Ak minaret, which is one of the oldest known mosques of Kahramanmaraş, crumbled like a cypress tree. It is also emphasized that bastions and towers in the Maraş castle were heavily damaged. In the manuscript, it is written that people were in panic and ran away to shelter.

As it is understood from the manuscript, the statement of “fall of chimneys, factory stacks, columns, monuments, walls” mentioned in the Modified Mercalli Intensity Scale (MMI), indicates the “VII” scale earthquake. Empirical formulas giving the magnitude of earthquake from the detected intensity value are available. Using these formulas the magnitude of earthquake was estimated.

$I=(1,129 \times M_b)+0,103$ (Bayrak, 2005)

where; I is the earthquake intensity and M_b is the body-wave magnitude.

$8=(1,129xM_b)+0,103$

Then,

$M_b=7,0$

With respect to the Length of the Fault

The magnitude of the earthquake, which the active strike slip fault could generate with respect to its length;

$M_W=5,16+(1,12 \times \log(L))$ (for strike slip faults) (Wells and Coppersmith, 1994)

$M_W=5,00+(1,22 \times \log(L))$ (for reverse faults) (Wells and Coppersmith, 1994)

where; M_W is the Moment magnitude and L is the fault length (km)

The maximum earthquake magnitudes of the active faults in Kahramanmaraş and its surround with respect to their lengths were estimated using the formula given above and on table 2.

Table 2- Faults and earthquake magnitudes which they could generate with respect to their lengths.

Name of fault	Length of fault (km)	Largest earthquake magnitudes which could be generated with respect to length (Mw)
Gölbaşı segment	90	7,3
Çardak fault	84	7,3
Sürgü fault	64	7,2
Savrun fault	63	7,2
Toprakkale fault	52	7,1
Amanos segment	40	7,0
Narlı segment	35	6,9
Çokak fault	25	6,7
Engizek fault	66	7,2
Kahramanmaraş Fault Zone	30	6,8

3.2. With Respect to the Fault Slip Rate

The slip rates in strike slip faults and the magnitude of earthquake which can cause this rate is as follows;

$M_w=6,81+(0,78 \times \log(MD))$ (Wells and Coppersmith, 1994)

Here, MD (Maximum Displacement) (slip rate of the East Anatolian Fault Zone; 5 mm/yr (Arpat and Şaroğlu, 1975; Öncel, 2000)) is given in meters in different studies using seismological data as 4-6 mm/y by Kasapoğlu and Toksöz, 1983; and 6 mm/y by Kiratzi, 1983 and Öncel, 2000). Again; the annual displacement of the Çardak Fault is 2 mm (Menekşe, 2016). In and around Kahramanmaraş; the earthquakes with M=7,4 in 1513 on Gölbaşı segment (Ambrseys, 1988) and M=6,8 in 1544 on Çardak Fault (Kondorsskaya and Ulomow, 1999) take place in historical records before the earthquake mentioned in the manuscript (Demirtaş and Erkmen, 2000; Duman and Emre, 2013; Figure 5). The maximum slip rate on the EAFZ is accepted as 6 mm/y. Thus, it was calculated that there had been a strain accumulation of 169 cm in 282 years from 1513 to 1795 on the Gölbaşı segment and 50 cm strain accumulation from 1544 to 1795 on the Çardak Fault in this study.

The magnitude of the earthquake M_w, which will release this strain on the Gölbaşı segment, is;

$M_w=6,81+(0,78 \times \log(1,69))=6,987\approx 7,0$

$M_w=7,0$

and the magnitude of the earthquake (M_w) that will release this strain on the Çardak Fault is;

$M_w=6,81+(0,78 \times \log(0,5))=6,575\approx 6,6$

$M_w=6,6$

3.3. Intensity of the Earthquake

Along active strike slip fault belts the earthquake intensity, which the magnitude of maximum earthquake could form, is as follows;

$I=5,867+1,5 \times M_W-(2,1 \times \ln(R+25))$ (Hu et al., 1996)

where; I is the Intensity, M_w is the magnitude, $R=(D^2+h^2)^{1/2}$ (D is the closest distance to fault of the

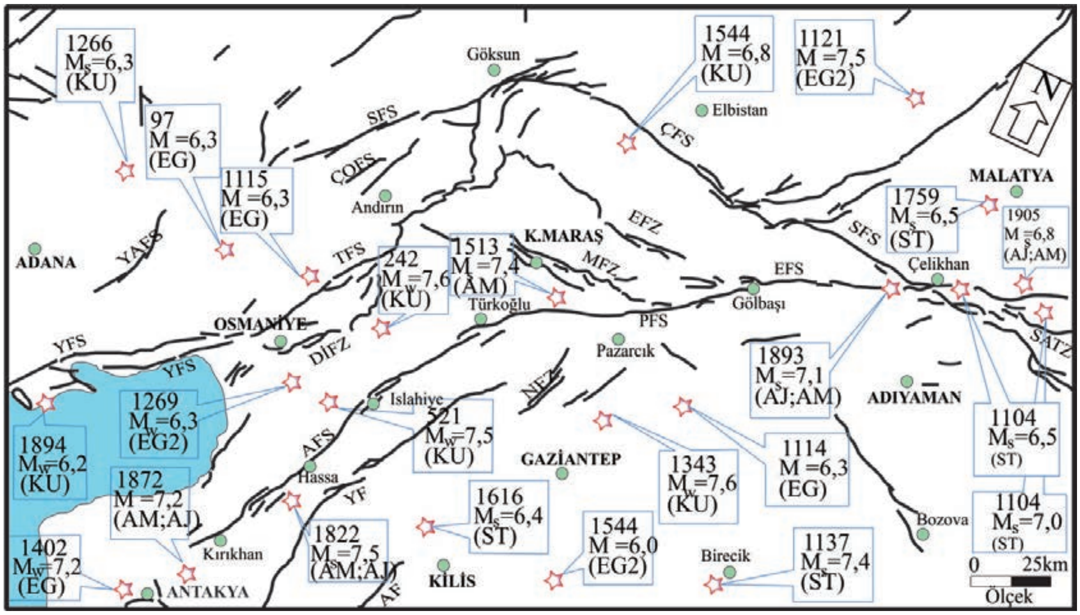

Figure 5- Historical earthquakes that occurred in Kahramanmaraş and its surround (modified from Ambrseys, 1988; Ambraseys and Jackson, 1998; Tan et al., 2008; Duman and Emre, 2013; abbreviations: ST, Shebalin and Tatevossian, 1997; KU, Kondorskaya and Ulomov, 1999; EG, Guidoboni et al., 1994; AM, Ambraseys, 1988; AJ, Ambraseys and Jackson, 1998).

study area (km) and h is the epicenter of earthquake (h=15 km for the Anatolian peninsula).

3.4. Duration of Earthquake

If we again use some empirical equations to predict the duration of earthquake as given below;

$t=10^{(M-2,5)/(3,23)}$ (Watabe, 1977; Arıoğlu and Yılmaz, 2000).

Where; t is the time (sec) and M is the earthquake magnitude, then

$t=10^{(7,0-2,5)/(3,23)}$

t=24,8 sec

t=4+11(M-5) (Donovan, 1973; Arıoğlu and Yılmaz, 2000)

t=4+(11(7,0-5))

t=26 sec

t≈L/V (Arıoğlu and Yılmaz, 2000)

logL=-3,55+0,74 x M_w (Wells and Coppersmith, 1994)

logL=-3,55+(0,74x7,0)

L=89,12 km

V=3,55 km/sec (accepted as the rupture velocity of the fault (Arıoğlu and Yılmaz, 2000)).

t=89,12/3,5

t≈25,4 sec

Thus, the duration of earthquake is predicted as; (24,8+26+25,4)/3=25,4 sec.

The Energy Generated by Earthquake

One of the magnitude parameters of earthquake is the "seismic energy". Different formulas were given in order to predict the seismic energy of earthquake. We can calculate the seismic energy using those formulas.

The formula suggested by Gutenberg and Richter (1944), which is associated with energy-magnitude relationship, is as follows;

logE=2,4 x M_b+5,8 (Bayrak, 2005)

where; E is the energy

Then,

$logE=(2,4x7,0) + 5,8$

$E_b=10^{22,6}$ erg

Ground acceleration of the Earthquake

There are formulas, which give the ground acceleration with respect to intensity that the earthquake would generate. Using these formulas the ground acceleration can be predicted.

$log_a=0,30(I)+0,014$ (Trifunac and Brady, 1975; Trifunac 1976; Arıoğlu and Yılmaz, 2000)

where; a is the horizontal ground acceleration

$a=259 cm/sec^2$

$I= 3,66+log_a-1,6$ (Wald et al., 1999; Arıoğlu and Yılmaz, 2000)

$a=419$ cm/sec^2

$log_a=(3/7)I-(9/10)$ (Hershberger, 1956; Arıoğlu and Yılmaz, 2000)

$a=337$ cm/sec^2

$log_a=0,25I+0,25$ (Murpy, 1977; Arıoğlu and Yılmaz, 2000)

$a=178$ cm/sec^2

If we take the arithmetical mean of all values, then the horizontal ground acceleration "a" is found as 298 cm/sec^2.

Recurrence Interval of the Earthquake

The recurrence interval of the earthquake for Kahramanmaraş and its surround is found by the formula given below;

$t\approx A_0/\Delta$ (Arıoğlu and Yılmaz, 2000)

where, A_0 is the mean offset of fault and Δ is the slip rate of fault in mm

$log(A_0)=-6,32+0,90\ M_w$ (Wells and Coppersmith, 1994)

$(A_0)=10^{(-6,32+(0,9x7,0)}$

$(A_0)=10^{(-0,02)}$

$(A_0)=0,955m=955mm$

If the minimum and maximum slip rates of the EAFZ are taken as 4 and 6 mm's, respectively, then t_{min} and t_{max} values are found as;

$t\approx955/4$ $t\approx955/6$

$t_{min}\approx159$ years $t_{max}\approx239$ years

Seismic Moment

The seismic moment that forms during the fault rupture is calculated by the formula given below;

$log(M_0)=1,33 \times M_s+17,32$ (Bayrak and Yılmaztürk, 1999)

where, M_0 is the seismic moment

So;

$(M_0)=10^{26.}63$ dyn.cm

$(M_w)=2/3 \times (log(M_0)-10,7$ (Arıoğlu and Yılmaz, 2000)

$M_w=7,05=7,0$

$M_b\approx M_w=7,0$

Other Information related to the Earthquake

The information given below is for the aftershocks of the earthquake in the manuscript. According to this; it is understood that the aftershocks of the earthquake continued forty days and fire occurred because of friction at the time of earthquake.

1st poetic, line 45:

Ruz u şeb oynadı kırk güne dek bu cirm-i zemin (The ground vibrated forty days after the earthquake)

2nd poetic, line 17:

Sahn-ı Mar'aş oynadı kırk güne dek yerde nâr (Maraş city vibrated forty days after the earthquake and fire occurred)

3rd poetic, line 39:

Kırk gün oynadı efendi bu cirm-i zemîn (The ground vibrated forty days)

Related to the events for earthquake it is stated that the water was cut off just before the earthquake.

3rd poetic, line 40:

Cûlar kesildi zelzele vaktinde bül-aceb (Waters were cut off before the earthquake)

3.4. The importance of the Earthquake

The earthquake stated in the manuscript is not mentioned in any of the historical earthquake catalogues as there is not any information; thus, it is not known by the investigators. Therefore; Kahramanmaraş and its surround is defined as the seismic gap and large earthquakes are predicted in this area in the near future (Table 3).

If it is accepted that this historical earthquake has not occurred, the maximum earthquake magnitude predicted for the study area can be calculated as explained below. If it is regarded that the slip rate of the EAFZ is 6 mm/y, and the latest and largest earthquake, which forms a surface rupture along the closest EAFZ segment to Kahramanmaraş is the 1513 earthquake (Demirtaş and Erkmen, 2000; Duman and Emre, 2013), then it was calculated that there had been a tension of 3,024 m along the EAFZ since 1513.

2017-1513= 504 years

504x6= 3024 mm= 3,024 m.

Thus; the magnitude of the earthquake M_w, which will release this tension, is calculated as;

M_w=6,81+(0,78 x log(3,024)) (Wells and Coppersmith, 1994)

M_w=6,81+(0,78 x log(3,024))=7,18≈7,2

M_w=7,2

Investigators, who calculated the magnitude values similar to that, expect devastating earthquakes in this section of the EAFZ.

The below calculation will be useful in order to better understand the situation.

According to the relationship of energy-magnitude by Gutenberg and Richter (1944),

logE=2,4 M_b+5,8 (Bayrak, 2005)

if we take M_b as 7,0 then,

logE=(2,4x7,0) + 5,8

$E_{7,0}=10^{22,6}$ erg

if we take M_b as 7,2 then,

logE=(2,4x7,2) + 5,8

$E_{7,2}=10^{25}$ erg

If we rate these energies then we find;

$10^{23,8}/10^{22,6}=10^{1,2}=16$

The strain energy that will be released by 16 earthquakes with magnitudes of 7 is equal to the amount of strain energy that will be released by one earthquake with magnitude of 7,2.

Table 3- The earthquake intensity predicted in the center of Kahramanmaraş when faults generate maximum earthquake.

Fault Name	Maximum earthquake magnitude (Mw) which could generate with respect to length	Distance to Kahramanmaraş (km)	Intensity (I)
Gölbaşı segment	7,3	10	8,9
Çardak fault	7,3	55	7,6
Sürgü fault	7,2	75	7,0
Savrun fault	7,2	60	7,3
Toprakkale fault	7,1	90	6,5
Amanos segment	7,0	35	7,7
Narlı segment	6,9	25	7,8
Çokak fault	6,7	53	6,7
Engizek fault	7,2	30	8,1
Kahramanmaraş Fault Zone	6,8	3	8,3

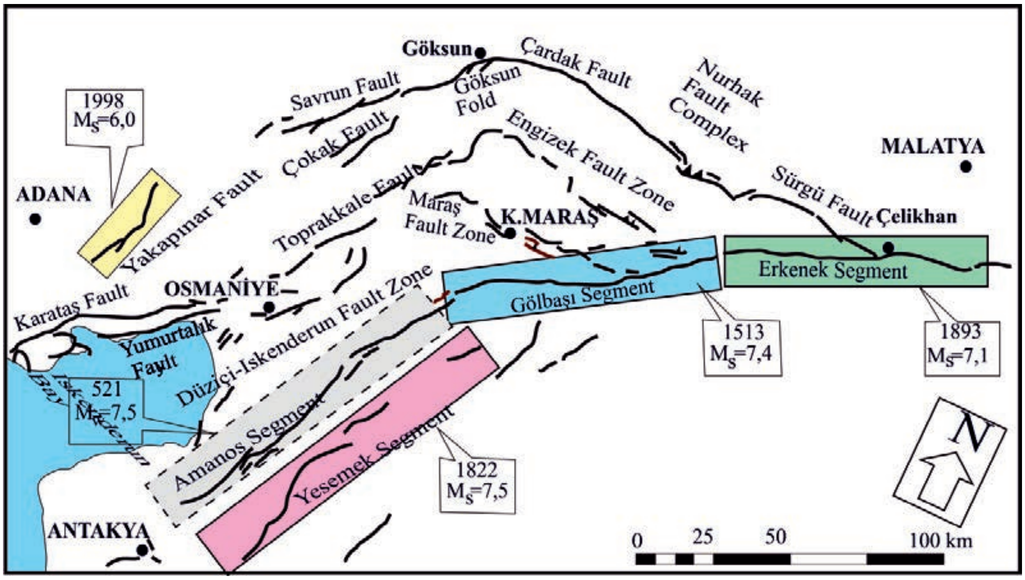

Figure 6- Surface ruptures formed by large earthquakes which formed in 19th and 20th centuries along the East Anatolian Fault System (modified from Arpat, 1971; Arpat and Şaroğlu, 1972; Seymen and Aydın, 1972; Ambraseys, 1988; Ambraseys and Jackson, 1998; Çetin et al., 2003; Herece, 2008; Karabacak et al., 2011; Duman and Emre, 2013).

4. Discussion

Erkmen et al. (2009) detected the traces of at least 2 or 3 faults (ancient earthquake) as a result of paleoseismological studies carried out on the Gölbaşı segment. According to the correlations of Optically Simulated Luminescence (OSL) dating results and sedimentary accumulations, the dates of ancient earthquakes were obtained as in between 148 BC and AD 115; AD 458-589 and towards the end of 1000's or the beginning of 1100's. There was not encountered any traces of 1514 earthquake in excavated trenches. These information state that an earthquake with magnitude of 7,0-7,5 has happened between the years of 1000-1100, and for approximately 900 years there has not been any large earthquake which forms a surface rupture. It can also be said that the Gölbaşı-Türkoğlu fault segment is in a position to form a seismic gap which has a very high earthquake potential in near future.

Çetin et al. (2003) emphasize that the last earthquake, which has occurred on the segment and formed a surface rupture, has happened after 1890 (Figure 6). They also state that this earthquake can be associated with the 1874 (M_s=7,1 (Ambraseys, 1988)) and 1875 (M_s=6,7 (Ambraseys and Jackson, 1998)) earthquakes in the study they carried out on the Palu-Hazar segment of the EAFZ. Moreover; it is considered that another large earthquake has occurred 100-200 years later than AD 1420 and could be associated with the 1513 (M_s=7,4 (Ambraseys, 1988)) earthquake. There have been two large earthquakes in AD 130 and AD 400-450 years. However, there has not been encountered any traces of the 995 and 1789 earthquakes which are associated with Karlıova-Bingöl segment. In the Palu-Hazar Lake segment the recurrence interval for the earthquake with M>7 is expected to be 100±35 as the minimum and 360 years as the maximum (Çetin et al., 2003).

It can be asserted that large earthquakes in the Gölbaşı segment of the EAFZ have empirically occurred (M≥7,0) once in approximately 200 years. However, as a result of paleoseismological studies carried out in Gölbaşı town and its surround, which is located on the Gölbaşı segment, the recurrence interval of large earthquakes (M≥7,0) were found to be as 403 years as the maximum and 253 ± 30 years as the minimum (Yüksel, 2009). When the average of these values are taken, a recurrence interval of 328 ± 30 years can be suggested. The youngest paleoseismological information detected during excavations date back to 371 ± 30 years and there is not encountered any younger earthquake data in the historical/instrumental period.

5. Results

This earthquake, which is mentioned in the historical manuscript, does not take place neither in domestic nor in international earthquake catalogues. It was assessed and introduced for the first time in the light of earth science data.

The earthquake stated in the manuscript exactly occurred in 1795 November the 29, on Saturday morning at 7 o'clock. The intensity of the earthquake was predicted as VIII based on the lines in historical poetics. The magnitude of the earthquake with respect to intensity was estimated as 7,0 using empirical formulas.

The lengths of active faults with the earthquake magnitudes (M_w) that could be generated in Kahramaraş and its surround were calculated as follows; the Gölbaşı segment 90 km with M_w=7,3, the Çardak fault 84 km with M_w=7,3, the Sürgü fault 64 km with M_w=7,2, the Savrun fault 63 km with M_w=7,2, the Toprakkale fault 52 km with M_w=7,1, the Amanos segment 40 km with M_w=7,0, the Narlı segment 35 km with M_w=6,9, the Çokak fault 25 km with M_w=6,7, the Engizek fault 66 km with M_w=7,2, the Kahramanmaraş Fault Zone 30 km with M_w=6,8.

It was also calculated that an earthquake with M_w=9,0 in the center of Kahramanmaraş might occur when an earthquake happens on the Gölbaşı segment with M_w=7,3. Besides; the occurrence of an earthquake on the Kahramanmaraş fault with M_w=6,8 also creates an earthquake with M_w=8 in the center of Kahramanmaraş.

There has been a strain accumulation of 169 cm on the Gölbaşı segment from 1513 to 1795. However, there has been a strain accumulation of 50 cm on the Çardak fault from 1544 to 1795. The earthquakes, which would release that much strain on the Gölbaşı segment and the Çardak Fault, were estimated to be M_w=7,0 and M_w=6,6, respectively.

Using empirical equations, the earthquake duration was predicted as 25,4 sec. The seismic energy of the earthquake was found as E_b=1022,6 erg. The horizontal ground acceleration that the earthquake could create was obtained as 298 cm/sec^2 using the related formulas.

The recurrence interval of the earthquake for Kahramanmaraş and its surround (if the lowest and highest slip rates of the EAFZ are taken as 4 and 6 mm, respectively) was calculated as t_{min}≈159 years and t_{max}≈239 years.

It is understood from the handwritten documents that there was a devastating earthquake in the vicinity of Kahramanmaraş in 1795. However, it is not clear by which fault the earthquake mentioned in the manuscript was generated. As a result of the estimations made the Gölbaşı segment, the Kahramanmaraş Fault Zone, the Engizek Fault and the Çardak Fault come to the forefront.

As a result; the presence of an earthquake, which had not previously taken place in historical earthquake catalogues and literature, were put forward. It is suggested that the slip rate and paleoseismological behaviors of the triggering fault, which generate this earthquake in terms of regional earthquake risk analyses, should be studied in detail.

References

Allen, C.R. 1969. Active Faulting in Northern Turkey. Contribution No: 1577, Division of Geological Sciences, California. Institute. Technology, 32 pp.

Ambraseys, N.N. 1971. Value of historical records of earthquakes. Nature, Vol. 232, 375-379.

Ambraseys, N. N. 1988. Temporary seismic quiescence: SE Turkey. Geophysical Journal, 96, 311–331.

Ambraseys, N. N., Jackson, J. A. 1998. Faulting associated with historical and recent earthquakes in the Eastern Mediterranean region. Geophysical Journal International, 133, 390–406.

Arıoğlu, E., Yılmaz, A.O. 2000. Çözümlü Problemlerle Yeraltı Mühendislik Yapılarına Depremin Etkileri. TMMOB Maden Mühendisleri Odası İstanbul Şubesi Yayını, İstanbul.

Arpat, A. E. 1971. 22 Mayıs, 1971 Bingöl Depremi Ön Rapor. Institute of Mineral Research and Exploration Report 4697.

Arpat, A. E., Şaroğlu, F. 1972. Doğu Anadolu Fayı ile ilgili bazı gözlem ve düşünceler. Bulletin of the Mineral Research and Exploration, 73, 1–9.

Arpat, A. E., Şaroğlu, F. 1975. Türkiye'deki bazı önemli genç tektonik olaylar. Türkiye Jeoloji Kurumu Bülteni, 18/1, 91-101.

Atalay, B. 1929. Maraş Tarihi Coğrafyası. Matbaa-i Amire, 235s.

Barka, A.A., Kadinsky-Cade K. 1988. Strike-slip fault geometry in Turkey and influence on earthquake activity, Tectonics. Vol.7, No 3, pp.663-684.

Bayrak, Y. 2005. Global Sismisite. Karadeniz Teknik Üniversitesi Mühendislik-Mimarlık Fakültesi

Yayını, Trabzon.

Bayrak, Y., Yılmaztürk, A. 1999. Türkiye ve Civarında Sismik Moment ve Gerilim Dağılımı. Hacettepe Üniversitesi Yerbilimleri Uygulama ve Araştırma Merkezi Bülteni, 21, 1-15.

Bozkurt, E. 2001. Neotectonics of Turkey-a synthesis. Geodinamica Acta, 14, 3-30.

Chorowicz, J., Luxey, P., Lyberis, N., Carvalho, J., Parrot, J.F., Yürür, T., Gündoğdu, N. 1994. The Kahramanmaraş Triple Junction (southern Turkey) based on digital elevation model and satellite imagery interpretation. Journal of Geophysical Research, 99, 20225-20242.

Çetin, H., Güneyli, H., Mayer, L. 2003. Paleoseismology of the Palu-Lake Hazar segment of the East Anatolian Fault Zone, Turkey. Tectonophysics, 374, 163–197.

Çıplak, R. 2004. Erkenek-Gölbaşı (Adıyaman) Arasında Doğu Anadolu Fayının Özellikleri, Master Thesis, İstanbul Teknik Üniversitesi Avrasya Yer Bilimleri Enstitüsü 76s. İstanbul (unpublished).

Daş, A. 2005. Hicri 1210 Maraş Depremi İlgili Manzum El Yazması Tarihler. I. Kahramanmaraş Sempozyumu 6-8 Mayıs 2004. Kahramanmaraş, Vol.1, page: 355-365.

Demirtaş, R., Erkmen, C. 2000. Deprem ve Jeoloji. Jeoloji Mühendisleri Odası Yayınları, 52s.

Dewey, J.F., Pitman, W.C., Ryan, W.B.F., Bonnin, J. 1973. Plate tectonics and the evolution of the Alpine system. Geological Society of America Bulletin, 84, 3137-3180.

Dewey, J.F., Hempton, M.R., Kidd, W.S.F., Şaroğlu, F., Şengör, A.M.C. 1986. Shortening of continental lithosphere: the neotectonics of Eastern Anatolia-a young collision zone. In Collision Tectonics. Coward, M.P., A.C. Ries (eds.). Geology Society of London, Special Publication, 19, 3-36.

Donovan, N.C. 1973. A Statistical evaluation of strong motion data including the February 9, 1971 San Fernando earthquake. Proceedings 5th World Conferences Earthquake Engineering, Rome, 1: 1252-1261.

Duman, T.Y., Emre, Ö. 2013. The East Anatolian Fault: geometry, segmentation and jog characteristics. Geological Society, London, Special Publications published online February 19, 2013 as doi: 10.1144/SP372.14

Emre, Ö., Duman, T.Y., Elmacı, H. 2012*a*. 1:250.000 Ölçekli Türkiye Diri Fay Haritası Serisi. Elbistan (NJ 37-5) Sheet. Seri No: 37, General Directorate of mineral and Exploration, Ankara.

Emre, Ö., Duman, T.Y., Olgun, Ş., Elmacı, H., Özalp, S. 2012*b*. 1:250.000 Ölçekli Türkiye Diri Fay Haritası Serisi. Gaziantep (NJ 37-9) Sheet. Seri No: 38, General Directorate of mineral and Exploration, Ankara.

Emre, Ö., Duman, T.Y., Özalp, S., Elmacı, H., Olgun, Ş., Şaroğlu, F. 2013. Açıklamalı Türkiye Diri Fay Haritası Ölçek: 1:1250 000, General Directorate of mineral and Exploration, Special Edition-30, Ankara.

Ergin, K. 1966. Türkiye ve Civarının Deprem Kataloğu. İstanbul Teknik Üniversitesi Maden Fakültesi Arz Fiziği Enstitüsü Yayınları, 170 s.

Erkmen, C., Eravcı, B., Özsaraç, V., Yaman, M., Tekin, B.M., Albayrak, H., Kuterdem, K., Aktan, T., Tepeuğur, E. 2009. Doğu Anadolu Fayı'nın Paleosismolojisi; Pilot Bölge Gölbaşı-Türkoğlu Arası. TUJJB Ulusal Deprem Programı Proje No: TUJJB-UDP-1-07, Ankara.

Göl, E. 2006. Cumhuriyet Döneminde (1923-1950) Maraş'ın Sosyo-Ekonomik Yapısı ve Gelişimi, Master of Thesis, Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Enstitüsü Tarih Anabilim dalı, 78s. Kahramanmaraş (unpublished).

Guidoboni, E., Comastri, A., Triana, G. 1994. Catalogue of Ancient Earthquakes in the Mediterranean Area up to the10th Century. Istituto Nazionale di Geofisica, Rome.

Gutenberg, R., Richter, C.F. 1944. Frequency of earthquakes in California. Bulletin Seismological Society of America 34, 185-188.

Gülen, L., Barka, A., Toksöz, M.N. 1987. Kıtaların Çarpışması ile ilgili Kompleks Deformasyon, Maraş Üçlü Eklemi ve Çevre Yapıları. Yerbilimleri 14, 319-336.

Harch, W., Kupher, T.,Rust, B., Sagesser, R. 1981. Seismotectonic consideration on the nature of the Turkish-African plate boundary, Geol. Rundsch., 70, 368-384.

Herece, E. 2008. Doğu Anadolu Fayı (DAF) Atlası. General Directorate of Mineral Research and Exploration. Special Publications, Ankara, Serial Number, 13, 359.

Hershberger, J.1956. A comparision of earthquake accelerations with intensity ratings. Bulletin Seismological Society of America 46, 317-320.

Hu, X.Y., Liu, S.C., Dong, W., 1996. Earthquake Engineering. E and FN Spon, an imprint of Chapman and Hall, London, 403 p.

http://www.ttk.gov.tr (2016, 6 May).

http://www.kahramanmaras.gov.tr (2016, 6 May).

İmamoğlu, M.Ş. 1993. Gölbaşı (Adıyaman)-Pazarcık-Narlı (Kahramanmaraş) Arasındaki Sahada Doğu Anadolu Fayı'nın Neotektonik incelemesi. PhD Thesis, A.Ü. Fen Bilimleri Enstitüsü, 138s. Ankara (unpublished).

Jackson, J.A., McKenzie, D. 1984. Active tectonic of the Alpine-Himalayan belt between western Turkey and Pakistan. Geophysical Journal of the Royal Astronomical Society, 77, 185-264.

Karabacak, V., Önder, Y., Altunel, E., Yalçıner, C., Akyüz, H. S., Kıyak, N. G. 2011. Doğu Anadolu Fay Zonunun güney batı uzanımının paleosismolojisi ve ilk kayma hızı. Proceeding of the Aktif Tektonik Araştırma Grubu 15. Çalıştayı (ATAG-15), 19–22 October 2011, Çukurova University, Karataş¸-Adana, 17.

Karig, D.E., Kozlu, H. 1990. Late Palaeogene-Neogene evolution of the triple junction region near Kahramanmaraş, south-central Turkey, Journal of the Geological Society, London, 147, 1023-1034.

Kasapoğlu, E., Toksöz, M.N. 1983. Tectonic consequences of the Arabian and Eurasian plates: finite element models. Tectonophysics, 100 71-96.

Kelling, G., Gökçen, S.L., Floyd, P.A., Gökçen, N. 1987. Neogene tectonics and plate convergence in the Eastern Mediterranean: new data from southern Turkey, Geology, 15, 425-429.

Kempler, D., Garfunkel, Z. 1991. Northeast Mediterranean triple junction from a plate kinematics point of view, Bulletin of the Technical University of İstanbul, Special Issue, 44, 425-454.

Kiratzi, A. 1993. A study on the active crustal deformation of the North and East Anatolian Fault Zones. Tectonophysics, 225, 191-203.

Koç, A., Kaymakcı, N. 2013. Kinematics of Sürgü Fault Zone (Malatya, Turkey): A remote sensing study. Journal of Geodynamics, 65, 292-307.

Koçyiğit, A. 1984. Güneybatı Türkiye ve yakın dolayında levha içi yeni tektonik gelişim. Türkiye Jeoloji Kurumu Bülteni, No: 27, 1-16.

Kondorskaya, N. V., Ulomov, V. I. 1999. Special catalogue of earthquakes of the Northern Eurasia (SECNE). http://www.seismo.ethz.ch/static/gshap/ neurasia/ nordasiacat.txt, 3 May, 2015.

Kozlu, H. 1987. Structural Development and Stratigraphy of Misis–Andırın Region. In Proceedings of the Seventh Turkish Petroleum Congress of Turkey, 6-10 April 1987, Ankara, 104–116.

Lovelock, P.E.R. 1984. A review of the tectonics of the northern Middle East region. Geological Magazine, 121, 577-587.

McKenzie, D.P. 1970. Plate tectonics of the Mediterranean region, Nature, 220, 239-343.

McKenzie, D.P. 1972. Active tectonics of the Mediterranean region. Geophysical Journal of the Royal Astronomical Society, 30. 109-185.

Menekşe, A. 2016. Probabilistic Seismic Hazard Assessment for East Anatolian Fault Zone Using Planar Source Models. Master Thesis, the Graduate School of Natural and Applied Science of Middle East Technical University, 112 p, Ankara (unpublished).

Muehlberger, R.W., Gordon, M.B. 1987. Observations on the complexity of the East Anatolian Fault, Turkey. Journal of Structural Geology, 9, 899-903.

Murphy, J.R. 1977. Seismic source functions for underground and magnitude determinations nuclear detonations. Bulletin .Seismological Society of America Vol. 67(1), pp1675-1692.

Öncel, A.O. 2000. Fraktal Analiz İle Türkiye'deki Doğrultu Atımlı Fayların Yapısal Ve Sismolojik Özelliklerinin Belirlenmesi. Deprem Araştırma Bülteni, sayı; 84, 5–109s.

Özmen, B. 1999. Türkiye ve Çevresinin Tarihsel Deprem Kataloğunun Bölgesel Düzenlenmesi. Deprem Araştırma Bülteni, sayı; 82, 5–83s.

Parlak, O. 2004. Çelikhan–Erkenek Arasında Doğu Anadolu Fayı'nın Özellikleri, Master of Thesis, Istanbul technical University, Avrasya Yer Bilimleri Enstitüsü 99s, İstanbul (unpublished).

Perinçek, D., Kozlu, H. 1984. Stratigraphy and Structural Relations of the Units in the Afşin - Elbistan -Doğanşehir Region (Eastern Tauros). O., Tekeli, M.C. Göncüoğlu (eds.). Geology of Taurus Belt, Mineral Research and Exploration Institute, p.181-198.

Perinçek, D., Günay, Y., Kozlu, H. 1987. New Observations on Strike–Slip Faults in East and Southeast Anatolia. Proceedings of the 7th Petroleum Congress of Turkey, 6–10 April, 1987, Ankara, 89–103.

Robertson, A. H. F., Ünlügenç, Ü.Ç. İnan, N., Taşlı. K. 2004. The Misis–Andırın Complex: A Mid-Tertiary Melange related tolate-Stage subduction of the southern Neotethys in S Turkey. Journal of Asian Earth Sciences 22, 413–53.

Robertson, A.H.F., Parlak, O., Ünlügenç, U.C. 2013. Geological Development of Anatolia and

Easternmost Mediterranean Region. Robertson, A.H.F., Parlak, O., Ünlügenç, U.C. (eds). Geological Society, London, Special Publications, 372, 495-529. doi:10.1144/SP372.14.

Rojay, B., Heimann, A., Toprak, V. 2000. Neotectonic and Volcanic Characteristics of the Karasu Fault Zone (Anatolia, Turkey): The Transition Zone between the Dead Sea Transform and the East Anatolian Fault Zone. Geodinamica Acta, 14, 197-212.

Rotstein, Y. 1984. Counterclockwise rotation of the Anatolian block, Tectonophysics, 108, 71-91.

Seymen,İ., Aydın, A. 1972. Bingöl deprem fayı ve bunun Kuzey Anadolu fay zonu ile ilişkisi. Bulletin of the General Directorate of Mineral Research and Exploration, 79, 1–8.

Sezgin, N., Pınar, A., Utkucu, M. 2002. Maraş Üçlü Eklem Bölgesinde Etkin Olan Tektonik Rejim. Istanbul University, Fac. Of Eng. Yerbilimleri Dergisi, Cilt: 15(1), 43-55.

Shebalin, N.V., Tatevossian, R.E.1997. Catalogueof large historical earthquakes of the Caucasus. Giardini, D., Balassaian, S. (eds). Historical and Prehistorical Earthquakes in the Caucasus. NATO ASI Series Partnership Sub-series 2, Environment, Kluwer Academic Publishers, Dordrecht, The Netherlands, 28, 201–232.

Soysal, H., Sipahioğlu, S., Kolçak, D., Altınok, Y. 1981. Türkiye ve Çevresinin Tarihsel Deprem Kataloğu. TÜBİTAK, Proje No: TBAG 341, İstanbul.

Şaroğlu, F., Boray, A., Emre, M. 1987. Türkiye’nin Diri Fayları, General Directorate of mineral and Exploration Rapor No: 8643, 394s. Ankara (unpublished).

Şaroğlu, F., Emre, E., Kuşçu, İ. 1992*b*. The East Anatolian fault zone of Turkey. Annalae. Tectonicae, 6, 99-125.

Şengör, A.M.C., Yılmaz, Y. 1981. Tethyan evolution of Turkey; A plate tectonic approach. Tectonophysics, 75, p.181-241.

Şengör, A.M.C., Görür, N., Şaroğlu, F. 1985. Strike slip faulting and related basin formation in zones of tectonic escape; Turkey as a case study. Biddle K.T., Christie-Blick N. (Eds.). Strike-slip Deformation, Basin Formation and Sedimentation. Society of Economic Paleontologists and Mineralogists, Special Publications, 37, 227-264.

Tan, O., Tapırdamaz, M. C., Yörük, A. 2008. The earthquake catalogues for Turkey. Turkish Journal of Earth Sciences, 17, 405–418.

Trifunac, M.D. 1976. Preliminary analysis of the peaks of strong earthquake ground motion-dependence of peaks on earthquake magnitude, epicentral distance and recording site conditions. Bulletin .Seismological Society of America 66, 189-219.

Trifunac, M.D., Brady A.G. 1975. On the correlation of seismic intensity scales with the peaks of recorded strong ground motion. Bulletin .Seismological Society of America vol. 65, No 1 pp 139-162

Wald, D.J., Quitoriano, V., Heaton, T.H., Kanamori, H. 1999. Relationship between Peak Ground Acceleration, Peak Ground Velocity and Modified Mercalli Intensity in California. Earthquake Spectra, Volume 15, No: 3.

Watabe, M. 1977. Digitized of strong-motion earthquake accelergrams in Romania. Romania Central Institute for Research, Design and Guidance in Building, March 4, 1977 Japan.

Wells, D.L., Coppersmith, K.J. 1994. New Empirical Relationships among Magnitude, Rupture Length, Rupture Width, Rupture Area and Surface Displacement. Bulletin .Seismological Society of America, Vol: 84, No: 4, pp 974-1002.

Westaway, R. 2003. Kinematics of the Middle East and Eastern Mediterranean Updated, Turkish Journal of Earth Science 12, 5-46.

Westaway, R., Arger J. 1996. The Gölbaşı Basin, Southeastern Turkey: A Complex Discontinuity in a Major Strike-Slip Fault Zone. Journal of the Geological Society 153, 729-744.

Westaway, R., Demir, T., Seyrek, A., Beck, A. 2006. Kinematics of Active Left lateral Faulting in SE Turkey from Offset Pleistocene River Gorges: Improved Constraint on the Rate and History of Relative Motion between the Turkish and Arabian Plates. Journal of the Geological Society of London 163, 149–164.

Yüksel, Ö. 2009. Gölbaşı (Adıyaman) Dolayında Doğu Anadolu Fay Sistemi’nin Paleosismisitesi ve Zeminlerin Değerlendirilmesi. Master of Thesis, Çukurova University, Institute of Applied Science, 117s, Adana (unpublished).