

THE ADANA -CEYHAN EARTHQUAKE of JUNE 27, 1998

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ABSTRACT

The Adana-Ceyhan earthquake of June 27,1998 had a magnitude of $M_s=6.2$ (USGS) and $M_w=6.2$ (USGS). 145 people were killed and over a thousand injured by this earthquake. According to the preliminary determination of General Directorate of Disaster Affairs, 9878 Private Residences(PR) and 490 Office Residences (OR) were heavy, 18094 PR and 1284 OR moderate, and 46968 PR and 3009 OR slight damaged. Macro seismic epicenter is near southern part of Abdioğlu village (35.56E, 36.89N) by maximum intensity of $I_0 = IX$ (MSK) according to our observations in the field, structures and over 150 questionnaires and personal communications with the people at 72 villages and towns. Any recent activity and displacement could not be traced continuously due to relatively great thickness of alluvial deposits and source depth. Faulting traced place to place as 15kms from southern Abdioğlu village to Yeni Küçük Kapılı farm at South and to Yakapınar at North. Right lateral displacement observed on some places in faulting area. Unexpected damage at Adana-Tepebağ resulted due to dense historical buildings in this site. Damage in Ceyhan is over than expected. Severe damage in concrete buildings caused by soil amplification especially at Hasevler district. Alluvial deposit and under ground water level of few meters increased the intensity and caused the severe damage in this area. Beside this, insufficient material, masonry and lack of reinforced concrete framing are also increased the damage. Sandblowings and liquefaction densely observed along the Ceyhan river about 45-50kms and some other places in Çukurova Basin. As it is clearly seen, unexpected damages in some villages and towns mostly caused by soil conditions. So, soil investigation should be taken into account more seriously as well as geological, geophysical and geotechnical aspects.

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* This work was supported by the Research Fund of the University of İstanbul.
Project Number: GP/12070998.

İ.Ü. Kütüphane ve Dok. D. Bşk.	
Demirbaş No :	M5595
Kayıt No :
Sınıflama No :

INTRODUCTION

The Adana-Ceyhan earthquake occurred in the Çukurova Basin. Çukurova Basin is bordered by Anatolian block at the North and African and Arabian Plates at the South. Anatolian Block escapes to the West due to the faster movement of Arabian Plate relatively to the African Plate toward the North (Figure 1). In general, this kinematic movement takes place through the right lateral strike slip faulting known as North Anatolian Fault Zone (NAFZ) and left lateral strike slip faulting as East Anatolian Fault Zone (EAFZ) (Barka, 1992). The Çukurova Basin developed in this tectonic regime.

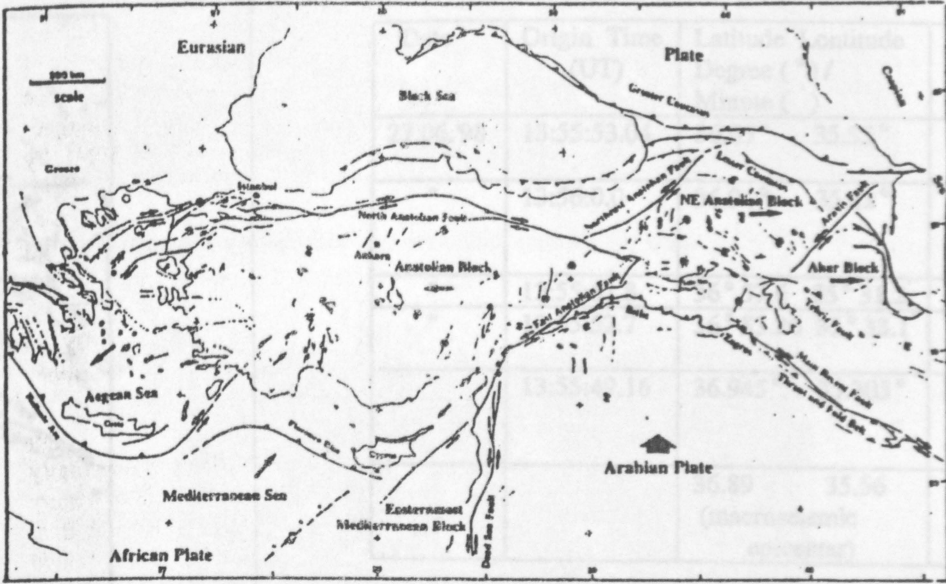


Figure 1: Tectonic map of Eastern Mediterranean and surroundings (Barka, 1992).

The historical earthquakes and seismicity of the area is given in Figure 2. There are two historical earthquakes with the intensity of IX (Soysal et al., 1981). The catalog of Kandilli Observatory is used for seismicity map. There are 121 earthquakes concerning the seismicity from 1900 to 1998. Ten of them has magnitude larger than 5.0.

The earthquakes of 20 March 1945 and 22 October 1952 are caused heavy damages in the area. Their epicenters should be revised concerning our personal communications with local people during the field observation.

According to the historical and instrumental data sets there is not any destructive earthquake in Çukurova Basin and near surroundings.

FIELD OBSERVATIONS

According to our observations, the macroseismic epicenter of the Adana-Ceyhan earthquake is at the near southern of Abdioğlu Village (Gündoğdu et al., 1998). Earthquake parameters and macroseismic epicenter of this earthquake for different sources are given at Table 1.

Table 1: Earthquake parameters of the 27 July 1998 Adana-Ceyhan earthquake for several sources. ERD Earthquake Research center, HRVD Harvard Univ., KAN Kandilli Observatory, MAM TÜBİTAK-Marmara Research Center, USGS United States Geological Survey.

Date	Origin Time (UT)	Latitude Degree (°) / Longitude Minute (')	Magnitude	Depth (km)	Max. Intens.
27.06.98	13:55:53.04	36.85° 35.55'	Md = 5.9	23 (ERD)	
"	13:56:0.0	36.94° 35.42'	Ms = 6.2 mb = 6.2 Mw = 6.3	15 (HRVD)	
"	13:55:51.8	36° 57.6' 35° 31.2'	Md = 6.3	18(KAN)	
"	13:55:52.7	36° 53.26' 35° 33.1'		22 (MAM)	
"	13:55:49.16	36.945° 35.305'	Ms = 6.3 mb = 5.9 Mw = 6.3	14 (USGS)	
		36.89 35.56 (macroseismic epicenter)			Io=IX (MSK) [4]

Macroseismic epicenter is in agreement with the epicenter given by TÜBİTAK-MAM (Figure 3). The epicenters given by USGS and Harvard are quite differs from the others. There are several focal mechanism solutions for this earthquake. Harvard Univ. and USGS 's focal mechanism solutions are both a strike slip faulting but former has a major reverse component. ERD also found a strike slip faulting with a major normal component. An earthquake occurred a week later on 04.07.1998 with a magnitude of mb=5.1. TÜBİTAK-MAM modelled this earthquake as a strike slip faulting with a major reverse component.

Source of faulting is in Çukurova Basin and the fault occurred with this earthquake could not continuously traced in the field due to relatively great thickness of alluvial deposits and source depth. Faulting could be observed with the indications of tension cracks, sandblowings and etc. Faulting traced from southern Abdioğlu Village at North to Yeni Küçükkapılı farm at South (Figure 4). In front of Kazime Özler Primary School, 7cm offset is measured. Although some researchers previously mentioned that faulting is at Misis Fault or Karataş Fault but, we had not observed any indication or

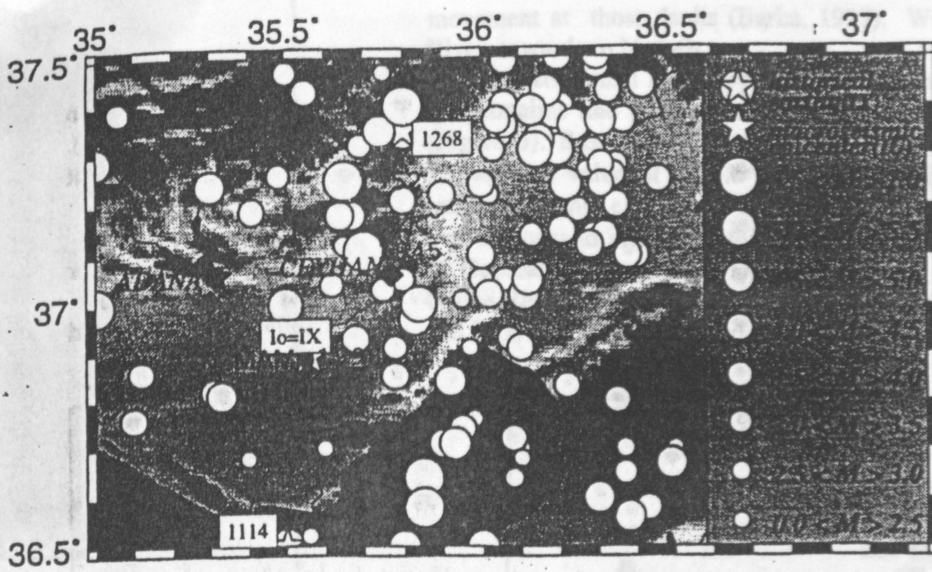


Figure 2: Historical earthquakes and seismicity map for the area.

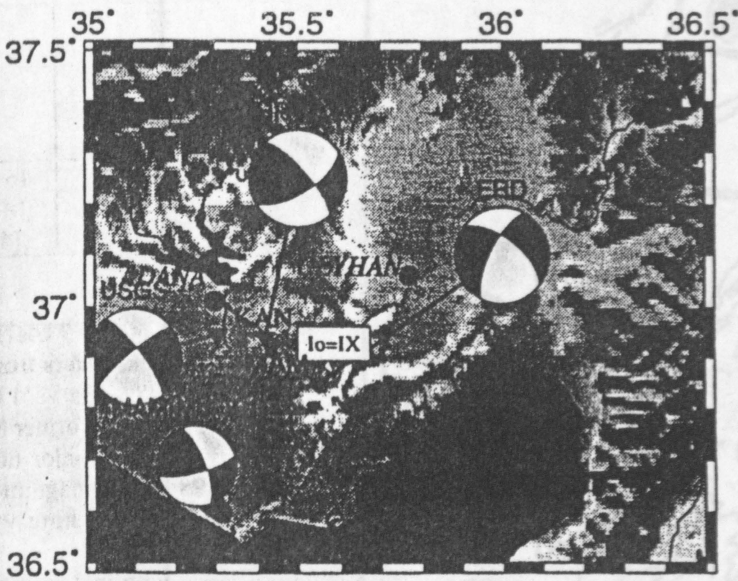


Figure 3 : Macro seismic epicenter and instrumental epicenters with focal mechanism solutions of different sources. ERD: Earthquake Research Department, HRVD: Harvard University, USGS: United States Geological Survey, MAM: TÜBİTAK Marmara Araştırma Merkezi, KAN: Kandilli Observatory, MAM(mb=5.1) the earthquake of 04.07.1998.

movement at those faults (Barka, 1998). We also observed a trace near the Ceyhan River towards to Nacarli.

The izoseismal map prepared after observations in the field, structures and 150 questionnaires and personal communications with the people at 72 villages and towns (Figure 5). Based on the sandblowings observed through the Ceyhan river and the acceleration value of 273.6 cm/sec^2 in the E-W direction in Ceyhan, the maximum intensity of this earthquake is decided as $I_0 = IX$ (MSK). 145 people were killed and over a thousand injured by this earthquake. According to the preliminary determination of General Directorate of Disaster Affairs, 9878 Private Residences(PR) and 490 Office Residences(OR) were heavy, 18094 PR and 1284 OR moderate, and 46968 PR, and 3009 OR slight damaged (Table 2).

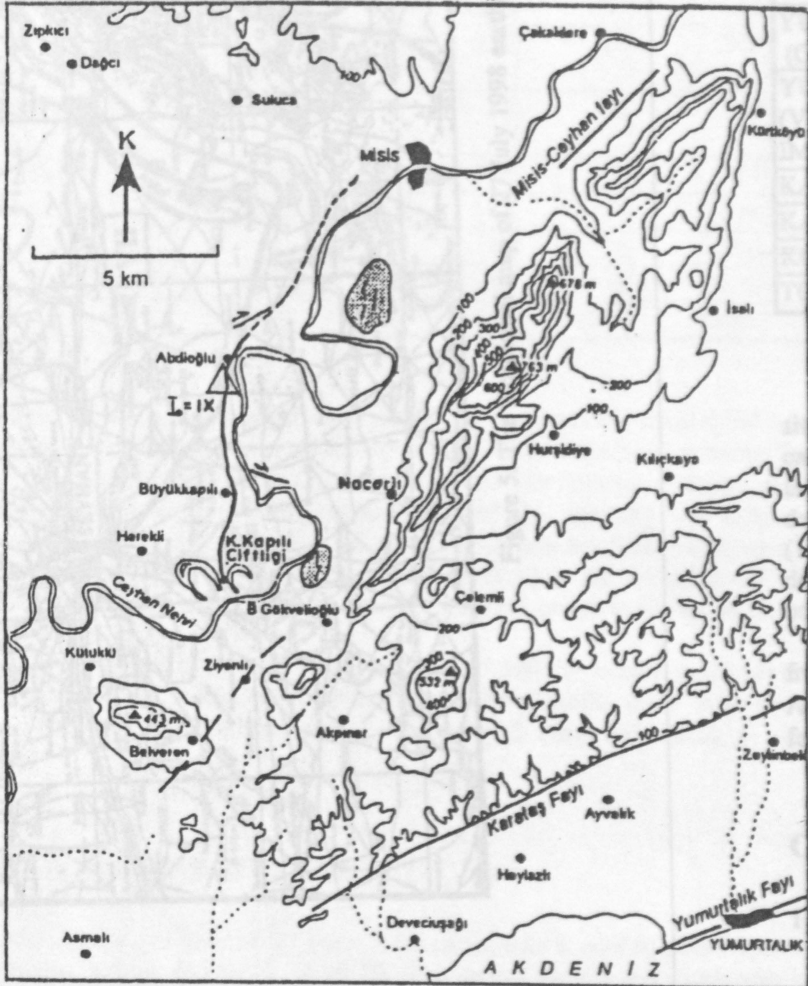


Figure 4 : Faulting occurred by Adana-Ceyhan earthquake. Δ shows the macroseismic epicenter.

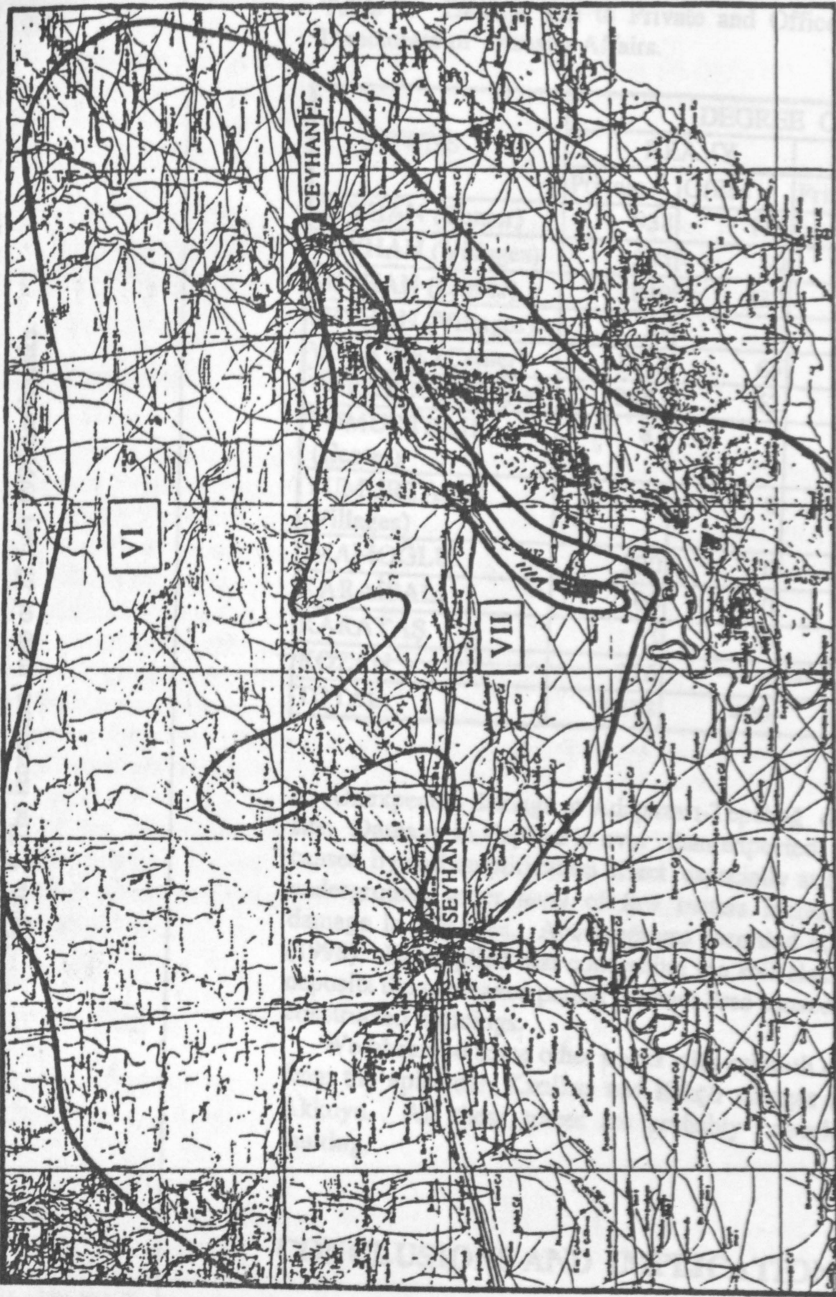


Figure 5: The isoseismal map of 27 July 1998 earthquake.

Table 2: Damage toll to Private and Office residences. Data supplied from the Directorate of Disaster Affairs.

TOWNS	DEGREE OF DAMAGE					
	HEAVY		MODERATE		SLIGHT	
	Private	Office	Private	Office	Private	Office
CEYHAN (Center)	938	119	2173	108	3725	281
CEYHAN (Villages)	505	10	911	23	2035	34
SEYHAN (Center)	2840	232	6156	701	17978	1601
SEYHAN (Villages)	51	0	153	2	466	5
YÜREYİR (Center)	1413	65	5152	291	16197	910
YÜREYİR (Villages)	3483	62	2636	57	4631	134
YUMURTALIK (Center)	87	2	227	97	503	12
YUMURTALIK (Villages)	10	0	50	0	110	0
İMAMOĞLU	220	0	165	0	367	4
KARAİSALI	100	0	183	1	374	3
KARATAŞ	5	0	14	1	156	4
KOZAN	226	0	274	3	426	21
TOTAL	9878	490	18094	1284	46968	3009

Unexpected damage at Adapazarı-Tepebağ due to dense historical buildings in this site. Damage in Ceyhan is over than expected. Severe damage in concrete buildings caused by soil amplification effect especially at Hasevler district. Alluvial deposit and underground water level of few meters increased the intensity and caused severe damage in this area. Acceleograms recorded at Ceyhan are interpreted by Eyidoğan (1998). He implied that concerning the soil classification and the thickness of aluvial deposits the resonance period is about 3sec caused the damage to higher and improperly constructed buildings.

We observed some other traces with azimuth of 340° by tension cracks at rather far from the epicenter, Kızılkış and Kılıçlı villages and a similar trace also observed at Akkuyu. All these traces are probably developed after mainshock as secondary faulting.

CONCLUSIONS AND IMPLICATIONS

1. Macroseismic epicenter of 27 June 1998 earthquake is near southern part of Abdioğlu village (36.89°N, 35.56° E). Any recent activity and displacement could not be observed on Misis Fault Zone.
2. Faulting traced place to place as 15kms from southern Abdioğlu village to Yeni Küçükkapılı farm at South and to Yakapınar at North.

3. Sandblowings and liquefaction densely observed along the Ceyhan river about 45kms and some other places in Çukurova Basin.
4. The earthquake with magnitude of $m_b=5.1$ was occurred on 04 July 1998. Concerning the epicenter and dynamic implications of two earthquakes we think that this earthquake has not an aftershock characteristics.
5. Unexpected damage at Adana-Tepebağ resulted due to dense historical buildings in this site.
6. Severe and heavy damage in concrete buildings at Hasevler site in Ceyhan due to soil amplification and the resonance effect. Insufficient material, masonry and lack of reinforced concrete framing are also increased the damage.

SUGGESTIONS

1. Adana and its near surroundings is second degree of earthquake zone. Eastern part of Ceyhan is first degree of earthquake zone. This region has great potential for destructive earthquakes concerning the occurred historical earthquakes. In the light of all these knowledge, exposing the buried faults by geophysical methods especially in the basin becomes extremely important and urgent to determine the potential risk such a fast urbanized area.
2. Local governs and other governmental associations should coordinate for obligation of the soil investigation before preparing the municipal plan controlling development and construction within an area.
3. Chambers concerned with as civil engineers, geophysical&geological engineers, city planners and architects should collaborate to solve the problems and activate the control mechanism together.
4. Finally, we believe that this earthquake is a kind of warning for the Adana city and surroundings. The area has great potential for a destructive earthquake, so all necessary precautions and planning should be done for saving of human life and economical loss.

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AĞUSTOS 1999
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