

## Temporary seismic quiescence: SE Turkey

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### SUMMARY

The Border Zone that is the contact of the Arabian plate with the three plates of Turkey, Eurasia and Iran to the north has been remarkably aseismic during this century. By extending the period of observation backwards in time by a few centuries it is shown that this seismicity is atypical of the long-term behaviour of the zone and due to a quiescent period in the activity of the area during the 20th Century. In turn, this implies that short-term data alone do not provide a reliable assessment of earthquake hazard.

**Key words:** seismic quiescence, Turkey

### INTRODUCTION

It is generally recognized that the 1000 km long Border Zone that defines the boundary between the Arabian and Turkish plates has been remarkably inactive, with only three 6.6–6.8 M earthquakes occurring during this century (Fig. 1). The predicted velocity between Arabia and Turkey is two orders of magnitude greater than that obtained from a summation of seismic moments of earthquakes in the 20th Century (Jackson & McKenzie 1988) and the seismic hazard deduced from 20th Century data is negligibly small, see Fig. 2 (Burton *et al.* 1984). What is not so generally recognized, however, is that the apparent quiescence of this zone is only temporary and that it does not represent the real tectonic activity that accommodates almost all the Arabia–Turkey motion and part of that between Arabia and Eurasia along this boundary.

The fact that all of our 20th Century records are for a quiescent period in the seismic activity can be demonstrated by extending the period of observations backwards in time by a few centuries.

### DATA AND ANALYSIS

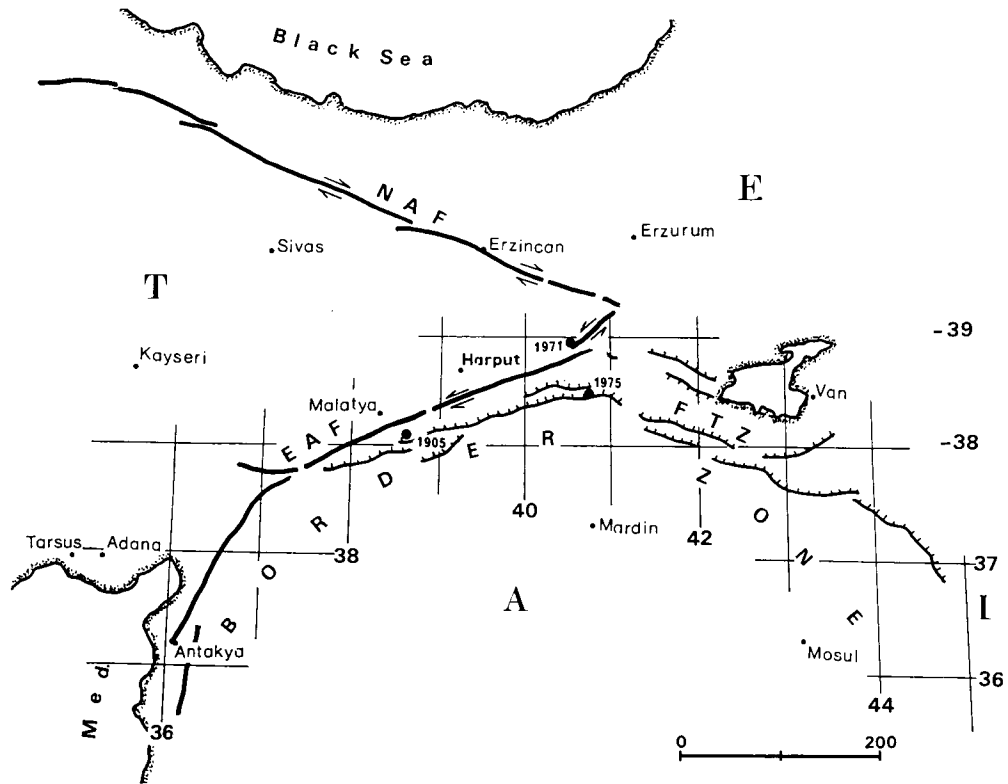
We chose to investigate the period 1500–1988, and to concentrate mainly on large earthquakes which are not only the most significant tectonically but are also less likely to be omitted from the historical record, thus reducing the chance of incomplete sampling. The source material available for this period at the moment is neither complete nor always reliable. However, it is adequate for a preliminary identification and location of the larger events.

The area of study, the Border Zone defined in Fig. 1, is a 1000 km long and average 150 km wide zone, the western half of which follows the East Anatolian fault zone, (McKenzie 1976), and the eastern half the Fold and Thrust zone that runs south of Lake Van and SW of the Zagros.

The Border Zone changes its character from a predominantly strike–slip boundary in the west to a broader boundary across which shortening occurs in the east. The North Anatolian fault zone, which marks the deforming zone between Eurasia and Turkey, terminates near the centre of the Border Zone, near 41°E, an area of many and large historical earthquakes excluded from our area of study, which does not extend north of 39°N.

The description of all large earthquakes that occurred in the Border Zone during the period 1500–1905, and for which we have been able to retrieve information, is given in the Appendix. These accounts contain the essential data available at present and the accompanying maps should help the reader identify the location of events, the extent of damage and felt areas. The earthquakes discussed are documented as fully as possible on the basis of primary and near-contemporary sources of information but only a few of the most relevant references are cited.

In assessing macroseismic epicentral regions we have followed the procedure used by Ambraseys & Melville (1982). Data provided by historical sources for large earthquakes on land and in populated areas are generally adequate to permit relatively good location of the epicentral region, particularly for events of the 19th Century. Earlier earthquakes are less well located and it is often difficult to ascertain their true epicentres. However, this has little effect on the assessment of their magnitude which can be estimated fairly closely in terms of felt areas. Table 1 lists the characteristics of the events identified and the coordinates of the epicentral regions, to which a quality factor is assigned that indicates possible location errors. In the Appendix we distinguish between historical observations and interpretations so that one should be allowed to draw his own conclusions from the available facts if he so wishes. Intensity assessment in the MSK (Medvedev–Sponheuer–Karnik) scale is also based on the methodology used by Ambraseys & Melville (1982). The space distribution of



**Figure 1.** Border Zone extends along strip covered by the grid. A: Arabian Plate; T: Turkish; E: Eurasian; and I: Iranian. EAF = East Anatolian Fault; NAF = North Anatolian Fault; FTZ = Fold and Thrust zone. Figure shows location of the three events during this century with  $M_s \geq 6.6$  in the Border Zone, i.e. of 1905, 1971 and 1975.

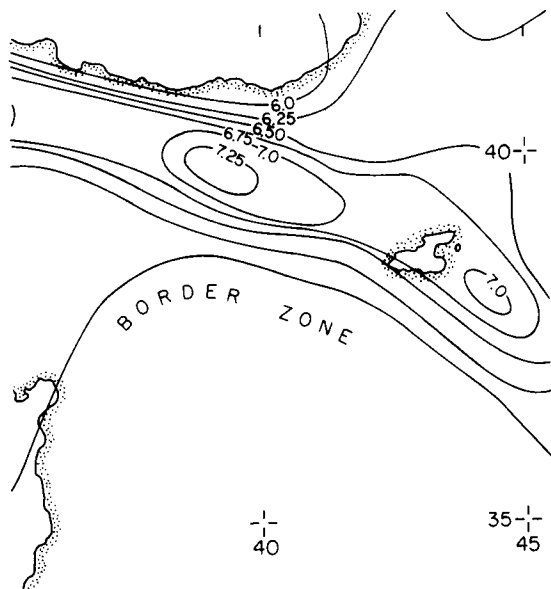
intensity is intimately connected with the estimation of the size or magnitude of the earthquake, and magnitudes were assigned from the radius of perceptibility or any epicentral distance for a given intensity. Our sources of information

are generally adequate to assess this, using the relationship derived for Turkey:

$$M_s = -0.53 + 0.58(I_i) + 1.96 \times 10^{-3}(r_i) + 1.83 \log(r_i), \quad (1)$$

where  $r_i$  are the available epicentral distances in km of intensity  $I_i$ .  $M_s$  is then the average value of equivalent surface-wave magnitude determined from the different epicentral distances or isoseismal radii. Equation (1) is valid for shallow shocks and there is generally good agreement ( $\pm 0.25$ ) between  $M_s$  determined from felt information in this way and  $M_s$  determined from teleseismic surface waves (Ambraseys & Finkel 1987; Ambraseys 1988).

Equation (1) was used, therefore, to estimate surface-wave magnitudes and select the larger events ( $M_s \geq 6.6$ ) in the Border Zone for the period 1500–1900. For later events, magnitudes were calculated from instrumental data, and Table 1 lists the earthquakes identified as having  $M_s \geq 6.6$ . The overall error in assigning individual  $M_s$  values for historical events is about 0.3 magnitude units, an uncertainty in  $M_s$  comparable to that of 20th Century  $M_s$  teleseismic determinations. This error arises mainly from uncertainties associated with the estimation of  $I_i$ , and to a lesser extent from uncertainties in epicentral distance. However, the error in  $M_s$  derived from more than four good individual intensity readings is usually not more than 0.3. We must add a word of warning: equation (1) represents the average attenuation of intensities in Turkey, derived from a large body of data which, however, contains a very small sample of  $M_s \geq 6.0$  earthquakes from the Border Zone and its extension into the Dead Sea system. There is some evidence



**Figure 2.** Seismic risk map of eastern Turkey after Burton *et al.* (1984). Contours show the largest earthquake magnitudes expected over a period of 75 years predicted using Gumbel's third asymptotic distribution of extreme values of 20th Century data. The Border Zone covers the area where no data exists.

**Table 1.** Large earthquakes ( $M_s = 6.6$ ) in the Border Zone 1500–1988

Date	Time	Epicentre		$Q$	$M_s$	$I_0$	$F$	QT	Location
		N	E						
1503	—	—	(37.4°–43.8°)	C	6.9–	—	0	0	Hakkari (?)
1513	—	—	37.5–36.5	B	7.4+	IX*	0	1	Tarsus–Malatya
1544	Jan	—	38.0–37.0	B	6.7+	X*	0	2	Zitun–Malatya
1573	c.	—	35.5–45.0	B	6.9–	IX*	0	2	Shahrizur
1648	Mar 31	2400	38.3–43.5	A	6.7	X	0	3	Van–Hayotsdzor
1666	Sep 22	—	37.0–43.0	B	6.6	IX*	0	1	North Mosul
1670	Aug 1	—	38.0–42.0	B	6.6+	—	0	1	Hizan
1685	Nov 22	2300	39.0–41.0	B	6.7	—	0	1	Gönek
1705	Jan 27	—	38.7–41.7	B	6.7	IX*	0	1	Bitlis
1715	Mar 8	0600	38.4–43.9	A	6.6+	IX*	0	2	Van
1789	May 29	—	39.0–40.0	B	7.0+	—	0	1	Palu
1796	Apr 26	0905	35.5–36.0	A	6.6–	VIII*	0	2	Latakiya
1822	Aug 13	2040	36.7–36.9	A	7.4+	X	1	3	Aafrine
1866	Jun 20	1400	38.5–40.9	A	6.8–	IX*	0	2	Kulp
1871	Mar 17	—	38.0–43.0	B	6.8+	—	0	1	Hakkari
1872	Apr 3	0740	36.4–36.5	A	7.2–	X	1	3	Amik Gölü
1874	May 3	0700	38.5–39.5	A	7.1+	X*	2	2	Gölcük Gölü I
1875	Mar 3	2248	38.5–39.5	A	6.7	VII*	2	2	Gölcük Gölü II
1884	Feb 10	0500	37.5–42.5	B	6.9–	VIII*	0	1	Sürt
1893	Mar 2	2251	38.0–38.3	A	7.1+	X	0	2	South Malatya
1905	Dec 4	0704	38.1–38.6	A	6.8*	IX*	1	2	Malatya
1971	May 22	1644	38.9–40.5	A	6.8*	IX	3	3	Bingöl (1)
1975	Sep 6	0920	38.5–40.8	A	6.6*	IX	3	3	Lice (2)

**Notes:**

$Q$  = estimated location accuracy, A: 10–40 km; B: 50–90 km; C: probably more than 100 km.

$M_s$  = estimated surface-wave magnitude from felt effects from equation (1). Plus/minus signs indicate estimates probably underestimated/overestimated respectively. Asterisk values are from teleseismic data.

$I_0$  = epicentral intensity (MSK). Asterisk shows maximum observed intensity.

$F$  = historical/field evidence for faulting. 0: no evidence; 1: poor evidence, probably of secondary nature; 2: evidence in need of authentication; 3: good evidence.

QT = overall quality of data. 0: poor; 1: medium; 2: good; 3: very good.

(1): Seymen & Aydin (1972); Ambraseys (1988).

(2): Arpat (1977); Ambraseys (1988).

that in these areas the attenuation of intensity may be somewhat slower, in which case, magnitudes derived from equation (1) may be overestimated. There is simply no comparable 20th-Century data from these areas that may be used to derive a strictly regional attenuation law.

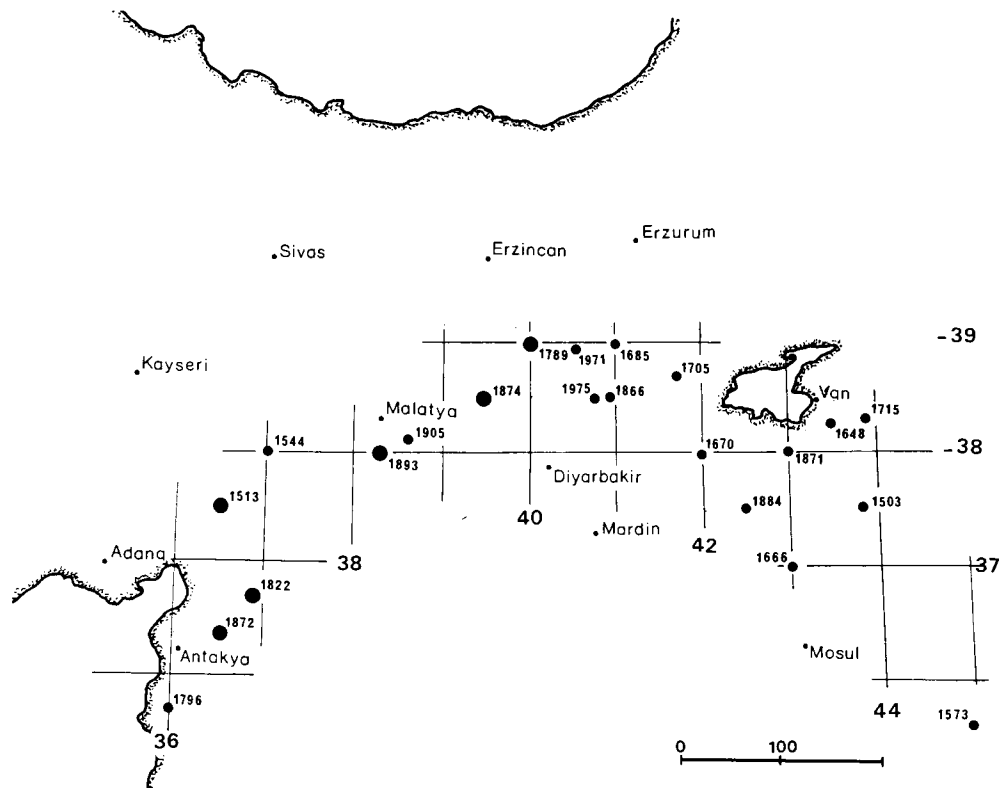
**DISCUSSION**

Fig. 3 shows the location of all earthquakes identified in the Border Zone with  $M_s \geq 6.6$  for the period 1500–1988, and Table 1 lists their main characteristics. This is a fairly representative sample of long-term activity, but by no means complete. The study of our source material suggests that for the whole zone and period studied, many moderate shocks ( $M_s < 6.6$ ) might not have been recorded, particularly in the Fold and Thrust zone. It is very probable, however, that any major or great earthquake has been noted, although not necessarily fully identified. It is reasonable to suppose, therefore, that the available data for the whole zone is incomplete for all magnitudes. Nevertheless, as can be seen by comparing Figs 1 and 3, the available data are sufficient to establish beyond doubt that all of our 20th-Century seismicity comes from a quiescent period.

From Fig. 3 we notice that the west part of the Border Zone, i.e. the East Anatolian Fault, is associated with relatively infrequent but large events, while the eastern part of the Zone, the Fold and Thrust zone, is characterized by

more frequent smaller events and this behaviour continues SE into the Zagros. The first instance is typical of large strike-slip faults on which a fair proportion of dislocation takes place in a few large earthquakes that are easier to identify in the historical record (Sieh 1978). The second instance is also typical of regional thrusting, where deformation takes place in more frequent smaller shocks diffused within a broader zone (Jackson & McKenzie 1984, 1988); in this case, because of their smaller size, earthquakes are more difficult to identify and the historical record is more likely to be incomplete.

This shows the need to separate deforming zones with different activities, in this case the East Anatolian Fault zone from the Fold and Thrust zone; each is about 500 km long, and they merge into one another at the end of the North Anatolian Fault zone near 41°E. The East Anatolian Fault starts from this point and extends SW all the way to Antakya, near where the 1796, 1822 and 1872 earthquakes suggest that it joins up with the Dead Sea Fault system. The East Anatolian Fault zone is marked by discontinuous segments showing Quaternary activity including the formation of closed depressions and sag ponds, such as the Gölcük Lake (Hazar Gölü) (Arpat & Şaroğlu 1972), localities associated with relatively large magnitude earthquakes in the period investigated as well as in earlier periods to be discussed elsewhere. Almost all of the few cases that allude to faulting, i.e. in 1822, 1872, 1874 and



**Figure 3.** Distribution of earthquakes in the Border Zone during the period 1500 to 1988 (Table 1), marked with year of occurrence. Size of dots corresponds to magnitudes 6.0 and 7.0 respectively.

1905, are for events in this 100 km wide zone that shows remarkably low background seismicity, not only during this century but also in earlier times. The East Anatolian Fault is clearly sinistral in its sense of displacement (McKenzie 1976) and the deformations associated with earthquakes in this zone seem to occur along the entire length every few hundred years during relatively short paroxysmal periods of large events. From Fig. 3 and Table 1 we notice that the first paroxysm in our period of observations ended in 1544 and the second started after two and a half centuries of relative quiescence in 1789. This period of low activity seems to be genuine and is in many respects similar to that being experienced by the zone during this century. In the following 116 years, that is between 1789 and 1905, a series of relatively large earthquakes began, alternating between the two ends and gradually converging to the middle of the East Anatolian Fault zone.

East of 41°E the tectonic style of the Border Zone distinctly changes into a broad zone of compression that merges into the Zagros and Caucasus zones. The width of the Fold and Thrust zone is difficult to define and the available sample of its historical seismicity is likely to be incomplete.

More work is undoubtedly needed to retrieve additional information and to refine important details over a much larger area before more can be said about the long-term interaction of the main tectonic elements in this part of the Eastern Mediterranean. However, the very preliminary evidence presented here demonstrates that the 20th-Century activity of the Border Zone is associated with a quiescent period atypical of the long-term seismicity of the region.

The same evidence suggests that on large strike-slip faults much of the slip may be associated with infrequent clusters of large shocks and relatively long periods of quiescence. It also suggests that in thrust zones much of the deformation may be taken up aseismically with only a small part being associated with medium magnitude events, which are more difficult to sample from the historical record.

It is expected that overall plate motions over the last few decades should not differ significantly from those over the past few million years. However, this does not mean that the associated seismicity should be constant with time. Rupture processes that control the generation of earthquakes do not depend solely on plate motions. They depend also on the capacity of the crust to store and release potential energy through flow, creep and fracture, which is highly variable. Large events on a given fault segment are likely to have repeat times of the order of hundreds of years and the long-term data from the Eastern Mediterranean region show conclusively that the past 88 years provide a very incomplete sample. Consequently, it is simply not logical to ignore the possibility that all of our observations may be for a quiescent period in the seismic activity of a region. This is one of the alternatives that must be borne in mind when making an assessment of seismicity, and this is the chief reason why statistics based on short-period data alone do not provide a reliable assessment of earthquake hazard.

Historical evidence for the Eastern Mediterranean shows that the seismicity of the East Anatolian Fault zone is in some ways similar to that of the Dead Sea system, where infrequent large earthquakes (Ambraseys & Melville 1988)

occur throughout its length, but the system has remained almost aseismic during this century.

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### APPENDIX

This Appendix contains descriptions of earthquakes identified in the Border Zone during the period 1500-1905 with  $M_s \geq 6.6$ . Some of these earthquakes are described in greater detail than others; the purpose of this is to highlight important aspects of an event and illustrate the nature of the information that can be found in historical sources.

Figure 4 shows the localities mentioned in the Appendix for events that do not merit construction of a separate map. Reference to maps relating to specific earthquakes should indicate the method used to assess macroseismic epicentres and equivalent radii of intensity for use in equation (1) and illustrate the basic pattern of the spread of felt effects. Isoseismals are of a generalized nature and they are drawn on the basis of the available data which are more numerous than shown on intensity maps. Place-names are spelt as given in contemporary sources and they may not be in use today. For the general location of the events that follow, see Figs 3 and 4.

#### 1503; Hakkari

Information about this earthquake comes from a late 18th century Arab history. It states that in 908 AH the city of Mosul, along with Tabriz and Azerbaijan, and the city of

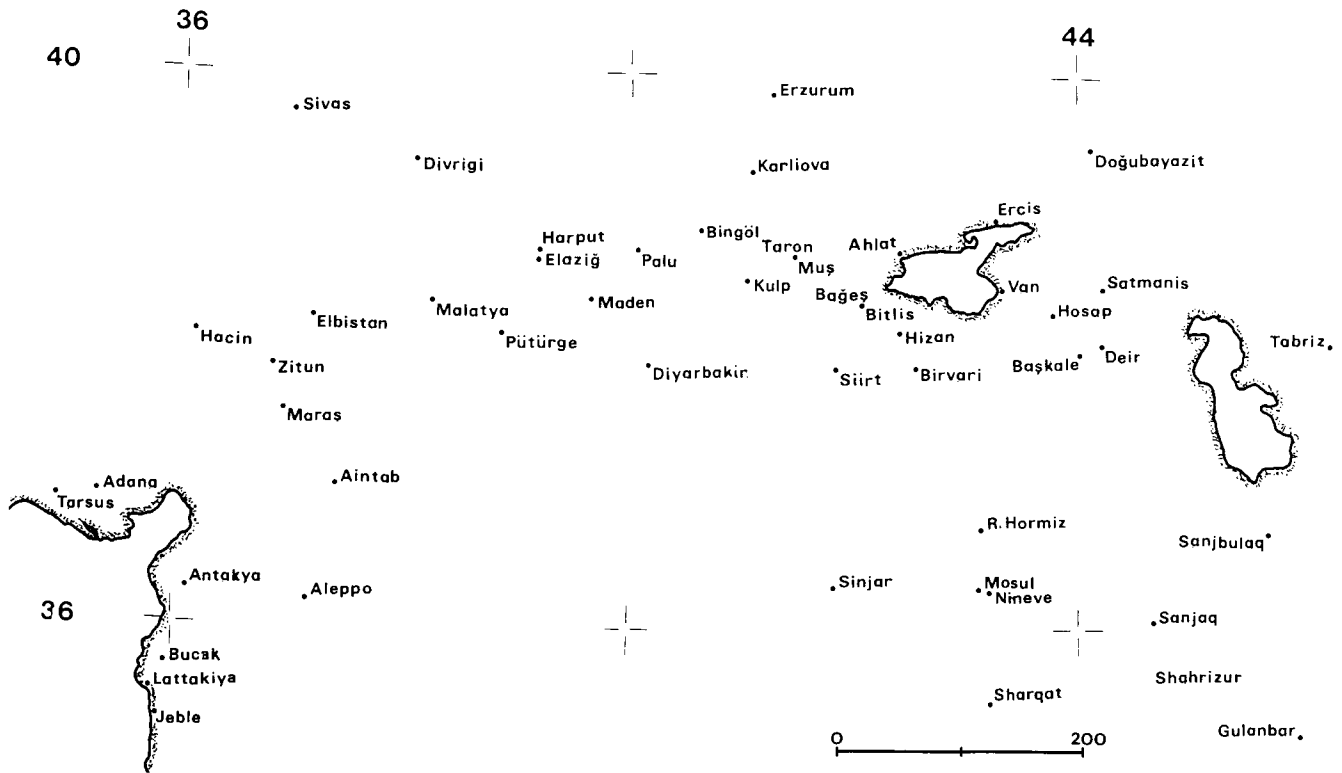


Figure 4. Location map of places mentioned in the Appendix.

Ahlat, were shaken by an earthquake which destroyed some houses. The sites said to have suffered some damage are situated about 360 km apart, around the inaccessible and sparsely-populated district of Hakkari, southeast of Lake Van. If the statement is correct—and we have no earlier source—it implies that the shock was of considerable magnitude. *al-'Umari* (c. 1800).

#### 1513; Tarsus-Malatya

We learn from a contemporary diary that in the first months of 1514 the Ottoman Sultan Selim I arrived in Konya where he found the pestilence raging and the towns of Tarsus, Adana and Malatya almost totally destroyed by an earthquake. The shock apparently affected the province of Cilicia, which in the 16th Century extended SE of Kayseri and along the south bank of the Kizilirmak river. Thus the earthquake must have occurred before 1514, and should have destroyed a large area stretching for at least 340 km along the Border Zone. This may be the earthquake felt in Lower Egypt on 1513 March 28 which, it is said, affected the region of Rum with its centre at Sivas: without further details the account is insufficient to indicate the precise date and area over which the event was felt. It is of interest, however, that sometime in the 15th or early 16th Century the river Berdan, that flowed through Tarsus, seems to have changed its course, and since that time it has flowed outside the town, further to the NE and SE. The remoteness and large extent of the area destroyed, as well as the survival of this information in a contemporary occidental source and allusions of damage to Armenian settlements around Hacin, suggest the comparative gravity of the event. Barbaro (1842, vii.1061); Ibn Iyas (1311/1893, i.278).

#### 1544 Jan; Zitun-Malatya

Contemporary sources describe briefly this large earthquake, which occurred in the same region as the earthquake of 1513, destroying a relatively large area. From a Greek marginal note we learn that the whole East was shaken by a great earthquake as a result of which Zitun was devastated. An Armenian colophon written in Sivas adds that one part of Zitun was destroyed by the shock, and the rest of the town was overwhelmed by the collapse of the mountain on which it was built. Half of Elbistan was also destroyed, and shocks continued for six months. Heavy damage apparently extended to Aintab and in the region of Maraş, where the Sajur intake for the water supply of Aleppo was seriously damaged. Although the exact extent over which the shock was felt is not known, there is no doubt that this was large and included Eastern Anatolia and Syria, from where it was also reported. Amantos (1932, 61); Hakobyan (1951, 171).

#### c. 1573; Shahrizur

A contemporary order from Istanbul to the Ottoman provincial authorities in Mosul informs us that as a result of an earthquake in the district of Shahrizur builders and stonemasons were sent from Diyarbakir to undertake reconstruction and repair of the fortress of Gülanber, which was almost totally destroyed. This document, which gives some details of the repair work to be done, provides only a *terminus ad quem* of early 1579: most probably it refers to the earthquake of 1573, mentioned by later sources, that

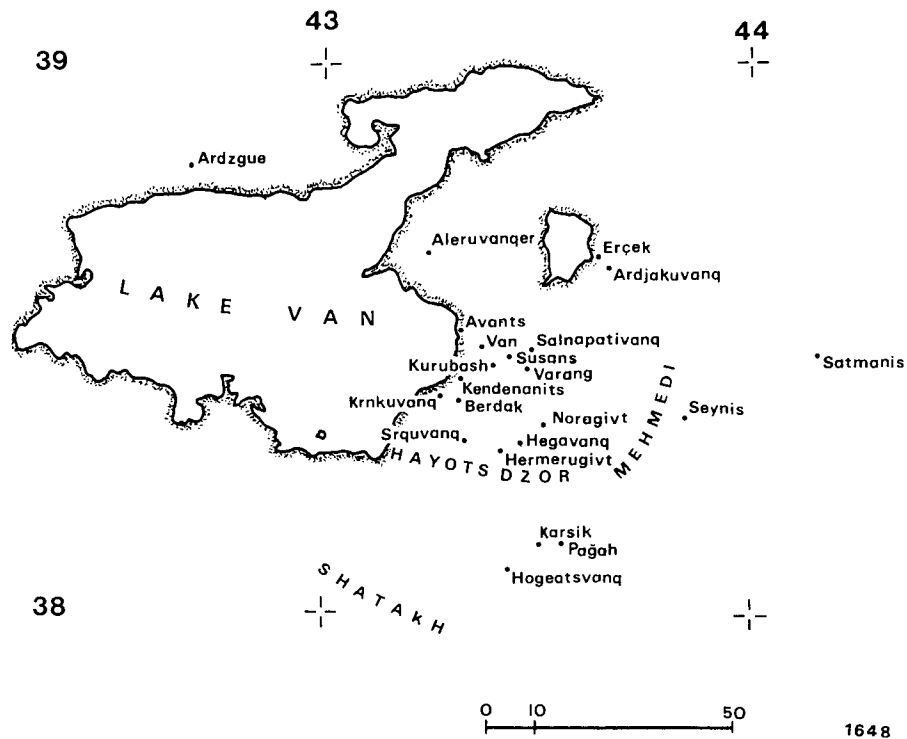


Figure 5. Epicentral region of the Van-Hayotsdzor earthquake of 1648.

destroyed a large number of houses and buildings in Mosul and in the Sanjaq region. The shock was severe in other parts of Iraq and in Azerbaijan. The extent of the area over which this earthquake caused damage suggests a relatively large event with an epicentre somewhere between Mosul and Gülanber. *Başbakanlık Archives* (MD 36/250); Sa'igh (1923); Longrigg (1925).

**1648 March 31; Van-Hayotsdzor**

This is a relatively well-documented damaging earthquake in the region of Van (Fig. 5). To the north of the Hoşap river the densely-inhabited region of Van was almost totally destroyed: the Armenian monasteries and cloisters of Aleruvanqer, Ardjakuvanq, Berdak, Kendenanits, Krnkuvanq, Kurubash, Noragivt, Salnapativanq, Srquvank, Susans and Varang were either destroyed or damaged so badly that they had to be rebuilt or abandoned. The town of Van was also damaged; the walls of the lower citadel from the Tabriz gate to the Haniburts quarter (?) collapsed, together with houses and a number of churches in the town and immediate vicinity. The shock caused twelve springs of water in Avants to dry up, and at Noragivt triggered a landslide that carried away and destroyed the village and nearby cloister.

Damage was equally heavy and more extensive to the south of the Hoşap river in the less densely populated valley of Hayotsdzor: here, all the cloisters were ruined and the monastery of Hegavanq was destroyed. At Ab-i Ghnerliarn, near Hogeatsvanq, landslides dammed the stream and caused the abandonment of a number of water mills; rockfalls killed a number of people in this region. At Hermerugivt the ground was deformed and slumped in places creating ponds, while at Eghnaberd and lower Pagah springs dried up causing six water mills to be abandoned and

the inhabitants to remove to Karsik. Damage was reported from as far as Ardzgue, from the district of Shatak, from Mehmedik, and probably from Seynis and Satmanis.

The shock was felt strongly in Tabriz and it was perceptible in other parts of Armenia. Aftershocks continued for about three months. Thierry (1972); Ambraseys & Melville (1982).

**1666 September 22; north of Mosul**

News of the disaster was reported from Aleppo where the shock was apparently felt, and was published with variations in a number of European news-sheets. In Mosul and its surroundings the shock was particularly strong and "threatened to reduce Nineveh to a heap of rubble". Many houses were destroyed in Mosul and also, allegedly, the cathedral that housed the tomb of Nebi Yunus (St Jonah). Monasteries to the north of the town were ruined, including that of Raban Hormiz: an inscription refers to the reconstruction of its north walls after the earthquake. In addition, five towns and 45 villages, the names of which are not given, were totally destroyed, and damage extended to Sinjar and Sharqat. It is said that as a result of the earthquake "four great mountains were raised up from the ground and thrust against each other, reducing themselves into dust", an allusion, perhaps, to landslides. Destructive shocks continued for several days. It appears that the earthquake was felt strongly in Van and Tabriz. However, because of dating problems, it is not certain whether this was the effect of the earthquake of 1666 September or of the larger earthquake of 1666 November 14 that affected the region between Erzincan and Van. Although the size of the epicentral area of the Mosul earthquake is not yet clear, the relatively large number of villages destroyed in such a

sparsely-populated region, and the great distance at which the shock was felt, are facts that imply a relatively large magnitude event. *Theatrum Europeum* (1617–1721, x.i.445); Hammer (1827–1835, vi.190); Fiey (1965).

#### **1670 August 1; Hizan**

We know that in 1670 the region between Hizan and Siirt, SW of Lake Van, was ruined by an earthquake as a result of which a number of people abandoned their villages. Armenian colophons refer to this event, which was felt in Van, in the district of Taron, and throughout Vaspurakan, causing great concern but no damage except to the east of Lake Van where a part of the Varag mountain fell into the valley blocking the river flow. These notes record other strong shocks that followed on August 2, 9 and 18, but give no details. Riggs (1909); Conybeare (1913); Hakobyan (1951–1956).

#### **1685, November 22; Gönek**

This earthquake was experienced by a European traveller and it is reported in Armenian notices. The shock occurred a little before midnight and caused severe damage to villages about 50 km SW of Erzurum, where the ground was also deformed. In Erzurum, successive shocks were felt for 15 min and aftershocks, described as violent, continued for 8 days. There is no evidence that the earthquake caused any damage to the north or east of Erzurum, but it was violent to the south, and particularly in Van. The location of the epicentral area is not known but it must have been somewhere along the Erzurum–Diyarbakir road, 8–10 leagues (i.e. 50 km) from Erzurum, past the Gönekale pass in the Sushar district, that is somewhere between Bingöl and Karliova. Avril (1692); Riggs (1909); Hakobyan (1951–1956).

#### **1705 January 27; Bitlis**

This was a destructive earthquake in the district of Baghesh that caused great loss of life. Details are lacking, but the available information implies severe localised destruction near Bitlis. Damage extended to the monastery of Surp Karapet, northwest of Muş, where many buildings collapsed. The shock, which was violent in Van, was preceded and followed by strong shocks felt throughout the district of Vaspurakan. Oskean (1953); Hakobyan (1951–1956); Thierry (1983).

#### **1715 March 8; Van**

A severe earthquake occurred at dawn in the region of Mahmatan, SE of Van. It destroyed villages in the Mehmedik plain, killing a considerable number of people. At Hoşap the walls of the fort were ruined and at Satmanis there was damage but no casualties. The earthquake caused the collapse of the dome of the church of St. Bartholomeus at Deir and the ruin of the fort at Sarai. In Van the shock caused some damage and few casualties, while in Ercis, on the north shore of Lake Van, the dome of the church collapsed causing casualties and there was other damage.

Apparently the earthquake caused widespread damage to public buildings, religious monuments, bridges and private property, that took a long time to repair. Thierry (1969); Ambraseys & Melville (1982).

#### **1789 May 29; Palu**

This earthquake seems to have been a catastrophic event that affected the region of Palu, just south of that devastated by the North Anatolian earthquake of 1784 July 18. The only primary source of information for this event is an official dispatch received in Istanbul from the district of Palu informing the authorities that an earthquake had completely destroyed a tract of land “21 hours of march long and 21 hours of march wide”—that is an area of a radius of about 75 km—within which 51 000 people were killed. This event is also registered in the almanac (*takvim*) for 1203 AH, and dated 4 Ramadan. A less precisely dated primary source is an Armenian marginal note written at Divrigi late in the 18th Century, which says that there was an earthquake in Tivrik and Malatya in 1229 AA that destroyed many places and killed a large number of people. Since there is no other note of an earthquake in 1239 AA, the year given for the event in the Armenian source may be in error by exactly 10 years.

Although details about this earthquake are lacking, it is clear that it was a major event in the Border Zone. Travellers in the decades following the event noticed the ruinous state of the district, and particularly of Palu, which they attribute to the constant earthquakes in the region. Also, Armenian sources refer to a destructive earthquake in the region which was felt at Erzurum, but this may be an altogether separate event. Kinneir (1818); Incicean (1822); Stepanian (1942).

#### **1796 April 26; Lattakiya**

A destructive earthquake in the Sahel district of Lattakiya on the Syrian littoral. The shock occurred in the morning and lasted for about 1 min, almost totally ruining the coastal plain between Jeble and Bucak. Most of the houses collapsed in Jeble, and water wells caved in and became dry. Most of the *miri* villages—those belonging to the Ottoman state—in the Nahr al-Kebir plain, an area about 40 km long and 15 km wide, were ruined. In Lattakiya, 1500 out of a population of 5000 were killed; one-third of the town collapsed and the remainder was damaged. The old castle, minarets, watchtowers and large buildings fell down. In the port area the tobacco customs-house, one of the most solidly-built structures, fell in and killed 400 people. It is said that the shock raised the surface of the ground several *toises*, but this may be an exaggeration. The earthquake had no effect on the sea, which remained calm, but it did cause the temporary drying-up of streams NE of Lattakiya, probably due to landslides. We do not know how far inland the shock was felt, but we do know that it was strongly felt at Saida, 230 km away to the south. Aftershocks continued to be felt for two months, preventing people from returning to their villages. *Consular Archives*; Olivier (1807); Cevdet (1309/1893, vi.222).



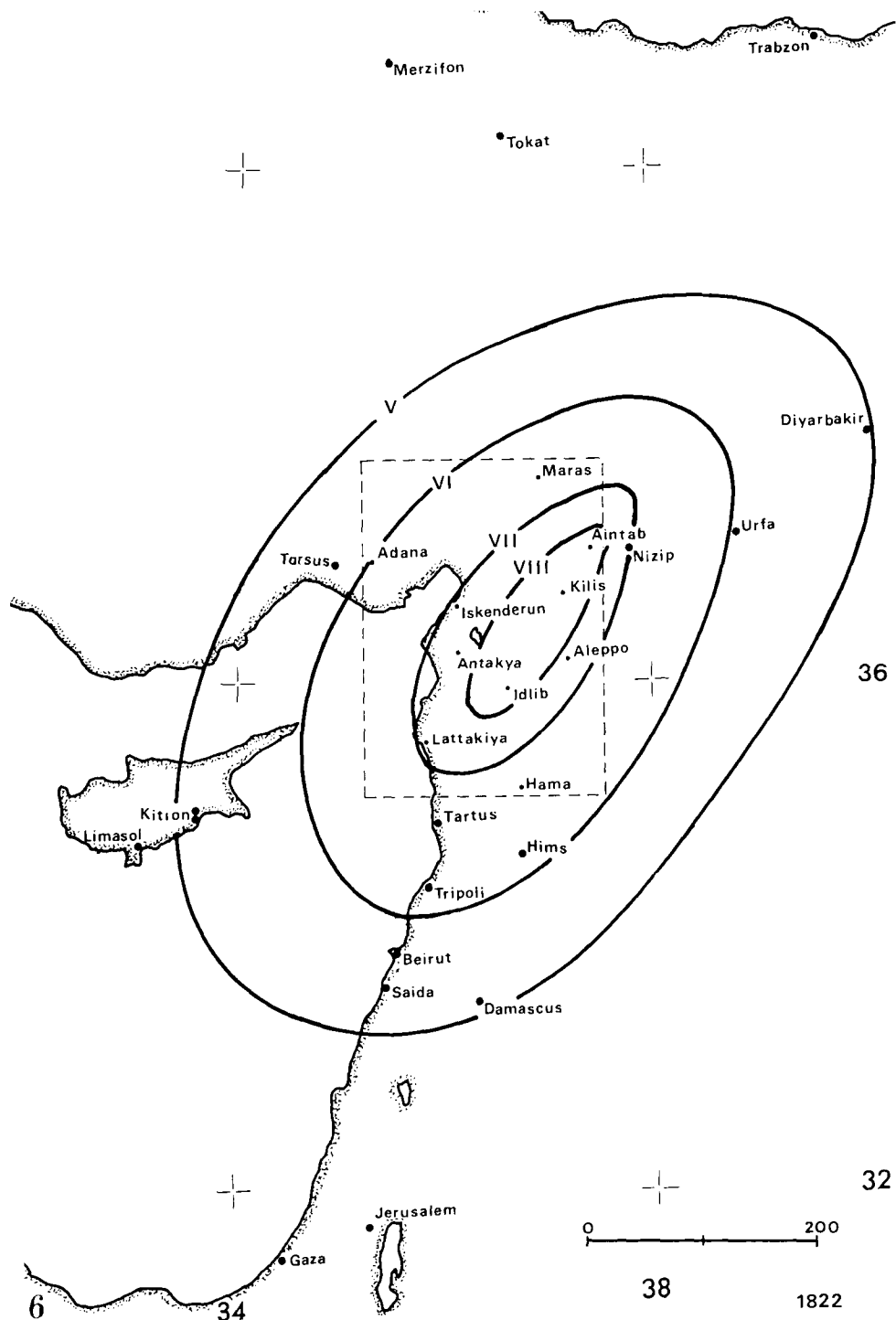


Figure 6. Felt area of the Aafrine earthquake of 1822. Lower isoseismals are approximate. Inset shows area in Fig. 7. Compare with Sieberg (1932, 195).

**1822 August 13; Aafrine**

This earthquake was the largest in the Border Zone in the last five centuries and will therefore be described here in some detail. The earthquake was felt from the coast of the Black Sea to Gaza (Fig. 6) and it was followed by an aftershock sequence that lasted almost 2½ yr. The shock almost entirely destroyed the region between Gaziantep and

Antakya in Turkey and Aleppo and Han Sheikhun in NW Syria, killing a very large number of people.

Slight shocks, reported mainly from Aleppo and Antakya, began on August 5 and continued intermittently until August 12, but since they were like many others which had been experienced in the past, they caused no alarm to the inhabitants. At 8 h 10 m pm on August 13 a strong shock was felt in the region between Lattakiya, Aleppo and

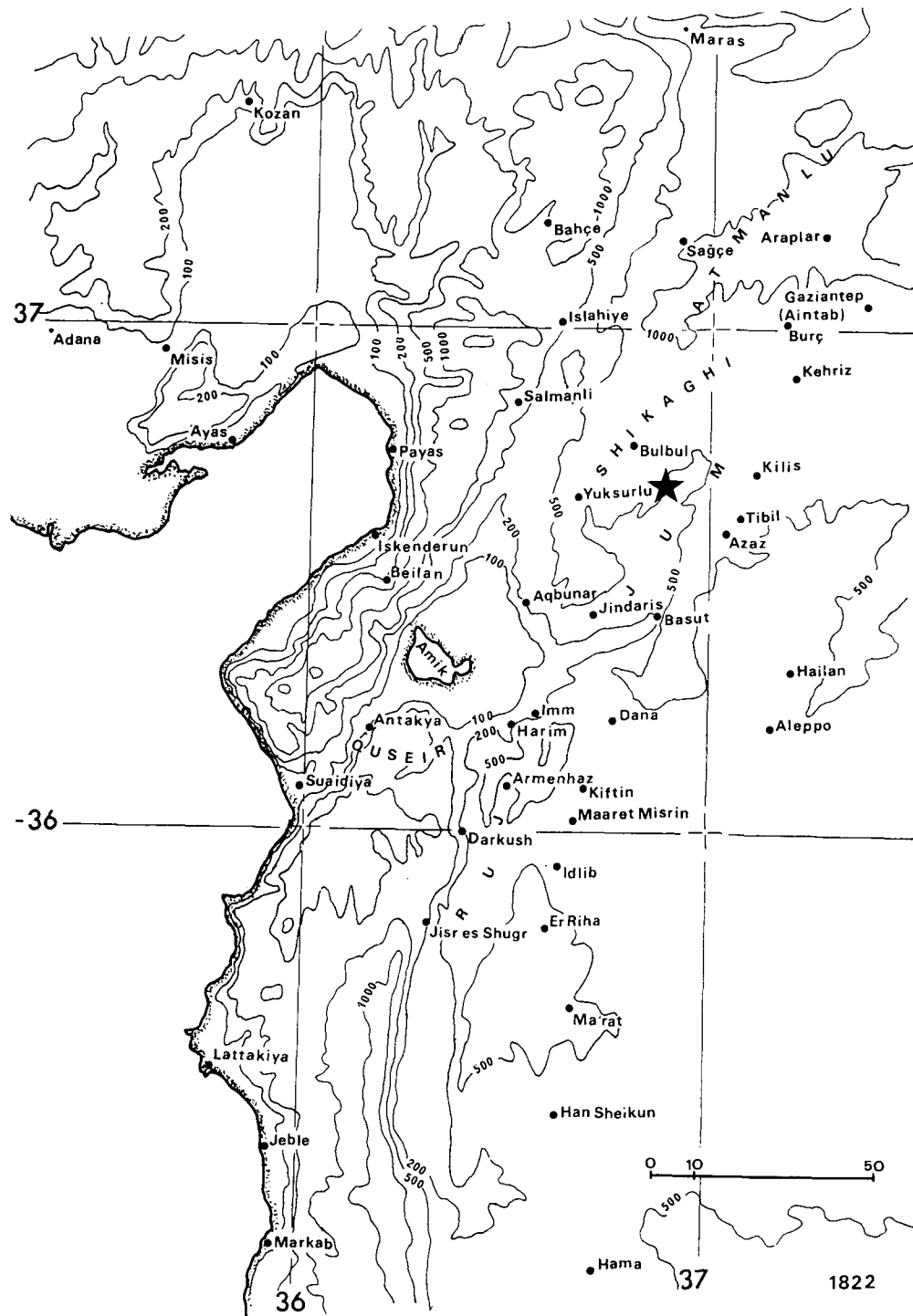


Figure 7. Epicentral area of the Aafriine earthquake of 1822. Contours in metres. Star shows location of adopted epicentre.

Antakya: this caused considerable concern and warned the people of what was to follow. The main shock happened 30 min later in three phases lasting altogether 40 s. A flash of light was seen in the sky over Aleppo, Antakya, Suaidiya and Iskenderun. After a short pause, the main shock was followed for about 8 min by successive shocks, about 30 in all, each of short duration but of damaging intensity; in Aleppo, Antakya and Aintab these were as strong as the

main shock and completed the destruction and caused the bulk of the loss of life.

The most northerly part of the area destroyed was that of Gaziantep and Atmanlu (Fig. 7). The chief town of Aintab was almost completely destroyed: most houses collapsed and the remainder were rendered uninhabitable; mosques, *medreses*, the old castle—already in ruins—part of the old aqueduct and the surrounding villages were destroyed with

great loss of life. The villages of Sağçe, Araplar, Burc and Kehriz were destroyed and many people and animals were killed. Survivors sheltered in tents and huts outside the villages for a long time after the earthquake.

Damage was equally heavy in the districts of Shikaghi and particularly of Jum and in the settlements along the Aafrine river, where it is said that the flow of water in streams was reversed for some time before they dried up, while elsewhere the flow of stream water temporarily increased. The ground opened up for some distance as a result of the earthquake; the Orontes river overflowed its banks destroying bridges and embankments so that cultivated land was flooded, and the river altered its course permanently. The exact location of these changes is not known, but may have been where the routes from Antakya and Lattakiya to Aleppo cross the Orontes, that is between Hadid and Jisr as-Shugr, rather than further north. The small town of Kilis was destroyed with loss of life—it is said that there existed an inscription on the Çekmeceli Cami in the town that commemorated the event.

Harim and Armenhaz, further to the south, were totally destroyed, and Darkush was ruined partly by the shock and partly by landslides that carried away part of the village. Near here, at an unknown locality, a landslide temporarily blocked the Orontes river in the valley to the north towards Hadid. South of Darkush narrow gorges of the Orontes collapsed and the village of Jisr as-Shugr was entirely destroyed with loss of life. Individual farmhouses and small settlements in the area of Jur were razed to the ground.

Han Sheikhun, Er Riha, Idlib and particularly Maarat were almost completely ruined but the loss of life was not great. Houses collapsed in these places but large buildings, although shattered, were left standing, except in Maarat where they were brought down by aftershocks which also crevassed the banks of the Orontes. It is said that damage extended to Hama and that the town suffered as much as Aleppo.

Aleppo, a city built almost entirely of stone, and with about 40 000 houses containing a population of about 200 000 including the suburbs, was ruined. Statistics for earthquake casualties are generally reckoned to be grossly exaggerated; however, the best estimate of casualties in Aleppo is that made by European consuls sometime after the event, who reckon that 7000 people were killed within the walls of the city (the gates of which were shut for the night at the time of the earthquake), and about 200 in the extramural part of Aleppo where most people were able to escape into the gardens. The shock, and its many destructive aftershocks in the ensuing 10 min, killed 5300 Arabs and Turks, including Sheikh Abdallah ar-Razah, a religious leader of Aleppo. The Jews suffered most, as their quarters were badly built and with very narrow lanes between the houses; out of a total of about 3000, 600 were killed, mainly women and children. The Armenian community lost about 1400 and the very much smaller European community lost 13 including the Grand Dragoman and the Austrian consul who was killed in the street by an aftershock occurring a few minutes after the main shock. Indeed, most of those killed within the walls of the city perished in the narrow lanes trying to escape during this aftershock period. The walls of the citadel were ruined but the 18 m high watchtower and the nearby 86 m deep draw-well were not affected. Many

hans and souks, including that of the perfume-makers, were ruined. The al-Fanig gate collapsed and the Hanaqa al-qadim was damaged. The houses of all the Europeans, both public agents and private individuals, were entirely destroyed, as well as all Christian convents and other buildings. The large building that had been the British consulate for 230 yr was ruined, although not entirely fallen in. In general, the upper part of the city of Aleppo and the European sector suffered less than the rest, but damage was so widespread that most European merchants removed to Cyprus after the earthquake.

It is said that before the earthquake the temperature of well water had perceptibly increased and that after the earthquake the flow of the Quwayq river was arrested for many hours near Hailan, where there was much damage.

The town of Antakya and its surrounding villages were ruined. The town was evacuated and its inhabitants camped in the open fields for a long time. Many small settlements in the upper and lower Quseir area were razed to the ground. The shock did not cause any extensive ground ruptures near Antakya, although crevasses were to be seen in the low ground near the town and in the Amik valley. Water issued out of many of these, but soon subsided, clear indication of the liquefaction of the ground.

Beilan was heavily damaged, presumably without casualties, but some of its more substantial buildings were almost totally destroyed. At Iskenderun the shock was strong enough to destroy a number of houses and to cause extensive liquefaction along the coast and in the plain at the foot of the Gavur mountain where areas of cultivated land turned into marshes, the ground water rising permanently to well above ground level and inundating a number of settlements. At Payas damage was more serious—some houses near the old port sunk into the ground but most of the people escaped unhurt.

Damage along the Syrian coast was also serious. One-third of Lattakiya was again destroyed and one-third damaged. Not a single warehouse in the harbour area was considered to have escaped; the convent and the French consulate were damaged and 48 people were killed and 20 injured. The town was completely evacuated. In the Marina, about 15 km from the town, the ruined fort, the mosque and the large han rebuilt after the 1796 earthquake collapsed and houses and stores were considerably damaged. Jeble was more heavily damaged and people were killed. The great mosque that housed the tomb of Sufi Ibrahim b. Adham collapsed. Damage was also reported from Markab where, among other buildings, the castle of the Crusaders on the mountain partly collapsed.

Damage extended to the region of Adana and Misis where villages along the road to Antakya were ruined. It is not known whether this was due to the severe shaking or to the widespread liquefaction of the ground which was reported from the low-lying plain of the Ceyhan river. Kozan, Maraş and Nizip also seem to have been affected, although contemporary reports seem to exaggerate the effects of the 1822 earthquake which they confound with that of 1811, a much smaller event which caused considerable damage to these towns.

Further away, the shock was strongly felt in Tarsus. At Homs it caused unspecified damage while in Tripoli and its dependencies it was violent and caused damage in places.

The earthquake was reported from Beirut and Sidon, and from Damascus where people spent the night camping in the open spaces and outside the city which is said to have suffered slightly. In Jerusalem and Gaza to the south, and in Trabzon, Tokat and Merzifon to the north, the shock was strongly felt; it was not, however, reported in Alexandria, contrary to later statements that confuse this place with Alexandretta (Iskenderun). The earthquake was felt throughout the island of Cyprus, particularly at Kition and Larnaca where it caused some concern, but it was not so strong at Limassol. Northeast of Aleppo, at Urfa and along the Euphrates, there is some evidence that both the main shock and the aftershocks of 1822 August 15 and 1823 June 30 were felt and caused some damage. Contemporary reports also suggest damage at Diyarbakir and add that the earthquake was perceptible throughout Mesopotamia (Jazira).

The main shock was felt by ships sailing between Cyprus and Lattakiya and halfway between Alexandria and Cyprus. There is no evidence that this event was associated with a seismic sea-wave in the eastern Mediterranean or with an abnormal fluctuation of sea-level. Destructive aftershocks occurred in 1822 August 15 and 23, September 5 and 29, October 18 and 1823 June 30, the sequence terminating in 1824 March.

The total number of people killed in this earthquake is impossible to determine. Contemporary estimates vary between 30 000 and 60 000, while more sober estimates put the total at 20 000 dead and as many injured. Internal evidence does suggest, however, that the destruction and loss of life may have been very great. For example, although the number of people killed in the Gaziantep region is not known, the fact that the authorities issued instructions after the earthquake to regulate the handling of inheritance cases that arose in the district is itself an indication of the gravity of the situation. A further indication is that Gaziantep, Aleppo and other affected districts were relieved from the obligation to provide supplies for the Ottoman troops in the area, the plea for assistance from the Ottoman Porte being met with the rejoinder that there was "no other solution than enduring God's decree". It is said that the loss of life amongst the Armenian population in Aintab, one-third of the total, was so great that there were no priests left to officiate at burials and that the property left by those killed without surviving relatives to inherit, and which passed to the state, was very great. At Kilis it is said that the loss of life was so great that there were too few people to pick the olive harvest that year.

The serious damage caused to the city of Aleppo had social implications. Many left and settled elsewhere, while business life was so much affected that the French consul requested permission from Paris to remove his office to Beirut; he was only one of the Europeans who never returned to Aleppo after the earthquake. Some built timber-framed houses outside the walls on a site that eventually became the al-Kattab suburb, and where permission was also given for a church to be built. The extent of damage to that part of the city outside the walls is reflected in the fact that the moat was soon filled with the rubble from the houses thrown down in the earthquake. One of the reasons for the decline of Aleppo as a commercial centre in the early 1800s was the earthquake of

1822 and its long and damaging aftershock sequence. For many years after the earthquake only a few huts were to be seen on the ruins of villages further south, along the Orontes river at Darkush and Jisr as-Shugr.

Much of the news about the earthquake originated shortly after the event from consular correspondence and letters from missionaries published in the European press. Communications with the stricken area were made difficult not only by the civil war raging at the time but also by the restrictions imposed on movements as a result of the cholera epidemic that spread into the region from Mesopotamia. To make matters even worse, Bedouin descended on Aleppo and the east bank of the Orontes from the Syrian desert and plundered the ruins. Marauding tribesmen and renegade soldiers made the countryside unsafe for a number of years after the earthquake.

News of the disaster reached the Ottoman Porte on August 28, but was kept from the public during the festivities of the Feast of the Sacrifice. Except for the temporary relief from taxation mentioned above, no evidence has yet been found that the affected areas received any outside assistance. The Levant Company raised subscriptions in London for the sufferers, but only a small part of this was spent since the Porte did not, on this occasion, permit its subjects to be relieved by a foreign nation.

The importance of the earthquake of 1822 lies not only in the fact that it was one of the largest shocks in the Eastern Mediterranean region, but mainly that it occurred in an area that has been totally quiescent during this century. *Consular Archives; Press Reports; Güzelbey & Yetkin (1970).*

#### **1866 June 20; Kulp**

The facts about the earthquake of 1866 June 20 in the district of Kulp are imperfectly known. News of an earthquake felt in Erzurum on May 12 that caused damage somewhere in the district was reported by the Russian consul and carried by the press without much detail. Sometime later the press reported another violent earthquake in Erzincan, Varto and Kiğı that caused damage in Muş and was felt in Erzurum too. Apparently, the destruction caused by this second shock was serious enough for the Erzurum authorities to dispatch a relief mission into the stricken area, which is not mentioned by name. Later reports from Diyarbakir, however, identify part of the region affected, which they say was between the rivers Tigris and Euphrates, not far from the town. The size of the area destroyed, and within which the ground opened up extensively, is given by different sources as either of a radius or of a circumference of 30 leagues (145 km).

Additional published and unpublished information retrieved recently shows that the first shock, felt in Erzurum on May 12 (but which is usually confounded with that of June 20), was a relatively small earthquake that originated, in fact, from the northern part of Çaldıran, to the east of Erzurum, where it caused serious but localised damage (Figs 8 and 9).

The second and much larger earthquake of June 20 affected the remote districts of Sasun, Çapakçur, and particularly Kulp where it seems to have caused great loss of life. It is said that many, mainly Kurdish villages, perched

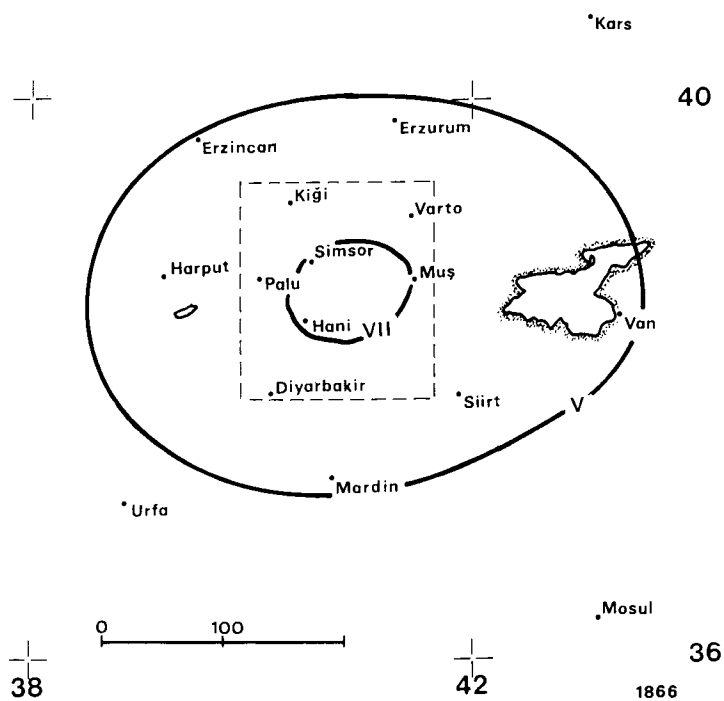


Figure 8. Felt area of the Kulp earthquake of 1866. Inset shows region in Fig. 9.

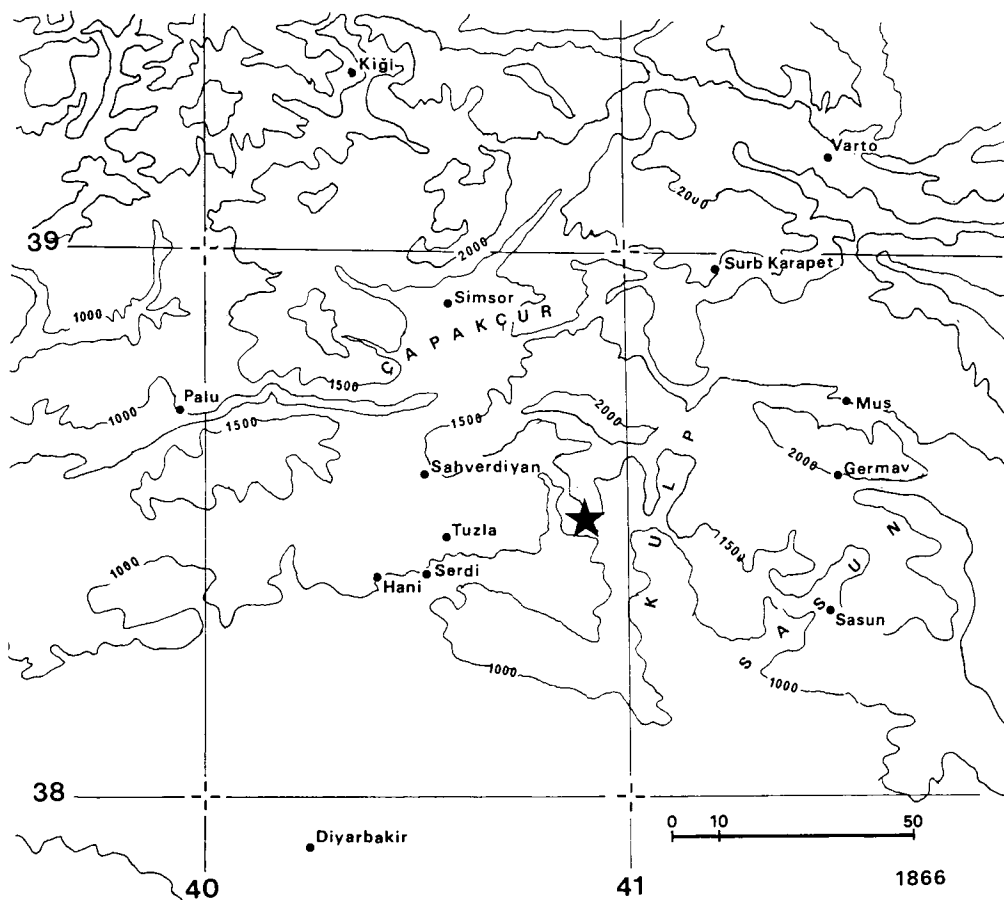
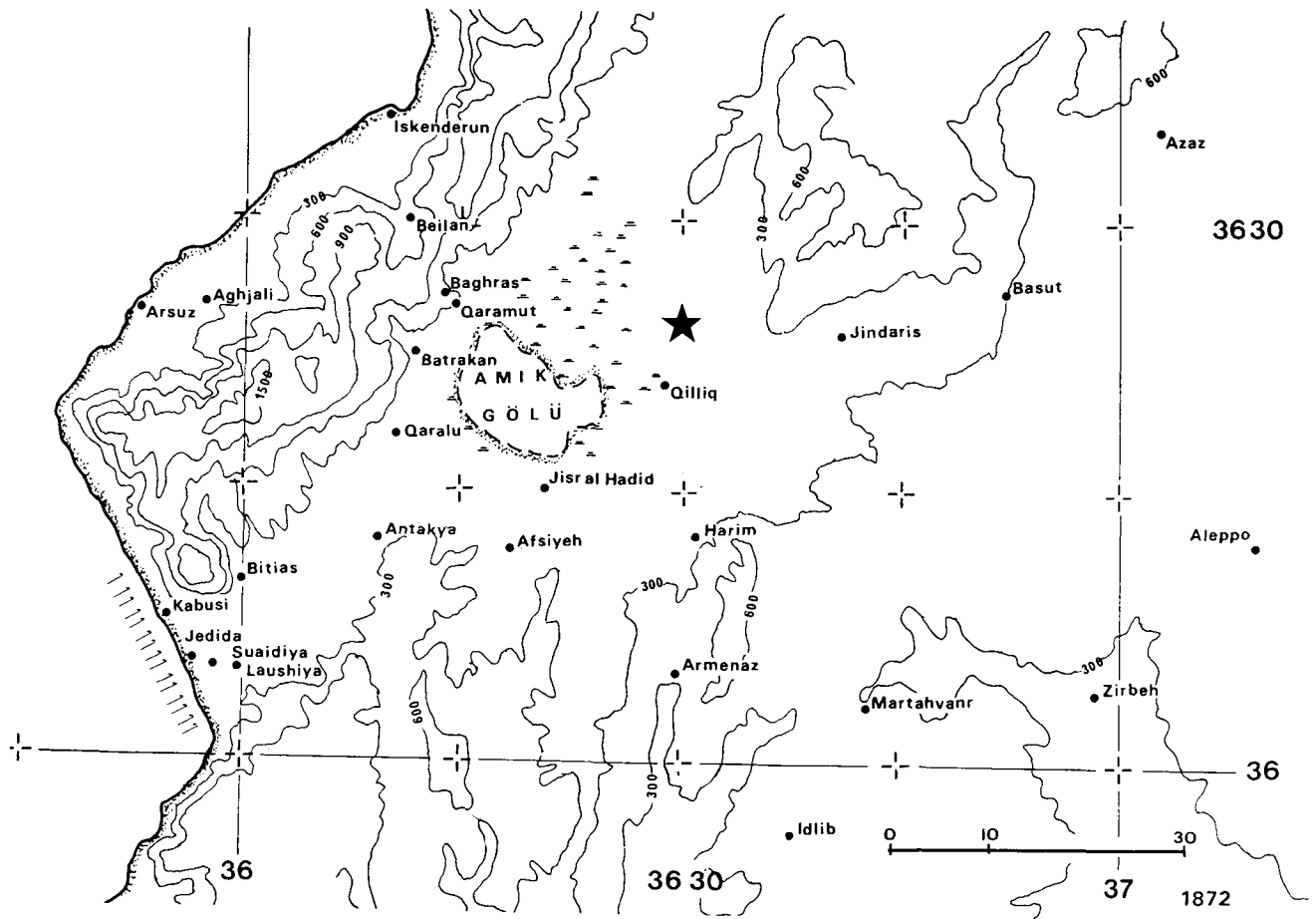


Figure 9. Epicentral area of the Kulp earthquake of 1866. Star shows approximate location of adopted epicentre.



**Figure 11.** Epicentral area of the earthquake of Amik Gölü of 1872. Star shows approximate location of macroseismic epicentre and arrows show coastal area subjected to flooding by sea-waves.

killing four members of the community. The East and North gates (of Bab Bulus) were thrown down and part of the citadel walls collapsed. The old Roman bridge of four arches was breached in several places and all manor houses, including that of the Scotsman Yate, were destroyed. By contrast with the lower part of the town, the upper part suffered less severely.

Thirty-eight villages between Suaidiya and Beilan were totally destroyed. 2150 houses were destroyed in Suaidiya, and more than 300 people killed or seriously injured. The nearby villages of Kabusi, Jedida and Laushiya were razed to the ground with loss of life. The sea rose after the earthquake, allegedly to a great height, flooding the coast. Qaramut and its district were completely destroyed. In the town itself there were 170 dead and 187 wounded; in addition to shops and public buildings, 3552 houses were razed to the ground. Heavy damage extended to the east of Amik Gölü. Qilliç was totally ruined with the loss of 300 lives, and neighbouring villages suffered similarly. Here, it is said, the earthquake split the ground in places and yellow sand filled the area, a description suggesting widespread liquefaction. Also, between Batrakan and Qaralu, the valley to the east of the hills is said to have dropped as a result of the earthquake and the ground was 'rent' all the way to Baghras, an allusion to faulting. Damage was very heavy and there was great loss of life to the north and south of

Qilliç, particularly in the region of Harim and Armenhaz, but details are lacking.

In Aleppo, 90 km from Antakya, the shock lasted 72 s and caused great panic. About 100 houses were badly damaged or collapsed, killing seven and injuring three people. Part of the citadel fell down and water sloshed out of cisterns. The absence of serious damage was attributed to the solidity of the stone masonry houses of Aleppo, rather than to the feebleness of the shock. Damage extended to Azaz, Basut, Zirbeh and Idlib as well as to settlements along the Mediterranean coast such as Arsuz and Iskenderun.

Damage must have been far more serious than our sources of information, which originate in the larger population centres, suggest. Many rural areas never reported their damage and others did so many months after the earthquake. Following the earthquake the Ansayri tribes descended from the mountains and plundered ruined villages, as result of which the Ottoman authorities marched a battalion of infantry to Antakya, thus rendering communications between this town and the hinterland more difficult until the end of the year. Damage to the south of Afsiyeh became known many months after the earthquake, as did damage to bridges and hans. The Orontes bridge at Jisr al-Hadid, a 12th Century, 120 m long structure with four arches, was damaged and its defence towers were thrown down.

The shock was very strongly felt at Adana, Aintab, Birecik, Hama, Homs and Tripoli, where it caused considerable concern. It was reported from Rhodes, Konya, Diyarbakir, Beirut and Damascus, and it was felt in every part of the districts of Karaman and Syria. The earthquake was not felt in Egypt as alleged by modern writers, who, as with the 1822 earthquake, confuse Alexandria with Alexandretta (Iskenderun). Aftershocks continued to be felt with decreasing severity throughout April and May, but did not cease altogether until 1873 February. *Consular Archives; Press Reports.*

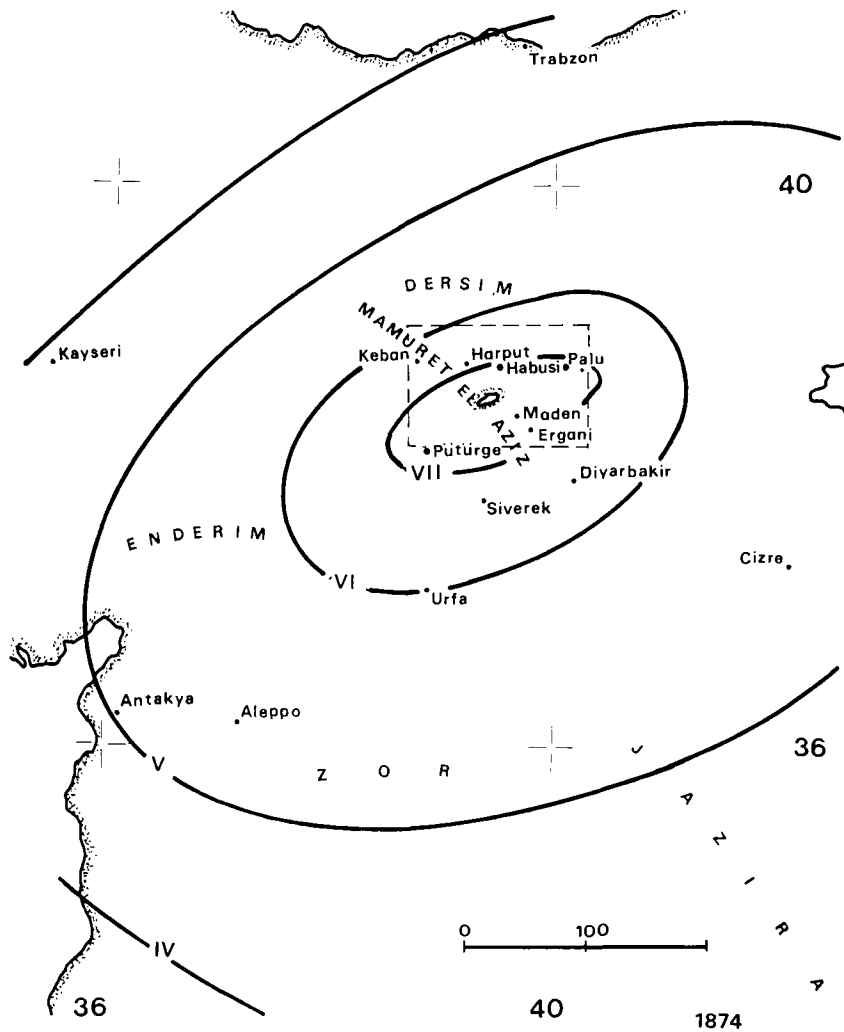
**1874 May 3; Gölcük Gölü (I)**

The first news, without much detail, of a destructive earthquake in the district of Mamuret ul-Aziz, was telegraphed from Diyarbakir to the Imperial Observatory in Istanbul and to the Ottoman and foreign language newspapers in Istanbul and Izmir. In the days that followed, more information was sent to the Observatory from widely-spaced parts of the country where the shock was felt, but no details were given about the effects of the shock in the epicentral area. A letter dated 1874 August from A.

Coumbary, the director of the Observatory, to his colleague J. Schmidt of the Athens Observatory says that the large area over which the shock was felt suggested to him that the disaster must have been very serious, and that he feared that the end had not yet come. Coumbary's fears were confirmed much later by letters from missionaries resident at the American station in Harput and by consular and official correspondence, including the report of the Prussian engineer in charge of the mines at Maden. These sources confirm the occurrence of a large magnitude earthquake in the East Anatolian Fault zone, associated with intense aftershock activity. A field trip to the region late in 1967 added absolutely nothing of value regarding these events, except that it confirmed their association with an active segment of the East Anatolian Fault zone between Palu and Pütürge.

The first shock occurred on 1874 January 14 and entirely destroyed Sarikamiş and a good many houses in nearby villages were thrown down; the Armenian villages of Tenik, Norgek, Güliskir and Haraba were particularly affected. It is not known whether the shock caused casualties but it was strongly felt in Diyarbakir, 90 km from Sarikamiş (Fig. 12).

Another shock, originating from the same region,



**Figure 12.** Felt area of the Gölcük Gölü (mod. Hazar Gölü) earthquake of 1874. Inset shows epicentral area in Fig. 13. Lower isoseismal approximate. Use same figure for location of places affected by the earthquake of 1875 March 27.

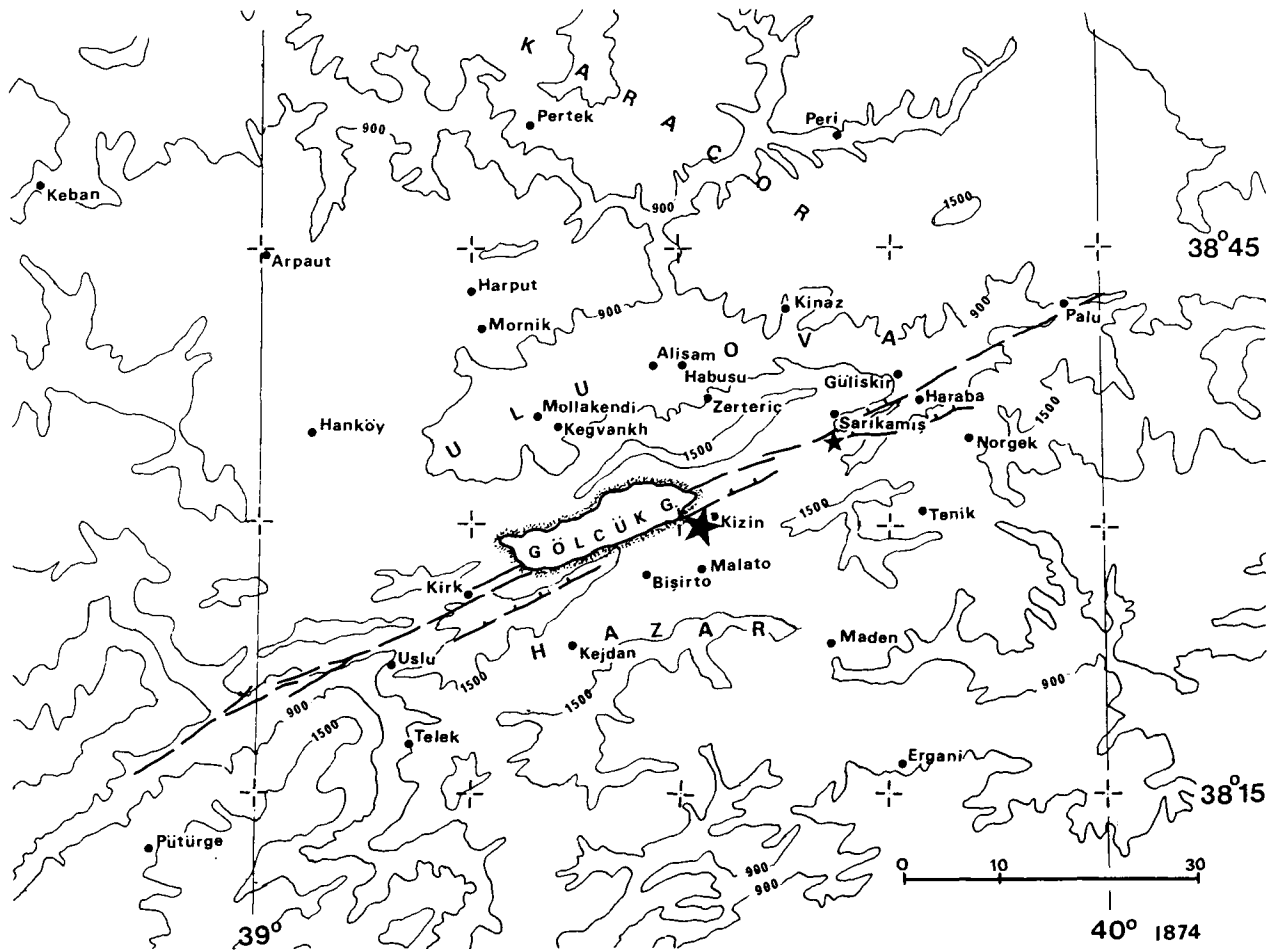


Figure 13. Epicentral region of the Gölcük Gölü earthquake of 1874. Dashed lines show approximate location of East Anatolian fault in the epicentral region. Large star indicates adopted location of epicentre and small star shows epicentre of foreshock of 1874 January 14.

occurred on April 29 at 12 h 45 m (pm?). It seems that it caused serious damage which, however, our sources do not differentiate from that caused by the earlier shock in January. The earthquake was strongly felt at Keban-maden and in Diyarbakir, where it caused no damage.

The main shock occurred on May 3 at 07 h in the morning. It lasted about one minute and totally destroyed most villages in the districts of Hazar and Ulu Ova, on either side of Lake Gölcük (Fig. 13). It is said that in the sparsely-inhabited and mountainous region of Hazar almost all the Armenian villages from Telek to Tenik were wiped out with loss of life, and that the mountain pass at Kizin and near Burnus Han—leading to Maden—was blocked by slides. The small settlements of Malato, Bisirto and Kejdán were destroyed. As a result of the earthquake the south side of Lake Gölcük was uplifted by a metre or two. The report of the director of the copper mines at Maden says that the valley at the southeast end of Gölcük, near Kizin and Burnus Han, through which the lake emptied itself by a stream running into the Tigris river, was upheaved. As a result of this, the stream ceased to flow and the lake began to rise steadily. Roads and tracks that ran along its shore were submerged, and villages on its margins were swamped and had to be abandoned. By the end of the year the water had almost reached the level of the uplifted valley. Press reports add that the ground split in two villages and for 3 h

red water appeared like mud. The location of these two sites is not mentioned, but it is likely that the reports refer to the more frequented valley southeast of Sarikamiş, rather than the south shore of Lake Gölcük where the valley was 'rent' all the way to Haraba. These accounts clearly imply that the earthquake was associated with faulting in which the region southeast of Lake Gölcük was uplifted by 1–2 m along a length of at least 45 km, and also that the shock caused liquefaction in places.

As a result of the earthquake the road that runs for some kilometres along the narrow gorge southeast of Kizin, following the Tigris valley to Maden, was blocked by slides and in places became impassable. At Maden several buildings belonging to the copper mines and a number of houses were demolished and the whole population of about 3000 fled outside the town and camped in tents. The extent of the damage to the mines is not known, but the fact that after the earthquake a small number of miners abandoned their concessions and returned to their homes on the Black Sea may be interpreted to mean that the mine works suffered some damage, although this is not mentioned in the engineer's report. Further south, at Ergani, the shock was strongly felt and caused some damage to the old town on the other side of the valley, presumably from rocks falling from the cliffs of the ravine.

Damage to the north of Lake Gölcük was equally serious.



particularly in the Ulu Ova (Fig. 13). The large village of Habusu, with a population of 2500 (and which is today submerged by the impounding of the Keban dam), was reduced to a heap of ruins with not more than a few houses left standing. The same happened to the villages of Alisam, Zerteriç and Mornik where many houses collapsed with heavy casualties. Damage was also severe in the region between Hanköy, Kegvanli and Uslu, where people and animals were killed; here the duration of the shaking was 20 s. Damage extended to Harput where some of the larger buildings and a number of houses suffered, part of the prison collapsed and the walls of the military hospital were rent. There was no serious damage to better-built houses, but some of the older dwellings in the lower part of the town were ruined and a few of them collapsed during the aftershock period, without casualties. In contrast, further north in the Karacor district, notably between Pertek and Peri, the shock caused more damage than in Harput and the loss of some lives. It is not certain whether there was damage at Pütürge and Arpaut, but the shock was violent at Keban and Diyarbakir. It was reported from as far as Trabzon, Kayseri, Antakya, Aleppo, Urfa, Siverek, Cizre and from the region of Baghdad. Strong aftershocks were reported throughout the area during the following 3 days. *Press Reports; Consular Archives; Riggs (1909).*

#### 1875 March 27; Gölcük Gölü (II)

About a year later another earthquake affected almost exactly the same region as the 1874 event, but it was more damaging in the thinly-inhabited area south of Lake Gölcük as well as in the Karacor area, where villages were ruined. Unfortunately, details of the damage wrought in the Ulu Ova and in the region of Harput are totally lacking, except for the general statement that many lives were lost in the earthquake. Also, there is no information from Maden, except the interesting observation that in this earthquake the valley through which Lake Gölcük emptied into the Tigris was again uplifted, causing the Lake to rise again to a total of 4 m and threatening to overflow the old valley, an allusion to further faulting along the same segment of the East Anatolian Fault zone. Contemporary information refers only to damage to a number of villages to the south of the Lake, but gives no details. The shock was reported from the districts of Enderim and Zor. At Aleppo the British consular residence was damaged by the heavy rains and flood of March 25/26 and by the earthquake. The shock was also felt in Jerusalem where a house collapsed, but this seems to have been due to the rainstorm that affected a large part of the Eastern Mediterranean region at the time. *Press Reports; Consular Archives; Riggs (1909).*

#### 1884 February 10; Siirt

This was a widely-felt, destructive earthquake in the remote region of Birvari, south of Lake Van. Villages between Makus and Hoşhayir were totally destroyed and further west towards Siirt a number of Nestorian villages were damaged without casualties. Damage seems to have extended much further to the south, and in Mosul a number of houses were cracked. The shock was felt throughout Azerbaijan and at Sanjbulak in Iran. Information about the maximum effects of this event is lacking. *Press Reports.*

#### 1893 March 2; South of Malatya

The earthquake of 1893 March 2 was a destructive shock that affected the regions south of Malatya (Figs 14 and 15). The event was recorded clearly by primitive seismographs in Rome, Rocca di Papa, Potsdam and in Strasbourg, 2700 km away, where a Rebeur-type horizontal pendulum of 20 s period and 100 magnification registered a maximum trace amplitude of the long waves of 28 mm. The calculated origin time of the earthquake is 22 h 51 m (GMT) on March 2, that is 02 h 30 m local time on the following day.

The most seriously affected districts were those of Kubeli, Behesni, Hisn-i Mansur, Akcedağ, Karakiahta and Mirdis, an area 220 km long, and 120 km wide. In the Akcedağ district, out of 11 740 houses, 2719 were totally destroyed, 1345 became uninhabitable and 2195 were damaged. In all, 885 people were killed and 164 injured. In the mountain villages between Malatya and Pütürge, 5100 out of 7000 housing units were completely destroyed and the rest damaged; 42 bazaars, two mosques, one church and a school were destroyed, 285 people were killed and 77 injured. Further, 3260 head of sheep and 226 cattle were killed and the damage extended into Mirdis, but there are no statistics for this latter district. In the district of Hisn-i Mansur destruction was heavier and loss of life particularly great, but details are lacking. In the town of Adiyaman, with a population of about 10 000, one-third of the 3500 houses were completely ruined and one-third heavily damaged with the loss of 26 lives and 22 injured in the old town. The Armenian church and a school collapsed and the Protestant church was ruined. The district of Karakiahta suffered equally heavy damage and destruction was particularly widespread in the mountain villages, but no damage figures were returned. The three remaining 1st Century AD Doric columns of the monument of Antiochus I on Nemrud Dağ—9.5 m high with their surmounting statues and 1.7 m in diameter—were left standing. Also left upright were the free standing columns at Sesong, of the same period and dimensions. It is said that the district of Behesni was also ruined but no specific information on the damage has been found; all we know is that there was damage to Erkenek and Tut, as well as in the district of Kubeli.

In Ulu Ova, damage was widespread and eight villages near Malatya, none mentioned by name, were totally ruined with the loss of 124 lives. In Malatya, a town with a population of about 30 000, many houses were totally ruined and a few collapsed, killing about 300 people. The shock destroyed 47 mosques, three churches, nine Muslim and five Christian schools, the barracks in the town and two telegraph stations. The han, the prison and the government building were damaged beyond repair and were rebuilt after the earthquake with funds provided by the Sultan. The barracks outside the town was not so seriously damaged. Apparently there was no serious damage done to the Protestant mission, but the destruction of old houses in Eski Malatya and shanty houses in the new town was widespread, resulting in the loss of about 10 000 domestic animals. Damage extended to Urfa where a number of houses were ruined without loss of life. At Rumkale many houses collapsed and at Birecik a dozen dwellings were damaged. Some damage was also reported from Aintab and Elbistan where a few houses and the government building were

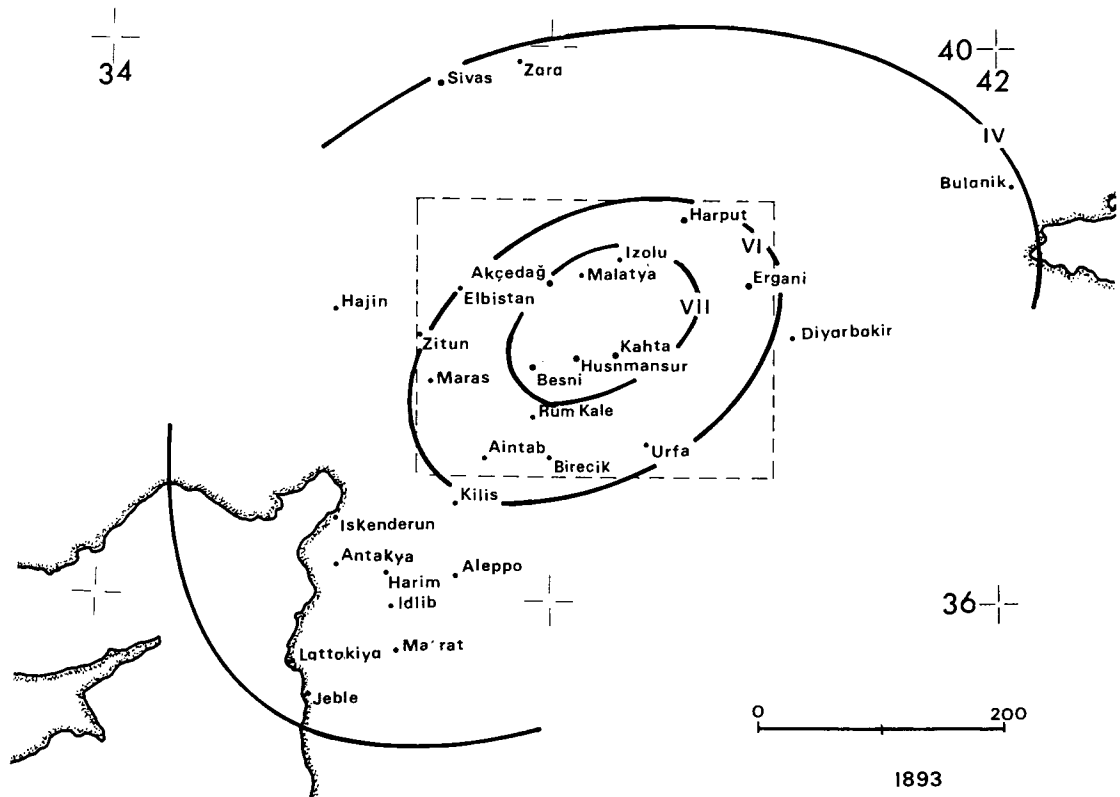


Figure 14. Felt area of the South Malatya earthquake of 1893. Inset shows area in Fig. 15.

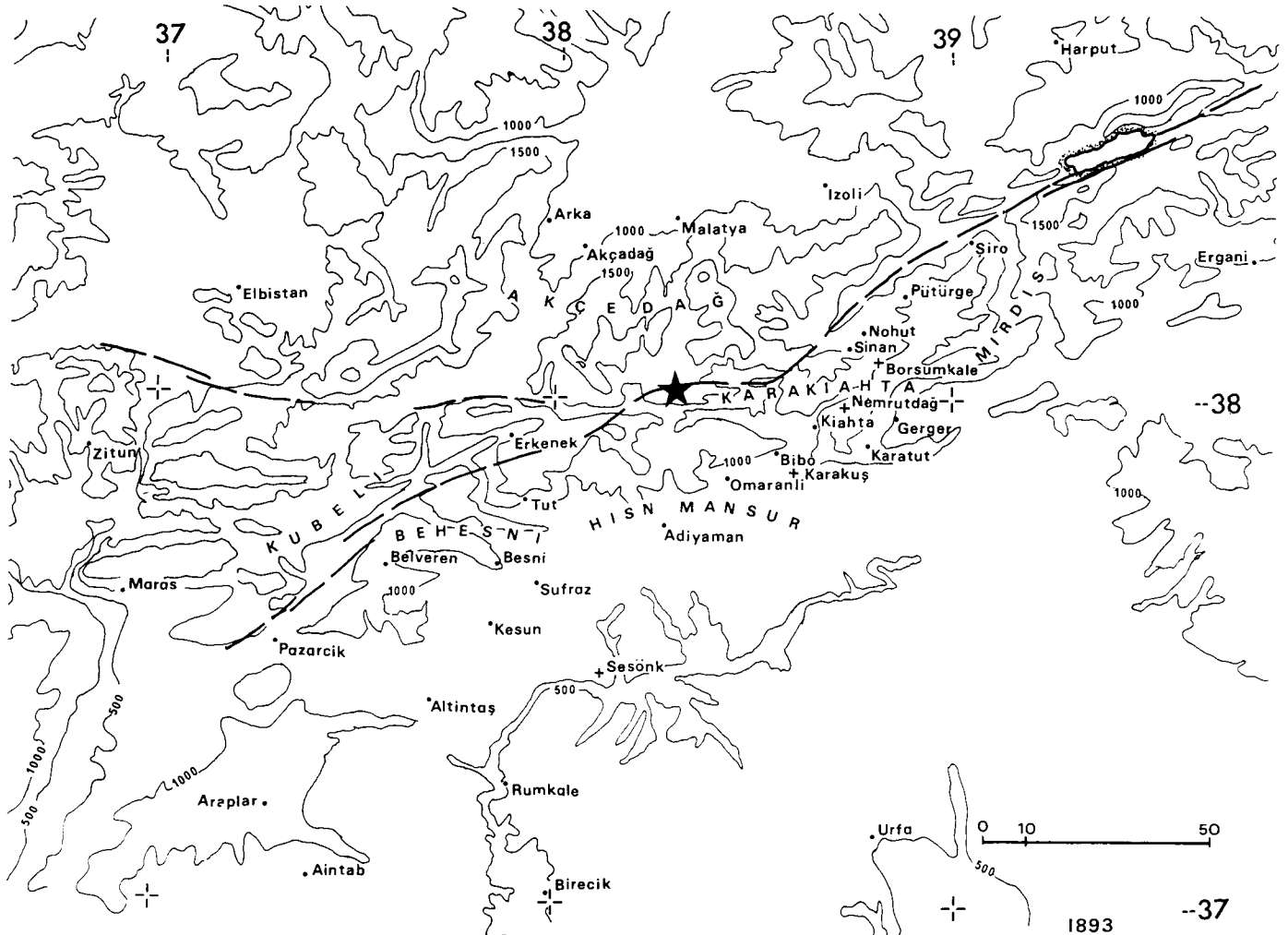


Figure 15. Epicentral area of South Malatya earthquake of 1893. Dashed lines show the East Anatolian fault and star shows adopted location of the epicentre. Crosses indicate abandoned sites.

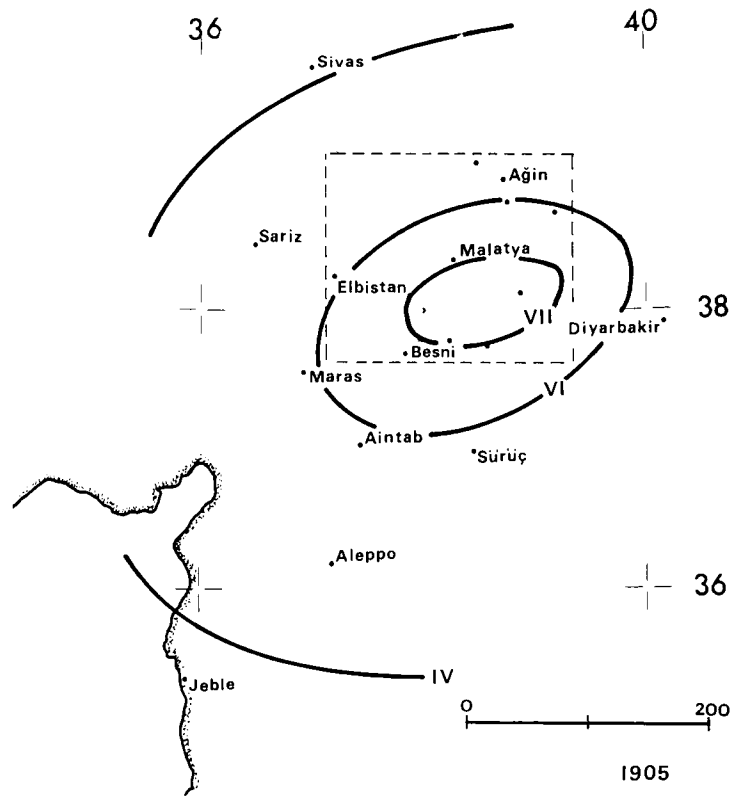


Figure 16. Felt area of the Malatya earthquake of 1905. Inset shows epicentral area shown in Fig. 17.

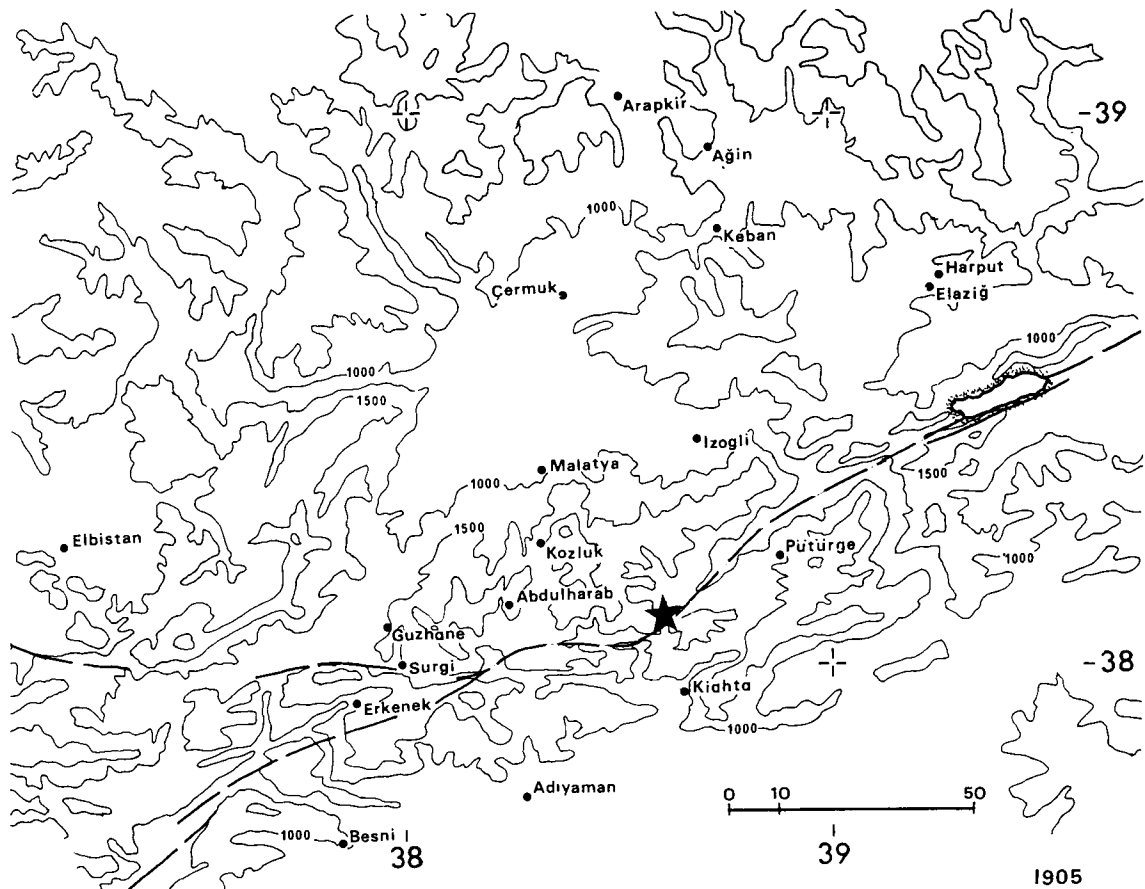


Figure 17. Epicentral area of the Malatya earthquake of 1905. Dashed lines show location of East Anatolian fault and star shows adopted macroseismic epicentre.

ruined. It is not certain whether the damage extended also to Harput, from where prisoners were evacuated to Ergani, but the shock was felt there violently.

The earthquake was strongly felt at Kilis, Iskenderun, Antakya, Harim, Idlib and Maarat, where some people awoke in panic. In Aleppo and Sivas the shock was perceptible, felt by all the inhabitants of the districts of Bulanik, Zara and Lattakiya as well.

Strong aftershocks continued until March 12, destroying a number of houses already damaged by the main shock. *Press Reports; Consular Archives; Rebeur (1895).*

#### **1905 December 4; Malatya**

This earthquake occurred SE of Malatya and it was recorded by 62 seismographic stations with an origin time of 07 h 04 m (GMT). The teleseismic surface-wave magnitude from six stations was 6.8 (0.3) and its body-wave magnitude from three stations was 6.9 (0.3). Instrumental readings confirm a location near Malatya but they are too crude to improve on position from felt effects (Fig. 16).

Heavy damage with loss of life occurred in the mountain villages between Pütürge and Surgi. The villages of Kozluk, Abdülharab, Guzhane and Erkenek were almost totally destroyed, as well as a number of settlements in the Adiyaman and Besni districts, for which we could find no

detailed information (Fig. 17). There was also extensive damage in the plain of Malatya, particularly near Izoli, a village totally ruined, where the shock caused widespread liquefaction of the Euphrates river deposits. In Kiahta the ruined castle and a number of houses suffered considerable damage, but the old bridge was unharmed. It is said that the earth was split in many places, the road being cut, presumably by landslides, between Kiahta and Malatya near Karacu and also near Nohut.

In Malatya there was some damage to houses, but apparently no casualties, although the shock caused some panic. Most of the houses in Malatya built after the 1893 earthquake survived the shock with slight damage. However, a considerable number of houses already damaged by previous shocks were ruined. Damage was more serious at Keban, Harput, Besni and in villages to the south between Rumkale and Maraş. At Aintab a few houses collapsed. The shock was felt strongly throughout the district of Mamuret ul-Aziz, in the region of Sivas, at Sariz, Arapkir, Sürüç, Aleppo and as far as Jebel on the Syrian coast.

The main shock was followed by few but very strong aftershocks, three of which had a teleseismic surface-wave magnitude of 5.5, and the sequence terminated two weeks after the main event. *Press Reports; Ambraseys & Finkel (1987).*