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BARTIN-AMASRA EARTHQUAKE, TURKEY

SEPTEMBER 3, 1968

by

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and

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7. Clay deposits of the Connecticut River Valley, Connecticut--a special problem in land management, by William H. Langer. 39 p., 13 pl., 3 figs.

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SEPTEMBER 3, 1968

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INTRODUCTION

A brief examination of the Bartın-Amasra earthquake area was made on September 23 and September 24, 1968, by the authors to determine whether or not geologic effects had been produced that were significant enough to warrant further detailed study by the Mineral Research and Exploration Institute of Turkey or by the National Center for Earthquake Research of the U.S. Geological Survey. In particular, the questions to be answered were whether this "natural experiment" had produced unique or unusual results that would cast light on means of controlling damage by geologic conditions, and whether or not surface faults or other tectonic deformation had developed which might help define the geologic control of earthquakes in northern Turkey.

The brief field examination was made jointly by personnel of the U.S. Geological Survey and Mineral Research and Exploration Institute of Turkey, because of the interest of both agencies in the earthquake hazard problem. Both agencies had participated in the Conference on Earthquake Hazard Minimization sponsored by the Central Treaty Organization held in Ankara in July 1968. The brief examination was, in part, prompted by the recommendations of the Conference group to take advantage of each significant earthquake to learn "how to live with earthquakes in greater safety."

No additional study of this earthquake by either organization seems warranted at this time, and our observations made during the brief investigation are reported here.

LOCATION AND TIME

The hypocenter was provisionally determined by the U.S. Coast and Geodetic Survey to be at 41.8° N., 32.3° E., and at a depth of 5 kilometers under the Black Sea off the Turkish coast. The Bartın-Amasra region of Turkey was the most severely affected (figs. 1 and 2).

The time of the main shock was at 08:19:52.2 GMT, on September 3, 1968.

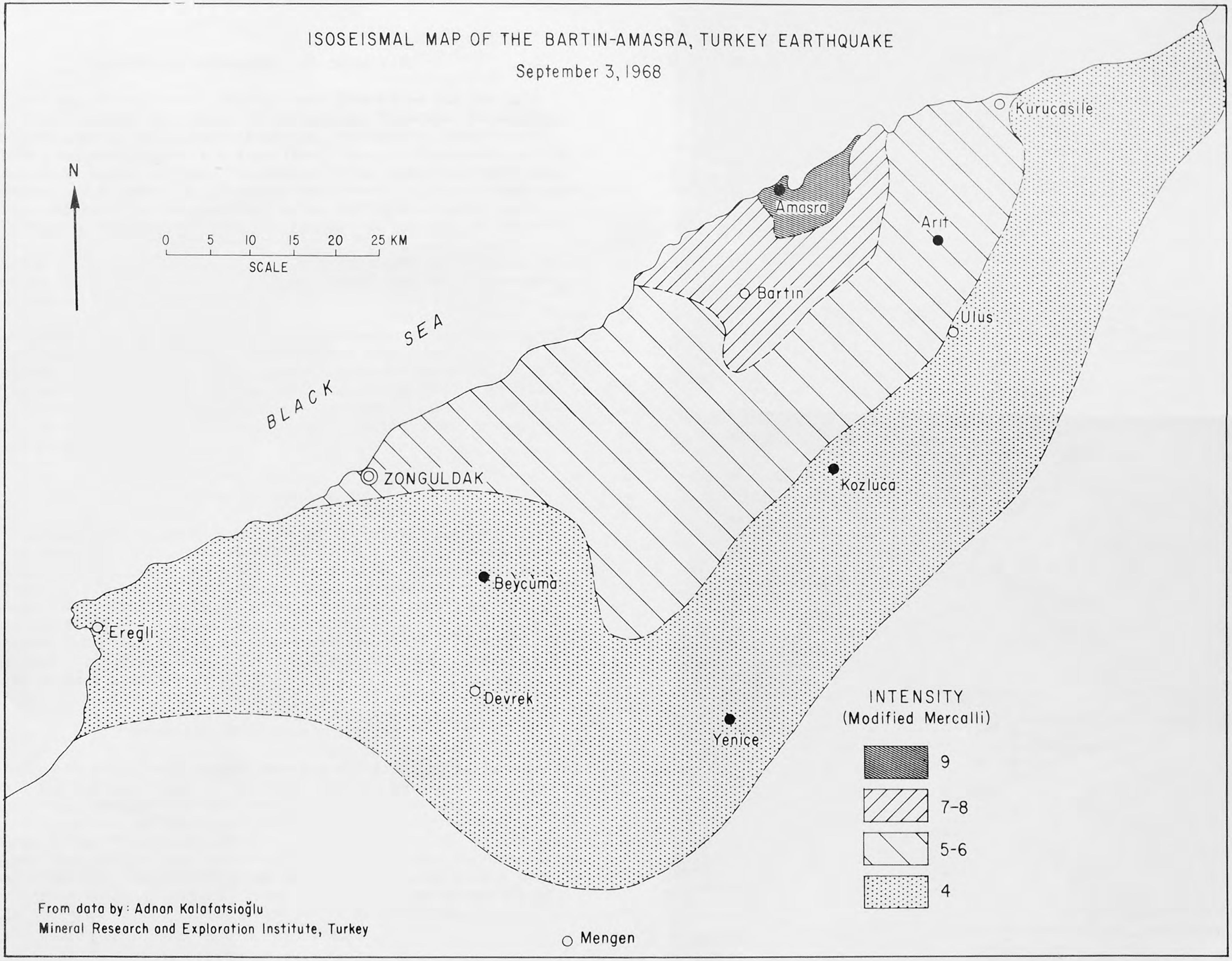
ISOSEISMAL MAP OF THE BARTIN-AMASRA, TURKEY EARTHQUAKE
September 3, 1968
N
0 5 10 15 20 25 KM
SCALE
BLACK SEA
Kurucasile
Amasra
Arit
Bartin
Ulus
ZONGULDAK
Kozluca
Beycuma
Eregli
Devrek
Yenice
Mengen
INTENSITY
(Modified Mercalli)
9
7-8
5-6
4
From data by: Adnan Kalafatsioğlu
Mineral Research and Exploration Institute, Turkey

Figure 1

MAGNITUDE, INTENSITY, AND CASUALTIES

Richter magnitudes of 6.5 and 6.7 were determined for the main shock by the California Institute of Technology, Pasadena, California, and the University of California, Berkeley, California, respectively. The Richter magnitude scale is a logarithmic scale. Each point on the scale represents about 30 times the energy of one magnitude unit lower on the scale. Magnitude 5 is generally considered to be the scale point above which damage is to be expected, if an earthquake occurs in a populated region; magnitude 8.9 is the largest earthquake yet recorded.

Maximum intensity on the modified Mercalli scale is estimated to have been IX. The earthquake was felt in Ankara, 200 km to the south, and in Istanbul, 280 km to the west.

Twenty-nine persons were killed and an unknown number were injured in the Bartın-Amasra earthquake. Two thousand houses were totally destroyed and 2,650 were partly damaged. Damage was principally in an area 15 km east-west by 20 km north-south, extending from a few kilometers west of Amasra to a few kilometers east of Çakraz on the Black Sea coast and south to the Kocaırmak (river). Most intense damage was in the Amasra-Çakraz area.

MAIN SHOCK AND AFTERSHOCKS

From local reports and observations of structural damage, motion during the main shock seemed to have been first a strong upward heave, followed by severe shaking for about 30 seconds in a generally north-south direction. Residents of Bartın and Çakraz reported a loud sound just before the shaking, but those in Amasra did not recall any sound. At Çakraz the sound was likened to a large bomb explosion. At Çakraz no foreshocks were felt but an estimated average of 35 aftershocks per day were felt for several days following the main shock. One was felt during the field examination.

TOPOGRAPHIC AND GEOLOGIC SETTING

The area is moderately rugged, and has an estimated maximum relief of about 1,000 meters. Most of the hill slopes are covered by scrubby trees and brush, but most of the principal rock units crop out moderately well. About nine or ten geologic units are exposed in the area affected. These range in age from Carboniferous to Late Cretaceous. Faults are common, and the geologic map indicates that they trend predominantly northeast (fig. 2). The faults shown probably represent only a small number of those actually present. Almost certainly there are thrust faults in the area which are not shown on the geologic map.

The main streams of the area converge in the vicinity of Bartın and empty into the Black Sea about 10 km northwest of Bartın. All the valleys are covered by alluvium, and exposures of the alluvium along stream channels are soil rather than gravel. This includes the small alluvial valley of Çakraz where the heaviest and most widespread damage was seen.

TECTONIC EFFECTS

At Çakraz, which fronts on a small bay about 300 meters wide, the sea receded 12 to 15 meters from its normal shoreline at the onset of the quake and never returned entirely to its original level. A high-water mark presently exposed around the entire shoreline in the vicinity of Çakraz shows that the seacoast was uplifted about 30-35 centimeters in that area. However, no such high-water mark exists at Amasra about 8 km to the southwest, and reportedly none is present at Göçgün about 6 km to the northeast; thus the uplift is only of local extent. Time did not permit a boat trip along the coastline to ascertain the extent of the uplifted area more precisely. However, the uplifted coastline and the generally heavier structural damage at Çakraz than elsewhere indicate that the earthquake epicenter must have been very close to Çakraz.

No tectonic fractures or surface faults were identified in the earthquake area, and none were reported to us by local residents. The fault or other tectonic feature on which the earthquake was localized could not be identified. The shape of the affected area and the presence of numerous north and northeast-trending faults (fig. 2) suggest that a fault of this general group may have been responsible. There appears to be no evidence that this event was in any way related to movement on the North Anatolian fault zone approximately 90-100 km to the south.

GROUND CRACKS OF NONTECTONIC ORIGIN

Cracks in soil were seen at several places along the river valley a short distance east of Bartın (figs. 3 and 4), several kilometers south of Bartın, and about one kilometer southeast of the seaside village of Çakraz.

Just east of Bartın, about 150 meters south of the Bartın-Amasra road and about 100 meters north of the river, a series of cracks trends S. 80° E. for about 50 meters, from which point they trend S. 40° E. for 30-40 meters, thence S. 80° E. for another few meters, and then they die out. On the west end the cracks are as much as half a meter wide and have dropped down on the north; maximum displacement is 8-9 centimeters. Further southeast where the trend turns S. 40° E., the south

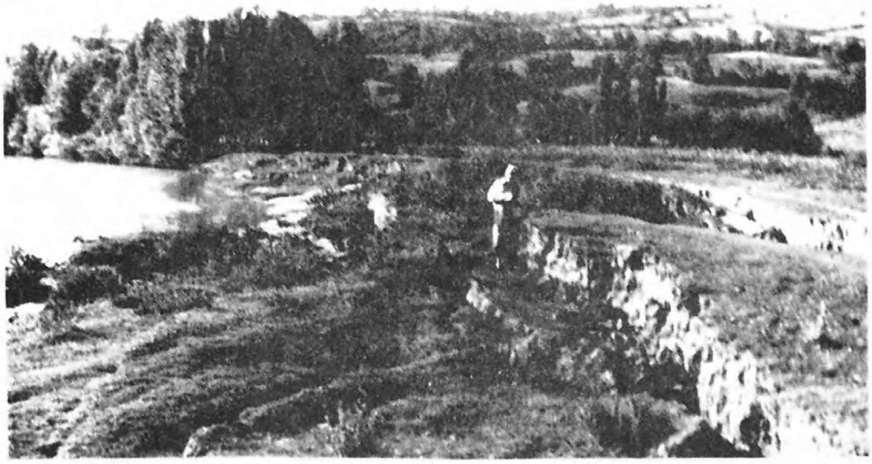

Figure 3.--Fracture along Bartın River east of Bartın, developed by slumping and landspreading.

Figure 4.--Fracture along Bartın River east of Bartın, developed by slumping and landspreading.

Photographs by A. Kalafatçioğlu, MTA

side is downdropped as much as 40 cm and the cracks are 60-70 cm wide. A graben structure 2 meters wide and about 20 cm deep was seen at one place along this zone of cracking, the total length of which is more than 100 meters.

About 75 meters south of the first zone of cracks and perhaps 25 meters north of the river a second area of five arcuate cracks is roughly parallel to the group described above; on each crack the south side has dropped down. The combined total downdrop on the five ruptures is about two meters. The total length of this arcuate zone is not more than 50 meters. Nearby to the north is a crudely circular depressed area about 10 meters in diameter and 10 to 20 centimeters deep.

Fifty or 60 meters away on the south side of the river in this same locality just east of Bartın, three scarps downdropped on the north side and face the scarps described above on the opposite side of the river.

Several kilometers southeast of Bartın similar cracks are present; most are parallel to the river where it flows north. The cracks are in soil and their downdropped sides are toward the river. The cracks were relatively inaccessible on the opposite side of the river and were not examined in detail.

Because of the close spatial and directional relationships between the cracks described above and the river basin, it appears that the cracks are not truly tectonic features but formed rather by the differential response to shaking of water-saturated ground and dry unsaturated ground. The soggy saturated ground of the river bed compacted, settled in response to shaking relative to the drier soil, and cracks formed in places along the boundary between. Unconsolidated ground in alluvial plains along rivers spread toward the river cutbanks, producing tension cracks subparallel to the river.

Another surface crack about 1 km southeast of Çakraz at the village of Ovaköy (fig. 5) trends N. 40°-50° E.; although it is entirely in soil, bedrock is exposed within one meter to the southeast. The crack thus appears to be the surface trace of a contact between bedrock and alluvium. Total length of the crack zone is 65-70 meters. The crack is as much as 80 cm wide and is downdropped a maximum of 30 cm on the northwest side. Soil on the northwest side of the crack is in a small swale or hollow about 50 meters wide and was soggy and water-saturated on September 25. The northwest side of the swale is bedrock but no cracks were formed along the contact between soil and bedrock on that side of the swale.

The crack at Ovaköy, like those along the river near Bartın, does not appear to be truly tectonic. It apparently results from the shaking and settling of water-saturated soil, in this case adjacent to bedrock.

Figure 5.--Fracture at Ovaköy near Çakraz. Bedrock is exposed a few feet to right of fracture.

Figure 6.--Damaged house, Çakraz Valley. Approximately 100 meters to right of building in background a high minaret built on alluvium was undamaged.

Photographs by A. Kalafatçioğlu, MTA

LANDSLIDES AND ROCKSLIDES

A few landslides were noted near Amasra along the road from Bartın, and an increase in the number of landslides was noted as we approached Çakraz along the road from Amasra. Rockslides could be seen from a distance in the mountains to the east and south of Çakraz.

INFLUENCE OF GEOLOGY AND CONSTRUCTION ON DAMAGE

A survey of the damage to buildings in various parts of the area shows a fairly definite relation to type of foundation material and to type of construction.

Bartın was shaken violently, according to local residents, and cracks developed in some buildings. However, there was no significant damage in the town which is built largely on Cretaceous limestone bedrock. Shaking was reportedly in a northwest-southeast direction in Bartın. Northwestward from Bartın to the Black Sea no damage was seen.

At Akpınar, a village about 5 km northeast of Bartın and built on alluvium, unreinforced stone and concrete buildings were heavily damaged. The upper one-third of a minaret built of unreinforced concrete toppled in a S. 40° W. direction from its base (fig. 7). Tension cracks developed commonly in stone, concrete, or brick building walls facing N. 40° W. and S. 40° E., but not in walls facing northeast or southwest.

Amasra, on the seacoast north and slightly east of Bartın, was very severely jolted, according to local residents, but damage was spotty. The first motion was reported to be upward, followed by shaking. Local residents did not report the direction of shaking, but most tension cracks are on the northeast and southwest sides of buildings, indicating shaking in a northwest-southeast direction. Amasra is built partly on Carboniferous limestone and apparently in part on alluvium which may be very thin. One partly reinforced concrete building in the central part of the town was very severely damaged, virtually destroyed, whereas brick buildings adjoining it on either side were apparently undamaged. All these damaged buildings appear to be built on thin alluvium.

Damage was generally severe in all the villages in the Çakraz valley (figs. 6 and 8), but even there some brick and cement block buildings withstood the shaking with little or no damage, whereas adjacent buildings were either extensively damaged or collapsed. The most severely damaged structures generally consisted of unreinforced brick, stone, or concrete walls supporting a 3- to 6-inch-thick flat concrete slab roof resting on light cross timbers. Although several minarets collapsed, at least one high minaret in the valley was left standing virtually undamaged.

Figure 7.--Toppled minaret, Akpınar Village.

Figure 8.--Collapsed house, Çakraz Valley. Tile roof propped up after quake.

Photographs by A. Kalafatçioğlu, MTA

We found only one wooden structure that was badly damaged or destroyed. This building was in the river valley about 8 km southeast of Bartın. In this same general area concrete and stone structures were heavily damaged. Cracks were mostly on east- and west-facing walls, and one minaret toppled due south, indicating a north-south shaking motion.