GEOLOGIC EFFECTS

By GEORGE PLAFKER, MANUEL G. BONILLA, and SAMUEL B. BONIS [1]

INTRODUCTION

This report is based on preliminary field studies of the geologic effects of the earthquake made during an 11-day period from February 5 to 16, 1976. During this period, we examined the main and secondary faults on the ground, using vehicles and helicopters for logistic support. In addition, several reconnaissance flights were made with fixed-wing aircraft over most of the area that was strongly affected by the earthquake to identify and map landslides, liquefaction phenomena, and damage to communities near the surface faults. Some of our interpretations may be modified by the more detailed field investigations that were being conducted by the U.S. Geological Survey and other organizations at the time this paper was written (March–April).

THE MAIN FAULT

The main fault along which the destructive main event (M_s=7.5) occurred was identified for 240 km in the Motagua Valley and the mountainous area west of the valley [2] (fig. 23). This fault is of special interest because it is the most extensive surface rupture in the Northern Hemisphere since the 1906 San Francisco earthquake. Identification of this fault permits evaluation of damage relative to the earthquake source and provides critical new information on the present mode of deformation to a major tectonic belt of Central America. The eastern part of this major fault, within the Motagua Valley, has been named the Motagua fault (Dengo and Bohnenberger, 1969; Instituto Geográfico Nacional, Chiquimula 1:250,000 sheet, 1969), and this name is herein applied to all the fault that slipped during the earthquake.

Ground breakage was observed in a discontinuous line extending 240 km from near Quebradas in the lower Motagua Valley on the east to about 10 km east of Patzaj on the west.[2] At the closest point, the fault is 25 km north of the center of Guatemala City. The fault could not be identified farther to the west because the area is characterized by young volcanic deposits and rugged terrane in which numerous earthquake-triggered slope failures effectively mask the fault-related surface fractures. At the eastern end, the fault trace is obscured in the lower Motagua Valley by swamps and dense tropical vegetation. However, the occurrence of aftershocks southeast of Puerto Barrios (Langer and others, this report) near the eastern coast suggests that the faulting probably extends at least that far. If so, the main break is on the order of 300 km long[2]. Some of the characteristics of the faulting at localities where it was studied on the ground are given in table 7.

The fault trace is a well-defined linear zone with a gradual change in average strike from N. 65° E. at the eastern end to N. 80° W. at the western end. It consists of right-stepping en echelon fractures and connecting low compressional ridges that locally form the "mole tracks" that are characteristic of strike-slip faults (figs. 24–28). Individual fractures within the zone may be as much as 10 m long; most are tightly closed, but some have spread as much as 10 cm. The fractures are oriented at angles of as much as 35° to the fault trace and have the northeasterly azimuths that are to be expected for sinistral slip. The width of the fracture zone is mostly 1 to 3 m, with a maximum observed width of about 9 m. At one locality near El Progreso, where the fault surface is exposed in a highway cut, the zone of slip is 1 to 3 m wide, and the dip is essentially vertical.

Displacement across the fault in most places is almost entirely horizontal and sinistral. The strike-

[1] Instituto Geográfico Nacional de Guatemala

[2] Later, more detailed studies indicate that the length of surface faulting is 230 km and that the main break from relocated epicenter data is 270 km.

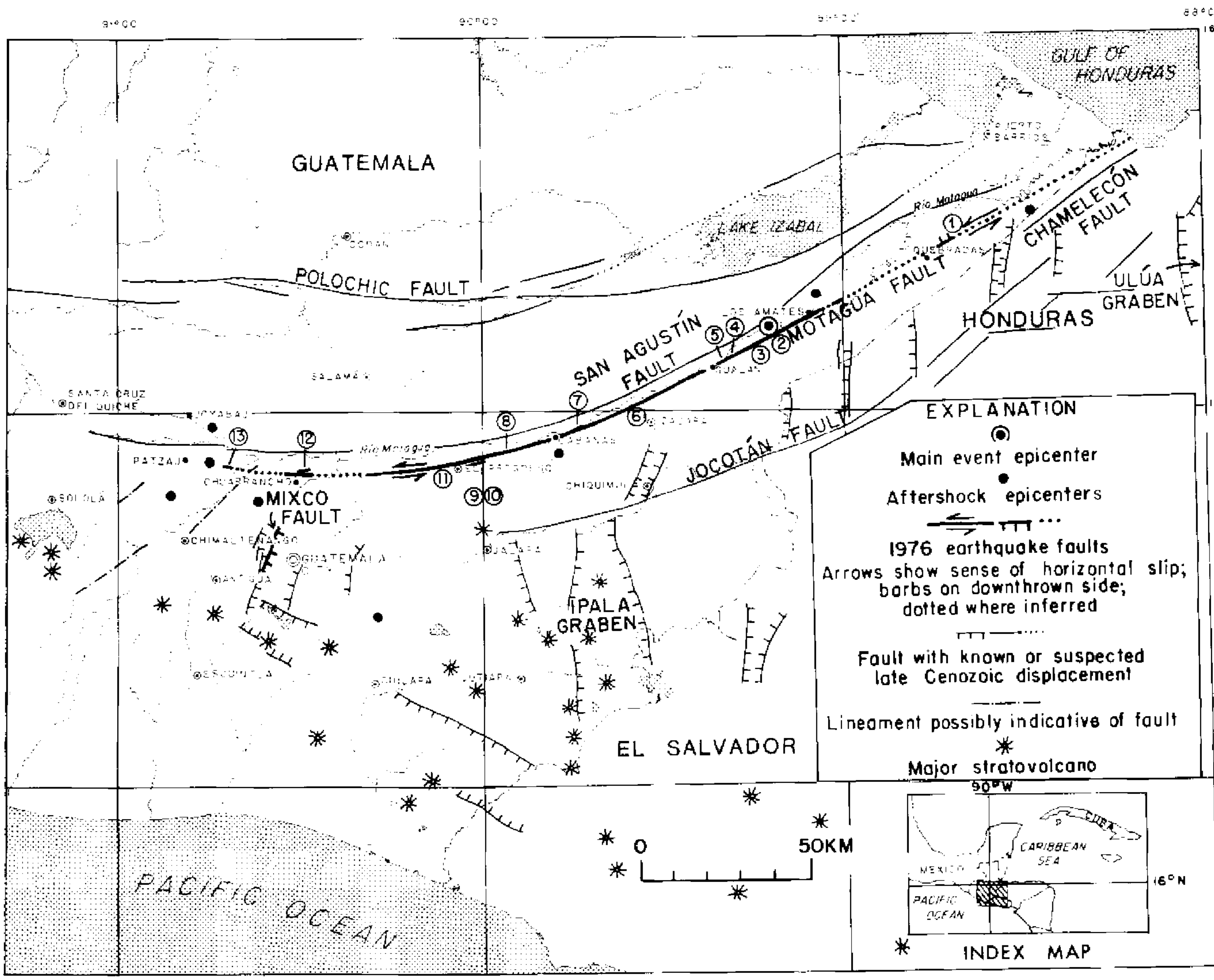

FIGURE 23.—Relationship of the Motagua and Mixco faults to the main-event epicenter, the epicenters of large aftershocks, and major structural and volcanic features in northern Central America. Numerals along the Motagua fault refer to localities listed in table 7. Epicenters are from data of the NEIS and Person, Spence, and Dewey (this report); faults and volcanoes are modified from Dengo (1968) and Bonis, Bohnenberger, and Dengo (1970).

slip component of displacement appears to increase irregularly from about 73 cm near near Quebradas at the eastern end of the exposed trace to a measured maximum on a single trace of 142 cm in the area due north of Guatemala City.[3] At the extreme western end of the observed trace, a single measurement suggests that displacement there may decrease to 68 cm. However, since this locality is in an area of large-scale gravity sliding, the reliability of the measurement is uncertain. The vertical offsets that we observed along the fault are generally minor (less than 30 percent of the horizontal component) and down to either the north or the south. An exception is the 10-km-long segment near Quebradas at the eastern end of the observed surface trace where the vertical displacement is consistently down to the north and locally as much as 50 percent of the sinistral component.

Subsidiary faults and splays appear to be relatively scarce along the Motagua fault; the only two occurrences noted in our preliminary reconnaissance are near El Progreso and Chuarrancho. Just northeast of El Progreso, a subsidiary fault about 1 km long with 20-cm sinistral displacement is oriented roughly parallel to, and 400 m south of, the main fault trace. Near Chuarrancho (north of Guatemala City), a prominent surface break splays off the main trace in a northeasterly direction at an angle of about 15°. This splay has a sinistral offset of 28 cm and was estimated from the air to be about 250 m long.

[3] Later studies indicate that maximum sinistral displacement is as much as 325 cm in the area between El Progreso and Chuarrancho.

TABLE 7.—*Characteristics of earthquake fractures along the Motagua fault*

[Measured aggregate displacement: +, estimate: (?), measured displacement probably not true value; >, measured displacement probably minimum value; S, sinistral or left-lateral; V, vertical. Leaders indicate no data. Observations by George Plafker, S. B. Bonis, and M. G. Bonilla, February 6-13, 1976]

Station (fig. 23)	Trend of fault zone	Approx. width of fault zone (m)	Average trend of fractures	Measured displacement (cm)	Sense of displacement	Ground surface	Remarks
1	N70E	1.5	------	72	S V	Pasture	Down-to-north. North-facing scarp as much as 5 m high along part of fault. See fig. 27.
2	N65E	3	N32E	>33	S	Dirt road	Minimum displacement, measured across the largest fracture in a zone containing 7 fractures.
3	------	------	--	(?)107	S	Railroad embankment	Offset railroad tracks. Unreliable measurement due to gentle curve in tracks.
4	N65E	1	N50E	93	S	Concrete-lined canal	Good displacement measurement.
5	N65E	5	N46E	89	S	Soccer field	Good displacement measurement on offset sidelines. See fig. 26.
6	N61E	1	N61E	>60	S	Asphalt highway	Displacement may be minimum value if highway fill partially decoupled from ground.
7	N70E	------	------	(?)120	S	Dirt road	Poor displacement measurement due to curve in road.
8	N75E	3.25-9	~N75E	~90	S	Plowed field	------------ ----
9	N80E	4	N40E	20	S	Pasture	Subsidiary parallel fault 1 km long, and 200 m south of main break.
10	N75E	2	------	100	S	Pasture	Fair displacement measured on offset cactus fence.
11	N75E	2	------	105 20	S V	Cultivated field	North side down. See fig. 25.
12	N75E	--	N40E	142	S	Pasture	Fair displacement on offset path. Splay to north off main fault trends N60E with 28 cm sinistral, and 17 cm vertical displacement.
13	------	5	N70E	(?)68	S	Dirt road	Poor measurement. Probably masked by landsliding.

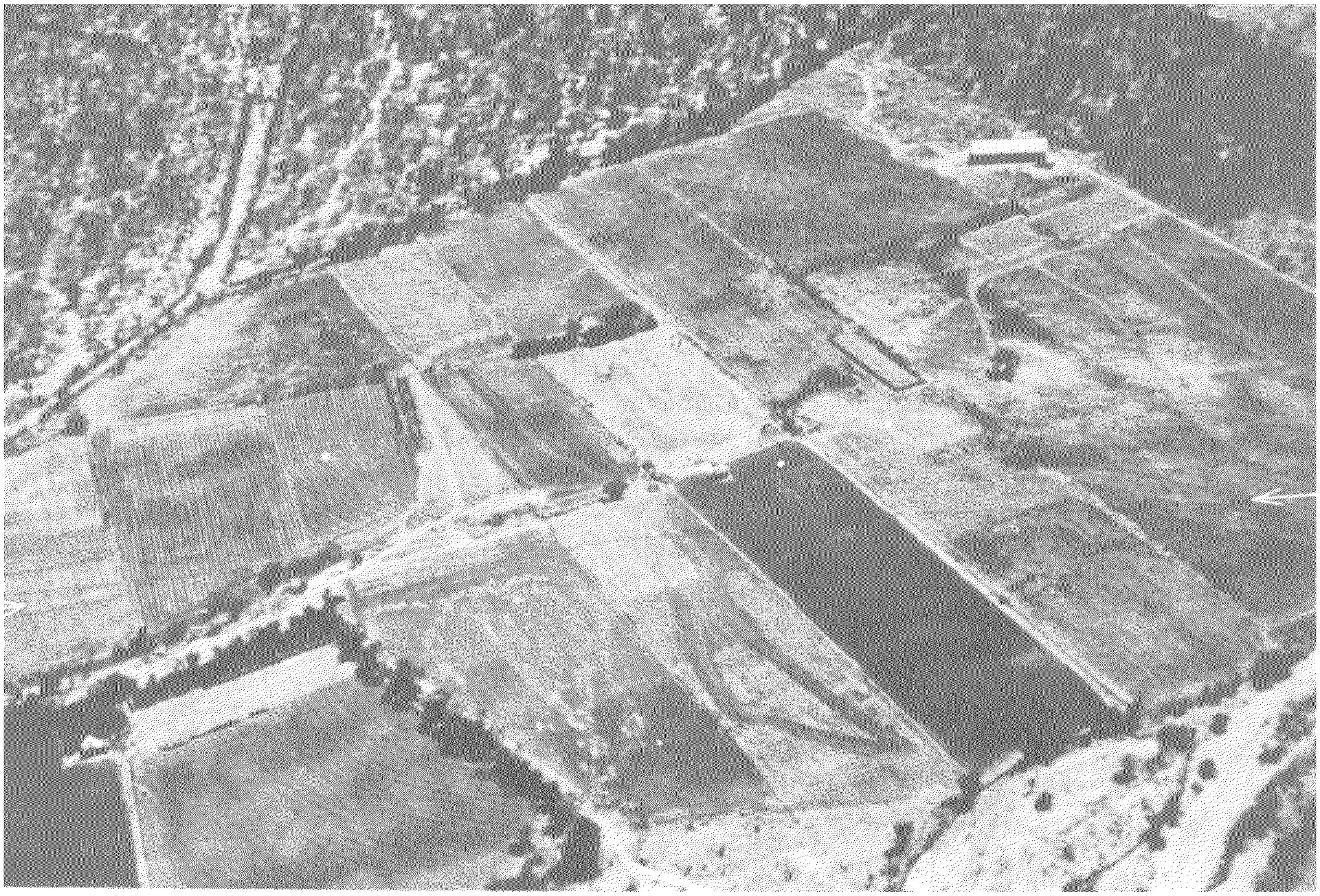

FIGURE 24.—Oblique aerial view looking south towards linear trace of the Motagua fault (arrows) in farmland west of Cabañas. Furrows with sinistral offset may be seen in the field at left. See figure 23 for location of Cabañas.

Faulting during the February 4 earthquake coincided closely with the previously recognized fault on the southern side of the Motagua Valley in the area east of El Progreso (Dengo and Bohnenberger, 1969; Bonis and others, 1970). Locally, however, the faulting of February 4 was as far as 1 km from the Motagua fault as it was mapped before the earthquake. Moreover, faulting related to this earthquake has shown that the Motagua fault extends 85 km beyond its previously recognized western limits.

Much of the Motagua fault trace is marked by linear stream valleys, minor scarps, shutter ridges, and sag ponds that are suggestive of repeated geologically youthful tectonic activity along this fault. Earthquakes that destroyed Omoa, Honduras, in 1859 (Montessus de Ballore, 1888) and caused damage at Quiriguá (near Las Amates) in 1945 (Seismological Society of America Bulletin, v. 35, p. 194) and at Puerto Barrios in 1929 (Seismological Society of America Bulletin, v. 19, p. 55) may have been generated along the Motagua fault or its offshore extension. However, because surface breaks were not observed and because the epicentral locations are not well constrained by the seismological data, it is not possible to preclude the alternative that these earthquakes were caused by movement on other faults in the area.

RELATIONSHIP OF FAULTING TO DAMAGE

The Motagua fault break caused extensive damage to buildings, roads, and the railroad. In Gualán, Cabañas, Subinal, and several smaller communities, structures that were astride the fault were damaged by the tectonic displacements. The most intense damage from shaking is within 40 km of the Motagua fault trace (Espinosa and others, this report) and is predominantly in areas of thick pumiceous ash-flow deposits of Pleistocene age. These poorly consolidated deposits may have amplified ground motions. However, other factors, such as lateral