A Note on Historic and Quaternary Faults in Western Taiwan

by M.G. Bonilla[1]

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[1] 345 Middlefield Road, Menlo Park, CA 94025

Introduction

This brief note provides a summary of pertinent information from two previous reports on young faulting in Taiwan (Bonilla, 1975, 1977). In addition to listing historic surface faulting, this note gives information about several Quaternary faults in the epicentral region that could have been involved in the 1999 Chi-Chi earthquake, and the relation of one of them (the Chelungpu thrust fault) to several other faults, including those that had surface ruptures in the 1906-1946 period.

The two reports (Bonilla, 1975, 1977) provide data and interpretations from still earlier reports, and can serve as background for post-earthquake investigations. The two reports are being processed for inclusion in the International Association of Seismology and Physics on the Earth's Interior (IASPEI) "International Handbook of Earthquake and Engineering Seismology," and are expected to be available on the Internet in the near future. In the meantime, this note may be of use to those investigating primary and secondary faulting in the September 21, 1999, Chi-Chi Taiwan earthquake.

Historic Surface Faulting

Surface faulting occurred at six different places in Taiwan prior to 1999, in association with five earthquakes whose magnitudes ranged from 6.75 to 7.3. Locations of these fault ruptures are shown on Figure 1, and the surface parameters, along with associated earthquakes and other information, are listed in Table 1 (from Bonilla, 1977).

Table 1. Historic surface faulting in Taiwan

Date (yr./mo./day)	Length (km)	Strike slip (m)	Vertical or dip slip (m)	Oblique slip (m)	Earthquake magnitude	Deaths	Map number
1906/ 3/17	>13	2.4	1.2	2.7	7.1	1258	26
1935/ 4/21*	15 12	-	3.0 1	-	7.0	> 3000	14 19
1946/12/ 5	12	2.0	0.76	2.14	6.75	74	30
1951/10/22	> 7	2.0	1.2	2.3(?)	7.1	45	43
1951/11/25	40±	1.63	1.3	2.08	7.3	20	42

* Two separate ruptures occurred at approximately the same time.

Quaternary Faults

One of several faults with Quaternary displacement in the epicentral region of the September 21 Chi-Chi earthquake probably was the causative fault for this earthquake, and others may have had secondary surface ruptures on them. The following description of these faults is from Bonilla (1975, 1977). Place names used below, taken from the cited sources, are not shown on Figure 1. The faults are described in geographic order starting with the easternmost.

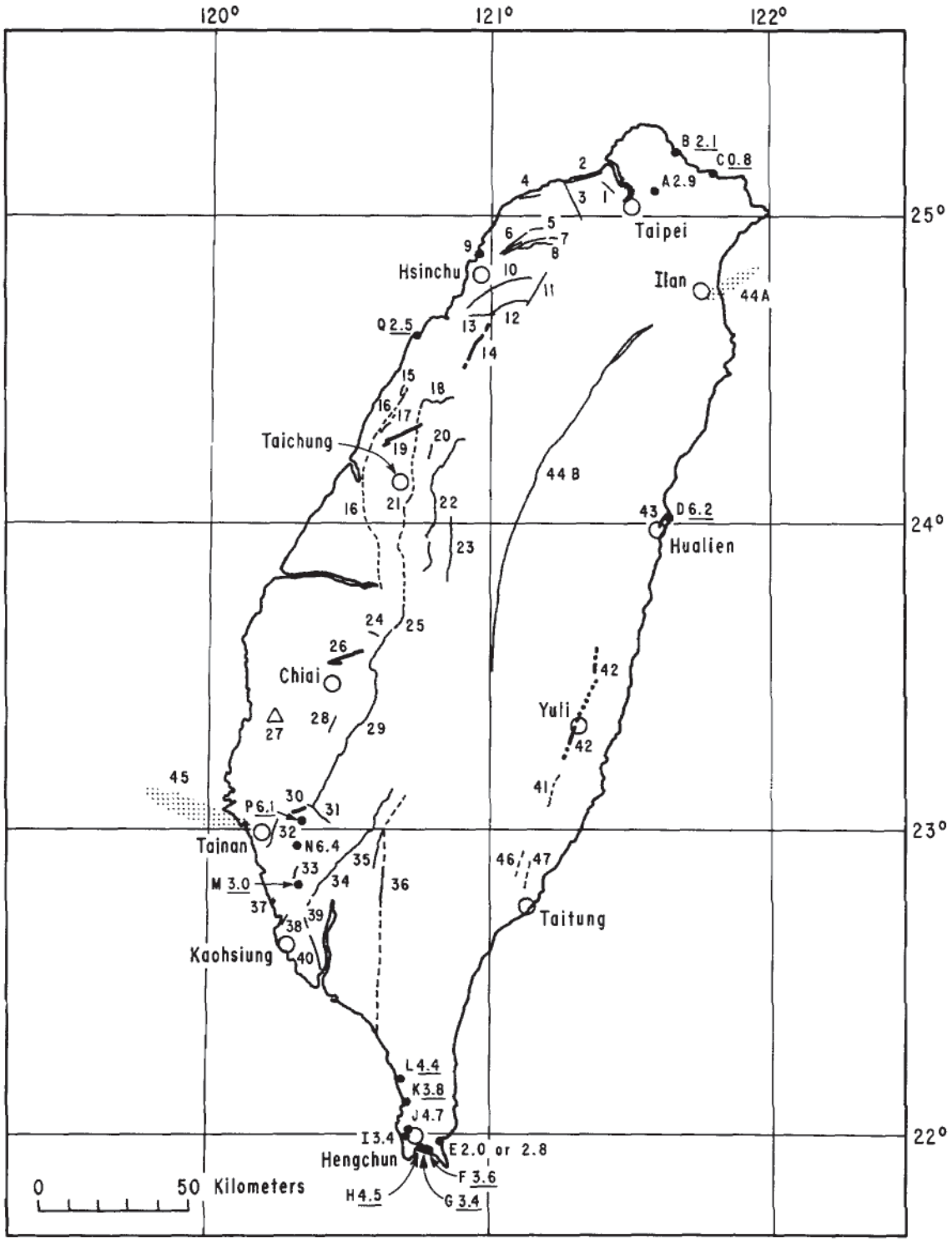

Figure 1. Map of Taiwan showing faults that cut Quaternary deposits. From Bonilla (1977, fig. 1). Surface ruptures (heavy lines) occurred in 1935 on faults numbered 14 and 19; in 1906 on fault number 26; in 1946 on fault 30; and in 1951 in eastern Taiwan on faults numbered 43 (October) and 42 (November). Alignments of epicenters (pattern of dots) at 44A (Tsai and others 1975) and 45 (Tsai and Chiu 1976) indicate concealed historically active faults. Letters A-Q and their associated numbers should be ignored as they relate to a preliminary estimate of rates of Holocene uplift.

The Shuilikeng-Tatakou fault (no. 23, fig. 1) is shown on a 1:200000-scale geologic map (Chinese Petroleum Corporation, 1971) with a solid line; therefore it apparently cuts the upper Pleistocene terrace deposits at points 19 km north of and just south of Shuilikeng. At terrace deposits of the same age 27 km north of and 3.5 km and 9 km (and farther) south of Shuilikeng, however, the fault may not displace the terrace deposits, as it is shown with a dashed line, representing a concealed or inferred fault.

The Tamaopu-Shuangtung fault (no. 22, fig. 1) cuts the Huoyenshan (lower Pleistocene) facies of the Toukoshan formation (Chang, 1971, fig. 1). The Chinese Petroleum Corporation (1971) map shows the fault also cutting upper Pleistocene terrace deposits. The geologic map by Chiu (1972, fig. 3) shows a northeast-trending fault that cuts the Shuangtung fault but apparently doesn't cut the upper Pleistocene terrace deposits; if true, this suggests that at least that part of the Tamaopu-Shuangtung fault is older than upper Pleistocene. However, the epicenter of a 1973 earthquake in the magnitude range 2 to 3 was on or near the Shuangtung fault according to a map of Hsiung and Lo (1973, fig. 4), suggesting very recent activity. The fault is of reverse type, upthrown on the east (Ho, 1959, p. 71), with a measured dip of 55° E. at one excellent outcrop of the fault (Chiu, 1972, fig. 6).

The Chelungpu thrust fault (no. 21, fig. 1) is inferred, on the basis of indirect evidence, to cut the Pleistocene Toukoshan formation even though the trace is locally covered by alluvium (Chang, 1971, p. 23-24 and fig. 7; Chou, 1973, section E-F).

Traced northward, the Chelungpu thrust fault joins or becomes the Sani fault (no. 18, fig. 1). The Sani fault cuts the Pleistocene upper Toukoshan formation near the west end of its east-west portion (Meng, 1963; Tang, 1969, fig. 1). About 13 km east of that point, where the fault is interpreted as a right-slip fault, Tang's map shows a fault scarp in Miocene-Pliocene formations. An earthquake with magnitude between 2 and 3 occurred on or close to the Sani fault in 1973 (Hsiung and Lo, 1973b).

Some Relations Between the Historic Ruptures and Known Quaternary Faults

The Chelungpu thrust fault, its companions to the north and south, and several of the historic ruptures suggest an important regional fault system under approximately east-west compression. The southern (right slip) 1935 surface rupture (# 19, fig. 1) apparently crossed the northern extension of Chelungpu thrust fault near where it joins the Sani fault (no. 18, fig. 1). Equally interesting is that the northern (reverse slip) 1935 surface rupture (# 14, fig. 1) seems to line up with the Chelungpu thrust fault, which in turn joins up southward with the Tachienshan fault (#25, fig. 1), and the Chukou fault (# 29, fig. 1) seems to terminate near, or possibly join, the 1946 surface rupture (# 30, fig. 1). The sense of slip on each of the historic ruptures (table 1) is compatible with east-west compression.

Concluding Remarks

The information in this note should provide useful background information, and guidance to some of the literature, for those investigating surface faulting and other earthquake-related topics. The suggestion made here that Chelungpu thrust fault, its companions to the north and south, and several of the historic ruptures constitute an important regional fault system has important practical and scientific implications.

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