Bulletin of the Seismological Society of America, Vol. 75, No. 1, pp. 313–317, February 1985

LETTERS TO THE EDITOR

RUPTURE ALONG THE GREAT SUMATRAN FAULT, INDONESIA, DURING THE EARTHQUAKES OF 1926 AND 1943

BY M. UNTUNG, N. BUYUNG, E. KERTAPATI, UNDANG, AND C. R. ALLEN

While investigating features of Quaternary displacement along the Great Sumatran fault zone in the Padang Highlands of Sumatra, Indonesia (Figure 1), the authors incidentally came across heretofore unreported evidence of significant surficial displacements along the fault during the $M_S = 6\frac{3}{4}$ earthquake of 28 June 1926 and the $M_S = 7.6$ earthquake of 9 June 1943. In both cases, eyewitness reports by long-term local residents allowed unequivocal documentation of the location and nature of the surficial fault displacements associated with the earthquakes, although it was only through the use of vertical aerial photographs to locate the active fault trace that it was possible to concentrate the questioning in promising areas. In every case, it was thus possible to locate the primary active fault trace to within a few hundred meters before commencing the search for local eyewitnesses.

The 1700-km-long Great Sumatran fault has been recognized by geologists for many years as a profound regional tectonic feature, and it has usually been thought to be associated with oblique subduction along the Sunda arc (Fitch, 1972). Although its recent activity has been summarized by Katili and Hehuwat (1967), the detailed neotectonic trace has for the most part not been mapped or investigated. Katili and Hehuwat (1967) present inferential evidence for right-lateral displacement during several historic earthquakes, mainly based on geodetic observations (e.g., Muller, 1895) or reported directions of strong ground motion (e.g., Visser, 1927), but the present report is, to our knowledge, the first documentation of surficial fault rupture during individual historic earthquakes.

Best documented is the fault rupture associated with the 1943 earthquake, which was described to us with remarkable memories by long-term residents in 13 selected localities along a 50-km-long segment of the fault near the town of Solok, between Danau (Lake) Singkarak and Danau Diatas (Figure 2). Since the rupture clearly extended into Danau Singkarak on the northwest, and it continued into an area of steep terrain and landsliding southeast of Danau Diatas, we estimate the total rupture length was at least 60 km. Ground cracking parallel to the fault was also described by local residents at least as far south as Surian, 15 km south of the southern border of Figure 2, but we judged this to be more likely related to landsliding than to true fault rupture. Vertical displacements of up to 2 m were described by many residents, varying in sense ("scissoring"), but virtually always in the same sense as that represented by the pre-existing Quaternary scarp. Particularly in the mid-section of the fault, numerous residents gave clear descriptions of strike-slip displacements (usually without prompting by us), and there was general agreement that the 1943 movement had been dextral and not sinistral—in keeping with the regional tectonic framework (Katili and Hehuwat, 1967; Hamilton, 1979). Although local residents estimated strike-slip displacements in 1943 of up to 5 m, the largest horizontal displacement of which we could still be convinced was 2 to 3 m, as represented by an offset road near Salayo.

Although the 1943 earthquake was of $M_S = 7.6$, reported damage was small, apparently due to the resistant nature of local wood and bamboo construction. Gutenberg and Richter (1954) indicate that another earthquake of $M_S = 7.4$ occurred

7 hr earlier with the same epicenter, but none of the local residents mentioned this earlier event. Based on Gutenberg's original notes (Goodstein *et al.*, 1980), it appears that he may have simply assumed that the two shocks were at the same location, and we prefer the conclusion of the International Seismological Summary (1953) that the earlier shock was centered some 200 km farther southeast; this conclusion is substantiated by recognizable differences in the waveforms of the two events as recorded at Pasadena. Gutenberg and Richter (1954) assign a 50-km depth to both events, but reexamination of Gutenberg's notes and the Pasadena seismograms reveals marginal justification for such a depth, and we suspect that both events were shallow. Limited first-motion data for the $M = 7.6$ event are consistent with dextral displacement on the Great Sumatran fault. The earlier earthquake may also have been centered on the fault along its prolongation to the southeast, where its recent trace is equally clear on aerial photographs but where access is more difficult.

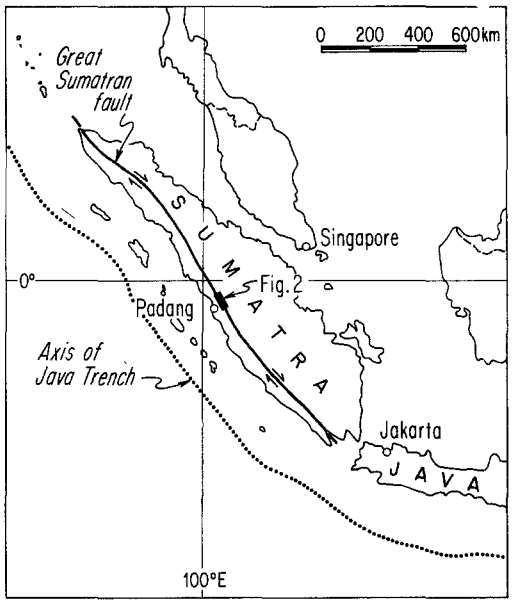

FIG. 1. Index map of part of southeast Asia, showing relevant tectonic features and location of Figure 2.

The absence of previous field reports of the 1943 earthquakes is partly due to the fact that they occurred shortly after Japanese occupation during World War II. Tjia and Posavec (1972) mention the $M_S = 7.6$ earthquake in connection with the possibility of minor fault offset on a transverse fault near Salayo (Figure 2), but even if true, this was clearly not the principal causative fault. Their map shows a great multiplicity of parallel and cross-cutting active fault strands in the Solok region, whereas both the neotectonic relationships and the 1943 rupture instead suggest to us that in most areas there is a single primary active trace, similar to other major active faults worldwide (Allen, 1965, 1975). Indeed, it was the identification of this principal trace on aerial photographs that permitted the field investigation. Particularly obvious is a continuous linear scarp, generally up on the southwest, cutting recent alluvium of the Sumani River Valley from Saningbakar southeast to near Kota Baru (Figure 2)—roughly coincident with the "horst" of

Tjia and Posavec (1972). On the other hand, considerable fault complexity does occur near Danau Dibaruh, where the fault abruptly changes trend and is locally associated with an appreciable vertical component of displacement. Massive landsliding athwart the fault trace in this area caused significant loss of life here in 1943.

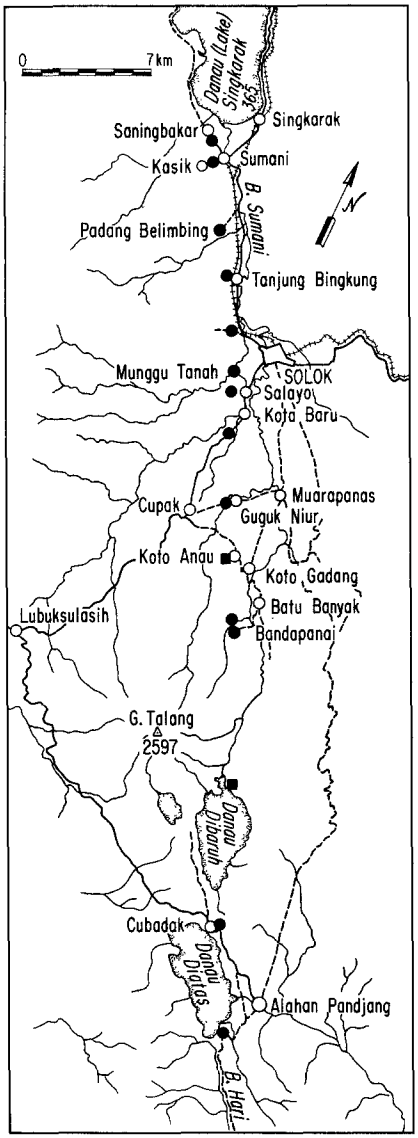

FIG. 2. Sketch map showing localities (solid circles) where local residents reported fault displacements during the 1943 earthquake. Solid squares are localities of major landslides athwart the fault trace. Open circles are towns and villages. Heavy solid lines are main roads; dashed lines are secondary roads.

Most of the same area was shaken by two damaging earthquakes on 28 June 1926, as documented by Visser (1927). Although he reported no surficial fault displacement, the most strongly shaken localities in the Solok region were clearly concentrated close to what we now recognize as the active trace of the Great Sumatran fault. Furthermore, at the three northernmost interview localities near

Danau Singkarak (Figure 2), elderly local residents report that cracking in 1926 occurred along exactly the same line as that of the subsequent displacement in 1943. The feature was described primarily as an open fissure, with no recollection of strike slip, although memories of the 1926 event are obviously faded. Farther south, credible local witnesses report the absence of surficial fault displacement in 1926. Thus it appears that there was some overlap between the fault ruptures of 1926 and 1943. Inasmuch as cities north of Danau Singkarak reported significant damage in 1926 and not in 1943, the center of activity in 1926 appears to have been farther northwest than that in 1943. Somewhat like the 1943 sequence, the 1926 sequence also comprised a doublet of two events ($M_S = 6\frac{3}{4}, 6\frac{1}{2}$) a few hours apart, with the second event centered still farther northwest. Perhaps in both the 1926 and 1943 sequences, the fault broke sequentially from southeast toward the northwest, with the initial earthquake effectively triggering its subsequent doublet. Although Gutenberg and Richter (1954) locate the 1926 events offshore of Sumatra more than 150 km to the west, both the damage and the surface faulting indicate that these were centered instead near Danau Singkarak.

Numerous other large earthquakes have occurred in Sumatra during the period which is still within the memories of local residents (Katili and Hehuwat, 1967). The present very brief study indicates how revealing such information can be, how remarkable are the memories of people who spend their lives in one small area, and how important it is that such information be gathered before it is too late.

ACKNOWLEDGMENTS

In performing our field work in Sumatra, we appreciate the encouragement and support of John Katili, Director General of Geology and Mineral Resources of Indonesia. Hiroo Kanamori helped us considerably in the seismological interpretations.

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GEOLOGICAL RESEARCH AND DEVELOPMENT CENTER
JALAN DIPONEGORO 57
BANDUNG, WEST JAVA, INDONESIA (M.U., N.B., E.K., U.)

SEISMOLOGICAL LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA 91125 (C.R.A.)
CONTRIBUTION NO. 4108

Manuscript received 10 October 1984