

PRELIMINARY REPORT ON THE TABAS, IRAN

EARTHQUAKE OF SEPTEMBER 16, 1978

by

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INTRODUCTION

At the invitation of the Institute of Geophysics, University of Teheran, the authors traveled to Iran for the purpose of investigating the Tabas, Iran earthquake. The shock occurred at 15:35 GMT (6:35 PM local time), September 16, 1978. Together with Drs. B. Akasheh and I. Eshghi of the Institute and V. E. Adler, Scientific and Technological Attache of the U. S. Embassy, Teheran, we visited the epicentral region of the earthquake on two occasions (see attached map). The purposes of the investigation were twofold. The first was to determine whether surface rupture had developed during the event, and if so, what was the geographic extent, the type of tectonic movement, and the amount of displacement of the earth's surface. The second was to obtain as much seismological information as was available.

Seismological Observations:

The Institute of Teheran located the epicenter of the earthquake at 33.18° N. Lat. 57.4° E. Long. The National Earthquake Information Center placed it at about the same location, 33.21° N. Lat. 57.39° E. Long. and a magnitude of 7.7  $M_s$ . (Oral communication with W. Person, November 8, 1978).

Data on shaking intensity in villages in the epicentral region based on the nature and extent of structural damage was made a few days before our visit by B. Akasheh and I. Eshghi. The village of Khosro-abad, about 7.5 km southeast of Tabas apparently suffered the highest intensity of shaking. Although several villages were within the intensity IX to X contour Khosro-abad was found to be more closely located to the surface ruptures (discussed below) than any other. Dr. Akasheh also observed that the relatively close contour spacing suggested a shallow focus earthquake. An isoseismal map (see figure) was prepared, using their data as well as information on the location of surface faulting. Most of the other heavily damaged villages were also located near surface faults which corresponded to the region of strongest shaking.

Dr. C. Scholz, Lamont Geological Observatory, and Messers Berberian and Ashud, Cambridge University, collected aftershock data in the epicentral region. A strong motion record of the main shock was obtained in the village of Tabas by officials of the Plan and Budget Organization of the Iranian government.

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With regard to unusual premonitory occurrences, in the village of Dehuk, on the east side of the Shotori Range many people reported lightning-like illumination of the sky in the direction of the mountains. However, villagers in and around Tabas noted no such effect.

Dr. Akasheh of the U. of Teheran, Institute of Geophysics, provided the following aftershock information:

First 10 hours after main event	-	54	aftershocks
Next 24 hours	-	73	"
Next 24 hours	-	72	"
5 next 24 hour periods	-	40 to 30	" each period

Magnitude of the largest aftershock -- less than 5.5; lower magnitude limit unspecified; aftershocks recorded at distance of about 400 km. from epicenter.

#### Casualty Information:

Casualty figures provided by the Red Lion and Sun during our visit to Tabas were as follows:

<u>City</u>	<u>Population</u>	<u>Dead</u>	<u>Percentage Dead</u>
Tabas	13,000	9,000	70%
Dehesk	3,500	2,500	71%
Khosro-abad	1,500	800	53%
Kurit	3,500	2,000	57%
Dehuk and Bazsg	2,500	100	4%
Asafahk (near Abbasabad)	1,000	100	1%
Boshruyeh	10,000	20	.2%
Villages near Tabas	1,000	100	1%
Gharan - (SW of Tabas)	600	200	33%
	<u>36,600</u>	<u>14,820</u>	<u>40%</u> (region)

#### Geological Observations:

Two separate trips were made to the Tabas region. During these trips, rupture zones exhibiting thrust fault characteristics were found to be discontinuously distributed along two main belts on the west side of the Shotori Range and slightly east of the towns of Tabas, Deshtak, Khosro-abad, and Kurit.

In our first trip, October 8 - 11, the Iranian Army Air Force provided about 2 hours of helicopter flight time, during which we discovered two separate strands of thrust faulting to the east of the towns mentioned above and also proved that candidate faults within the Shotori Range, where the preliminary instrumental epicenter from WWSSN stations was located, had not moved during the earthquake. The surface ruptures located from the helicopter were inspected on the ground surface.

The second trip to Tabas and vicinity on October 18 was by air from Teheran. On the basis of air photo linears we suspected additional faulting farther southeast of Tabas, and through the efforts of V. E. Adler, we obtained permission to fly a U. S. Embassy aircraft to this region. During this flight we discovered much additional faulting along the photo linears whose surficial expression, as judged from the air, was nearly identical to the thrust faults that had been examined on the ground. The length of these ruptures, when added to those found earlier, amounted to about 55 km. With respect to the preliminary instrumental epicentral location, the surface rupturing appears to be asymmetrically located to the north and west (unilateral faulting), but this may prove to be incorrect because of uncertainty in the real epicentral position.

#### First Trip:

In our first trip surficial faulting was observed only on the partially alluviated surface west of the Shotori Range, rather than within it. Preliminary instrumental epicenter from WWSSN stations placed the epicenter near the axis of the range, where in reconnaissance geologic mapping studies several active or potentially active fault structures had been recognized (Stocklin and Nabari, 1969).

Two surface rupture zones were found quickly by aerial reconnaissance by helicopter provided by the Iranian Army Air Force. Both rupture zones were nearly linear, oriented north-south, approximately parallel to fault structure within the Shotori range. The two zones were about 8 km apart. Both fault zones lay along the western margins of two badland areas within which highly deformed Neogene sediments were exposed. The boundaries of the badland areas are readily interpreted as old fault scarps, east side up in both cases, because the new ruptures closely followed them.

The two fault traces nearest Tabas are quite similar to one another; they consist of multiple, subparallel, anastomosing breaks that locally converge into a single or double break. Zone widths are quite variable, but widths as great as 20 m are common if the widely spaced antithetic breaks at greater distances to the east are excluded. Describing the width of rupture is nearly impossible because of the very great number of separate and isolated breaks in the upper plates of the thrusts.

At the western margins of the rupture zones uplift is uniformly on the east side relative to west. Disassembly of some of the overhanging and collapsed flaps of alluvium showed surficial dips ranging from very flat ( $50^\circ - 100^\circ$ ) to perhaps  $300^\circ - 400^\circ$ . There is no way of knowing with present data if the faults represent bedding plane slips to considerable depth. There is a strong possibility that surficial dips at some places are anomalously low from the effect of the free surface and that dips steepen at very shallow depth below the surface.

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## Second Trip:

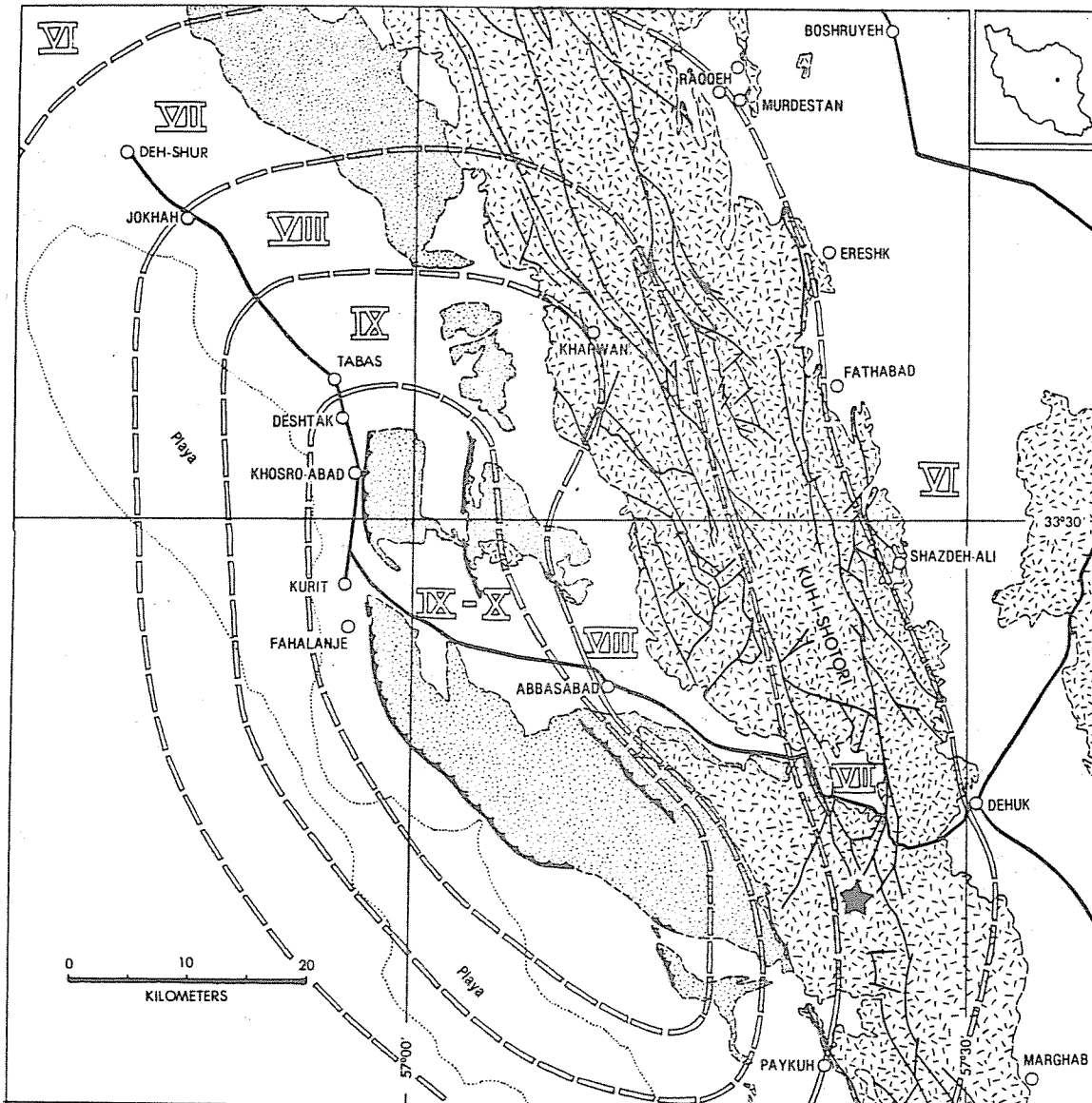
At least three additional breaks were discovered in this reconnaissance. They include the longest rupture and probably the zone of greatest displacement. The total length of all surface ruptures is at least 55 km, which includes both the earlier found and later found breaks. The newly found ruptures did not connect with the earlier found breaks but they very definitely are on line with them. We were informed by Chris Scholz after our trip that the road from Dehuk to Tabas which we drove on our first (surface) visit to Tabas, was broken in an area between the projected traces of the east and west fault breaks. Both the western and eastern lines of surface faulting were discontinuous, and the main road crossed both in unbroken intervals.

The largest vertical components of slip, probably, on the order of 1 to 2 meters, appeared to be developed along the southernmost part of the eastern break. The surface ruptures at this location reach the point of closest approach to the Sotori Range, and it is possible that the displacement there more closely approaches the displacement on the root of the thrust faults that presumably extend under the range.

## Conclusions and unusual features of this surface rupture

The thrust faulting found in the Tabas region reemphasizes an important lesson for all countries plagued with earthquake hazards. The faulting that ruptured the ground surface there clearly occurred on pre-existing but previously unrecognized fault structures. The fact that these faults were overlooked in earlier reconnaissance geologic studies underscores their innocuous appearance compared to the really obvious major geologic fault structures within and along the Sotori Range. In this regard, perhaps this faulting should be compared to the White Wolf fault movement in 1952 and the San Fernando faulting in California in 1971. In both of these examples of faulting, pre-earthquake evidence for the existence of the faults was largely ambiguous, and surficial expression of the faults was such that many geologists would have been unwilling to label them as faults with thrust components without additional evidence from the subsurface.

An especially unusual aspect of the Tabas surface rupturing, not previously elaborated upon but of possibly great engineering importance, was several broad zones of cracking and displacement on a subparallel set of fractures between the east and west thrusts east of Tabas. What is especially important here is that a region many kilometers wide and long was broken by small faults every few tens to hundreds of meters. These features suggest the possibility that the hanging walls of thrust plates are especially vulnerable to internal deformation and widespread surface rupture. The hazard posed to urbanized areas built over such difficult-to-recognize active thrust plates is obvious.



Surface faulting near Tabas, Iran. Star represents preliminary instrumental epicenter from WSSN stations. Discontinuous thrust faulting associated with the earthquake is shown by heavy barbed lines west and north-west of epicenter. Dotted pattern indicates exposed Neogene sediments. Random dashed-line pattern represents pre-Neogene sedimentary and volcanic rocks. Unpatterned areas represent Quaternary alluvium and playa deposits. Intermediate weight lines represent faults recognized within Kuh-i-Shotori (Shotori Range). Modified Mercalli intensities shown with open lines and Roman numerals. Intensity contours from data of B. Akasheh and I. Eshghi, drawn to conform with surface faulting.



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