THE TABAS EARTHQUAKE OF SEPTEMBER 16, 1978 IN EAST-CENTRAL IRAN

A PRILIMINARY FIELD REPORT

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Abstract. The largest historic magnitude earthquake of inland Iran occurred at 15H, 35M and 53.05 (GMT) on Sept. 16th, 1978. This event measured 7.7 in Richter scale and left behind over 15,000 casualties in township of Tabas, a traditional oasis at the edge of east Iranian desert. The area of total destruction extended for 1,000 km_2 along the western foot of the Shotori Range. Other earthquake effects such as fresh thrust faulting, extensive landsliding, stone up-throw and collapse of underground irrigation channels were observed within the mezoseismal area. A principal contraction to the east could be taken as the causative agent, which is in accord with the general tectonic regime of the area.

Introduction

On the 16th of September, 1978, a destructive earthquake of $M_S = 7.7$ occurred in Tabas area, east central Iran (Figure 1). This shock killed over 15,000 people and caused total destruction in an area of 50 by 20 km in dimension along the western foothills of the Shotori Range. The mezoseismal intensity did not exceed IX on the Mercalli Scale and the preliminary epicenter given by USGS - (33.21N, 57, 35E, D = 33 km) and AEOI both fall at a distance of 40 to 50 km to the southeast of the macroseismic epicenter, outside the area of maximum damage (Figure 2). For AEOI's instrumental epicenter, a total of 23 stations in Iran were used, which resulted in the following parameters:

Origin Time (GMT) : 15 H 35 M 53.05
Latitude : 33.35 N Longitude : 57.40 E
Depth : 5 km Magnitude : 7.7.

The Tabas plain, Shotori Range and northern Lut desert are major geomorphic elements of the area. The Shotori Range is a north-south running, fault bounded, strongly tectonized and uplifted feature between two regions of considerable rigidity, known as Lut and Tabas blocks (Stocklin, 1968).

In contrast to the general seismicity of most parts of eastern Iran, there is no documented historic shock near the epicentral area of this earthquake. In the 20th century, a few instrumentally located events of small magnitude were observed about 40km to the north of Tabas,

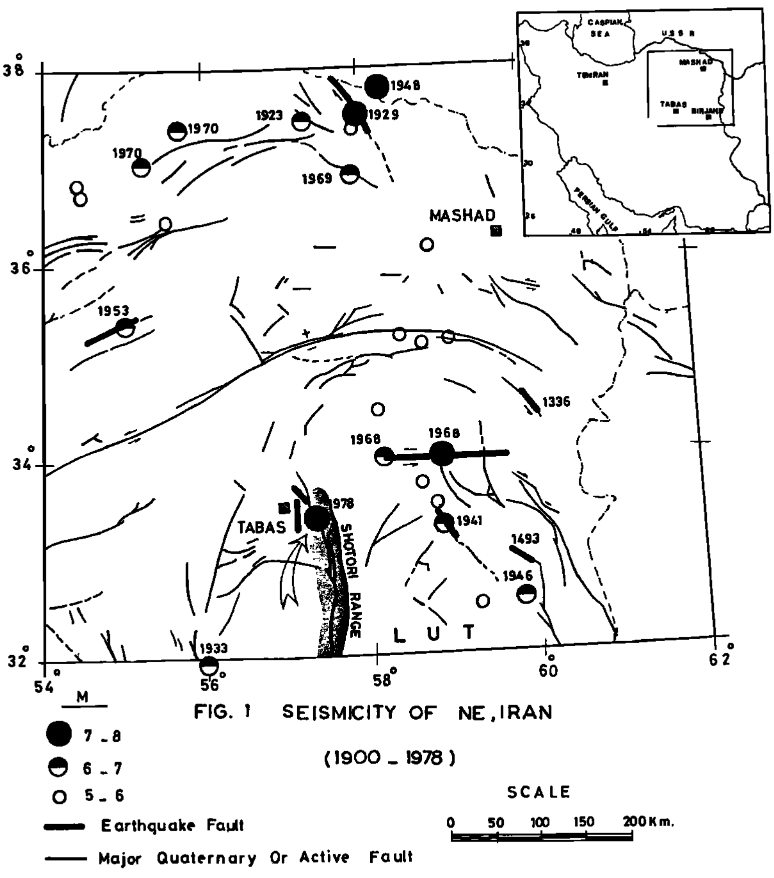

FIG. 1 SEISMICITY OF NE.IRAN (1900 - 1978)

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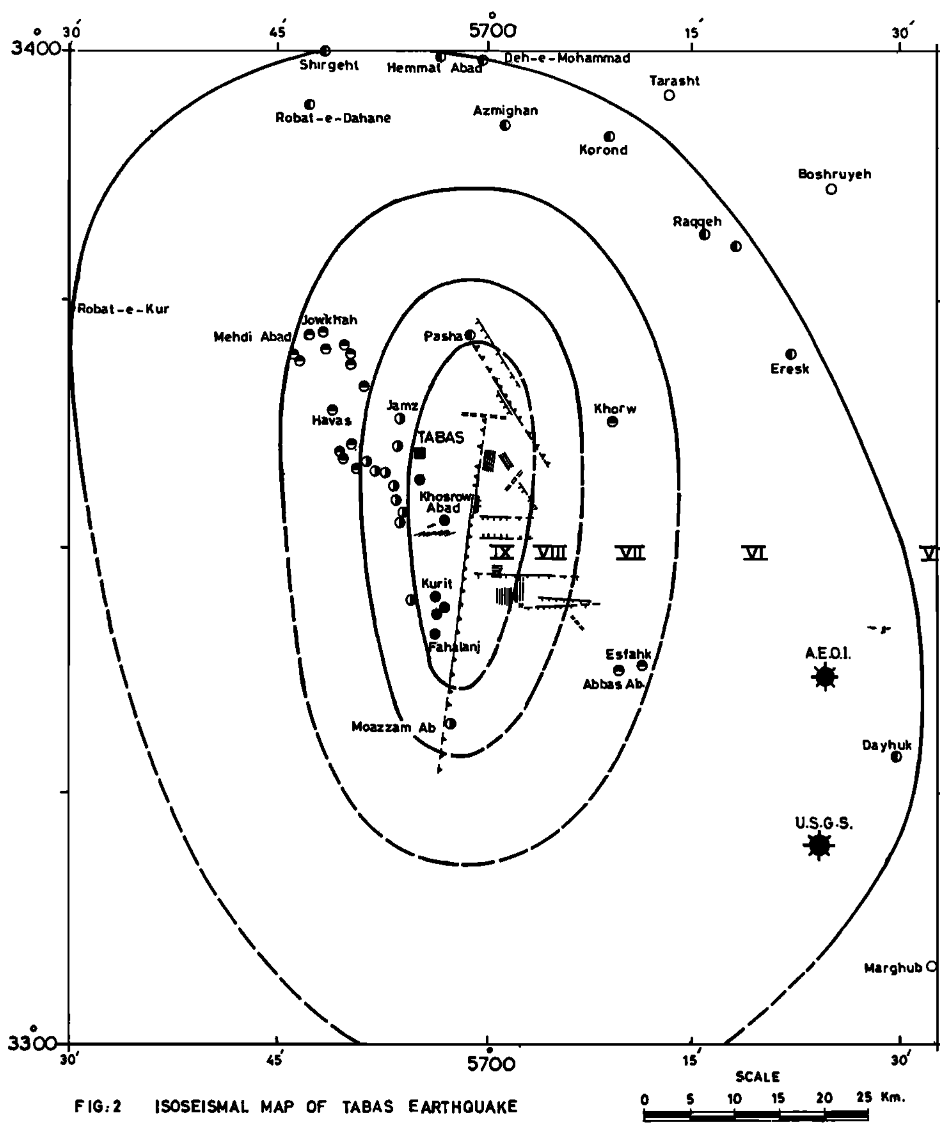


FIG:2 ISOSEISMAL MAP OF TABAS EARTHQUAKE

SEPT-16-1978

Fig. 2. Isoseismal map and fresh faulting and fracturing associated with the Tabas Earthquake of September 16, 1978.

- Instrumental epicenter
- Villages with total destruction
- Villages with major damage or destruction
- Villages partially damaged
- Villages slightly damaged
- Strongly felt no damage
- Fresh and reactivated thrust faulting
- Secondary fractures and faulting

which are insignificant compared with the severe earthquake experienced in adjacent active areas such as Torbat-e-Heidarieh in 1923, Birjand in 1946 and Dasht-e-Bayaz in 1968 (Figure 1). Nevertheless, on the basis of neotectonic considerations the Tabas area was designated as having the potential for severe damage, on the seismic zoning map of Iran prepared by Mohajer-Ashjai and Nowroozi (1978).

Post earthquake observation in Tabas area consisted of aftershock monitoring for a period of one month and observation of earthquake effect in terms of surface faulting and damage distributions. An array of 9 portable stations was installed in the epicentral area 4 days after occurrence of the main shock. Over 50 events were recorded daily and initial location of 300 well recorded aftershocks show a random distribution over an area of 60 by 40 km along the western foothills of the Shotori-Range where the fresh faultings were observed. The full results of this work will be published separately.

Earthquake Effects and Damage to Structures

The traditional building style is based on easily available sun dried clay bricks and heavy arch roofs, which totally destroyed within the mezoseismal area. The only exceptions were a few dome structures, locally used to cover water storages. Traditional architecture and the historic style of housing in the town of Tabas were among the archeologically protected areas of Iran. Therefore, most of the

Fig. 3 Maximum offset of fresh faulting observed in the field. (Measured throw is 30cm across a low angle thrust)

Fig. 4 Rejuvenation of a Quaternary fault 3.5km east of Tabas.

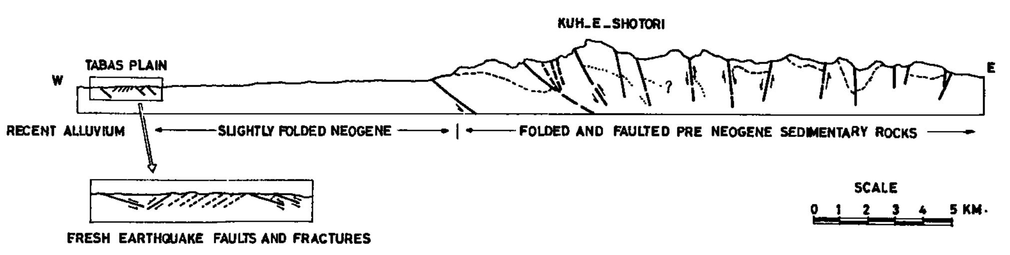
houses in this town were several hundred years old and the oldest mosque of the town has apparently survived for 700 years with no serious damage. This is another indication for lack of previous seismic activities, or possibly a very long return period for major shock around the Tabas area. Apart from houses built in the traditional style, the area contains some better built, masonry schools, three small bridges, a new hospital, and a few elevated metal water tanks. Although, these engineering structures were not specially designed for major earthquakes, none of them had total collapse or were as badly damaged as the traditional building. Among other important earthquake effects were collapse of underground irrigation channels and extensive land sliding. In several cases, stones were thrown up and over turned near Tabas and Kurit, indicating high vertical acceleration in the order of 1.0g.

Fresh Faults and Fractures

Several sets of fresh faulting and fracturing appeared on the ground surface within the area of maximum damage, some of which could be of vibratory nature. The most prominent fresh faulting was observed 2.5 km east of Khosrow-Abad and 4 km east of Dehashk, which extend at NIOE for about 40 km showing a pure thrust movement with throw of about 30 cm (Figure 3). Up to 11 parallel sets of similar but smaller faults and fractures were developed all within a belt of about 2 km wide. The most westerly member showed over-thrusting of the eastern block over the west along a low angle fault plan dipping 15 degrees to the east. At about 600 meters towards the east, another prominent fresh fault showed a reversed sense of dip-slip across which the western block over-thrusted the eastern one along a 29 degree dipping plane. The later faulting was conspicuously related to rejuvenation of an important Quanternary thrust fault showing cummulated offset of 170 cm with a total throw of 100 cm (Figure 4). A typical cross section of the above fault system indicated several horst blocks uplifed by thrust movements in opposite directions (Figure 5). Similar but much larger scale tectonism was observed in older geological formations within the Shotori Range (Stoklin, et.al., 1965).

Another set of thrust faulting and fracturing was observed 5 km northeast of Tabas airport, striking at N40W with dip angle of about 30 -

FIG. 5 SCHEMATIC STRUCTURAL SECTIONS THROUGH SHOTORI RANGE



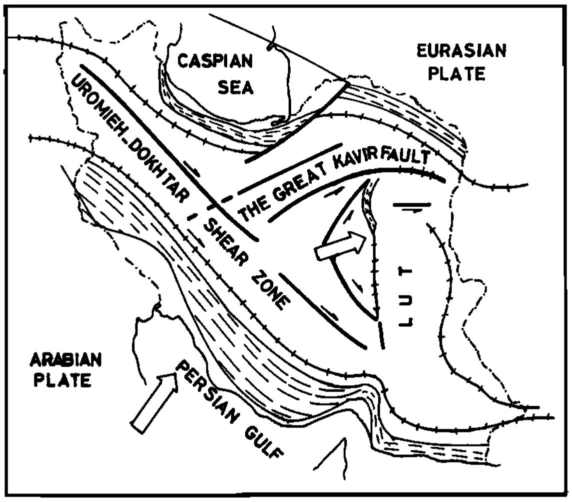


FIG.6 NEOTECTONIC MODEL OF IRAN

MAJOR OROGRAPHIC BELT

CONTRACTION BOUNDARY

MAJOR SHEAR FAULT ZONE

COMPRESSIVE MOTION

degree to the northeast. This fracture system closely follows the western flank of Neogene anticline at the foot of the Shotori Range. A series of tension and secondary fractures occurred randomly in northern and central parts of the damage area mainly at E-W to NE direction.

Conclusions and Neotectonic Implications

The Tabas earthquake of September 16, 1978 is not only the largest event of inland Iran, but it is one of the most complicated shocks observed in recent years. Initial evidence such as considerable distance between instrumental and macroseismic epicenters, complex pattern of fresh faulting and fracturing and inconsistency of first motion polarities on stations within Iran, would indicate multiple sources for this event, which seems to be compatible with the neotectonic model of the area.

In explaining the regional fold and thrust structures of Shotori-Range and Neogene foothills, Mohajer-Ashjai, et.al. (1975) have assumed a major contractional force ranging from east to the northeast direction, as the causative agent. The same tectonic force should explain for the earthquake effect observations. It is likely that the tectonic developments of Shotori-Range and particularly, the foothills Neogene folding continues.

The implication of the earthquake associated movements in Tabas area on the regional neotectonic model fits the sense of motions observed in other parts of Iran. The relative motion of the Arabian with respect to the Eurasian plate seems to be the prime source for contractions in eastern Turkey and Zagros as well as subsequent horizontal motions of Western Turkey and central Iran (Nowroozi, 1972, and Takin 1972). As noted by Mckenzie (1972), observed dextral movement along the North Anatolian fault, coupled with subduction at the craton arc, requires a sideway movement of the Western Turkish plate to the west, in order to escape the northsouth compression between Arabia and the Causasus. A somewhat symmetrical situation seems to occur for Central Iran, which moves eastward, with dextral movement along the northwest striking faults, which includes the Main Recent Fault system of Zagros, Uromieh Dokhtar dextral shear Zone (Khoury and Mohajer-Ashjai 1978), and Kuh-Banan fault; and sinistral movement along ENE fault system, of the Great Kavir (Doruneh) fault and Shahrud fault complex (Figure 6). The faults mentioned above are, however, only samples of a much more extensive population of faults which prevade the whole of Iran and subdivided the "plates" into subplates and the subplates into minor blocks. On a more local scale, the Lut and Tabas blocks appear as masses within the interior of the Central Iran that move even further to the east and could have given rise to the Shotori-Range and the recent large magnitude earthquake in Tabas area.

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