An Earthquake Engineering Study of the Buyin-Zahra Earthquake of September 1st, 1962 in Iran.

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Abstract. The first instance of major faulting in Northwest Iran was provided by the earthquake of September 1, 1962. A field study (2) of the event showed that:

i) Contrary to the existing beliefs, the Ghazvin area is highly seismic, and that this area borders Tehran.
ii) The immediate vicinity of the fault-break exhibited lower intensities than regions at some distance from the fault.
iii) The results of a fault-plane study agree remarkably well with the field evidence.
iv) A study of the damage caused by the earthquake pointed to the urgent need of improving, rather than replacing, local building materials and methods of construction.
v) During the eighteen months following the earthquake, the fault-break appears to have crept considerably.

Introduction.

The Buyin-Zahra earthquake of 1st September 1962 originated in the Ghazvin basin at a point about 90 miles west of Tehran. The earthquake killed 12,000 (3) and injured 2,800 persons. It damaged beyond repair 21,300 houses and killed 35% of the livestock in the area.

The main characteristics of the earthquake and of its after-shocks are summarised on Table 1. Accounts of the effects of the earthquake have been published in a number of papers and reports; Ambraseys (1)(2)(3)(4), Abdalian (5), Mohajer (10), Omote (13).

In the following, we shall discuss briefly certain aspects of the event.

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(2) The epicentral region was visited by the writer on a Unesco mission in September-October 1962 and in April 1964. This paper is published by permission of the Unesco Paris, and it should be considered as representing the writer's views only and not necessarily those of Unesco.

(3) Variously estimated by different observers: Abdalian (5) 9,136; Mohajer (10) 15,000 etc.

The Seismicity of the Ghazvin Area.

Our knowledge of the seismicity of the Ghazvin area(34°½ to 36°½N and 48°½ to 51°E), and in particular of its central part, the Buyin region (35° to 36°N and 49° to 50°½E), is remarkable for its incompleteness.

A number of studies, based on instrumental data for the period 1909-1957, failed to reveal any significant seismic activity in the area, consequently the Buyin region had been classified as one of the least seismic regions in Iran, Peronaci (14), Abdalian (5, p.13). It seems very probable that the Buyin region was in fact quiescent for over 100 years and that no earthquake as strong as that of 1962 had occurred for at least two centuries.

But from the seismo-tectonic point of view, the whole of the Ghazvin area, which includes the Buyin region, is located in the centre of the alpine fold. It has undergone intensive tectonic movements in the Eocene which have continued to recent time (8). The area has been subject to considerable Quaternary uplift elongated along the strike with local linear subsidences marked by steep gradients, numerous fractures and renewed movements on ancient faults.

We find evidence of this activity in the considerable number severe earthquakes that have occurred in the Ghazvin area, particularly during the paroxysmal period between the IXth and XIIIth centuries and in the correlation of these earthquakes with structural features. Indeed, the Ghazvin area as a whole, and the Buyin region as part of it, is one of the most seismically active areas in Iran.

The material that we used for the investigation of the seismicity of the Ghazvin area is rather limited, (7)(9)(14)(15)(17)(19)(20)(21). For the period 1924 to 1963, epicentres both macroseismic and microseismic, which seemed to have an undoubted origin in the area and about it, and for which sufficient information was found, are plotted on Figure 1. This figure covers an area much larger than that of the Ghazvin basin. An additional 100 earthquakes for the period 830 to 1923, have been excluded. Many of these omitted may have been genuine earthquakes, but the evidence at our disposal

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(4) Mohajer (10) suggests that the numerous ruins of villages revealed by the photogeological studies carried out in this region before the earthquake indicate the results of earlier earthquakes. These ruins were noticed also by the writer. His inquiries showed that these ruins were not caused by earthquakes; the sites were merely deserted by their inhabitants after the local ghanats (underground water supply gallaries) had dried out.

was insufficient to place their location and nature beyond doubt. However, the location of the regions which were devastated by earthquakes between 830 and 1872 is shown on Figure 1.

A striking difficulty with the regionalisation of Iran is the total lack of macroseismic information. Press reports are difficult to interpret and hard to find; questionnaires and specific reports on earthquakes are restricted for the period after 1959. Consequently, before 1959 written evidence referred for the most part to widespread disasters and, since small earthquakes were never reported, only the macroseismic evidence of the large earthquakes is traceable.

As a result of this, it was not possible to correlate macroseismic with microseismic data. For the earthquakes with $7\frac{1}{2} \geqslant M \geqslant 5$ which occurred after 1935 the following relation between magnitude and intensity was derived:

$$M = 0.65(I_0) + 1.3 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

The analysis of a number of earthquakes that occurred after 1956 shows that focal depths increase around the Caspian sea area. The most rapid increase in depth follows a direction at right angles to the general strike of the fault-system of the area (i.e. from SW to NE). Focal depths near Hamadan were found to vary between 6 and 20 kilometres, while north of the Elburz mountains depths of over 60 kilometres were not uncommon. In general it is believed that earthquakes in the Ghazvin area are very shallow to superficial and that the largest of them are of the thrust type.

The generalised isoseismals of the area are shown on Figure 1, and they have been constructed on the basis of the material available after 1933. These lines also contain the regions which have been devastated by old earthquakes (in Hamadan, Ghazvin, Shah-Rey, Demavend and Mazanderan). This suggests an intensive seismic activity, probably interspersed with periods of relative quiescence, but nevertheless continuous since early times.

If this suggestion be accepted, Tehran, a modern city of nearly 2,000,000 inhabitants, is situated in a highly seismic zone. Admittedly, the seismicity of the Tehran area proper is not well known. The fact, however, that Shah-Rey, an old city situated a few miles from Tehran, was destroyed four times in its history suggests that on the basis of the data available there are no valid reasons to believe that Tehran is free from the hazard of severe earthquakes.

An attempt to find the "unit energy" (5) distribution for the Ghazvin area gave isoenergetical contours identical with those of the generalised isoseismals. Heavy figures in the upper left corner of each square of the grid in Figure 1 refer to the unit energy released by earthquakes with focal depths of less than 25 kilometres during the last 40 years in the square.

Deformations Accompanying the Earthquake.

The first instance of major faulting accompanying an earthquake in Northwest Iran was provided by the shock of September 1, 1962. The fault-break and its branches run for 64 miles, from Ipak (50°45'E 35°59'N) to Takhrijin (35°62'N - 49°21'E) about N-85°-W, Figure 2.

During the earthquake and its aftershocks, at least 64 miles of surface rupture occurred progressively along this line, and at least two stages of progressive surface faulting were involved. As a matter of fact, the analysis of the seismograms recorded in Tehran indicates that the main earthquake was composed of a series of shocks closely spaced together, Ambraseys (4), Abdalian (5,p.77). Also, statements from reliable observers in the epicentral region indicate that during the earthquake the ground movements were interrupted by sadden pauses. Probably, during the first stage of faulting the fracture reached the surface along the 35-mile length of the eastern branch of the fault. In the second, or, in the following stages, the fault-break progressed on the surface westward completing the observed fracture of 64 miles.

In general, the fault trace was modified very little by the topographic features. On rock the throw did not exceed 7" and the slip 3", Ambraseys (3,p.731; 4). On talus and on weathered rock formations the throw reached a maximum of 30" with a slip of about 20".

Eighteen months after the earthquake the writer re-visited certain parts of the fault-break where measurements of the net slip were made immediately after the earthquake. Rough measurements at the same points in April 1964 showed that the original movements had continued and that the throw was now on the average greater. The strike-slip did not seem to have changed, while the dip-slip was the greatest on weathered rock formations.

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(5) The "unit energy" is defined as the energy in ergs released by earthquakes per unit time per unit area.

Immediately after the earthquake certain parts of the fault-break were difficult to detect at close quarters, but eighteen months later, some of them, were easy to distinguish from some distance away, while others had disappeared altogether. With the exception of certain parts, the fault-break was found to be still very clear. Plate 1 shows the eastmost part of the fault eighteen months after the earthquake.

In 1962, the east part of the fault exhibited a strong diagonal slip with thrust from the south, and the character of the resulting motion from field evidence was quite clearly left-hand with predominant dip-slip components. The average value for the slip angle (b) on rock was found to be

$$\mathrm{arc}(\tan b) = 7''/3'', \quad \text{or} \quad b = 67^{\circ} \quad (3,\text{p.}731;4).$$

Near the east and central parts of the fault the dip of the plane of fracture from surface evidence was found to be 10° to the south (measured from the vertical) or, 80°-south (measured from the horizontal).

Near the middle of the fault-trace, both the strike- and the dip-slip became extremely small and the fault-break was obscured by a wide band of cracks running parallel with the main fault direction for over 3 miles. Most of these branch faults have now disappeared. Further west (west of Rudak), the fault-break again becomes very clear but with a slight reversal of the relative vertical movements of the blocks.

The epicentral region is a graben and the general trend of faulting is roughly east-west. The Palaeozoic and Mesozoic rocks in the northeast part of the region are thrust from the north onto the Tertiary rocks. In the south, the Eocene volcanics are thrust from the south over the Upper Red formations of Fars, Ambraseys (2)(4) Mohajer (10). The fault-break of September 1962 occurred along a set of existing relatively recent faults.

The fault movements and the mechanism as deduced from field evidence, as well as the results from a fault-plane solution obtained by Petrescu (16) are summarised in Table II. The agreement between Petrescu's solution and the field evidence is indeed remarkable.

Ground Movements During the Earthquake.

In an economically developing rural area the assessment of the intensity poses special problems since many of the criteria needed for the grading of the intensity are partly or even totally lacking. A typical example is the Buyin-Zahra area.

This is a sparcely populated area and with very few exceptions all houses are of adobe-brick or mud-wall construction with heavy roofs of tamped earth. There are very few properly built houses and even fewer types of other construction which could serve as a measure of the intensity.

Where properly built houses or other standard types of construction were found side by side with the adobe constructions damaged by the earthquake, it was obvious that an intensity not greater than VII (MM) was sufficient to damage beyond repair the typical Iranian rural house, while an intensity of VIII- (MM) meant total collapse for the adobe construction.

Thus, from the behaviour of the local houses alone, intensities greater than VIII- (MM) could not be assessed. There were no underground water pipes, wooden houses, or other types of construction whose damage or destruction due to vibrational effects would help to assess intensities greater than VIII- (MM). The value of fissures and of landslides as items that help to determine higher intensities were found to be questionable. In most cases it was practically impossible to determine how strong or how slight a ground movement would be sufficient to produce these effects.

Other difficulties were the language barrier and the large number of villages deserted after the earthquake where there was no one to interview. Moreover, there was no response to the questionnaire sent out by the seismological observatory in Tehran.

These difficulties meant that personal reactions during the earthquake were extremely unreliable in many parts of the region, a fact which added to the uncertainties involved in the assessment of the intensity. Thus, in assessing the intensity of the Buyin-Zahra earthquake without the benefit of the proper test items, personal observations led to unduly subjective interpretations.

In general, it was found that the (MM) intensity scale failed to be adequate for regions such as of rural Iran. In order to make this scale useable, additional criteria based on statistical elements, such as percentage of fatalities and damage per unit area had to be added, Ambraseys (3)(4).

The maximum intensity based on vibrational effects in the fault zone did not exceed VIII (MM), but with a minimum of VI (MM). By including important non-vibrational effects, the maximum intensity was rated at IX- (MM).

Although intensities in the fault zone were variously estimated by different observers, Mohajer (10) VIII (MM), Omote (13) IX (MM), Abdalian (5) IX+ (MM), there can be no doubt that on a statistical basis the maximum intensity was rather low, varying within short distances by as much as two degrees. Near the fault-break, this variation produced a striking anomaly in the intensity distribution; specifically, that a zone bordering the fault-break showed definitely lower intensities than areas further away from the break. Many villages and settlements situated on bed-rock a few hundred feet from the fault, particularly those situated on the footwall, showed intensities far smaller (VI) than those situated on alluvial ground (VIII). A few miles away from the fault-break this difference betwee alluvium and bed-rock was not so marked and in many instances there was no difference in intensity between two neighbouring sites, one on alluvium and the other on bed-rock.

Within the epicentral region the variation in damage, and hence in intensity showed inexplicable anomalies. On a statistical basis, damage was much more closely related to the type of the ground rather than to proximity to the fault-break.

The manner in which identical structures were damaged near the fault-break and at some distance away from it suggests that the ground movements in the immediate vicinity of the break should have been of very high frequency. It is of interest that waves in ponds and in small reservoirs were noticed throughout the area, except near the fault zone. Some ponds situated 10 to 30 miles from the fault lost a third of their water content in an east-west direction. Water waves in ponds were reported from places up to 110 miles from the epicentre. But near the fault zone all reports were negative.

The tacit assumption, therefore, that in the vicinity of a fault break the ground motions may not reach their maximum intensity seems, in this case, to be tenable.

<u>Regional Conditions and Damage</u>.(6)

The great destruction and the large number of deaths caused by the earthquake was largely due to the poor construction methods and materials used for the building of houses. This is by no means typical of rural Iran. In areas not deeply affected by the industrial revolution, as in most of the North African countries and in Asia generally, house design and construction carries on traditions frequently centuries old. Thus, in Iran, the bulk of the rural housing is constructed using strictly local materials and with local workmanship. Flat roofs, thick adobe walls, and small windows for

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(6) See also: Ambraseys (1)(2)(4), Despeyroux (6), Moinfar (11)(12), Zare (18)

insulation, are characteristics of the local traditional architecture, dictated by climatic conditions and village life. Millions of people live in houses of this type, and in them, thousands lose their lives every year from earthquakes.

The problem of improving the earthquake resistant qualities of this type of construction is not an easy proposition. These houses are usually jointed to each other on at least three sides forming a bee-hive structure. Streets are very narrow and crooked. Walls, of adobe or tamped earth, are usually built directly on the surface of the ground. The usual method of making adobe in Iran consists of wetting a quantity of soil in a pit or on the surface of the ground, which is then trampled with bare feet. Sometimes a small quantity of straw or hay is added during trampling. The addition of straw helps to prevent shrinkage cracks during the curing process but does not add any structural advantage. The crushing strength of some of the adobe bricks tested from the Ghazvin area varies from 250 to 600 lb/in^2. However, when improperly cured they disintegrate after a rainfall.

The adobe bricks are laid in a mortar of the same material whose quality is as a rule inferior to that of the bricks. Then the wall is finished with a coat of "kharghel" (adobe containing large quantities of straw) or sometimes with gypsum or lime plaster.

Roofs as a rule are made of adobe bricks in the shape of domes. Thin wafer adobe bricks are used and are of better quality in general than those used for the walls, Plate 2. Cylindrical vault roofs are also used.

Where timber is available, flat roofs resting on trunks of poplar or other kinds of timber are used. The trunks are usually placed directly on the adobe or mud-wall and are covered with branches and foliage on which adobe mud is placed in great thickness and then tamped, Plate 3. Flat roofs are in general preferred to domed ones because they can be used for drying crops, storing fuel and for sleeping in the summer.

For plastering the outside of an adobe house "kharghel" is used. Apart from its insulation properties, it adheres to the adobe bricks, it is light, waterproof and can take considerable amount of deformation before it cracks. It also protects the mortar joints from erosion by rain and wind.

Adobe houses in the Buyin-Zahra area were found to have undergone extensive repairs before being damaged or destroyed by the earthquake. The main defect of these houses is the deterioration of their walls near the ground. In many cases damaged or destroyed walls near their foundation were thickened by adding adobe, thus forming a continuous counterfort. Where repairs were required in supporting the flat roof these were carried out by propping it in the middle with timber or supporting the end beams with pillars of mud-bricks. In many instances this type of repair was required because the timber cutting into their supports crushed the adobe walls upon which they rested.

The earthquake of September 1, 1962, destroyed or damaged beyond repair 21,310 houses of this type, leaving over 25,000 families homeless. This great destruction caused by the earthquake was mainly a result of the poor construction methods and materials which allowed bearing adobe-walls to spread apart and heavy roofs to collapse crushing the inhabitants within.

The use of adobe bricks for building in many countries in Asia results partly from the scarcity of timber, partly because of the ease of construction and partly because of its insulation value. The physical properties of adobe bricks when tested as a building material indicate a strength suitable for one-storey houses. When properly constructed, a single-storey (1+0) adobe house, with a light roof, is more earthquake resistant than brick or stone masonry construction, laid in poor mortar.

After the earthquake it became apparent that it was economically impossible to replace adobe brick by any other building material in quantities sufficient to cover the needs of constructing 21,000 houses.

After an earthquake disaster, the need for a drastic change away from traditional materials and methods of construction poses enormous economical and special problems which many developing countries have tried to solve with varying degrees of success so far. But in the most successful cases of reconstruction in Asia and in the Middle East no more than 20% of the destroyed houses were ever rebuilt with new methods and materials. For the remaining houses the traditional methods and the local materials had to be used.

The improvement of the local building materials and methods of construction for permanent housing is, therefore, of great importance. In the case of the Buyin earthquake the following simple ideas for improving the adobe construction were suggested.

Adobe brick walls should be built on solid waterproof foundation or else the capillary rise of ground and rain water will cause the lower courses of adobe to disintegrate with time. For this purpose the first few courses of the wall should be built of properly baked bricks with lime mortar, and the exterior face of the wall should be plastered with "kharghel".

Improving the strength of adobe bricks by admixtures or impregnating them with stabilisers is better than replacing them by improperly baked kiln-bricks whose strength will depend on the quality of the poor mortar used.

Mud-walls layed by hand in courses are in general very weak structures, particularly when big stones or pieces of wood are embedded into them in the belief that these will bond the mass. Mud-walls should not be considered as load-bearing walls since they are a potential danger to safety under earthquake conditions.

Domes made of wafer adobe bricks, resting on robust walls constitute an adequate method of roofing. Timber beams for the construction of flat roofs can be used effectively provided that they are properly anchored to the walls and rest on a timber spreader or on a continuous wall plate. However, since the Buyin region suffers from termites, timber must be used with caution. The thickness of the tamped soil usually placed on the roof over branches and foliage used in lieu of boarding, Plate 4, must be reduced to an absolute minimum; or preferably replaced by slabs of compressed straw impregnated with silica and covered with asphalt.

When kiln-bricks of local construction are used, special care must be taken to ensure that both the mortar and the workmanship is adequate. With one or two exceptions, all houses built of kiln-bricks in the region (about o.5% of the total number of houses) showed that the mortar used in their construction was extremely poor, being simply pure earth mixed with water. Kiln-brick walls that collapsed due to the shock turned into a heap of rubble with all bonds between individual bricks broken clean. Brick roofs in the form of "Iranian arches" resting on kiln-brick walls were all destroyed. As R.S. J's are laid directly on the brick-work without wall plates, the beams could "open up" and the brick-arch between them consequently collapsed, or individual units of the arch were thrown to the ground.

Strengthening ordinary adobe-brick houses in an earthquake area can be achieved by girdling the structure at different levels either with steel straps (like those used in crates and packing-cases) or by steel wires. During or after construction of the house, two timber posts should be pushed into the ground side by side at each corner of the structure. Then straps or wires at four levels (above the wall plate, below the spreader, at lintel level and at ground level) should be tightened either with a lever (for steel straps) or with turnbuckles, at the four corners between the posts and then locked. A diagonal bracing of straps or wires should also be applied on the roof. The wires should then be covered with "kharghel" plaster.

This method of strengthening is inexpensive and can be applied either during or preferably after the construction and drying of an ordinary adobe house, Ambraseys (2). It can be used also for strengthening houses with walls cracked by the earthquake. In kiln-brick houses of small dimensions, the corner posts may be replaced by steel channels and the tightening elements may be steel wires connected woth turnbuckles.

Such tightening of the walls of small single-storey houses will prevent them from spreading apart during an earthquake and allowing the roof to collapse. Diagonal deformations will be resisted by the roof bracing. These methods are now being investigated in more detail, Ambraseys (4).

It cannot be sufficiently stressed how important it is to give solutions applicable to local materials and methods of construction, when considering this problem of building for earthquakes in developing countries. A purely theoretical solution based on materials unobtainable locally,financially will become impracticable and would merely result in the repetition of earthquake disasters.

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Annuals: ISS, BCIS, USCGS, also references in (3).

Explanation of Figures and Plates.

Figure 1: Preliminary seismo-tectonic plan of the Samnan-Kermanshah zone. (1) Regions devastated by earthquakes between 850 AD and 1872. (2), (4), (6), (8) Microseismic epicentres of intensity group* II, III, IV, and V respectively. (9) Microseismic epicentre of unknown intensity group. (3), (5), (7), (10) Macroseismic epicentres of intensity group* II, III, IV, and V respectively; small lines point to corresponding microseismic epicentres. (11) Fault-plane solution data. (12) Fault-breaks from field evidence. (13) Major regional fault trends. (14) Towns. (15) Villages, settlements. (16) Maximal isoseismals for the period 1933-1963. (17) Unit energy values in ergs 10^{16} per year per 100 sq.kms. Intensities in (MM).

Figure 2: Topographic and fault map of eastern part of earthquake region. (1) Fault-break of measurable deformations. (2) Fault-trace or fault-zone of comparatively small deformations and of parallel cracks. (3) Left-hand movements. (4) Vertical movements: + Up; - Down. (5) Thrust (6) Tension cracks. (7) Dip and dip-angle (average values) (8) Weak traces of uncertain origin: Ⓦ, Ⓩ probably of landslide origin; Ⓧ probably connected with "ghanaht" alignements; Ⓥ partly connected with ghanahts and partly with fault movements; zone between Ⓥ and main fault-trace is heavily fissured. Ⓨ very weak but continuous zone of shattered young basalt outcrops probably connected with

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* As defined in the USSR Atlas of Earthquakes, 1962, Akademi' Nauk, Izdatel.Akad.Nauk, Moscow.

fault movements. U complicated fault-break system. (9) Epicentre of main shock after BCIS. (10) Epicentres of aftershocks. (11) Slide and rock-fall areas. (E) Plate 1 of this paper.
This Figure supersedes figure 5 of reference 3. For details see reference 4. The fault-zone was mapped by sextant, pace-and-compass traverses, and by aneroid barometer. The fault-trace in Figure 2 of this paper differs slightly from that of figure 5, reference 3. This is due to the fact that the triangulation control system used in ref.3 has now somewhat been improved.

Plate 1 : Fault-scarp between Tangebar and Ahangeran, photographed eighteen months after the earthquake (cf. plate 2, f.3).

Plate 2 : Damaged domed roof. (A) Adobe wafer brick-work. (B) Tamped earth insulation. (C) Kharghel plaster. (D) Mud-wall. (E) Adobe brick-work.

Plate 3 : Destroyed adobe house.

Plate 4 : One of the very few adobe houses standing in Buyin. (A) Timber beams. (B) Lintel beams. (C) Adobe brick-work (D) Mud-wall. (E) Kharghel plaster. (F) Strappings.

TABLE I

Date	Time h:m:s	Epicentre	Depth (km)	M	I_o	r_o (km)
1 - 09-62	192040	35°.63N - 49°.87E	15-20*	7.2**	IX-	270
1 - 09-62	202737	35.6 - 49.9	-	4½	-	-
2 - 09-62	071203	35.7 - 49.4	-	5	VII-	-
2 - 09-62	132118	35 - 48.5	-	4	-	-
4 - 09-62	133012	35.6 - 49.9	-	5	VII-	-
13 -10 -62	102337	35.7 - 50.0	-	5½	VII	-

* Focal depth determined from macroseismic data:
Kövesligethy h = 10 km
Shebalin h = 18 km
Gutemberg h = 13 km
BCIS h = 27 km ± 9 km
USCGS h = 20 km.

** Average of 22 stations.

TABLE II

	Field Evidence	Fault-plane solution.				
	Plane	Plane	Motion Vector	Plane Action	Press.	Tension
Fault-type	Thrust	Thrust				
Faulting	Oblique	Dip-slip				
Motion	Left-hand	Left-hand				
Shock-type	-	Pressional				
Length (km)	56	-				
Strike	N-82-W	N-77-W	S-82-W	N-18-E	S-33-W	N-14-W
Dip Direct.	S-08-W	S-13-W	-	N-72-W	-	-
Dip	80	80	64	66	31	49
Slip angle	67	-	66	-	-	-

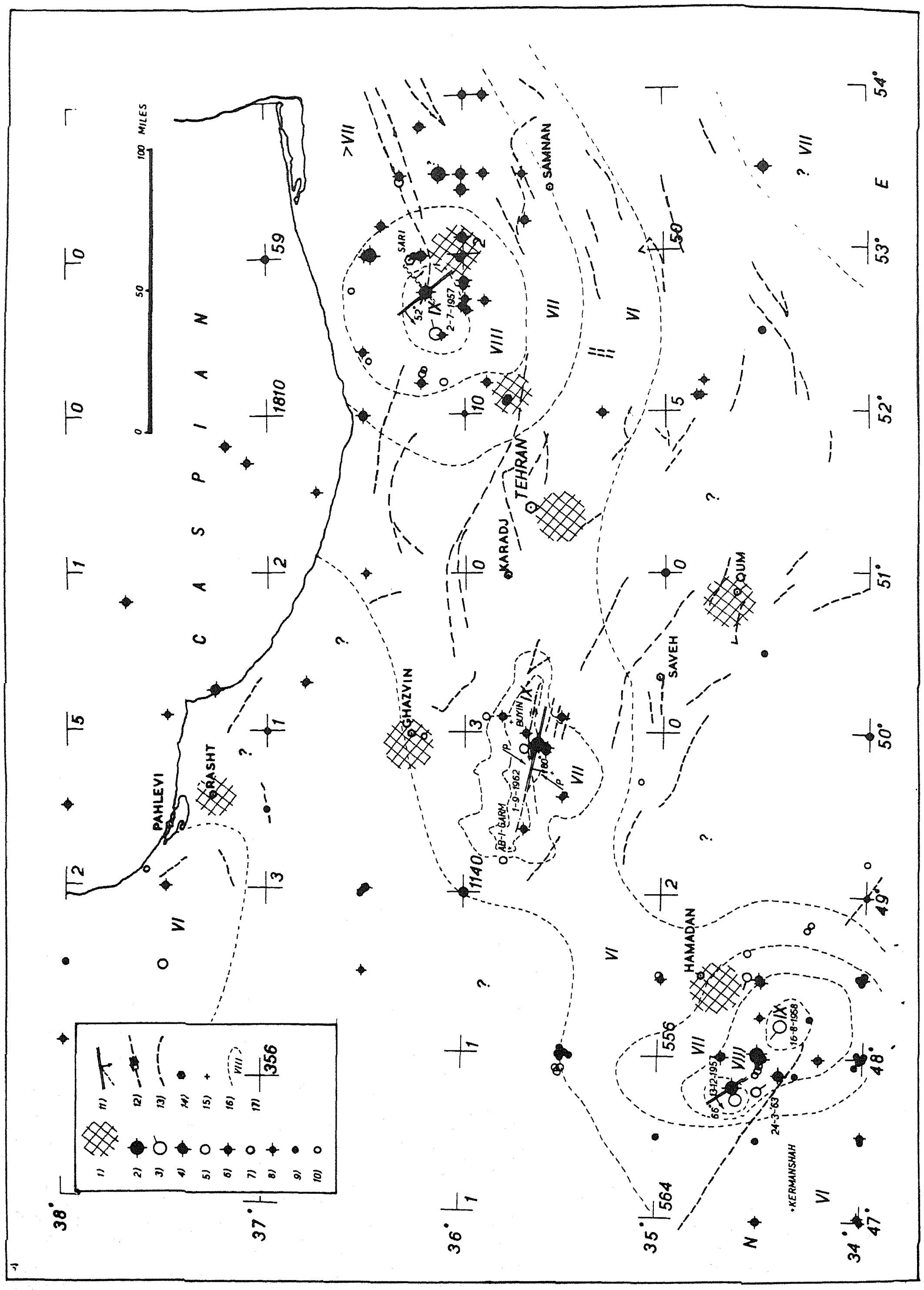
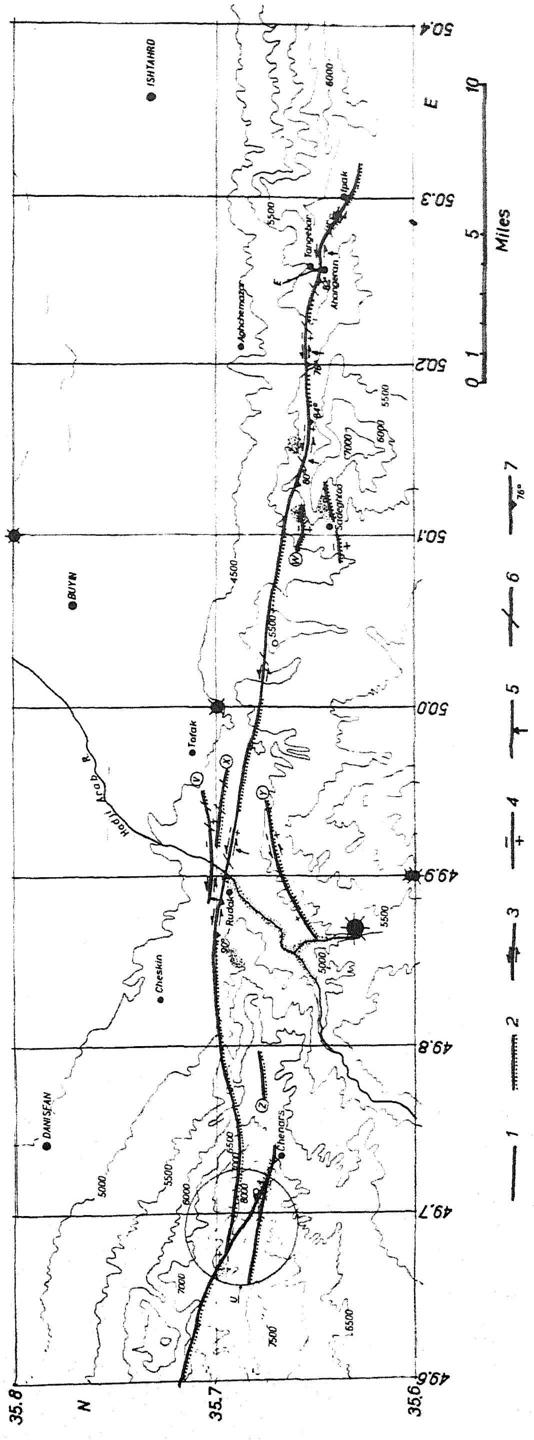

C A S P I A N
PAHLEVI
RASHT
GHAZVIN
KARADJ
TEHRAN
SAMNAN
SARI
QUM
SAVEH
HAMADAN
KERMANSHAH
AB-I-GARM
BUYIN
IX
2-7-1957
1-9-1962
16-8-1958
13-12-1957
24-3-63
VI
VII
VIII
>VII
0
50
100
MILES
38°
37°
36°
35°
34°
47°
48°
49°
50°
51°
52°
53°
54°
N
E
356
564
1140
1810
556
59
1)
2)
3)
4)
5)
6)
7)
8)
9)
10)
11)
12)
13)
14)
15)
16)
17)

FIG. 1



35.8
35.7
35.6
N
49.6
49.7
49.8
49.9
50.0
50.1
50.2
50.3
50.4
E
DANISFAN
Cheskin
Rudak
Tarak
BUYIN
ISHTAHRD
Aghchemazar
Tangebar
Khangeran
Ipak
Chenars
Hadji Arab R.
4500
5000
5500
6000
6500
7000
7500
8000
0
1
5
10
Miles
1
2
3
4
5
6
7
8
9
10
11
76°

FIG. 2

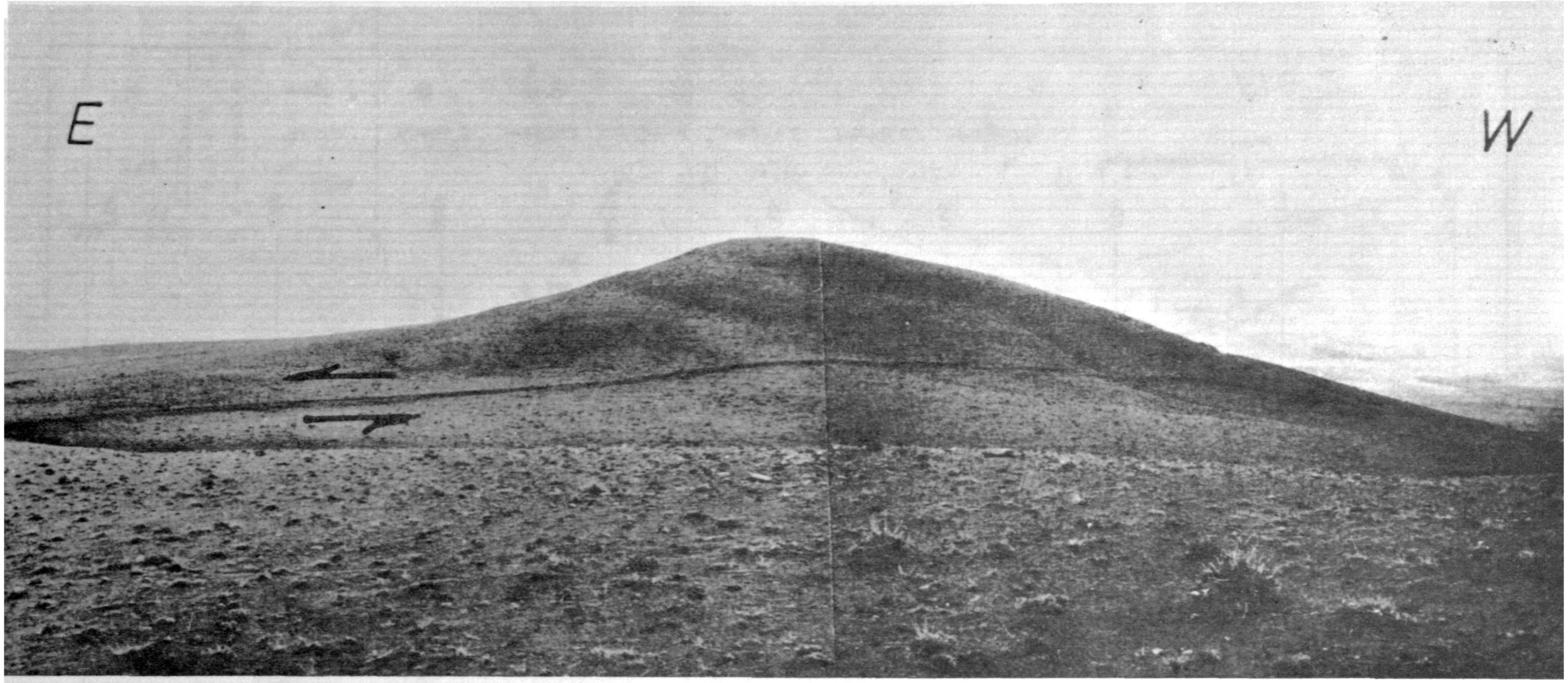


Plate 1

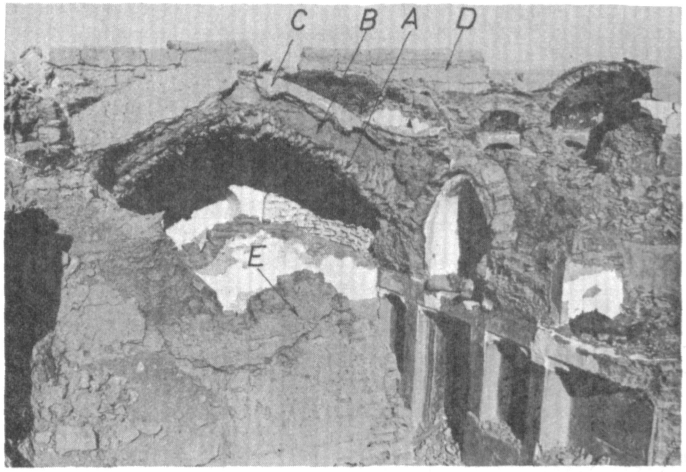


Plate 2

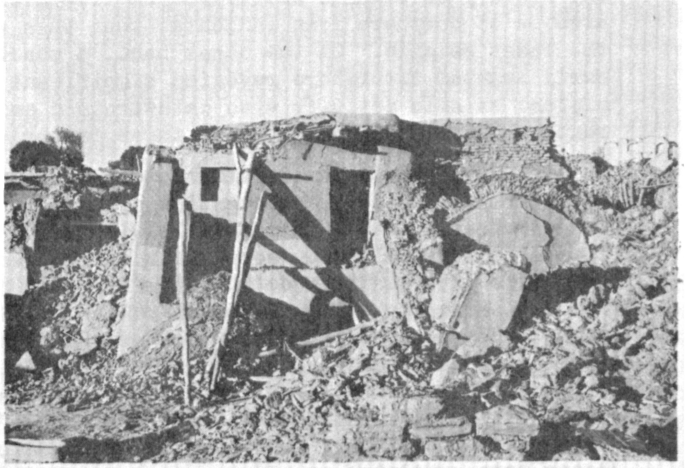


Plate 3

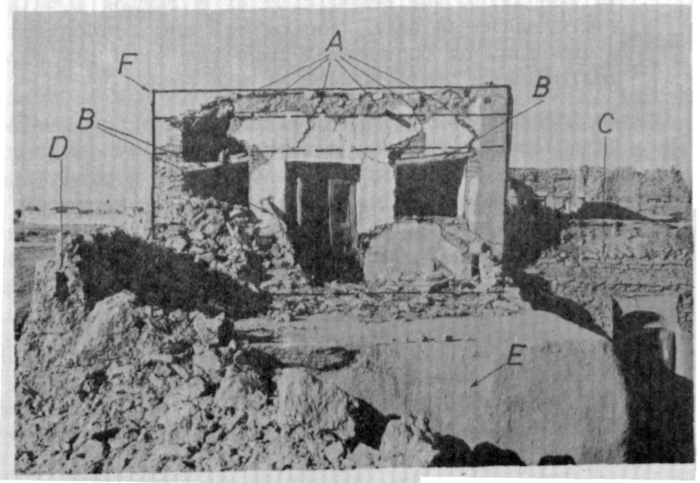


Plate 4

AN EARTHQUAKE ENGINEERING STUDY OF THE BUYIN-ZAHRA EARTHQUAKE OF SEPTEMBER, 1st, 1962

BY N.N. AMBRASEYS

QUESTION BY:	G. LENSEN - NEW ZEALAND Seismological evidence alone did not point out that this area was a serious earthquake risk. In such cases, where it is economically warranted, is it possible to use geological evidence for zoning?
AUTHOR'S REPLY:	It is true that the Buyin-Zahra area showed no significant history of seismic activity. Earlier microseismic studies of northern Iran indicated that this area was the least seismic. On the other hand, a search in the early Iranian literature revealed significant intermittent seismic activity with catastrophic earthquakes reaching paroxysms every two to three centuries.

Undoubtedly, microseismic evidence alone is insufficient to determine the seismic potential of a region. The length of time that seismological evidence usually covers is negligibly small when compared with the geotectonic timescale that is involved in the seismicity of a region. For the seismologist concerned only with instrumental data, some recent earthquakes such as the Agadir (Morocco), Barce (Libya), Skopje (Yugoslavia), Buyin-Zahra (Iran) may be classified as "surprise-earthquakes". There was no microseismic evidence to suggest that these areas were potentially seismic. For the geologist, these areas were suspect.

In assessing the seismicity of a region I think that micro/macro-seismic, geological and geotectonic information must be considered together with the superficial geology and hydrogeology of the area.

In the absence of microseismic and/or of macroseismic data, geological and geotectonic evidence supplemented by microtremor studies can be used for a preliminary assessment of the seismic potential of a region. A temporary network may produce results for a study of the effects of frequent, small events, which, coupled with geotectonics might enable the seismic hazard in a new development area to be assessed rapidly.

Considering the state of the development of instrumental seismology and of its interpretation, it might not only be inadequate to attempt zoning without due consideration to the geology and seismic history, but it may also be misleading.