

**The seismicity of Iran.**  
**The Karkhaneh (Kangavar) earthquake of 24 March 1963**

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**SUMMARY.** — The Karkhaneh (Iran) earthquake of the 24th of March 1963 was a medium magnitude ( $M = 5.8$ ) shock which belongs to the series of earthquakes that began in 1909 and which has successively delineated a zone of seismic activity about 300 kilometres long. The meizoseismal area of the Karkhaneh earthquake lies between and overlaps the meizoseismal areas of the earthquakes of 1957 and 1958, thus filling a gap of low seismic activity since 1958. The earthquake destroyed 4,000 houses in 22 villages, injuring about 50 people. Its meizoseismal area did not exceed 300 square kilometres. The felt area was comparatively large, about 45,000 square kilometres and the predominant epicentral intensity was VI to VII (MM). The earthquake, which was followed by a dozen strong aftershocks, caused considerable ground deformations along the Kangavar valley which run for at least 8 kilometres parallel with and to the northwest of the Kurram river. There is no evidence that these deformations are of tectonic origin.

**RIASSUNTO.** — Il terremoto di Karkhaneh (Iran) del 24 Marzo 1963 di media magnitudo (5.8), appartiene a quella serie di terremoti iniziata nel 1909 che ha, in seguito, individuato una zona di attività sismica di circa 300 km. L'area meizosismica del terremoto di Karkhaneh giace fra le aree meizosismiche dei terremoti del 1957 e 1958, sovrapponendosi loro, e colmando così dal 1958, una lacuna di bassa attività sismica. 4000 furono le abitazioni distrutte e 50 ca. i feriti in 22 villaggi. L'area meizosismica non superò i 300 km<sup>2</sup>, mentre al confronto fu grande l'area macrosismica (45000 km<sup>2</sup>); l'intensità predominante epicentrale fu tra il VI e il VII grado (MM). Il terremoto, con una dozzina di forti repliche, causò considerevoli deformazioni nel terreno lungo la valle di Kangavar che segue parallelamente, in direzione NW, il fiume Kurram per almeno 8 km. Non esiste alcuna prova che queste deformazioni siano di origine tettonica.

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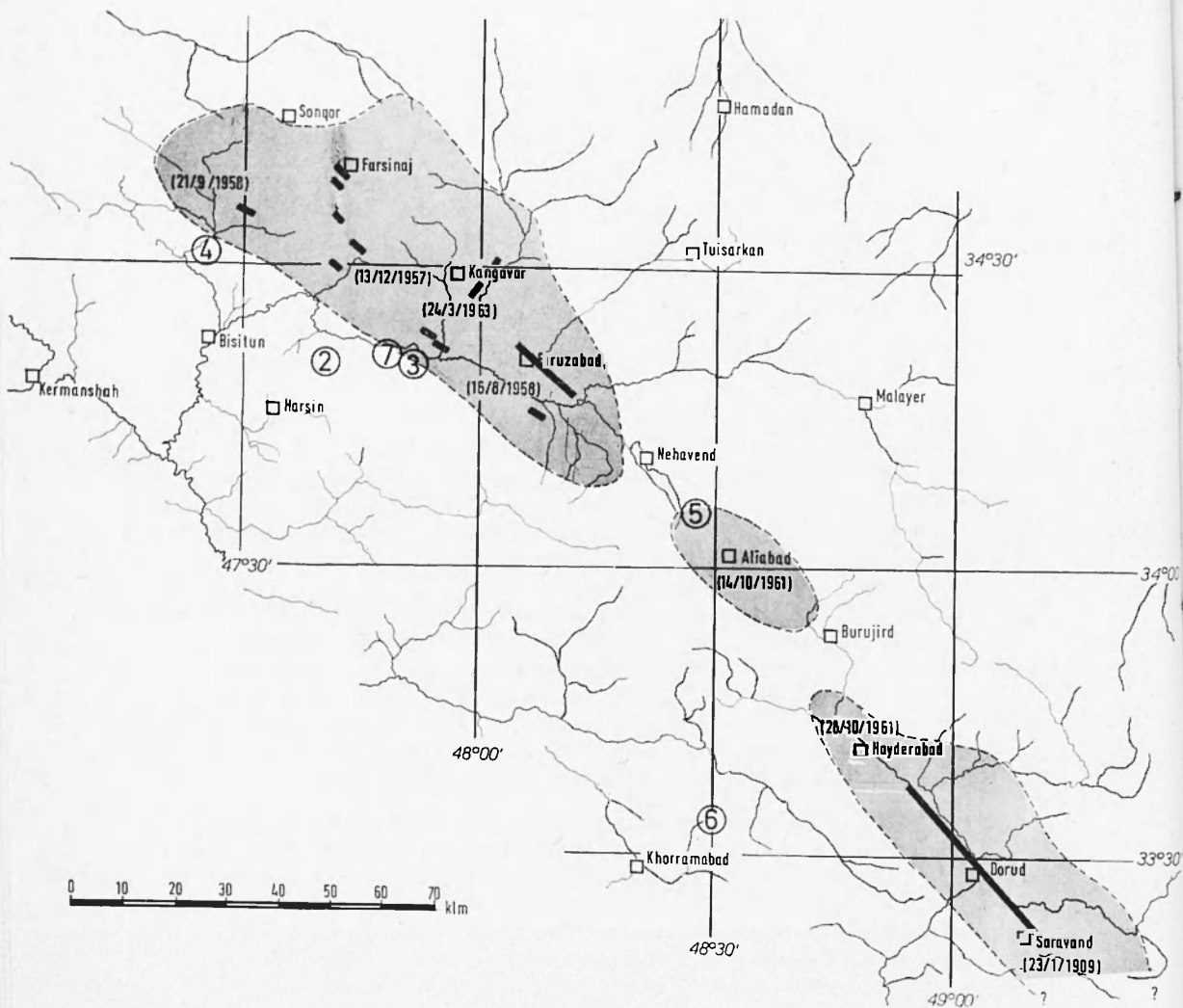


Fig. 1 - Seismic activity in Central Zagros during the period 1901-1963. Contoured areas show meizoseismal regions of major earthquakes the date of occurrence of which is shown in brackets. Numbers in circles show epicentres of these events (4).

2 - Farsinaj earthquake of 23 December, 1957; 3 - Firuzabad earthquake of 16 August, 1958; 4 - Dinawar earthquake of 21 September, 1958; 5 - Aliabad earthquake of 14 October, 1961; 6 - Hayderabad earthquake of 28 October, 1961; 7 - Karkhaneh earthquake of 24 March, 1963. Ground deformations shown by heavy straight lines are not necessarily of tectonic origin.

## 1 - INTRODUCTION

After a period of relative quiescence the region of Karkhaneh in the Kangavar Valley, Central Zagros in Iran, was damaged at 04<sup>h</sup>15<sup>m</sup> p.m. local time on March 24, 1963, by an earthquake of magnitude 5.8.

The Karkhaneh earthquake of 1963 had a smaller magnitude than did the last major earthquakes in the same area in the Zagros which occurred in 1957 ( $M = 7.1$ ) and in 1958 ( $M = 6.6$ ). These two large shocks and their numerous and strong aftershocks caused serious damage to villages in the Kangavar valley<sup>(1,2,3)</sup>. The Kerkhaneh earthquake of 1963 completed the destruction in the valley and its meizoseismal region filled the gap between the meizoseismal regions of the earthquakes of 1957 and 1958.

The remarkable series of earthquakes in the Zagros that began in 1909<sup>(3)</sup>, have successively delineated a zone of seismic activity about 300 kilometres long, from southeast to northwest. Following the Firuzabad earthquake of 1958 minor shocks were being felt in this zone causing considerable concern but no significant damage. On the 14th of October, 1961 a strong earthquake caused considerable damage in the district of Bardeh Sareh which is situated about 50 kilometres to the southeast of the epicentral area of the Firuzabad earthquake of 1958. It ruined the villages of Aliabad, Ashgharabad, and the two settlements of Magh Olia and Magh Sofla (Maghasan) where one person was killed and many were injured. The main shock occurred at 10<sup>h</sup>35<sup>m</sup> a.m. and was followed by many aftershocks, one of which, at 23<sup>h</sup>15<sup>m</sup> seems to have been more damaging than the main shock. It caused the total ruin of the Magh villages as well as the collapse of more ruins in Aliabad, Bardeh, and Gamasb, killing one more person. The earthquake and its aftershocks caused some damage as far as Qaleh Khatum where a few walls cracked and some collapsed. At Fathabad and Jafarabad also, houses were damaged, the shocks causing great panic among the villagers. Minor damage was reported from Burujird, further to the southeast, and from Junabad. The shock was felt in Malayer, Nehavend and in the villages to the south of Tuisarkan. It was not reported from Kermanshah, Asadabad, Hamadan and Kangavar.

The facts surrounding the Aliabad-Magh earthquake and its aftershocks of the 14th of October 1961, are not clear. The shock was

felt with an intensity  $V^+$  over an area of at least 800 square kilometres, but as might be expected it is not known whether this was the result of a single shock or of the main shock and of its strong after-shocks. Figure 2 shows a map of the region affected by the Aliabad-Magh earthquake. This map depicts only the area within which heavy damage occurred and the limits within which shaking would have been very strong. Table 1 briefly gives the information available concerning these events.

Two weeks later, at  $14^h 15^m$  local time, on the 28th of October, 1961, another earthquake of magnitude 5 occurred even further to the south-east, in the region of Hayderabad. The shock was felt over a large area with an intensity not greater than V (MM). Locally, at Hayderabad the intensity reached perhaps VI; there, a few houses were dam-

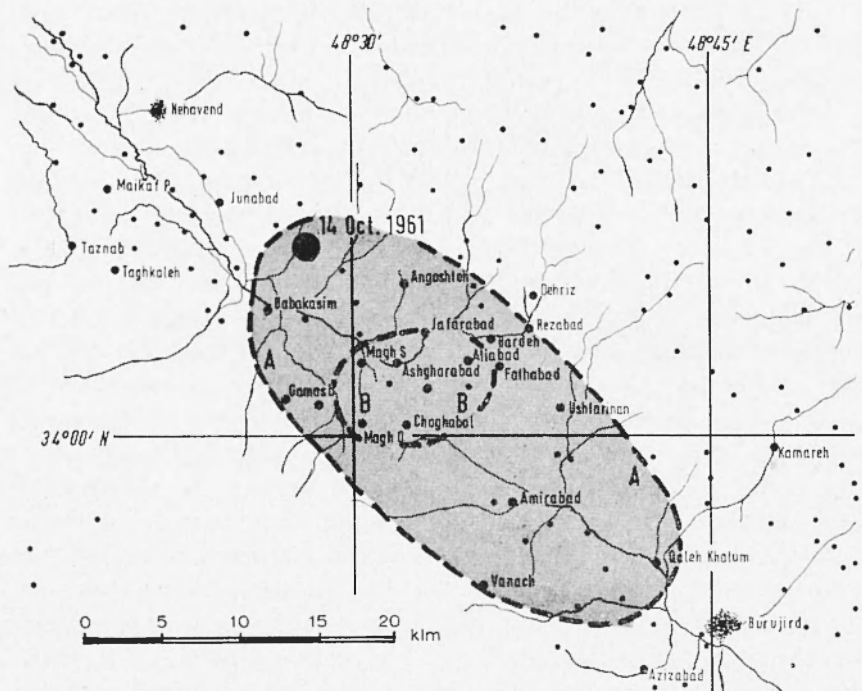


Fig. 2 - Epicentral area of Aliabad earthquake of 14 October, 1961. Area B, region of maximum damage; A, meizoseismal region. Epicentre after Nowroozi (4). Large dots show villages affected by the shock; small dots indicate location of unaffected villages.

aged and three collapsed without casualties. At Dinarabad walls cracked and a few old roofs caved in. Villages in the Burujird valley suffered slight damage and at Khorramabad a few old walls cracked. At Burujird, the main shock lasted about 30 seconds and it caused great panic. Aftershocks continued for about two weeks, Table 1.

During the following year a few strong earthquakes caused some concern in the region between Burujird and Kangavar, but no damage. Few of these shocks were strong enough to allow a reasonably accurate determination of their epicentres (<sup>4</sup>).

On the 24th of March, 1963, the Karkhaneh earthquake occurred. Information about this earthquake and concerning the seismic activity that preceded and followed this event was obtained from local inhabitants during a reconnaissance field trip made in the spring of 1973, from reports by the Red Lion and Sun and news media, and from data collected at the time by the Seismological Station of Shiraz (<sup>5</sup>). As might be expected there was a wealth of data from the densely populated valleys but very little data from the large, sparsely settled outlying mountain regions.

## 2 - THE KARKHANEH EARTHQUAKE OF THE 24TH OF MARCH 1963.

The Karkhaneh earthquake was not preceded by any identifiable foreshock. The last seismic event in the region had occurred about two weeks prior to the main shock and it was felt at Malayer. It was also recorded, but only at Tehran and Shiraz.

The epicentre of the main shock was relocated by Nowroozi (<sup>4</sup>) [Table 1], and magnitudes on the earthquake, reported by a number of seismological stations varied between  $5\frac{1}{2}$  and  $6\frac{1}{3}$ , with an average value of 5.8.

A location map of the felt area showing Modified Mercalli (MM) intensities is shown in Figure 3, from which it can be seen that the felt area of the shock extended from Aveh to Kermanshah and from Sanandaj to Malayer, an area of about 45,000 square kilometres. A maximum intensity of VI<sup>+</sup> has been assigned to the damage sustained in the region of Karkhaneh and immediate vicinity.

Figure 4 shows a detailed map of the affected region. The earthquake was strong enough to destroy or damage beyond repair about 4,000 housing units in 22 villages. No deaths occurred but 52 people

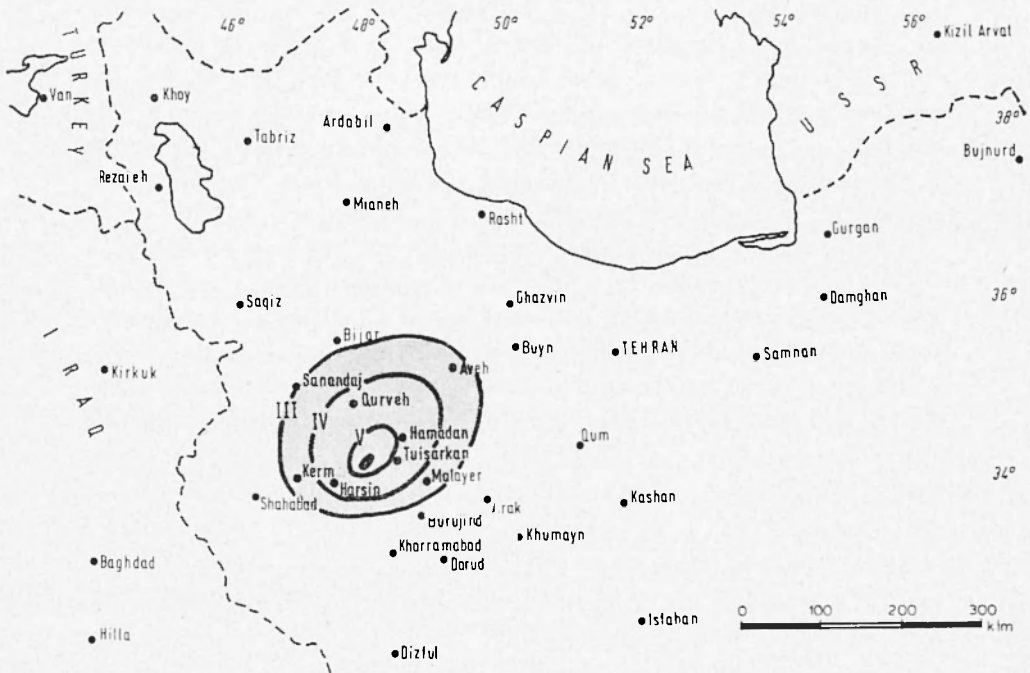
Table 1

Date	Time GMT			Epicentre		Depth km	<i>M</i>	Local time h m	Macroseismic effects
	h	m	s	°N	°E				
1958 Sep. 26	07	22		-	-	-	-	11	Series of shocks felt at Malayer.
1959 Aug. 3	-	-		-	-	-	-	05	Felt at Nehavend IV
Sep. 27	-	-		-	-	-	-	-	Two shocks felt at Nehavend, V
1960 Apr. 2	22	35	59	34.25	48.25	25	5.1	26	Slight damage in some villages of Asadabad and Malayer. Felt strongly at Hamadan, Kermanshah and Tuisarkan. At Hamadan IV-V.
	23	33	13	34.20	48.17	40	5.0	27	Felt in the region of Malayer and Asadabad. At Hamadan IV-V.
June 18	00	35	30	34.00	47.5	-	4	-	—
1961 June 21	15	40	47	34.10	48.30	n	-	-	—
Oct. 3	09	34	53	34.38	47.81	69	4.8	13 30	Felt at Kangavar VI
14	07	00	51	34.11	48.46	84	-	10 35	At Aliabad-Magh, about 30 km from Malayer one house collapsed and other damaged killing 2 people (VI-VII); at Kaleh-Hatum many walls cracked and few collapsed (VI); also at Burujird a few houses cracked (V-VI); felt at Malayer without damage (IV).
	19	45		-	-	-	-	23 15	Strong shock damaged all houses at Aliabad-Magh causing a few to collapse; people injured; felt slightly at Burujird.
	-	-		-	-	-	-	23 30	Very strong at Burujird, causing panic, accompanied by noise.

Date	Time GMT			Epicentre		Depth km	M	Local time h m	Macroseismic effects
	h	m	s	°N	°E				
1961 Oct. 14	21	19		-	-	-	-	24	Strongly felt at Burujird.
15	-			-	-	-	-	-	Shocks continued for 48 hours in the region of Malayer.
28	10	46	41	33.56	48.50	43	5	14 15	At Hayderabad three houses destroyed (VII); at Burujird, slight damage, the shock lasting 30 secs (V); strongly felt at Khorramabad where a few old walls cracked (V); felt in other parts of Lurestan. After-shocks felt at 10 <sup>h</sup> 55 <sup>m</sup> , 11 <sup>h</sup> 05 <sup>m</sup> , 18 <sup>h</sup> 20 <sup>m</sup> and 21 <sup>h</sup> 45 <sup>m</sup> GMT.
Nov. 5	08	40	48	33.63	48.23	80	-	12 10	Two shocks felt at Burujird (V).
1962 Mar. 31	23	36	45	34.07	47.94	35	-	27 00	Felt at Hamadan, Nehavend and Malayer. A number of villages suffered minor damage.
May 1	23	29	30	34.5	48.00	-	-	27	Strongly felt at Nehavend and nearby villages without damage (V)
June 16	17	36		-	-	-	-	21	At Burujird strongly felt causing panic without damage; followed by five after-shocks in six hours.
1962 Aug. 13	05	58		-	-	-	-	09 30	Strongly felt at Nehavend (V).
Sep. 3	06	48		-	-	-	-	10	Strongly felt at Hamadan.
Nov. 9	01	11	03	33.54	47.23	38	5	04 40	Strongly felt at Pol-i-Dokhtar and surrounding (V). Felt within a radius of 110 km.
1963 Jan. 4	-			-	-	-	-	19 20	Minor shock felt at Pol-i-Dokhtar (IV).
Mar. 9	23	10		-	-	-	-	26 40	Very strong shock at Malayer lasting 40 secs. caused panic; no damage.

Date	Time	Epicentre		Depth km	M	Local time	Macroseismic effects
	GMT h m s	°N	°E				
1963 Mar. 10	02 00	-	-	-	-	05 30	Felt at Malayer.
24	12 44 05	34.37-47.80	37	5.8	16 15	MAIN SHOCK at Karkhanch. Aftershocks at 17 <sup>h</sup> 46 <sup>m</sup> , 19 <sup>h</sup> 55 <sup>m</sup> , 21 <sup>h</sup> 33 <sup>m</sup> , 25 <sup>h</sup> 48 <sup>m</sup> .	
27	14 06	-	-	-	17 35	Very strong shock causing the collapse of ruins in the Kangavar region.	
28	03 55	-	-	-	07	Violent shock in the Kangavar region; one person died of fear (VI); Felt at Sahneh; shocks continued.	
Apr. 8	09 21	-	-	-	13	Strongly felt in Malayer and neighbouring villages without damage (IV). At Kangavar the shock caused damage to the main power plant and new cracks in walls (VI).	
12	21 35	-	-	-	24 00	Four shocks in Kangavar, one of which very strong; they caused no damage.	
21	-	-	-	-	-	At night, two shocks in Kangavar, caused panic (IV).	
May 13	-	-	-	-	-	Two violent shocks at night in Kangavar caused the collapse of one house.	
June 30	07 41 09	33.34-49.20	49	5.1	11	At Tapeh and in neighbouring villages of the Ali Gudarz district, 200 houses destroyed or damaged beyond repair; no one was injured (VII).	
Oct. 27	02	-	-	-	05 30	Felt at Malayer.	
	02 54	34.5-48.5	-	-	06 30	Very strong at Malayer, lasting 30 secs. (V); equally strong at Ilamadan (V) without damage.	





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Fig. 3 – Isoseismal map of Karkhaneh earthquake of 24 March, 1963. Contours other than III, approximate.

were injured (\*). The lateness of the hour of the shock and particularly the alertness of the villagers who had experienced similar situations before, no doubt minimised the loss of life.

The worst-hit village was that of Karkhaneh. Five years earlier, the Farsinaj earthquake of 1957 and its aftershocks had caused considerable damage to the 140 houses in the village of which 109 were damaged and a few collapsed. Six months after the Farsinaj earthquake in the summer of 1958, the Firuzabad earthquake caused additional damage to hastily repaired houses. The shock of 1963 destroyed all houses in Karkhaneh, including the mosque and the public baths which collapsed injuring about 25 people. Today the village has been rebuilt on the same site.

(\*) No precise estimate of the number of people injured has ever been made but the total of 300 given by press reports is now regarded as excessive.

To the southeast of Karkhaneh, near the Kurram river, the village of Aliabad was also ruined. The earthquake of 1957 and 1958 had caused damage to 54 out of 60 houses in the village; the 1963 earthquakes added to the damage causing the total ruin of Aliabad. The earthquake injured 12 people and killed a large number of animals; it also caused foundation settlements and slumping of the ground, as a result of which a number of houses collapsed.

Tahirabad, a large village situated about 5 kilometres upstream from Aliabad on the Kurram river, was also totally ruined and a number of people were injured. Aftershocks of the Farsinaj earthquake early in 1958 had damaged beyond repair about 70% of the houses and at the time of the earthquake of 1963 many of them had been abandoned and new houses had been built. The Karkhaneh earthquake

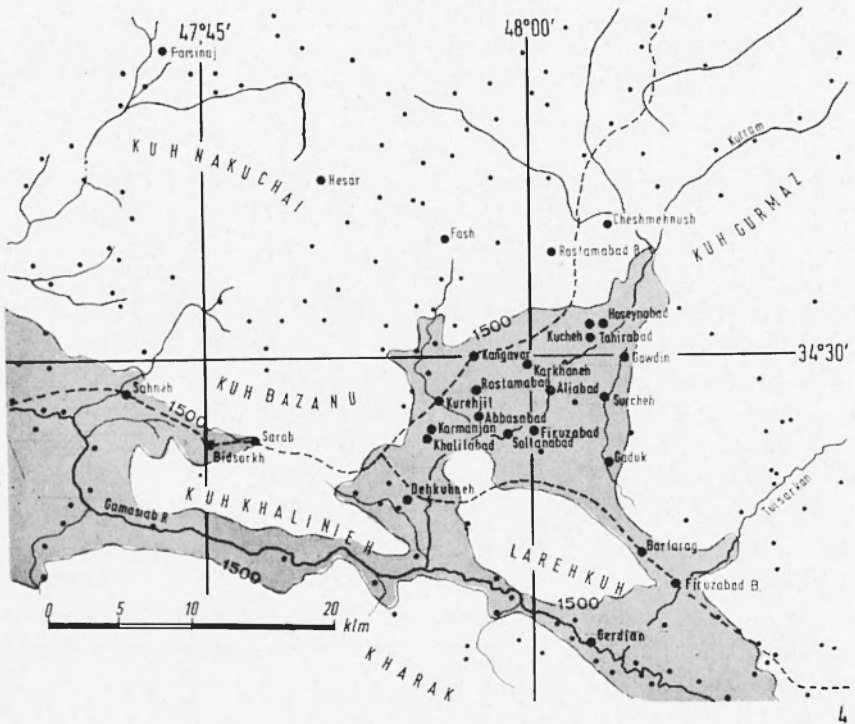


Fig. 4 — Location map of meizoseismal region of Karkhaneh earthquake of 24 March, 1963. Shading shows terrain below 1500 metres above sea-level.

destroyed almost all abandoned houses in which many animals were killed; it also demolished quite a few new ones damaging the rest beyond repair.

The damage was equally serious at Firuzabad Tepe and at Kucheh. However, about one kilometre from Tahirabad, at Hoseynabad only 50% of the houses were damaged and only a few collapsed. Further away from Tahirabad, damage decreased rapidly with distance from the river and although all villages suffered cracks in their walls, very few of them were rendered unsafe.

To the southwest of Karkhaneh, at Abbasabad, all 50 houses of the village were shattered but none collapsed; most of them were later abandoned.

Damage in other villages in the Kangavar valley was widespread but not serious. At Gowdin, only 30 out of 300 houses in the village were damaged and at Sureheh, although all houses were cracked only one collapsed. At Firuzabad many houses, both old ones and newly built after the 1958-1959 earthquakes, were badly shaken and some of them were abandoned soon after. At Soltanabad damage was more serious in that all houses were rendered unsafe due to the spreading out of their walls which left heavy flat roofs on the verge of collapse, making almost the whole village homeless. At Kangavar damage was not serious but widespread. Almost all houses developed cracks in their walls and two ruined and abandoned two-storeyed dwellings collapsed. At Rostamabad a few houses, three of them built after the 1957-1958 earthquakes collapsed injuring a small number of people.

Figure 5 shows the distribution of damage caused by the Karkhaneh earthquake. The principal causes of damage, apart from the nature of the sites were the extremely weakened condition in which most of the houses in the region were found after a long series of damaging earthquakes five years earlier; also, the improper kind of repair work carried out, which consisted of tamping more soil on flat roofs, of undercutting and rebuilding the lower courses of adobe brick work, and the introduction of modern techniques in the construction of rural houses using unsuitable building materials.

Influenced by local soil conditions and a relatively high water table, non-vibrational damage was noticeably more serious near the terraced planes of the Kurram river (area B in Figure 5). As a result of the earthquake the ground slumped and in places cracked, fissures of all sizes forming irregular patterns in the ground, particularly near Karkhaneh. No evidence of these features was visible in the spring

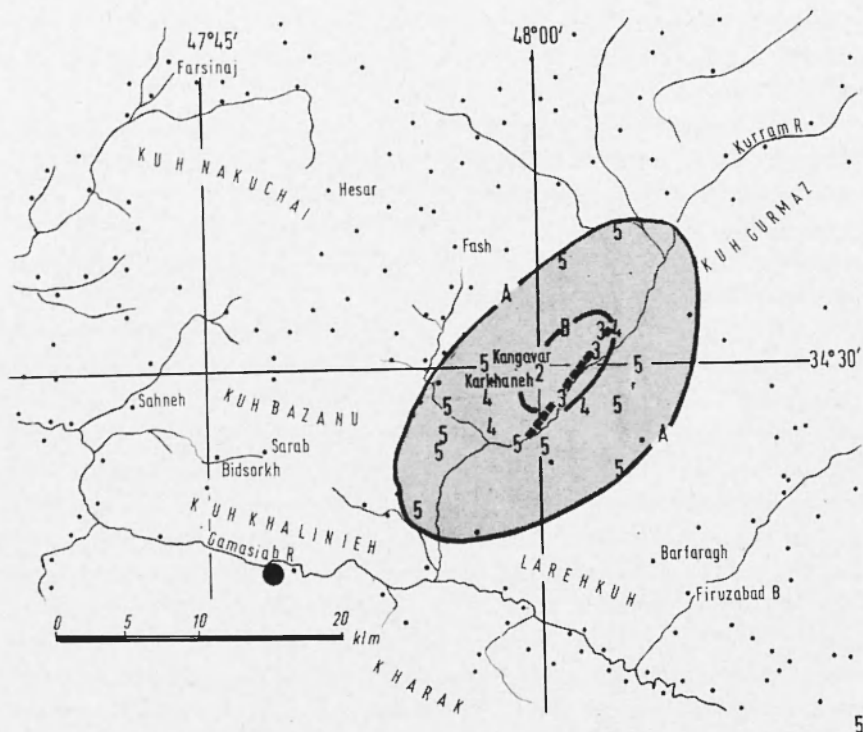


Fig. 5. - Damage distribution map. **A**, meizoseismal area of predominant intensity VI (MM); **B**, region of maximum damage due to ground deformations.

Numerals show degree of damage: **2** - 100% of houses destroyed, people were injured; **3** - 100% of houses damaged beyond repair or destroyed; **4** - 50% to 99% of houses damaged beyond repair without casualties; **5** - damage less than 50% of total number of houses without casualties. Heavy dashed line shows location and extent of ground deformation associated with earthquake; southeast side downthrown by 30 centimetres. Large black dot shows location of epicentre (<sup>4</sup>). Small dots show localities unaffected by shock.

of 1973. Outside this area and within the Kangavar valley, there was no clear relationship between damage and foundation material.

All available data point to the fact that in the meizoseismal area (area **A** in Figure 5) ground movements were not strong enough to cause total collapse of houses, and that the predominant epicentral intensity was about VI (MM) over an area of about 300 square kilometres. Since repairs to houses obviously could not be made properly

between earthquakes, and since damage from 1957 was cumulative, larger intensities, that can be deduced from the effect of the Karkhaneh earthquake on man-made structures in the Kangavar valley, are somewhat doubtful.

Outside the meizoseismal area, the earthquake was felt at Bid-sorkh, Sahneh and Abasabad where it caused rafters to creak and doors to rattle but otherwise it caused no damage. In Hamadan and Tuisarkan the shock lasted more than 30 seconds and it was felt by all the inhabitants. It was equally strong at Qurveh. In Kermanshah not everyone felt the shock and those who did reported a very short duration not exceeding 2 to 3 seconds. At Sanandaj, Aveh and Malayer and in some of its villages to earthquake was generally felt as a series of jolts, mainly vertical. The shock was not felt or, at least was not reported from Qum, Ghazvin and Khorramabad. The felt area, therefore was large, and its extent may be seen in the isoseismal map of Figure 3, in excess of 40,000 square kilometres.

The meizoseismal area of the Karkhaneh earthquake lies between and overlaps the meizoseismal areas of the 1957 earthquake of Farsinaj to the northwest and of the 1958 earthquake of Firuzabad to the southeast.

The epicentre of the main shock was recently relocated<sup>(4)</sup> at  $34.37^{\circ}\text{N} - 47.80^{\circ}\text{E}$ , about 10 kilometres south of Sarab, Figure 5. This location, like others of events in the Central Zagros place epicentres outside and systematically to the southwest of meizoseismal regions. In the case of the Karkhaneh earthquake the instrumentally located epicentre lies about 25 kilometres to the southwest of the macroseismic epicentre.

Aftershocks, at least a dozen of them, continued for about a month. Some of them were very strongly felt locally and evoked rather more concern in the press than larger shocks in other parts of Iran, Table 1. These shocks were very poorly recorded by the 1963 seismological network, being too small to yield a reliable focal determination.

As a result of the earthquake the ground settled and slumped along the northwest side of the Kurram river and about 500 metres from it, particularly between Firuzabad and Aliabad. Long cracks running in the ground for many hundreds of metres, and in places gaping open by as much as 20 centimetres, could be followed by villagers from the vicinity of Firuzabad to Aliabad. These ground deformations did not show any vertical motion; in places they were associated with mud volcanoes which allegedly were observed by the

villagers during the earthquake ejecting water and sand. No evidence of these features was visible in 1973.

Another much longer strand of ground cracks and fractures was reported running almost continuously from Aliabad to a place between Kucheh and Tahirabad. From interviews with local people it appears that along this feature there were no mud volcanoes and no gaping fissures; instead the ground dropped by about 30 centimetres on the southeast (river) side. Some evidence of recent terracing along this feature was visible in the spring of 1973. The origin of these terraces is not clear and it may be due to large scale slumping related to differences in the level of the water table in the Kangavar valley to the northwest and southeast of the Kurram river. It is interesting perhaps that no ground deformations of any kind were reported from the southeast side of the Kurram river.

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