

**The seismicity of Iran:  
The Torud earthquake of 12th february 1953**

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RIASSUNTO. - Il terremoto di Torud del 12 Febbraio 1953 ebbe una magnitudo  $M_s$  di 6.4 ed avvenne, dopo un lungo periodo di relativa calma, nella zona di faglia omonima nell'Iran settentrionale, una regione desolata ai confini con il Kavir. La scossa fu sentita in un raggio di 290 km e provocò la morte di 800 persone, per lo più nel villaggio di Torud. Non c'è nessuna concreta testimonianza che il terremoto sia stato associato alla faglia. Ad ogni modo, il sisma causò la liquefazione dei depositi saturi del deserto.

SUMMARY. - The Torud earthquake of 12th February 1953 had a magnitude  $M_s$  of 6.4 and it occurred, after a long period of relative quiescence, on the synonymous fault zone in northern Iran, a desolate region on the borders of the Kavir. The shock was felt within a radius of 290 kilometres and it caused the death of about 800 people, mainly in the village of Torud. There is no conclusive evidence that the earthquake was associated with faulting. However, it did cause the liquefaction of saturated desert deposits.

INTRODUCTION.

The earthquake of the 12th February 1955 occurred in one of the most desolate parts of Iran, in the region of Torud on the borders of the Kavir, the great salt desert of Central Iran (Figure 1). It was felt over an area of 260,000 square kilometres, as far as Tehran, Tabas and Turbat-i Haidariyyeh, and it devastated the sub-district (Dehestan) of Torud where about 800 people were killed in the main village of Torud and in its six smaller villages. The shock, which occurred at

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about noon local time on Thursday 23rd Bahman 1331, had a surface-wave magnitude of 6.4 and was associated with ground deformations. The event was studied in the field by Prof. S. Abdalian who visited the area shortly after the earthquake (<sup>1</sup>). The results of this field study are invaluable but leave a number of important questions unanswered, such as the extent of the meizoseismal area and the nature of the observed ground deformations.

In an attempt to supplement the information already available about this important earthquake in Iran, and also in order to resolve the ambiguity on the nature of the ground deformations so far reported, the authors visited the site in the spring of 1975.

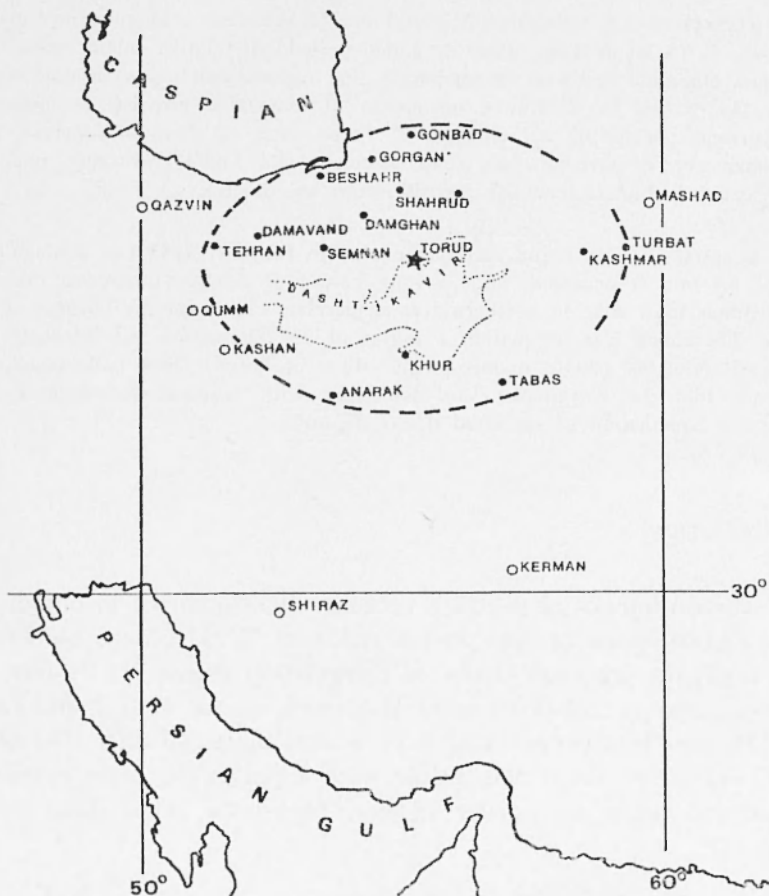


Fig. 1—Location map of the Torud earthquake of 12th February 1953. Solid dots show localities where the shock was felt. Open circles show major neighbouring towns where the shock was not felt.

## THE TORUD EARTHQUAKE OF 12th FEBRUARY 1953.

The area affected by the Torud earthquake belongs to the wasteland that borders to the northeast the Dasht-i Kavir, the great salt desert of Central Iran, Fig. 1. More specifically, the shock affected the Dehestan of Torud which has an area of 22,000 square kilometres and a total population of about 3,200 sedentary people. The Dehestan consists of the capital village of Torud, which, before the earthquake, had a population of just over 200, and of six smaller villages the population of which does not exceed 500. Out of 120 farmhouses and small settlements, 50 are uninhabited, and most of them are scattered along the main caravan routes to the south and northeast, in the vicinity of copper and turquoise mines.

The meizoseismal area of the Torud earthquake is shown in Fig. 4, together with the re-calculated location of the instrumental epicentre of the main shock (<sup>9</sup>) and the less accurate location of aftershocks. Table I lists the characteristics of the main shock and of its aftershocks as well as the magnitudes of these events calculated from reported amplitude-period readings.

TABLE I

	Time	Epicentre	$M_s$	
1953 Feb.	12 081530	35.40 — 55.08 ( <sup>9</sup> )	6.4 (0.2)	$m_p = 6.9$ (0.3), $r_3 = 290$ km; $r_4 = 190$ km; $r_5 = 110$ km (VIII)
	12 082727	36.00 — 55.00 ( <sup>11</sup> )		Aftershock
	13 043628	35.60 — 54.70 ( <sup>12</sup> )	4.5	«
Apr.	1 022435	35.50 — 55.20 ( <sup>3</sup> )	4.0	«
Jul.	11 152508	35.90 — 55.10 ( <sup>12</sup> )	4.3 (0.2)	«
Jul.	24 053056	35.80 — 55.40 ( <sup>12</sup> )	4.5	«
Aug.	24 162030	35.40 — 54.80	4.7 ( ) .3)	« $m_p = 5.2$ (0.2)

Torud is the largest village affected by the earthquake. It was built originally on the edge of a 20-metre high terrace, overlooking the desert to the south and about 50 hectares of cultivated land surrounded by wasteland. In 1888 the village contained 200 to 250 dwellings. It

obtained its water from the Rudkhaneh-pa'i Kaleh, a small river of seasonal flow with its source about 36 kilometres off to the north, that had cut deeply into the silts of the terrace, which stood on both sides into vertical walls 12 to 15 metres high, in places hollowed into caves by the running water. Some of these caves had been enlarged into temporary dwellings and storehouses and used by the villagers during the dry seasons. The only perennial supply of water for Torud was provided by an old qanat whose wells were sunk right through the silts, its stream emerging at the toe of the terrace, above which stood the dilapidated citadel of the village (<sup>4</sup>). By 1906 the village had grown and many of its new houses were built at the foot of the terrace, in front of which stood an Imamzadeh facing south. More caves had been excavated into the silts of the vertical walls of the Rudkhaneh for the storage of straw, firewood and for the housing of animals. In 1906 Torud had a population of not more than 1000 and about 250 proper houses. Fig. 2 shows views of Torud sketched in February 1906 (<sup>6, 7</sup>). By the mid-50's the size of the village had doubled and its population had risen to almost 2000 with 400 houses (<sup>4</sup>), and two smaller qanats were dug to supply water for irrigation (Figure 3, points 13 and 24). At the time of the 1955 earthquake, Torud had a population of about 2.100.

The earthquake completely destroyed Torud and only a few houses did not collapse. One of them is still there, located at the southwest limit of the new village (Fig. 3, point 20). Most of the casualties occurred in the old part of the village and in its narrow streets (Plates 1 and 2). No one was killed in the caves which stood up to the shaking far better than the ordinary houses of the village. Estimates of the casualties reported so far differ considerably, varying from 2000 to under 900 (<sup>2, 8, 10, 11</sup>).

Most of these estimates were based on rather exaggerated press reports and on official estimates for Torud and for its Dehestan which were added together. From interviews with a number of local officials and survivors of the event, the best estimate for the casualties in Torud is 720 killed about 160 seriously injured.

The earthquake damaged the main qanat that today issues between the old and the new villages (Fig. 3, points 12, 14), as well as a much smaller qanat that runs to the south towards Dagg-Kulud. The former was soon repaired but its yield never rose above half of that yielded



Fig. 2 — Sketches of Torud made by Sven Hedin in early February 1906. (a) looking south-west; compare with Plate I. (b) looking due south; notice terrace cliffs undercut by erosion. (c) looking north-east.

before the earthquake; the latter was damaged by ground deformations and after being repaired its water turned brackish.

At the time of the earthquake the underground water table in the fields that lie at the foot of the village, was only one to two metres below ground level, and it was almost at ground surface in the vicinity of the outlet of the main qanat (Fig. 3, point 14). In these fields, the shock caused the ground to slump and a series of long cracks to open up from

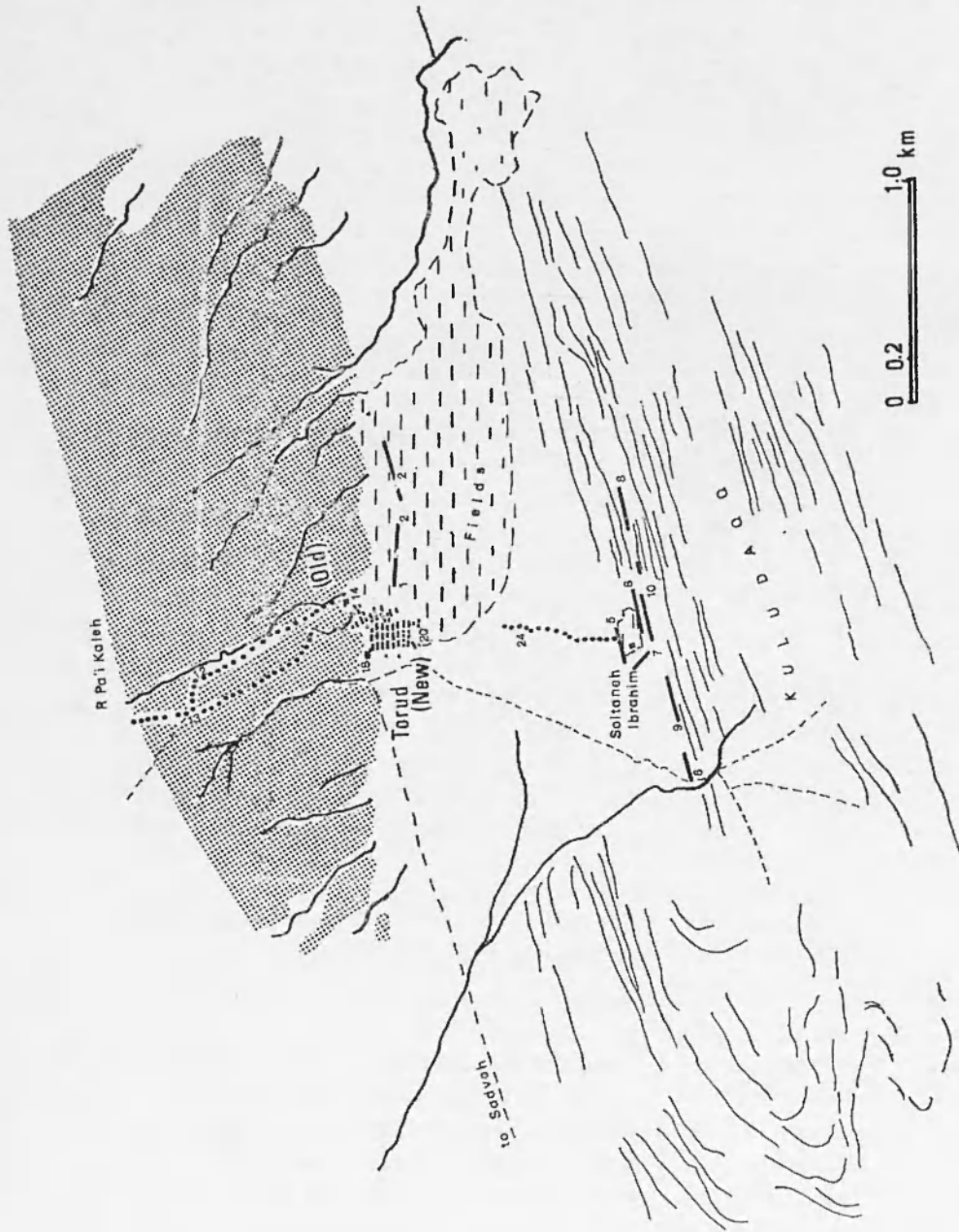


Fig. 3 — Map of the immediate vicinity of Torud showing location of ground deformations (No. 1, and 2 slumping of the ground below the qanat outlet No. 14; no. 5, 6, 7, 8, 9 and 10, shattered and in places eroded mudstones along bedding; no. 7, the only conjugate zone fractures in the form of shattered harder rocks. Compare with Plate 5.



1 — Ruins of old Torud and caves in 1975: compare with Figures 2a and 2b.



2 — Ruins of the upper part of old Torud, looking towards Daqq Soltaneh Ibrahim. New village, on the extreme right.

which brine and sand were ejected, particularly in the Paredasht farm where they were about 20 metres long (Fig. 3, points 1, 2). These are most probably the new cracks referred to by Gansser (<sup>5</sup>). Although the cracks are no longer visible except in two places, local information suggests that they were formed by the ground opening up within a narrow zone which runs discontinuously in an east-west direction for about 800 metres, from just south of the outlet of the Rudkhaneh-pa' i Kaleh to the east edge of the fields. Low adobe walls built after the earthquake across this zone today show no sign of subsequent displa-

cements. Nor is there any evidence that this zone of slumping extended beyond the limits of the fields into the pediment material and gravel fans. It is of interest that with the exception of this zone, within which liquefied material was ejected to the surface of the ground, there is no evidence of mud volcanoes or ejected sand in the rest of the fields.

There is evidence, however, of extensive liquefaction of Kavir sands south of Torud, as well as of thin dunes in the Labsureh depression, about 9 kilometres north of the village (Fig. 4), where allegedly a camel crossing what was previously a safe track during dry weather, was swallowed up.

Ground deformations, about one kilometre to the south of Torud and near the farm of Sultaneh Ibrahim were reported by Abdalian (<sup>1</sup>). This farm is situated at the foot of Kulud-Dagg, a low hill formed by the erosion of the south limb of a northeast-southwest trending anticline of bedded Miocene saline mudstones and harder sandstones of the Upper Red Formations. The hill consists of parallel ridges of the harder beds along which Abdalian mentions, in passing, the presence of a zone, about 15 metres wide and several kilometres long, within which he observed that locally the ground was downthrown to the south by 20 to 140 centimetres. Evidence for ground deformations near the farm is still visible but only along very short lengths along the strike of the bedding (Fig. 3, points 5, 6). Erosion has removed any evidence from which to judge the amount and sense of movement today. As a matter of fact, several parallel zones of disturbance in the softer and to a lesser extent in the harder beds, are still visible south of the farm, most of them running east-northeast with a few disturbed zones following a conjugate direction (Fig. 3, points 7, 8, 9, 10), plate 5. Similar local disturbances were found further to the southeast of the farm in marls and sandstones near Gerda and Chah-i Morghab (Fig. 4).

The kavir lies about 10 kilometres to the south and east of Torud and is totally uninhabited for almost 200 kilometres.

To the southwest of the village, the first inhabited place is the small settlement of Bidestan (Pejestan or Paiesk) which, at the time of the earthquake, had about 100 houses and a population of 480. The shock destroyed 75 houses killing 18 and injuring 10 people, and caused slumping of the ground within a zone two metres wide and a few tens of metres long, between the settlement and the fields of Kelau which run parallel with the qanat. Today, the village has been rebuilt next to the ruins of its old site.

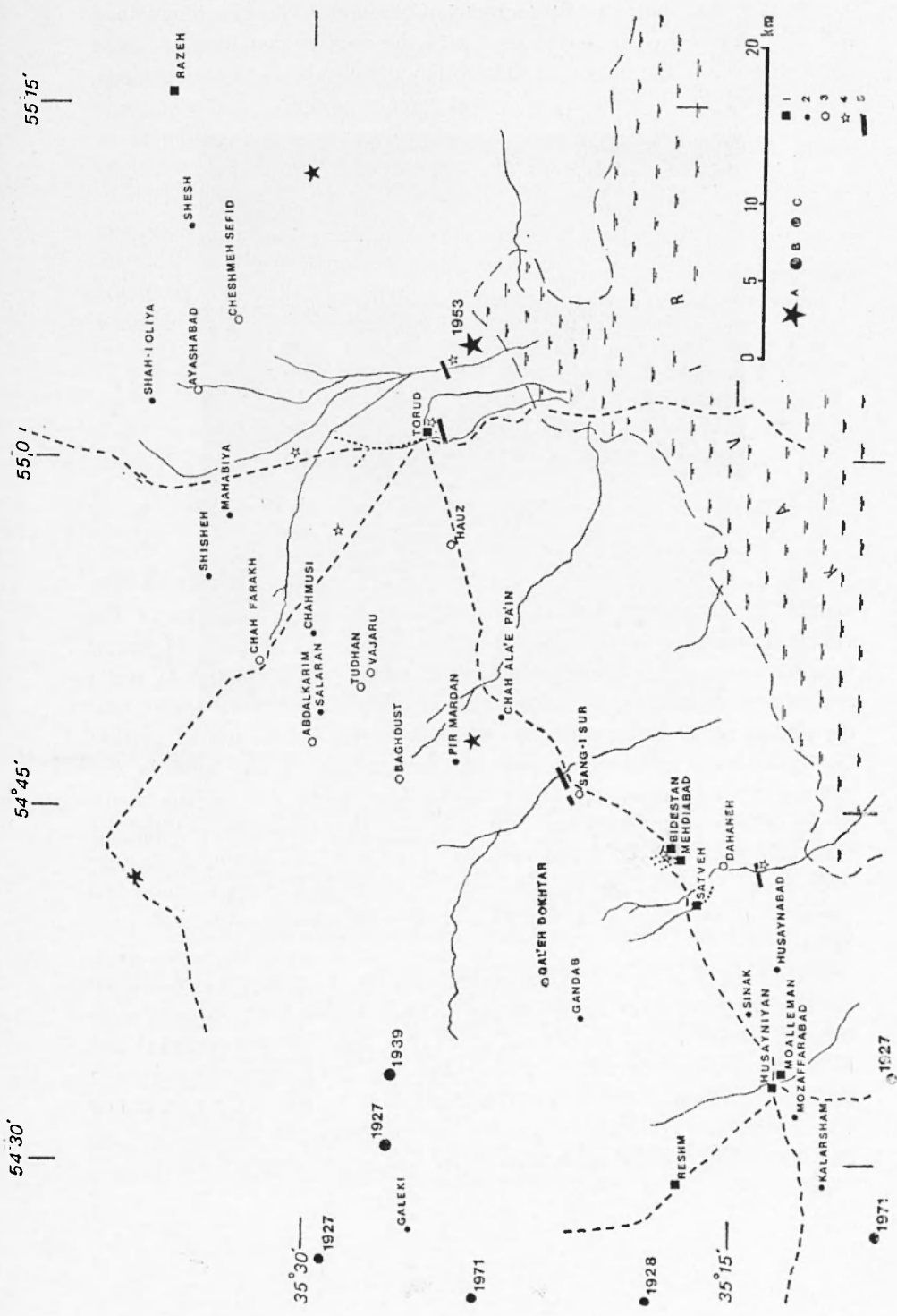


Fig. 4 — Meizoseismal area of the Torud earthquake. 1 = villages with a population of more than 45 affected by the shock; 2 = affected settlements with a smaller population; 3 = uninhabited settlements; 4 = locations where there is evidence of liquefaction of the ground associated with the earthquake; 5 = ground deformations; A = location of main shock and of aftershocks; B and C = epicentres of all other known instrumentally determined epicentres.

Next to Bidestan, a smaller settlement of about 20 houses, Mehdiabad was also ruined by the earthquake with the loss of two lives. A short qanat dug below the bottom of the erosion stream about 15 metres deep, was blocked by the shock but it was later repaired.



3 — View of area of ground fractures No. 6, 7 and 10 of Figure 3.

In Satveh (or Sadfeh) half of the houses collapsed. Out of 500 people, 8 were killed and 10 injured and of the four qanats of the village, three were damaged temporarily causing a serious lack of water. Ground motions were strong enough to make people unable to stand and to cause water to slosh from containers. At the time of the earthquake the underground water table was about 3 metres below ground surface but there is no evidence of ground deformations of any kind in the vicinity of the village. However, about four kilometres to the south of Satveh, in the fields near the ruins of the abandoned village of Dahaneh, near the old qanat and also further to the south, there was widespread liquefaction in the bed of an erosion furrow and also cracking of saturated silty deposits, from which water and sand were ejected.

Damage was less serious at Husayniyan, a village of about 40 houses, 50 kilometres southwest of Torud, where three people were injured. Only a few houses collapsed but the rest were ruined. At Moallemman, a near-by village of the same size, all houses suffered some damage but without casualties. The shock did not affect the qanats nor was there any evidence of ground deformations. At Husaynabad no one was killed but the six houses of the settlement were ruined.

To the north of Husayniyan, the old village of Reshm sustained minor damage and only a few houses needed repair. However, the shock caused a temporary change in the yield of the spring that provided the sole source of water for the village. Further to the north of Reshm, at Galeki (or Galuki) a semi-abandoned village, damage was equally small.

The only other village in the area, Razeh, is about 30 kilometres northeast of Torud. No one was killed in Razeh itself, but half of its 20 old houses were shattered and some of the ruins of the old village collapsed. There was no damage to a small qanat, but the sole spring of water in the area dried up.



4 — The old Hauzi Paistan still standing.

Damage to isolated farmhouses and abandoned settlements in the area was found to be difficult to assess. About 7 kilometres southwest of Torud, Hauzi Paistan, an ab-ambar or water reservoir covered with a dome of stone masonry was not damaged (Plate 4). About 18 kilometres from Torud in the same direction, Chah Ala'-e Pain, a farmhouse, was damaged. Two other farmhouses, uninhabited at the time of the earthquake and located in the hills between Chah and the site of the Imamzadeh Pir Mardan (or Nur 'Ala'), collapsed completely and a spring of water dried up. At 26 kilometres from Torud on the road to Satveh, near the disused ab-Ambar of Sangi-i Sur, the shock caused another spring of brackish water to dry up. At this place, a few hundred metres northwest of the main road, the earthquake caused some slumping of the ground. According to local information this should have occurred where

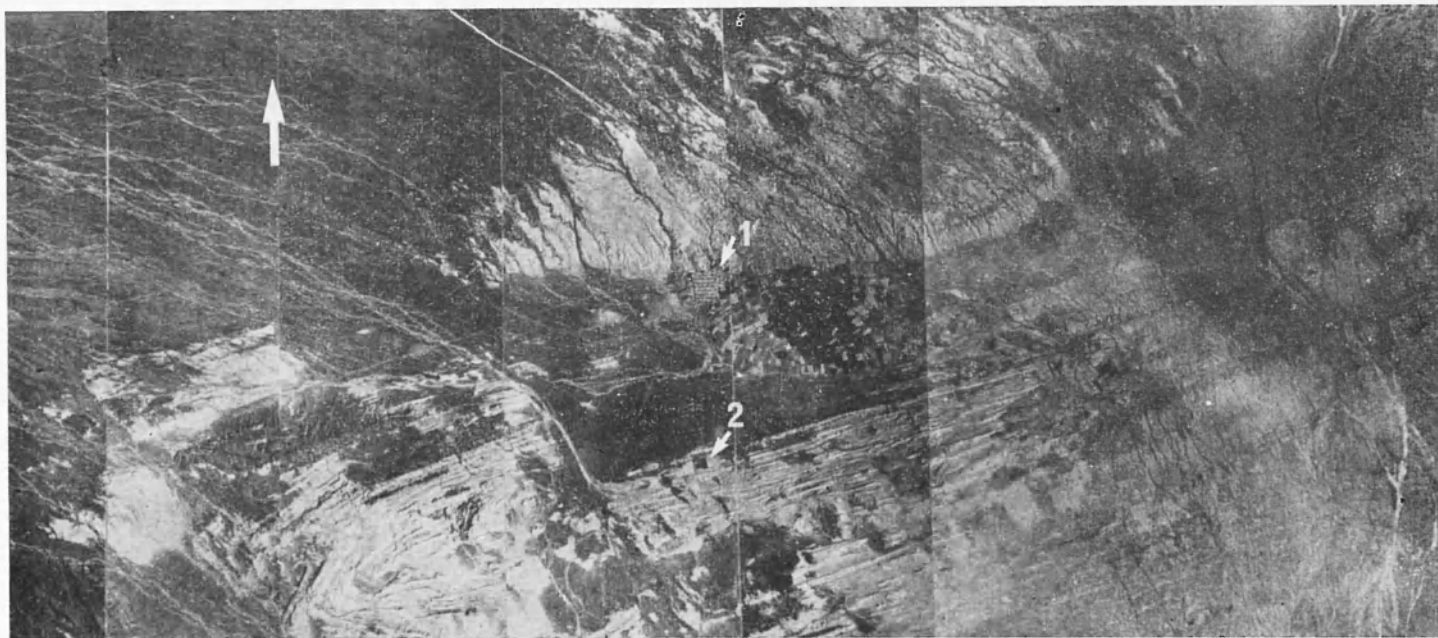
a stream course running to the southwest cuts into a series of young terraces. There is some evidence here that as a result of the earthquake the alluvium to the southeast was downthrown against the brecciated volcanic rocks to the northwest.

Southwest of the abandoned site of Qal'eh Dokhtar, the qanat of Gandab was damaged, allegedly not by the earthquake of February but by a later shock. There is also some unauthenticated evidence that after the earthquake and for a few years, the desolate pastures of Baghdust, Vajaru and Tudhan were covered with a rich vegetation unusual for this type of terrain, perhaps suggesting a temporary change of the water table. Further north, at the farm of Salaran and the copper mine of Chahmusi, all of the houses, of which there were 10, were damaged. In the region of Mahabiya and Shisheh, damage was more serious. Out of 12 houses, 6 were destroyed without casualties. The qanat at Mahabiya was not affected but the spring of water Shisheh was temporarily blocked. The shock triggered small rockfalls near Shisheh Oliya. At Cheshmeh Sefid, a deserted settlement of a few ruined houses, the earthquake caused slumping of the saturated ground at some distance from the old qanat. According to local reports there was little damage at Imamzadeh Shah-i Oliya.

Chah-i Jam, about 35 kilometres north of Torud, a small settlement of about six houses was also damaged. There was no damage to the walled settlement of Chah Baba, now abandoned, nor to its water supply. At Dizak, about 10 kilometres south of Shahrud, the shock cracked a few walls and in Shahrud and Damghan it caused panic. It was strongly felt at Semman, Sangsar, Miyandasht and Dashtgird. At Khur, 180 kilometres south of Torud, a few old walls collapsed. The earthquake was felt in Tehran, Damavand, Behshahr, Gorgan, Gonbad-i Kabus, Jajarm, Kashmar, Torbat-i Haidaiyyeh, Tabas and Anarak. It was not felt in Qumm, Kashan and Mashad.

#### DISCUSSION.

The region of Torud has never been an area of importance, being remote and arid, and as such has provided no known notices about historical earthquakes. Gansser (<sup>5.5 bis</sup>), on the authority of local information mentions an earthquake early in the 19th century that allegedly devastated the area of Reshm, an event that could have been



5 — Photomosaic of the Torud area; 1 = new village; 2 = Daqq Soltaneh Ibrahim.

associated with one of the large shocks of the first quarter of the last century that affected southeast Mazanderan and Qahabrastan.

During this century, the Torud region, encompassed by  $35^{\circ}N - 36^{\circ}N$  and  $54^{\circ}E - 55.5^{\circ}E$ , has been subjected to frequent shaking of moderate intensity, mainly from known earthquakes with epicentres outside the region of Torud. Some of these events are still remembered by the older inhabitants of Torud, Satveh, Reshm and Chah-i Jam. The earliest earthquake remembered in Torud occurred around 1915 but it caused no damage. The earthquake of 22nd July 1927 of magnitude 6.3, is remembered vividly, particularly for its strong aftershocks that caused minor damage in Satveh. The epicentre of this event lies outside the region of Torud, about 150 kilometres west of Torud, but nevertheless it was strongly felt, causing some panic in the village. The earthquake of 14th April 1928, which allegedly caused minor damage in Satveh, is usually confused with the earthquakes of the previous year. About a decade later, there was again some slight damage in Satveh and rockfalls near Tang-i Reshm caused by the earthquake of 6th April, 1939. Thus, the only known damaging shock in the Torud region is the earthquake of 12th February 1953 which was followed by a long and well-established period of seismic quiescence.

There are at least four more earthquake that are often placed erroneously in the Torud region. The first, on 10-23 January 1908, with a reported epicentre at  $35.5^{\circ}N - 55.5^{\circ}E$ , is given by Wilson (<sup>15</sup>) on the authority of Shtelling (<sup>13</sup>). In fact, Shtelling refers to the Silakhor earthquake of 1909 that took place 590 kilometres away from Torud, on the 10th January (old Style) or on the 23rd January (new Style). Wilson commits three consecutive errors therefore: he gives 1908 instead of 1909, he does not notice that 10=23 January in the old and new Styles, and he does not seem to have read the paper he quotes, in which Shtelling dismisses the original location of the earthquake given by Galitzin, namely  $33.5^{\circ} - 55.0^{\circ}$  for a more precise one determined from macroseismic data.

The other three earthquakes that are usually given the erroneous location of  $35.5^{\circ} - 55.0^{\circ}$ , a location of an adopted ISS epicentre, are those of 17th September 1923 and 3rd July 1924 at 0803 and 0818 (GMT). In fact these earthquakes occurred 350 kilometres away from Torud, near  $37.8^{\circ} - 57.3^{\circ}$  where they caused considerable damage.

The Torud earthquake of 1953 is the only relatively large event known to have occurred on a major fault zone such as the Torud fault

zone. Neither the magnitude of the shock nor the seismicity of the zone before and after this event suggest the presence of a recent active tectonic lineament. And although there is ample evidence for a Recent fault zone running along the Torud-Satveh-Reshm axis, the information that can be gleaned today in support of fault movements associated with the 1953 earthquake is indeed both meager and inconclusive. The three isolated cases of limited ground deformations found south of Torud and Dahaneh associated with the 1953 earthquake seem to suggest features of secondary nature, perhaps associated with local readjustments caused by movements in deeper structures. The case noticed north of Sang-i Sur may well be due to local slumping along a pre-existing contact face, and the ground deformations in the fields just south of Torud are most certainly of secondary nature. While it is difficult to prove that there was no faulting associated with the 1953 earthquake, the fact that our sole authority for it (Abdalian (1955)), did not map the fault-breaks, taken together with the absence of any conclusive field evidence today in support of faulting, makes the conjecture of faulting unreliable at best.

There is conclusive evidence, however, that the Torud earthquake caused the liquefaction of saturated, silty sands, both in the Kavir as well as in isolated depressions filled with aeolian deposits in the Torud area (Fig. 4). However, fluctuation of the underground water table in the Kavir is considerable. At the time of the 1953 earthquake the water table was high, almost at ground surface, and this time of the year, even under normal conditions, caravans would follow tracks differing from those used during the dry season to avoid being stuck in « soft » areas of the desert.

The damage caused by the Torud earthquake is typical of other events of similar magnitude in Iran. Damage was mainly due to the poor construction of the houses and its maximum intensity should not have exceeded VIII (MM). There is no evidence that houses built on the terrace of Torud suffered more than those built elsewhere. Nor is there any evidence from the study of the ruins of the village that with the exception of the houses built on the edge of the loess terrace, that foundation failures contributed to the destruction. The lack of timber for roofing and the use of flat vaults, as well as the narrow streets, are thought to be one of the main reasons for the large number of casualties.

## ACKNOWLEDGEMENTS.

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## REFERENCES

- (1) ABDALIAN, S., 1953. - *Le tremblement de terre de Toroude en Iran*. « La Nature »,
- (2) ANONYMOUS, 1953. - « Bulletin Seism. Soc. Amer. », **43**, p. 185.
- (3) ATLAS ZEMLETR' SENII V CCCP, 1962. - « Akademia Nauk », Moscow.
- (4) GABRIEL, A., 1953. - *Durch Persiens Wüsten*. Strecker & Schröder, Stuttgart.
- (5) GANSSER, A., 1969. - *The large earthquakes of Iran and their geological frame*. « Eclogae Geologicae Helvetiae », **62**, 2, pp. 443-466.
- (5 bis) GANSSER, A., 1977. - *Private communication*.
- (6) HEDIN, S., 1910. - *Overland to India*. 2 Vols., Macmillan, London.
- (7) HEDIN, S., 1918. - *Eine Routenaufnahme durch Ostpersien*. 2 Vols., Stockholm.
- (8) KHURASAN, *Ruznameh*. 26-28 Bahman 1331, Tehran.
- (9) NOWROOZI, A., 1971. - *Seismo-tectonics of the Persian Plateau, Eastern Turkey, Caucasus, and Hindu-Kush regions*. « Bull. Seism. Soc. Amer. ». **61**, pp. 317-341.
- (10) PARHAM, B., 1972. - *Reconstruction of earthquake damage: Torud*. « Dept. Research & Planning, Ministry of Housing & Development », **52**, Part 1, Tehran.
- (11) ROTHE, J. P., 1955. - *Chronique Seismologique* « Rev. pour l'Etude des Calamites », Geneve, **33**, p. 22.
- (12) RUSTANOVICH, D. N., 1967. - *Seismichnost' territorii Turkmenskoy CCP i Ashkhabadskoe zemletriasenie 1948 g.* « Vaproc. Inzen. Seismol. Byul. 12. Akademia Nauk », Moscow.
- (13) SHTELLING, E., 1910. - *Svedenii o zemletr' senii v Persii 10/25 Janvar 1909goda*. « Acad. Imper. Sc.. C. R. Comm. Seism. Perm. », **3iii**, St. Petersburg.
- (14) VAUGHAN, H. B., 1890. - *Report of a journey through Persia*. « Intelligence Branch Quarter Master General's Dept. in India », Calcutta.
- (15) WILSON, A. T., 1930. - *Earthquakes in Persia*. « Bull. School Orient. Studies. London, **6**, Pt. 1, pp. 105-131.