

THE QUETTA EARTHQUAKE: *A paper read at the Evening Meeting of the Society on 8 June 1936, by*

C. P. SKRINE

AT the time of the earthquake of 31 May 1935 I held the appointment of Political Agent, Kalat and Chagai, in the Baluchistan Administration. My summer headquarters were at Mastung, a busy little township which has for centuries housed the Hindu traders who minister to the economic needs of the otherwise exclusively Muhammadan population. The Mastung *niabat* boasts the richest lands in all the province of Sarawan and its wheat is as renowned for its fine-milling qualities as its fruits and vegetables are for their size and flavour. It is ruled over by a *mustaufi* or district officer of the Khan of Kalat, whose wide but thinly populated territories comprise about three-quarters of British (as opposed to Iranian) Baluchistan. Its broad, flat-bottomed valley, some 5600 feet above the sea, adjoins the bleak uplands of Quetta 32 miles to the north, from which it is separated by a rocky chain culminating in the towering crags of Chiltan (10,850 feet). From the *lak* or pass by which the Quetta-Kalat road crosses the ridge the view southwards is impressive; in the middle distance the apricot orchards and mulberry groves of the Mastung group of villages lie like cloud-shadows upon the plain, and in the far south you can see on clear days the blue Harboi hills which screen the secluded uplands of Kalat, ancient home of the Ahmadzai Khans of the Brahui Confederacy.

On that fateful Friday night I had motored into Quetta to dine with a friend and see a film. The Baluchistan capital was at the height of its spring season. A week of official and private gaieties centring on the King's Birthday celebrations was about to begin. Four or five hundred British civil and military officers and their women-folk were next afternoon to meet a similar number of prominent local Indians at the annual garden party given by the Agent to the Governor-General and Chief Commissioner, Sir Norman Cater, at the Residency, famous for its lawns and the beauty of its rose gardens. The King's Birthday was to be celebrated on the Monday with a march-past befitting the second greatest military station in the British Empire; several open-air dances, including one for four hundred guests at the Residency, were coming off during the next few days; polo, tennis, cricket, aquatic sports, and other activities were in full swing. The weather was of the perfection which dwellers in the highlands of Baluchistan take as a matter of course in early summer and autumn; the winter snows and spring rains had been exceptionally copious, grazing was plentiful, and a bumper wheat crop was about to be harvested. Trade was improving and the influx of summer visitors from Sind and the Punjab greater than ever. Altogether, prospects in town and country were bright, and the summer season which had opened auspiciously with the Jubilee Celebrations in early May bade fair to be the happiest and most prosperous that Baluchistan had enjoyed for years.

At about half-past twelve I returned alone to Mastung, a full hour's run over hilly country in the dark. The Residency there was a long, roomy bungalow embellished by two squat machicolated towers of (apparently)

solid masonry, standing on a flat-topped mound above a most delectable and productive garden. Some 300 yards to the west stood the somewhat smaller house of my Assistant with its garden round it. I was the only European in Mastung that night, my Assistant and his wife having, fortunately for them, left for the week-end that very afternoon. My wife, no less luckily, was spending the summer in Kashmir. I remember going to bed, dog-tired, at about a quarter to two. In previous years I had been in the habit of sleeping out of doors long before the end of May; but the weather was exceptionally cool and I was still using a large, high-ceilinged bedroom on the eastern side of the house. The next thing I knew was that I was out of bed in my pyjamas and bare feet, groping about in pitch darkness with one idea in my head, "Get under a doorway." The air was full of acrid dust and I could scarcely breathe. I cannot say for certain that I heard any sound of earthquake or felt the ground move, but I have a vivid recollection of a faint distant clamour of human voices from the direction of the town. This ceased abruptly and was followed by silence as of the tomb. My bed had been within easy reach of a double doorway leading from the large, lofty bedroom into an empty, low-roofed sun-room. I had already nearly reached the double doorway when I awoke, and had thus, as it turned out, literally sleepwalked into safety, for my bed was already under the massive debris of the ceiling and main roof of the bungalow, while the sun-room (originally a veranda which had been built in) remained standing. This prompt action of the subconscious mind was the more remarkable in that I had had no previous earthquake experience whatever.¹ In mortal fear I groped my way over broken glass and fallen wardrobes to the outer door and tried to open it, but it had jammed. The open windows were protected with strong wire gauze, and I had for a moment the sense of being trapped and at the mercy of any further shocks which might occur. Somehow I managed to break a pane of glass in the door without cutting myself, and putting my head through shouted for help. To my relief, a Gurkha sentry of the guard came up. He seized my hands and pulled me through, and I stood leaning on him for a few moments, completely unnerved. Soon my servants came in the darkness from their quarters with a lantern. Their small and solidly built houses had only partially collapsed and no one had been seriously hurt. They found a blanket and a pair of native shoes for me, and when the dust had cleared we crept round the house at a safe distance and saw in the starlight what had happened. The place was a ruin. Nearly

¹ Another possible explanation of my curious experiences may be that I woke up and made for safety when my bed began to shake, but the noise and mental shock caused loss of memory of the few seconds immediately succeeding them. Cases of amnesia in such circumstances are not unknown. Similarly, the deathly silence which so impressed me may have been due to the dulling of my senses by intense excitement. Professor D. B. Langford, in his account of his experiences on the Manazuru peninsula in the Yokohama-Tokyo earthquake of 1923 (*Bull. Seismol. Soc. America*, vol. XIII, p. 135), describes how he and a companion watched a 300-foot cliff above them collapse without hearing a sound. "The apparent silence of the crumbling cliff," he says, "has struck me several times since. It is possible that the intense excitement dulled our senses." Mr. H. Weightman, I.C.S., who had an even narrower escape than mine when his bungalow collapsed at Quetta, told me that the silence immediately after the shock was so intense as to give him the impression that everybody in the world except himself was dead.

all of the roof and some of the inner walls had collapsed; the two squat towers mentioned above had crashed, the east one on top of my private office and part of the drawing-room, and the west one on my wife's bedroom. If she had been in it at the time she could not possibly have escaped being buried in a few seconds 8 feet deep in broken masonry and twisted girders. Likewise, if the east tower had fallen more to the north, or the west tower more to the east, the doorway under which I took refuge must have been crushed as well as the bedroom, and I should almost certainly have perished. All the interior of the house was a chaos; the rooms were nothing but heaps of bricks mixed with beams splintered to matchwood and heavy iron girders lying about like spillikins. Even so, the ruin was not so complete as that of my Assistant's bungalow, which I saw later in the morning. That had been simply flattened out by the roof settling down over the crushed walls like an extinguisher. No human being sleeping in it could possibly have escaped; the watchman told me that the place was flat within a few seconds of the shock. Three of Captain Bazalgette's four dogs were however dug out alive, two the same day and the third, a beloved dachshund, no less than five days later.

Clad in pyjamas, a battered Burberry, and my bedroom slippers I made my way through the garden to the clerks' lines and was much relieved to find them all safe, collected in panic-stricken groups outside their ruined houses. One had lost his wife, another a child, a third his servant, no more. The hill on which the clerks' quarters, club, library, etc., were built seemed to have been less badly shaken than the rest of the town, of which scarcely one brick remained above another. Forming ourselves into parties for rescue work, we who had escaped so lightly pushed on into the town. The first thing I noticed was the silence. Why were there no groups of frightened inhabitants standing about in knots, why no shouting and excitement? Never shall I forget the horror with which I realized that there was scarcely anybody left alive to shout—the majority of the people were buried under the ruins, and the few survivors were either too dazed to make a sound or were trying to pull their folk out of the debris. The work of rescue was made no easier by the minor earthquakes which followed each other in quick succession throughout the rest of the night. Every now and again, as we frantically pulled and scraped at some pitiful bundle of clothes and tortured flesh pinned down by wall and rafter, the terrible deep thunder of earthquake would be heard again and the ground would shake and sway, sending us scuttling out into the open like bolting rabbits.

By dawn it was clear that the whole town was in ruins with 60 or 70 per cent. casualties, mostly dead. The only doctor, a Sub-assistant Surgeon, was doing what he could for the scores of injured who were being brought to him, but his instruments and medicines were buried in the ruins of his dispensary and he was desperate. The telegraph line was broken, so there was obviously nothing for it but to try to get into Quetta for help. It did not occur to any of us that the state of Quetta could be anything like that of Mastung and that help would not be immediately forthcoming. Accordingly I returned to the Residency, salvaged a pair of trousers and a shirt from the remains of my dressing-room, and examined the garage. Much to my relief, the office lorry and two big touring cars were not seriously damaged, though battered



1. Hindu quarter at Mastung



2. The Residency, Mastung: showing in the middle the author's bedroom



3. *Twisted rail near Mastung*
W. D. W.



4. *Bridge on the Quetta-Mastung road*
W. D. W.



5. *Quetta: earthquake-proof bungalow in Lytton Road*
W. D. W.



6. *Quetta: incomplete Railway Hospital*
W. D. W.

by falling bricks. But the building had partially collapsed and the doors were jammed, and the only car we could get out and start was the little Austin Seven tourer, from which we had to rip its tattered hood. In this at a quarter-past seven my head mechanic, Haji Gul Muhammad, my bearer, Ahmad Din, another driver and I sallied forth with pick and shovel. Before starting I "shot" the ruined Residency and other scenes with my cine-camera, which to my great joy I had discovered undamaged in the porch, with nearly 50 feet of unexposed film in it. These pictures, and others I took on the road and at Quetta the same day, came out very well and form a unique record of the morning after the earthquake.

It took us an hour and a half to clear with pick and shovel a narrow track for the car out of Mastung and its environs, the walls and buildings having in many places fallen across the road. Everywhere was desolation. The only living beings visible were a few apathetic men and women wandering about among the ruins of their homes, and a few injured lying under the trees with no one to look after them. Five miles down the road we nearly upset into a fissure in the road; for about a mile the earth was cracked in many places and though none of the cracks were deep we had to shovel in quantities of stones and earth before we could get the car across. Then came a bridge which was badly knocked about and obviously very unsafe; we had to dive into the ravine it crossed, dash the sand at the bottom, and crawl up the bank on the further side, making a road for the car as we went. Then came the pass, where the roadway, to our surprise, had not fallen down the hillside, though we had to hug the inner ditch to avoid the cracked outer edge. The precipices of Chiltan towering 4000 feet above us were still raining down boulders, the dust from the rockfalls flying up in great clouds which made the whole mountain smoke like a volcano. With painful anxiety we reached the top of the pass, whence Quetta is visible 15 miles away in clear weather. What were we going to see? Our worst fears were confirmed when we looked across the void and saw a huge, sinister, pale brown cloud brooding over the distant town. Never shall I forget the shape of that cloud. The morning breeze and the smoke of fires had caught it up into a peak at one end, giving the impression of an awful misshapen hand stretched over the city. We pressed on as fast as the little car would carry us along the last 16 miles into Quetta. Any remaining hopes we might have had were dashed to the ground by the sight of the first bungalow we passed 4 miles out of Quetta on the Sariab road. It was nothing but a crumpled roof lying on top of a heap of bricks and broken timber, and all the other villas we passed, residences of retired officials for the most part, were the same. Nowhere was any sign of life to be seen. Then came a most welcome sight. The railway line to India runs parallel to the Sariab road at a distance of about half a mile. There, scudding southwards, was a rail-motor trolley! There was somebody alive in Quetta, then, after all. I heard afterwards that it was the Divisional Superintendent, Mr. Bean, proceeding most hazardously down the line to see whether it had been destroyed in the Bolan Pass, as might well have been the case. He got as far as Kolepur at the head of the Bolan, and his telegrams to Simla and Lahore were, I believe, the first intimation the Government of India received of the disaster. The slightness of the damage done to the main

line was one of the most providential as well as remarkable features of the earthquake.

We made our way to the suburb in which lived Gul Muhammad's brothers. Gul shouted in Brahui to a neighbour he saw in the road. I could not understand the reply, but there was no doubt as to its nature; Gul burst into tears and I had to seize the wheel to prevent the car running into a ditch. The houses where the two families lived had been completely flattened out. Not one brick stood above another. The three men got out and went clambering over the ruins while I sat under a tree, overwhelmed with the pity and horror of it all. Under the same tree were two women and a man, apparently uninjured, but dazed and beaten. They were the only survivors of a family of eighteen, in which all the children had been killed as well as some of the adults. The man with a pathetic attempt at hospitality brought a turned-up packing case for me to sit on. I felt I ought to follow Gul over the mounds and help him with his relatives, but I simply could not face the spectacle of their sorrow. When the three men came back, they told me that Azim and Amir Bakhsh and their wives had escaped with injuries, but the former had lost two of his three little boys including Muhammad Nur, the apple of his eye, and Amir Bakhsh all his three daughters. Promising medical assistance and food as soon as possible I got into the car again and drove through scenes of awful desolation to the Civil Lines.

Here, in shady Gymkhana and Lytton Roads, hardly a house could be seen standing. Through the trees, in the midst of flower gardens and orchards, bungalow after bungalow of my colleagues of the Civil Administration lay in ruins. My relief was unbounded when I came to the big two-storeyed Residency and found it standing, though badly knocked about, and the Agent to the Governor-General, Sir Norman Cater, standing with two or three friends on the lawn, calm and collected though grave, and immaculately turned out as ever. He had escaped from the house a few seconds before the heavy porch and double-storeyed veranda had crashed in ruin, killing three of the Gurkha guard. Tents had already been pitched under the great spreading planes, the nucleus of what afterwards developed into a camp for civil officials. I anxiously asked after my other friends in Civil Lines. The Irrigation Engineer with his wife and child, I was told, were crushed dead beneath the fallen roof of their house; a newly married Political couple who had just returned from their honeymoon, together with the bride's mother, were buried under the ruins of their bungalow in Lytton Road and almost certainly dead; two other Political officers and the Civil Surgeon had lost children; the Revenue Commissioner had been dug out alive but badly hurt from his completely flattened bungalow, in which a guest of his remained, almost certainly dead. Two ladies had been badly injured and the Civil Surgeon had a double fracture of the thigh, while another officer had received serious head injuries and would have to be invalided home. Other European casualties, including military officers and their wives and permanent residents of Quetta, were not known but estimated at 200 including 100 deaths; among these I afterwards found the names of several friends and acquaintances. The Indian death-roll was appalling and was already known to include many distinguished retired Government officials and men of substance in the town,

some of them men whose friendship I valued highly. The whole of Quetta had already been placed under martial law and rescue work had been in progress since 3.30 a.m.

My place was obviously back at Mastung, so after exchanging escape stories with surviving friends at the Residency I took my leave of the A.G.G. and drove round Quetta to see for myself the extent of the catastrophe. I went first to Cantonments. I found that by an extraordinary and most merciful dispensation the earthquake area came to an end about half a mile beyond the line of the Habib Nullah, the open drain which divides the City and Civil Lines from Cantonments. The houses, including Flagstaff House, immediately to the north of this boundary were as badly hit as any in Civil Lines; the next line of bungalows was definitely less affected, and beyond Hibbert Road I could find no external signs of serious shaking except fallen chimneypots. The Garrison Church, half a mile within the cantonment area, was standing and above all the British and Indian Military Hospitals were undamaged; this was particularly fortunate as the Civil and Mission Hospitals had been razed to the ground and most of the patients and staff killed.

Returning to the Civil area, I found myself in Bruce Road, the Piccadilly of Quetta. Though prepared, I could hardly believe my eyes. Scarcely two or three of the familiar shops were recognizable, and none were standing. Soldiers were on guard at many points and others were clambering about the ruins on rescue work, accompanied by a few—a very few—inhabitants. That was what struck me most forcibly. In this crowded city, in the middle of the day, with none of the houses inhabitable, only handfuls of people here and there could be seen. The rest were all there—under the great mounds of bricks and plaster and wood and iron sheeting. The appalling thought was that many of them must still be alive and, except for those lucky ones whom the toiling soldiers might rescue, must die a lingering death. I heard afterwards that the troops did dig out many hundreds of living persons from the ruins during the course of the next three days, as well as 3000 or more corpses. At least 4000 injured were treated at the Indian Military Hospital. Burials were to begin at 3 p.m. under military supervision; there was no possibility of separate graves, and trenches were being dug in selected areas outside municipal limits. Smoke from the funeral pyres of dead Hindus could already be seen ascending at several points. With a heavy heart I turned the nose of the car southwards and, picking up poor Gul on the way, drove back to Mastung.

By six o'clock I was back at my ruined headquarters, to find that my excellent servants had salvaged some bedding and other necessities as well as a little food for me and were themselves encamped under the trees. That night I was joined by my Assistant, Captain Bazalgette, and very glad I was of his company in my tent in the rose garden which was to be our home for the next few weeks. The evening and night were punctuated by earth-tremors of varying degrees of noise and violence. The next few days were spent by us working at fever heat in cooperation with the surviving Kalat State officials to convert chaos into some sort of order. We found that some 1125 persons had been killed in and around Mastung alone and another 2000 in the rest of

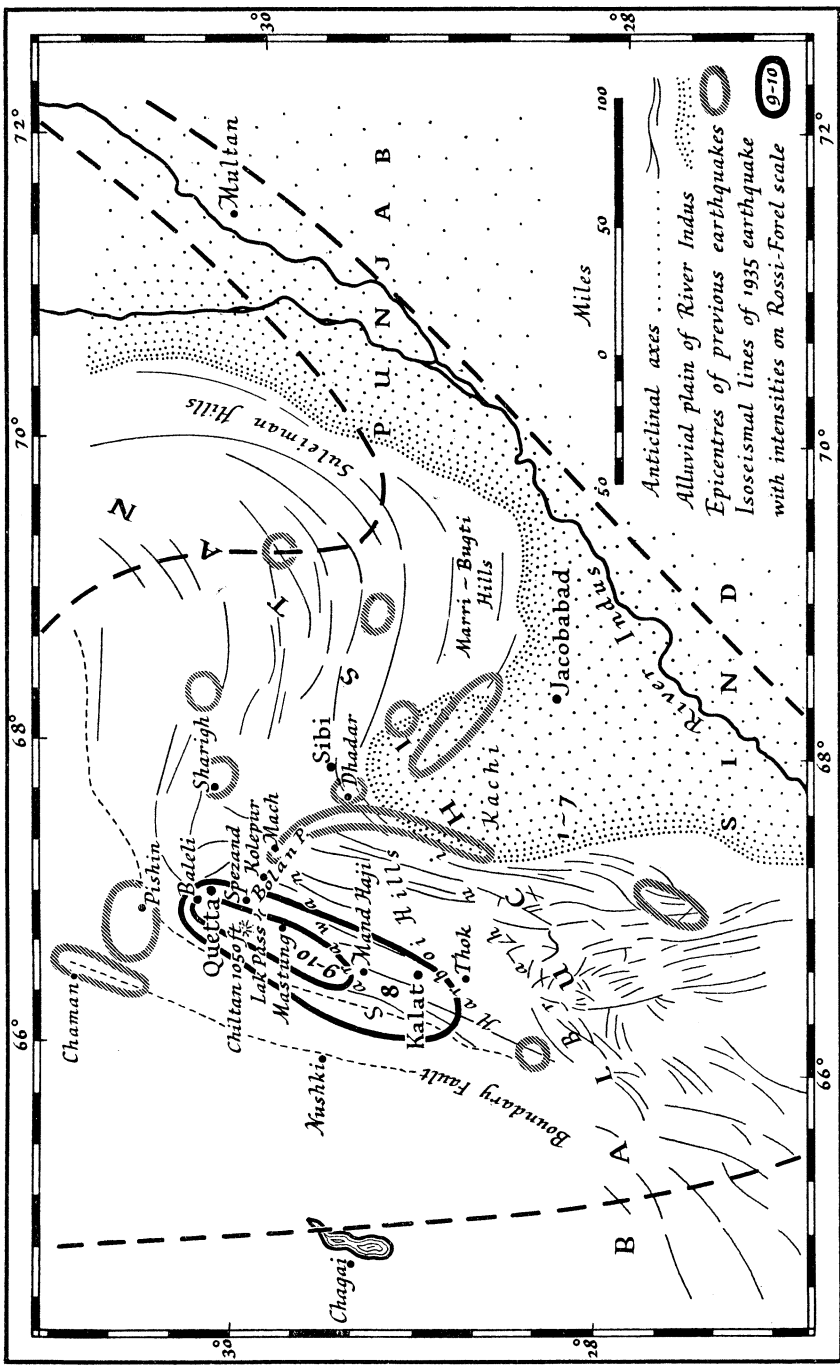
the earthquake area of the Kalat State. The bulk of the survivors needed only encouragement and what little assistance we could give them in the burying and burning of their dead and in the salvage of their property. All, Hindu traders and Muhammadan agriculturalists alike, worked with remarkable energy after the first shock had passed off. But hundreds were severely injured, and as I have already said there was only one small dispensary with an Indian doctor in charge to look after them. Hundreds more were destitute and had to be fed and sheltered. Last but not least, Mastung and other bazaars had to be protected by reinforcements of frontier militia, brought from far-off posts on the Afghan and Persian borders, against the marauding bands which roamed around the countryside. We did our best, but our resources were quite insufficient to cope with the situation, and had it not been for the prompt response of the military authorities at Quetta, the plight of Mastung and neighbouring villages from Kanak in the north to Mangochar in the south, a distance of some 58 miles by road, would have been sorry indeed.

It is time however that I turned to the scientific aspect of the earthquake, which perhaps interests this Society more than administrative details of the work of relief, salvage and reconstruction. Not being myself a seismologist—having in fact had seismology almost literally thrust upon me—I must content myself with bringing to the notice of Fellows the admirably lucid “Preliminary Geological Report on the Baluchistan (Quetta) Earthquake of May 31st, 1935,” compiled by Mr. W. D. West, Assistant Superintendent, Geological Survey of India, as a result of his investigations in the earthquake area during the month following the disaster.¹ Mr. West had already been in Quetta some days when at my invitation he came to Mastung and spent five or six days touring round the affected area in Kalat State. I was fortunately able to spare the time to accompany him on more than one of his expeditions, notably to the fissure shown in Plate 8 and to the mud volcano, Plate 7. At Mr. West’s request, detailed questionnaires were put to a considerable number of witnesses, including Brahui and Dehwar cultivators from numerous villages on the outskirts of the earthquake area, and the replies received were of material assistance to Mr. West in determining the limits of the epicentral zone. The “Preliminary Report” should be read with chapters I, II, VII, and VIII of Mr. West’s “Report on the Baluchistan Earthquakes of August 25th and 27th, 1931.”²

The diagrammatic map opposite, which is based on the maps appended to Mr. West’s reports, shows the isoseismal lines of the 1935 earthquake together with the positions of the epicentres of the fifteen recorded earthquakes which have shaken Baluchistan since the middle of last century. It will be noticed at once that they are grouped in a curious way round a sharp re-entrant which exists in the mountain system of the province. The mouth of the Bolan Pass and the town of Sibi, only 450 feet above the sea, are at the head of this salient; the hills on its western flank rise to nearly 10,000 feet in the Kalat territory, while those on the eastern side are considerably lower, but still very rugged and precipitous. Now the mountains of Baluchistan are

¹ *Memoirs of the Geological Survey of India*, Calcutta, 1935, pp. 203–240.

² *Op. cit.*, vol. LXVII, Pt. 1, Calcutta, 1934.



9-10

Anticlinal axes
 Alluvial plain of River Indus
 Epicenters of previous earthquakes ○
 Isoseismal lines of 1935 earthquake
 with intensities on Rossi-Forrel scale

Miles
 0 50 100

merely a southward branch of the great Tertiary system, of which the Himalayas are a part; and it is now generally accepted that the folds in these mountains "have been formed by the movement of the old stable mass of Central Asia towards the stable mass of Peninsular India, resulting in the compression of the soft marine rocks in between to form the mountains." Mr. West thinks that the re-entrant mentioned above may have been caused by a wedge of continental India jutting north-westward under the alluvium of the Indus Valley, which has held up the movement of the folds to the south-east. This process must result in a condition of special strain, and it is in just such a region that earthquakes might be expected to occur. Of the earthquakes prior to 1935 shown on the map, those of 1892 (Chaman), 1909 (Kachi), and 1931 (Sharigh and Mach) were all severe. That of 27 August 1931 destroyed Mach, Dhadar, and other villages with the loss of over 100 lives, and severely shook Quetta without causing any deaths.

Mr. West judges the maximum intensity of the Quetta earthquake of 1935 to have reached 10 on the Rossi-Forel scale at various points within an area about 68 m. long by 16 m. wide extending from Baleli just north-west of Quetta to Mand-Haji about 20 m. north of Kalat.¹ This area, marked 9-10 on the map, may be taken as the epicentral zone, and the focus of the 1935 earthquake may be located beneath its major axis and at a comparatively shallow depth (probably less than 5 miles). Mr. West writes with the utmost caution at this stage, but he evidently leans to the view that this earthquake was due to movement along a hitherto unsuspected thrust fault deep in the Earth's crust. In this connection special interest attaches to a remarkable line of fissuring in the ground which Mr. West visited first with me at a point some 2½ miles west of Mastung. He describes it as extending on and off for about 65 miles, from the south side of Chiltan to near Kalat. Over the greater part of this distance it took the form of a crack or network of branching cracks in the soil. "Where the effect had evidently been most severe, just west of Mastung," he says, "the ground on the west side of the fissure had subsided abruptly about 2½ feet, though a little farther south the subsidence was on the east side. In some places, instead of a subsidence or a gaping crack, the ground had been heaved up, the elevated portion being a foot or more high and several paces wide, indicating compression of the soil. To account for these varying phenomena, it seems likely that the motion of the ground during the earthquake was one of alternate compression and tension. Where the line of fissuring crossed the railway track that runs from Spezand to Nushki, at about 2 miles west of Mastung Road station, the track had been uprooted and the rails crumpled exactly along the fissure, although the latter was here comparatively insignificant" (Plate 3). As it could only be traced where the soil is of an alluvial nature, and no fracturing of solid rock was found, Mr.

¹ More than three-fourths of this area lies within the thinly populated territories of the Khan of Kalat, and it is only because the British Indian portion at the northern end included the capital of the province, Quetta, with a summer population of about 65,000 that the mortality was so high. At least 24,000 persons died in Quetta itself and another 3000 in neighbouring villages, while some 3250 more were killed in the Kalat State. From the point of view of lives lost, the earthquake must be accounted the most disastrous that has visited India within historic times.



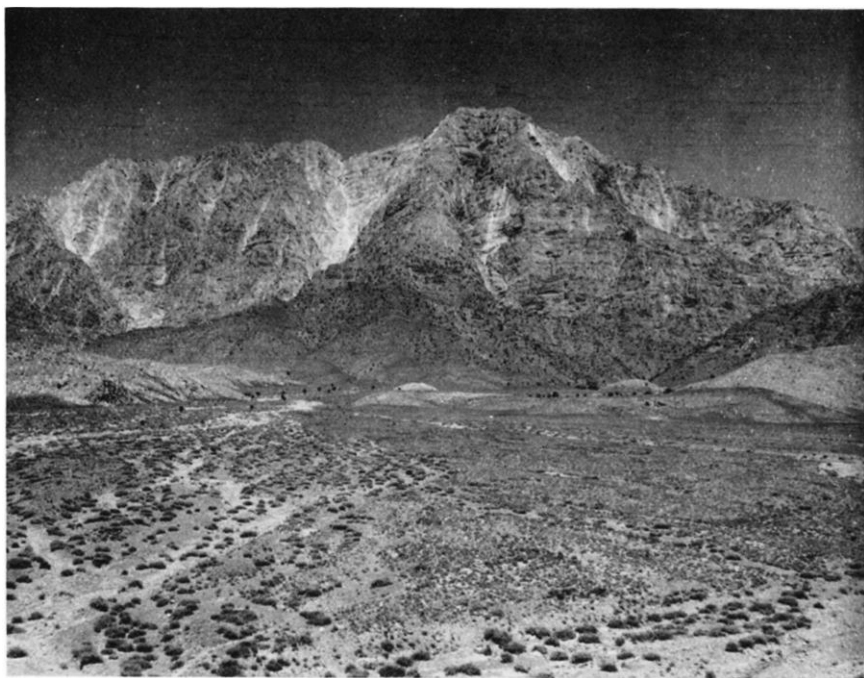
7. The mud volcano at Thok



8. Fault scarp near Mastung



9. *Mount Chiltan (10,850 ft.) before the earthquake*



10. *Mount Chiltan after the earthquake, showing scars of rock-falls*

West considers this fissure to be a purely surface phenomenon affecting only the alluvium and not penetrating the solid rock beneath. He admits however that it coincides both in direction and in position with the long axis of the epicentral area, *i.e.* with the line of maximum disturbance. The inference, which Mr. West evidently hesitates to draw without further investigation, is that this is one of the comparatively rare cases of the formation of a "fault-scarp" during an earthquake. Well-known instances of this phenomenon, which is of the greatest importance in connection with the tectonic origin of earthquakes, include the fault-scarp formed in the Mino-Owari earthquake of 1891, the Assam earthquake of 1892, and the earthquake in Eastern Greece in April 1894. These fault-scarps or lines of fissuring are described in his 'Origin of Earthquakes,' by Dr. Charles Davison, one of whose most important contributions to seismology was his demonstration of the fact that most earthquakes are caused by sudden movements of the underlying rocks along an existing "fault" or crack in the Earth's crust. Usually these earthquake faults are so deep that they leave no trace on the surface, but in certain circumstances they do, and some of the surface phenomena in the cases mentioned above closely resemble those of the Chiltan-Mastung-Kalat line of fissuring. Dr. Davison writes as follows about the Mino-Owari fault in Japan: "When the vertical displacement in the plains or valleys was small, the path of the fault was marked by a rounded ridge of soft earth from one to two feet in height, which closely resembled what might be produced by the burrowing of a gigantic mole. When the displacement reached a height of several feet, the fault-scarp formed a cliff which, being of earth, soon crumbled down into a slope."¹ Again after the earthquake in Eastern Greece, in 1894, "a fissure was traced for a distance of about 34 miles running in an east-south-east and west-north-west direction through the epicentral district, and varying in width from an inch or two to more than three yards. That it was a fault and not an ordinary fissure, was evident from its great length, its uniform direction, and its independence of geological structure."² In Baluchistan itself, within 50 miles of Mastung, movement along the well-known Chaman fault revealed itself after the 1892 earthquake in a fissure or fault line traceable for 120 miles.³ In the last case crumpling of the railway line took place very similar to that observed by Mr. West and myself near Mastung Road railway station.

The fault-line (if it is one) of the Quetta earthquake would if extended northwards pass under Chiltan, a conspicuous mountain rising to a height of 10,850 feet and composed mainly of limestone. On the morning of the earthquake and again after the violent after-shock of 3 p.m. on June 2, vast clouds of dust were for several hours observed rising from the sides of Chiltan. These were due to rock-falls on an enormous scale, one of which is clearly visible in one of the telephoto "shots" of my 16-mm. film. Plates 9 and 10 clearly show the difference in the aspect of the mountain before and after the earthquake. The white marking is due to the chipping and scraping effect

¹ Davison: 'Origin of Earthquakes,' p. 72.

² Davison: 'A Study of Recent Earthquakes,' pp. 340-1.

³ *Mem. Geol. Surv. Ind.*, XXVI (1893), p. 57; *Geogr. J.*, vol. 9, p. 402 (1897).

of the rockfalls on the black oxidized surface of the cliffs laying bare the unweathered limestone beneath.¹

Another interesting phenomenon which I heard about from Brahui tribesmen and took Mr. West to see was a "mud volcano" at a place called Thok, 12 miles south of Kalat and more than 30 miles beyond the southern end of the epicentral zone (Plate 7). The neighbourhood is desert except for a spring and the shrine of a local saint about a mile away. The mud buildings of the shrine collapsed on the night of May 30-31, killing fourteen out of the seventeen persons sleeping there. The survivors told me that a neighbouring hillock burst with a loud roar, and when day dawned clouds of smoke (probably steam) were rising from it and hot mud oozing in large quantities from a crater at the top. The flow continued until noon on May 31. Mr. West, describing the hillock in his "Preliminary Report," said that he recognized at once that it was an old "mud volcano" which had burst into eruption again. "The old mud," he says, "was a dirty brown colour, whereas the new mud was a bluish-grey, so that the new flows showed up very clearly against the old. At their edges the flows were mostly less than a foot thick, though they were probably thicker near the vent." The maximum breadth of the mud-flow, which when we saw it had dried up and caked with the appearance of lava, was 300 yards and the height of the hill about 100 feet. These "mud volcanoes" are common on the Arakan coast of Burma, and are also found along the Mekran coast of southern Baluchistan. The term is really a misnomer, as they are not thought to be connected with volcanic activity. Hobbs² definitely places them in the category of earthquake phenomena and mentions similar exudations of plastic mud during the earthquake of 12 February 1902 at Chemakha, in Russian Turkistan. The mud formed high hillocks of pasty material surmounted by craters, and these in turn were disturbed and fractured by subsequent movement on the same fault planes.

A feature of the Quetta earthquake was the complexity of the ground-motions. Several witnesses say that they felt horizontal shaking both from north to south and from east to west, as well as vertical movement. Four stone monuments examined by Mr. West in the Quetta cemetery were found to have rotated on their bases, one to the extent of no less than 43° anticlockwise.³ The movement also varied from place to place, but was everywhere rapid, "like a dog shaking a rat," as a Brahui villager near Mastung graphically described it to me. The most interesting account of the actual shock comes from an officer who happened to be marching with his men on night operations 4 miles north of Quetta on the Baleli road. The main shock, according to this account, "came from the south, and may have been preceded very slightly by the sound, which resembled the sound heard in an Underground station as a train approaches in a tunnel, rapidly increasing to a roar.

¹ The "smoking" of Chiltan on May 31 and June 2 seemed to support the belief, universal among the local population, that the mountain had become a volcano and that the overwhelming of the survivors by its eruptions was only a matter of time. This belief greatly facilitated the task of the military authorities in evacuating the surviving population to Sind and the Punjab.

² 'Earthquakes,' p. 134.

³ Possible causes of this interesting type of earthquake phenomenon are discussed by Davison, 'A Study of Recent Earthquakes,' pp. 293-6.

Those who did not lie down at once were either flung down or were just able to stagger about. The ground heaved as in a rough sea, or in the way a small boat behaves in the wake of a larger steamer. The direction of the waves was mainly from south to north, but occasionally from east to west. The motion subsided gradually, fading away towards the north-west, accompanied by the sound of falling rocks." ¹ Others present described also how the trees on either side of the highway swayed violently to and fro until their branches swept the ground. A motor-driver in the employ of the Khan of Kalat told me that he was driving into Quetta on the night of the earthquake and had reached a point about 11 miles from the town, when the car suddenly got out of control and he had the utmost difficulty in bringing it to a standstill without overturning into the ditch. He then realized that the earth was shaking violently. Looking up, he and his companions saw flashes of light running along the flanks of the mountains on both sides of the valley. ²

A point in connection with the earthquake which is not mentioned in the "Preliminary Report" is that it occurred at new moon. I understood from Mr. West that the idea that earthquakes occurred more frequently at new or full moon was no longer regarded seriously. There is however a considerable body of opinion in favour of lunar periodicity, and of tidal stresses as a secondary or contributing cause of earthquakes. The question is discussed very fully, with a complete bibliography, by Professor Leo Cotton in his paper on "Earthquake Frequency and Tidal Stresses," in the *Bulletin of the Seismological Society of America*, vol. 12 (1922).

Of more practical interest, perhaps, is the question of the possibility of further earthquakes and their location in Baluchistan. We have already seen that all the earthquakes which have been recorded in the province during the last eighty or more years have had their epicentres in or near the curious re-entrant in the alignment of the mountains, the apex of which is the Bolan Pass (see map facing p. 420). Actually they have all occurred within a radius of 140 miles from Dadar, a village in the Kalat State 16 miles west of Sibi. But, as Mr. West points out, the focus of an earthquake has never occurred at the same place as that of a previous one. Each major shock has relieved the stresses which have been accumulating in the underlying rocks in that area. If the "seismicity" of Baluchistan were connected with volcanic activity it would be a different matter. But there is no sign of volcanic activity nearer than the almost extinct Kuh-i-Taftan, 400 miles to the west. In all probability therefore Quetta is one of the safest places within the earthquake area for a considerable time to come. But there is no certainty in the matter, and in deciding, for compelling reasons into which I need not enter here, to rebuild the cantonments and civil lines on the old sites the Government of India have taken other factors also into consideration. ³ The first of these is the great progress which has recently been made in Japan and the United States

¹ West: "Preliminary Report," pp. 212-3.

² Luminous phenomena have frequently been reported in earthquakes, but the evidence is not definite enough to furnish data for an explanation. In the present case the most likely explanation would seem to be sparks from the friction between moving rocks on the steep, dry hill-sides.

³ See Government of India Press Communiqué of 23 December 1935.

along various lines of research connected with "earthquake-proof" building. In chapter VII of his "Report on the Baluchistan Earthquakes of August 25th and 27th, 1931," already cited,¹ Mr. West summarizes the conclusions arrived at in those countries and applies them to Baluchistan. Further lessons to be learned from the 1935 earthquake are to be found in the "Preliminary Report," section 11. It has been proved in Japan and America that by applying certain principles of construction and using suitable materials, it is possible to build houses of two or more storeys up to a maximum height of 100 feet which are capable of resisting the most violent shocks hitherto recorded.

The main principle is rigidity. It has been found that in most earthquakes the period of oscillation of the ground is one to one and a half seconds; accordingly, buildings must be constructed with a much shorter period, say 0.5 or 0.6 seconds, so that the whole structure will move as one unit. Foundations, especially in loose alluvial ground, should be of solid concrete at least 3 feet thick. The shape of the building should be compact, with few irregularities such as long unsupported wings, high gables, copings, tall heavy chimneys, towers, porches, and so on. Internal walls should run in both directions, and be so united with the external walls that they form one piece with them. Roofs should be light, with the weight evenly distributed along the walls. Above all, the walls supporting the roof should be strong and homogeneous, as nearly "monolithic" as possible. In this connection Mr. West has much to say on the subject of the "mud mortar," or rather paste made with sand or powdered bricks instead of lime, the use of which has become almost universal in Baluchistan during the last fifteen or twenty years. After the 1931 disaster Mr. West wrote: "The custom in Baluchistan of using large limestone blocks set in mud mortar is about as unsatisfactory a method of construction from an earthquake point of view as could possibly be devised. It lacks completely any sort of homogeneity, and when an earthquake occurs the heavy blocks simply slide over the mud mortar, and the wall collapses. . . . There can be little doubt that an earthquake of the severity of the Kangra Valley earthquake of 1905, or even one considerably less severe, would lay in ruins the

¹ Mr. West cites the following American and Japanese authorities: H. M. Hadley, "Earthquake-proof Building Construction as revealed by the Japanese Earthquake," *Bulletin of the Seismological Society of America*, 14, p. 6 (1924); H. D. Dewell and Bailey Willis, "Earthquake Damage to Buildings," *op. cit.* 15, p. 282 (1925); Tachu Naitu, "Earthquake-proof Construction," *op. cit.* 17, p. 57 (1927); H. M. Engle, "The Earthquake Resistance of Buildings from the Underwriter's Point of View," *op. cit.* 19, p. 86 (1929).

In addition to the above, J. H. Freeman's recent paper on "Data for Construction of Earthquake-resisting Structures" (*op. cit.* 20, pp. 67 ff. (1930)) will be found of particular interest. The writer emphasizes the uncertainty of the data on which the prevailing standards of earthquake-proof construction are based, and urges the necessity of establishing strong-motion accelerometers of simple design in all earthquake areas. He describes recent Japanese shaking-table experiments, and researches into such questions as the natural or "preferred" vibration of the ground in particular localities, the behaviour of tall buildings artificially oscillated, and the measurement of infinitely small earth-tilts with a view to the possible prediction of earthquakes in the neighbourhood of known faults. The Ishimoto tilt-meter, it seems, can measure a tilt of one-thirtieth of a second of arc, which is equivalent to one-tenth of an inch on a radius of 1 mile!

greater number of the buildings in Quetta, so poorly are they built.”¹ This prediction proved only too correct. The manner in which the houses we lived in crumbled away like so much dust under the weight of the roofs was a revelation to most of us who went through the Quetta earthquake.

For future building, Mr. West recommends a frame of steel girders with walls of hollow concrete blocks.² In this connection it may be mentioned that after the 1931 earthquake one department, the North-Western Railway, with commendable foresight decided to reconstruct their damaged buildings on earthquake-proof lines. Several bungalows, one of which is seen on Plate 5, were built of vertical and horizontal rails with a panelling of bricks. Another method tried was to make brick walls of normal thickness and reinforce them with expanding metal laid horizontally between the bricks at every fourth course. None of the completed earthquake-proof bungalows of the North-Western Railway fell, or were even appreciably damaged.

Another factor which influenced Government in their decision to rebuild Quetta on the same site was the remarkable degree of immunity enjoyed both in 1931 and in 1935 by the north-eastern portion of the cantonment area, which is situated upon dry alluvium. The only serious damage done to cantonments was in a belt about half a mile wide immediately adjoining the city and civil lines, and even here there was a rapid decrease in intensity towards the north-east. Throughout the earthquake area destruction was at a maximum on water-filled alluvium. This phenomenon, which has been observed in most great earthquakes, is explained as follows in the “Preliminary Report”: “In water-filled alluvium the pore spaces are filled with water, and the rigidity of the water transmits the shock with full force. But in dry alluvium the pore spaces are occupied by air, and this has a cushioning effect on the shock, damping it out considerably.”³

It was accordingly decided⁴ during the cold weather following the earthquake to clear completely the site of ruined Quetta, leaving a framework of roads, drains, and electric and water mains on which the plan of a new and better city could be laid out. The width of many of the roads will be increased; stringent building regulations will be laid down and enforced; the lay-out of the city and the designing of government buildings will be entrusted to experts in town-planning and earthquake-proof construction whose services have already been engaged. The work is proceeding apace; with the help of huge drag-line excavators, scores of motor lorries, and a narrow-gauge

¹ *Mem. Geol. Surv. Ind.*, LXVII, p. 80.

² West, “Preliminary Report,” 1935, p. 234.

³ *Ibid.*, p. 230. See also *Bull. Seism. Soc. America*, 23, pp. 43-56 (1933), for an account of the Long Beach earthquake of 10 March 1933. This earthquake was very similar in area, intensity, and effects to the one with which we are dealing. The following passage is worth quoting: “As on previous occasions, much of the spectacular damage was due (1) to bad natural ground or grading—made land, or deep water-soaked alluvium or sand; and (2) to bad or unsuitably designed construction—bad foundation structures, little or no provision against the stresses caused by earthquakes, bad or unsuitable materials, bad workmanship, or some combination of these factors. . . . More than usual this earthquake ‘picked on the cripples.’ The amount of the structural damage was out of proportion to the energy and violence of the shock.”

⁴ Government of India Press Communiqué of 23 December 1935.

railway the old Quetta is being dumped bodily into borrow-pits in the surrounding desert. In its place it is hoped to create a new Quetta on modern scientific lines with adequate protection not only against possible future earthquakes, but against malaria and other epidemic diseases. A crore of rupees (£750,000) has already been spent, and the cost of reconstruction is estimated at about a crore a year for at least seven years.

Thirty thousand people killed, thousands more seriously injured, untold ruin and misery caused to the survivors, eighty million rupees lost to the Indian taxpayer—all done in twenty seconds, because man does not yet know how to locate strains in the crust of his planet and predict their breaking-point.

DISCUSSION

Before the paper the PRESIDENT (Major-General Sir PERCY COX) said : My Lords, Ladies and Gentlemen,—I think most of you know Mr. Skrine quite well. He has received an Award of this Society and has been frequently on our platform. Wherever he has been in the course of his service, alike in Central Asia, Turkestan, and Persia, he has always been at pains to study the country from a geographical point of view. He is also a skilful photographer as those of you will have realized who saw the film he recently showed the Society. He is the son of a great traveller who came across Asia fifty or sixty years ago, and it is a pleasure to welcome here Mrs. Skrine, his mother, who has flown over from Paris in order to be with us to-night.

Mr. Skrine is going to give us an account of his experience during the Quetta earthquake. We also have with us Sir Norman Cater, who was Agent to the Governor-General at Quetta at the time and himself had a very narrow escape. I hope that he will give us a brief account of his own experience, and there are others in the audience who will do likewise.

I now ask Mr. Skrine to deliver his lecture.

Mr. Skrine then read the paper printed above, and a discussion followed.

Sir NORMAN CATER: I have been asked to say a few words as to my personal experience in the Quetta earthquake, and it is just as well to lay emphasis on "few." If I once began talking about the Quetta earthquake I could go on for hours.

As to my own personal experience in the earthquake, I can hardly tell you anything. It was my fortune, or misfortune, during my time as Agent to the Governor-General to experience two earthquakes, one in 1931 and the one about which you have heard this evening. I would however like to contradict a report which appeared in at least one English newspaper that in the earthquake of 1935, which happened at 3 o'clock in the morning, I was entertaining a gay party of guests. Actually I was fast asleep. My first conscious recollection was "Well, this is another earthquake and it is very much worse than the last one. The sooner I get out, the better." I tried one door which led to the verandah. It was jammed. Then I managed to get out through the porch which had fallen down, and how on earth I got out alive I simply cannot tell you. After that I went to the bazaar and saw that the whole place was wrecked. However I cannot now go into all that.

There were three crowning mercies of the last Quetta earthquake: firstly, that the water supply was not affected; secondly, that the railway stood up to it; and thirdly, that the cantonment was unaffected and we had the assistance, as you have heard, of the military. You must all have read, and heard too, what General Karslake and his soldiers did for us. It is perfectly certain that but for

them there would have been far greater loss of life. There would have been a terrible outbreak of looting and disorder, and an almost inevitable outbreak of epidemic disease. We were saved from all that by the soldiers.

But let us also remember what was done by the civilians of Quetta. When I say civilians I mean Indian as well as British, and non-official as well as official. There were some who succumbed to the strain. That cannot be denied. I am the last to criticize if some did suffer from the reaction, but for one who did there were ninety-nine who rallied round and volunteered their services and did everything they possibly could.

You may perhaps have formed from the pictures some idea of the magnitude of the disaster which befell Quetta but, as I have said to many people, no one can realize what happened that night unless they were there and saw and experienced it. Those who came to the Residency within an hour or two of the earthquake and volunteered their services were people who had lost their relatives, lost their houses and their all and, with scarcely an exception, they came forward and tried to do their best not only then but during the weeks that followed. Let us remember that. As I say, it was not only the British but Indians also who volunteered in that way. So if the Quetta earthquake was a disaster of the first magnitude it was also one more example of the way in which British and Indians can and do work together for each other's welfare.

The PRESIDENT: I am sure it would be of interest to you to hear some comparison between the type of earthquake at Quetta and the similar calamity which occurred at Messina some years ago. I will ask Admiral Sir William Goodenough to say a few words on that subject from the tablets of his memory.

Admiral Sir WILLIAM GOODENOUGH: You may be interested to hear some comparison between this tremendous upheaval at Quetta and that at Messina, both of which caused such a great amount of human suffering. It always surprises me that there is not a greater change of formation of the actual Earth's crust in view of the immense pressures that are exerted by Nature on such occasions. I was at Messina within forty-eight hours of the great earthquake. We were naturally warned to exert the greatest possible vigilance as there would probably have been great changes in the soundings and depths of water. There were actually not any at all. When one thinks of the great stresses and pressures put on things, sufficient to part the *Exmouth's* 2½-inch chain cable by some sudden jerk, this is astonishing.

It is interesting to recall that the houses in Messina and on the coast opposite were, curiously enough, not built to withstand earthquakes. They were very high. It appeared as if the whole movement was, as it were, on a hinge, for as we walked along what had been streets and were then covered with rubble we could see where the houses had apparently moved one way and back again; the front wall had fallen out and the whole place had opened like a child's dolls' house. Where the bed had not fallen out of the room into the street one could see a man's coat and trousers hanging on it.

Mr. Skrine spoke of those who had been for many hours entombed at Quetta and found unhurt. I remember one case particularly of a woman entombed in Messina. There was a stream of water running through the spot where she lay which had been formed into a sort of big cave. The woman was rescued after thirteen days. Not only was she alive though much emaciated, but her child, born whilst the woman was entombed, was alive and perfectly well.

There is one remark I would add, sir, and I hope I shall not be taking something from your speech. Sir Norman Cater spoke of three crowning mercies of the Quetta earthquake. There was one other which I am sure we all feel with great pride, that was that there were men like Sir Norman, like General

Karslake and others there to show great courage, devotion and absolute self-sacrifice without any thought of themselves.

The PRESIDENT: It has been a great privilege, as I am sure you will all agree, to have heard at first hand the individual experience of these two British officers who, fortunately, survived the earthquake. As Sir Norman Cater said, it is quite impossible for anybody really to comprehend the awfulness of the tragedy unless he or she was on the spot. As Admiral Goodenough has just remarked, such happenings at any rate provide an object lesson, and innumerable opportunities for courageous and selfless assistance to others in distress.

I now ask you to join me in thanking the lecturer. As you have realized, aided by his remarkable photographs he has been able to put before us, as far as anybody possibly could, a thoroughly realistic idea of the terrible tragedy. Please join me in thanking him very heartily.