country, it is to be hoped that the Government of India will take early steps to give effect to the recommendations of the experts and arrange for an Economic Census of India at an early date, even if the Economic Advisory Organisation recommended by Sir Arthur Salter is to wait till the new Constitution is in operation.

The Baluchistan Earthquake of May 31, 1935.*

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THE earthquake which occurred in Baluchistan on May 31st was remarkable in two respects. It was of high intensity at the epicentre, causing great mortality and much damage to property, yet it was felt over a comparatively small area, a little over 100,000 square miles. This is a rather characteristic feature of earthquakes in Baluchistan, and indicates that they must have a shallow focus. The epicentre, where the greatest damage was sustained, extended from the north-west of Quetta to half-way between Mastung and Kalat. Its position is shown on the accompanying map, together with the epicentres of the earthquakes of 1931 and 1909.

Since most of the inhabitants were asleep at the time of the earthquake, little information was forthcoming regarding the beginning of the shock. It so happened, however, that night operations were being carried out that night at a place about 4 miles to the north of Quetta, and it appears from the evidence of those taking part that about 5 to 10 seconds before the main shock started there was a preliminary tremor sufficiently strong to be recognised as an earthquake shock. The main shock came from the south and was accompanied by a noise like the roar of a train in a tunnel. The motion was described by the same observers as being like the action of a small boat in a choppy sea. People in Quetta itself generally described it as a sharp horizontal shake.

The shocks seem to have lasted nearly half a minute. During this time the whole of Quetta City, part of the Civil Lines, the Railway Quarters, the Police Lines and the R. A. F. Lines were laid in ruins. The northern and north-eastern part of Quetta, in which are situated the Cantonment and the Staff College, was much less affected; and although the city must have suffered a shock of almost intensity 10 on the Rossi-Forel Scale, at the Staff College, distant only 3½ miles from the city, the intensity was only 6. In fact, many people living in the Staff College area went back to bed after the earthquake, and were surprised the next morning when, on going towards the city to do their shopping, they found the whole place in ruins. This was almost certainly due to the varying nature of the ground, the area where destruction was greatest being situated on water-logged alluvium, while the Cantonment and the Staff College are situated on dry alluvium.

One striking feature of the earthquake, which caused many people to think that it had a volcanic origin, was the great quantity of dust which arose from the surrounding hills, and specially from Chiltan mountain, both at the time of the main shock and also on the afternoon of June 2nd, when a very severe aftershock occurred. Needless to say the "smoke," which was thought to have been seen ascending from Chiltan, was only dust caused by the collapse of thousands of tons of limestone as a result of the severe shaking which the mountain received.

Another feature of the earthquake which aroused much interest was a line of fissuring in the ground which extended on and off for over 70 miles, from the south side of Chiltan to near Kalat. In places along this line the alluvium was severely fissured, in other places the ground had subsided two or three feet on one side or the other, while elsewhere the ground had heaved up a foot or two. Careful examination of this area, however, showed that the fissuring was purely a surface phenomenon, coinciding with the line of greatest intensity of shock, and it was clear that it did not penetrate the solid rock beneath. Where this line of fissuring crossed the railway line from Quetta to Nushki, the rails were severely crumpled.

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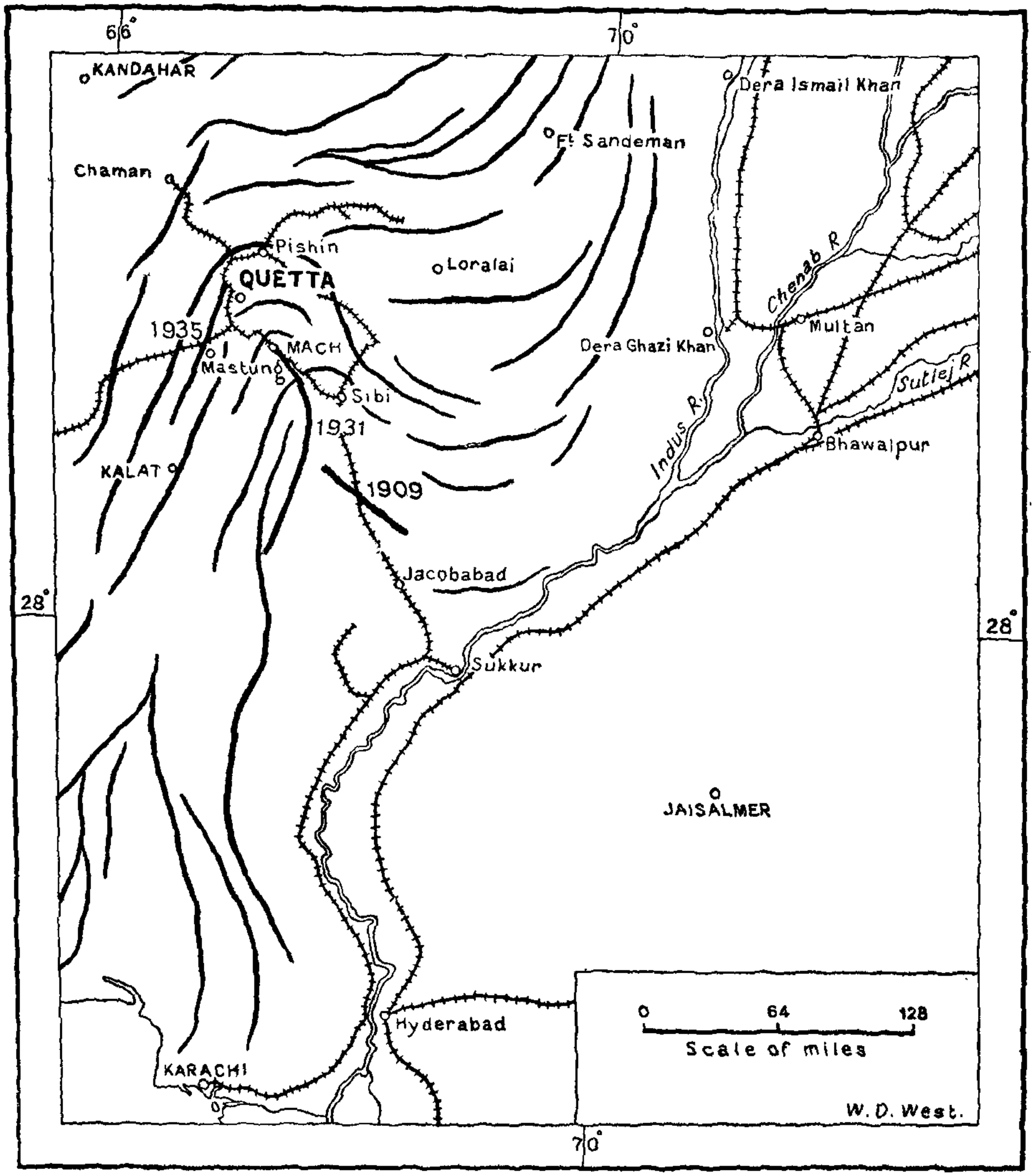
About 100 miles south of Quetta an old mud volcano burst into eruption at the time of the shock, and continued ejecting hot mud for about 9 hours. The term 'mud volcano' is really a misnomer, since it is generally accepted that these phenomena have no connection with true volcanic activity.

In discussing the origin of the earthquake, it is necessary to take into consideration the geological structure of Baluchistan. The general alignment of the mountains is shown very well on the accompanying map, and since the geology and geography are very closely related, in that the axes of the rock folds are parallel to the main mountain ranges, the map also gives an idea of the general geological structure of the country. These folds have been formed by a compression of the rocks in a N. W.—S. E. direction, so that, taking the area as a whole, the folds should be aligned in a N. E.—S. W. direction. This, however, is not the case, and instead the mountains are looped up

Fig. 1.
An earthquake-proof bungalow built by the North-Western Railway.

Fig. 2.
The Dak Bungalow, Quetta.

to the north-west between Jacobabad and Quetta. Now it is generally accepted that these folds 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. It is therefore suggested that this sharp deflection in the alignment has been caused by some underground obstacle



MAP OF BALUCHISTAN AND SIND, SHOWING THE ALIGNMENT OF THE MOUNTAINS AND THE EPICENTRES OF THE LAST THREE EARTHQUAKES.

which is obscured from view by the alluvium of the Indus valley, and which has prevented the free movement of the folds towards the south-east. The effect may be likened to the waves of the sea, when they are deflected in their course towards the shore by the obstruction of a break-water. The waves flow freely on either side, but are held up by the break-water. Whether or not this hypothesis is correct, it is a fact that the geology around Quetta is more complicated than it is in any other part of Baluchistan, and the rocks have yielded here not only by folding but also by fracture. It is around this re-entrant angle that the greatest strain must occur, and it is here that one would expect most earthquakes to originate. In actual fact this is the case, and most of the severe earthquakes which have visited Baluchistan have been confined to an area within a radius of about 150 miles of Mastung.

In the case of the last three severe earthquakes which have visited Baluchistan, namely those of 1909, 1931 and 1935, the epicentres of which are shown on the map, no connection could be traced between the location of the epicentres and any known fault. It therefore seems clear that the earthquake, if it was due to movement along a fault, must have been connected with some fault which does not reach the surface of the ground.

The enormous death roll which occurred at Quetta is directly attributable to the very poor manner in which nearly all the buildings were constructed. Owing to the scanty rainfall in this part of India, it has been the practice in the past to use a mud mortar. Such a mortar has very little bonding power, and when an earthquake occurs, the very heavy lateral force to which the building is subjected simply causes the bricks to slide over one another, and the building collapses. In the case of the present earthquake a feature of great interest was provided by certain North-Western Railway bungalows which had been built since the 1931 earthquake and had been designed on earthquake-proof lines. Although surrounded by smashed buildings, they are without a single crack. The accompanying photographs show the completely ruined Dak bungalow in Lytton Road and one of the new earthquake-proof Railway bungalows situated on the other side of the road. It is difficult to imagine a more striking illustration of the efficacy of sound earthquake-proof construction, in which rigidity has been the main consideration. By making a building as rigid as possible, instead of the building falling apart during an earthquake, due to the different parts of the building behaving differently, it will move as a whole and so avoid being cracked. That these Railway bungalows did move as a whole was clearly shown by the fact that those who were living in them were so severely shaken that they were unable to stand up inside the bungalow during the earthquake, while heavy almirahs were also thrown down. These bungalows had been made rigid by bracing with vertical and horizontal iron rails, and had been constructed to withstand a horizontal acceleration of 3·2 feet per second per second. From this, however, it is not to be inferred that the acceleration of the earthquake motion was less than 3·2 feet per second per second, because in constructional work a considerable factor of safety is always allowed, which may be as much as 3 or 4.

It will be seen from the map that the centre of earthquake activity has gradually moved north-westwards since 1909. It is doubtful, however, if any conclusion regarding the location of the next earthquake can be inferred from this. Such knowledge as we have of previous earthquakes, in Baluchistan shows that they jump about from place to place in accordance with no apparent law. If, however, an earthquake be regarded as affording relief to the strains which have accumulated in the rocks, then it may be fairly safely predicted that the next earthquake, when it occurs, will not be located along the same line as the present one.