

THE EARTHQUAKE IN BALÚCHISTÁN.

THE *Records of the Geological Survey of India*, May, 1893, contains some notes on the earthquake in Balúchistán on December 20, 1892, by Mr. C. L. Griesbach, one of the Superintendents of the Survey. The paper is illustrated by two photo-etchings, one of which is here reproduced with the description of the occurrence.

The following quotation is from the report of the Executive Engineer of the North-Western Railway at Shalabagh :

"On the 20th December, at 5.40 a.m. (Madras time),¹ this district was visited by a somewhat severe earth-

quake. The water tower is standing, but most of the turrets are loose. . . . The oscillation of the ground caused the water to spill out of the iron tanks. . . . The station building, including the station-master's and signaller's quarters and out-houses, are very badly shaken, and will require rebuilding to a considerable extent. The whole of the chimneys have been thrown down.

"Lower down the line the only serious damage to the permanent-way occurred. There is visible at this spot to the eye, for a considerable distance, as far indeed as the eye can reach, a line of division in the soil, and where this intersects the railway at an angle of about 15° or 20°, the metals of the permanent-way were distorted in a most extraordinary way, the pairs of rails in each

line immediately above the crack in the ground having suffered most. They were bent into a sinuous curve, which is represented approximately in the accompanying illustration.

"I have followed the line of fissure in the surface of the ground for a considerable distance on each side of the line, and it extends beyond Old Chaman on the one side for several miles I am told ; I myself followed it for one mile beyond Old Chaman, and could then see it extending far into the distance. In the other direction, I am informed by an Achakzai, who had just come from there, it cuts the line of the Khwája Amran range obliquely, and can be traced to the peak of that name, some eighteen miles off.

"There appears to have been a shearing action on the surface of the ground, the line of shear being tangential to the line of cleavage.

"The rails having resisted this motion were crumpled up in consequence. The joints in the rails on each side of the contortion have all been closed up, although of course, originally, clearance for expansion had been left.

"While tracing the crack in the ground through Old Chaman, I found that it crossed all the collecting pipes of the Military Works Department at Old Chaman. Most of these pipes crossed the crack at approximately a right angle and had not suffered, but one 1½ inch pipe which cut it obliquely was pushed up and off the ground and formed a sort of arch over the crack. . . ."

"A week after the earthquake," says Mr. Griesbach, "I visited the Kójak range in company of Mr. Hodson. We first inspected the damage done by the

earthquake to the houses and works in the neighbourhood of Shalabagh station at the eastern entrance of the Kójak tunnel. Though there was much mischief done to buildings, &c., not much could be learned from these effects of the earthquake. If the scene of destruction had been in a closely-built town, it might have been possible to detect some method, if I might use the expression, in the damage done, but at Shalabagh the houses are far apart, built on unequal hilly ground, and the workmanship in the buildings, mostly constructed of sun-dried bricks, is also very unequal, so that all one can say is that the shocks of earthquake have affected all the weak points of these buildings, many of which will have to be entirely reconstructed.



View showing distortion of rails caused by earthquake between Sanzal and Old Chaman.

quake. It was followed by several lesser shocks, and at Shalabagh² they continued at frequent intervals during the day, and have occurred at frequent intervals up to the present date.³ The exact time of the shock was shown by the stoppage of a pendulum clock in my office.

"Effects at Sanzal,⁴—The station building at this place has apparently suffered most, its close proximity to the line of fissure, which runs in a north-east and south-west line about half a mile below the station, being probably

¹ At Quetta the shock was felt at 5.46 a.m., the distance from Shalabagh to Quetta being 53 miles in a straight line.

² Shalabagh is a station on the Sind-Peshin Railway at the eastern entrance to the Kójak tunnel.

³ 22nd December.

⁴ Sanzal is the first station on the western side of the Kójak tunnel.

"The Kójak tunnel fortunately escaped serious damage, though it is interesting to hear that the water-supply from some springs which issue inside the tunnel and which now escapes in a regular drain from the western (or Chaman side) of the tunnel, was considerably increased after the earthquake shocks.

"The block-house which defends that entrance to the tunnel received some slight damage in the shape of cracks which have appeared in the solid masonry.

"The effects of the earthquake shocks are visible almost all along the made banks on which the permanent way is laid between the tunnel and Sanzal station. In their case the earthquake acted most beneficially, inasmuch as the artificially built-up material of these banks was well shaken down, and, though the latter had sunk here and there and cracks have appeared in places, their settling down and consolidating was equal to a season's rain, as the engineer of that section reports.

"The real interest of the earthquake, however, centred in the damage done between Sanzal station and Old Chaman.

"The line of railway descends to New Chaman from the Kójak tunnel in several great curves and in zigzag fashion. Sanzal station is situated near the upper margin of a great and rapidly descending glaciis, which slopes down from the Kójak range to the great plain in which New Chaman is situated.

"About half a mile west of Sanzal station there is a path which runs from the Khwája Amran peak (8864 feet) in a north-northeast direction along this glaciis. It appears that at the immediate foot of the Kójak range a great number of springs rise, close to which of course there is always a certain amount of grazing to be found, and thus this line of springs has been connected by a regular path, made by flocks passing along these patches of pasture-land. The water escaping from these springs has furrowed and denuded the glaciis into an infinite number of small channels. Another feature is that the path with its springs and patches of grazing grounds all lie as it were in a natural depression, running parallel with the range of the Kójak itself, whilst immediately to the westward of it the ground of the glaciis rises somewhat, before finally descending to the plains. This is well marked near Old Chaman, the foot of which is built on this rising ground.

"About seven to eight miles south of Old Chaman this insignificant rise of ground becomes an auxiliary range of hills, which runs west and parallel with the Kójak range towards the Khwája Amran peak itself.

"I expect to have further opportunities of geologically examining this ground when the weather will permit in the spring; until then I will only state my belief that the present path which connects the springs described indicates, as near as can be, the existence of an old fault-line. At the present time I have no further proof for it than this, that as far as I have been able to ascertain during this hurried visit, the line of path is, roughly speaking, also a geological boundary between the slaty formation of the Kójak and a grey earthy limestone, the latter of which is very probably of upper cretaceous or lower eocene age; this boundary being here suspiciously abnormal in appearance. The springs which rise along it tend further to the opinion that they appear along a line of dislocation, which view is further strengthened by the fact that in the neighbourhood of the springs not only a kind of travertine is visible, but a curious breccia, consisting of debris of both the limestone and the slates of the Kójak and cemented by calcareous rock, is *in situ* and in strong force all along the line of path, but not off it, which breccia I now look upon as a fault-rock. The glaciis itself is chiefly made up of recent deposits, fans from the range above, but I hope to discover a

more exposed section further south, where the structure of this dislocation, if it is one, will be clearly demonstrated. Finally, but not least, the fault seems to be proved by the earthquake itself, which has originated in a further, though slight, dislocation along a line which exactly and absolutely coincides with the present path connecting the numerous springs.

"In my theory explanatory of this earthquake, I therefore start with the assumption that an old line of fault exists, which runs more or less parallel with the Kójak range itself. In a mountain range entirely formed by flexures, which chiefly correspond to the strike of the range itself, such faults usually exist on a large scale. The lateral pressure which caused the folding of the strata in such cases frequently results in one or several systems of dislocations, as we may observe in numerous instances within folded mountain ranges. . . ."

"From the foregoing it would appear that the process of contracting and folding, with resultant dislocations, of this area in Balúchistán, is still proceeding. At some previous date in the history of the Khwája Amran Mountain range this process of compression, as it must have been, has led to the formation of the line of fault conjectured in these notes; the process, from whatever cause, is still active, and the tension having become too great has further resulted in a slight increase to the amount of dislocation already in existence. The two areas adjoining the fissure have moved about eight inches vertically and a couple or more feet horizontally from each other, which sudden establishment of a temporary equilibrium in this tension is no doubt quite sufficient to account for the vibration of the ground to a considerable distance, which vibration is commonly called an earthquake.

"I need scarcely say that there is no indication of any kind which would point to the existence of volcanic activity at, or anywhere near, the area affected by this earthquake; I mention this only, because it was also in this case, as in other instances elsewhere, the popular theory advanced by many of those who personally experienced the alarming symptoms of this perfectly natural phenomenon."

SCIENCE IN THE MAGAZINES.

OF the August magazines the strongest in articles of scientific interest is the *Fortnightly Review*. Under the somewhat misleading title "The Wanderings of the North Pole" Sir Robert Ball contributes a rather diffuse article descriptive of the variations of latitude; adopting Mr. Chandler's conclusion that the earth's instantaneous axis of rotation revolves about that of maximum moment of inertia, with a radius of thirty feet, measured at the earth's surface, in a period of 427 days. This result is expressed by Sir Robert Ball in the following language:—

In that palæocrystic ocean which Arctic travellers have described, where the masses of ice lie heaped together in the wildest confusion, lies this point which is the object of so much speculation. Let us think of this tract, or a portion of it, to be levelled to a plain, and at a particular centre let a circle be drawn, the radius of which is about thirty feet; it is in the circumference of this circle that the Pole of the earth is constantly to be found. In fact, if at different times, month after month and year after year, the position of the Pole was ascertained as the extremity of that tube from which an eye placed at the centre of the earth would be able to see the Pole of the heavens, and if the successive positions of this Pole were marked by pegs driven into the ground, then the several positions in which the Pole would be found must necessarily trace out the circumference of the circle that has been thus described. The period in which each revolution of the Pole around the circle takes place is about 427 days; the result, therefore, of these investigations shows, when the observations are accurate, that the North Pole of the earth is not, as has been so long supposed, a fixed point,