NOTES ON THE EARTHQUAKE IN BALÚCHISTÁN ON THE 20th DECEMBER 1892.

BY

C. L. GRIESBACH, C.I.E.,
SUPERINTENDENT, GEOLOGICAL SURVEY OF INDIA.

[FROM THE RECORDS, GEOLOGICAL SURVEY OF INDIA, VOL XXVI, PT. 2, 1893.]

Notes *on the* earthquake *in* Balúchistán *on the* 20th December 1892, *by* C. L. GRIESBACH, C.I E., *Superintendent, Geological Survey of India.*

Early on the morning of the 20th December 1892 an earthquake was felt over the greater portion of Balúchistán, concerning which a few facts have been collected by several officials of the North-Western Railway and also by myself, which I have condensed in the following notes.

Through the courtesy of Mr. C. W. Hodson, the Engineer-in-Chief of the Frontier Section of the North-Western Railway, I am enabled to give some particulars which have been reported by officials serving under his orders, and after Christmas I visited the Kójak range in company of that gentleman to inspect the damage caused by the earthquake. Mr. L. Gordon, District Traffic Superintendent, has taken very instructive photographs of the effects of this earthquake, which were obligingly placed at my disposal; reproductions of two of them being given here.

I quote herewith extracts from the report of the Executive Engineer at Shalabagh:

"On the 20th December, at 5-40 A.M. (Madras time[1]), this district was visited by a somewhat severe earthquake. It was followed by several lesser shocks, and at Shalabagh[2] 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 shewn 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 the cause. 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.

[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.

"Lower down the line, at mile 643, * * 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 annexed tracing and the photograph.

* * * *

"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 18 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.

"The down line has now been put in order; the rails which were removed consisted of:

4 pairs of 30′	=	120′
1 pair ,, 24′	=	24′
Total	=	144′

and these have been replaced by—

5 pairs of 24′	=	120′
1 pair ,, 21′6″	=	21′ 6″
Total	=	141′ 6″

thus showing that the line has been contracted approximately 2½ feet.

"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."

In addition to the above, the report of that officer contains a detailed statement of damages to railway buildings at Shalabagh which were very severe, of a slight damage to the defences on the western side of the Kójak tunnel and of the effects on banks and bridges on the line, which, though showing the force of the shocks, can tell us little beyond that there was a severe earthquake, which had found out the weakest parts of those buildings and works.

A week after the earthquake 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, etc., 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.

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 have 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. A glance at the map of the Kójak pass (No. 87 $\frac{\text{N. W.}}{4}$ & $\frac{\text{N. W.}}{3 \text{ \& } 4}$, scale 1 mile — 2 inches) will explain the scene of the earthquake.

The line of railway descends to New Chaman from the Kójak tunnel in several great curves and in zig-zag fashion. Sanzal station is situated near the upper margin of a great and rapidly descending glacis, 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 will be observed a path which runs from the Khwája Amran peak (8,864′) in a north-north-east direction along this glacis. 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 glacis into an infinite number of small channels which are well shown in the map. There is another feature which is at once apparent, and that 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 westwards of it the ground of the glacis 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 7 to 8 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 glacis 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.

What I could see of the effects of the earthquake in that region is soon told, and has been already described in the report of the Executive Engineer of Shalabagh. I will omit the damage done to station or other buildings and describe at once the fissure which has been mentioned above. It crosses the line of railway below Sanzal station at mile 643 and absolutely coincides with the line of path aforementioned, never being further away from it than a few yards. It is therefore practically laid down on the large scale map with sufficient accuracy. I followed it north and south of where it traverses the line for several miles, and could moreover see it clearly in the distance following the same direction for very many miles. Mr. Hodson, to whom I am indebted for additional evidence, has had the fissure traced by some of his subordinates as far as the Khwája Amran peak, where it is said to bifurcate, one of the cracks going east of the peak, the other west of it. The country is now under snow, and we shall have to wait till the spring weather permits further explorations.

But a few facts can be learned from the fissure as we see it. All the features connected with it tend to the fact that the entire area west of the fissure has not only slightly subsided, but also bodily moved southwards. The lowering of the area seems to be about 8 inches to a foot, but exact measurements are difficult, and the subsidence is probably not equal at all points of the line of fissure. But it is fairly exactly proved that this area has shifted at least 2 feet to $2\frac{1}{2}$ feet southwards. The fissure itself is mostly closed, the ground on the surface being generally soft debris, but here and there a gaping fissure has resulted, from a few inches in width to several feet, the sides of which seem to be vertical. Fragments of turf and dry masses of the ground adjoining the crack have been carried along by the movement southwards, if the mass came from the eastern side of the fissure, or the reverse if it was detached from the western margin of the dislocation. But where the movement may best be observed is in the permanent-way itself and in pipes crossing the fissure. The mass of the western area having pressed southwards and against the line of fissure, the rails which cross the latter have been forced into curves as already well described in the report quoted, and the joints left open for expansion, have all been closed, as the movement was exerted in a direction more or less parallel with the permanent-way.

Very nicely illustrated was the movement by the damage done to the water pipes. One, which crosses the fissure obliquely, was bent, having no other means of yielding to the pressure. The others have merely been shifted and lifted out of the surrounding loose earth and debris. Different measurements may be obtained along the various points of the line of fissure. Here and there the dislocation of the pipes does not appear to be more than from a foot to eighteen inches or even less than that. It is probable that also within the mass of the ground adjoining the fissure compression had been active, and here and there where the strata were of a yielding nature has resulted in very little dislocation apparently of the ground itself, whereas along other points the effect is much greater. So far the largest measurement taken amounts to a shift of 2 feet 6 inches; this was the result in the permanent-way at mile 643 and near several irrigation drains, which crossed the fissure at right angles, and which have suffered a displacement of that larger amount. It is highly probable, considering the variation of the measurements consequent on the difference in lithological character of the ground through which the fissure runs, that the sum total of the movement exceeded $2\frac{1}{2}$ feet considerably, but of that we have so far no direct proof.

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 8 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.

G. I. C. P. O.—No. 1, D. G. Survey 7-7-93. 60.

C. L. Griesbach.

Records, Vol: XXVI. Pt. 2. Pl. I.

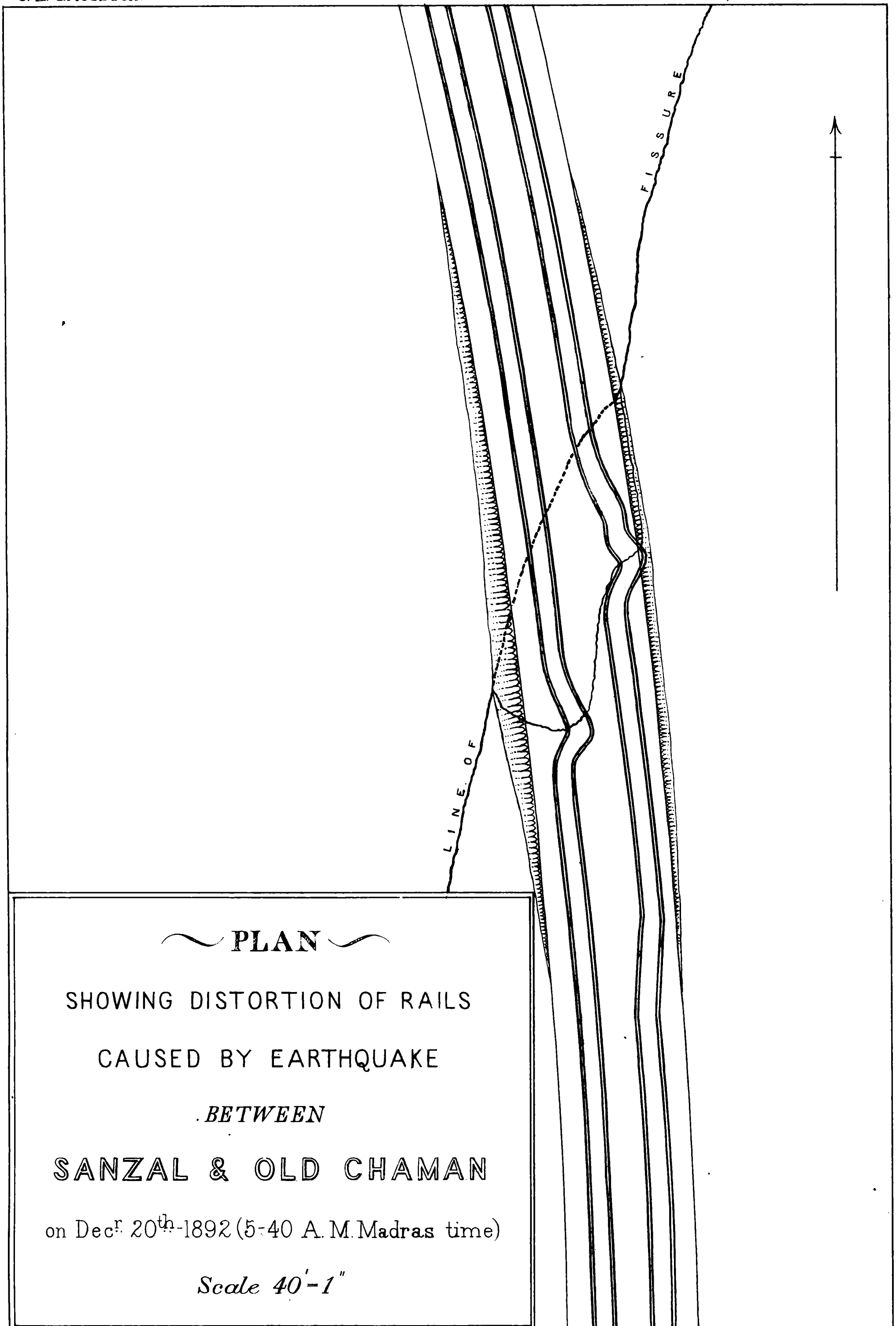
Photo-etching.

Survey of India Offices, Calcutta, April 1893.

View showing distortion of Rails caused by Earthquake between Sanzal & Old Chaman.

Photo-etching. Survey of India Offices, Calcutta, May 1893.

View of the fissure produced by the Earthquake between Sanzal & Old Chaman.



PLAN

SHOWING DISTORTION OF RAILS

CAUSED BY EARTHQUAKE

BETWEEN

SANZAL & OLD CHAMAN

on Decr. 20th-1892 (5-40 A. M. Madras time)

Scale 40′-1″

Lithographed & Printed at. Geological Survey Office.