

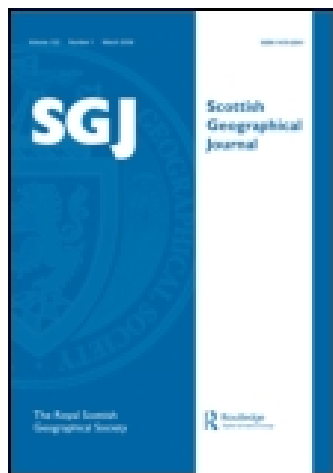
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The Whangie and its origin

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the Turkish forces from the Suez Canal. This last object is probably one of the main aims of the Persian Gulf operations, which are obviously not of such a nature to have much direct effect upon the final event of the war, although we recognise how important it is for us to retain a hold on the southern outlet of the Baghdad railway.

One other thing may be pointed out in conclusion. Unquestionably one of the most striking things in this war has been the whole-hearted manner in which all the members of the Empire have joined in with us to prosecute this war. And in that also it seems to me a certain geographical significance may be recognised. Our Empire is scattered all over the world with numerous seaboards giving it opportunities of trading with every other seaboard, and inevitably begetting the desire on the part of the self-governing portions of the Empire to have complete control of their commercial relations. More than a century ago the attempt of the mother country to establish control over the commercial relations of her plantations in America was among the chief causes which led to these plantations breaking away. That gave us a lesson, and we took it to heart. We now see the results of a policy the example of which may perhaps induce other countries that follow a different course to imitate it. But it is also to be noted that this policy has caused the outlying portions of the Empire to feel that in this war they are fighting in their own interests; has caused more particularly Australia, New Zealand, and South Africa to feel that they are fighting for their own freedom against a power which could not be expected to respect their liberties if it were victorious.

THE WHANGIE AND ITS ORIGIN.

By G. W. TYRRELL, A.R.C.Sc., F.G.S., Lecturer in Geology,
Glasgow University.

(*With Illustrations.*)

THE Whangie is situated at the north-western extremity of Auchineden Hill, which itself forms the north-eastern buttress of the volcanic plateau of the Kilpatrick Hills. The name is applied to a huge fissure which separates a slice of rock from its parent mass in one of the great cliffs so common in the volcanic plateau (Fig. 1). This "landslip," as it is called, has attracted much attention from lovers of the picturesque, and is a favourite rendezvous for picnic parties in the summer, and for the hill walker at all seasons. It may be reached from Blanehead Station, from which it is about five miles westward; or from Milngavie, from which the route is *via* the Drymen Road, and the walking distance about seven and a half miles.

The name "Whangie," "Wanzie," or "Quhanzie," as it is sometimes called, seems to be derived from a Scottish word meaning a "slice"; and if so is aptly descriptive of the phenomenon to which it is applied.

Many good descriptions of the Whangie have been written. A recent one appears in Macdonald's *Rambles about Glasgow*. Older accounts are to be found in the *Statistical Account of Scotland*, vol. viii., 1845; and in David Nimmo's *History of Stirlingshire*, vol. ii., 1817. In describing the Whangie I cannot do better than quote these accounts, both of which

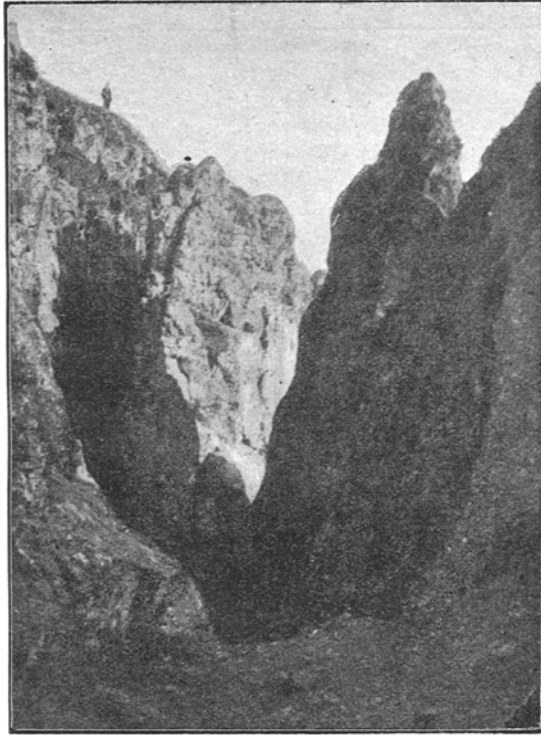


FIG. 1.—The Whangie, entrance to fissure from the north. Height of man (six feet) standing on top of the cliff gives the scale.
(Photo S. Fingland.)

contain important information bearing on the origin of this so-called landslip.

The description in the *Statistical Account of Scotland* (p. 62) is as follows:—

“In the trap formation, near the south end of the parish [of Killearn], there is a singular chasm called the Wanzie. A transverse section of a hill, running east and west, seems to have slipped off, probably from the partial decay of the subjacent sandstone leaving it without support. The width, where greatest, is 10' 2", where least, 2' 6". The depth at present is about 30', but as the bottom is filled with rubbish it may originally have been much greater. It takes a zig-zag direction, and it is easy to mark the exactness with which the angles and surfaces on one side answer to those on the other (see Fig. 2). There were many

fissures in the same hill, which have been filled up by the tenants since the introduction of sheep. Near the north corner of the hill there is still one left open, running in a zig-zag direction, 185 feet in length, and generally 6 inches in breadth."

The observer in this account appears to have been misled as to the direction of the fissure, which runs north and south, not east and west.¹

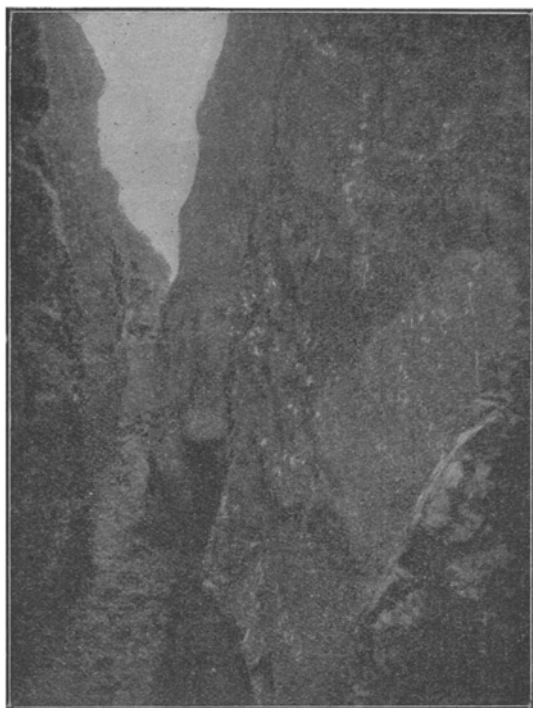


FIG. 2.—The Whangie, inside the fissure, looking south. Note correspondence of sides, and the curved surfaces ("backs") along which the fracture has taken place. (Photo H. Fleck.)

In Nimmo's *History of Stirlingshire* (vol. ii. pp. 607-8) we have the following account :—

"A slope from Strathblane, rising west a thousand feet in two miles, is terminated by a precipice of at least 150' from north to south. Here the face of the rock, as if unsupported on the western side, has separated from the mountain, forming a crevice 60' deep, near 200' long, and in width from 14' to 15' at the north end, and $2\frac{1}{2}'$ at the south. The slice is of unequal thickness, in some places about 20', in others 3' or 4'. In one or two parts it has totally fallen away, leaving narrow openings (see Fig. 1) through which, as from the embrasures of a castle, the spectator can look down on the immense fragments of rock with which the

¹ The direction, however, may refer to the hill, and not to the fissure.

ground below is covered (see Fig. 8). The impression made by this striking object is that of a rock split by an immense wedge. The angular surfaces of the opposite sides leave no room to doubt of their having once adhered and fitted each other."

It will be noted that these accounts are discrepant, especially in the matter of the dimensions of the fissure ; but the figures vary for different positions, and the observers may not have taken the measurements in the same places.

These two accounts give the essential features of the phenomenon, and there is little for the present-day observer to add. It should be remarked, however, that the base of the severed slice is embedded in a steeply-sloping bank of grass-grown talus, on which are scattered the huge fallen blocks of Nimmo's account. The correspondence of features,

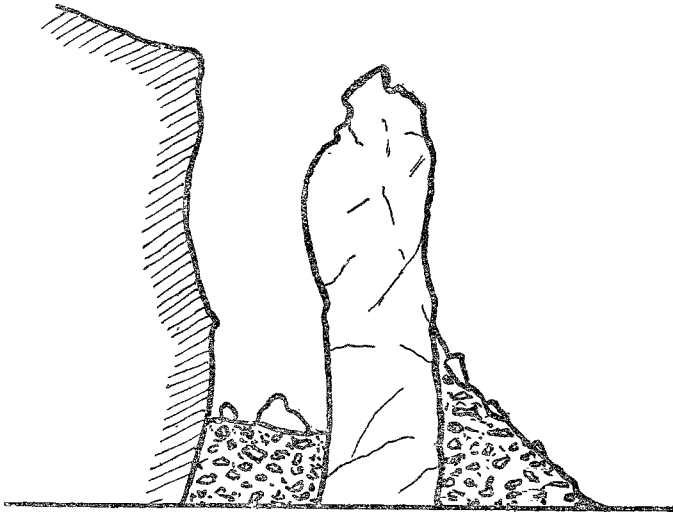


FIG. 3.—Diagrammatic cross-section of the Whangie, showing correspondence of features on either side of the fissure, and slight raising of the severed slice.

such as angles, bulges, and depressions on either side of the fissure, as mentioned in both of the above accounts, is certainly very striking (Fig. 2). A very remarkable point, however, seems to have escaped the earlier observers. It is that, at one place, these features prove that the severed slice is slightly higher than the parent mass, and that in moving away from the cliff it has also moved upwards. In many places the separation of the slice has taken place along the curved surfaces of rock known to quarrymen as "backs." These backs are sometimes crossed by rounded horizontal ridges ; and it is by the comparison of these ridges with the corresponding grooves on the other side of the fissure that the relative elevation of the severed slice may be proved (Fig. 3).

This feature might be explained by the lateral or longitudinal tilting of the severed block, just as is often seen in the collapsed portion of a stone pier or a sea-wall. A longitudinal tilt might elevate one end of

the block above the corresponding features on the face from which it has slipped (Fig. 4a). But in this case the corresponding features on the sides of the fissure, such as the horizontal ridges mentioned above, would depart from parallelism. There is no such departure, however, in the Whangie fissure, at least in the portions which admit of comparison between opposite sides, and accordingly a longitudinal tilt is disproved.

A lateral tilt (Fig. 4b) might result in a slight elevation of the severed portion, especially if it were thick. In this case, however, the fissure should become wider towards the top. This is actually the case in some parts of the Whangie fissure, but only where the upper portions of both block and cliff-face have been broken and disintegrated, and fallen blocks have made the bottom of the fissure less wide than formerly. Where the rock is still intact, and the sides of the fissure correspond

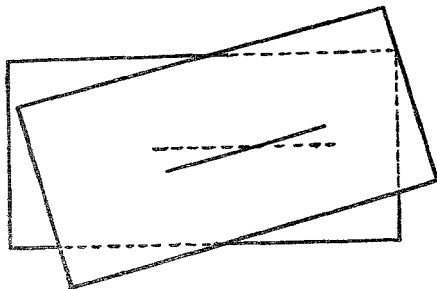


FIG. 4a.

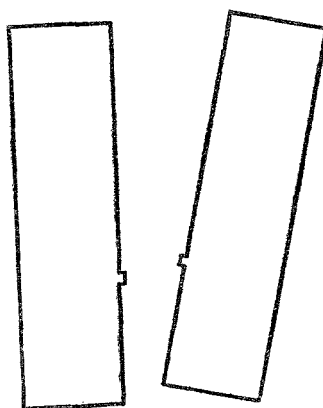


FIG. 4b.

Diagrams showing effects of longitudinal and lateral tilting of blocks.

from top to bottom, the parallelism is almost exact, and no noteworthy lateral tilt can be postulated (see Figs. 1 and 2).

Origin.—The Kilpatrick Hills are built of a series of gently inclined lava flows, which have been ejected from a row of vents along the northern and western edges of the plateau. Each flow forms a well-marked terrace terminating in a cliff, resulting in a remarkable step-like profile which can be seen from any suitable view point (Fig. 5). The Whangie fissure apparently occurs in one of these steps, which have been worn back by denudation along the soft band of vesicular material which separates contiguous flows. Sometimes, however, beds of tuff or volcanic detritus are found between the flows.

The current explanation of the Whangie is that it is a landslip along either the soft weathered material or a bed of tuff at the base of the flow which is supposed to form the rock of the Whangie. In Nimmo's account reference is made to a probable slip upon a subjacent bed of sandstone. This view, however, is open to insuperable objections. First of all, no bed of tuff, or zone of soft vesicular material, or of sand-

stone, is exposed anywhere near the base of the Whangie, and there is no evidence that such exists. There is certainly tuff and sandstone at the base of the volcanic platform; but the Whangie hill rises not on the lowest but on the third lava-flow from the base. Secondly, on this view, the severed slice has slipped in a direction opposed to the dip of the flows, which is prevalently south-east. Third, there is positive evidence that the rock of the Whangie is not a lava flow at all, but that it is a volcanic intrusion or plug which descends to the depths, and can therefore have no tuff or vesicular material beneath it in the required position. When viewed from the south it is obvious that the Whangie hill, instead of conforming to the step-like profile, cuts across the outcrops of the third and fourth flows of Auchinaden Hill, and is therefore intrusive (Fig. 6). There are one or two other vents near by, which pierce the Calcareous Sandstone lying below the lavas, and it is almost certain that the Whangie hill is a lava-filled vent which pierces the lavas

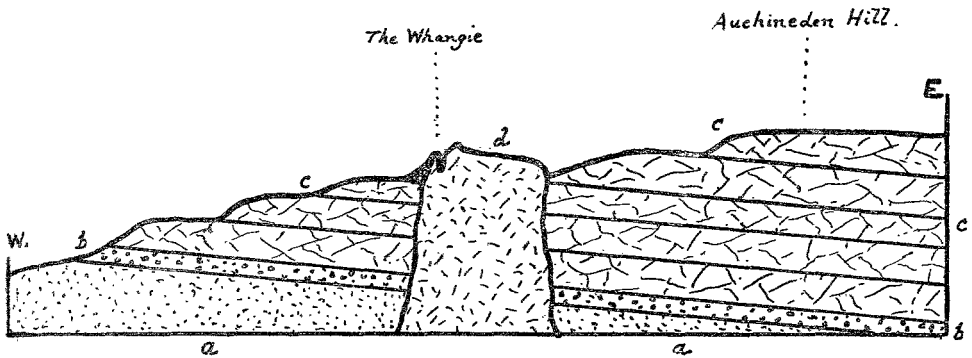


Fig. 5. — Geological section across volcanic plug of the Whangie Hill: *a*. Upper Old Red Sandstone; *b*. Tuffs; *c*. Basaltic lava flows; *d*. Volcanic plug (basalt).

themselves. This is the view also taken by the Geological Survey officer (Mr. G. W. Grabham) who surveyed this area some years ago.¹ Finally, a settling or slipping under the influence of gravity would mean a resultant downward movement of the severed slice, but this does not appear to have taken place.

The separation of this huge slice of rock, which has moved slightly upwards, or at least horizontally, for an average distance of four feet outwards from the face of the cliff, would require a certain measurable amount of energy. Now this energy could not have been supplied by gravitation, which acts uniformly downwards. We are thus led to inquire from what other source the required energy might come. Apparently the only other adequate source is an earthquake vibration, which may act horizontally or in any direction.

Now, in unsupported ground, such as a cliff-face or escarpment, an earthquake shock frequently brings about a landslide. The earthquake

¹ *Summary of Progress of Geological Survey for 1905 (1906)*, p. 138.

motion is transmitted from particle to particle of the rock, and each particle vibrates through a small amplitude. The vibration is resisted by the juxtaposition of the neighbouring particles. But where the impulse passes out from a cliff-face into the air, the vibration is transformed from molecular to molar movement, and the outer slice of rock tends to move away from the cliff. If the rock is fissured or jointed, or of weak cohesion in any way, this separation is much facilitated. If, however, it is tough, massive, and unfissured, it may resist the jerk or jolt of the earthquake shock and remain intact. The principle is just the same as that which operates when the first of a row of marbles in close contact is struck. The force of the blow is transmitted through the row, and it is the last marble in which the force of the blow is transformed into movement. Another illustration is that of a row of

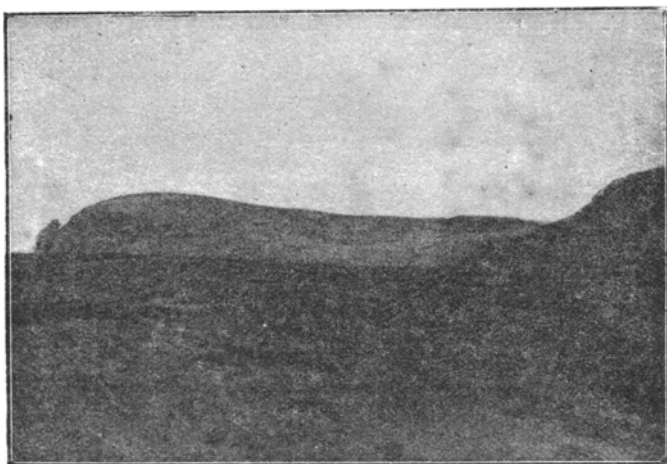


FIG. 6.—The Whangie Hill, from the south. Shows that the Whangie intrusion cuts across the outcrops of two lava flows. (Photo G. W. Tyrrell.)

boys each of whom has his hands resting on the shoulders of the boy in front. A push applied to the last in the row is transmitted to the first, who, being unsupported, falls forward.

Such landslide phenomena are common effects of earthquake shocks, and in general the rock or earth dislodged is unsupported beneath and falls downwards. Frequently the whole mass disintegrates into large and small fragments which slump down into the tumbled aggregate so characteristic of landslide topography. It is frequently impossible, therefore, to distinguish the landslide effects due to earthquake shock from those due to gravitation alone. It is only under special circumstances, such as those outlined below, that the severed slice indicates the direction from which it received the shock, and gives a clue to the agent involved in its severance.

Suppose, however, the cliff-face to be mantled in a sloping accumulation of loose débris. Unless the severed slice were bodily overthrown,

or disintegrated into small fragments, it would not tend to fall downwards as a whole, but would rather tend to be driven forward on and through the accumulation of débris, and the resistance of the débris might even force it to take a slight upward movement. An upward movement of the severed slice might be imparted by a slight inward inclination of the fracture-plane at its base, as shown in Fig. 7. The block would ultimately come to rest on a bed of débris, and in favourable circumstances would retain its perpendicularity and parallelism to the cliff-face.

This, then, is conceived to be the mode of origin of the Whangie. It is probable that a partial shattering took place at the same time, giving rise to the fallen blocks which strew the slopes below, and breaking the severed block itself at the northern end. It is noteworthy that there are numerous small landslips of the normal type along the

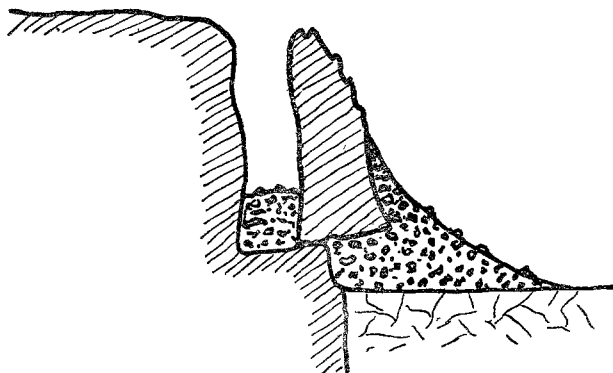


FIG. 7.—Conjectural section across Whangie to show supposed mode of support, and cause of the slight uplifting of the severed slice.

steep northern escarpment of Auchineden Hill. Here the severed portions have been broken to pieces, and now show the peculiar confused and tumbled landslip topography.

Some confirmation of earthquake origin may be derived from the fact mentioned in the *Statistical Account of Scotland*, that there were many fissures in the same hill (by which is probably meant Auchineden Hill), but that all save one had been filled up on the introduction of sheep. At this date (1845) one was still left open near the north corner of the hill. This fissure was said to run in a zig-zag manner, and was 185' in length by 6" in breadth. This, however, does not seem to be in existence at the present time, and has probably also been filled up. Such fissuring is a common accompaniment of earthquake shocks, and may or may not be accompanied by vertical movement on one side of the fissure. The Kilpatrick Hills, with their cliff and terrace topography, would be very susceptible to earthquake fissuring. When a fissure opens up in this way without vertical movement on either side, the result resembles, on a small scale, the phenomenon of the Whangie. A possible alternate

explanation of the difference of elevation of the sides of the fissure is that there has been a slight faulting movement.¹

The fissure appears to have opened up along the broad, curved surfaces known as "backs." This kind of fracture appears to be developed only by a shock of some kind, such as blasting, and as far as my observation goes it is never seen in a natural section due to erosion. It is especially well developed in quarries and other excavations in which a large amount of blasting is done, and only occurs in compact igneous rocks. Fine examples are to be found along a road leading up to Craigallian, two and a half miles north-north-west of Milngavie; and were also seen in a puddle-trench excavation in the Calciferous Sandstone lavas at North Third, near Bannockburn. The following is a description of the latter occurrence:—

"These backs consist of large, smooth, curved surfaces, of any size from one to twenty feet in diameter. These surfaces are sometimes crowded together, forming a series of concentric, spherical shells of rock, from which occasionally large, curved plates about $\frac{1}{2}$ -inch thick may be broken off. The smooth surfaces of the backs are sometimes crossed horizontally by a few blunt, rounded ridges.

"These surfaces are not developed by weathering, but only become apparent on fracture. The authors believe they are due to a series of concentric surfaces of weak cohesion developed during cooling, which, while they cannot be detected in the unweathered, unbroken rock, control its fracture when broken by such a violent means as blasting."²

The similar surfaces of fracture in the Whangie fissure (see Fig. 2) have probably also been caused by shock; but as blasting is out of the question, a severe earthquake vibration seems to be the only other adequate cause.

The explanation of the Whangie fissure adopted here requires the formation of a talus-slope of loose débris. The rock of the Whangie plug is easily decomposed, and on weathered surfaces is seen to break easily along numerous joint-planes, giving rise to small, angular fragments. The severed slice itself is fast breaking away in many places (Fig. 8), and it is only near the south end of the fissure that the "backs" are preserved in their original smoothness. It is probable then that the original cliff-face of the Whangie hill was mantled in a slope of loose débris as is required on the hypothesis adopted here.

The retention of the "backs" in some parts of the Whangie fissure gives it an appearance of extraordinary freshness and recency, and I do not believe that, geologically speaking, it can be very old, perhaps not more than a few hundred years. The account given in Nimmo's *History of Stirlingshire*, dated 1817, has a footnote appended to this effect: "We have given in the text the spelling in writs 200 years old. The word is perhaps from the Scottish 'Whang,' signifying slice." The Whangie was therefore in existence in 1617; but Dr. David Murray

¹ See *The Earthquakes at Yakutat Bay, Alaska, in September 1899*, by R. S. Tarr and L. Martin. Professional Paper No. 69, U.S. Geol. Survey (1912). Plates xvii. and xvi. B.

² Tyrrell and Martin, *Trans. Geol. Soc., Glasgow*, vol. xiii., part ii., 1908, p. 243. See also plate xiii., fig. 2.

to whom I applied for information on this question, informs me that all writs relating to land in Scotland have been registered since the year 1617, and that there are other registers extending back to a much earlier period. It is possible, therefore, that more information as to the age of the Whangie may be obtainable from the study of these documents. Dr. Murray considers that the name does not affect the question, as it probably applies to the place quite as much as to the rift in the rock. It seems to me, however, that a name which means "slice" must have been given because of the fissure. Dr. Murray also thinks that if the landslip took place as recently as, say, three hundred years ago, there would have been some record of it or some tradition. But the landslip took place in a bleak and lonely spot, remote from human habitation even now, and more so in earlier times. It may easily have escaped notice for

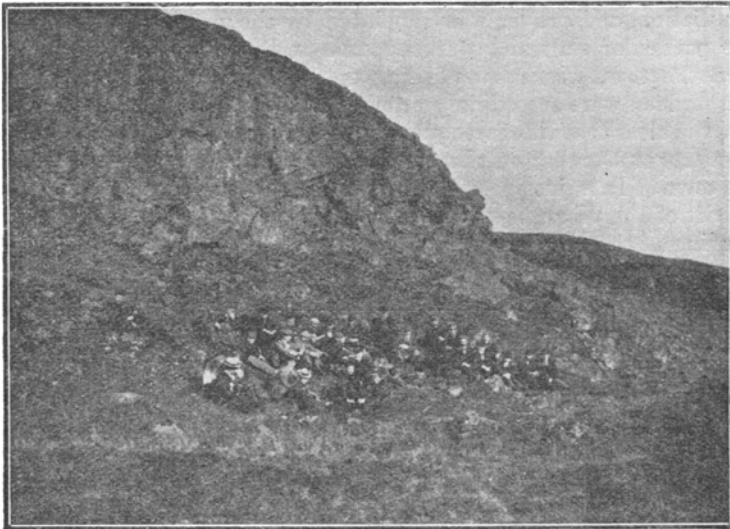


FIG. 8.—The Whangie, western front, showing broken and fissured condition of rock, and boulder-strewn talus-slope. (*Photo S. Fingland.*)

a long period. The absence of tradition centring around this phenomenon might serve equally well as evidence for its recency as for its age. Much lesser phenomena in Scotland and other countries have legends and traditions attached to them. It is astonishing that the Enemy of Mankind, for example, has not been named in tradition as the author of the Whangie. It is just the place where the fiend, "tired of his dark dominion," might have alighted on the earth, and split the ground with the impact of his fall. The absence of any such tradition might be taken to imply that the slip took place at a period later than that in which the devil took such a prominent part in terrestrial, and especially in Scottish, affairs.

Assuming that the hypothesis adopted in this paper is correct, and that the Whangie is of earthquake origin, also assuming that it is com-

paratively recent, it becomes of interest to inquire whether there has been any severe earthquake in this part of Scotland during the last few hundred years. In Calderwood's *History of the Kirk in Scotland* is given an account of a great earthquake which shook a large part of Scotland, and was especially felt at Dumbarton. The date is 1608, and the account runs thus: "Upon the 8th of November there was an earthquake at nyne houres at night, sensible eneugh at St Andrewes, Cowper, Edinburgh, Glasgow, Dundie, but more sensible at Dumbartane; for there the people were so affrayed that they ranne to the kirk, together with their minister, to cry to God, for they looked presentlie for destruction. It was thought that the extraordin dreuth in the sommer and winter before was the caus of it." Dr. David Murray, in a letter, to the *Glasgow Herald* (20th December 1910), remarks that the people of Aberdeen were much alarmed by this shock, and a day of fasting, humiliation, and prayer was appointed by the magistrates and clergy. The particular sin which was supposed to have brought this judgment upon the town was salmon-fishing on Sunday; and the salmon-fishers of Aberdeen were accordingly brought before the Session and rebuked.

It is clear that this earthquake was severe, and we may conclude from its effects at Dumbarton that its epicentre may have been situated near this town. It is just possible that it was this earthquake which caused the rift of the Whangie, and the accompanying landslide phenomena and fissuring of the Kilpatrick Hills.

THE BURRINJUCK DAM AND THE MURRUMBIDGEE IRRIGATION AREA.¹

By JOHN M'FARLANE, M.A.

(*With Sketch-Map and Illustrations.*²)

IN the Presidential Address which he delivered at Adelaide in 1914 to Section E of the British Association, Sir Charles Lucas dwelt upon the important part played by man as a geographical agent. No subject could have been more appropriate in Australia, where human action is altering in no uncertain way the appearance of the land as designed by Nature. The effect on man himself is no less important, and in the interaction which takes place between him and his environment, his political, economic, and social activities may all undergo change. A visit which the present writer paid to the Burrinjuck Dam and the Murrumbidgee Irrigation Area afforded some interesting illustrations of this human response to geographical control.

The Murrumbidgee Irrigation Area (*see map*) is situated on the western plains of New South Wales, and runs in a north-westerly direction from a

¹ A paper read before the British Association at Manchester, September 1915.

² I am indebted to my friend Mr. D. M. S. Watson for the photographs.—J. M'F.