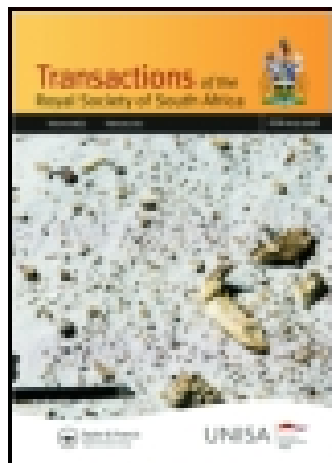


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A. W. Rogers M.A., F.G.S.

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THE VOLCANIC FISSURE UNDER ZUURBERG.

BY A. W. ROGERS, M.A., F.G.S.

(Read June 28, 1905.)

The general structure of the Zuurberg was described many years ago, first by A. G. Bain,* who drew a section (No. 11 of his paper) through the range in the area with which this paper deals, and secondly by R. Pinchin,† who made a carefully executed map and section of the same area. Both these geologists gave substantially correct explanations of the range, though the exaggerated vertical scale used by Pinchin obscures one of the main features of the mountains, that they were reduced to a comparatively level surface, on which the differences between the harder and softer strata are scarcely noticeable, before the great kloofs were carved out of them; the view of Bain that the Dwyka conglomerate was a contemporaneous volcanic rock, and Pinchin's opinion that it was a metamorphic rock, did not affect the general question of the structure of the range, as both authors knew that it lay conformably amongst the other beds forming the mountains.

During the past month I have been working along the southern flank of the Zuurberg, between Enon on the west and Bellevue on the east. The main part of the range is made of the Witteberg beds thrown into two or three great folds, the vertical height of which must be over 1,000 feet, and the limbs of these folds are at places themselves folded on a small scale, especially along the shale bands. The Dwyka conglomerate, accompanied by both the Upper and Lower shales, follows to the south, where the dips are very high in that direction, or rather some 5° to 20° west of south.

The great area of Uitenhage beds occupying the lower portion of the valleys of the Bushman's and Sunday's Rivers is ushered in by the Enon conglomerates, typically developed near Enon, where they form a belt of bushy country about three miles wide at the foot of

* A. G. Bain, "Trans. Geol. Soc.," Second Series, vol. vii.

† R. Pinchin, "Q. J. G. S.," vol. xxxi., p. 106, and figs. 3; 4.

the Zuurberg. Further east, along the road to the Zuurberg Pass, the conglomerates are much less conspicuous, and they can hardly exceed a width of half a mile. Along the Coerney River they widen out again, but near Sandflats they perhaps disappear completely at the surface, for the red and grey marls of the Uitenhage beds are almost in contact with the Witteberg quartzites, and I could only find a narrow band of conglomerate at a few spots. At Sandflats Station a borehole has been sunk within two miles of the Witteberg beds to a depth of 1,500 feet through sandstones and marls of the Uitenhage formation without striking any conglomerate; the beds penetrated lie practically flat, as is the case with the similar rocks at a few miles distance from the mountains further west. The exposures on or near the southern edge of the conglomerate show considerable southerly dips up to 45° . I cannot here go fully into the question of the relationship of the Enon beds to the marls and sandstones of the Uitenhage series, but one result of my recent journey has been to strengthen the opinion previously arrived at, that the three subdivisions (*i.e.*, Enon, Wood beds, Sunday River beds) of the series are not strictly successive deposits, but were partly contemporaneously formed under different circumstances. On this view, as on the supposition of a strict succession of the three subdivisions, the great variation in width of the Enon outcrop along the foot of the Zuurberg requires explanation, and the most probable explanation is that the area now occupied by the Uitenhage formation has been let down along a fault following approximately, but not exactly, the trend of the Zuurberg range. The increased but varying dip of the conglomerates towards their northern boundary supports this supposition, which is in accord with the observations of Mr. Schwarz * in the Willowmore and Uniondale Divisions, that the outliers of the Uitenhage beds there are faulted down against the older rocks to the north of them. The high dip of the Enon beds is expressed on Bain's section No. II., but the dips there given to the succeeding beds are much too high. In Pinchin's section (Fig. 4) the dip is also shown, but the relations of the conglomerate to the finer-grained deposits further south are wrongly given. The few sections available along one line of section, *e.g.*, from the Zuurberg Pass to the heights behind Coerney Station, certainly show that the southerly dip decreases regularly as one travels southwards, and that low northerly dips appear in places.

The northern boundary of the Bushman-Sunday Rivers' area of Uitenhage beds, then, we may take to be a fault. Mr. Schwarz noticed extensive shattering of the beds, either of the Uitenhage

* E. H. L. Schwarz, "Ann. Rep. Geol. Comm. for 1903," pp. 72-137.

beds themselves or of the older strata against which they lie, along the fault lines in Willowmore and Uniondale, but this shattering seems to be greatly in excess of what one would expect along faults of no very great throw.

Along the fault south of Zuurberg there are not only breccias somewhat similar to those of Uniondale and Willowmore, but a most remarkable band of lavas, accompanied by breccias of a more peculiar type than those mentioned above.

The country I am now dealing with is not a favourable one for geological observations; it is well covered with bush, which is in places quite impenetrable, and the rich development of soil hides the underlying rock over wide areas. The stream beds, too, although they lie in almost precipitous valleys and have very steep grades, are usually choked with a mixture of soil, fallen rock fragments, and vegetation. The following description is therefore necessarily incomplete, and may be somewhat modified by future work.

Travelling along the road from Coerney Station to Zuurberg Pass, after crossing the waterless Coerney River, one sees occasional roadside quarries in coloured marls, which dip south at 25° at one place, and near the lower end of the long hill in the valley trending south-east there are artificial exposures of the red Enon conglomerate dipping south at about 35° . The road lies about W.N.W., but the trend of the rocks is nearly east and west, and after an interval of some hundred yards the rock exposed in the ditch by the roadside is a highly vesicular lava, dull red outside and reddish-black within. In the bottom of the valley at this place a well has been dug, and most of the material thrown out is a heavy, dark, almost black, rather soft igneous rock, with many amygdaloids of some black substance. Near the surface the rock has a similar appearance to that seen along the roadside, and the apparent difference between the two rocks is probably due to weathering. As I have not yet had the opportunity of making a close examination of the lavas and other rocks of this fissure, I shall not go into the question of their petrological nature. Proceeding up the road the next outcrop is seen in the ditch about 400 yards above the well, and there we have greatly disturbed thin shales and limestones, belonging to the Upper Dwyka shales, and a few yards further on there is a road quarry in typical Upper Dwyka shales, which are here also highly disturbed; there follows the usual downward succession through the Dwyka conglomerate, Lower Dwyka shales, and the Witteberg formation (see Fig. 1). I could not get a close estimate of the width of the dyke-like body of amygdaloidal lava, but it is not more than 100 yards wide. From the well to the top of the ridge south of the road, but

further west than the well, is a vertical height of about 300 feet; fragments of the lava are met with at intervals along the cattle tracks up it, and outcrops occur on the summit near some Kaffir huts. I followed this lava ridge four miles to the west, where it is cut through by the White River, but the lava is continued at least



FIG. 1.—Section south from Zuurberg. Distance 8 miles. Vertical scale twice the horizontal.

1. Witteberg beds. 2. Lower Dwyka shales. 3. Dwyka conglomerate.
4. Upper Dwyka shales. 5. Volcanic rock. 6. Enon conglomerate.
7. Shales, &c., of Uitenhage beds.

six miles further to the west behind the red conglomerates of Enon. On the farm Kremlin (on the eastern boundary of the Uitenhage Division) the lava dyke widens out to about 300 yards, and it is in contact on the north side with the Dwyka conglomerate, the Upper

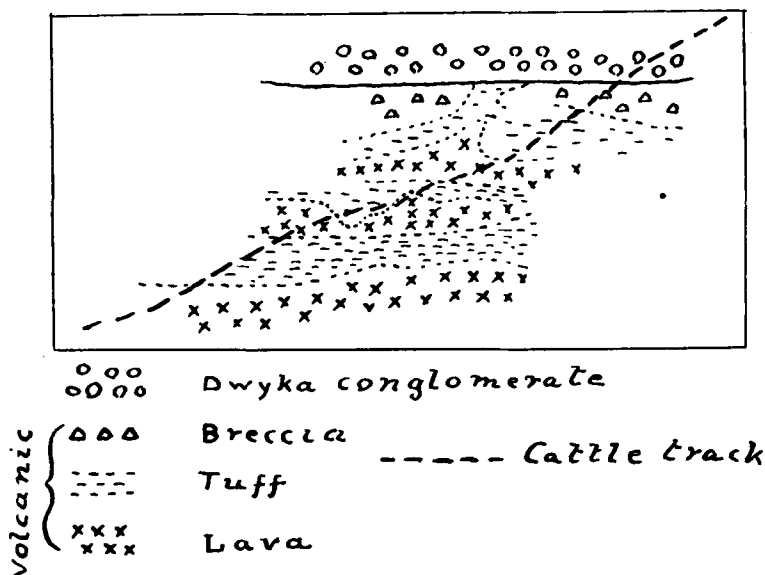


FIG. 2.—Plan of lava and fragmental rocks on Slag Boom.

shales being cut out. On Slag Boom the volcanic fissure widens to about 800 yards, and the lava is accompanied by masses of red, yellow, and white tuff, and buff-coloured breccia containing a few pieces of quartzite that may have come from the Witteberg forma-

tion. The lava in this wide portion of the fissure varies considerably; it is usually very full of amygdales, or it is vesicular owing to the infilling substance having been removed, but at places it becomes nearly compact. The relationship of the lava to the tuff in this locality, as in others to be mentioned below, is difficult to ascertain for want of outcrops, but on a part of the ridge near the south-east boundary of Slag Boom I was able to make the plan shown in Fig. 2. There is one general rule concerning the relationship of the two kinds of rock, tuff or breccia and lava, which fill the fissure; pieces of lava do not occur in the fragmental rocks, but pieces of the tuffs are often enclosed by the lava. In Fig. 2 it is obvious that the lava forms vein-like bodies in the tuff. On Slag Boom the volcanic fissure following the fault bends nearly north-west before again taking a westerly course through the Enon Mission ground. The height of the volcanic rocks at the top of the Kremlin-Slag Boom ridge is about 800 feet above the White River on Slag Boom, and the position of the volcanic fissure appears to be practically vertical (Fig. 3). I have not followed the rock westwards beyond Enon.



FIG. 3.—Section through Slag Boom, about 3½ miles. Vertical and horizontal scale the same.

1. Witteberg beds. 2. Lower Dwyka shales. 3. Dwyka conglomerate.
4. Volcanic rock. 5. Enon conglomerate. 6. Shales, &c., of Uitenhage beds.

Throughout this part of the fissure's course the rock to the south is almost certainly Enon conglomerate, though the actual contact has not been seen. The conglomerate country is always marked by a change of character in the soil, which becomes brighter red in colour and more or less heavily charged with rounded pebbles and boulders of quartzite derived from the conglomerate. Where exposures occur, as on Enon, the track from Slag Boom to Coerney, and the Zuurberg Pass road, the nearest rock to the lava on its south side is the ordinary red Enon conglomerate.

Turning now to the country east of the Zuurberg road, the volcanic rock trends about E. 10° S. towards the Coerney River, but beyond ascertaining the presence of the lava along this line I did not follow the fissure across this dense bush country. The lava itself seems to come to an end about a mile from the Coerney River, for I could find no trace of it in that valley or on the hill just to the west, where it should be seen if present. In the bed of the Coerney River, just north of the boundary between Buffel's Kuil and Coerney,

there are outcrops of Dwyka conglomerate separated by an interval of 60 feet of swampy ground from the next outcrop to the south, which is a breccia of quartzite fragments, angular and sub-angular, set in a matrix with much calcite. This rock crops out for some 30 yards, when there is nothing else seen till one meets with the red Enon conglomerate dipping at an angle of 45° to S. 30 E. on the right bank of the river on Coerney farm. I was uncertain of the nature of this calcitic breccia until I found a very similar rock in close association with the tuffs, breccia, and lava of Duncairn and Mimosa.

Following up the fault line eastwards from Coerney River the lava is again seen about a mile from the river on the ridge to the north of a side valley descending westwards from Mimosa.* The width of the band of lava rapidly swells to some 1,000 yards, and this is maintained, or increased, as far as the main valley descending from the Nieuw Post escarpment through Mimosa, where the width is reduced to about 700 yards, but it again swells near the Duncairn boundary. The most easterly trace of the lava and tuffs I could find are on Duncairn, where they terminate bluntly towards the east without any apparent gradual reduction in width. The termination takes place on the divide between the valley in which Mr. Reed's boreholes are situated and the next kloof to the east. East of this I found a thickness of some 20 feet of quartzitic breccia between the Enon conglomerate and the Witteberg quartzites, and at one place, just east of the road to Waggwa, the transition from this breccia to the solid unbroken quartzite can be followed inch by inch in a distance of about 30 yards. In the above-mentioned valley descending from Mimosa to Coerney River and on the hill north of it there is some red tuff amongst the lava, but this part of the fissure is mainly filled with lava; in the northernmost head kloof of this valley, which almost reaches the Nieuw Post escarpment, a great body of tuff and breccia is met with. This mass of fragmental rock is quite 1,000 yards wide from north to south, and on the north it is probably in contact with the Witteberg quartzites, cutting out the Dwyka conglomerate and perhaps the Lower Dwyka shales, which were found both to the west and east. The shape of the tuff and breccia mass cannot be determined on account of the soil and bush, but it is probably a true volcanic neck in the form of an enlargement of the fissure we have been tracing. The Nieuw Post escarpment is a very

* The farm Mimosa, belonging to Mr. Walton, is not marked as such on the latest Divisional Map of Alexandria. It includes the farm called Thornleigh on that map and a part of Gorah (V. F. 7, 6), but I do not know its boundaries. Mimosa Station is on it.

steep face of Witteberg quartzites dipping at angles of 70° – 80° S. 15° W. It ends below in bush-covered slopes, but along the cattle track from Mimosa to Nieuw Post there are several outcrops on the divide between the steep kloofs descending east and west. The northernmost 700 yards or so of the divide is sandy ground sprinkled with quartzite fragments and overgrown with bush. If the Dwyka conglomerate occurred here I think it would show itself, at least in fragments, as it does so in similar situations further west; the Lower shales do not make themselves so prominent, and they may or may not be present. South of the sandy ground one first meets with a brown micaceous sandy rock with bright green spots, a rock quite different from any known from the Dwyka series, and it certainly belongs to the very varied tuffs of the neck; then follow soft and quartzitic breccias with many fragments of Witteberg or other quartzite, then comes a peculiarly bright green breccia with fragments of sedimentary rocks in it, and this is followed by a soft pink tuff, which soon gives place to a red tuff with vesicles partly filled up, and this again to a soft red or white mottled tuff, which is followed by buff-coloured breccias with much quartzite in them; soft pink tuff is the last, and southernmost, fragmental rock of this neck. About 20 feet from the last outcrop of tuff the usual amygdaloidal lava is met with, but it contains a great quantity of tuff caught up when it was in a fluid condition.

A good number of outcrops of the lava were found by following the ridge along which the track goes to Mimosa, but there was no tuff seen on this ridge. The lava varies in compactness by the increase or decrease of the amygdales. The amygdales are of various minerals; calcite and chalcedony occur, but zeolites are more common. It was curious to find large chalcedony amygdales that look as if they might have come from the Vaal River.

In a garden at the end of this lava ridge in the main valley on Mimosa there is a larger outcrop of the lava than is usually met with, and in it are seen bands of more and less vesicular lava, without any definite dividing plane. There are also irregular bands of pipe amygdales; these are arranged perpendicularly to the layers of varying texture, and individually may reach a length of 3 inches. All these layers dip towards S. 10° W. at an angle of 20° . The occurrence of the pipe amygdales, which were noticed again on the Duncairn boundary though not in place, is very remarkable, for they have hitherto been found only in surface lava flows.

Going up the valley north of this garden one does not find outcrops till one passes a well sunk in the Dwyka conglomerate, above this only the Dwyka and Witteberg series are seen.

At the place where two kloofs join to form the main valley a few hundred yards east of the well, there is a small mass of buff and pink tuffs, followed to the south by lava with many tuff inclusions. This body of tuff seems to be a neck similar to, but smaller than, the large neck below the Nieuw Post escarpment.

A striking feature in the breccias is the absence of fragments of the Dwyka conglomerate, but this may be due to lack of observations. The breccias and tuffs are different from any that have been described from South Africa, but some of them show points of resemblance to tuffs of the Stormberg area, and others are not unlike some of the Saltpetre Kop breccias, so far as one can judge from hand specimens.

From this small neck I followed the lava up to the divide between Mimosa (Thornleigh) and Duncairn along a bush-covered slope and in the valley below; there were very few outcrops, but the Dwyka conglomerate was seen at one point in the stream bed, and nothing but pieces of lava and tuff or breccia above this outcrop. On the divide there is a short interval of covered ground between the Witteberg slope and the northernmost outcrop of lava; there is no room for the occurrence of the Dwyka conglomerate here, and probably the Lower shales are also cut out; south of the lava there is an area 500 yards wide on which tuff and breccias only occur; these resemble in general characters those on the large neck on the Nieuw Post track, but they include a coarse breccia of the type seen in the Coerney River bed. The red tuff in the south part of the neck is penetrated by lava, and numerous fragments of tuff occur in that rock, which occupies a belt of country some 500-700 yards wide south of the neck. To the east the amygdaloidal lava continues as a band of about 600 yards wide for another mile. There is much tuff mixed with the lava in places along this part of its course, and at one spot a borehole was put down 250 feet through a rock described to me as "pale-coloured sandstone," but of which I could not see a specimen. It was probably a tuff like the buff or pink tuffs of the larger necks. The lava is in contact with the Witteberg quartzites to the north along this part of its course, and where the lava ends the Enon conglomerate is in contact with the quartzites without the intervention of the Dwyka series. It is interesting to note that the front face of Witteberg quartzite on Duncairn is shattered into a breccia, in precisely the same manner as along the faulted contact with the Enon seen near the Waggywa road. The angular pieces of quartzite are embedded in a matrix of still further comminuted quartzite. There has been little addition of cementing substance, and the breccia is now as a whole a much more fragile

rock than the solid quartzite owing to the want of a uniform cementation.

The total known length of the volcanic band is 19 miles, but it is probably continued further west than Enon.

The general habit of the rocks in this band proves that they occupy a nearly or quite vertical fissure, the only exception being the southerly inclined layers of different texture in the Mimosa valley, but this is a small outcrop in the middle of a band of 800 yards width. I searched every exposure of the Enon conglomerate for fragments of the lava and tuffs, but could find none, and the general form of the whole band is not consistent with the view that the volcanic rocks are contemporaneous with the early stages of the Uitenhage period; moreover, no volcanic intercalations have ever been found in those strata. It is also evident that the volcanic rocks in their present form have not been subjected to the forces that bent and twisted the Witteberg and Dwyka series to the north, for they show none of the incipient cleavage that characterises the latter rocks in the Zuurberg range. There remains no other view than that assumed early in this paper, that the volcanic rocks reached their present position by eruption along the line of fault between the Uitenhage beds and the Zuurberg.

The question as to whether the eruption accompanied the faulting, or followed it, is not an easy one to settle, but from the presence of rather broad bands of shattered rock both on the boundary of the volcanic fissure on Duncairn, and their presence further east where the fault alone is observable without the volcanic rocks, I am inclined to believe that the eruption accompanied the faulting. The similarity of the breccia seen near the Waggwa road to those of Uniondale and Willowmore, and the occurrence of the quartzite breccia at Duncairn in connection with the volcanic rock, lead to the suspicion that the brecciation of the rocks along the faults is due to some sort of explosive action, and that the breccias differ in this respect from the usual type of broken rock which is developed on a comparatively small scale along many faults.

Hitherto volcanic rocks have not been found to accompany faults in this Colony. The only possible exception yet described is the pipe of melilite-basalt on Spiegel River, which is situated very near the northern boundary of the Heidelberg outlier, and this boundary is probably a fault. The distribution of the scattered pipes of the Kimberley and Saltpetre Kop type has not been connected with any structural lines of the country, nor have the Stormberg volcanic necks any definite arrangement,* though their south-eastern limit in

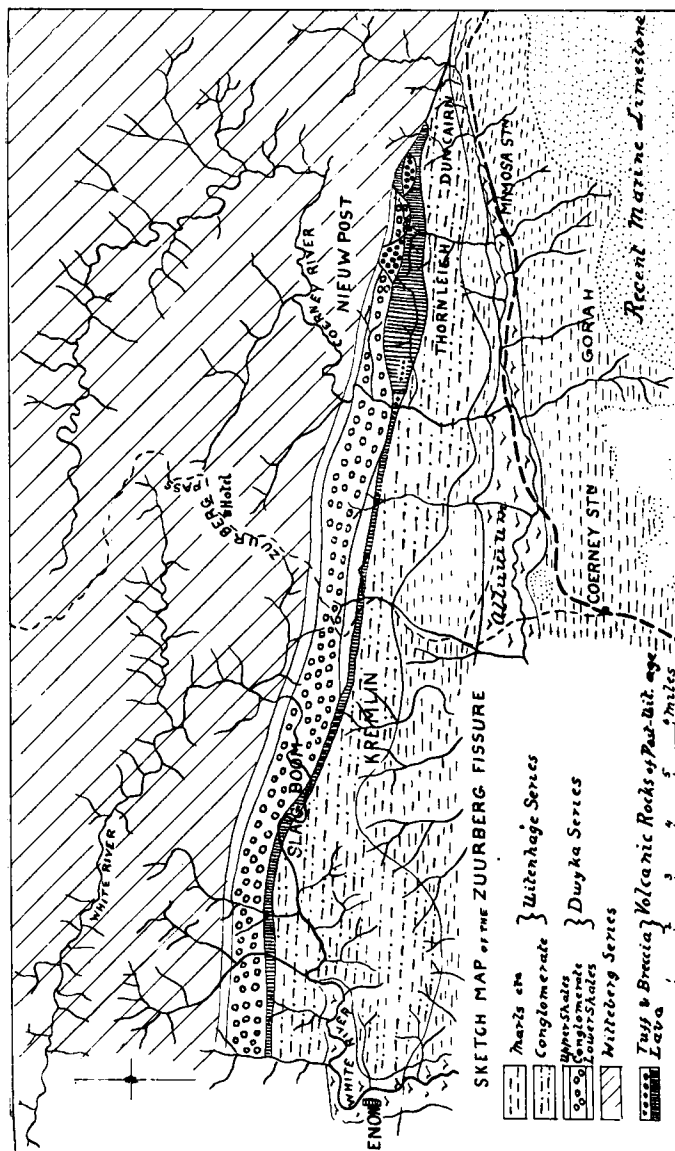
* Du Toit, "Ann. Rep. Geol. Com. for 1904," map.

Matatiele runs more or less parallel with the Pondoland coast and the post-cretaceous faults on that coast.

In East Africa the recent volcanic rocks are connected with the downthrown areas called the Rift Valleys, but they present no precise parallel with the Zuurberg volcanic belt.

There can be no doubt that the eruptions along the Zuurberg fault took place after the deposition of the Uitenhage beds, which are of Lower Cretaceous age, but the only later limit which can at present be set to the event is laid down by the fact that the tops of the volcanic ridges are cut down to a surface which was once continuous with the Zuurberg slope; and these tops are still capped in places by gravel similar to that on the main slope, from which they are now separated by valleys several hundred feet deep. No trace of lava flows or beds of ash ejected from the fissure has been found on Zuurberg or the country to the south. If such materials were ever thrown out they have long since been swept away. Although there is no direct evidence of surface outflows, the highly vesicular character of the lava shows that there must have been open access to the air, otherwise the water vapour could not have expanded so freely. The total absence of recognisable lava fragments in the breccias and the relationship of the tuffs and lava show that the violent explosions which produced these breccias were succeeded by the more gentle rise of the lava. The explosions occurred not only at the well-defined enlargements of the fissure but at so many other places, as shown by the presence of breccia and tuff at intervals throughout, that we may regard the whole line as having once been their site, but the direct evidence of this is now lacking owing to the rise of the lava and its replacement of the fragmental rock.

As to the origin of the material forming the tuffs and breccias little can yet be said, but quartzites like those of the Witteberg series are the most abundant recognisable rocks in them.



SKETCH MAP OF THE ZUURBERG FISSURE.