and the disturbed area may be attributed to variations in the amount of slip throughout the seismic focus. (1) If the amount of slip be everywhere very small, the sound-focus may occupy the whole of the slip-area, and thus sound may be the only phenomenon perceptible at the surface to the unaided senses. This seems to have been frequently the case amongst the series of small slips which produced the numerous slight shocks at Comrie, Pignerol, and elsewhere. (2) If the sound-focus occupy nearly the whole of the slip-area, the amount of slip in the rest of it being small, but still great enough to produce a slight shock, then the sound-area and the disturbed area might be approximately co-extensive, or the sound-area might in places entirely overlap the disturbed area. (3) But very frequently, especially in the more pronounced seismic areas, the maximum amount of slip within the seismic focus will be so great that the disturbed area will be large compared with the sound-area, and, in severe earthquakes, will extend far beyond it. (4) Lastly, the slip might take place suddenly, and its amount be so great, that the sound-focus might be confined to the lateral margins of the slip-area. The slip would then extend up to the surface of the earth, and, if great enough, might be traceable there as a difference of elevation on the two sides of the fault-line; the sound-area would consist of two detached portions at some distance from the region of maximum disturbance, and the sounds consequently might escape observation and record.

But while earthquakes of such extreme intensity are very unusual, very slight slips must frequently take place; so that earthquake-sounds without an accompanying shock should be of far more common occurrence than earthquakes without attendant sounds.

V.—NOTES ON THE ASH-SLATES AND OTHER ROCKS OF THE LAKE DISTRICT.

By W. MAYNARD HUTCHINGS, Esq.

(Concluded from page 161.)

TAKING the other and coarser constituents of such slates as are not wholly made up of the fine "base,"—the constituents which may be spoken of as "porphyritic,"—the *lapilli* vary very greatly in number and distinctness. In a large part of the roofing-slates they are either no longer discernible at all or are so exceedingly faded and blurred as to be just barely recognizable, often as patches altered to chlorite, or chlorite and calcite, in which the felspar-laths of the original andesitic ground-mass may still be seen comparatively little altered. In cases where there is reason to suppose that the lapilli were largely of more *basic* nature, this almost complete alteration of them is observed, as might naturally be expected.

In other cases the crushing and rolling-out of the rock has sufficed to obliterate all traces of original fragments of whatever sort. On the other hand, there are many slates in which lapilli, in great abundance, are still so perfectly preserved as to exceed in freshness

most of the andesites, etc., which can be collected *in situ*. Even in some cases where the slates are most highly cleaved, and the "base" and some of the other constituents, as chlorite and calcite, are drawn into streaks often flowing round the still angular lapilli, these latter have almost wholly escaped mechanical damage. In these cases of strikingly good preservation basic lapilli are absent. The slates from Mosedale quarry have already been mentioned as offering beautiful examples of well-preserved lapilli, and equally good ones are seen at other places.

It is to be noted that though rhyolite is exposed in comparatively few localities in the district, it is more or less represented in almost every specimen of slate in which the lapilli are still distinct. This frequent occurrence of rhyolite in the fragmental rocks of the Lake District has been noticed also by Harker and Marr (*On the Shap Granite, etc.*, Quart. Journ. Geol. Soc. vol. xlvii. 1891).

In addition to volcanic lapilli, many of the slates and tuffs show also the presence of fragments of sedimentary rocks, presumably broken through and ejected by the explosive eruptions. I have formerly recorded (*Geol. Mag.* 1891, p. 462) the occurrence of such a mixed volcanic and sedimentary material in a tuff at Falcon Crag. It may be observed again, though in less marked degree, in rocks from Honister Crag, both roofing-slates and coarser tuffs and breccias, in which fragments of grits and gritty slates occur; and in material from several other localities careful search shows that fragments of ordinary sedimentary slates are present, recognizable, among other things, by the rutile-needles contained in them. In many cases these fragments are crushed and drawn out so as to be almost incorporated beyond recognition with the volcanic material, and it is most likely that, as might be expected, a large proportion of the ashes and tuffs of the district contain more or less of the sedimentary strata underlying them.

Angular clastic grains of quartz, some of good size, are also tolerably frequent, suggesting a derivation from some coarse-grained acid rock, probably granite.

None of the finer-grained slates, so far as my observations go, contain any trace of augite or other ferro-magnesian mineral. These are now represented entirely by chlorite, calcite, and some epidote. Chlorite is always present in large quantity in the coarser slates, as patches and rolled-out streaks, as well as in the minutely-felted form in the base. Calcite is exceedingly abundant, disseminated as small grains down to fine dust, or as larger grains and crystals. These frequently contain fluid-cavities with bubbles, showing the conditions of pressure, etc., under which this calcite was deposited. In many slates the calcite is so plentiful that it very nearly obliterates everything else except the chlorite, the rolled-out mixture of the two appearing at first sight to make up nearly the entire rock.

It is interesting to note that though the mineral changes which have taken place in the finely-powdered ash-material of these slates are in a most important point similar to those which have occurred in the deposits to which we owe our fireclays and shales and most

of our sedimentary slates, inasmuch as a very large amount of new mica has been formed, yet in the matter of the titanitic acid contained in the material acted upon the result is very different.

It is beyond question that the volcanic rocks of the Lake District contain a quite considerable amount of titanitic acid, though it has not been determined in the analyses made.¹

Probably a portion was combined in the form of sphene, but most likely the greater part was contained in the augitic minerals. In the weathered and much altered andesites as we now have them, *secondary* sphene is one of the most constant constituents, in granular form and also as little clusters and groups of crystals, often evenly disseminated throughout the rock. This sphene has probably been mainly formed during the decay of the augites and the basic portion of the ground-masses. At Shap, under the influence of contact-action, the sphene of the andesites and ashes appears to have been re-dissolved and re-deposited, one of the most striking features of the altered rocks being the considerable number of large grains of deep-coloured, very dichroic sphene which have been formed, wholly different from anything seen in the rocks at a distance from the contact. Sometimes these large grains of sphene occur in cavities in such relationship to quartz and other infiltrated matter as to leave no room for doubt as to the manner of their deposition.

Notwithstanding this considerable amount of titanitic acid, however, the slates resulting from the chemical and mechanical alteration of the andesitic ashes do not ever show the rutile-needles so universally characteristic of the sedimentary clays and slates. From a considerable observation of these rocks from all over the district I am able to state that rutile in that form is never noticed in them, except in those cases in which it is explained by included sedimentary matter originally containing it. To the best of my belief, based on much study of this special point, it may be pretty safely said that rutile in the form we know as "slate-needles,"—a form so very characteristic and always recognizable,—occurs only as the result of decomposition, under certain conditions, of deposits partially consisting of biotite. As I have noted in a former paper (GEOL.

¹ Even now that the general presence of titanitic acid in rocks is more fully known than formerly, it is very rarely determined by analysts. This arises to some extent from the fact that its non-determination does not affect the total addition of the analysis, as in the ordinary course of the estimations it is weighed partly with the silica and partly with some of the bases. But the non-determination is more largely due to the fact that the exact quantitative separation of titanitic acid is a very tedious and difficult operation.

In the "American Journal of Science" for December, 1891, is an interesting paper by Mr. F. P. Dunnington, "On the Distribution of Titanic Oxide upon the Surface of the Earth," in which he gives the results of 72 determinations on soils from various parts of the world, as well as on a few rocks. The universal diffusion of this oxide in appreciable quantity is fully demonstrated. These many determinations were not made by Mr. Dunnington in the ordinary tedious gravimetric manner, but by a rapid calorimetric process which is described in the paper. It is to be supposed that this method has been fully checked and proved to be reliable. That being so, the determination of titanitic acid in our rocks and minerals ought to become the rule instead of the exception, since an easy and rapid method is available for it.

MAG. 1891, p. 537), biotite appears to be practically absent from the rocks of the Borrowdale series.¹

The titanitic acid in these slates takes other forms. It largely occurs, as in the altered andesites, as disseminated granules and small crystals of secondary sphene. Slates showing this, to the exclusion of any other form of occurrence, are exemplified in the quarries at the top of Kentmere Valley, and on the other side of the same ridge in Troutbeck Valley.

Rutile occurs, though on the whole sparingly, in the form of blunt crystals and grains lining cavities, the central parts of such cavities being usually filled in with quartz, or calcite, or both.

Another and more widely-spread form of occurrence is as anatase in small double pyramids, with or without the prism-band, exactly as in the altered Coniston Flags at Shap.² These anatase crystals were first noticed in a slate from Honister Crag, and some difficulty was at first experienced in accepting the true nature of their origin. I was disposed to regard them as having been introduced in metamorphosed sedimentary fragments, as in the case of the tuff at Falcon Crag, and to suppose that the crystals had remained distinct after the other material of the fragments had been completely obliterated and absorbed into the rest of the slate. But longer observation of this particular occurrence, and of numerous others subsequently found, quite dispelled that idea. There is no doubt that the solutions which have permeated the ash-beds, and which have acted under high pressure (as witnessed by the bubbles in the calcite) and probably high temperature also, have dissolved titanitic acid and allowed it to re-crystallize (according to differences of conditions we are not able to specify), either as anatase, more sparingly as rutile deposited in cavities, or in combination with silica and lime as sphene. The anatase occurs mainly as clusters in patches of chlorite. With the perfect crystals are often large numbers of grains not showing definite forms, but apparently deposited at the same time. The mineral occurs also in secondary quartz-grains which are abundant in some of these rocks; in calcite, though rarely, and now and then in felspar-substance. In some cases cavities are seen lined with rutile, and filled in with quartz in which are perfect little crystals of anatase; so that between the time of deposit of the rutile on the sides of the cavity and the final in-filling with quartz a change of conditions as to nature or temperature of solutions, or both, had taken place, which altered the crystal-forms of the titanitic acid being deposited.

It may be noted that in slates which show very much sphene anatase does not usually occur. Otherwise a large number of the

¹ It is also to be remarked that the small crystals of tourmaline, so usual in clays, shales, and slates, are never seen in these ashes.

² Since the above was in print, I have had the opportunity of examining some of these minute anatase crystals by means of a $\frac{1}{2}$ inch oil-immersion objective. This has enabled me to see them very much better than I ever did before, and to ascertain that I was mistaken in stating that the prism-band is present on some of them. The apparent band disappears when the crystals are seen under the great magnification, together with fine definition, which the use of this objective gives us.

slates contain it in varying amount, sometimes very scarce and sometimes in crystals so small as to require very careful search for its detection, but at other times very abundantly and of larger sizes, ranging up to $\frac{1}{3000}$ th of an inch in length.

The various experiments on record as to the artificial formation of crystallized titanitic acid by sublimation show that variations of temperature cause variations in the resultant crystal-form;—rutile, anatase or brookite being obtained at different parts of the apparatus. Similarly the three minerals may be obtained by fusion of titanitic acid in different solvents. The same no doubt applies as regards solutions of titanitic acid in liquids, and its crystallization out of them under various conditions; but there appear to be very few experimental data as to this, and we can only speculate as to the exact nature of the solutions which have acted in these rocks. It is stated by Doelter (*Allgemeine Chemische Mineralogie*, p. 155) that by means of water containing sodium fluoride he succeeded in re-crystallizing titanitic acid in the form of rutile. He also gives interesting figures (*loc. cit.* p. 189) showing a very noticeable solubility of titanitic acid (powdered rutile) even in pure water, in sealed tubes at 80° C. From various considerations it is probable that the solutions acting in these rocks were largely charged with alkaline silicate; a solution of alkaline titanate was probably formed at the same time, out of which carbonic acid would liberate titanitic acid. It seems likely that so far as concerns temperature, pressure, etc., the conditions existing in many of these beds of the Borrowdale Series when the main changes took place, did not materially differ from those under which the Conistone Flags at Shap were metamorphosed near the granite, exactly similar solution of the titanitic acid and re-crystallization as anatase having taken place in some of these flags (Harker and Marr, *Quart. Journ. Geol. Soc.* vol. xlvii. 1891; also Hutchings, *GEOL. MAG.* 1891, p. 462).

Among the various changes which have taken place in the minerals of these rocks, those which concern the feldspars have the greatest interest. The points involved are, of course, the same whether we study the feldspars in the slates and other detrital rocks or in the altered andesites, and what follows may be taken as applying equally to both classes.

The normal decomposition of the feldspars of these rocks does not seem, so far as can be made out, to lead to kaolinization.¹ The three main types of decay, sometimes singly, sometimes together, give rise respectively to white mica, a very pale chloritic mineral, and calcite. The formation of white mica is very usual all over the district. In many andesites and ashes the feldspars, while retaining their original outlines perfectly sharply, are internally quite full of mica flakes, often of good size, hardly ever showing any sort of orientation to the crystal-planes of the containing crystal, but occurring equally in all directions and often as tangled clusters of flakes at all azimuths. This lack of orientation of the mica formed in feldspars appears to be not unusual. I have noticed it in other rocks; and it is pointed out by Rosenbusch (*Microscop. Physiog. der Gesteine*, p. 23).

¹ It is usually considered to be difficult, and indeed often impossible, to distinguish

Among the mica in the larger crystals may often be seen quartz, and usually more or less of perfectly glassy clear felspar.

Where the alteration has given rise to the pale chloritic mineral, a more definite orientation appears to largely prevail. This chlorite is very faintly dichroic, and polarizes in thin sections in tints up to yellowish-white of the first order.

Calcite frequently accompanies the other two products, and often occurs by itself, in all stages up to the total replacement of felspar crystals by pseudomorphs in calcite.

Mr. Alfred Harker, in a petrological appendix to a paper by Prof. Nicholson and Mr. Marr ("The Cross Fell Inlier," *Quart. Journ. Geol. Soc.* vol. xlvii. pp. 512-525), alludes to the fact that in some of the rocks in question the evidence goes to show that a large part of the felspars are "regenerated," and have a secondary twinning due to crushing. He specially alludes to a rock from Wythwaite Top, giving details as to his observations on the porphyritic felspars contained in it and their alterations (p. 515).

Similar occurrences may be noticed more or less all over the Lake District, and these rocks offer a splendid field for the investigation of the many questions, as yet only partially understood, as to the re-generation and re-crystallization of felspars, with or without secondary twinning, due to crushing and shearing. Specimens may be obtained at many points from ashes (fine tuffs and slates), and often from altered lavas, in which the usual turbid felspars full of mica, chlorite, or calcite, with the twinning nearly or wholly obliterated, are replaced by more or less glassy clear crystals often beautifully twinned. These are not crystals and fragments which have escaped decay, but are obviously felspars which are re-formed *in situ*,—often, apparently, completely re-crystallized and re-twinned. The rocks in which these occur all give full evidence of great stresses, and the felspars themselves are often bent, broken, and re-cemented with chlorite in a most complex manner.

In the slates of Honister Crag, and many other quarries, any number of bits may be seen, as clear as fragments of window-glass except for a little brownish dust in some cases, a large proportion of such bits showing beautiful twinning in polarized light. Many other bits, equally clear and glassy, show no twinning whatever, nor any cleavage, and are only to be discriminated from quartz by

microscopically between kaoline and muscovite as alteration-products in decomposing felspars. Rosenbusch, for instance, points this out very emphatically (*Physiographie der Mineralien*, pp. 516, 561). The flaky alteration-product in felspar is certainly sometimes so minute, and occurs in such an indistinct manner, that decision as to its exact character is very uncertain or impracticable. But as soon as the flakes are larger and more distinct (and this is often eminently the case in the rocks now under consideration), I venture to think that the identification of the mica can be safely made. The bi-refraction of kaolinite is high, but so far as my observations go it is *very distinctly* less than that of muscovite, observing transverse sections in each case. Then again, edge-sections of the mica extinguish parallel, while edge-sections of kaolinite give such very decided angles that no confusion of the two minerals appears possible. I have used for these comparisons the well-known kaolinite crystals from Anglesey, and also those which occur abundantly (though of smaller size) in the interstices of many coarse sandstones and grits of the Coal-measures.

optic tests in convergent light; and in some cases, in tuffs, large decayed felspar-fragments have been re-generated into mosaics of clear grains in the well-known manner.

What these felspars now are it does not seem possible to decide on optic tests alone, in thin sections. The multiple twinning in most cases points to plagioclase, and extinctions appear to indicate albite, oligoclase, and andesine as probably the varieties. But nothing short of a laborious isolation and analysis of specimens could give a safe decision. It appears to be usually considered that albite and andesine are the varieties chiefly produced by the dynamic re-generation of decayed original felspars.

In the paper above referred to Mr. Harker brings forward the question of the formation of new felspar by deposit in vesicles, and describes a case of such an occurrence in one of the Cross Fell rocks, the felspar in question being well-twinned plagioclase with extinction-angles pointing to albite or andesine.

According to my own observations, this mode of occurrence is not by any means very rare, and I can point to several cases of cavities in these rocks which are lined with chlorite, etc., and contain felspar in such a manner as to apparently forbid any other explanation than that the mineral has been crystallized from infiltrations into the cavities. The question first attracted my attention in connexion with the altered rocks round the Shap granite. Messrs. Harker and Marr allude to felspars formed in vesicles by the metamorphism of their contents. They refer to one particular slide in which this is observed, but state that it does not seem to have commonly occurred. Whether it be due to contact-action or not, my own impression is that it is very usual at some points round the granite, as I have several slides in which well-defined felspar, often in good large individuals, frequently occurs in vesicles with quartz, biotite, hornblende, etc. It is mostly plagioclase, but I have one slide, which I have submitted to Mr. Harker, in which occur grains of what seems to be orthoclase, perfectly clear, beautifully cleaved, and extinguishing quite parallel to the cleavages. One such grain is over $\frac{1}{4}$ inch in diameter filling an irregular cavity, which may have been a vesicle, but seems more likely to have been due to the removal of some former mineral. I at first attributed these large grains, as also the smaller plagioclase in vesicles, to the action of the granite, and this may be correct, but it is not necessarily so, as later observations showed me that all these occurrences are paralleled in rocks far outside the contact-zone. Cavities with plagioclase, and apparently also orthoclase, occur not rarely in the coarser slates at Mosedale, for instance; and the grains of well-cleaved felspar, apparently orthoclase, are seen again in sections of the andesite of Harter Fell, Mardale, where the mineral occurs in a precisely similar manner as large, irregular, perfectly glassy-clear, untwinned grains in a rock whose original felspars are all sharply and definitely bounded, and are now exceedingly turbid.

I look upon all these cases as due to causes wholly distinct from the dynamic regeneration of decayed felspars, and as explained by

simple deposit from solutions, exactly as albite, orthoclase, etc., are known to be deposited on a larger scale in veins and cavities.

There are also, so far as I can make out, what certainly appear to be orthoclase crystals in some of these rocks, which seem to require another explanation. They are not in cavities, and for various reasons they do not appear to be original crystals, but to be "regenerated" like so many of the plagioclase crystals. I have come, after much consideration of them, to regard them as not improbably pseudomorphs after former plagioclase, on the theory (or hypothesis) that solutions containing silicate of potash have acted upon these former feldspars, removing soda and lime and replacing them with potash. One such crystal observed, which optically fully corresponds to orthoclase, contains a cavity lined with deposited rutile, evidently formed at the time that solutions were strongly acting on the original crystal.

In some of the normal andesites the much-altered feldspars full of mica, chlorite or calcite, show in among these secondary products, as before stated, more or less of clear glassy material. It is not an uncommon thing to see this glassy feldspar in considerable quantity in long streaks and patches, and where the outline of the crystal is fully preserved, as often is the case, to see that this feldspar is optically uniform all over the crystal, is quite free from twinning and extinguishes perfectly parallel to the crystal-boundaries, or at angles which point to orthoclase. In some of the rocks crystals are frequent which are wholly glassy clear, save for trifling inclusions, and behave as above described, occurring together with plagioclase which is obviously regenerated.

Such changes as I suggest may have taken place do not appear at all unlikely under the conditions which we have reason to infer obtained during the alterations these rocks have undergone, and there appears to be good independent evidence that they have been observed and chemically proved elsewhere. A leading authority in this class of investigation appears to be Lemberg. I have not at present an opportunity of consulting his original papers, but in Roth (*Chemische Geologie*, vol. i.) among other abstracts from and references to Lemberg's work are certain facts which bear very directly on the point in questions.

Thus, Lemberg analyzed oligoclase from the tourmaline-granite of Monte Mulatta, and its green alteration-products in four examples, *a, b, c, d.* The alkalis were as follows:—

	<i>Original Oligoclase.</i>	<i>a.</i>	<i>b.</i>	<i>c.</i>	<i>d.</i>
Soda	= 7.26 per cent.	2.14 p.c.	0.70 p.c.	2.23 p.c.	0.84 p.c.
Potash	= 2.10 "	3.00 "	5.28 "	4.54 "	7.43 "

water is also taken up at the same time.

Other analyses of Lemberg's are also given, showing similar changes in oligoclase, some chloritic mineral being apparently formed, with a simultaneous removal of soda and increase of potash. An analysis of labradorite is also given, together with that of its alteration-product, showing—

	<i>Original labradorite.</i>	<i>Alteration-product.</i>
Soda ...	5.43 per cent.	0.88 per cent.
Potash...	0.92 „	8.51 „

and in another still more extreme case the alteration-product contained Soda = 0.17 p.c.; Potash = 9.71 p.c.

From this latter alteration-product acid extracted 37.61 p.c. of a silicate of magnesia, alumina and iron oxides,—evidently a chloritic substance. The residue left after this extraction contained very nearly all the potash, “and corresponded in composition to orthoclase.” These alterations appear to be exactly cases of what I suppose to have taken place in some of the andesites.

A chloritic mineral is formed, with a simultaneous more or less extensive *chemical* alteration of the soda-lime felspar, tending to convert it into orthoclase. In these Lake District rocks powerful dynamic action, following on the chemical change, may be supposed to have completed the work in *re-crystallizing* the felspar-substance. It will not affect the question, whether chlorite, mica or calcite is formed during the chemical stages of these processes.

In commenting on the above results of Lemberg, Roth points out that it is not indicated from what source the potash was supplied which was taken up during the changes of the felspars. In the case of the rocks we are considering there is no difficulty as to such source. I have shown how frequently white mica is formed in the alteration of some of the felspars of these rocks, and how specially and very largely this is the case in the beds of fine ash and tuff. In these ash-beds the finely-pulverized material has undergone these alterations as a *whole*, including the portion which in the massive andesites is consolidated as ground-mass, considerably richer in potash than the rest of the rock, but undergoing these changes, as a rule, in a very much less degree.

These changes, as we have seen, entail a considerable liberation of potash as soluble silicate, and we may be sure that during their progress all these rocks, as a whole, were permeated by solutions containing that salt, and also carbonate of potash. These solutions would play an important part in further changes, and acting upon soda-lime felspars (themselves containing more or less of potash) already in course of decay, would easily and naturally bring about the alterations supposed. No doubt similar explanations would apply in the cases proved by Lemberg.

Lemberg was apparently able to isolate the special felspars, the alterations of which he wished to study. Such isolation is, unfortunately, not possible in the case of the rocks to which I refer. The felspars are so small that the picking-out of them is not practicable, and their isolation from the crushed rock by means of dense solutions is a tedious and difficult matter. Also it is not possible in this manner to separate the different *varieties* of felspar one from the other, as even in the most favourable of the occurrences examined, the included secondary minerals, though small in amount, suffice to completely counteract the normal differences of specific gravity.

Under these circumstances it has not been possible to obtain any very effective chemical evidence on the point in question.

The most favourable rock in my possession is an andesite from a point not far from Ulleswater, on the road to Matterdale. Its ground-mass is fine-grained, and appears to have been originally "hyalo-pilitic." There are numerous well-defined pseudomorphs of chlorite after augite. The porphyritic feldspars are numerous, but small, ranging from about $\frac{1}{8}$ th of an inch in length as maximum. They are largely more or less glassy clear, and contain comparatively little of secondary minerals;—chlorite, calcite, a little epidote, with but little mica in this case.

A good many of them show the appearances above stated which lead me to suppose they are perhaps orthoclase. The rest are plagioclase, of which, as usual, it is not possible to safely determine the variety, though oligoclase appears to be present. A large piece of this rock was pulverized and reduced to uniform very small grains by means of wire gauzes of suitable mesh. The powder was subjected to repeated separations in liquids of diminishing specific gravities, the lighter portions being successively concentrated, a final separation being made in a liquid in which a fragment of pure labradorite just remained suspended. In this manner, with plenty of time and patience, it was possible, in spite of the unfavourable nature of the rock and of the smallness of the grains, to separate from a large bulk a small quantity of material which proved to be feldspar, free from ground-mass, and contaminated only by small amounts of chlorite and calcite. This was finely powdered, digested a short time in hydrochloric acid of moderate strength (sufficient to decompose chlorite), and finally in dilute potash liquor to remove separated silica. The residue, well washed and dried, was practically pure feldspar.

A sample of the bulk of the powdered rock contained: Silica, 62.43 per cent.; Soda, 4.13 per cent.; Potash, 2.28 per cent., as kindly determined for me by Dr. J. B. Cohen. This does not differ appreciably from the average run of analyses of local andesites, though the potash is perhaps a trifle higher than usual.

The isolated feldspar-substance was analyzed by Mr. Paterson and contains Soda 8.52 p.c.; Potash 4.1 p.c.

Having regard to the facts that in all rocks of this class the potash concentrates in the ground-mass, and that the average of the entire rock is here only 2.23 p.c., we should not expect to find anything like so much as 4 p.c. potash in the porphyritic feldspars. Its presence in them in this amount would seem to justify the inference that some of them are specially rich in it, and that, indeed, some potash-feldspar is probably present together with the plagioclase.

In some of these rocks, again, there appear to be examples of those very interesting phenomena which have been so beautifully described and illustrated by Prof. Judd in his paper, "On the Growth of Crystals in Igneous Rocks after their Consolidation" (Q.J.G.S. vol. xlv. 1889).

They are not so large nor so striking as the instances quoted and

figured in that paper, but there are in some specimens crystals which show all the principal appearances enumerated by Professor Judd, and which cannot, I think, be explained satisfactorily in any other manner than that which he has given us.

NOTICES OF MEMOIRS.

I.—THE OOLITIC ROCKS AT STOWE-NINE-CHURCHES, NORTHAMPTONSHIRE. By BEEBY THOMPSON, F.G.S., etc. (Journ. Northamptonshire Nat. Hist. Soc. Vol. VI.)

IN this paper Mr. Thompson describes a section of especial interest, as it shows the sequence of beds from the Northampton Sands to the Oxford Clay. The tract near Stowe, situated about seven miles west of Northampton, is a faulted one, and to this cause is due the preservation of the Great Oolite and higher beds, which elsewhere in the immediate neighbourhood have been removed by denudation. The beds have been quarried chiefly to supply limestone for fluxing purposes to the Heyford furnaces near by.

The chief new points in this paper concern the identification of the small area of beds overlying the Great Oolite, as these were not indicated on the Geological Survey Map. The highest bed beneath the Drift soil is a blue clay grouped as Oxford Clay. There can be little doubt that this represents the clay usually found between the Cornbrash and Kellaways rock, and sometimes designated the Kellaways Clay.

The Cornbrash contains some of the usual fossils met with in the formation, and it rests on a series of beds grouped with the Forest Marble and Great Oolite Clay. The presence of beds of flaggy limestone resembling varieties of Forest Marble is of interest, as they are only occasionally met with in the country to the north-east of Bicester, in Oxfordshire.

The Great Oolite Clay is not, as Mr. Thompson thinks, the bed to which the term 'Cornbrash Clay' has been applied; that Clay, where it occurs, overlies Cornbrash rock, partly replaces it, and passes up into the Kellaways Clay.

The Great Oolite Limestone and lower beds are described by Mr. Thompson, and lists of fossils are given from these as well as from the higher strata. A photographic plate and a plate of diagram-sections illustrate the paper.

H. B. W.

II.—NOTES ON THE FOSSIL APHIDÆ AND TETTIGIDÆ.

IN Mr. G. B. Buckton's late Monographs on British *Aphides* and *Cicadæ*, are thoughtful remarks on the known fossil forms of these two great families of Insects, and we here reproduce them as interesting to our readers.—premising that these Insects belong to the *Homoptera*, whose zoological relationship is as follows—

HEMIPTERA: A. HOMOPTERA: *Aphides*, *Coccidæ*, *Cicadæ*, *Fulgoridæ*, etc.