grandævus, Heer, but which belongs to a new genus of Apidæ, in which the neuration more closely resembles that of *Eucera*.

EXPLANATION OF PLATE VI.

FIG. 1. *Drymadusa speciosa*, Heer, sp.; male fore-wing $\frac{2}{1}$.
FIG. 2. *Acridium Œningense*, sp. nov.; fore-wing $\frac{2}{1}$.
FIG. 3. *Stenolestes iris*, Heer, sp.; outer portion of fore-wing $\frac{3}{1}$.
FIG. 4. *Calosoma Heeri*, sp. nov.; elytron $\frac{4}{1}$.
FIG. 5. *Necromyza pedata*, sp. nov.; $\frac{12}{1}$.

IV.—AN INTERESTING CONTACT-ROCK, WITH NOTES ON CONTACT-METAMORPHISM.

By W. MAYNARD HUTCHINGS, F.G.S.

FOR a considerable time past I have been engaged, in collaboration with Mr. E. J. Garwood, in an investigation of the rocks in contact with the Whin Sill. The results of our joint work, geological, petrographical, and chemical, will be published in detail in due course. In the meantime there are some special observations, made on some of the rocks in question, which have more or less bearing on some of the points dealt with in a paper I contributed to the GEOLOGICAL MAGAZINE last year (GEOL. MAG. 1894, pp. 36 and 64).

These observations having been made since that paper was printed, I have thought that it may be worth while to give an account of some of them, more especially as regards an interesting bed of altered shale which occurs at Falcon Clints. It is at this locality that the contact-action of the Whin Sill is very strikingly developed, there being an exposure showing fine garnet-limestones and other altered rocks. The bed in question is 75 feet below the contact, from which it is separated by a series of layers of limestones, sandstones, and shales, all altered. It is 8 feet thick, and rests on the basement conglomerate of the Lower Carboniferous.

It is for the most part a darkish gray, compact rock, with no remaining fissility. Its appearance is in many respects like that of some felsites. Its most striking macroscopic characteristic is that it contains large numbers of spherical, and approximately spherical bodies, like peas, and of various sizes up to rather over half an inch in diameter. These nodules are of a darker colour than the rock. They are not at all evenly dispersed in it, being at some places comparatively rare and scattered, while at others they are closely packed, and in some cases touch one another. At some parts of the rock they can be easily taken out unbroken, leaving perfect hollows where they have been; at others they are not in this loose condition, and can only be got out in bits by smashing the specimen. This difference is due to a slight weathering-action having, in some of them, caused the formation of a less coherent skin between the nodule and the containing rock.

Microscopic examination shows that this bed is not quite uniform in its nature throughout, and chemical tests confirm this. Thicker beds of shale or clay in the Carboniferous are nearly all found to vary in nature, as successive layers contain varying proportions of quartz and of fine clay-material, so that their chemical composition may differ a good deal *quantitatively*; and it is partly to such initial variations, and partly to consequent differences in the metamorphic action of the igneous rock, that we must ascribe the differences that we find in the microscopic examination of slides from several points in this bed, which is macroscopically a fairly uniform mass.

To give an idea of this interesting rock it will be best to describe separately two or three typical sections, whose nature will give a good general idea of the various points to be observed at this exposure of the bed in question.

Thus, from numerous hand-specimens collected near together, several slides have been made in which some of the spots have been included; in this case spots which are firmly incorporated in the rock and cannot be detached.

In ordinary light a very thin section shows the main portion of the rock to be composed of a uniform gray mass, in which are bedded abundant grains of clastic quartz of an average size of about $\frac{1}{80}$ inch, but ranging up to as much as $\frac{1}{30}$ inch in diameter. The gray ground-mass shows a vast number of rutile-crystals of very small size. They are not in the form of the "clay-slate needles," but in the relatively short and blunt form, with definite terminal developments, so usual in altered rocks. There are also the numerous small zircons, and the small hemihedral crystals of tourmaline, so characteristic of clays, shales, and slates. In all respects this rock corresponds to an altered moderately quartzy clay or shale, such as can be examined in any number of instances in the Carboniferous beds.

In polarized light this gray ground-mass shows, however, most interesting developments. Most of it is seen to consist of rounded, irregular, or more or less definitely bounded grains of a mineral, or minerals, lying bedded in and surrounded by a material which is mostly quite isotropic, but at other times shows an indistinct effect of birefractive substances developing within it.

At some places we have the polarizing grains closely packed together, with so little of the surrounding isotropic material that they amount to a true interlocking mosaic; at others they are very much more separated, and we have quite large spaces of the surrounding material, perfectly isotropic, but containing the swarms of minute rutiles, small flakes of white mica, and a certain amount of indistinct dusty and granular substances diffused in it.

A large portion of the polarizing grains can be proved to be quartz, some of them can be identified as felspar, though this is more difficult, and a good proportion cannot be made to give any definite optic tests at all. The grains are not yet water-clear, nor yet so sharply defined as those of a perfectly developed contact-mosaic; there is a certain amount of dimness in them, which is accentuated also by their envelopment in isotropic base full of microlites. It is, however, certain that we have here a production, due to the metamorphism of the shale, of quartz with more or less of felspar. All these grains are in every way perfectly and sharply distinguished from the original clastic grains of the shale; not one could by any possibility be mistaken for original material, even if only for the reason that they are full of minute rutiles and other material from which the clastic grains are quite free.

Here and there white mica is developed in larger flakes, lying in all directions, and, as before remarked, there is a good deal of the mineral in minute flakelets. But, on the whole, mica is a subordinate mineral in these special slides.

The clastic quartz-grains are a very interesting study. They are all more or less corroded and altered round their outer portions. The angular outlines of the original grains are in nearly all cases quite preserved, but the outer portions are no longer quartz. They are seen to be attacked and altered by the material of the isotropic base, and the altered rim so produced contains a large amount of white mica. In many grains this mica is seen to penetrate well into the quartz in little bays and gulfs, or as isolated streaks. It is largely in the form of sheaves and radiating groups of flakes.

In some cases the corrosion and alteration of the quartz-grain has taken an even more striking form. Thus, *e g.*, one grain with an average diameter of $\frac{1}{45}$ inch is altered to about half its extent. The inner portion is still pure unaltered quartz, with its cavities and bubbles; the outer part is faint yellowish in colour, and quite sharply marked off in ordinary light from the original mineral. With lowered condenser it shows a granular and fibrous structure; in polarized light it is seen to consist of clear transparent isotropic matter, and to contain numerous sheaves and spherulitic bundles of polarizing fibres and needles, which can be optically identified as felspar. The outer boundaries of the original grain are quite sharply marked off against the surrounding mass of hard mosaic and isotropic matter.

In other corroded quartz-grains nests of anthrophyllite have formed, as clusters of prismatic needles; or we have beautiful little deposits of andalusite crystals in elongated prismatic form, with the dichroism unusually well shown.

Turning now to the nodules which are cut in these sections, we find points of great interest, which assist us in interpreting the nature of the rock and the processes by which it has been altered. The nodules are sharply defined, and are darker at the edges than towards the centres. This darkness is due to concentration of pigment, and also to the presence of some ferruginous colouring in parts. In these nodules are large patches of perfectly clear, transparent, almost colourless, and quite isotropic matter, containing no rutiles or other enclosures. With high powers and with suitable illumination, it may be seen that these patches are not quite structureless. There is a minute granulation discernible, and in some of them it passes to a fibrous condition. Other patches of similar material contain large bundles and sheaves and spherulitic aggregates of felspar-needles with a little quartz.[1] And inter-

[1] It used to be considered that in sheaves and spherulites of this description all *negative* fibres were felspar and all *positive* fibres were quartz, but it has been

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mediate stages may be seen in which the needles of felspar and quartz are beginning to form in the isotropic matter, and so on down to a stage where the patches just begin to pass from the isotropic state into a development in which they commence to show a faint and speckly polarization.

In some of the nodules large amounts of anthrophyllite needles have formed in the patches, and a little andalusite is also seen. These fields of isotropic matter, and the new formations of minerals, are seen in these special slides, mainly at the outer portions of the nodules, and at these parts there are none, or very few, of the original clastic quartz-grains, while such as are there are much corroded away, and often represented only by small residues.

In the inner portions the clastic grains are as abundant and as regularly diffused as in the main mass of the rock, while the new formations are much less, or are absent, except that a little isotropic matter lies in among and around the grains, and here and there a little new mosaic is formed.

Full study of these sections gives the impression that we are here looking at a very interesting and instructive stage of the metamorphism of a shale. The finer-grained material has been completely affected by the re-solution of a large part of its original constituents, and out of the matter so formed a mosaic of quartz with felspar is seen in process of crystallizing. The process was brought to a close before such re-crystallization was complete, and so we have left for our observation a large proportion of the residual substance, which we may regard as representing the indefinite product of solution, or of aqueous fusion, of some of the original constituents, which we have such good reason to conclude takes place in the processes of contact-metamorphism.

In the larger quartz-grains we see that this process of solution was attacking them to a considerable degree, and had it continued, would have completely dissolved them away. That we can here see all this in progress, as it were, is due to the fact that we are dealing with the effects of only a moderate bulk of igneous rock, and to other favourable circumstances. If, for instance, the metamorphism were due to a large mass of granite (or to a similarly large mass of dolerite), the earlier conditions which caused the solution (or aqueous fusion) of the constituents would have lasted long enough to destroy the clastic quartz-grains to a far greater extent, or entirely; and the conditions during which the re-crystallization went on would have also lasted longer, and we should have had a completed "contact-mosaic" with either no residual "base" or only a small amount of it, and this not, or only to a small extent, isotropic, such as we may see in the aureoles round some granites.

In the nodules, as above described, we have the same process

demonstrated that this is not necessarily so, as felspar fibres may also be positive, though it is more rare. So that though negative fibres are felspar only, positive fibres may be either felspar or quartz, and the relative degree of bi-refraction must assist in distinguishing as far as possible. (See full *resumé* of this subject in Zirkel's Petrographie, vol. i. 1893, pp. 474 and 476.)

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going on, but under special modifications which are not readily explicable. The solution of original materials has taken place very completely at the outer parts of the nodules, so much so that here even quartz-grains have disappeared and we have areas wholly made up of the product of the solution. Here also we see a gradual and unmistakable crystallizing out of felspar and quartz in this material, in an even more striking manner than in the main mass of the rock, because we can here more distinctly trace the passage of this isotropic base into an aggregate of different minerals.

It may be noted that the formation in these nodules, and elsewhere in the rock, of isolated patches of anthrophyllite and andalusite, tends to the conclusion that the inter-action of the components of the shale was not limited to such very short distances as have been inferred by observers in other cases (*see* Harker and Marr, Quart. Journ. Geol. Soc., vol. xlix. p. 368), but that a more considerable amount of interchange and transfer of materials has taken place. A similar opinion was expressed by Miss Gardiner in respect of contact-rocks at New Galloway (*see* Quart. Journ. Geol. Soc., vol. xlvi. p. 579). The analysis of a hand-specimen from which some of the sections described above were cut gives—

Silica	60·15	per cent.
Alumina	25·43	,, ,,
Ferric oxide	3·95 [1]	,, ,,
Lime	0·45	,, ,,
Magnesia	trace	,, ,,
Potash	1·25	,, ,,
Soda	2·01	,, ,,
Water	7·20	,, ,,
	100·44	

We can now consider other series of slides and see other phases of the same processes. As regards the main mass of the rock, we have variations in the relative amounts of the components, and of their present condition. At some parts there is much more mica and very little of the mosaic of good-sized grains of quartz and felspar forming, with little or none of the isotropic matter. The amount of clastic quartz, and the size of the grains, varies also, and so does the degree to which they are attacked and corroded. Other specimens may be obtained of which slides show that they consist in the main of a fine-grained aggregate of quartz and felspar, passing down into a quite cryptocrystalline felsitic-looking mixture, and opening up, on the other hand, here and there into numerous clear and glassy patches, which in polarized light are seen to consist wholly of groups of well-twinned plagioclase, which can be identified as albite in many individuals, whilst the extinctions of some others point to the probable presence of a species allied to oligoclase.

These very fine-grained mixtures of quartz and felspar (mainly albite) are a frequent product of the alteration of shales or slates by dolerites (diabase), and are fully described by authorities writing

[1] A part is present as ferrous oxide—hence excess in the analysis.

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on such alterations in the Harz and elsewhere. They are also seen at other parts of the Whin Sill contacts, besides the locality with which we are now dealing. They are known as *adinoles*, and will be so spoken of in what follows. A large part of the typical adinoles shows the mixture of quartz and felspar in a quite unresolvable, cryptocrystalline condition, and its true nature, apart from chemical evidence, can only be ascertained through the circumstance that nearly all occurrences of it open up here and there, in perfect continuity, into patches of so much coarser grain that the components can be clearly made out.

It is usual to designate as adinole more specially the contact-rock close to the intruded igneous mass, and to associate with the name also an increased percentage of silica, which it can be shown in many cases to possess. But there are many reasons, upon which I need not enter here, why these restrictions should not be placed upon the name, and in favour of the rationality, in adopting the term, of applying it to all the alteration-products of shales, slates, etc., by basic intrusions, in which a fine-grained mixture of quartz and plagioclase has resulted.

As regards the nodules, they vary mineralogically in every degree of *quantitative* composition, but seem to be all due to the different degrees of the same processes indicated above. Many of them show nothing beyond an aggregation of pigment, and a quite narrow ring of material differing from the rock outside and inside their areas. These occur in parts of the rock which are not so much affected by re-solution of materials. The quartz-grains are very little attacked in these cases, and are the same inside as outside the ring. Such nodules are really to be described as mere shells of a special alteration-product, enclosing areas of the less altered or differently affected material among which they have been formed. In other nodules, again, the shell widens and can be better studied, and it is seen that instead of fields of isotropic matter with sheaves and spherulites of felspar and quartz, we often have the adinole-material varying from cryptocrystalline to microcrystalline. In such bands the clastic quartz is in all stages of disappearance. Sometimes it is quite gone, but more usually corroded grains may still be seen, the final stage being that only small blebs and speckles of it remain to show where the larger grains once were. Where the shell is of any considerable width it is very often distinctly banded in concentric layers of more or less varying colour, and it frequently varies also in the degree of crystalline development in these layers. There are also frequently concentric cracks in these shells, which appear to indicate some strain during final cooling of the rock, or more probably during the final consolidation and crystallization of the material forming the shells.

These shells of more considerable width still surround and enclose, in most cases, a kernel of the altered rock, similar to what exists outside, but there are also cases in which the entire nodule consists of this adinole material, and we have then approximately spherical bodies of more or less banded substance, yellow to brownish in colour, with no remains of the quartz-grains of the rock except the little residual blebs and grains, and streaks.

Where such largely or fully-developed nodules of adinole are seen we have also a formation of the same material in the main mass of the rock, among the clastic quartz-grains; but the action in these nodules has always been, as it were, intensified. We do not see in the main mass any such areas of complete dissolving of the quartz, and complete development of adinole, comparable to those of some of the large nodules.

It may be mentioned that in addition to this exposure at Falcon Clints, there is another occurrence of nodules known in the contacts of the Whin Sill. It is seen exposed at Rowntree Beck, and is here again in a bed of altered shale, 24 feet below the junction. They are of larger size than those described, having longest diameters of as much as 2 inches, and are more flattened in shape. One such large nodule, studied in thin sections, shows that the outer portion is again composed mainly of adinole, while the inner part is a mosaic of quartz, perfectly "regenerated," the grains interlocking and containing abundance of the enclosures of little rounded fused-looking globules, so characteristic in typical contact-mosaics. Dispersed through the nodule is a large amount of anthrophyllite, and there is also a good deal of chlorite (delessite) which has resulted from its decomposition.

These large nodules differ in some respects of detail from the former examples; but there can be no doubt that they owe their formation to the same processes and respresent the drawing together and concentric deposition of a substance formed in the shale during contact-metamorphism, the action of the substance having been also intensified and more highly developed owing to such concentration.

In my former paper on contact-action, I spoke of a material which can be seen in among the minerals of some altered slates at granite-contacts. In its most typical form of occurrence it shows a characteristic granular structure in ordinary light, and with crossed nicols it shows either a minutely speckly polarization, or stages of the development of this into white mica and other minerals. I pointed out that this material is perfectly *new*, bearing no relationship to anything which existed in the unaltered slates or shales, and that its appearance is so very characteristic that once remarked and studied it can never be overlooked. My suggestion was that this material also represents in these rocks the residues of the dense solutions, or aqueous fusions, of some of the constituents, such solutions having acted as solvents and transformers of other components not originally dissolved.

This substance, with all its appearances and characteristics as described, is more or less present in many of the altered shales near the Whin Sill. It is seen in varying amount in the rock I have been describing, though here its development is not very pronounced, the isotropic matter being in much greater abundance. It always bears the same relationship to the other minerals as it does at granite-contacts.

Since writing the former paper I have examined specimens of it on a much better scale than any I had then seen. Thus there are occurrences of shale at contact with, or enclosed in the Whin Sill mass, which have been left altered mainly, and in one case almost wholly, to this condition. One such rock gives sections which are made up entirely of a ground-mass of this fine speckly material, not far removed from an isotropic condition, with a good amount of white mica and a little dark mica crystallizing out of it in radial bunches and fan-shaped aggregates. Not a vestige of anything of the original shale has remained, except the ever present zircons and the abundant re-crystallized rutiles. This has been a shale rather unusually rich in alkalies (over 7 per cent.), and very free from quartz. It has been extra amenable to solution-action, and it is not possible to study thin sections of it in its present condition and doubt that very nearly all its ingredients had passed into some sort of solution, and that the indefinite and amorphous product was not very far advanced in a process of re-crystallization when fall of temperature put a stop to further development.

It is assuredly a circumstance worthy of note, that in the contact-metamorphism of rocks of the same general nature (clays, shales, and slates) by intrusions of granite, and again by intrusions of dolerite, we can find one and the same characteristic substance appearing, and playing one and the same part in its relationship to the formation of certain minerals, this substance being an absolutely *new* product never seen in the original rocks, nor seen, so far as I am aware, in anything but this particular class of contact-rocks.

Finally, to return to the special bed of rock at Falcon Clints, we may look again at the analysis. It is not intended here to enter into any detailed consideration of the interesting chemical questions involved in the alteration of shales, etc., by *basic* rocks, which questions will be more fully gone into at some future time. I may, however, briefly allude to the point as to the increase of soda in such altered rocks. That such increase has frequently taken place is quite beyond question, as I pointed out in my former paper, unless we wish to absolutely reject much very excellent evidence.[1] Many of the altered shales of the Whin Sill contact will also bear testimony to the same effect. It is not possible in this case to compare analyses of any given stratum of the rock at successive stages of approach to the actual contact, because the Whin Sill is intruded parallel to the strike, and the thickness of any

[1] High authorities, in reviewing all the evidence, have had to come to the conclusion that such transfer takes place at basic contacts; as, for example, Zirkel in his detailed consideration of the contact-effects of diabases (Petrographie, vol. ii. 1894), and also Roth (Chemische Geologie, vol. iii. 1893). No geologist has made such a special study of the chemical side of petrology as Roth, and a great amount of the evidence on this particular question is collected and summarized in the volume named. In reviewing this evidence Roth says that, according to it, "there is a decided contrast between the contact-effects of granite, syenite, etc., and those of diabase: in the former case no introduction of material into the altered slates and no chemical differences due to distance from the eruptive rock; whereas in contact with diabase we have introduction of silica and soda into the altered slate, and at the same time chemical difference according to distance from the eruptive rock."

given bed affected is not sufficient to allow of comparisons. Thus, the bed we have specially considered is eight feet thick. Its alteration is as intense at the bottom as it is at the top, and chemical tests also show that no differences occur on which stress could be laid in this connection. And so with the other beds affected. But we know that clays and shales in the Carboniferous beds invariably contain much more potash than soda, say from three to four times as much. This is fully borne out also among the rocks at the Whin Sill. Some of the shales of which I have made analyses show that no chemical change has taken place in them, and in such cases the potash and soda are in the normal proportions,—as near as may be, for instance, as in the analyses published by me of clays from the Coal-measures.

When in these beds we find altered shales or clays with more soda than potash, or even with an approach to equality in these bases, we are quite safe in concluding that this striking alteration in the normal proportions is due to the intruded soda-bearing rock in some way. This is the case with the rock we are now considering; the soda is considerably in excess of the potash. As to how the transfer has taken place in these cases, there seem to be three possible causes to be considered. It may have taken place at the time of the intrusion, by actual passage of igneous magma; it may have been effected after intrusion, and during the subsequent heating and cooling of the sedimentary rocks, by the passage of hot aqueous or vaporous compounds, or both; or, it may be brought about after complete cooling, and long after all "contact-action," by the percolation of water from the igneous rock during weathering.

The first of these conditions may apply, to a limited extent, close to contact. It certainly does not apply to the bed now in question, which is 75 feet from contact, and separated from it by several other alternating beds of shale, limestone, and sandstone. The third condition may frequently apply to a small extent and sometimes to a considerable one. But, in the present special instance (and in others in the same district), microscopic study of the rock precludes the supposition that subsequent percolation has deposited soda-compounds in it. When we have a specimen consisting of a hard, compact, felsite-like mass, which the microscope shows to consist of a mosaic of quartz and felspar, we cannot readily understand how the original rock could be removed, and this deposited, by percolation. And still less can we do so when we have a rock consisting of quartz, felspar, isotropic matter and white mica. It would be different if it were more or less cracked and rotten, and showed zeolites in it, but of this there is no trace.

We must deal with the fact that transfer *does* take place, in spite of the many difficulties in the way of understanding exactly how it is effected; such difficulties as arise when we have to note that in one given section of beds there will be cases in which evidence of transfer is wanting, though beds further from the contact are strong in such evidence. Such difficulties are, at any rate, not greater than, and are indeed analogous to, others which we have to face

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in considering some undoubted facts as to contact-metamorphism in general.

So far as concerns the particular case in point, and the conclusions we may draw from it, the question is not in any way affected by the manner of transfer of the soda, nor even by the possible denial of any such transfer at all.

(*To be concluded in our next Number.*)

REVIEWS.

I.—Reported Discovery of an Animal intermediate between Man and the Anthropoid Apes.

Pithecanthropus erectus. Eine menschenæhnliche Uebergangsform aus Java. By Eug. Dubois. 4to. pp. 1–39, with two Plates. (Batavia, 1894.)

REPORTS of the discovery of the remains of animals intermediate between Man and the Anthropoid Apes are always to be received with scepticism, since the resemblances between the skeletons of the higher Primates are so considerable that abnormalities, due to disease and other causes, are liable to be regarded as evidence of the existence of intermediate forms. There can be little doubt that this is what has happened in the present instance, portions of an abnormal human skeleton having been made the types of a new genus and species, *Pithecanthropus erectus*, for the reception of which a new family, the Pithecanthropidæ, has been established. The name *Pithecanthropus* was originally employed by Haeckel to denote a hypothetical animal forming a connecting link between man and the higher apes, and it is in this light that the creature, to which the name is now applied, is regarded, where they were found associated with extinct mammalia.

The remains upon which such important conclusions have been based consist of the upper portion of the cranium, a tooth (m. 3), and a left femur, all of which were found near the village of Trinil, on the Bengawan River, Java, and are considered to have belonged to a single individual. The rock from which these bones were obtained is a volcanic ash, a deposit which in a country like Java, subject to frequent volcanic eruptions, must often enclose the remains of men and animals that have been overwhelmed. A somewhat similar case of the discovery of human remains in volcanic rock is recorded by Scrope in his work on the volcanoes of Central France, two skeletons having been dug out of a bed of "tuff" near Le Puy, in the Auvergne district.

The skull, of which the upper and hinder portions are preserved, is dolichocephalic, and measures 18·5 cm. in length. All the sutures are closed, and there are no bony crests for the insertion of muscles. The photographs show that the whole surface is covered with pits and rugosities which might be the result of weathering and *post-mortem* injuries, but have much the appearance of a diseased

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