was thought that this rounding of the crystals was caused by fusion, but the lecturer remarked that it was often the most infusible of minerals that had their angles rounded. These crystals of foreign minerals belong to veins. A portion of a vein was exhibited containing, first, a layer of apatite, then one of quartz, then a coating of white calcspar, and lastly, a layer of sulphate of barytes. Another showed a layer of orthoclase, then one of pyroxene, and lastly, one of graphite. Some geologists have thought that these crystalline limestones have an eruptive origin, analogous to trap; but the beds, the lecturer stated, are distinctly stratified. Crystalline limestones are either indigenous, that is, are formed in situ, or they are endogenous, *i.e.*, have been formed by crystallization in veins. A rounded crystal of apatite, from a cavity, was exhibited.

It was stated that springs containing mineral matter in solution sometimes are affected by great chemical changes, and that, perhaps, in this way the same waters which produce crystals, under altered chemical conditions, have, in some cases, the power of wholly or partly re-dissolving them, and rounding their angles. Crystals of apatite and quartz, supposed to have been thus rounded, were exhibited. The crystals of felspar were said to be indissoluble, and as further examples, crystals of spinel, oriental ruby, brown tourmaline and of pyroxene, from the crystalline limestones were shown, presenting sharp and unrounded angles.

In the indigenous rocks, also, that is in the main body of the limestones, many of the foreign crystals are rounded, but not as in the vein stones.

Attention was then called to the discovery of organic life in these ancient rocks, and a description was given of the *Eozoön*. It was shown that the chambers of the shell of this species became filled with serpentine or pyroxene, the crystals of which have thus acquired a rounded form. It was stated, also, that Dr. Gümbel, who has studied closely the Laurentian rocks of Bavaria, had determined that many other rounded crystals of foreign origin in crystalline limestones are due to organic agency.

Principal Dawson moved a vote of thanks to the lecturer, and in doing so took occasion to defend the genuineness of the discovery of organic life in Laurentian rocks, and stated the doubts entertained by some Irish naturalists, as to the organic nature of Eozoön, were entirely due to a misconception on their part, and that what they had taken for Eozoön was mineral matter.

CORRESPONDENCE.

To the Editor of the GEOLOGICAL MAGAZINE.

SIR,—In the February number of your Magazine, Mr. D. Forbes, in an article entitled "On the alleged hydrothermal origin of certain granites and metamorphic rocks," has made two recently published papers of mine the subject of some remarks. "The appearance of

these memoirs," he says, "apparently representing in some measure the views entertained by the Geological Survey of Great Britain, decided the writer in at once protesting, etc." It is as well to assure Mr. D. Forbes and your readers that the Geological Survey is no way to be identified with opinions expressed in "extra-official" communications; for these the writers themselves are alone responsible.

If I do not misunderstand Mr. D. Forbes, his opinion seems to be that a profound knowledge of chemistry and mineralogy is necessary to the geologist who would attempt the investigation of metamorphic phenomena; that, in short, if he be neither a practised chemist nor mineralogist, his purely geological observations go for little or nothing. Every one, indeed, is aware that the subject of metamorphism has for many years occupied the attention of able chemists and mineralogists; and it is never denied that without their aid the geologist cannot hope to do much towards clearing away the many difficulties by which the subject is surrounded. It is not doubted that the question of metamorphism is one which can only be settled by the zealous co-operation of the various sciences involved. But if it be true that these sciences are all equally concerned in this matter, then it follows that there must be different kinds of evidence, viz., chemical, mineralogical, and geological evidence; and three classes of investigators,—chemists, mineralogists, and geologists. It is quite possible, indeed, that an individual observer may combine in himself a fair knowledge of the three sciences, but highly improbable that he shall be equally good as a chemist, mineralogist, and geologist. One of the three studies is sure to exert a preponderating influence upon his mind, so as in some measure to prevent absolute impartiality in his investigations. According as his bent is chemical, mineralogical, or geological, he will prefer a particular line of evidence. It is vain to hope for an "admirable Crichton," who shall be at once a profound chemist, mineralogist, and geologist, with a mind so equally balanced that he shall be able to accord to each kind of evidence its proper place and value. All that we can expect is, that each labourer, be he chemist or geologist, shall honestly state his convictions as deduced from data, for the study of which he has had a special training. Cases of metamorphism, which the unassisted geologist never could have discovered for himself, have been detected by chemists and mineralogists. On the other hand, it is no less true that the metamorphic origin of certain rocks is capable of being proved by evidence purely geological. Nor can it be denied that there are instances where both the work of the laboratory and the labours of the field observer are equally necessary before the metamorphic origin of some rocks can be decided upon. If eminent chemists and mineralogists, who are sometimes "not much at home" in geology, have, nevertheless, contributed largely to our knowledge of metamorphic phenomena, it can scarcely be presumption if a geologist believes that he, too, although confessedly not versed in chemistry, may yet be able to see something of the subject, by viewing it from his own peculiar

stand-point. The geological evidence in favour of metamorphism is quite as deserving of study by the geologist, as the chemical evidence is by the chemist. Mr. D. Forbes admits, indeed, that the geologist has something to say in the matter; but subsequently observes, in reference to certain geological evidence bearing upon the origin of some granites, that chemical analyses "may not improbably entirely annihilate" it. If geological proofs and evidence are thus liable to be "entirely annihilated," it is difficult to see why, in such investigations, chemists and mineralogists should be bored with the company of their hammer-bearing brethren.[1]

I have looked over my paper on the Carrick metamorphic rocks, and must own that I have been careless and unguarded in the use of chemical phraseology. Thus I admit that I have frequently spoken of magnesia, of lime, and of alkaline matter, when I ought to have stated that what I referred to was the magnesia of highly magnesian minerals, and the lime of the carbonate of lime. I was quite aware that the green tinge so characteristic of many of the rocks within the area described was not due to the presence of the oxide of magnesium, but to that of certain minerals which contain a large percentage of magnesia. Notwithstanding Mr. D. Forbes' opinion, that "from the style of this memoir (but for its errors), it might have been written by a chemist," I believe an impartial reader will acknowledge that my arguments are based chiefly on geological data, which in their very nature cannot be "annihilated" by future chemical analysis. My references to the chemistry of the subject are very meagre, as I had to content myself with the usual tests employed by field-geologists, and certainly never dreamed that any one should think that I based "my entire conclusions on chemistry."

Mr. D. Forbes imputes to me the opinion that "granite, diorite, serpentine, porphyrite," etc., may be derived from one and the same bed of greywacké. There is nothing in the memoirs to warrant this; but I have distinctly stated my belief, and have brought forward evidence in support of it, that present differences of composition among metamorphic rocks point to original differences in the composition of the strata. Certainly I am not alone in this belief, nor can I agree with my critic that it is "a waste of time, thought, and energy," to place such a view "before a rational public."[2] The greywackés familiar to Scottish geologists do not "consist essentially of seventy-five per cent. of quartz," nor have they any definite composition whatever. The term "greywacké," as used by Scottish geologists, is applied exclusively to the hardened felspathic, and sometimes argillaceous sandstones of the Silurian regions, in which, although quartz is freqently present, it is yet by no means a necessarily preponderating ingredient. They vary in texture from fine-grained, almost compact, rocks, to pebbly conglomerates.

[1] Some interesting remarks on the value of chemical analyses of rocks will be found in Cotta's "Rocks classified and described" (1866) p. 79.

[2] Similar opinions, based upon long-continued study of the chemistry of the subject, have been placed "before a rational public," by, among others, Delesse, and Sterry Hunt.

It seems that "the petrologist may throw up his hands in despair when he finds Mr. James Geikie describing minette as a quartzless granite." As the pages of this Magazine are probably sometimes scanned by readers who may not be quite familiar with the term *minette*, but to whom the composition of granite must be well known, I could think of no shorter or more apt description of minette than that given, and cannot see how it is likely to mislead anyone. No one would dream of labelling a museum specimen of minette as quartzless granite, nor of ranging it under the granites in a system of classification.

My critic further finds fault with my use of the term *dioritic*, and then proceeds to teach how the petrologist defines diorite and greenstone. In my remark that "under the term *dioritic* are included all those rocks which consist essentially of silicates of lime and magnesia set in a felspathic base or matrix," I referred only to the rocks alluded to in my paper as characteristic of the district described, viz., the diorites, hyperites, etc.; nor can I imagine how I should have been understood to mean more. The closely allied nature of hornblende, hypersthene, and diallage seemed to warrant me in using *dioritic* as a convenient general term for the rocks in which those minerals make their appearance.[1]

From the tone of Mr. Forbes' remarks one might gather that the terminology of petrology was as fixed as that of the exact sciences. Scarcely two petrologists, however, can be found to agree in their definitions of many rocks. "The petrologist," we are told, "regards greenstone as that variety of diorite in which green or dark coloured hornblende either predominates, or, when the rock is fine-grained, renders more obscure the presence of the felspar." Now the term *greenstone* has long been employed by writers on Scottish geology as a generic and not a specific term. Hence we read of *hornblendic* as distinguished from *augitic greenstones*.[2] As it is sometimes impossible to tell in the field whether a rock is to be classed as a diorite or dolerite, the use of *greenstone* as a generic term has proved of some utility.[3]

It appears to be "difficult for a petrologist to understand what a

[1] Cotta includes hyperite, diorite, diallage-rock, and some other allied rocks in his Greenstone group.

[2] The term *augitic greenstone* is not, however, confined to the pages of writers on Scottish geology; Cotta has the same expression. [See "Rocks classified and described," p. 146.] He describes the "greenstones" as "compounds of some species of felspar with pyroxene, or hornblende, as essential ingredients, etc.:" among the species of greenstone *augite-porphyry* is mentioned. In Professor Phillips's "Manual" we find mention made of *augitic greenstone* (augite and felspar) as distinguished from *greenstone* (hornblende and felspar); and Sir C. Lyell, while he defines greenstone to be a compound of felspar and hornblende, yet takes care to state that "the name has usually been extended to all granular mixtures, whether of hornblende and felspar, or of augite and felspar." (Elements of Geol., p. 594).

[3] J'emploie le terme de grünstein pour les roches trappéenes cristallisées verdâtres, que je n'ai pas examinées, et qui ont été décrites sous ce nom, et pour celles que j'ai bien observées en place, mais dont je n'ai conservé aucun échantillon pour pouvoir constater à présent si ce sont des dolérites ou des diabases." Boué, *Essai Géologique sur l'Écosse*, 1820, p. 135.

granitoid diorite may be, especially since he is immediately informed that 'it is simply an admixture of hornblende with white and pink felspar.'" For the meaning of granitoid, reference may be made to the glossaries of geological terms. In Mr. Page's handbook it is said to be applied to "such rocks as have the granular-crystalline aspect of granite * * without being so in reality." The expression *granitoid hornblendic greenstone*, however ridiculous it might appear to "the petrologist," ought to be intelligible to anyone acquainted with the literature of geology.

Mr. Forbes observes that "trap is an extremely vague name to designate rocks by." I have never designated any particular rock by the name of trap, but have used the term in a general way as applied to that great series of igneous rocks which includes many dolerites, melaphyres, basalts, diorites, etc.

Again, my critic remarks that I have laid "great stress upon the circumstance that, as instead of being flattened and drawn out, the vesicles found occurring in the rocks are spherical, and are so over considerable areas, the rocks therefore cannot be trappean or igneous." This is an overstatement of what is said. I merely observe that "these appearances, along with other considerations, threw doubt upon the igneous character of the rocks under review." Had this been all the evidence to be gathered it is not likely that I should have regarded it in any other light than as a somewhat anomalous fact, as I had never seen nor heard of so wide an area of amygdaloid destitute of flattened cavities.[1]

It is absurd to say that the development from aqueous strata of certain crystalline rocks (as granite, syenite, hyperite, diallage-rock, and diorite) is a notion supported only by my own assertion. Even those geologists who hold most strenuously by the igneous and eruptive character of all granite must admit with Cotta that the proofs of such an origin are sometimes wanting, and that "there are many circumstances that point to a contrary assumption in certain districts."[2] Bischoff has brought forward a vast accummulation of chemical data to show that many of the rocks held by geologists to be of igneous origin may, nevertheless, be due to processes of metamorphism.[3] Prof. Keilhau,

[1] No one has of late years done more towards the explanation of metamorphic phenomena than the well-known chemist and mineralogist attached to the Geological Survey of Canada. Dr. Sterry Hunt is of opinion "that heated alkaline waters have produced the alteration of sediments," and "that, except in local and comparatively rare cases, the process has only taken place in sediments so deeply buried as to be directly affected by the internal heat of the earth." Whether we agree with him or not in his conclusions as to the causes of metamorphism, those among us who may still cling to the notion that all crystalline rocks which cannot be classed among the gneisses and schists must be of igneous origin, will do well to study the details furnished in the "Reports" of the Canadian Survey. We there find rocks described as metamorphic which at one time would certainly have been coloured upon a geological map as igneous; for they frequently present appearances (as, for instance, *an amygdaloidal structure*) which are commonly believed to be characteristic of igneous rocks only. See Geology of Canada (1863), pp. 603, 607.

[2] Rocks Classified and Described, p. 388.

[3] It is instructive to find this eminent chemist thus endeavouring to "prove" the formation in the wet way of certain crystalline rocks which geologists on the other hand are frequently (not always) well assured must be of igneous and eruptive origin.

so long ago as 1836, described[1] the crystalline rocks of the neighbourhood of Christiania; and after detailing the various appearances presented by the granite, syenite, porphyry without quartz, amygdaloid and basaltic rocks, eurite-porphyry, greenstones (diorites and aphanites), and rhombic porphyry, came to the conclusion that all these rocks were the result of metamorphic action. The metamorphic rocks of Canada, which have been so ably investigated by Sir W. Logan and his associates, abound in serpentines, diorites, hyperites, euphotides, and granites, which, as Dr. Sterry Hunt observes, "have by most geologists been regarded as rocks of igneous origin, whereas they appear to be for the greater part undoubtedly altered sedimentary layers or masses."[2] Professor Ramsay has likewise adduced[3] striking evidence of the metamorphic origin of the Cambrian quartz-porphyry of Llanllyfni, and the granite of Anglesey. Similar references might be multiplied, but I will only cite one more. Dr. Dana classes[4] under the metamorphic rocks granite, syenite, hyperite, diallage-rock, diorite, pyroxenite, etc., etc. His definition of metamorphic rocks is—"they are made from the sedimentary rocks by some crystallizing process." He adds "they are sometimes called *plutonic*, to distinguish them from the true igneous rocks." It is strange that Mr. D. Forbes, during his "careful examination of the literature of the subject," should have overlooked the expressed opinions of so noted a mineralogist and geologist as Professor Dana.

Mr. Forbes objects strongly[5] to my remark that "we must beware of assuming an igneous character merely from the appearance of veins ramifying from crystalline into granular non-igneous beds. This may in general be an excellent test of eruptive origin, but it certainly cannot always prove that the main mass, from which the veins appear to have come, has been forcibly thrust into its present position." If we are to take the sending-out of veins as an invariable test of igneous action, then we must believe that serpentine is an intrusive rock, all other evidence to the contrary notwithstanding.

[1] See his memoir in the first number of the "Nyt Magazin for Naturvidenskaberne," a translation of which (with notes by Professor Jameson) will be found in the "Edinburgh Philosophical Magazine," Vol. xxiv., p. 387.

[2] Geology of Canada, p. 586. The Canadian geologists also describe certain granites which they consider to be eruptive, designating them as *intrusive granites*, in contradistinction to those having a metamorphic origin, which are termed *indigenous granites*.

[3] Geology of North, Wales Mem. of Geol. Survey, vol. iii., pp. 140 et seq; 190 et seq. After describing certain phenomena exhibited in the neighbourhood of the quartz-porphyry, Professor Ramsay remarks that he can only account for these appearances by the supposition that the beds associated with the quartz-porphyry have, as it were, been partly *eaten into* by heat, and themselves converted into porphyry. He comes to similar conclusions in regard to the granite of Anglesey.

[4] Manual of Geology, p. 74, et seq.

[5] My critic represents me as refusing any longer to accept the definition of eruptive or intrusive rocks which geologists have been accustomed to give, viz., that they "are such rocks as are met with apparently breaking through, protruding into, or sending out ramifications, dykes, or veins, into the adjacent stratified deposits." Now all that can be inferred from what I have said is, that some of these appearances are simulated by metamorphic rocks, and in this I believe "most geologists will concur with" me.

Some gneiss will be equally well proved to be of igneous origin;[1] nay, even masses of crystalline limestone must frequently be classed as igneous rock.

It is needless, however, that I should follow Mr. Forbes into all the minute criticism which he has thought proper to bestow upon my papers. He remarks that "the crystallographer will be rather puzzled" with my somewhat careless expression, *porphyritic felspar crystals;* if so, it will not argue much for the crystallographer's penetration.

The writer concludes his remarks by disclaiming "any feeling of personality against a gentleman whom he has never even seen." Surely in a discussion of this kind, such a disclaimer ought to be quite unnecessary. Personalities are here utterly out of place, and I would, with deference, submit that personal details are equally so. Is it not beside the question altogether, that a gentleman so well known as Mr. Forbes should tell his readers that he "does not speak upon the strength of an acquaintance with this subject of a few months or years, but for more than twenty years has continuously occupied himself in a special and minute study of the crystalline and metamorphic rocks;" that he should assure us that he has examined these rocks "in the field over a great part of Europe, North and South America, Polynesia, part of Africa, etc., with all requisite appliances at his command, and without having neglected the study of chemistry and mineralogy;" that besides pressing upon us the fact of his being a qualified chemist, mineralogist, and petrologist, he should be at the trouble to point out that he knows how to handle the microscope, and that he has gathered together "above 900 sections of crystalline and metamorphic rocks from about 480 localities, in different parts of the world;" that, in addition to all this, we should be informed that he is well acquainted with "the English, French, German, Spanish, Italian, Swedish, and Danish languages?" Surely the many memoirs and articles contributed by Mr. D. Forbes to British and foreign scientific publications ought to testify enough to his rare opportunities for observation, and be sufficient guarantee of his accomplishments.

I am, Sir, faithfully yours,

JAS. GEIKIE.

EDINBURGH, *February 26th*, 1867.

FAULTS IN DRIFT.

To the Editor of the GEOLOGICAL MAGAZINE.

DEAR SIR,—As the subject of faults in the Drift has been before your readers for some time past, I venture to send you a sketch, taken a few months since at Rochdale, in Lancashire, during the progress of excavations for the new Town Hall. Though personally inclined to be incredulous regarding the occurrence of faults in these deposits, knowing how subject they are to sundry irregularities of

[1] I am well aware that some geologists are fully persuaded of the igneous and eruptive character of certain gneissic rocks.