

*Hofsjökull*, *Baldjökull*. *Þestareykir*. *Fremri-Námar*, *Hverfjall*, *Sandfellsjökull*, *Herðubreið*, *Skaptárjökull*, *Sólheimajökull*, *Breiðamerkjökull*, *Þórsmörk*. *Torfajökull*, *Mosfell*, *Helgafell*.

The following eruptions are referred to wrong dates: *Hekla*, 1004, 1029, 1113, 1374, 1583, 1625, 1772; *Katla*, 1717, 1727; *Trölladyngjur*, 1475; *Herðubreið*, 1341, 1510; *Selajökull*, 1728; *Orafajökull*, 1720; an eruption in *Breiðfjörðr*, by *Snæfellsnes*, 1219, and 1345; *Hverfjall*, 1748–1752; *Þingvallhraun*, 1587; *Þórsmörk*, 1300–1350.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, FIFTIETH MEETING, SWANSEA, AUGUST 26TH, 1880.

TITLES OF PAPERS READ IN SECTION C. (GEOLOGY).

Opening Address by H. C. SORBY, LL.D., F.R.S., President.—“On the Comparative Structure of Artificial Slags and Eruptive Rocks.” (See p. 468.)

*C. E. De Rance, F.G.S.*—Report on the Circulation of the Underground Waters in the Permian, New Red Sandstone, and Jurassic Formations of England; and on the quality and character of the water supplied to towns and districts from those formations.

*A. R. Hunt, F.G.S.*—Notes on the Submarine Geology of the English Channel off the Coast of South Devon.

*Prof. W. Boyd-Dawkins, M.A., F.R.S.*—On the Action of Carbonic Acid on Limestone.

*F. C. J. Spurrell, F.G.S.*—On the Site of a Palæolithic Implement Manufactory, at Crayford, Kent.

*Prof. J. P. O'Reilly.*—On the Relations to be Established between Coast-line-Directions represented by Great Circles on the Globe, and the localities marked by Earthquakes in Europe.

*G. H. Kinahan, M.R.I.A., Pres. Geol. Soc. Ireland.*—On the Hiatus said to have been found in the rocks of West Cork.

*W. H. Dalton, F.G.S.*—Note on the Range of the Lower Tertiaries of East Suffolk.

*W. Pengelly, F.R.S., F.G.S.*—Sixteenth Report of the Committee appointed to explore Kent's Cavern, Devonshire.

*Prof. A. Leith Adams, F.R.S.*—Report on the Exploration of Caves in the South of Ireland.

*Prof. H. G. Seeley, F.R.S.*—Report on the Viviparous Nature of the *Ichthyosauria*.

*G. R. Vine.*—Report on the Carboniferous Polyzoa.

*W. Whitaker, B.A. Lond., F.G.S.*—Report on the “Geological Record.”

*Prof. W. J. Sollas, M.A., F.G.S.*—On the Island of Torghatten, Norway; and on the Influence of Joints on Denudation.

*Prof. W. J. Sollas, M.A., F.G.S.*—On the Contortion of a Quartz-vein in Mica-schist from Bodö, Norway.

- W. T. Blanford, F.R.S., F.G.S.*—On the Geological Age and Relations of the Sewalik and Pikermi Vertebrate and Invertebrate Faunas.
- E. Wethered, F.G.S.*—On the Sandstones and Grits of the Lower and Middle Series of the British Coal-field.
- Dr. H. Hicks, F.G.S.*—On some Pre-Cambrian Rocks in the Harlech Mountains.
- Prof. J. Prestwich, M.A., F.R.S.*—On a Raised Beach with Diluvial Drift in Rhos Sili Bay, Gower.
- Prof. J. Prestwich, M.A., F.G.S.*—On the Geological Evidence of the Submergence of the South-west of Europe during the early Human Period.
- Charles Moore, F.G.S.*—Proofs of the Organic Nature of *Eozoon Canadense*.
- J. H. Collins, F.G.S.*—On the Fault-systems of Central and West Cornwall.
- Dr. G. M. Dawson, F.G.S.*—Sketch of the Geology of British Columbia.
- Dr. J. S. Phené, F.G.S.*—On the Geology of the Balearic Islands.
- Prof. W. J. Sollas, M.A., F.G.S.*—On the Action of a Lichen on Limestone.
- Prof. W. J. Sollas, M.A., F.G.S.*—On a Striated Stone from the Trias, of Portishead.
- Prof. W. J. Sollas, M.A., F.G.S.*—On Sponge Spicules from the Chalk of Trimmingham, Norfolk.
- W. H. Baily, F.G.S.*—Report on the Tertiary Flora of the Basalts of the North of Ireland.
- Rev. H. W. Crosskey, F.G.S.*—Report on the Erratic Blocks of England and Wales.
- W. Whitaker, B.A. Lond., F.G.S.*—On the Geological Literature of Wales.
- Lieut.-Col. Godwin-Austen, F.R.S.*—On the Post-Tertiary and Glacial Deposits of Kashmir.
- R. Bruce-Foote, F.G.S.*—Notes on the Occurrence of Stone Implements in the Coast Laterite, South of Madras, and in High Level Gravel and other formations in the South Mahratta Country.
- C. E. De Ranee, F.G.S.*—On the Pre-Glacial Contours and Post-Glacial Denudation of the North-west of England.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SWANSEA, AUGUST 26, 1880. Address to the Geological Section by Henry Clifton Sorby, LL.D., F.R.S., F.G.S., President of the Section.

IN selecting a subject for an address to be given in accordance with the custom of my predecessors, I was anxious that it should be, in some way or other, connected with the locality in which we have met. If I had been adequately acquainted with the district, I should have thought it incumbent on me to give such an outline of the general geology of the surrounding country as would have been useful to those attending this meeting. I am, however, practically a stranger to South Wales, and must therefore leave that task to others. On reflecting on the various subjects to which I might have called your attention, it appeared to me that I could select one which would be eminently appropriate in a town and district where iron and copper are smelted on so large a scale, and, as I think, also equally appropriate from a geological point of view. This subject is the comparative structure of artificial slags

and erupted rocks. In making this choice I was also influenced by the fact that in my two anniversary addresses as President of the Geological Society I have recently treated on the structure and origin of modern and ancient stratified rocks, and I felt that, if in the present address I were to treat on certain peculiarities in the structure of igneous rocks, I should have described the leading conclusions to which I have been led by studying the microscopical structure of nearly all classes of rocks. It would, however, be impossible in the time now at disposal to treat on all the various branches of the subject. Much might be said on both the purely chemical and purely mineralogical aspects of the question; but though these must not be ignored, I propose to draw your attention mainly to another special and remarkable class of facts, which, so far as I am aware, have attracted little or no attention, and yet, as I think, would be very instructive if we could fully understand their meaning. Here, however, as in so many cases, the observed facts are clear enough, but their full significance somewhat obscure, owing to the want of adequate experimental data or sufficient knowledge of general physical laws.

A considerable amount of attention has already been paid to the mineral constitution of slags, and to such peculiarities of structure as can be learned independently of thin microscopical sections. A very complete and instructive work, specially devoted to the subject, was published by Von Leonhard about twenty-two years ago, just at the time when the microscope was first efficiently applied to the study of rocks. Since then Vogelsang and others have described the microscopical structure of some slags in connexion with their studies of obsidian and other allied volcanic rocks. At the date of the publication of Von Leonhard's work the questions in discussion differed materially from those which should now claim attention. There was still more or less dispute respecting the nature and origin of certain rocks which have now been proved to be truly volcanic by most unequivocal evidence; and I am not at all surprised at this, since, as I shall show, there is such a very great difference in their characteristic structure and that of the artificial products of igneous fusion, that, but for the small portions of glass inclosed in the constituent crystals, described by me many years ago under the name of 'glass-cavities,' there would often be no positive proof of their igneous origin. There was also considerable doubt as to the manner in which certain minerals in volcanic rocks had been generated. The observed facts were sufficient to prove conclusively that some had been formed by sublimation, others by igneous fusion, and others deposited from more or less highly heated water; but it was difficult or impossible to decide whether in particular cases certain minerals had been formed exclusively by one or other process, or sometimes by one and sometimes by the other, or by the combined action of water and a very high temperature. I must confess that, even now that so much may be learned by studying with high magnifying powers the internal structure of crystals, I should hesitate very much in deciding what were the exact conditions under which certain minerals have been formed. This hesitation is probably as much due to inadequate examination and to the want of a complete study of typical specimens, both in the field and by means of the microscope, as to the unavoidable difficulties of the subject. Such doubt, however, applies more to the origin of minerals occurring in cavities than to those constituting a part of true rock-masses, to which latter I shall almost exclusively refer on the present occasion. In the formation of these it appears to me that sublimation has occurred to a very limited extent. In many cases true igneous fusion has played such a leading part that the rocks may be fairly called *igneous*, but in other cases, water, in some form or other, has, I think, had so much influence that we should hesitate to call them *igneous*, and the term *erupted* would be open to far less objection, since it would adequately express the manner of their occurrence, and not commit us to anything open to serious doubt.

In studying erupted rocks of different characters, we see that at one extreme they are as truly igneous as any furnace-product, and, at the other extreme, hardly, if at all, distinguishable from certain deposits met with in mineral veins, which furnish abundant evidence of the preponderating, if not exclusive, influence of water, and have very little or nothing in common with products certainly known to have been formed by the action of heat, and of heat alone. Between these extremes there is every connecting link, and in certain cases it is almost, if not quite impossible to say whether the characteristic structure is due more to the action of heat than of water. The great question is, whether the presence of a small quantity of water in the liquid or gaseous state is the true cause of very well-marked differences in structure;

or whether greater pressure, and the necessarily slower rate of cooling, were not the more active causes, and the presence of water in one state or another was merely the result of the same cause. This is a question which ought to be solved by experiment; but I fear it would be almost impossible to perform the necessary operations in a satisfactory manner.

What I now propose to do is to describe a particular class of facts which have lately attracted my attention, and to show that the crystalline minerals in products known to have been formed by the action of heat alone, have a certain very well-marked and characteristic structure, which is gradually modified as we pass through modern and more ancient volcanic to plutonic rocks, in such a manner as to show at once that they are intimately related, and yet differ in such characteristic particulars that I think other agencies than mere heat must have had great influence in producing the final result.

In dealing with this subject, I propose, in the first place, to describe the characteristic structure of products formed artificially under perfectly well-known conditions, and then to pass gradually to that of rocks whose origin must be inferred, and cannot be said to have been completely proved.

*Crystalline Blowpipe Beads.*—Some years ago I devoted a considerable amount of time to the preparation and study of crystalline blowpipe beads, my aim being to discover simple and satisfactory means for identifying small quantities of different earths and metallic oxides, when mixed with others; and I never supposed that such small objects would throw any light on the structure and origin of vast masses of natural rock. The manner in which I prepared them was as follows: A small bead of borax was so saturated with the substance under examination at a high temperature, that it became opaque either on cooling or when slowly re-heated. It was again fused so as to be quite transparent, and then very slowly cooled over the flame. If properly managed, the excess of material held in solution at a high temperature slowly crystallised out, the form and character of the crystals depending on the nature of the substance and on the presence of other substances added to the bead as test reagents. By this means I proved that in a few exceptional cases small simple solid crystals are formed. More frequently they are compound, or occur as minute needles, but the most characteristic peculiarity is the development of complex skeleton crystals of extreme beauty, built up of minute attached prisms, so as to give rise to what would be a well-developed crystal with definite external planes, if the interspaces were all filled up. In many cases the fibres of these skeletons are parallel to three different axes perpendicular to one another, and it might be supposed that the entire skeleton was due to the growth of small needle-shaped crystals all uniformly elongated in the line of one crystalline axis, so that the resulting mass would be optically and crystallographically complex; but in some cases the different systems of fibres or needles are inclined obliquely, and then the optical characters enable us to prove that the separate prisms are not similar to one another, but developed along different crystalline planes, so as to build up one definite crystal, mechanically complex, but optically and crystallographically simple, or merely twinned. In a few special cases there is a well-pronounced departure from this rule, and truly compound groups of prisms are formed. In the centre, that is a definite simple prism; but instead of this growing continuously in the same manner, so as to produce a larger prism, its ends, as it were, break up into several smaller prisms, slightly inclined to the axis of the first; and these secondary prisms, in like manner, break up into still smaller, so as ultimately to give rise to a curious complex brush-like growth, showing in all positions a sort of fan-shaped structure, mechanically, optically, and crystallographically complex.

I have done my best to describe these various kinds of crystals seen in blowpipe beads as clearly as can be done without occupying too much time, but feel that it is impossible to make the subject as simple as it really is without numerous illustrations. However, for the purpose now in view, it will, I trust, suffice to have established the fact that we may divide the crystals in blowpipe beads into the following groups, which on the whole are sufficiently distinct, though they necessarily pass one into the other.

1. Simple crystals
2. Minute detached needles.
3. Fan-shaped compound groups.
4. Feathery skeleton crystals.

It must not be supposed that crystals of one or other of these groups occur pro-

miscuously and without some definite relation to the special conditions of the case. Very much depends upon their chemical composition. Some substances yield almost exclusively those of one group, and other substances those of another, whilst in some cases a difference in the rate of cooling and other circumstances give rise to variations within certain limits; and, if it were possible to still further vary some of the conditions, these limits would probably be increased. Thus, for example, the earliest deposition of crystalline matter from the glassy solvent is sometimes in the form of simple solid prisms or needles, but later on in the process it is in the form of compound feathery tufts; and if it were possible to cool the beads much more slowly whilst they are very hot, I am inclined to believe that some substances might be found that in the early stage of the process would yield larger and more solid crystals than those commonly met with. This supposition, at all events, agrees with what takes place when such salts as potassium chloride are crystallised from solution in water. Some of my blowpipe beads prove most conclusively that several perfectly distinct crystalline substances may be contemporaneously deposited from a highly heated vitreous solvent, which is an important fact in connection with the structure of igneous rocks, since some authors have asserted that more than one mineral species cannot be formed by the slow cooling of a truly melted rock. The great advantage of studying artificial blowpipe beads is that we can so easily obtain a variety of results under conditions which are perfectly well known, and more or less completely under control.

*Artificial Slags.*—I now proceed to consider the structure of slags, and feel tempted to enter into the consideration of the various minerals found in them which are more or less perfectly identical with those characteristic of erupted rocks; but some of the most interesting, like the felspars, occur in a well-marked form only in special cases where iron ores are smelted with fluxes, seldom, if ever, employed in our own country, so that my acquaintance with them is extremely small. My attention has been mainly directed to the more common products of our blast-furnaces. On examining these, after having become perfectly familiar with the structure of blowpipe beads, I could see at once that they are very analogous, if not identical in their structure. In both we have a glassy solvent, from which crystals have been deposited; only in one case this solvent was red hot, melted borax, and in the other glassy, melted stone. Thus, for example, some compounds, like what I believe is Humboldtite, crystallise out in well-marked solid crystals, like those seen occasionally in blowpipe beads, whereas others crystallise out in complex feathery skeletons, just like those so common in and characteristic of the beads. In both we also often see small detached needles, scattered about in the glassy base. These skeleton crystals and minute needles have been described by various writers, under the names, *crystallites*, *belonites*, and *trichites*. Though we have not the great variety of different forms met with in the beads, and cannot so readily vary the conditions under which they are produced, yet we can, at all events, see clearly that their structural character depends both on their chemical constitution and on the physical conditions under which they have crystallised. None of my microscopical preparations of English slags appear to contain any species of felspar, but several contain what I believe is some variety of augite, both in the form of more or less solid prisms, and of feathery skeletons of great beauty and of much interest in connection with the next class of products to which I shall call your attention, viz., rocks artificially melted and slowly cooled.

*Rocks Artificially Melted.*—I have had the opportunity of preparing excellent thin microscopical sections of some of the results of the classic experiments of Sir James Hall. I have also carefully studied the product obtained by fusing and slowly cooling much larger masses of the basalt of Rowley, and have compared its structure with that of the original rock. Both are entirely crystalline, and, as far as I can ascertain, both are mainly composed of the same minerals. Those to which I would especially call attention are a triclinic felspar and an augite. The general character of the crystals is, however, strikingly different. In the artificial product a considerable part of the augite occurs as flat, feathery plates, like those in furnace slags, which are quite absent from the natural rock, and only part occurs as simple solid crystals, analogous to those in the rock, but much smaller and less developed. The felspar is chiefly in the form of elongated, flat, twinned prisms, which, like the prisms in some blowpipe beads, commence in a more simple form, and end in complex fan-shaped brushes, whereas in the natural rock they are larger than in the artificial, and exclusively of simple character. On the whole, then, though the artificially

melted and slowly cooled basalt is entirely crystalline, and has a mineral composition closely like that of the natural rock, its mechanical structure is very different, being identical with that of blowpipe beads and slags.

*Volcanic Rocks.*—Passing now to true natural igneous rocks, we find some, like obsidian, which closely correspond with blowpipe beads, slags, and artificially melted rocks, in having a glassy base, through which small crystalline needles are scattered; but the more completely crystalline volcanic rocks have, on the whole, a structure very characteristically unlike that of the artificial products. I have most carefully examined all my sections of modern and ancient volcanic rocks, but cannot find any in which the augite or magnetite is crystallized in feathery skeletons. In the case of only one single natural rock, from a dyke near Beaumaris, have I found the triclinic feldspar arranged in just the same fan-shaped, brush-like groups as those in similar rocks artificially melted and slowly cooled. The large solid crystals in specimens from other localities sometimes show that towards the end of their growth small flat prisms were developed on their surface, analogous to those first deposited in the case of the artificial product. In slags composed almost exclusively of what I believe is Humboldtite, the crystals are indeed uniformly as simple and solid as those in natural rocks, but the examination of different blowpipe beads shows that no fair comparison can be made between altogether different substances. We must compare together the minerals common to the natural and the artificial products, and we then see that, on the whole, the two classes are only just distinctly connected by certain exceptional crystals and by structural characters which, as it were, overlap enough to show that there is a passage from one type to the other. In the artificial products are a few small, solid crystals of both augite and a triclinic feldspar, which closely correspond to the exceptionally small crystals in the natural rocks; but the development of the great mass of the crystals is in a different direction in the two cases. In the artificial products it is in the direction of complex skeletons, which are not seen in the natural rock; but in the natural rock it is in the direction of large simple solid crystals, which are not met with in the artificial products. There is a far closer analogy in the case of partially vitreous rocks, which, independent of the true glassy base common to them and the artificial products, often contain analogous crystalline needles. Even then, however, we see that in the artificial product the crystals tend to develop into complex skeletons, but in the natural rocks into simple solid crystals.

It must not be supposed that these facts in any way lead me to think that thoroughly crystalline modern and ancient volcanic rocks were never truly fused. The simple, large, and characteristic crystals of such minerals as augite, feldspar, leucite, and olivine, often contain so many thoroughly well-marked glass enclosures, as to prove most conclusively that when the crystals were formed they were surrounded by, and deposited from, a melted glassy base, which was caught up by them whilst it was still melted. This included glass has often remained unchanged, even when the main mass became completely crystalline, or has been greatly altered by the subsequent action of water. I contend that these glass enclosures prove that many of our British erupted rocks were of as truly igneous origin as any lava flowing from a modern volcano. The difference between the structure of such natural rocks and that of artificial slags must not, in my opinion, be attributed to the absence of true igneous fusion, but to some difference in the surrounding conditions, which was sufficient to greatly modify the final result, when the fused mass became crystalline on cooling. The observed facts are clear enough, and several plausible explanations might easily be suggested, but I do not feel at all convinced that any single one would be correct. That which first suggests itself is a much slower cooling of the natural rocks than is possible in the case of the artificial products; and I must confess that this explanation seems so plausible that I should not hesitate to adopt it, if certain facts could be accounted for in a satisfactory manner. Nothing could be more simple than to suppose that skeleton crystals are formed when deposition takes place in a hurried manner, and they so overgrow the supply that they develop themselves along certain lines of growth before there has been time to solidly build up what has been roughly sketched in outline. I cannot but think that this must be a true and, to some extent, active cause, even if it be inadequate to explain all the facts. What makes me hesitate to adopt it by itself is the structure of some doleritic rocks when in close contact with the strata amongst which they have been erupted. In all my specimens the effects of much more rapid cooling are perfectly well marked. The base of the

rock when in close contact is sometimes so extremely fine-grained that it is scarcely crystallised, and is certainly far less crystalline and finer-grained than the artificial products to which I have called attention, and yet there is no passage towards those structures which are most characteristic of slags, or at least, no such passage as I should have expected if these structures depended exclusively on more rapid cooling.

We might well ascribe something to the effect of mass, but one of my specimens of basalt melted and slowly cooled in a small crucible is quite as crystalline as another specimen taken from a far larger mass, though I must confess that what difference there is in this latter is in the direction of the structure characteristic of natural rocks. The presence or absence of water appears to me a very probable explanation of some differences. When there is evidence of its presence in a liquid state during the consolidation of the rock we can scarcely hesitate to conclude that it must have had some active influence; but in the case of true volcanic rocks the presence of liquid water is scarcely probable. That much water is present in some form or other, is clearly proved by the great amount of steam given off from erupted lavas. I can scarcely believe that it exists in a liquid state, except at great depths, but it may possibly be present in a combined form or as a dissolved vapour under much less pressure, and the question is whether this water may not have considerable influence on the growth of crystals formed prior to eruption, before it was given off as steam. I do not know one single fact which can be looked upon as fairly opposed to this supposition, and it is even to some extent supported by experiment. M. Daubrée informs me that the crystals of augite formed by him at a high temperature by the action of water have the solid character of those in volcanic rocks, and not the skeleton structure of those met with in slags. The conditions under which they were formed were, however, not sufficiently like those probably present during the formation of erupted lavas to justify our looking upon the explanation I have suggested as anything more than sufficiently plausible, in the absence of more complete experimental proofs.

*Granitic Rocks.*—I now proceed to consider rocks of another extreme type, which for distinction we may call the granitic. On the whole, they have little or nothing in common with slags, or with artificial products similar to slags, being composed exclusively of solid crystals, analogous in character only to slag-crystals of very different mineral nature. As an illustration, I would refer to the structure of the products formed by fusing and slowly cooling upwards of a ton of the syenite of Grooby, near Leicester. Different parts of the resulting mass differ very materially, but still there is an intimate relation between them, and a gradual passage from one to the other. The most characteristic feature of those parts which are completely crystalline is the presence of beautiful feathery skeleton-crystals of magnetite, and of long flat prisms of a triclinic felspar, ending in complex, fan-shaped brushes. There are no solid crystals of felspar, hornblende, and quartz, of which the natural rock is mainly composed, to the entire exclusion of any resembling those in the melted rock. As looked upon from the point of view taken in this address, the natural and artificial products have no structural character in common, so that I think we must look for other conditions than pure igneous fusion to explain the greatly modified results. We have not to look far for evidence of a well-marked difference in surrounding circumstances. The quartz in the natural rock contains vast numbers of fluid-cavities, thus proving that water was present, either in the liquid state or as a vapour so highly compressed that it afterwards condensed into an almost equal bulk of liquid. In some specimens of granite there is indeed clear proof that the water was present as a liquid, supersaturated with alkaline chlorides, like that inclosed in the cavities of some minerals met with in blocks ejected from Vesuvius, which also have to some extent what may be called a granitic structure. In the case of one very exceptional and interesting granite, there is apparently good proof that the felspar crystallised out at a temperature above the critical point of water—that is to say, at a temperature higher than that at which water can exist as a liquid under any pressure—and it caught up highly compressed steam, comparatively, if not entirely, free from soluble salts; whereas the quartz crystallised when the temperature was so far lowered as to be below the critical point, and the water had passed into a liquid, supersaturated with alkaline chlorides, which have crystallised out as small cubes in the fluid-cavities, just as in the case of minerals in some of the blocks ejected from Vesuvius.

Confining our attention, then, to extreme cases, we thus see that rocks of the

granitic type differ in a most characteristic manner from the products of artificial igneous fusion, both in the structure of the crystals and in containing liquid water, inclosed at the time of their formation. The question then arises, whether these differences were due to the presence of the liquid water, or whether its presence and the characteristic structure were not both the effects of the great pressure of superincumbent rocks. I do not see how this can be decided in a perfectly satisfactory manner, but must confess that I am inclined to believe that, whilst great pressure was necessarily the reason why the water did not escape as vapour, the presence of liquid water during final consolidation must have had a very considerable influence in modifying the structure of the rock, and had a great share in developing what we may call the granitic type.

It would be very instructive to follow out the gradual passage from one extreme type to another far more completely than is possible on the present occasion. The most interesting examples of rocks intermediate between the granitic and volcanic types that I have been able to examine in adequate detail, are the various Cornish elvans and other quartz felsites, which furnish all but a complete passage from pitchstone to granite. Some specimens prove that quartz may crystallize out from and inclose a perfectly glassy base, without a trace of liquid water; and at the same time other specimens prove equally well that, as we approach the granitic type, the quartz was not deposited from a glassy solvent, but inclosed more or less water. In the few intermediate cases there appears to be evidence of the conjoint presence of uncombined water and melted stony matter. On the whole, if we take into consideration only the external form of the larger crystals, rocks of the granitic type are very much as though the crystals met with in truly volcanic rocks had been strained out from the glassy or fine-grained base, and the intermediate spaces filled with quartz. The internal structure of the crystals is, however, very different, the cavities in one class containing glass, and in the other water. This most essential and characteristic difference proves that rocks of the true granitic type cannot have been formed simply by the more complete crystallization of the general base of the rock. If the crystals in granite were analogous to those developed in volcanic rocks, and the only essential difference were that the residue crystallized out more slowly and completely, so as to give rise to a more coarsely crystallized base, the crystals first formed ought not, as I think, to differ so essentially as that in one case they should inclose only glass, and in the other only water. Taking all into consideration, we can therefore scarcely suppose that the crystals in granitic rocks were deposited from a truly melted, dry, glassy solvent, like those in volcanic rocks or in slags.

*General Results.*—I have, I trust, now said enough to show that the objects here described may be conveniently separated into three well-marked groups, viz., artificial slags, volcanic rocks, and granitic rocks. My own specimens all show perfectly well-marked and characteristic structures, though they are connected in some cases by intermediate varieties. Possibly such connecting links might be more pronounced in other specimens that have not come under my notice. I must, however, base my conclusions on what I have been able to study in an adequate manner, by examining my own preparations, and leave it for others to correct any errors into which I may have been led from lack of more numerous specimens. In any case the facts seem abundantly sufficient to prove that there must be some active cause for such a common, if not general, difference in the structural character of these three different types. The supposition is so simple and attractive, that I feel very much tempted to suggest that this difference is due to the presence or absence of water as a gas or as a liquid. In the case of slags it is *not* present in *any* form. Considering how large an amount of steam is given off from erupted lavas, and that, as a rule, no fluid-cavities occur in the constituent minerals, it appears to me very plausible to suppose that those structures which are specially characteristic of volcanic rocks are in a great measure, if not entirely, due to the presence of *associated or dissolved vapour*. The fluid-cavities prove that water was sometimes, if not always, present as a *liquid* during the consolidation of granitic rocks; and we can scarcely hesitate to conclude that it must have had very considerable influence on the rock during consolidation. Still, though these three extreme types appear to be thus characterised by the absence of water, or by its presence in a state of vapour or liquid, I think we are scarcely in a position to say that this difference in the conditions is more than a plausible explanation of the differences in their structure. At the same time, I do not know any facts that are opposed to this conclusion, and we should, perhaps, not greatly err in thus correlating

