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1. *On CONCRETIONARY PATCHES and FRAGMENTS of OTHER ROCKS contained in GRANITE**. By J. ARTHUR PHILLIPS, Esq., F.G.S.
(Read November 19, 1879.)

[PLATE I.]

No one who is in the habit of visiting granite-quarries, or who has had frequent opportunities of examining granite, either in a dressed or in a polished state, can have failed to observe that it frequently contains patches which resemble imbedded fragments of older rock. These patches or nests are usually, although not always, darker in colour than the granites in which they occur, while their form may be either rounded or more or less angular. In the first case the patch resembles an enclosed pebble, while in the second it often presents the appearance of a fragment of slate or mica-schist. Such patches most frequently have their outlines clearly and sharply defined, but they occasionally merge by almost insensible gradations into the enclosing granite.

They are usually finer in grain than the granites in which they are found, and, from being less easily attacked by atmospheric agencies, not uncommonly stand out in considerable relief from the surfaces of weather-worn boulders. The union of the enclosed patch with the enclosing rock is generally complete, and their

* In this paper fine-grained granitic patches or nodules, although not exhibiting a concentric structure, are spoken of as concretionary. They are also sometimes mentioned as concretions.

cohesion is so perfect that it is seldom difficult to obtain hand specimens exhibiting the line of junction of the two.

Such bodies sometimes enclose crystals of felspar similar in all respects to those of the enclosing granite, excepting that in the majority of cases their angles are more distinctly rounded; patches of this kind occasionally contain others either of a lighter or of a darker colour than themselves. The inclusions in granitic rocks, although they have long attracted the attention of geologists, do not appear to have been often a subject of investigation; they have, however, been mentioned by various authors, who have accounted for their presence in different ways.

In his 'Geological Classification of Rocks' (p. 230), published in 1821, Dr. John Macculloch writes as follows:—

"The magnitude of the parts in granite is extremely various, each constituent mineral sometimes exceeding an inch in dimensions, and at others being almost invisibly minute. Various textures are also often united in a very limited space, or the rock passes imperceptibly from fine- to coarse-grained. Occasionally also irregular patches or veins, of a fine texture, are seen imbedded in a coarser variety. In one rare instance the parts affect a spheroidal arrangement."

Naumann (1858) observes :—"Pseudofragmentary Concretions. These appear like more or less sharp-angled fragments, but without being so. Such concretions occur not unfrequently in granite and syenite and in other rocks made up of crystalline silicates; they have sometimes been quite erroneously interpreted, having been really taken for what they seem to be" *.

The same author subsequently remarks :—"In this connexion we have yet another opinion to consider, to which attention has already been called (i. p. 919), the opinion, namely, that these fragments are not really to be regarded as such, but merely as fragment-like concretions. That concretions really sometimes occur which in their form possess a deceptive resemblance to angular or rounded fragments is certainly no more to be denied than that occasionally fragments acquire the appearance of concretions (i. pp. 422 and 560) by the fusion and rounding of the contours" †.

Hochstetter states that the island of Billiton is, like Banca, principally granite, and that the rocks closely resemble the stanniferous granites of the Carlsbad district, including a porphyritic granite like that of the neighbourhood of Marienbad, containing the same highly micaceous fine-grained dark enclosures of globular form ‡.

Under the heading of "Segregation of Granites," Jokély makes the following observations :—"Besides the lamellar, spherical, concentrically-coated, and more irregular segregations also make their appearance. The spherical is usually combined with the scaled, whilst the spheroidal or ellipsoidal forms which are met with in

* C. F. Naumann, *Lehrb. der Geognesie*, 2. Auf. vol. i. p. 422.

† *Ibid.* vol. ii. p. 203.

‡ F. Hochstetter, *Jahrb. k.-k. geol. Reichsanstalt*, 1858, p. 285.

many places are usually only the interior, harder nuclei of former larger blocks of concentric structure, which remain behind as such after their outer bark, as it were, has peeled off. Within such round blocks there is frequently an inner concretion, from $\frac{1}{2}$ to 2 feet and more in diameter, which consists essentially of aggregations of mica, and probably may in most cases have been the first inducement to the concentric scaled structure. Locally these concretionary enclosures are called 'souls.' This segregation occurs in most varieties of granite, but especially in the finer-grained ones" *.

A still more recent writer on the geology of Bohemia makes the following observations on the granites of that country:—"One of the most remarkable peculiarities of this variety of granite (hornblende granite) is the innumerable fine-grained enclosures which it contains. They are always sharply segregated from the containing rock, and are of all sizes, from that of the fist to that of a pin's head. The ground-mass of these fragments is of a dark colour, consisting of mica and small quartz-grains, in which white orthoclase crystals are for the most part porphyritically developed. The enclosures also contain hornblende crystals, although not in such quantity as in the enclosing rock. It is difficult to say any thing as to the mode of production of these fragments; but from the identity of the constituents and from their great abundance, it would appear that they were not derived from a rock broken through, but the product, during the solidification of the whole mass, of a process of segregation, the nature of which is entirely unknown to us. The circumstance must be noted, however, that they are exclusively confined to the area of the hornblende granite, but entirely absent in the other varieties" †.

A very remarkable example of concretionary granite is described in the U. S. Report on the Geology of Vermont ‡. "The basis of this remarkable variety of granite is rather fine-grained, white and highly felspathic. The mica, however, is usually dark, and where it exists in large quantities it gives the rock the aspect of syenite. But there is no hornblende present. Scattered through this base occur numerous spheroidal or elongated and somewhat flattened nodules of black mica, from half an inch to two inches in diameter; and when elongated the longer axis is sometimes seen as much as four or five inches long. They are usually more or less flattened, and have a shrivelled appearance like dried fruit. They sometimes become so thin as to consist only of a few plates. When the nodule is elongated and the wrinkles correspond, as they always do, to the longer axis, the resemblance is very striking to a dried

* Johann Jokély, "Geogn. Verhältnisse in einem Theile des mittleren Böhmen," Jahrb. k.-k. geol. Reichsanstalt, 1855, p. 375.

† F. von Andrian, "Beiträge zur Geologie des Kaurimer und Taborer Kreises in Böhmen," *ibid.* 1863, p. 166.

‡ Report on the Geology of Vermont, by Edward Hitchcock, LL.D., Edward Hitchcock, Jun., M.D., Albert Hager, A.M., and Chas. H. Hitchcock, A.M., vol. ii. p. 564, 1861.

butternut, more especially when stripped of its epicarp. No wonder they should be called 'petrified butternuts' If a specimen, somewhat flattened, be placed on its edge, and a moderately sharp blow be given to it with a hammer, concavo-convex scales will be chipped off even to the centre. They are composed of layers of mica with granular quartz, and probably some felspar interposed. The structure is evidently concretionary; yet, as already intimated, one can hardly avoid the suspicion that something has been abstracted from some of them, causing a shrinkage."

At page 721 of the same volume, the Rev. S. Hall remarks:—"These singular nodules seem to be imbedded in the granite mass 'like plums in a pudding.' They extend only a short distance from the place where first found in Stanstead. From that place to Craftsbury the granite exhibits no unusual appearance. At the south village in the latter town is an immense bed of nodular granite, some of which seems to be composed almost entirely of nodules slightly cemented by grains of mica and quartz. Other parts of the rock are very solid, and not inclined to decomposition more than other granite."

In a paper "On the Metamorphic Origin of certain Granitoid Rocks and Granites in the Southern Uplands of Scotland" *, Mr. J. Geikie, F.R.S., describes "nests" of altered rock which occur in some of the grey granites of that district. These, he says, often exhibit distinct traces of lamination; and their most usual character is that of an exceedingly fine-grained mica-schist, the dark or almost black shade being due to the abundance of mica. They are very irregular in shape, and by no means confined to those portions of the rock which abut upon the outlying bedded or aqueous strata, but are, on the contrary, scattered indiscriminately throughout the granite. He subsequently proceeds to account for the presence of these nests, and states that they "either represent such little detached portions of shale as are of common occurrence in the Lower Silurian greywackes, or they may be remnants of thin bands or beds of shale that interleaved the original strata. Those who deny the metamorphic origin of granite will probably suggest that the 'nests' of altered rock may have been caught up by the granite during its progress through the strata that envelope it. But if this had been the case, we should certainly expect to find the 'nests' not only more abundant near the junction of the granite with the stratified rocks, but indeed almost, if not exclusively, confined to that area. They are not more characteristic, however, of one portion of the granite than of another, but, as already remarked, are scattered indiscriminately throughout. I am therefore forced to conclude that the crystalline rocks described above have resulted from the alteration *in situ* of certain bedded deposits. The occurrence of the 'nests' cannot be accounted for on any other theory."

None of the published descriptions of these concretions or enclosures in granites appear to have resulted from investigations founded either upon chemical analysis or upon a microscopical examination

* Geol. Mag. vol. iii. p. 533.

of thin sections; and I have consequently been induced to avail myself to some extent of those methods of research in the hope of being thereby enabled to more clearly determine than has hitherto been done the nature and origin of such bodies. In carrying out this work, I first examined some of the principal quarries in the granite districts of the west of England, and subsequently those in the neighbourhood of Shap, in Westmoreland. I afterwards made myself acquainted with those in the vicinity of Aberdeen and Peterhead in Scotland, and examined numerous specimens from the district about Fort William collected by Mr. C. W. Merrifield, F.R.S.; finally the granite-quarries situated in the vicinity of Newry and Castlewellan in Ireland were visited.

In the following pages I propose to describe the various granites and their respective inclusions in the order in which the several districts were examined, beginning with a quarry at Lamorna Cove in West Cornwall, five miles south-west from the town of Penzance.

English Granites.—The granite-quarries at Lamorna are situated mainly in the cliff forming the more easterly shore of Lamorna Cove, and they have, at various times, been somewhat extensively worked for building-material. The granite from this locality is grey in colour and moderately coarse in structure, occasionally enclosing crystals of white felspar an inch and a half in length, together with numerous smaller ones possessing a distinctly greenish shade. Crystalline granules of a brownish transparent quartz are also abundant, as is likewise a nearly black mica, which is disseminated in minute scales throughout the other constituents. Black patches are exceedingly abundant in this granite, and have generally the appearance of fine-grained enclosures with irregular outlines; not unfrequently these exhibit a texture closely resembling that of a hardened slate or micaceous schist, and they are sometimes observed to be traversed by strings or veins of the enclosing granite. The frequency of the occurrence of black patches in this rock considerably detracts from its value as a building-material, as may be seen in the Museum building at Penzance, the front of which is constructed of Lamorna granite containing numerous dark spots. In this quarry the dark patches sometimes include imperfect crystals of quartz of considerable size, resembling in all respects those of the surrounding granite.

When examined under the microscope the mica of this granite appears to be chiefly of a dark brown colour, and is observed to be marked by circular, or nearly circular, spots of a much darker shade; in the centre of many of these markings a crystal of apatite occurs as a nucleus. This mica is often penetrated by well-formed crystals of unaltered magnetite, which is also found, although with less frequency, in the crystals of felspar and quartz. The presence of white mica is somewhat exceptional; but this granite contains light-brown tourmaline as well as a few small crystals of apatite.

The quartz of this rock encloses the usual liquid-cavities, which, however, are not generally numerous; the felspar is in part orthoclase, but a notable proportion of a plagioclastic species is also

present. The crystals of orthoclase often enclose grains of quartz and patches of a triclinic felspar.

Six different sections were prepared of as many dark micaceous inclusions from this locality, and, with the exception of two, they were found, when examined under the microscope, to differ from one another in the fineness of their grain only. Four of the specimens consist essentially of a mixture of granular quartz with felspar, through which numerous flakes of dark mica are disseminated.

The felspar does not very often exhibit any traces of triclinic striation; but the plates of mica are usually arranged with their axes approximately parallel to the same plane. As is almost invariably the case in this locality, the inclusions are much closer in grain than the granite, and the quartz, which is found chiefly in patches, occurs mostly in granules from .75 millim. to 1 millim. in diameter. In addition to the foregoing constituents, these patches enclose minute and imperfectly crystallized garnets of a dark-green colour, magnetite, or ilmenite, and imperfect crystals of tourmaline. The larger crystals of garnet are sometimes .5 millim. in diameter, while the smaller ones are frequently made up of an aggregation of exceedingly minute blebs separated from one another by spaces filled up with quartz.

The two remaining sections of inclusions from this locality differ from the preceding only in containing a less proportion of felspar, the absence of which is compensated for by the presence of a large quantity of a bacillar colourless mineral, which is probably tremolite.

At Wicca Pool, Zennor, granite in the form of veins penetrates for a considerable distance into the mica-slates forming the sea-cliff, and fragments of slate which have been detached from the general mass have become enclosed in the granite. These enclosed fragments are angular, their outlines are sharply defined, and their union with the surrounding granite along the surfaces of contact is complete.

In general appearance the included fragments can scarcely be distinguished from specimens of the general mass of the micaceous rock taken from along the line of its direct contact with the intrusive granite, excepting that foliation has been almost obliterated. Sections of the mica-slate in contact with the granite are seen under the microscope to consist of a mixture of granular quartz, brown mica, and a little white mica—the last being present in very small quantity only, with a few occasional minute garnets and a considerable amount of magnetite in the form of disseminated grains.

Thin sections prepared from fragments found by Mr. H. Bauerman enclosed within the granite do not differ materially from those made from contact specimens, excepting that both the quartz and mica are in this case more distinctly crystalline.

When seen in polarized light, sections cut from the included fragments and those from the slate in immediate contact with the granite veins are scarcely to be distinguished from one another, as the grains of quartz in the contact-specimens then become well defined; their average diameter, from .07 millim. to .1 millim., is the same in both instances.

The grey granite extensively quarried in the neighbourhood of Penryn is almost entirely free from patches differing materially, either in texture or colour, from the surrounding rock. Such bodies are, however, to some extent, represented by occasional aggregations of a few large flakes of mica. One of these nests, of about the size and thickness of a shilling, from Carnsew quarry was found to consist of a mixture of greyish-white and black micas without any admixture either of quartz or felspar.

The granites in the neighbourhood of St. Austell, the majority of which are to a greater or less extent schorlaceous, and which are sometimes marked by reddish-brown spots resulting from the peroxidation of ferrous compounds, are generally free from nests differing in texture or colour from the surrounding rock; and although several quarries in this district were examined, no specimens of inclusions were obtained.

At Gready, in the parish of Luxulyan, a large quarry has been opened upon a coarse-grained grey granite containing a moderate amount of black and silvery-white mica, with occasional crystals of schorl. This granite sometimes contains spheroidal or ovoid bodies very dark in colour, and closely resembling water-worn pebbles of fine-grained "greenstone"; these are firmly imbedded in the rock and exhibit distinct and sharply defined outlines.

An inclusion from the Gready quarry, one half natural size, is represented in fig. 1, Pl. I.

An examination of thin sections of the coarse-grained granite from this locality does not afford much information which might not be obtained by a careful study of hand specimens with the aid of a lens.

The black and silvery-white micas are, however, seen to be often interlaminated, while the former frequently encloses a considerable amount of magnetite with occasional minute crystals of apatite. The dark mica in this rock is affected by the deeper brown spots previously referred to as occurring in the micas of other Cornish granites, and the quartz contains the usual liquid-cavities. A notable proportion of the felspar is triclinic, and the rock contains a few small garnets.

Sections cut from rounded pebble-like patches found in this quarry, when examined under the microscope, are found to be, with perhaps the exception of schorl, composed of the same minerals as the enclosing granite; but the crystals are much smaller and the proportion of black mica is larger. A large portion of the felspar has been rendered cloudy by an opaque product of alteration; but wherever the crystals have retained their original transparency a preponderance of triclinic felspar becomes apparent. An alteration-product of a greenish shade is also present.

The following analysis of a specimen of granite from Gready quarry has, for convenience of comparison, been placed side by side with one of a close-grained dark-coloured ovoid inclusion from the same locality. The granite selected for analysis was that immediately surrounding the inclusion of which the composition is given.

	Granite.	Inclusion:
Water { hygrometric	.13	.18
{ combined	.59	1.25
Silica	69.64	65.01
Phosphoric anhydride	trace	trace
Alumina	17.35	17.37
Ferric oxide	1.04	4.95
Ferrous „	1.97	1.86
Manganous oxide	trace	trace
Lime	1.40	2.11
Magnesia	.21	1.34
Potassa	4.08	1.82
Lithia	trace	trace
Soda	3.51	4.14
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	99.92	100.03
Specific gravity	2.72	2.73

The results of chemical analysis are thus perfectly in accordance with those which might have been anticipated from a microscopic examination of the two rocks. A considerable proportion of the orthoclase in the granite is, in the inclusion, represented by a soda-lime felspar, probably oligoclase, while the marked increase in the quantities of ferric oxide and magnesia in the latter are doubtless chiefly referable to an augmentation in the proportion of mica present*.

The granite of the Cheesewring quarries, near Liskeard, is without inclusions, but is traversed by veins of fine-grained granite, containing a pinkish biaxial mica (lepidolite), in which triclinic felspar is abundant.

At Gunnislake the granite does not contain any patches presenting definite and distinct outlines; but wherever spots occur they gradually merge into the normal rock. Sections prepared from these indistinct aggregations are found to consist of a fine-grained granite, in which triclinic felspar is perhaps somewhat more abundant than in the surrounding rock.

The only granite which I have examined from the county of Devon is that raised at the extensive quarries of Foggen Tor, near the great prison of Prince's Town on Dartmoor. This is a grey granite, generally without pebble-like inclusions bounded by distinct and well-defined outlines. A few patches of fine-grained granite, considerably darker in colour than the surrounding rock, were, however, found. The outlines of these are moderately sharp, and, in one instance, a patch of this description encloses a crystal of orthoclase, the angles of which are rounded, as well as two distinct crystals of quartz, similarly modified. Fig. 2, Pl. I., represents this specimen, natural size.

* The Rev. S. Haughton, F.R.S., states that the second felspar in Cornish granites is albite (Proc. Roy. Soc. vol. xvii. p. 209). There are, however, probably exceptions to this; and, in the present instance, the results of analysis render the presence of orthoclase probable.

When thin sections of Foggen-Tor granite are examined under the microscope, they are all seen to consist of orthoclase, quartz, dark-brown mica, schorl, and a little silvery-grey mica; a plagioclastic feldspar is also present; but no magnetite was observed. It may, however, be remarked that this rock, like some of the granites in the neighbourhood of St. Austell, is occasionally marked by reddish-brown spots, apparently resulting from the oxidation of some mineral containing ferrous oxide.

A section of the fine-grained patch enclosing crystals of quartz and a rounded crystal of orthoclase, when examined under the microscope, is seen to be composed of the same minerals as the surrounding rock, the only difference being in the dimensions of the component crystals and the presence of a larger proportion of nearly black mica.

This is, therefore, simply a nest of darker-coloured granite, and is probably a concretionary product, although it has been ascertained, by cutting through the specimen, that the large rounded crystal of orthoclase does not extend beyond the darker fine-grained patch into the normal granite. This granite sometimes contains large druses or "vughs" lined with quartz crystals, while it occasionally becomes decomposed into a soft kaolin, in which dissociated silica is imbedded in the form of aggregated crystals of nearly transparent quartz.

The well-known granite of Shap in Westmoreland, which is remarkable for its beautiful crystals of pinkish-red orthoclase, and is extensively wrought for ornamental purposes, encloses numerous rounded patches of a darker colour than the surrounding rock, which, at first sight, present the appearance of fine-grained inclusions of trap. This granite, in hand specimens, is seen to consist of a ground-mass of quartz, feldspar, and black mica, porphyritically enclosing large crystals of red orthoclase; but, when examined under the microscope, it is found to contain, in addition to those minerals, magnetite, titanite, a little apatite, hornblende, and occasionally some triclinic feldspar.

The patches in this granite are well defined, and generally more or less rounded in outline, varying in size from that of a pea to that of a water-melon. They are commonly much finer in grain than the surrounding rock; and, on account of the presence of a larger proportion of black mica, are, in a great majority of cases, considerably darker in colour. In some instances a portion of the mica included in these dark patches would appear to have become segregated from the surrounding granite, which, in the immediate neighbourhood of the inclusion, is comparatively free from the presence of that mineral.

The rounded pebble-like bodies which occur in this granite frequently enclose crystals of the beautiful red orthoclase characteristic of the surrounding rock; but these are generally imperfect in form and have their angles considerably rounded.

Fig. 3, Pl. I., represents a sharply defined inclusion in the Shap granite, scale four-tenths natural size, which, in addition to nume-

rous small patches of red orthoclase, contains a large crystal of that mineral, the angles of which are rounded.

A large dark-coloured fine-grained patch observed in this rock contains a smaller one considerably lighter in colour and presenting very distinct outlines. Besides imperfect and much-rounded crystals of red and white felspar, this specimen encloses a large milky felspar crystal of which the angles are perfectly sharp.

Six sections were examined, from as many rounded enclosures, from the Shap quarries, and, without exception, the ground-mass of the whole of them was found to contain all the various minerals constituting the normal granite of the district, although the proportion of dark mica present was in considerable excess. Triclinic felspar appears to be more abundant in the inclusions than in the surrounding granite, and a portion of this mineral shows cross striation in polarized light; a few of the crystals exhibit concentric lines of growth.

In exceptional cases the patches in Shap granite, from the almost total absence of black mica, are lighter in colour than the surrounding rock; and occasionally two distinct inclusions, differing both in texture and colour, are found one within the other.

In addition to the rounded masses already described, this granite encloses others of a more schistose character, which are often softer than the rock in which they are contained. Sections of inclusions of this kind are seen under the microscope to consist either entirely of mica, or of mica associated with quartz and occasional crystals of felspar. When composed of mica alone, these inclusions can scarcely be regarded otherwise than as being of segregatory origin; but where quartz in considerable quantity is also present a fragment of mica-schist may sometimes have become enclosed in the granite.

The method of occurrence of such bodies in Shap granite will be understood by reference to Pl. I. figs. 4, 5, natural size, carefully drawn by Mr. Frank Rutley. Whether these be the result of included flakes of a stratified rock, or of the segregation of mica only, it is evident that they must have been at least partially consolidated previous to the crystallization of the felspar. It will be observed that in fig. 4 the inclusion is completely divided by a large crystal of orthoclase, while in fig. 5 a crystal of that mineral is traversed by fragmentary portions of a similar body. It is somewhat unfortunate that, as the drawings were made from a polished pillar, it was impossible to obtain thin sections of these particular inclusions.

Scotch Granites.—The Scotch granites of which I have examined the inclusions are those in the neighbourhood of Aberdeen, Peterhead, and Fort William.

The Aberdeen granites are grey in colour and fine in grain, and are mainly composed of quartz and felspar, with colourless and dark or nearly black micas. The granite of this district is regarded by Prof. Haughton as being of metamorphic origin*, and is apparently almost free from rounded or pebble-like inclusions.

* Proc. Roy. Soc. vol. xviii. p. 313.

When thin sections are examined under the microscope they are found to be composed, in addition to orthoclase and quartz, of a large proportion of a triclinic felspar, which Profs. Haughton and Heddle have determined to be oligoclase*; this granite also contains a colourless and a nearly black mica, a few minute garnets, and occasionally crystals of apatite and sphene†. A portion of the felspar exhibits cross hatching in polarized light, and the quartz is frequently traversed by hair-like crystals, which are probably either schorl or rutile.

A subangular inclusion obtained from Rubislaw quarry, two miles west of Aberdeen, is about 5 inches in length, and resembles a contorted fragment of mica-schist. Sections of this specimen are seen to be composed of quartz and felspar, with dark and colourless micas. A considerable proportion of the felspar is triclinic, and the cleavage-planes of the micas are parallel to the foliation of the rock. One or two small garnets were also observed. Other inclusions from this locality, of nearly similar appearance, but of smaller dimensions, were collected, and on examination were found to have the same composition.

At Sc lattie quarry, near Buxburn, I found a large piece of silvery grey schistose rock, weighing several pounds, enclosed in granite. Its surfaces, which were in no way altered, were most completely united with the granite, which was itself quite unaltered in the immediate proximity of the enclosure; the line of junction of the two rocks was therefore perfectly well defined. This inclusion, which has the appearance of a mica-schist or a highly micaceous gneiss, was found to be composed of quartz, felspar, and white and dark micas. Many of the crystals of felspar evidently belong to a triclinic species, while others exhibit cross striation when examined in polarized light. A few crystals of apatite were observed in sections prepared from this inclusion.

Another inclusion found in the granite of Sc lattie has nearly the following dimensions—length 9 inches, width 7 inches, and thickness 3 inches. This specimen, which is exceedingly hard, is of a darker colour than the enclosing rock, and exhibits angles which are but slightly rounded. It is distinctly stratified by alternate bands of nearly colourless quartz and of some darker material, and the whole of its exterior is so covered by a layer of black mica as to render its separation from the surrounding granite an easy operation. Under the microscope this is seen to consist, to a large extent, of granular quartz, of which the outlines sometimes appear slightly rounded. With this quartz are mixed a few fragmentary crystals of felspar, of which some belong to a triclinic species, whilst others show cross striation when examined in polarized light. This specimen contains a considerable amount of brown or black mica; but white mica is also present, although in a less proportion. The quartz and mica occur in more or less distinct layers; and the black and colourless micas are much interfoliated, their laminæ being frequently enclosed in quartz.

* Haughton, Proc. Roy. Soc. vol. xviii. p. 313; Heddle, Trans. Roy. Soc. Edinb. vol. xxviii. p. 265, note.

† One very minute crystal only of sphene was observed in the sections examined.

The inclusions found in the grey granite at Dyce quarry, six miles north-west of the city of Aberdeen, are, for the most part, foliated subangular masses of a dark bluish-grey colour, not unlike the first of those described as having been obtained at Sclattie. They are all distinctly foliated, and, on sections being examined, are seen to be composed of quartz, felspar, and the usual dark- and light-coloured micas; these inclusions also contain a few minute garnets, and a little magnetite, together with occasional needle-like crystals of apatite. Some of the bands of this enclosed rock are almost entirely composed of the two descriptions of mica, while others decidedly resemble gneiss in their constitution.

One of the most remarkable specimens from this quarry was in the form of a lenticular mass weighing considerably over a hundredweight, and so covered externally by a thin layer of mica that it readily separated from the enclosing rock. On being broken it was found to consist of a granite possessing the same characteristics as that around it, but at least one half finer in texture. Sections were prepared from the fragments, and were found to be composed of the same materials as the enclosing rock, with the addition of a little magnetite, the presence of which was not observed in the latter. Triclinic felspar (oligoclase) was also more than usually abundant.

At Kemnay, three miles west of the railway-station at Kintore, a quarry is extensively worked on a granite of the same general character as that wrought nearer the city of Aberdeen. In this locality inclusions are extremely rare; but one of the specimens there obtained is of great interest as affording evidence that some of the dark patches in granites, which at first sight closely resemble enclosures of a schistose rock, may in reality be the result of segregation.

Fig. 6, Pl. I., represents the specimen referred to, one half natural size.

Sections of the dark material forming the inclusion in this rock are, when examined under the microscope, found to be composed entirely of black and colourless micas with their planes of cleavage all lying approximately in the same direction.

The granite in this quarry is traversed by a dyke of very fine-grained black mica-trap, which has sometimes a thickness of several feet, but sends off various branches, some of which are not much thicker than cardboard. This trap is so firmly soldered to the enclosing granite that blocks of which one portion is granite and the other trap do not, when struck, show a greater tendency to divide along the junction than in any other direction. When cut perpendicularly to the plane of junction, the granite and trap are seen to be joined along a line as distinct as when two pieces of differently coloured wood are planed to a joint, glued together, and subsequently polished. Some small fragments of granite which have become enclosed in this trap are not in the slightest degree altered, and their edges are as sharp as when first separated from the parent rock.

Under the microscope this trap is found to consist of a crystalline felspathic ground-mass in which small flakes of dark mica and distinct crystals of felspar are porphyritically enclosed. The crystals

of felspar usually show twinning; but the largest of them do not exceed .2 millim. in length, while the flakes of mica seldom exceed .15 millim. in diameter. In addition to felspar and mica this rock contains a few minute grains of magnetite.

The granites in the neighbourhood of Peterhead differ from those in the vicinity of Aberdeen in their dominant felspar being of a pinkish-red hue, instead of colourless or greyish-white, as in the last-named locality. These granites are regarded by Professor Haughton as being of eruptive origin, and their second felspar is albite*.

Under the microscope thin sections of the granite from this district are seen to consist of quartz, orthoclase, a subordinate amount of a triclinic felspar, black or very dark-brown mica, a few needle-like crystals of apatite, and occasional crystalline patches of titanite. In addition to these minerals, vermicular chlorite occurs in the granite of Black Hills, where the quartz also occasionally encloses filamentary crystals, which are perhaps rutile.

The principal quarries worked in the district are situated at Stirling Hill and Black Hills, a few miles south of the town of Peterhead. In both these localities the inclusions almost invariably assume an ovoid form, and usually vary in dimensions from the size of a nut to that of a large apple; considerably larger ones are, however, sometimes met with. They are in nearly all cases darker in colour and much finer in texture than the enclosing rock; their outlines are sharply defined, and they frequently enclose, porphyritically, rounded crystals of pinkish-red orthoclase.

Seven different sections were prepared of as many ovoid inclusions from this district, and in every instance they were found to consist of an exceedingly fine-grained granite containing all the various minerals present in the enclosing rock. The proportions of mica and of triclinic felspar are, however, greater than in the normal granite, and the amount of quartz is somewhat less.

This agrees with the results obtained by analyses of the average granite and of the dark-coloured rounded enclosures:—

	Granite.	Inclusion.
Water { hygrometric	.21	.19
{ combined	.40	.76
Silica	73.70	64.39
Alumina	14.44	15.99
Phosphoric anhydride	trace	trace
Titanic „	distinct traces	distinct traces
Ferric oxide	.43	1.47
Ferrous „	1.49	5.98
Manganous oxide	trace	trace
Lime	1.08	2.57
Magnesia	trace	1.67
Potassa	4.43	2.46
Soda	4.21	4.96
	<hr/> 100.39	<hr/> 100.44
Specific gravity	2.69	2.73

* Proceedings of the Royal Society, vol. xviii. p. 313.

On comparing the foregoing analyses with those made of corresponding Cornish specimens (p. 8) it will be observed that the proportion of ferrous oxide as compared with ferric oxide is larger in the latter than in the former case. This, perhaps, in some measure arises from the black mica in the Peterhead granites being Haughtonite, a highly ferruginous mineral, in which the iron is mainly in the state of protoxide, and which Professor Heddle has shown to be present in many of the Scotch granites.

The only exception to the rounded form of inclusion observed in this district was found in a quarry at Black Hills, and is represented two thirds natural size in fig. 7, Pl. I.

Under the microscope this specimen is seen to be composed of a mixture of dark brown or black mica with granular quartz and an occasional crystal of felspar, the laminæ of the mica being so arranged as to produce foliation. A small quantity of magnetite or ilmenite is also present. In all rocks in which the mica in hand-specimens appears black, its colour in thin sections varies from brown to greyish brown.

Near the lighthouse at Buchan Ness this granite is traversed by a large dyke of micaceous felsite, which, in places, becomes porphyritic by enclosing crystals of quartz and orthoclase.

The granite of the Ardshiel quarries situated at Ballachulish, about ten miles south-east of Fort William, consists essentially of a fine-grained mixture of quartz, nearly colourless felspar, and dark mica, very closely resembling in general character the granites of the Mourne Mountains in Ireland. Under the microscope this rock is found, in addition to the minerals above enumerated, to contain hornblende, magnetite, sphene, and apatite; it is further observed that both orthoclase and a triclinic felspar are present.

This granite contains numerous inclusions which are often darker in colour than the enclosing rock, and frequently angular or sub-angular in form. Some of these have evidently the same general constitution as the enclosing granite, while others are manifestly enclosed fragments of foliated rocks. Ten thin sections of as many different inclusions from this locality were examined under the microscope with the following results:—

The non-foliated crystalline inclusions, some of which exhibit sharply defined angular outlines, were, without exception, fine-grained granites precisely resembling the enclosing rock in all respects, except in being finer in grain, in dark mica and hornblende being more abundant, and perhaps also in a somewhat larger proportion of triclinic felspar being present.

The enclosures exhibiting a decidedly schistose structure vary considerably in composition, and have obviously been derived from rocks differing both from one another and from the surrounding granite.

Such specimens are sometimes composed of granular quartz, a few fragmentary crystals of felspar, greenish-brown or nearly black mica, a little hornblende, occasional small garnets, and a little magnetite. In other cases hornblende and mica constitute a considerable pro-

portion of the rock, and these are associated with granular quartz and fragments of felspar; besides which there are often traces of an amorphous felsitic ground-mass. Less frequently hornblende and mica decidedly predominate—quartz, a small quantity of felspar, garnets, and a little pyrites being also present. The hornblende and mica in such rocks generally enclose numerous granules of transparent quartz.

A fine-grained inclusion from this locality of over a foot in length is composed of contorted bands varying in colour from light grey to dark green. Under the microscope it is seen to consist largely of a mixture of colourless and dark mica and hornblende, with a few small garnets and a mineral which is probably sahlite, the shade of the several laminae varying with the relative proportions of the different minerals present in each. This rock does not contain much free quartz; but a few small crystals of orthoclase and of a triclinic felspar, as well as a small amount of a felsitic ground-mass, are present.

The analysis of an average specimen of this inclusion afforded the following results (sp. gr. = 2.93):—

Water	{ hygrometric	..
	{ combined	.70
Silica		52.43
Phosphoric anhydride		trace
Alumina		12.76
Ferric oxide		1.34
Ferrous „		4.54
Manganous oxide		trace
Lime		14.16
Magnesia		9.75
Potassa		1.09
Soda		2.94
		<hr/>
		99.71

In many granites inclusions occasionally take the form of more or less perfect crystals of felspar; and such specimens can only be regarded as being an extreme development of the enclosure of quartz and mica in crystals of that mineral. This inclusion of other minerals in felspar is a phenomenon well known to microscopical petrologists.

A good example of a pseudomorphic inclusion of this kind was brought by Mr. Merrifield from Glen Nevis, and on thin sections being examined under the microscope the granite and its included pseudomorph are found to consist of the same minerals in nearly similar proportions, except that dark mica is somewhat more plentiful in the latter than in the former. The minerals present, in both instances, are orthoclase, a triclinic felspar, dark greenish mica, hornblende, sphene, magnetite, and apatite.

Irish Granites.—The only Irish granites which I have examined are those of the north-eastern portion of the island; some of these

are remarkable for the number and variety of the dark-coloured inclusions they contain, and they consequently afford unusual facilities for the study of such bodies.

The Newry granite is essentially composed of quartz, orthoclase, and black mica, and is usually made up of small and somewhat imperfect crystalline grains. It is, however, sometimes coarser in texture, and occasionally becomes porphyritic by enclosing fragments of felspar imbedded in a fine-grained ground-mass of a bluish-grey colour.

Near the Goragh-Wood railway-station granite is exposed for a length of over 400 yards and to a maximum height of above 20 yards. The rock is here principally of the description locally known as "white granite;" but close to the station it becomes porphyritic for a width of about 35 yards, and this "blue granite" is extensively quarried for ornamental purposes. It exhibits some slight indications of foliation, and its colour is due to the presence of numerous minute scales of black mica disseminated through the mass; the imperfect crystals of felspar, porphyritically enclosed, rarely exceed the dimensions of a small bean.

Immediately opposite the railway-platform the porphyritic granite terminates abruptly against beds of a fine-grained schistose rock, tilted at a high angle; this rock, which is above 60 feet in width, separates the blue granite from the ordinary white variety.

The granites of Newry, or Slieve Croob, are regarded by Prof. Hull* as being of metamorphic origin; and Mr. F. W. Egan, author of the memoir explanatory of the geological map of this portion of Ireland, believes them to be derived from Silurian rocks by transition through mica-schist and gneiss†. Mr. Kinahan, on the other hand, classes them with eruptive granites and describes the blue granite of Goragh Wood as an elvan which has come up through the Newry granite and must consequently be of more recent date‡.

Examined under the microscope this granite is seen to be composed of quartz, orthoclase, a felspar exhibiting cross striation, a very few small crystals of a distinctly triclinic felspar, a dark or black mica, green hornblende, sphene, a few needles of apatite, with occasionally magnetite, pyrites, and perhaps a little rutile. A specimen of the schistose rock taken near the centre of the band against which the blue granite abuts, and consequently about 30 feet distant from the granite on either side, was found to be a fine-grained mica-schist. It is composed of finely granular quartz, occasional fragments of felspar, numerous minute nearly colourless garnets, small flakes of mica, usually of a dark colour, a little green hornblende, and a few spots of magnetite and pyrites.

A specimen of the same schistose rock obtained from its immediate junction with the blue granite is rather coarser in texture and is

* Building and Ornamental Stones of Great Britain &c., p. 45, note.

† Explanatory Memoir to accompany sheet 59 of the maps of the Geological Survey of Ireland, p. 12.

‡ 'Geology of Ireland,' pp. 209, 210.

darker in colour than that at a greater distance from it, but does not otherwise differ, excepting that fragments of felspar are somewhat more numerous, and that the mica has become almost entirely replaced by green hornblende.

Some of the inclusions found in this locality are unquestionably fragments of a rock of the character of that exposed in the cutting opposite the railway-station. These, when of moderate dimensions, are generally almost black; and when thin sections of them are examined under the microscope they are found to consist of granular quartz with a few fragments of felspar, dark mica, green hornblende, often some minute garnets, crystalline patches of sphene, and occasionally a little pyrites.

When included fragments of this quartzose rock are of large size they, in the majority of cases, do not undergo alteration throughout, but are darkened by the presence of a disseminated material of a nearly black colour to a depth of about an inch only. In such cases the junction of the inclusion with the surrounding granite is perfectly defined, and the union of the two rocks is complete; but the disseminated dark flakes gradually become less plentiful, and towards the centre of the mass almost entirely disappear.

On examining thin sections of the interior or central portions of such inclusions they are found to be composed of a rock containing granular quartz, some felspar, numerous nearly colourless garnets, a little dark mica, a few flakes of hornblende, and occasionally specks of pyrites.

The exterior or altered portions are found to contain the same granular quartz mixed with a few fragments of felspar, much green hornblende porphyritically enclosing grains of quartz, some dark mica, a few small garnets, an occasional small crystal of sphene, and sometimes a little iron pyrites or magnetite.

The following analyses show the composition of the unaltered and altered rocks respectively:—

	Unaltered rock.	Altered rock.
Water { hygrometric	·13	·08
{ combined	·38	·36
Silica	63·51	66·64
Alumina	13·42	13·77
Phosphoric anhydride	trace	trace
Titanic „	traces	traces
Ferric oxide	1·14	2·15
Ferrous „	3·91	3·68
Manganous oxide	trace	trace
Lime	10·80	6·08
Magnesia	3·03	3·42
Sulphur	trace	trace
Potassa	·23	·40
Soda	3·54	3·39
	<hr/>	<hr/>
	100·09	99·97
Specific gravity	2·84	2·79

In addition to inclusions obviously derived from adjacent rocks, there are smaller ones of a somewhat similar dark shade, of which the origin is not so immediately apparent. When sections of these are examined under the microscope, they are found to be composed of granular quartz with a subordinate amount of felspar and a considerable proportion of dark mica; with these are associated crystalline patches of green hornblende porphyritically enclosing twinned crystals of felspar, occasional small garnets, and, exceptionally, minute crystals of sphene.

Besides included fragments of extraneous rocks, the Goragh-Wood granite encloses bodies which are apparently of concretionary origin. These comprehend all the constituent minerals of the surrounding rock, although not quite in the same proportions as in the normal granite, since they are sometimes of lighter colour, from the comparative absence of black mica, while in other cases they exhibit a dark shade in consequence of the greater abundance of that mineral.

Fig. 8, Pl. I., represents a concretionary enclosure in the Goragh-Wood granite, one half natural size. Thin sections of this specimen are found to be composed of quartz, orthoclase, triclinic felspar, black mica, sphene, a few needles of apatite, and some imperfect crystals of magnetite or ilmenite. In these spotted concretions the sphene is usually enclosed in white patches consisting of a mixture of felspar and quartz; and sometimes assumes the form of crystalline aggregations porphyritically enclosing either twinned crystals of felspar or irregular grains of magnetite. In coarsely-grained granites concretionary inclusions sometimes affect the form of more or less imperfect crystals of felspar.

The porphyritic granite near Bessbrook, which has been opened out by extensive quarries, closely resembles that at Goragh Wood, and appears to be nearly free from inclusions of every description.

At Moor Quarry, $1\frac{1}{2}$ mile south of Newry, the granite does not materially differ from that at Goragh Wood, except that, besides exhibiting less trace of foliation, it is somewhat lighter in colour and rather coarser in texture; under the microscope it is seen to have an essentially similar composition.

Similar inclusions to those found at Goragh Wood are of frequent occurrence in this granite; but those which appear to be of concretionary origin are relatively more numerous than in that locality.

All who have carefully examined the Mourne granite appear to agree with regard to its eruptive origin. Professor Hull further regards it as having been intruded among the stratified rocks in a state bordering on solidity, and with a temperature only sufficient to indurate, but not to metamorphose, the Silurian rocks by which it is surrounded*.

One of the most convenient localities from which unweathered specimens of this granite and its inclusions can be obtained is Ballymagreehan near Castlewellan, whence were procured the blocks which now form the base of the Albert Memorial in Hyde Park. This quarry is no longer worked, but the rock, which is of a brownish-

* Building and Ornamental Stones of Great Britain, p. 44.

grey colour, is finely granular and contains numerous dark inclusions.

When thin sections of this rock are examined under the microscope they are found to be composed of quartz, orthoclase, a triclinic felspar, which Prof. Haughton has determined to be albite*, a dark greenish mica, green hornblende, some needles of apatite, a little sphene, and occasionally magnetite or pyrites. The quartz of this granite is often traversed by minute hair-like crystals, which are perhaps rutile; and the hornblende and mica are so mixed as almost to suggest the possibility of one being sometimes an alteration-product of the other.

The inclusions in this rock are, as is usually the case in granites, of two kinds. The first variety is commonly more or less ovoid in form, is finer in grain than the surrounding granite, considerably darker in colour, and sometimes encloses crystals of orthoclase of considerable size. Such bodies contain all the constituents of the enclosing rock and, with the exception that dark mica is in considerable excess, they are present in nearly the same proportions.

Those belonging to the second category are angular or subangular in form, very dark in colour, and often exhibit a distinctly foliated structure. These are composed of granular quartz, black and greenish-black micas, green hornblende, a few imperfect crystals of felspar, specks of magnetite, with pyrites, and occasionally a little apatite. A few minute crystals are also sometimes present of a mineral which may perhaps be epidote.

General Conclusions.

The inclusions contained in granites are of two distinct kinds. Those of the first class are the result of an abnormal arrangement of the minerals constituting the granite itself; while those belonging to the second represent fragments of other rocks enclosed within its mass.

Inclusions of the first class are frequently, but not always, more or less ovoid in form, and are, essentially, composed of a fine-grained variety of the granite in which they occur; the proportion of triclinic felspar present in such granitic inclusions is often greater than in the rock which encloses them.

They are sometimes porphyritic in structure, and contain crystals of the characteristic felspar of the enclosing rock. Thus, when the felspar of the surrounding granite is either red or pink in colour, that which is porphyritically distributed in the inclusion will, as a rule, be correspondingly red or pink; whereas if white felspar be a characteristic of the ordinary granite, the porphyritic crystals of the inclusions will be likewise white.

The angles of felspar crystals so contained in inclusions are frequently much rounded, and the presence of a large proportion of

* Quart. Journ. Geol. Soc. vol. xii. p. 189.

mica or dark hornblende in such bodies often causes them to be of a deeper colour than the surrounding rock*.

In addition to their general similarity in mineral constitution to the adjoining granite, further evidence of the concretionary origin of such inclusions is afforded by the fact that a second similar nodule, differing from the first in colour or in fineness of grain only, is occasionally found within them.

Crystalline granitic inclusions not unfrequently assume the form of imperfectly defined crystals of felspar; these may be regarded as an extreme development of the well-known phenomenon of the enclosure of quartz and mica in felspar.

Another form of inclusion, giving rise to the production of a dark fissile patch in granite, results from a segregation of mica from the surrounding rock. An example of this kind of inclusion is seen in the granite from Kemnay, Scotland, fig. 6, Pl. I., where it will be observed that in the immediate vicinity of the enclosure the rock becomes comparatively free from mica.

The formation of rounded inclusions in granite is believed to have been usually contemporaneous with the solidification of the general rock-mass, and to be due to forces of the same nature as those which have resulted in the production of nodules in the well-known Napoleonite or orbicular diorite of Corsica. It is, however, probable that inclusions having a similar form may have been sometimes produced by the enclosure of pebbles of extraneous rocks.

In a few instances only have well-defined angular inclusions of a fine-grained granite been observed in granites of a coarser description; in some cases these may be enclosed fragments of an older granite, but in all the specimens which have been examined, such inclusions have invariably exhibited the distinctive characteristics of the enclosing rock.

Inclusions belonging to the second class are often schistose in structure and are usually irregular in outline, being sometimes traversed by veins of quartz, or divided by strings of granite, which appear to have filled spaces caused by the floating apart of slaty fragments in a granitic magma.

In many instances they are not materially altered, and in a majority of cases inclusions belonging to this class are easily recognized as being fragments of either gneiss, mica-schist, hornblende-schist, or garnet-schist; comparatively few specimens only have been met with so modified as to render their derivation difficult to determine.

Slaty inclusions are, as a rule, either highly micaceous or highly hornblendic; and an examination of the schistose rock in contact with the granite at Goragh Wood, and of partially altered inclusions from the same locality, shows that in that case the production of those minerals is a result of granitic contact†. It will be observed,

* When sections made through both a pebble-like inclusion and the enclosing granite are examined along their line of contact, minute crystals are observed to extend from the former into the latter.

† Mr. S. Allport has observed that in many cases slates in the immediate vicinity of the Land's-End mass of granite have become schorlaceous (Quart. Journ. Geol. Soc. vol. xxxii. p. 408).

on referring to the analyses p. 17, that the chief chemical changes which have taken place in the rock are an increase in the proportions of silica, iron oxides, magnesia, and potash, while there is a decrease in the quantity of lime.

Inclusions distinctly belonging to the two different classes not only occur in the same granites, but good examples of both descriptions may be sometimes found in the same cubic foot of rock.

When schistose inclusions are found in ordinary eruptive granites, they can only be regarded as fragments of extraneous rock which have been caught up by the granite and enclosed within its mass. In the case of granites which may, on the contrary, be supposed to be of metamorphic origin, they will doubtless be looked upon by those entertaining that opinion as portions of older rocks which have, to a great extent, withstood the action of granitic metamorphism.

The foregoing conclusions have been arrived at after an examination of only a limited number of rocks, but are probably capable of more extensive application.

EXPLANATION OF PLATE I.

- Fig. 1. Ovoid inclusion from Gready quarry, Luxulyan, Cornwall, one half natural size. A fine-grained granite containing a large proportion of dark mica: p. 7.
2. Inclusion in granite from Foggen Tor, Dartmoor, natural size, porphyritically enclosing granular quartz and a large crystal of orthoclase, of which the angles are rounded: p. 8.
3. Ovoid granitic inclusion in granite from Shap, Westmoreland, enclosing a rounded crystal of red orthoclase, four tenths natural size: p. 9.
4. Inclusion in Shap granite, natural size, divided by a crystal of red orthoclase: p. 10.
5. A similar inclusion, natural size, in the same block of granite, passing in a broken line through a crystal of orthoclase: p. 10.
6. Segregatory inclusion of mica, one half natural size, Kemnay quarry, near Kintore: p. 12.
7. Schistose inclusion in red granite from Peterhead, Scotland, two thirds natural size, composed of dark mica, granular quartz, and a few crystals of felspar: p. 14.
8. Inclusion, one half natural size, in granite from Goragh Wood, Ireland. In the centre of each of the light-coloured porphyritic patches there is a crystal of sphene: p. 18.

DISCUSSION.

The PRESIDENT said that he had examined cases of this kind in the Aberdeen granite, and had found that some were really fragments of another rock, and others concretionary. He therefore quite agreed in the limited observations with which Mr. Phillips had concluded from a much larger number. He thought the paper most valuable, especially as bearing on the temperature at which granite was formed.

Mr. ATTWOOD remarked that on the western slope of the Wahsatch range, in Utah, these concretionary nodules were very common in the granites. Tunnels showed that they did not extend deep into the rock, but occurred only near the point of contact with other rocks.

Mr. ORMEROD said he had observed these inclusions on the eastern side of Dartmoor; there the inclusions were generally oval, and called "mare's eggs," and the phenomena agreed with those described by Mr. Phillips.

Prof. RAMSAY said these inclusions might be seen remarkably well on the steps of the Duke-of-York's column. The subject appeared to him to have been admirably worked out by Mr. Phillips. He thought, however, that Mr. Phillips's remarks were not inconsistent with the idea that some granites were metamorphic.

Mr. W. W. SMYTH congratulated the author of the paper, with whom he heartily agreed. There were many cases to be seen in Cornwall of fragments torn off from the neighbouring rocks. When, however, you find aggregates, as of schorl, like balls, they must be due to some kind of concretionary action. The Elba granites showed a tendency to aggregation with schorl and with mica.

Prof. SEELEY quoted cases from the internal structure of crystals of augite and hornblende of the Siebengebirge, where similar concretionary masses occur plentifully in the trachytic rocks. They generally have angular sides, as though large felspar masses had been altered and removed. They are mostly rich in augite, are often limited by a film of kaolin, and are quite as large as those in granite. He thought they were analogous to septarian concretions in clay, and due to the percolation of water removing materials from one place and putting them down in another.

Prof. JUDD said Mr. Phillips had undoubtedly proved that there are two kinds of these enclosures in granite. He suggested that a third class might exist, namely, fragments brought up from below, like the nodules composed of augite, olivine, and enstatite, which are found in so many basic rocks.

Mr. BAUERMAN thought that no great dependence could be placed upon external contour as evidence of the local or foreign origin of an included mass, as in graphic granite the quartz might take the angles of the felspar or might be freely developed; then the rounded form of olivine masses might be due to interrupted development, and not to their being included fragments. He exhibited a piece of zircon syenite from Labrador; in it was a fragment, as it seems, of a hornblende and soda-lime felspar rock, which, on the other side, took a true crystal form of hornblende.

Dr. HICKS stated that spheno was common in the hornblende gneisses of Scotland. He had observed many cases similar to those described by Mr. Phillips, where the surrounding rock and included fragments were identical, and where there was but little alteration produced by the intrusion.

Mr. PHILLIPS thought the disappearance of rounded fragments on sinking deeper in the rock, referred to by Mr. Attwood, was only an accident. He had found concretionary inclusions at all distances from junction-surfaces. He thought that fragments coming up from below, as referred to by Prof. Judd, would generally be dissolved or greatly diminished in size during their passage.