GENERAL COMMITTEE.

T. Brain.	T. Lovick.
Edm. Jones, F.G.S.	T. Dexter.
C. Evans.	Dr. C. T. Richardson.
S. Highley, F.G.S.	W. H. Leighton.
W. N. Lawson, M.A.	J. Rofe, F.G.S.
J. Jones.	J. Noyes.

HONORARY SECRETARY.

J. Cumming, F.G.S., 7, Montague Place, Russell Square, W.C.

HONORARY LIBRARIAN.

A. Bott, A.A., F.G.S.

Ordinary Meeting, Tuesday, January 5th, 1864.

E. Cresy, President, in the Chair.

A vote of thanks was passed to the President and other officers for their services during the past year.

The following gentlemen were elected members of the Association:—Mr. John Gardner, Mr. Edmund Gardner, and Mr. Robert Irving.

The following donations were announced:—

“*Abstract of Proceedings of the Geological Society.*” By the Society.

A paper was read:—

“On the Fauna of the Carboniferous Epoch.” By Professor Morris, F.G.S.

Ordinary Meeting, Tuesday, February 2nd, 1864.

E. Cresy, President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. Edward Cooper.

The following donations were announced :—

“*Abstract of the Proceedings of the Geological Society.*” By the Society.

“*Versteigerung einer Mineralien-Sammlungs.*”

“*Quarterly Journal of the Geological Society.*” By the Society.

A paper was read,

“On Stones picked up in the Streets of London.” By C. T. Richardson, M.D., Cantab.

Of all the classes of rocks there is not any class more easily recognised than that to which granite belongs. To the practised observer so distinctive and characteristic are the granite-rocks, that whether surveying them in the field as portions of the mountain-mass, or studying hand-specimens, we may say, in the words of one of our most intelligent naturalists, when describing the features of a granite mountain, Tres Montes, in South America, 2,400 feet high,—“Granite to the geologist is classic ground; from its widespread limits, and its beautiful and compact texture, few rocks have been more anciently recognised.”—*Darwin's Naturalists' Voyage*, p. 284.

Of the critical specimens in the cabinet, scarcely a momentary doubt ever arises.

In the language of the text-books, and of most authors, granite is described as belonging to the Plutonic division, as distinguished from the Volcanic division of Igneous Rocks; or those presumed to have been formed under circumstances implying situations of great depths and other conditions of great pressure for their formation, as contrasted with those supposed to have been formed nearer to, at, or above the surface of our globe. Sir C. Lyell, taking a less general and more restricted view, apart from all other conditions, has named granite and its allies from the position in which it is usually found in relation to other rocks, designating them *Hypogenous* or *Nether-formed* rocks, as lying at the base of all.

The appearance which granite presents is familiar to most all of you, and is that of a granular crystalline mass, an assemblage or aggregation of crystalline substances of varying degrees of size, all more or less uniformly and thoroughly incorporated together, pre-

senting a highly sparkling appearance upon recent fracture. To these may be added a greater or less degree of hardness—density and closeness, or compactness of structure, with an almost entire absence of the features of stratification, foliation, lamination, or cleavage, which so peculiarly prevail throughout the sedimentary and altered rocks, and distinguish them as a class from the crystalline igneous rocks.

Thus summarily reviewed and described, granite, as a rock, is of easy recognition; but when more closely examined and scrutinized, its structure reveals to us features of far more definite character, value, and importance, varying in interest only with the purposes, views, and objects, of the investigator, and the course and method of his examination. For instance, the *Geologist* will content himself with the recognition of the presence and co-existence of certain substances of crystalline form well known to him, mixed up and incorporated together, more or less intimately, without any definite or perceptible order, and coupling therewith the characters just enumerated, sees and describes it only as a crystalline amorphous rock, containing certain elements, and of a presumed special source and origin, found usually in certain uniform relations to other rocks.

The Mineralogist will separate the elements composing the mass from each other, and by the mode of his investigation discovers the elements of the mass to consist of substances well known to him, presenting certain definite, constant, and unvarying forms called crystals, which pervade and are met with throughout the whole series and varieties of allied rocks; and he is thus enabled, according to the character, proportions, and variety in which they are present together, to base thereupon a classification, and calls the mass either a binary, ternary, or quarternary compound rock, modified by the presence of any distinctive element.

The Chemist also investigates, but still more closely, and examines into the intimate composition of these several supposed elements, and in revealing to us their nature and history, tells us that this apparently simple crystalline amorphous mass (granite) is a composition, possessing very highly interesting and complex chemical interest, containing combinations of definite and intricate proportional accuracy, of minutely divided degrees of atomic combining

power; and that not only were these combinations brought about and affected by laws not dissimilar to those which still affect and regulate the present great operations of nature, but that they must, from their very nature, only have been realized under their long continued intensity, and almost incomprehensible degree of active force; and so are we thus led on from the simple mechanical consideration and thought, to the far wider field of philosophical investigation, and mental contemplation of the interesting question of the source and origin of granite, and the supposed conditions under which it has been formed.

But before entering upon this it will be as well to consider some of the simpler and necessary features of its composition and history, and of the substances entering therein.

Granite in the ordinary form so well known to us is a compound of the three crystalline substances, *Quartz*, *Felspar*, and *Mica*, of general uniform size, and in certain proportions, and so thoroughly incorporated and dispersed in the mass as to present a tolerable regularity and compactness of structure, varying only with the size of the several crystals in its degrees of fineness, &c. Under this form it is usually spoken of as true, typical, or standard granite, and from the necessary co-existence of the three elements of its composition, it is called also ternary granite. From this type there are many variations, not only in the co-existence of these three elements and the degrees and proportions in which they are present, but also from the absence of some of them, and their substitution by some one or other of a class of substances other than those already spoken of, which are found to be present in some granite, and thus, according to the number of elements present we get binary, ternary, or quaternary compounds as granites.

Composition of ordinary granite is—

Silica.....	72·3
Alumina	15·3
Alkalis	7·4
Lime, magnesia, iron	5·0
Consisting thus generally of about	40 per cent. of felspar.
„ „ 30 or 40 „	quartz.
„ „ 10 to + 20 „	mica.

The substances thus entering into the composition of all granites whether *binary*, *ternary*, or *quaternary*, and those which by their presence constitute the variations from the true character of granite, and give especial designation to the varied compounds, may be divided into two classes:—

The Essential—consisting of quartz, felspar, mica, hornblende.

The Accidental—hornblende, hypersthene, actinolite, steatite, talc, and schorl or tourmaline.

QUARTZ is present in all true granite, and in most granitic rocks, and is generally a very prominent and visible element of their composition, presenting more or less perfectly the clear transparency of crystalline character, varying in colour from that of a silvery gray to white and other colours, according to circumstances, and in the size of its crystals from distinct isolated nodules of the coarser textures to that of the smaller granules of the closer and more compact. Its chemical composition is that of pure silica (SiO_2), belonging to the 3rd system of crystalline forms, or that of the hexagonal or six-sided prism, terminated by corresponding pyramidal surfaces, and having a specific gravity of 2.65, and a very great degree of hardness.

Of FELSPAR we have three recognised forms or varieties in granite, differing from each other in the nature of the alkaline base of their composition, and the proportions in which the base enters into combination with the other substances. Thus we have—

Orthoclase or Potash-felspar, with Potash as a base.

Albite „ Soda-felspar, „ Soda as a base.

Oligoclase „ Soda-felspar, „ Soda as a base.

But this latter in greater proportional combinations.

ORTHOCLASE is composed of 1 equivalent of trisilicate of potash, and 1 monosilicate of alumina; as a crystalline form it assumes that of the 5th system or the oblique prism, it is slightly flesh-coloured, less hard than quartz, and has a sp. gravity of 2.5 or 6.

ALBITE, or Soda-felspar, has one equivalent of monosilicate of soda, and 1 equivalent of monosilicate of alumina; crystallises in the form of the 6th system, or that of the doubly oblique prism; is of a more or less dull white aspect, and has a specific gravity of 2.6.

OLIGOCLASE is supposed to be composed of 3 equivalents of

monosilicate of soda, and 4 equivalents of monosilicate of alumina ; crystallises also according to the form of the 6th system, or doubly oblique prism, and has a specific gravity of 2·6, with a degree of hardness similar to that of orthoclase.

There are, however, many varieties of Felspars, but they have a general composition of silica about 65 ; alumina, 18 ; potash or soda, 12 to 16. (See Catalogue of, or Guide to the Jermyn-street Museum, p. 78.)

Felspars enter of necessity into the composition of all granite, and form also a very prominent element, more or less, of nearly all igneous rocks, and give by their presence, according to the respective variety, much of the distinctive characters which granites assume, and also some of those features which are of the most importance in the practical sphere to which my observations more especially relate this evening, namely, in paving-stones. Felspars occur in all varieties of size, as crystals, and in some forms of granite, as the porphyritic, of distinct size and separate.

Felspar seldom forms less than half the mass, and never less than one third, whilst both mica and quartz are in smaller proportions, sometimes in so very reduced quantities as to be scarcely visible.

MICA, the third of the essential elements to be considered, is always present in what is called true granites, and is usually seen as smaller or larger lamellæ, or scales of bright sparkling or glistening character, and of almost every variety of colour, from that of the lightest shade of white to that of the deepest black. There is also similar variety of composition, some containing potash, lithia, lime, magnesia, iron, &c., in varied quantities, and presenting corresponding varieties of appearance. There are, however, three more distinctly recognised and more usually met with than others, viz. :—

Margarodite, *Lepidomelane*, and *Muscovite* or Potash-mica, the most frequent of all, being the ordinary form usually seen.

Muscovite or Potash-mica is crystalline, biaxal, of the 5th or oblique prismatic system, is composed of 1 equivalent of trisilicate of potash to 3 equivalents of tribasic silicate of alumina, part of the potash being replaced by lime and protoxides of iron and man-

ganese, and part of the alumina by sesqui-oxide of iron, manganese, &c.

Margarodite or pearl-white Mica is also biaxial, has specific gravity 3·0 1, and is of a pale greenish white, with a pearly lustre.

Lepidomelane or black Mica is uniaxial, of dark colour, and of metallic lustre.

These two differ considerably in their composition, not so much as to the actual substances entering into as in the proportions in which they are present. Their minute analysis is not necessary or our purpose, the presence of mica and its varieties being all that is required.

THE ACCIDENTAL SUBSTANCES.

Talc.—5 equivs. of silica to 4 of magnesia. Of 3rd S., occurs in rhombic and 6-sided tabular crystals. Sp. gr. 2·7.

Steatite.—4 equivs. of silica to 3 of sp. gr. magnesia 2·6.

Hornblende or *Amphibole*.—6 equivs. of silica to 5 of mag. and lime, with protoxide of iron and manganese, is of 5th S. or oblique prismatic. Sp. gr. 3·2. Colour dark-green, sometimes almost black.

Actinolite.—Similar composition to Hornblende; is coloured green by chromium and iron. Sp. gr. 3·03.

Pyroxene or *Augite*.—Monosilicate of magnesia and lime, or 2 equivs. of silica to 1 of magnesia and 1 of lime, is of 5th S. or oblique prismatic.

Schorl or *Tourmaline*.—A combination of a double silicate with a *borate*. An obtuse rhombohedron of the 3rd system. Sp. gr. 3·3. Softer than quartz. Variously coloured. Has every degree of transparency from clearness to opacity.

Analysis of Schorl.—10 per cent. boracic acid.

39	„	silica.
31	„	alumina.
4 to 12		protoxide of iron.
2 to 9		magnesia.
		Lithia, potash, soda.

Associated also with granite as a paving-stone in our streets, are other rock-substances of closely allied characters and history as to origin, composition, and surrounding circumstances; and, although they do not realize and attain to what is considered and recognised as the true formula of the composition of granite as true and typical, are yet commonly spoken of as such, and used for some of its ordinary purposes. They possess many of the general external

characters, have a similar amorphous and irregular arrangement of their semi-crystalline and granular structure—are hard, dense, compact, and differ from true granites rather as chemical compounds, in the absence, either proportional or entire, of some of the essential elements, and the substitution and introduction of some of the class of accidental elements, than in their physical and external characters, and are consequently spoken of and described as Granitiform and Granitoid Rocks, from their greater or less similitude or approach to the aspect of True Granites. Of these the most prominent illustrations are Syenite, and its variations and allies, Greenstones, Porphyries, and such like, all frequently found either in the well-known size of modern street-pavement, or in the more comminuted form applied to the macadamized road. In some of the older street-pavements in bye-neighbourhoods, where the modern and costly system of dressed stones has not been introduced, the old-fashioned water-worn stone or cobble, little altered in shape, may yet be met with in roadways or crossing-pavements, and after rain these may be seen to consist of a great variety of stones of this class, as well as of granites of all colours, textures, and densities. I have also found other hard compact trappean rocks, basalt, and gneiss, but all more rarely.

Syenite possesses many of the external characters of granite, and approaches so closely to it in some forms that we are accustomed to hear syenitic granite spoken of and described, and we see it to have been applied in the days of the older kingdoms of the world to numerous similar purposes to that of granite, as the contents of our several collections of antiquities bear evidence.

It is a very hard stone, and as such was sought for for the purposes of paving even before the general adoption of granite, being generally far more durable than many of the varieties of that rock.

Its composition is not very dissimilar to granite, containing one element in excess of that of true granite.

Quartz, Felspar, and Mica constitute true granite, but when Hornblende (a substance composed of 6 equivs. of silica and 5 equivs. of magnesia and lime, with protoxide of iron and manganese) enters into the composition, we have a Quaternary, or Syenitic, or Horn-

blendic granite. And when the Mica disappears, and we have a compound of three, Quartz, Felspar, and Hornblende, it is considered a Syenite. It therefore differs only in the substitution of one chemical element of its composition for another, Hornblende instead of Mica, and preserves more or less the appearance of a crystalline aggregated mass, as does granite.

Greenstone, in like manner, by the forfeiture of quartz, consisting of Felspar and Hornblende, presents sometimes a coarsely grained or compact crystalline character, hard and dense, rendering it a serviceable substitute for granite as a paving-stone. It is an igneous rock, but differs from granite in many points as to the mode of its occurrence and other features.

This brief and cursory outline of the chemical composition of granite, and of some of the other rocks allied to it in constitutional characters, and associated with it in our economic and practical uses, will be sufficient upon the present occasion to show to you the beauty, interest, and complexity which they present when minutely scrutinised and investigated,—how apparently slight, though definite, are the degrees and shades of variation of the several elements which compose them; and also enable me to call your attention more immediately to the circumstances which render these several rock-masses so especially qualified by their lasting and enduring properties to fulfil the purposes to which we adapt them in our streets.

According to the Descriptive Guide of the Jermyn-street Museum, there are exported—

From Bovey Heathfield, Devon, 20,000 tons annually.

In 1855, 60,188 tons of china-clay or kaolin were obtained and exported from Cornwall, and 1,100 from Devonshire.

In that year alone the quantities exported from the Cornish and Devon districts, *as potters' material*, represented a money-value of £80,059 4s.

The facilities with which granites decompose and decay, as will be readily understood, depend partly upon the characters of their structure as to compactness and closeness, and their varied degrees, and also to the nature of mineral matters entering into their compositions. The denser and closer textures will longer resist the

admission of water than the coarser, and thus one great decomposing agent is rejected for a longer or shorter time. Much diversity of opinion, however, exists, even among men well qualified to judge upon the matter, as to which is the element most easily yielding, and promoting the process of decay; and nearly each element of the mass has in turn had its advocates—one cites some especial form of felspar, another points to some peculiar form of mica, another to the yielding of the matrix cementing the materials in one, another to the interstitial absorption of water and its disintegrating action under the several variations of thermal influence, and another to the chemical action of water when so admitted in promoting the oxidation, with more or less ease, of some particular mineral element existing in the mass. That each and all may in turns be right is beyond all doubt, for we see and recognise in any of the older mountain-watercourses the whitened margin betokening the felspathic decay of the fractured water-worn pebble of some igneous rock, and the well-known brown and weathered aspect of hornblendic rock under similar circumstances; we see quartz set free from both, and mica exfoliate; and many a granite-surface which comes perchance bright, clear, and glistening fresh from the chisel to-day, ere very long has become dulled and lustreless by the exposure to the action of our ordinary atmosphere. The mechanical absorption of water, the interstitial, as distinguished from the hygroscopic or chemical water existing in most crystals, with granites is doubtless a very potent agent co-operating with atmospheric and thermal variations in inducing disintegration and decay—the coarser-grained structures admitting it most easily, and disintegrating with great readiness in comparison with the closer and more compact; hence the existence of the large amount of special interest attached to the Cornish and Devonian granite-regions already mentioned, as compared with other localities. A paper read before the Society during one of our previous sessions, upon the relative qualities of our ordinary building-stones, told us that even the densest of all granites was capable of absorbing water to the amount of 1 per cent. And it is related by the well-known authority of Wilkinson's *Practical Geology and Ancient Architecture of Ireland*, and by Sir

R. Kane in his *Industrial Resources of Ireland*, that Irish granites, varying in weight from 143lbs. to 176lbs. per cubic foot, absorbed, after 88 hours' immersion in water, quantities varying from $\frac{1}{4}$ of a pound to 2lbs. and 4lbs. It has been said, and would also seem to bear the evidence of truth, if one may judge from the quantity of coarse-grained granites used for building-materials as foundations upon proper bases, constantly under water, that they not only do not then decay, but are capable of great endurance, a circumstance corroborating the action which is ascribed to atmospheric exposure.

Granite is generally considered as not a strictly eruptive rock, not poured out like modern lava, overlying and enveloping all beneath it, but coming from beneath in greater or less masses, elevating districts with an apparently long and gradually acting force over wide areas, as our Devonian and Cornish instances may well illustrate.

The Channel Islands also present a very large and interesting variety of crystalline igneous rocks, mostly in the form of syenites, porphyries, and gneissose rocks; granite, as true granite, forming a very small portion of their masses.

I hope, however, enough has been said to enlist you into the consideration of the paving-stones of our streets, and to invest them with interest in your thoughts.

Ordinary Meeting, Tuesday, March 1st, 1864.

Mr. E. Cresy, President, in the Chair.

The following gentleman was elected a member of the Association:—Mr. James Romanes.

The following donations were announced:—

“*Abstract of Proceedings of the Geological Society.*” By the Society.

“*Quarterly Journal of the Geological Society.*” By the Society.

“*Proceedings of the Liverpool Literary and Philosophical Society.*” By the Society.