d'arbres innombrables, les cellules pyramidales, qui, grâce à une culture intelligente, peuvent multiplier leurs branches, enfoncer plus loin leurs racines, et produire des fleurs et des fruits chaque fois plus variés et exquis.

Du reste nous sommes très loin de croire que l'hypothèse que nous venons d'esquisser puisse à elle seule expliquer les grandes différences quantitatives et qualitatives que présente le travail cérébral chez les divers animaux et dans la même espèce animale. La morphologie de la cellule pyramidale n'est qu'une des conditions anatomiques de la pensée. Or cette morphologie spéciale ne suffira jamais à nous expliquer les énormes différences qui existent au point de vue fonctionnel entre la cellule pyramidale d'un lapin et celle d'un homme, ainsi qu'entre la cellule pyramidale de l'écorce cérébrale et le corpuscule étoilé de la moelle ou du grand sympathique. Aussi à notre avis est-il très probable qu'en outre de la complexité de leurs rapports les cellules pyramidales possèdent encore une structure intraprotoplasmique toute spéciale, et même perfectionnée dans les intelligences d'élite, structure qui n'existerait pas dans les corpuscules de la moelle ou des ganglions.

"On Rocks and Minerals collected by Mr. W. M. Conway in the Karakoram Himalayas." By Professor T. G. Bonney, D.Sc., F.R.S., and Miss C. A. Raisin, B.Sc. Received February 15,—Read April 19, 1894.

During his journey in the Karakoram Himalayas, Mr. W. M. Conway collected more than 300 specimens of rocks and minerals, which, however, were generally rather small. These were sent to us for examination at University College, London. Thin slices have been prepared of the specimens which promised to be the more interesting. Of the rest, the mineral composition was verified in cases of doubt by examining pulverised fragments under the microscope.

Since the detailed results of our examination, which practically form an annotated catalogue of the specimens, will be printed as an appendix to Mr. Conway's forthcoming volume,* we restrict ourselves in this paper to a summary of our work, and to a notice of a few specimens which appear to be of more than local interest.

(1.) *General Description.*

Commencing with the crystalline rocks, and with the most basic of these, we find one specimen of a dark green serpentine, containing

* Since this paper was read, the first or descriptive part of the work has been published ('Climbing and Exploration in the Karakoram-Himalayas'), which gives the positions of the localities mentioned herein.

small glittering crystals of bastite, brought from *débris* at foot of a slope at the village of Mapnun on the Burzil Pass. The rock has been evidently affected by pressure, and is practically identical with a type of serpentine rather common in the Alps.

Many varieties of diorite have been collected. Of these, some are almost hornblendites (see below), others are normal diorites varying from coarse to fine grained, others, again, are really hornblende-schists. In some of the last it is likely that the foliation (as we believe to be generally the case with the hornblende-schists of the Lizard and of Sark)* is the result of fluxional movements anterior to consolidation, while in others this structure is more probably due to pressure, and to consequent mineral changes subsequent to the first solidification of the rock.

Granites are rather numerous. Some are of a normal type, moderately coarse grained, the mica (variable in quantity) being generally biotite. Certain of these are slightly gneissoid in structure. More definitely foliated, almost certainly as a result of pressure, are some rather micaceous (biotite) granites. Yet more distinctly gneissic rocks occur, with a mineral banding as well as a foliation, in which pressure modification is generally to be noted. One group of these has a rather markedly different character; they are fine grained gneisses, modified by pressure (to which, however, the texture does not appear to be due), not rich in quartz, consisting mainly of felspar (orthoclase or microcline and plagioclase) and biotite, with a more or less definitely banded structure. They present a considerable resemblance to certain rocks found in the district about Blair Athol (Scotland), which Dr. H. Hicks, in consequence of their rather peculiar aspect, has named the "pepper and salt" gneisses. We find also a coarse granite, rather porphyritic in structure, and rendered gneissoid by pressure, which contains large red impure garnets, up to about $\frac{3}{4}$ in. in diameter. Similar garnets, but of smaller size, also occur in several varieties of granite and gneiss; one of these might almost be called a kinzigite, others are granulites (leptynites).

The compact acid igneous rocks are not numerous; but a rather remarkable series from the neighbourhood of the Golden Throne calls for a little notice. Some come from the moraine proceeding from the west foot of the mountain. These are compact, but show a schistose structure with slightly micaceous or talcose aspect, indicative of crushing. They are parti-coloured; a grey, varying from slightly to markedly greenish, being streaked, spotted, and blotched with a dull Indian red, small white specks showing in some of the patches. The texture of the lighter part under the microscope is

* T. G. Bonney and General C. A. McMahon, 'Quart. Jl. Geol. Soc.,' vol. 47 (1891), p. 497; E. Hill and T. G. Bonney, 'Quart. Jl. Geol. Soc.,' vol. 48 (1892) p. 145.

speckled, or somewhat fibrous, with indications of minute aggregate polarisation, this being most conspicuous when it makes an angle of 45° with the vibration planes of the crossed nicols. The fibrous mineral very closely resembles the so-called sericite of some porphyroids. Here and there are grains of quartz, decomposed and sometimes broken felspar crystals, and some dark reddish, flaky patches. The dark microscopic spots contain corroded grains of quartz, decomposed or partly corroded felspar crystals, and the same dark red flaky minerals in a crypto- to micro-crystalline matrix. In one rounded lump, at first sight very like a pebble, some grains of crystalline calcite are enclosed. The smaller patches, though varying in detail, present a general resemblance, and there can be little doubt that they are fragments of a devitrified acid igneous rock. In the absence of definite characters, it is difficult to speak positively as to the nature of the matrix, but most probably it was once a volcanic glass, which has since undergone micro-mineralogical change, mainly in consequence of pressure.*

Though the red patches occasionally look very like pebbles, it is more probable that they are due to a flow brecciation. If we are right in our inferences, these rocks of the Golden Throne indicate an outpouring of acid lavas prior to the mountain making. Other specimens from the same district are generally similar to the above-described, but present varietal differences, and a small specimen of an Indian red colour from *débris* on the Baltoro glacier is very probably a tuff, though the amount of crushing makes it difficult to be sure.

The crystalline schists include epidote-, Piedmontite-, and various mica-schists. The first of these very probably occurs as a band in a hornblende-schist, and a rock very similar to it may be found at more than one locality on the Lizard peninsula, in Cornwall. The second schist will be described more fully below. The third group contains several varieties, one of which will receive a separate notice. Of the rest, it may suffice to say that with one exception they are ordinary types; this, however, though a well known one, has sufficient interest to warrant a slightly fuller description. The rock, which comes from the Hunza Valley, between Gulmet and Tashot,† is a dark lead-coloured schist containing garnets. The latter, on microscopic examination, are found to be a pale reddish colour, sometimes fairly regular in outer form, cracked, granular in structure, and often containing a fair amount of dusky enclosures. These have a somewhat dendritic grouping; the angles which the tufts make one with another are such as to suggest relations with the process

* As has happened in many porphyroids (T. G. Bonney, 'Proc. Geol. Assoc.,' vol. 9, 1885, pp. 250—258).

† Many fragments of this rock were lying along the bottom and slopes of the valley. Multitudes of garnets were found a little higher up the valley.—W. M. C.

of crystal building. Also tubes or fibrous cracks are present, arranged generally at right angles to the faces of the garnet. Rather irregular crystalline grains of yellowish staurolite with many enclosures occur; also irregular grains of magnetite, and numerous little patchy flakes of brown mica. These are all set in a crystalline matrix, consisting of white mica and (apparently) granular quartz, with usually a considerable quantity of opacite (probably graphite), a few small tourmalines (strongly dichroic, changing from a light to a brownish or dull greenish tint), and some small rutiles. A similar schist comes from near Askole, and one without garnets, but in other respects like these, from the south flank of Crystal Peak. The chief interest of these garnet-bearing mica schists is their very close resemblance to schists in the Lepontine Alps,* as described by one of us, where the rock is a local variety of a dark micaceous schist, and it occurs, to his knowledge, at intervals for a distance of over 30 miles in a straight line along the chain.

With the mica schists we may mention, under the general name of sericite schists, several very much crushed rocks from Kamar nala, Mir, and the Dar Valley, Bagrot, and then pass on to a group of more or less calcareous schists, such as are developed in the Alps, and are there associated with quartz schists, green schists, and the aforesaid black garnet schists. In that chain they not unfrequently pass into crystalline limestones or dolomites, and rocks of this character also occur in Mr. Conway's collection. One or two contain malacolite, and some show distinct signs of having been affected by pressure.†

Passing on to the ordinary sedimentary rocks, we find a number of limestones, more or less impure, some containing fragments of other rocks, with schistose calcareous grits, besides argillites and slates, one or two of the latter resembling the slates of Llanberis (North Wales). A few of the specimens contain much crystalline material, so that it is difficult to decide whether they are very crushed dark schists, or slightly altered slates largely composed of detrital crystalline material. Rocks may be found in the Alps which present similar difficulties.

Sandstones, grits, and conglomerates occur; some of the gritty rocks show a cleavage, and certain near the Golden Throne probably contain volcanic materials. A conglomerate from Mapnun, in the Burzil Valley, contains a fragment of a quartz diorite, which obviously had been already modified by pressure when it was made into a pebble, indicating that in this mountain region, as in the Alps, earth move-

* T. G. Bonney, 'Quart. Jl. Geol. Soc.,' vol. 49 (1893), p. 105, &c. We are informed by Mr. G. Barrow, F.G.S., that a similar schist occurs in the Central Highlands of Scotland.—T. G. B.

† T. G. Bonney, 'Geol. Mag.,' 1889, p. 483, and 1890, p. 536.

ments must have occurred long anterior to those which have produced the existing chain. Lastly, two partially altered sedimentary rocks are of some interest. The first, from a fallen fragment halfway between Samaiyar village and Strawberry Camp, on the left bank of the valley, is a blackish, compact, slightly-cleaved rock, not distinctly crystalline, in which are scattered several crystalline grains, the largest slightly more than one-eighth of an inch in diameter. This has one fairly well-marked cleavage, with a subvitreous, slightly oily lustre, and a second more imperfect, meeting it at an obtuse angle. The hardness seems to be slightly less than 5. Under the microscope the ground-mass is seen to consist of minute films of a sericitic mica mixed with a minute colourless mineral and granules of opacite and ferrite. In this are scattered larger irregular grains and plates of a black mineral, with raggedly outlined flakes of biotite, containing much of the ground-mass, some prisms (probably rutile), and two or three specimens of a larger mineral (probably the same species as that already mentioned). The best defined has two cleavages, one more strongly developed than the other, meeting at an angle of about 76°, and extinction takes place at an angle of 30°, or a little less, with the former. The crystals exhibit a rather irregularly outlined prismatic form, the sides being roughly parallel with these cleavages, and are crowded with minute materials, apparently identical with the ground-mass. This presents a slight resemblance to that of the ottrelite rock of the Forges de la Commune, Ardennes, and of one or two schistose rocks from the Alps, which do not belong to the most ancient group. Both the biotite and the above-named mineral appear to have been formed *in situ* at a time when molecular movements were not easy. We are unable to identify the latter with any mineral known to us, but it somewhat recalls to mind the "knoten and prismen" from certain Jurassic rocks in the Lepontine Alps,* and even the couseranite from Vicdessos (Pyrenees). It does not seem to be tetragonal. We venture to suggest that it is a hydrous alumina-lime-silicate allied to the scapolite group. The matrix around the crystals is slightly coarser than elsewhere. Possibly the peculiarities in this rock may be the result of contact metamorphism. The other rock from near Trough Camp, on the right side of the névé, obviously contains rather angular fragments of white marble imbedded in a hard matrix, grey, speckled with dark green, in colour. The larger marble fragments are stained externally with limonite; many of the smaller are altogether brown. Microscopic examination shows these to consist alike of crystalline calcite, fairly coarse in the whiter parts, fine-grained in the iron-stained. Both structures are sometimes present in the same fragment, and their relations suggest that the fine-grained one comes from a

* T. G. Bonney, 'Quart. Jl. Geol. Soc.,' 1890, vol. 46, pp. 213—221, 232—236.

crushing of the coarser. The matrix has a sub-crystalline aspect, and is variable in character. In one part sub-angular grains appear to be, as it were, set in a matrix composed of small scales of mica (mostly white, but some green), and of a chalcedonic material. This condition closely resembles that described in some Huronian conglomerates, and probably results from the alteration of a felspathic grit. In other parts a large grain of quartz is occasionally seen, commonly fairly well rounded, and the ground-mass consists of a mixture, resembling that already described, of minute mica with felspathic-looking granules, enclosing larger crystals of green and brown mica and crystals of a second mineral. These are fairly developed, rather elongated prisms (varying from about 1 : 4 to 1 : 8) up to 0·04 in. in length, rather full of microlithic enclosures, very pale yellowish-green with transmitted light, with dichroism almost imperceptible, and moderately bright-coloured with crossed nicols. The mineral shows a rather irregular transverse cleavage with occasional hints of one parallel to the sides of the prism, and extinguishes straight or nearly so with the latter. Though it has a general resemblance to epidote, the cleavage parallel with the above-named sides is not so marked as usual. It is, however, more like this mineral than andalusite, with specimens of which we have compared it. The mica, which occurs in flakes, is dichroic, changing generally from a light straw colour to a brownish-green. It has formed after the epidote, and as it frequently borders the fragments of marble it may possibly be a lime-mica. It produces the impression that it is slowly eating up the ground-mass. Of other minerals present in parts of the slice, rutile, sometimes in geniculate twins, is rather abundant, and is included in both the epidote and the mica. From its mode of occurrence a derivative origin seems probable. A few granules of iron oxide, apparently limonite, occur, also a rounded grain of zircon, and one small crystal of brownish tourmaline, secondary in origin.

(2.) *Remarks on Certain Specimens of Interest.*

We proceed next to describe more particularly those rocks already mentioned which are more specially interesting. First of these are some rocks consisting almost wholly of hornblende.

Hornblendites.—One of them from a fallen block on the west side of the Astor Valley above Dashkin is a dark green, rather friable rock, which consists chiefly of hornblende, mostly in porphyritic crystals about $\frac{3}{4}$ inch long. More than one variety of this mineral appears on microscopic examination : one is blue-green (for rays along the $\mathfrak{c}$ axis), and a yellower green (for direction at right angles); the other, in larger crystals, is strongly dichroic ($\mathfrak{a}$ straw colour, $\mathfrak{b}$ dark bronze-green, $\mathfrak{c}$

similar but slightly darker). In the latter, enclosures, probably hæmatite, are rather frequent, which apparently lie in the pinacoidal planes.* We find also some plagioclase felspar, a little pseudobrookite, rutile, and pyrite. The rock has suffered from pressure, which has caused locally the formation of a chlorite, and possibly of some secondary felspar.

Another specimen from the same locality seems to be a schistose form of a similar rock. It consists mainly of a blackish, glittering, fibrous hornblende, and thus is very dark green in colour. Its surfaces are somewhat slickensided and are covered with films of green copper ore. A few elongated grains of clear felspar or quartz appear on microscopic examination, but the slice consists almost entirely of hornblende in rather elongated prisms, with a very definite orientation. This is markedly dichroic, changing through bluish-green (𝔠 axis) to grass-green (𝔟 axis), or almost colourless (𝔞 axis); it contains occasionally small crystals of rutile, rather impure, arranged along the cleavage planes. A system of parallel planes extends continuously across the crystals of the slice whatever their orientation, roughly making angles of 70° and 110° with the foliation. Even in a grain of (?) quartz lines of enclosures seem to continue the direction of these planes. The rock is now a hornblende schist, but it was probably produced by pressure from one closely allied to a pyroxenite.

Piedmontite Schist.—We come next to specimens of Piedmontite schist, all from near the Gargo glacier. One from the left bank or moraine shows in a rich purple compact matrix a number of dull white spots, rather fragmental in aspect. These exhibit a slight orientation, and traces of divisional surfaces are perceptible, cutting this at an angle of rather more than 35°. Quartz, white mica, and piedmontite, the first being the most, the second the least, abundant, and some felspar, are the principal minerals shown in the slice. The quartz contains enclosures, generally minute but variable in size, occasionally with bubbles. The piedmontite occurs in more or less clustered grains or irregular short prisms. With ordinary transmitted light the mineral exhibits a great variety of tints, from rather dull pale orange or straw colour to a rich purplish-pink or strong orange-red, inclining sometimes to a burnt sienna, sometimes to a more purple hue. On testing for dichroism, we find in sections parallel to the orthodiagonal the colour changes from pale pink (parallel to 𝔟 axis) to rich pink (𝔠 axis, as stated by Lévy), and in sections more or less transverse from pale yellow to burnt sienna, and in some sections from deep amber (𝔞 axis)† to a rich pink or slightly orange-purple.

* These might be similar to the enclosures in schillerised pyroxenes described by Professor Judd, which, however, consist of mixtures of limonite and other oxides. See 'Quart. Jl. Geol. Soc.,' 1885, vol. 41, pp. 379, 381, 384, &c.

† 'Les Minéraux des Roches,' p. 184.

The grains are apt to be irregular in external form, and seldom exhibit a perfect crystal outline; besides this they have generally a rather dusty look, as if they contained numerous small enclosures We find also one or two grains of a mineral rather irregular in outline, which has two cleavages crossing at a large angle, and exhibits not very high polarisation tints. It is probably monoclinic or triclinic, and a secondary product. In parts of the slide crystalline granules of iron oxide (? hæmatite) are fairly abundant, and exhibit a somewhat streaky arrangement. Under the microscope the white spots of the rock consist almost wholly of crystalline quartz, and have a somewhat brecciated aspect. This suggests that the specimen may be from a vein, but the rest of the rock in structure more resembles a schist. There seem to be some slight indications of mechanical disturbance, but if this has occurred it has been followed by very considerable recrystallisation.

The next specimen (fig. 1) comes from a small boulder on the south bank of the stream flowing from the east through the "maidan" of Gargo. This appears to be a rather compact and hard schist, which

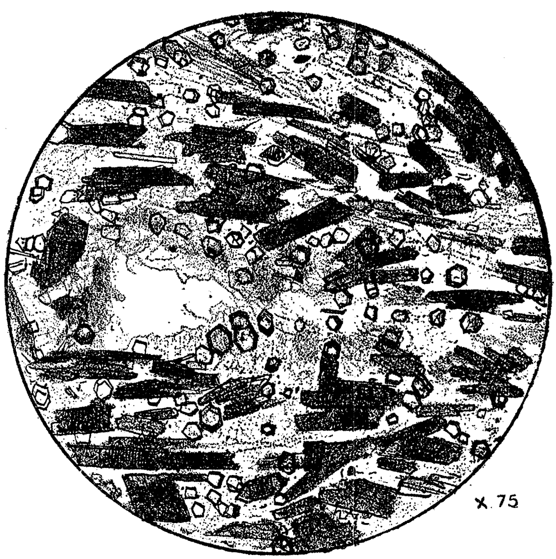

FIG. 1.—Piedmontite Schist, near Gargo Glacier.

evidently contains a fair amount of white mica in very small scales, and is rather rich in piedmontite. At the first glance the slice exhibits a large number of crystals of piedmontite, similar to those already described, together with small garnets and two micas, one

colourless, the other brown, in little films, all scattered in a fairly glass-clear ground-mass; one or two grains of iron oxide and possibly of rutile occur. The crystals generally have a foliated arrangement, and are somewhat irregularly grouped, comparatively free lacunæ occurring here and there. The garnets are clear, and contain a few enclosures (? cavities); they usually occur in well-formed dodecahedra, and are about 0·002 inch in diameter. This is seldom and very slightly exceeded, but much smaller specimens are not rare. The white mica is less abundant where the garnets are common, and has a tendency to occur in larger crystals and group itself round the lacunæ. With crossed nicols the greater part of the ground-mass exhibits a rather minute mosaic structure, and is probably, at least to a considerable extent, secondary felspar. The larger interspaces prove to be in some cases aggregated granules of quartz, in others an almost water-clear felspar, cleavage planes and occasional twinning being perceptible The outline of the felspar is very irregular, and it is associated sometimes with granules like those above mentioned, as though it had been partly replaced by them. There can be no doubt that the piedmontite, the garnet, and possibly some of the white mica are of secondary origin. It is even doubtful whether all the larger grains of felspar and quartz are intact, for some contain more microliths than might have been anticipated. Calcite occurs locally in patches; in one place also a slightly granular mineral, giving bright tints with crossed nicols. The rock is now a piedmontite schist, but it is difficult to suggest what its original condition may have been, not improbably a fairly coarse-grained gneissoid or granitoid rock.

Another specimen from the left half of the Gargo glacier bears some resemblance to the preceding, but is less micaceous and paler in colour; also it contains a vein of quartz with some minute calcite. Even on microscopic examination the distinctions for the most part are only varietal, but broken felspars of considerable size are rather more conspicuous in the specimen, and the rock generally affords very marked indications of fracture and reconstitution. There is another specimen from the left side or moraine of the Gargo glacier (below the icefall), which has a general resemblance to the last but one, but has a slightly more slabby character.

These rocks have been compared with a specimen of the piedmontite schist of Japan, presented to one of us by the kindness of Professor Koto. This contains the characteristic mineral about as abundantly and as well developed as the Gargo specimens, but has more iron-glance (?), and more white mica, which sometimes seems to be slightly tinted by the manganese. The rock also is more definitely foliated.

Schist with Conspicuous Secondary Mica.—From Dasskaram Needle comes a pale grey, closely laminated silvery schist, markedly cal-

careous (effervescing with HCl), including minute dark grains. It contains numerous crystals of dark mica, as much as a quarter of an inch across, their outline being clearly defined and sometimes hexagonal. These commonly traverse the foliation planes at a high angle, and are unusually thick. Thus the edges, which project from a weathered silvery surface, have the form of oblong prisms, and somewhat resemble, as the colour varies from a very dark green to almost black, crystals of hornblende. Under the microscope the ground mass exhibits a foliated and slightly banded structure, and apparently consists in part of small grains; some seemingly calcite, while others —rather irregularly formed, partly free from enclosures, of a water-clear mineral, giving somewhat low polarisation tints and with a kind of zoned structure—are probably secondary felspars, which may retain traces of an original nucleus. The ground-mass contains also mica with, perhaps, a little chlorite. The larger crystals of mica exhibit a curious and interesting structure. They are generally a light brown in colour, but they assume a greener tint near to the outside. The former part is fairly dichroic, varying from a light, slightly greenish-brown to a fairly rich warm brown; but the greener parts are paler and not dichroic. The crystals are usually somewhat irregular in outline, but the cleavage is fairly good. In parts of the slide the mica appears in numerous small patches, mixed up with the ground-mass. These in some places seem to coalesce by

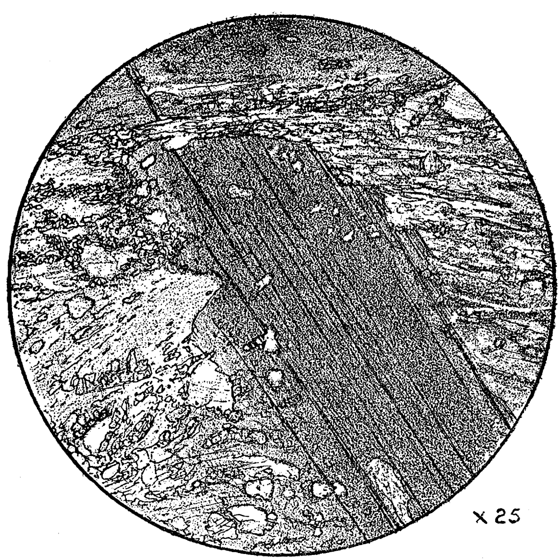

FIG. 2.—A Grain of Secondary Mica in Schist from Dasskaram Needle.

a gradual replacement of portions of the ground-mass, so as to form ultimately a kind of setting for the grains which remain. In other parts, however, though a considerable portion of the ground-mass persists, the characteristic cleavage of the mica can be readily detected,* its pleochroism being wanting, while a straight extinction is quite discernible. In these cases we have, as it were, the ghost of the mica, but commonly, as the mineral becomes more and more characteristic and pleochroic, the constituents of the ground-mass correspondingly disappear, until at last only few of them remain (fig. 2). In these, however, the original orientation is still preserved. Towards the edge of some of the grains the white mica, chlorite, &c., of the ground-mass seem, as it were, to pierce the brown mica. It is quite clear that this mineral has been formed after the production of the cleavage-foliation in the rock.† The manner of its occurrence suggests very strongly that its composition differs but slightly (except for the absence of CO_2) from that of an average sample of the ground-mass.

We are indebted to Mr. P. Williams for the following analysis of this mica, made in Professor Ramsay's laboratory at University College. As only a very small amount of the mineral could be spared for the purpose, he was placed under considerable difficulties, and found it necessary to compute the alkalies as potash. It must be also remembered that the crystals are rarely quite free from particles of ground-mass:—

SiO_2	30·3
Al_2O_3	24·7
Fe_2O_3	7·7
CaO	7·3
MgO	8·6
K_2O	14·0
H_2O	9·6
	102·2

The analysis corresponds generally with that of a hydrous mica, but has more potash (or alkalies) than is usual. It differs from biotite, which the mineral most resembles, in the higher percentage of alumina (in which it comes nearer to muscovite), and in the large amount of lime. So far as the mineral can be classified it appears to be a hydrous biotite, with a considerable part of the magnesia re-

* The cleavage locally is so strongly marked that at first sight one almost anticipates a twinning. The cleavage seems to be present, if one might say it, almost in advance of the mica.

† See T. G. Bonney, 'Quart. Jl. Geol. Soc.,' 1893, vol. 49, pp. 104—113, fig. 1, p. 107.

placed by lime. It is roughly intermediate between a lime-margarite and a meroxene described by Dr. Grubenmann.*

(3.) *Mineral or Vein Specimens.*

A considerable number of the specimens brought by Mr. Conway are vein-stones, or representative of minerals rather than of rocks. Quartz, of course, is common; calcite, dolomite, and chalybite not unfrequent. Besides these are found the following:—Anhydrite, actinolite, idocrase, noble serpentine, copiapite (probably from decomposition of pyrite), and almandine. There are numerous examples of common garnet, many of epidote and of tourmaline; also of pyrite, with chalcopyrite and other copper ores, usually in small amount. We have looked carefully for gold in the pyritiferous quartzose veins and other specimens, but have not detected any traces. One specimen alone seems to call for special notice—a pseudojade—and this perhaps is, more strictly speaking, a rock rather than a mineral, but we place it here since it was a fragment on a moraine (left half of the Baltoro Glacier), and nothing is known as to its origin. Its form is angular, being partly limited by joints; it is of a variably greenish colour, irregularly mottled by a pale yellowish tint. The hardness is about 6·5, the sp. gr. 3·26, and the general appearance suggests a jade, but it differs in microscopic character from the few specimens of that rock which we have examined.† A slice exhibits, in ordinary transmitted light, a ground mass of a very pale yellowish colour, containing irregular, dusty looking patches and lines, variable in their distribution. The parts freer from these enclosures are almost inert on polarised light, but contain at places a fibrous flaky mineral, extinguishing straight, and very faintly polarising with dull, olive-brown colours. This we find to correspond generally with the greener parts of the specimen. The more dusty intervals (those corresponding with the paler parts), exhibit, with crossed nicols, distinctly marked aggregates of very minute granules, and also a fibrous prismatic mineral, rather more brightly polarising, extinguishing at a fairly high angle, and having a somewhat matted arrangement: not improbably a pyroxene. There are some rather clustered granules and grains of a translucent brown mineral, seemingly isotropic, possibly a variety of garnet.

We have to thank Mr. P. Williams, of University College, for the following analysis, made in Professor Ramsay's laboratory.

* Quoted in 'Quart. Jl. Geol. Soc.,' vol. 46 (1890), p. 227.

† General C. A. McMahon has been good enough to examine the slide and to give us the benefit of his experience of Indian rocks, determining at the same time the specific gravity of the specimen and making a qualitative analysis.

SiO_2	38·22
Al_2O_3	13·83
Fe_2O_3	7·81
CaO	25·55
MgO	3·73
K_2O	7·07
Na_2O	2·46
Loss at red heat	1·89
	100·56

Microscopic examination, no less than chemical analysis, shows that this specimen cannot be referred to nephrite, and consists almost certainly of more than one mineral. But it is very difficult to ascertain what these may be. The microscope does not give much help, for it indicates an aggregate of ill-defined constituents, which sometimes recall the structures seen in examining the material named saussurite. The chemical analysis is remarkable for its richness in lime and alkalies (especially potash) and comparatively low percentages of silica and alumina. The general character of the rock suggests the possibility of jadeite being an important, if not the main constituent. But, according to Krenner,* the normal analysis of this mineral is $SiO_2 = 50·23, Al_2O_3 = 25·37, Na_2O = 15·40$, and, though the actual analyses of specimens (doubtless being mixtures) have generally rather more silica, and less alumina and soda, with a little lime and protoxide of iron, still they do not correspond with the present one. Apart from the difficulty of the presence of so much potash, we should find, if we supposed the alkalies to be contained in jadeite, hardly any silica or alumina left to go with the lime and other protoxide constituents. Saussurite would account for some of the alkalies and of the lime, but it has nearly the same silica percentage as jadeite, and a rather higher one of alumina. Zoisite (proper) epidote, the scapolite group, and elæolite present, in each case, important differences. Certain of the constituents agree fairly well with one of the lime garnets.† The rock in which this occurs is said to be homogeneous, tough, with a rather waxy lustre, and a yellowish-white colour—hardness = 7, and sp. gr. = 3·33 – 3·64. It gave, on analysis, $SiO_2 = 44·85$; $Al_2O_3 = 10·76$; $Fe_2O_3 = 3·20$; $CaO = 34·38$; $MgO = 5·24$; loss by ignition, 1·10. Total, 99·53; and of this Dr. Hunt takes, for the garnet, $SiO_2 = 22·69$; $Al_2O_3 = 10·76$; $Fe_2O_3 = 3·20$; $CaO = 21·07$. Total, 57·72. Such a mineral as this, if present in considerable quantity, would leave in the Karakoram rock a fair amount of silica for the alkalies and remaining protoxide bases. A

* 'Neues Jahrb. f. Min.,' 1883, ii, p. 173.

† T. S. Hunt, 'Amer. Jour. Sci.,' vol. 27 (1859), p. 342.

mineral resembling a pyroxene seems to be present. On the whole, after consulting many analyses of rocks and minerals, we venture to suggest that this rock may be composed of a lime garnet,* a potash jadeite, a mineral of the scapolite group, and a little pyroxene (or, possibly, even wollastonite or pectolite). It is more probably a vein product, for the low percentage of alumina seems to exclude the possibility of a felspathic euphotide.

(4.) *Geographical Distribution of the Rocks.*

Mr. Conway's collection commences with some specimens from the Jhelam Valley below Barramula. These are a limestone and slates, not unlike some which occur in the Secondary series of the Alps. The next specimens are from Gurai, in the side valley north of the Tragbal Pass. These (fallen blocks) are granite and diorite. Advancing thence up the valley of the Kishanganga and the Burzil Valley, †phyllites,† a †conglomerate and then a †granite were collected, and fallen blocks, near Mapnun, furnished a slate and a serpentine. Descending from the Burzil pass towards the Astor Valley, †hornblende diorite and †chlorite schist were found; in fallen blocks diorites and a micaceous gneiss; and one water-rolled specimen of argillite. Near Astor, two varieties of gneiss were obtained from boulders. Below Astor, a †diorite on the west of the river, and apparently also on the east, and fallen blocks of hornblendite on the west, a †garnetiferous gneiss (near Parri), common as big boulders down the valley; and then †granulite and †fine-grained gneiss (these two abundant by the roadside). The strikes and dips recorded by Mr. Conway in some cases may be planes of jointing rather than of bedding, and in crystalline masses they are most probably to be reckoned as results of pressure. Down to this part of the Astor Valley, the strikes vary from 15° W. of N. to 10° E. of N., the dips varying from 30° eastward to vertical. From the lower part of the valley, and from below Hatu Pir come †micaceous gneisses, and †diorite at Ramghat. In the valley the strikes vary from N.N.E. to nearly N.E., the dips being on the south-eastern side from 30° to 45°, while below Hatu Pir the strike varies between 10° N. or S. of E., the dips being 33° on the southern side.

The first specimens brought by Mr. Conway from the valley of the Indus come from the neighbourhood of Bunji. They are †granite, hornblendite, decomposed diabase, and micaceous gneiss. The next specimens are representatives of the Bagrot Valley; its stream enters

* The constituents of the greater part of the rock are so feebly double-refracting that a fair quantity of an isotropic mineral, if disseminated in granules, might easily elude discovery.

† Specimens marked thus † were obtained *in situ*.

Gilgit (a tributary of the Indus), carring the drainage of a line of lofty peaks and their southern spurs, which curve round from Rakipushi on the west to Emerald Peak on the east. From below Sinakar, in the lower part of the Bagrot Valley, comes a †hornblende schist (the general strike being nearly E.N.E., dip 55° northerly) and a †diorite. Hence to a fork in the valley near the foot of the Bagrot glacier, the specimens represent apparently †crushed gneiss, and diorites of more than one kind. One of these is said to extend far along the valley; others are common in the *débris*. Some strikes are recorded to easterly or east-north-easterly points, but the dips vary. The Bagrot glacier issues from a loop of peaks, and Mr. Conway remarks that the mountains on the western side of the glacier as far as Rakipushi consist of hornblende rocks, like those of the Bagrot Valley. From the ridge he collected a †crushed gneiss, and from the Kamar nala beyond a crushed †quartzose mica schist. On the eastern side of the glacier were collected a calcareous †sillimanite schist and a †hornblende schist, the latter being pretty certainly a crushed doleritic rock, and not unlike some of the "grüner schiefer" of the Alps. From the glacier come a diorite, common in the left moraine, and a crushed mica schist. Passing up the eastern fork, Mr. Conway collected a †hornblende schist (or pressure-modified diorite), a †mica diorite, and some †sericite schists, before reaching the foot of the Burchi glacier which, descending from the north, joins the yet larger Gargo glacier. The specimens from near the former represent a crushed †calc-mica schist (*in situ* on the spur between the two glaciers) and (from the left moraine) a diorite, an impure limestone, and a phyllite, so that there must be here an infold of comparatively unaltered rock. From the other glacier a crushed †actinolitic schist occurs on the left bank of the valley beyond Gargo; yet further up on this side comes a †gneiss (crushed). The glacier was now crossed again to the slopes beneath Emerald Peak, on the ascent of which †sericite schist and †chlorite schist were obtained. The right moraine of the Gargo glacier furnishes sericite schists, the left moraine or left side, piedmonite schists, chlorite schist, diorite, hornblende schist or schistose diorite, calc-mica schist, and phyllite; from the more disturbed material is another diorite. Piedmontite schist also comes from a boulder farther down the valley on the left side. The exact locality where this interesting rock occurs *in situ* is not determined, but it is clearly somewhere in the buttresses of the Gargo Peaks. These are part of a huge spur which extends from the Emerald Peak to Dubanni. The strikes along the Gargo Valley from the fork are generally between 5° S. of E. to 7° S. of E.S.E., the dips on the south side of the valley and on a peak east of Gargo, are northward (from 40° to 80°) or vertical; on the north side of the valley they are southward 60°. On the hill above the icefall, how-

ever (left side), and on Emerald Peak, the strike is N. of E.N.E., the dip southerly 30° to 75°.

The next set are from the valley leading to the Gilgit river from Chalt. The geology of this region was investigated by Surgeon Captain Giles. Here Mr. Conway took but few specimens (†diorite and †hornblendite), and remarks that the rocks are similar to those of the Bagrot Valley. Approaching and passing Chalt, †crystalline limestone *in situ* and a †chloritic rock occur; the strike of these varies from 8° E. of S.E. to 13° S. of E., the dips being northerly from 50° to 85°. It is noted that much nearer Gilgit the strike of the rocks was E., with a varying dip, and that on going northward it bends round to be a little more nearly in the direction of the valley.

The next set of specimens represent the rocks between Gulmet and Shaiyar; they are †schistose calcareous grit, †fine-grained gneiss (both sides of the river), a †granulite, a †crystalline limestone, a †micaceous gneiss (at Shaiyar), and as loose specimens, garnets, common near the crystalline limestone, a felstone (Gulmet), and black garnet-schist (abundant). It is highly probable that we have in this region, as in parts of the Lepontine Alps, a series of gneissic rocks overlain by a group of crystalline schists, probably metamorphosed sediments, over which comes a newer series of comparatively unaltered strata. The strikes at this part are stated to be "parallel with the valley near Gulmet, the dip being 30° in a southerly direction"; above this they vary apparently from E.N.E. to E.S.E., the dips being generally on the southern side, from 20° to vertical.

In the Samaiyar Valley, below the glacier, are a †fine-grained gneiss, †granite (left side, west of camp), and, from fallen fragments on the same side, a schistose (?) dipyr rock, crystalline limestone, a mica schist (with some secondary mica), and a schistose grit (brought down abundantly by avalanches). The character of these rocks suggests the possibility that the granite is intrusive in the sedimentaries. The strikes in this part of the valley vary from 5° N. of N.E. to 7° S. of S.E., the dips being very high, generally from 85° to vertical. Along the Samaiyar glacier, on the left bank, is a †somewhat micaceous gneiss. On the right, near Trough Camp, is a †micaceous conglomerate, which recalls some rocks of Huronian age in Canada. On the same side, near the east end of "Trough Saddle," is a †fine-grained gneiss (common down the left moraine of the glacier). The strikes below Trough Camp are between E.S.E. and 10° S. of S.E., dip southerly 55° to 80°, but at the east end of "Trough Saddle" the strike is nearly N.N.E., the dip vertical. After returning to the Nagyr Valley and ascending to Hopar, there come, beyond it, a †fine-grained gneiss, a †mica-diorite, and as loose specimens along the left side of the Nagyr Valley, and of the Bualtar glacier (apparently from the Crown of Dirran), diorites; from the medial

moraine of the glacier a granite, and from the right one a "number of rocks similar to those of the Bagrot Valley." Thus it would seem as if dioritic or doleritic rock or some modified form of either, extends over a large area along and east of the Nomal Valley north of the Gilgit River. The strike below Nagyr is 10° E. of S.E., dip northerly 75°, but south of Hopar the strikes vary from 5° S. of S.E., dip southerly 30° (recorded at more than one place), to 7° S. of E.S.E., dip southerly 50°. Along the Shallihuru glacier, at and above Mir Camp, come a †fine-grained gneiss, a †crushed mica schist, a †calcareous mica schist, a †limestone breccia (left bank), and from the Dasskaram Needle a †fine-grained gneiss, and a †mica schist with secondary mica (two varieties). A fine-grained gneiss is recorded as common in the Mir Moraine, and said by Mr. Conway to correspond with that on the "Trough Saddle." The strikes along the valley and on Dasskaram Needle vary from 5° S. of S.S.E. to 15° E. of S.E., the dips being south-westerly from 75° to 85°. From the Samaiyar Bar glacier come a crushed mica schist (left side), and a crushed calc schist (right moraine). The Rash ridge on the right bank of the Barpu glacier was climbed in more than one place. The eastern part consists of a †garnetiferous gneiss, †crystalline limestone, and a †mica diorite forming all the upper part of the ridge; the more western part of †garnetiferous gneiss and (?) †kinzigite,† micaceous gneiss, †banded gneiss, and a †diorite ("forming a thin vein at the top of the ridge"). The ridge must thus consist very largely of gneissic rocks, which, however, are pressure-modified igneous rocks. The strike is recorded as from 10° to 25° S. of S.E., the dips varying, those above Barpu Camp being southerly 30° to 60°.

In ascending by the long Hispar glacier to the pass of the same name the following rocks were collected: on Shukurri, near the foot of the glacier, a †fine-grained gneiss, also abundant in the moraine, and a †micaceous gneiss (left bank); and on the right (nearly three-fifths of the way up) a †granite, which, according to Mr. Conway, is common down the right moraine, and considerably higher up (camp by Hispar Snowfield) a †micaceous gneiss. The strikes vary from 2° E. of E.S.E. to 10° S. of E.S.E.; the dips recorded from the lower part of the glacier, on the left bank, are vertical and 75° southerly, from the upper part, right bank, vertical and 60° northerly. The loose specimens are (in fallen blocks) from the right bank below Shukurri a micaceous gneiss, from the left, on Haigutum slopes, a banded gneiss (common); also a sandstone characteristic of the moraine of the Kero Lumba glacier, and from the right moraine a fine-grained gneiss (common). Evidently the rocks on either side of this huge Hispar glacier are crystalline, but an infolded mass of comparatively unaltered sedimentaries must exist somewhere among the peaks to the south.

In the descent from this pass over the Biafo glacier, a †gneissoid granite was found on the right side at Snow Lake Camp (the first halting place), the structure striking 10° N. of E., dipping 60° northerly, then at "Ogre's Camp" (on the same side), and again at Nambla Camp, near the lower end of the glacier, a †micaceous gneiss —in the former place striking 5° E. of S.E., dipping 80° on the southern side. From the left bank, at the foot of Latok glacier (eastern angle), comes a †granite, which, according to Mr. Conway, forms the bulk of the *débris*. Moraine specimens are: granite (the rock which "appears to form the needles"), fine-grained gneiss, and two specimens of crystallised actinolite (these, however, may be only vein products) (right side), and a slate (obtained a few yards from Ogre's Camp). Thus the crystalline rocks along both the Hispar and the Biafo glaciers appear to be generally granite or gneiss. The strikes recorded, both in these districts and further west along the Hunza, the Samaiyar, and the Nagyr valleys, seem to have a general tendency towards a point between S.E. and E., roughly corresponding with the direction of this part of the main chain.

From the valley of the Biaho, rather west of the entrance of that from the Biafo glacier, comes (near Askole) a †mica diorite, and as loose fragments, garnetiferous (?) quartzite, two varieties of garnet schist, one (water-worn) the black kind already mentioned, the other containing chlorite and green mica, and a fine-grained sandstone. The ascent to Skoro La pass (roughly south of Askole) gave a †micaceous gneiss. The specimens indicate that the rocks enclosing the Biafo glacier correspond generally with those on the west side of the Hispar Pass, and that the belt of sedimentaries, already noted as occurring somewhere among the mountains on the left bank of the Hispar glacier, possibly is prolonged into those on the right bank of the Biafo glacier.

A rather large valley descends into the Biaho Valley, carrying the drainage of the Punmah glacier, and separated from the one occupied by the Biafo glacier by a spur-like range of lofty mountains. The western side of the extremity of this contains †crystalline dolomite and a †fine-grained gneiss, the eastern side a †crystalline limestone, a †hornblende schist, a †fine-grained gneiss, and a †garnetiferous mica schist. The strike of the dolomite on the one side, and of the limestone on the other, is 11° S. of S.E., the dip being 40° towards the south-west. Ascending the Biaho Valley above the junction with that bringing the water from the Punmah glacier, Mr. Conway obtained, just at the angle between them, a †fine-grained gneiss, striking 5° E. of S.E., and dipping 70° on the south-westerly side. Near the foot of the Baltoro glacier, above the camp, comes a †granite and a sandstone from the blocks in the bed of the river. By this glacier on the north side were †granite, a †fine-grained gneiss

(into which apparently the granite is intrusive), a †crystalline limestone, the second striking 7° S. of S.S.E., dipping 10° on the western side, the third striking 10° N. of E., dipping 85° southerly, but with many contortions. On the south side are †granites, of which, according to Mr. Conway, the mountains rising on this side of the lower part of the glacier consist. The moraine on the right bank furnished an ordinary limestone, a black argillite, and a crystalline limestone; the medial one a fine-grained gneiss, a sandstone, a slaty (? felsitic) tuff, a limestone, a pseudo-jade (marked as rare), and three other specimens (of which the bulk of the moraine is said to consist), viz., a crushed gneiss, a sandstone, and a slate.

About this point a marked change takes place in the scenery. From the higher part of the Biafo glacier the mountains are characterised by needle-like forms; further to the east, though lofty, they are more rounded in outline. In this part Crystal Peak rises on the right bank of the Baltoro glacier. From its southern slope come (order uncertain) †fine-grained gneiss, a †calcitic quartz schist, a †dark mica schist, †dolomite, and †limestone (both crystalline), a †fine-grained gneiss, and another gneiss (crumpled). A specimen from the summit of Crystal Peak unfortunately consists mainly of crystallised quartz, but to this a little brecciated rock adheres, some fragments in which effervesce slightly and may be limestone. The mass of practically unaltered sedimentary rocks, of which the moraine has already given ample evidence, may therefore include the Crystal Peak. On the ascent to White Fan Pass, south-east of the same peak, were collected a †mica syenite, and a crystalline but fine-grained †white dolomite. A greyish †crystalline limestone occurs, it is said, apparently belonging to a mass of green rock, in which are thin seams of †noble serpentine. Halfway up to this pass the strike is recorded as S.E., the dip being 75° to the south-west. A diorite comes from the Angle Peak, *i.e.*, that which rises from the above-named mass west of the Godwin-Austen glacier.

The moraines from Gusherbrum give a sandstone and earthy limestones. The right bank of the Throne glacier †phyllite, †argillite, †limestone (these three being associated), †slate, and a †limestone breccia (this, however, might be a fault product). From the left bank of the same glacier (whether *in situ* is uncertain) a fine-grained gneiss, a granite, and a dolomite (the last is said also to occur on the Golden Throne). The strike in the mountains by the glacier is said to be 7° S. of E.S.E. (dip about vertical) and this continues all along the valley. The moraine starting from the western foot of Golden Throne affords sandstone, grits, and calcareous grits (both schistose), limestones, and dolomite, and the peculiar felstone described above. Mr. Conway states that the last-named rock occurs on the mountain, and appears to form bands in the

schistose grits. On the Pioneer Peak the first point reached on the arête yielded schistose grits, one of which (a purple specimen with small pebbles) occurred again at the second peak, striking 5° E. of S., and dipping 35° to the east. It is evident that a considerable mass of sedimentary rock must be infolded in the range from Gusberbrum to Golden Throne.

The valley of the Indus from Parkutta to Tolti (roughly S.W. of the district last described) lies among alternating diorites and granites. Higher up, from Himis to the turn for Lama-yuru, or on either side of Leh, it is among †argillite and †slate (just like the redder slate of Llanberis); these are said by Mr. Conway to be "sandwiched" with granite.

Again and again throughout this district of the Himalayas, rocks bear evidence of severe pressure, the result of earth movements. Putting aside those which are either certainly or probably of igneous origin, we find three rather well-marked groups. One, fine-grained, speckled gneisses, very similar to those which occur on the south side of the Central Highlands of Scotland (*e.g.*, about Blair Athol); secondly, crystalline schists, limestones, and dolomites, doubtless metamorphosed sedimentaries, several of which are practically identical with specimens described by one of us from the Lepontine and Pennine Alps*; and, thirdly, a group of sedimentary rocks (not more than mechanically altered), which sometimes are very like the Mesozoic rocks of the Alps, though occasionally some have a rather more ancient aspect. With these the peculiar felstones of the Golden Throne appear to be associated, and in one or two places the presence of somewhat altered fragmental rocks is suggested. In all probability the history of the Karakoram-Himalaya region is very similar to that of the Alps. First is a great floor of crystalline rock, partly igneous, partly metamorphic (in the more strict sense of the word). On that was laid down (possibly with interruptions and marked intervening disturbances and denudations) a series of sedimentary rocks. This ended, all were affected bv a process of folding on a gigantic scale and upreared into a mountain mass, which has been carved, by the usual agents of denudation, into peaks and valleys far surpassing in wildness and grandeur even those of the Alps.†

* T. G. Bonney, 'Quart. Jl. Geol. Soc.,' 1890, vol. 46, p. 187; and 1893, vol. 49, p. 89.

† The following altitudes are taken from Mr. Conway's volume: Dasskaram Needle, 17,660 feet; Rash Ridge, 15,930 feet; Hispar Pass, 17,650 feet; Crystal Peak, 19,400 feet; White Fan Saddle, 18,750 feet; Pioneer Peak (near Golden Throne), about 23,000 feet (at least 22,600 feet).

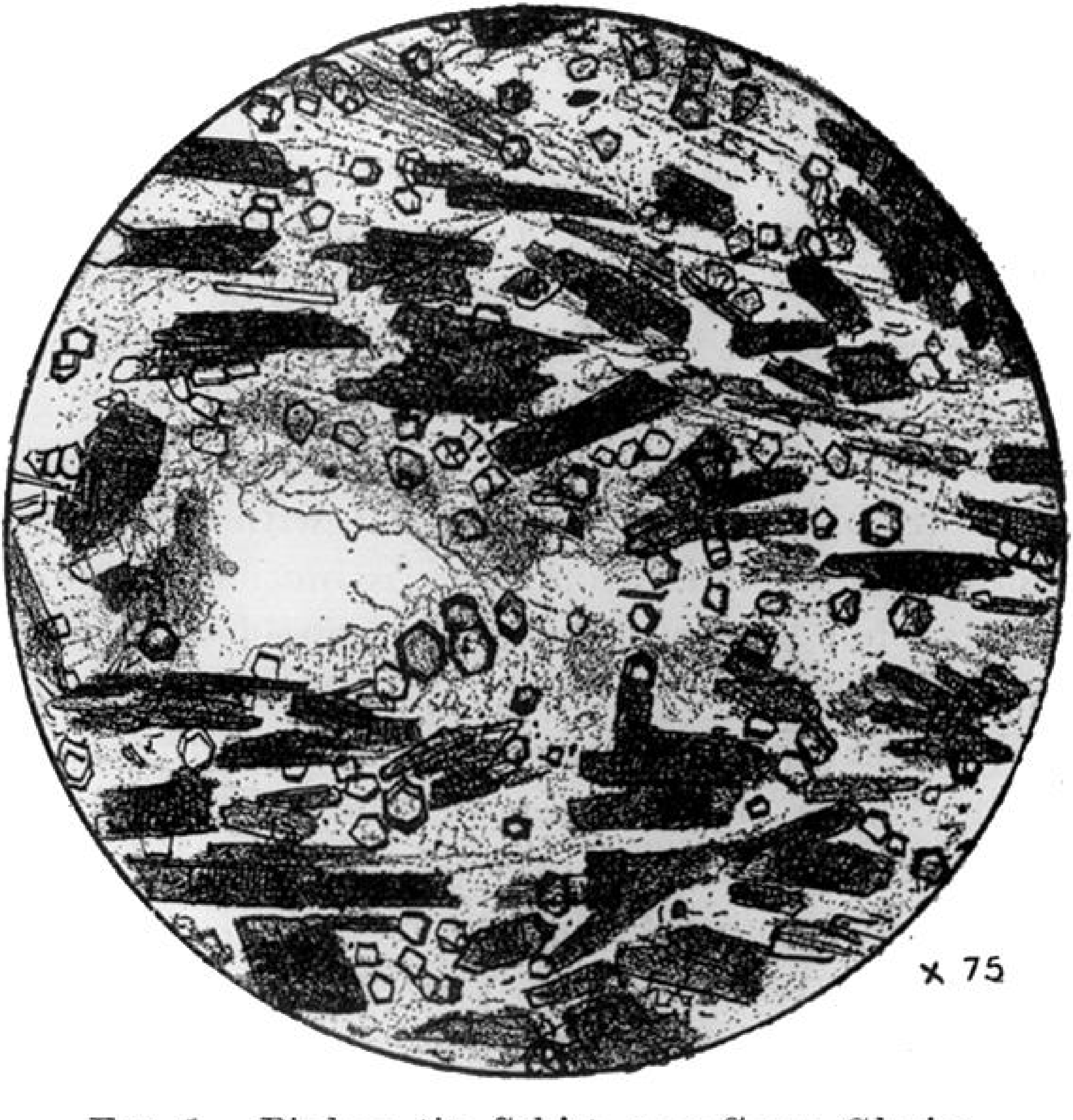

FIG. 1.—Piedmontite Schist, near Gargo Glacier.

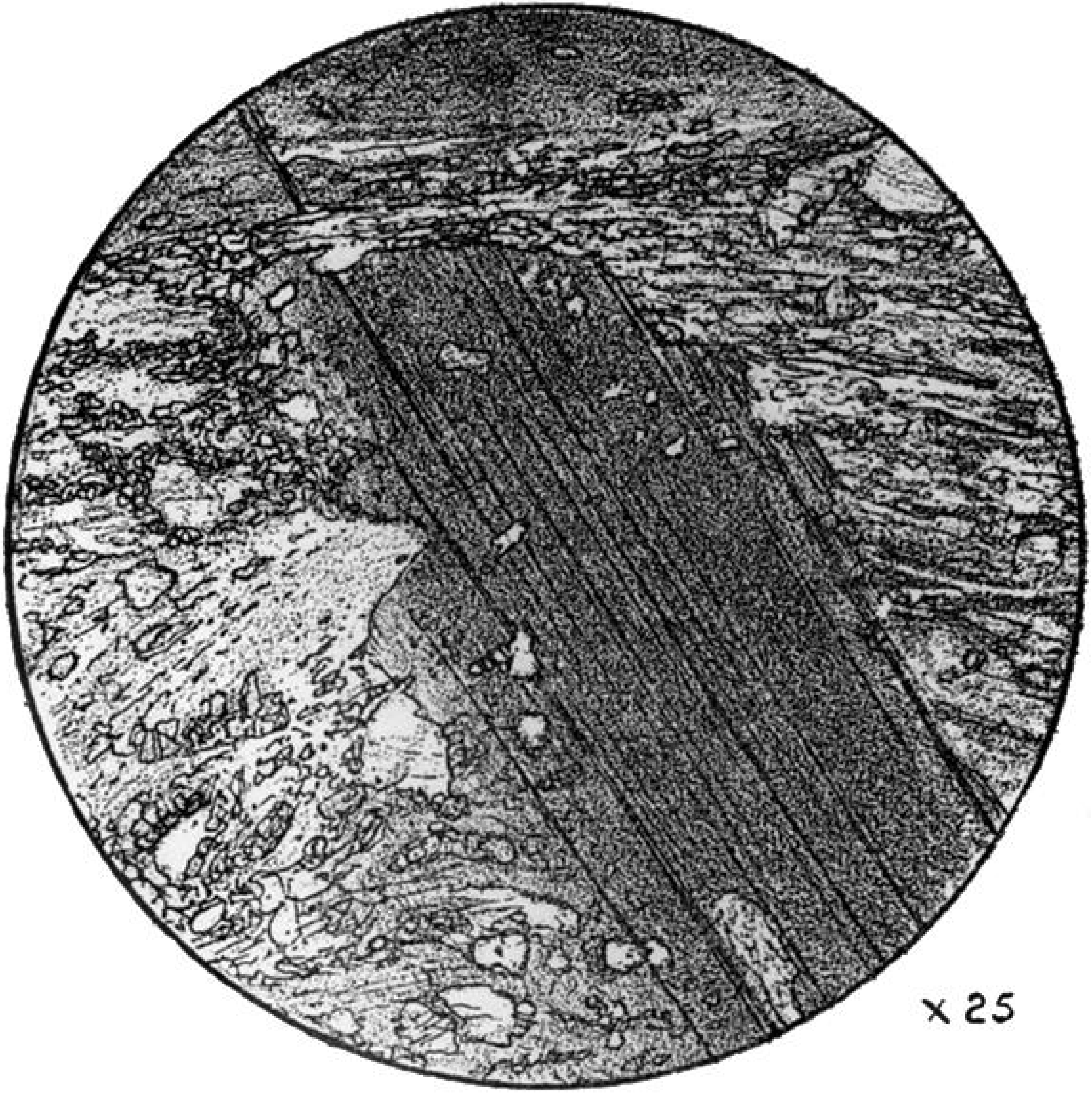

Fig. 2.—A Grain of Secondary Mica in Schist from Dasskaram Needle.