ON THE FELSITES AND ASSOCIATED ROCKS OF MOUNT READ AND VICINITY.

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Associated with the schists of Mount Read and district are some obscure igneous rocks, siliceous in nature, compact in grain, often slightly schistose, which are what the field geologist calls felsites or felstones. These terms, however convenient, need explanation, for in different countries they carry different meanings. In Germany the word felsite (or micro-felsite) is applied to the compact homogeneous-looking groundmass of quartz porphyries. These porphyries are the acid volcanics of pretertiary age. In England, on the other hand, felsite designates the rock, not its groundmass merely. If the petrographers of each country could throw over the historical significance of their terms and come to some international agreement as to rock nomenclature and the meaning to be attached to terms, much of the present deplorable confusion would disappear. At present the discordance is considerable. The following extracts serve to indicate the English usage :—

*Cole.**—Quartz-felsite=Eurite=" the fine-grained and compact forms of granite." " Felsite is so differently used by different writers that its reputation as a rock name is lost."

Hatch.†—Felsite= " the acid quartzo-felspathic lavas—the devitrified rhyolites and obsidians."

Rutley.‡—Felsite= " devitrified obsidians and pitchstones. Felsites are not exclusively devitrified rocks ; in some cases they occur as dykes and then approximate to the micro-granites or granophyres." Quartz-felsite=" apophyres of deep-seated granite masses (Elvan group)."

Harker.§—Felsites=" acid intrusives. The name 'felsite,' or, if containing evident phenocrysts of quartz, 'quartz-felsite,' has been applied in this country not only to these rocks but also to many volcanic rocks (acid and intermediate), and their usage lacks precision and significance."

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* Aids in Practical Geology, 1893, p. 201.

† An Introduction to the Study of Petrology, 1891, p. 85.

‡ Granites and Greenstones, p. 15.

§ Petrology for Students, 1897, p. 100.

*Teall.**—Acid rocks="Felsite, Eurite petrosilex. These terms are practically synonymous. They have been applied to compact stony rocks, the mineralogical composition of which cannot be ascertained by examination with the naked eye or with a lens."

Jas. Geikie.†—Quartz-felsite=Quartz-porphyry. "In this rock we have a compact groundmass of felsitic matter, through which are scattered macroscopic or microscopic crystals or crystalline granules of quartz and orthoclase. . . . . . It seems probable that micro-felsitic matter is simply the result of devitrification of a glassy base."

Sir A. Geikie.‡—Felsite (felstone.) "Originally vitreous lavas like the rhyolites, but which have undergone complete devitrification, though frequently the perlitic, spherulitic, and flow structures."

Teall.§—Acid intrusives=felsophyre, granophyre, micro-granite. Acid volcanic=devitrified rhyolites, obsidians, and pitchstones.

These samples show that, what with acid intrusives, acid volcanics, elvans, devitrified obsidians and rhyolites, granophyres, micro-granites, quartz-felspathic lavas and the rest, the term has come to mean nothing more precise than a compact ancient acid rock. Hence some petrographers abandon its use altogether, and parcel out the rocks covered by it, some among the ancient rhyolites, the rest among micro-granites.

A different nomenclature is adopted in Germany. This family is included by Rosenbusch in Liparites and quartz porphyries. In his recent work‖ he says :—"The difference between liparite and quartz porphyry is one of age : quartz porphyries are pretertiary palæo-volcanics, liparites are neo-volcanic tertiary rocks, consequently young quartz porphyries." He defines them as effusive rocks of normal granitic magma, and divides them into two sections, viz., (*a*) microgranitic and granophyric quartz porphyries, (*b*) felsophyric and vitrophyric quartz porphyries. Under different names we see there are still two main groups, the microgranitic and the rhyolitic ; though, as they are both classed as effusive rocks, we cannot carry out any exact comparison with the English usage.

It is accordingly necessary to explain the sense in which we attach names to the Tasmanian rocks. While the particular name has a certain importance, it is equally important for us to understand the rocks to which it is applied. Seeing that quartz porphyry is so widely used

* British Petrography, p. 291.

† Outlines of Geology, 1888, p.p. 152-153.

‡ Text Book of Geology, 1893, p. 161.

§ British Petrography, p. 296.

‖ Elemente der Gesteinslehre, 1898, p. 239.

in England for compact granitic protrusions, we propose to confine the terms felsite and quartz felsite to devitrified acid lavas. The term quartz-keratophyre is applied to the same rocks when containing an alkali-felspar rich in soda. Keratophyre, the syenitic equivalent = soda felsite : quartz keratophyre = soda quartz felsite. This terminology can be correlated with Rosenbusch as follows :—

Here defined.	*Rosenbusch.*
Felsite.	Felsophyre felsite rock.
Quartz felsite.	Felsophyric quartz porphyry.
Keratophyre = Soda felsite.	Keratophyre.
Quartz-keratophyre = Soda-quartz-felsite.	Quartz-keratophyre.

The groundmass of felsites is characteristically felsitic. What felsitic matter really is has occasioned much discussion among petrologists, and a definite result can hardly be said to have been yet attained. The compact groundmass irresolvable by the naked eye or the hand lens is often resolved by the microscope into an intimate aggregate of minute crystalline-granular quartz and felspar, giving a confused speckled appearance between × nicols.

When the component individuals of the aggregate become more minute and indefinable, the groundmass is what Rosenbusch calls crypto-crystalline. This is the felsitic material. And, following the process of resolution still further, we arrive at the ultimate isotropic vitreous base. But more frequently further resolution discloses a minute aggregate of isotropic granular or flaky material which we assume to be a devitrification product, though this is mostly not susceptible of proof (miscro-felsite, Rosenbusch). From Vogelsang's researches it is probable that this micro-felsitic material is no longer a mechanical aggregate of quartz and felspar, but an independent silicate. (See the lucid exposition given by Rosenbusch, Mass. Gest., p. 668.)

Under such conditions it is not wonderful that the Mount Read rocks, masked by great geological age, and distorted and mineralogically reconstructed by intense dynamic metamorphism, should prove puzzling to the geologist. Their felsitic nature is often obscured by green colouration due to the free development of chlorite, which gives a very different appearance from that of the light coloured hälleflinta-like aspect of so many of the more typical felsites. It must be premised that the rocks not only occur in the Zone of the West Coast argillitic and phyllitic schists, but have themselves been affected by the forces which produced the foliation of the schists. Hence they have a more or less banded or schistose appearance, though, owing to their greater hardness compared with the slates, they are not foliated to anything like the same extent. The effect is often only shown by obscure banding or streaking, while elsewhere there is a more decided approach to schistosity. Sometimes a few reddish porphyritic felspars are discernible, but as a rule the rock has a streaked reddish and greenish flinty aspect, as if the original porphyritic crystals had been rolled out and their material diffused. The colour of different varieties, however, varies a good deal, ranging from yellowish white to reddish.

Specific Gravity.

Teall states the sp. gr. of felsites and liparites as ranging from 2·53 to 2·7. Our determinations of the Mount Read felsites, comprising numerous selected specimens, are :—

2·6, 2·62, 2·63, 2·65, 2·68, 2·7, 2·74.

The specific gravities of the Lenne-porphyries of Westphalia (Keratophyres and Quartz Keratophyres) given in O. Mügge's important paper may be usefully compared.

Quartz-keratophyre, 2·648, 2·654, 2·647.
Felso-keratophyre, 2·62 (non-schistose), 2·638, 2·74 (high sp. gr. due to chlorite), 2·65, 2·75.

Also those furnished by Rosenbusch :—

Keratophyre, 2·611, 2·677.
Quartz-keratophyre, 2·709, 2·647, 2·620, 2·64 2·634, 2·614, 2·632.

The specific gravity of the Tasmanian felsite is consequently quite in accord with what has been observed elsewhere.

Intrusive or Effusive.

The relations of the rocks to the argillitic metalliferous schists are far from being definitely established, and require close working out over an extended area. Owing to the densely timbered country and paucity of serious mining operations, this is a task of extreme difficulty. All that has been done hitherto has been to notice the fact of their occurrence here and there, especially where the country has been cleared a little for mining work. On the north side of Mount Read on the North Hercules, Barlen, and Consols sections, this rock is prevalent, sometimes as a greenish flinty schistose or fissile felsite, and towards the bottom of the track going down to the Ring River valley in abrupt massive cliffs of a green and reddish streaked compact siliceous felsite. It has here the appearance of an intrusive mass, but this may be with equal probability the exposure of a thick lava mass. A common characteristic of metamorphosed felsites and their tuffs in schist areas is the indefinable nature of the boundary line separating them from the schists. This seems to be the case in this region, and is a fact in support of their contemporaneity. We have seen the same felsite in the shaft at Mount Black Mine, and still further north on the Tasmanian Copper Company's property between Rosebery Township and the Pieman River. Further south, too, it occurs in the direction of Red Hills and Mount Darwin ; and a very coarse granular chlorite-stained variety of the same series is found on the White Spur between Moore's Pimple and Mount Read. This zone therefore extends in a N. and S. direction for about twenty miles, while E. and W. its breadth is comparatively small. The zone of felsites seems to mark the upturned edges of sheets of lava roughly parallel with the axis of the present West Coast range. These lavas were probably geologically contemporaneous with the argillaceous sediments now converted into schists, and with them were folded, crumpled and rolled out into the schistose, banded conditions in which we now find all the rocks of this belt of country. At least this interpretation is the one which seems to us the most feasible in the present state of our knowledge of this difficult piece of country.

Their relations to the Ore Beds.

This fact confronts us : Whenever the felsite appears in tunnels driven through the metal-bearing phyllites or schists, ore is no longer found ; the felsitic rock is barren. The occurrence of a band of this felsite in an adit is suggestive, at the first blush, of an intrusion ; but the absence of sharply-defined walls is against the idea, and it can be explained quite satisfactorily on the supposition that it is an intercalated sheet. It cuts off the ore simply because the ore is not contained in a lode fissure, but has been deposited by a process of segregation, or has replaced the original rock by metasomatic substitution. The ore bodies on Mount Read form lenticular masses in the argillitic schists parallel with the plane of foliation, and disposed at irregular intervals in directions parallel to each other. The deposition took place probably subsequently to foliation, judging from the parallelisms with the enclosing schists. This is seen on a small scale in some of these mines, where the ore follows a minute arching and folding of the schist without dislocation. These lenticular masses have been looked upon as segregations of mineral along crevices or lines of weakness in the rock. It is rather difficult to imagine cavities of the required size existing in the rock in readiness for filling up with mineral ; but there is nothing improbable in supposing the parting planes of the schists to be the first channels for the precipitation from solutions of their metallic contents. The process of replacement might then very well start from these channels and remove the country rock on either side, leaving ore in its place. The suggestion that the lenticular ore bodies represent old lake bottoms has not the testimony to support it which can be adduced in favor of the metasomatic hypothesis. The sulphides of the Rio Tinto Mine in Spain which have been appealed to are mostly bodies filling fissures which separate slates and intrusive quartz porphyry ; and it is only iron ore lying in horizontal beds of miocene age with plant remains which can be referred to a sedimentary origin. Those conditions are not comparable with the mineral zones on Mounts Black and Read. Here the ore bodies follow the dips and foliation planes of the enclosing schists which on Mount Read dip easterly at a high angle with a strike from 10° to 20° W. of N. The lenticular forms of these bodies are suggestive of replacement having gone on *pari passu* with the operation of a solvent. They differ from true lodes in always being found conformable to the surrounding schist, and from both fissure and segregation veins in having no gangue or matrix different from the country rock. The foliation planes have apparently served as initial channels for the mineralised solutions which attacked and removed the schist on each side, and left their mineral contents *in sitû*. It is obvious that in such a process there would be a beginning : the attacking solution would attain a maximum of power and gradually decrease to a minimum. The result would be a lens-shaped body of mineral. The question presents itself, are such deposits as permanent as true lodes ? But this is hardly the appropriate form for such a query. It would be more proper to ask, are these ore deposits as reliable as the *pitches* or *shoots* of ore in true lodes ? We know very well that, though mineral veins or lodes go down to apparently quite inaccessible depths in the earth's crust, the courses of ore which they contain are inconstant and irregular. A metalliferous zone is followed by a barren one, or *vice versâ*. Therefore, to institute a just comparison, we must imagine the partings of the schist to correspond with a lode fissure, and the lenticular ore bodies with the ore shoots in a lode. The depths to which these foliation planes extend depends (1) upon the magnitude of the anticlinal or synclinal flexure to which the sedimentary rocks were subjected, and (2) upon the extent to which the secondary foliating agency affected them. This form of deposit has an advantage over most bodies, in that there has often been the opportunity for the formation of numerous ore bodies on parallel lines following parallel parting planes of the schist. The ore bodies come in and die out in these channels as ore courses do in a lode; and there is in reality no more nor any less reason for timidity or despondency in exploiting either. It will be noticed that on this supposition the ore was not deposited in the beds before they were crushed and foliated; consequently, by simple exclusion and without further argument, the hypothesis that the metals were precipitated on ancient lake bottoms which have since been raised and tilted, falls to the ground as far as the Mount Read ore bodies are concerned. To gain some knowledge of the true nature of the slates and schists, some of the unaltered slate (a dark greasy variety) from Mount Read was powdered and treated in the test tube, first with a cold saturated solution of citric acid, then heated, but no effervescence took place. Subsequent boiling in HCl. gave the same result. The non-metalliferous schist from the same locality was subjected to the same treatment. Some of this behaved in a similar manner; but another piece gave signs of the presence of a carbonate. The microscopical test showed calcite. Slides of the schist in the tunnels of the Hercules Mine sometimes show abundant calcite, occasionally in a granular condition, as if broken up by earth movements. That minor later movements have occurred is evidenced by the "greasy headings" in the mines. These are false walls, or parting planes, where the rock has been shifted by earth stress. Under the microscope the powdered schist reveals its derivation from the slate very plainly. Both consist of grains of alumina or aluminium silicate, with a little quartz. This schist is perhaps the most common on the Hercules group of sections on Mount Read. It is hardly a true schist, hardly even phyllite, which is a lustrous slate. Argillite, or argillaceous schist, would perhaps be the most suitable name. There are, however, other descriptions on the range. There are clay slates, glossy with mica; these are true phyllites. There are siliceous schists, which have resulted from the foliation of sandstones: and quartz schists, probably from quartzites: and talc schists, as on the Jupiter section, which must have had a different origin from the argillitic and quartz series. Talc schists are most likely to originate from pyroxenic rocks, but nothing is known yet of the relations of the Jupiter rocks. Micaceous schists occur, but not the true mica schists of the gneissose Archæan series. At Cutty Sark, near the Pieman River, there is a dark, compact, granular rock, of doubtful origin, which has been involved in the movements of the chain, and received an impress of schistosity. In fact, all through this zone of metamorphism and foliation, no matter what kinds of rock, they have been caught up in the process of schist formation, their original characters more or less obliterated, and a new stamp of rock structure impressed upon them. An exceptional occurrence in the schist zone is the Mount Black lode at Rosebery, which is a banded true fissure lode containing gold, wolframite, bornite, bismuthinite, chalcopyrite, iron and arsenical pyrite, and black tourmaline. The occurrence of wolframite and tourmaline is noteworthy. Just south of this, at the South Mount Black, is a dyke, black with tourmaline. The acid nature of this dyke and lode seems to indicate some connection with the movements of the granite magma in the West Coast area. This relationship naturally involves a much younger age than that of the surrounding schists and felsites. The tourmaline quartz-porphyry at South Renison Bell, the axinite at the Colebrook, and the Mount Black fluor and tourmaline rocks, probably all belong to one and the same eruptive phase.

The schists are repositories of numerous minerals and ores, which vary in the extent of impregnation to both extremes, inasmuch as these are more commonly simply represented by a few sparsely scattered minute crystals and flakes of pyrites, often of a cupriferous tendency, with occasional patches of galena and zinc sulphide. More rarely these metallic minerals are found in great quantity, sometimes wholly replacing the substance of the rocks, until they assume the character of a dense mass of sulphide ore of enormous extent. It is such masses of mineralised schist which are operated upon by the miners in the districts of Mount Reid and Rosebery. The change does not assume a general character, for often within a restricted area one or other of the copper, lead, zinc sulphides preponderates; but, as a rule, zinc is present. At the Tasmanian Copper and adjacent mines the ore is practically that of a zinc-copper nature; at the Hercules the zinc-lead impregnation is the most pronounced; while at the King River, the East Hercules, Red Hills, and others, the ore is almost zinc free; and at the Mount Read Mine almost all degrees of admixture may be obtained. A small quantity of associated gold and silver is very general, and in favourable localities for decomposition, where large masses of gossan have formed, the precious metals have been obtained in greater abundance, and have in one instance been worked by methods common to the alluvial gold-miner. In the workings of the Hercules and South Hercules mines, bunches of crystallised carbonate of manganese of great beauty are occasionally met with, and in the schists of the East Hercules the ores of bismuth have been detected, while in the vicinity of Lake Dora cobalt minerals occur; but the ores of these metals are not by any means abundant, and are, as at present known, simply curiosities of interest to the mineralogist, but of no practical value to the miner.

The following is a list of the more important minerals which have been detected:—

Arsenopyrite.	Cuprite.	Limonite.
Absolite.	Chalcocite.	Malachite.
Azurite.	Erythrite.	Psilomelane.
Barite.	Fluorite.	Pyrites.
Bornite.	Galenite.	Pyrolusite.
Bismuthinite.	Göethite.	Rhodochrosite.
Cerussite.	Gold.	Siderite.
Chalcopyrite.	Hematite.	Sphalerite (Blende).
Cobaltite.	Huascolite.	Stibnite.
Copper, native.	Jamiesonite.	Tetrahedrite.

The Mount Read felsite does not appear to have yielded sufficiently to the foliating force to provide planes along which solutions could travel freely, or was not so easily attacked by the latter; hence it contains no ore bodies. This is not, however, a universal rule. At the Red Hills an igneous rock, probably felsite, occurs, which has been more strongly foliated, and, in a specimen received from the Government Geologist (*see* Report on Lake Dora District, 1898, p. xxi.,) we noticed a decided illustration of the replacement process. A few felspar crystals remained unaltered, but the rest of the rock had been converted into hematite. But at the Mount Read mines the ore is confined to the argillitic schists. The question arises, whether the proximity of the igneous rock bears any casual relation to the ore in the schists—has the eruptive rock in any way stimulated ore deposition? An answer in the affirmative would have a practical effect on mining, as the discovery of felsite would indicate the proximity of ore. The case of the white melaphyre at Zeehan, which favourably affects the silver-lead lodes there, suggests the possibility of something similar ruling in the case of the Mount Read felsite. But the two cases are not parallel. At Zeehan the lodes in question traverse the eruptive rock; at Mount Read the ore bodies are outside it. And it is difficult to see how the latter would affect ore deposition in the schists, when, as appearances indicate, the ore was deposited subsequently to the foliation and metamorphism of both felsite and schist. It is true that ore is found never very far away from the felsite. A very natural way of accounting for this is that schists and felsite are geographically associated, and form together one mountain complex.

Age of the Felsite.

If our interpretation as set forth above be correct, the geological age of the schists and felsite is the same for both. There is no direct evidence of precise age yet available. The schists themselves in the vicinity of Mount Read are argillites and phyllites, and occasionally retain in places less altered remnants of slate, but no fossils have been found in them. The most recent determinative work done in this direction is R. Etheridge, jun.'s description of Mr. A. Montgomery's collection of Silurian fossils from the limestones of Zeehan and the Heazlewood. Mr. Etheridge says they "present both a lower and an upper Silurian facies, but with a preponderating tendency towards the latter." He thinks "it is not improbable that they represent a series of beds homotaxially equivalent to the lower portion of the upper Silurian."* Judging from the succession, the Mount Read and Mount Black schists are somewhat older than the Zeehan series, and are probably not younger than the lower Silurian. But great caution is necessary here, as the evidence is of a negative character. The test of superposition is unreliable, as the persistent easterly dip of the strata on the west slope of Mount Read points to overfolding on a large scale, which has produced an inverted succession of the beds. In any case, the felsite is much older than any of our known granite rocks.

Determination of the Felsite.

Anticipating for a moment the results of our microscopical examination, we may say that the predominance

* Description of a small collection of Tasmanian fossils.—R. Etheridge, jun.

of plagioclastic porphyritic felspars led us to suspect that the rock belonged to the sub-group of soda felsites or keratophyres (in their altered sheared form often called porphyroids). To avoid all chance of error, we sent samples of the rock to Professor Rosenbusch, who very kindly favoured us with his opinion, as follows :—"Undoubtedly we have here strongly dynamically altered forms of the acid eruptive rocks. The typical porphyritic structure, the nature of the phenocrysts, the still recognisable fluidal structure, the nearly entire absence of dark constituents, the occasional spherulitic forms still recognisable in their replacement products (quartz, albite), all point with certainty to members of the quartz porphyry family, and, with great probability, not to quartz porphyry in the narrower sense, but to quartz keratophyre and keratophyre. . . . . The rocks greatly resemble our German occurrences in Westphalia, the Fichtelgebirge and Thüringen, and especially the occurrences in Wales. These are the forms which in Germany were originally called porphyroids and flaserporphyries."

Microscopical characters of the Felsite.

As the aspect of the rocks differs in the field in different parts of the same mass, so their microscopical structure varies to an equal extent. Sometimes they are typically porphyritic, though the crystals are never very large ; or the porphyritic crystals are set so closely together as to resemble somewhat a plutonic rock-like granite ; or they are broken and mutilated, giving a fragmentary appearance to the rock. The mineral constitution, too, varies. There is a set in which quartz phenocrysts accompany those of felspars, and another series from which they are absent. Nevertheless, despite all these variations, the observer recognises that he is looking at one and the same group, the acid and the sub-acid eruptives.

The mineral constituents of one or other of the members of the group may be classed as under :—

Essential.	Accessory.	Secondary.
Orthoclase.	Magnetite.	Albite.
Oligoclase ?		Chlorite.
Albite.		Epidote.
Quartz.		Sericite.
		Calcite.
		Limonite.
		Sphene.
		Zoisite.

The changes are all rung on these minerals, the secondary ones replacing or obscuring the essential constituents in varying degrees.

In addition to orthoclase, a felspar of the albite or oligoclase-albite series appears as a porphyritic constituent, and is sometimes very abundant, becoming the prevailing felspar. This shows us that these are not the ordinary orthoclastic felsites.

The material upon which we have founded these preliminary microscopical studies comprises an extensive series of rocks collected from Mount Read, on the sections owned by the South Hercules, North Hercules, East Hercules, Crown Hercules, and Ring River Companies, from Tipperary Creek on the west side of Mount Read, from the White Spur between Dundas and Mount Hamilton, from the Tyndal Track and Creek south of Mount Read, from the Red Hills east of Mount Read, from Mount Black and the Tasmanian Copper Company's property north of Rosebery, &c. The following micro. details will be of interest to students :—

We note that in the porphyritic types on the North Hercules section the felspars have a habit of collecting in nests, and there is a good deal of water-clear secondary felspar surrounding the phenocrysts. The phenocrysts float in a matrix of this secondary felspar, with which calcite is sometimes associated. Carlsbad twins may be often seen bent by dynamical stress, and strongly seriticised. In the more granitic or crystalline forms, on this property, there is abundant quartz, which often has a fragmentary aspect, being in all sorts of irregular shapes. Hexahedral forms are rare. Some of the grains are embayed ; others are stretched, cracked, or broken. Strain shadows are frequent : minute fluid cavities present occasionally. Between the felspars there is a good deal of bright green chlorite. Sericitic streaks curve between the phenocrysts ; this may represent original flow structure. The rock on the White Spur is a counterpart of that of the North Hercules. The crystalline form is the dominant type. Fragmentary deformed quartz frequent. Schistose structure marked ; the lines of schistosity bend round the unyielding quartz grains, causing a streaky appearance, and probably marking former flow lines. The ordinary porphyritic form of rock also occurs on the White Spur.

In the keratophyre of Tipperary Creek the felspars are strongly sericitic, and the rock is veined with albite. This felspar veining occurs also in the same rock at Red Hills, in which there are rather peculiar nests of albite crystals. The keratophyre here is rich in bright green chlorite. On the Tyndal Creek there is a rather fresh keratophyre, with a good deal of chlorite. On the track to Mount Tyndal the felsite is much epidotised; some of the Carlsbad twins have one half replaced by epidote, and chlorite is developed abundantly. The felspars of the keratophyre in the Ring River adit have been replaced by aggregates of secondary albite and quartz: the crystals of felspar here have sectional fields very characteristic of keratophyres. There is a keratophyre on the Crown Hercules overlying the ore body, with slate on both sides. At the Mount Black mine the shaft is in keratophyre, identical with that of Mount Read. The porphyritic felspars are here, too, surrounded by secondary felspathic growth. Further north, on the Tasmanian Copper Company's property, there is a band of felsite in the lower adit 40 feet wide, in which the few felspars are broken up into aggregates of secondary albite. With reference to the groundmass of these rocks, Professor Rosenbusch writes to us :—"Nothing is left of the original groundmass; it has been converted into sericite, quartz, and albite. The newly-formed albite felspar can be distinguished quite easily from the older phenocrysts. The chlorite indicates original pyroxene rather than biotite."

Summarising the above, we have here the characteristics of felsite and quartz felsite, and especially of keratophyre and quartz-keratophyre. The rocks have a compact quartzo-felspathic (felsitic) groundmass, with quartz and orthoclase and albite phenocrysts, sometimes distributed sparingly, at other times so crowded as almost to lose the porphyritic stamp. In the typically porphyritic varieties are altered spherulites and signs of flow structure. In a word, these are ancient, now devitrified, lavas of the alkali-granite and alkali-syenite families. The quartz keratophyres are the granite volcanics: the keratophyres are of syenitic nature.

There are no plutonic masses in the neighbourhood with which we can connect this series of lavas. The syenite, which occurs in boulders north of Rosebery, has not been found *in sitû*: and the granite at Heemskirk is of younger date. There is some pegmatitic granite on Jolly's section at Lake Dora, which microscopically appears fresh and post-Silurian. The mass or dyke of syenite porphyry at Lynchford is evidently of great age. The mechanical deformation of its crystals indicates that it was subjected to the same earth movements as the slates; and there is consequently a likelihood of it being quite as old as the felsites. The long line of felsite, with its axial direction parallel with that of the West Coast range, shows that below that area, in Silurian times, there must have been a corresponding plutonic body of rock, which the vast period of post-Silurian denudation has not been sufficient to uncover.

Mr. W. F. Ward's Analysis of Quartz-keratophyre from the North Hercules Section, Mount Read.

Professor Rosenbusch suggested to us that a chemical analysis of this rock was highly desirable, in order to confirm the results of optical examination. This analysis has been made by Mr. W. F. Ward, Government Analyst, who states it as follows :—

Constituents.	Per cent.
Silica	75·73
Alumina	12·70
Oxide of iron	2·25
Lime	2·00
Magnesia	0·60
Potash	2·04
Soda	3·48
Loss at red heat	1·20
	100·00

From the above it will be seen that the reference to quartz-keratophyre is fully sustained. The percentage of silica shows it to be an acid eruptive, while the excess of soda over potash indicates the keratophyre group.