calcite, in the rocks described by him, have arisen by the alteration of silicates under the influence of carbon dioxide.

It seems equally clear, however, that the process of dedolomitization is not quite so simple as has been supposed, and its explanation seems to call for still more facts.

III.—THE GRANITE MASS OF FOXDALE, ISLE OF MAN; WITH SOME NOTES ON DENDRITIC MARKINGS IN MICROGRANITE DYKES.

By WILLIAM C. SIMMONS, B.Sc., A.R.C.S.

(MAP, PLATE XVI.)

THE mining village of Foxdale, situate a little towards the southern end of the north-east to south-west central trend-line of the Isle of Man, lies just north of the barren heath-covered hill called "Stoney Mountain". On the 6 inch Ordnance Survey Map the northern part of this hill is called Granite Mountain and the southern portion Windy Common. The whole forms a long, regularly sloped hill with its greatest length—about 2 miles—approximately north and south. Though of small altitude its singular barrenness makes it conspicuous in a moderately well-cultivated district. To the west South Barrule and the Barrule Slate Quarries rise considerably above it, though on the other sides the ground slopes gently off to more distant hills.

The granite occupies only about a third of the whole area of Stoney Mountain, and that all at the northern extremity. A small isolated exposure of the granite occurs a short distance to the east, near the little village of Eairy. These granite masses are intrusive into the Manx Slate Series, which have been in places considerably altered.

In both the larger Foxdale granite mass and the latter smaller one thick veins of quartz and coarse pegmatite occur. Sometimes these quartz veins, then resembling dykes, are found outside the granite intruded into the country rock. Lastly there are the characteristic microgranite dykes, associated with the granite mass and usually intruded in the slates with a N.E.—S.W. trend.

The field relations of the "Granite and its Elvans" are discussed in the Survey memoir of the Isle of Man (G. W. Lamplugh, 1903), to which also notes on the petrology of the rocks by Professor Watts are appended. Much quarrying has since been carried on in the quartz veins for silica, and consequently better sections can now be seen. It seems that a few further notes upon these very peculiar 'quartz dykes' may not be out of place.

Mr. Lomas¹ has described some of the veins and gives a rough description of their distribution, arriving at the conclusion that both those in the granite and those in the country rock are of igneous origin. Beyond brief notices in the Survey memoir and elsewhere, and a short description by Mr. A. Harker,² little other literature on the matter has come to hand.

¹ Lomas, *GEOL. MAG.*, 1903, pp. 34-6.

² A. Harker, *Naturalist* (Leeds), March, 1894 (note). *Id.*, "Grainsgill Greisen": *Q.J.G.S.*, vol. li, p. 143.

DESCRIPTION OF THE MAP. (Plate XVI.)

The map is on the scale of 4 inches to 1 mile, and shows the shape of the outcrop of the granite mass. At the points marked J actual junctions between the granite and the altered country rock are exposed. Elsewhere the boundary is lined or dotted according as to whether the mapping is certain or only probable.

In the quarry below the Foxdale lead-mines (see Map, "slate, grit, and granite quarry.") a good junction is seen. Between the granite and the slate a thick vertical strip of finer-grained granite occurs, which is continuous with a fine microgranite dyke on the other side of the quarry.

Tracing the boundary south it can be seen to cross the stream (Struan Barrule) in several places and then to sweep east up the hill till we come to the apophyses marked on the map. These apophyses can be easily traced round the slate quarry, and at J is the slickensided junction with a dip of 30° (approx.) to the south-east under the slates, described in the Survey memoir. The granite of the apophyses is very fine-grained, or rather, contains strips of fine-grained microgranite. Further east the boundary is somewhat obscured by bog, but is fairly clear as one approaches the farmstead of Renshent, where a junction with highly altered slates is seen in a little cutting. Then no other junctions are seen till the Foxdale Silica Quarry is reached (see Section, Fig. 2, p. 349), north of which a small apophysis runs out from the granite (Survey memoir, p. 165).

So far we are more or less in agreement with the Survey 1 inch map, but on this map the quartz veins are not shown. There may be other veins besides those shown upon the accompanying map, as there is considerable peat and boulder-drift, but the main veins are indicated as far as they can be traced. It will be noticed that these veins lie in three sets, somewhat radial, or approximately in two directions, viz., north and south, east and west. In the Foxdale Silica Quarry (Fig. 2, p. 349)—"the Spar Quarry"—there are several thick veins to be later described. The veins occur in greatest number to the south of the intrusion and several of them are 12 feet thick, while one for a short distance attains a thickness of 18 feet, but soon thins out to 2 or 3 feet on either side. Opposite Renshent (see Map, Plate XVI) a vein 12 feet in maximum thickness can be traced some way up the 'mountain', and it seems as though it is continuous with the vein outcropping in the stream to the east, but there is boggy ground between. The Eairy granite mass to the east is a smaller mass in every way similar to the main outcrop. Between the two outcrops the slates and grits are much altered and are exposed in the little stream. In the Survey memoir the question is raised as to whether this Eairy mass is connected with the Foxdale mass below or as to whether it is merely a portion of the latter that has been thrust into its present position. Since the Survey visited the spot a section of the junction of the granite with the slate has been exposed by quarrying in the Eairy mass for silica, and there seems evidence here that the mass is *in situ* and is a similar and connected intrusion. (See description of Section, Fig. 3, in Eairy Silica Quarry.)

Quartz and pegmatite veins occur in this mass also. The boundaries, except at the above-mentioned junction, are nowhere seen owing to thick boulder-drift. The distribution of the heath and boulders and the levels give the probable mapping.

THE QUARTZ VEINS.

The Foxdale Silica Quarry (see Map, Plate XVI, and Section, Fig. 2, p. 349).

Judging from the surface outcrops of the pegmatite veins an observer sees little to lead him to any other conclusion than that these consist simply of walls of white quartz spangled in places with mica, which project through the peat among the granite blocks and can be traced for a considerable distance up the mountain. They seem on the surface to be simple dykes; but when exposed in section in the quarries the apparent simplicity gives way to a complexity at first confusing, but which a little consideration easily elucidates. In the quarry the 'dykes' are seen to be thick, nearly upright veins which send out offshoots into the granite, dipping up at a high angle. The figure gives a diagrammatic representation of the facts (Fig. 2). The quarry face is irregular, and in the sketch the whole is brought to one plane. The main veins are the two upright ones to the right of the figure. The larger does not reach up to the surface, and it sends offshoots to the right which have a high dip into the quarry face. The irregular surface is here largely due to irregularity in the quarry face combined with this high dip. To the left are three veins with a dip of approximately 45° to the west, and farther out a larger vein is seen which includes parts of the granite. The whole of the material between the veins is a rather coarse-grained muscovite granite. The quartz locally passes into pegmatite, which consists essentially of quartz with spangles and matted masses of pale-bronze coloured mica, which is of the same type as the mica of the granite.

Several interesting things are to be observed in this quarry. In one case (not shown in the Figure) a vein occurs which is practically upright and has on its sides a felted mass of pale-bronze mica between it and the granite. This selvage is about half an inch in thickness and could be traced for two or three yards. On the west side of the quarry a vein occurs which can be seen running up the hill for some distance (see Map). In a little cutting outside the quarry the whole of the vein for a short distance has been cleaned out, and the side walls remain perfectly smooth and upright. These walls consist of granite with a coating of a mixture of quartz and orthoclase felspar, half an inch and less in thickness. This is a peculiar selvage; the felspar is idiomorphic and the quartz more or less allotriomorphic though with parallel growth, and it is quite water-clear. The selvages are of importance in considering the origin of the quartz veins.

Another interesting fact here is the occurrence of 'lochs' in parts of the quartz veins. Large drusy cavities occur which are lined with good quartz crystals, in continuity with the quartz of the vein, and usually therefore there is a tendency to a parallel growth in them. Rarely the crystals are water-clear, but usually they are milk-white, like the veins themselves (due to inclusions, see Mr. Lomas' paper). These

druses, called 'lochs' by the quarrymen, are said by them often to contain water. Now the veins are much jointed and cracked, and after breaking open many blocks with druses we succeeded in finding one or two containing water, but which evidently had filtered in along the cracks, as attested by the iron-stained path taken by it. All the quartz veins in the Foxdale Silica Quarry are of one type. They consist of almost pure quartz crystallized on a large scale, sometimes with flakes of mica. These are the quartz veins proper. At Eairy Quarry we get also fine-grained quartz-mosaics, forming the vein instead of the large crystals seen at Foxdale Quarry.

The Eairy Quarry (see Map, Plate XVI, and Section, Fig. 3, p. 349).

It is here that a junction of the slate with the granites may be seen, and here are thick pegmatite and quartz veins, with microgranite and granite giving an interesting section. The Figure (Fig. 3) explains itself. There is here much glacial drift covering the rocks, giving in one case quite a peculiar fold to the fragments.

The junction of the slates with the granite is quite a normal one, and the former are altered to mica schists and phyllites close to the granite. If the Eairy granite mass has been thrust off from the larger Foxdale mass, then the junction and slates too must have been subjected to the thrust. This does not seem probable, but evidence is wanted to prove that the slates are continuous with the main mass of the country rock. It should be noted that in few places are the slates so altered as between the two outcrops of granite. In the quarry section, next to the junction, a thick mass of jointed pegmatite cuts across the granite and slates (Fig. 3, *P, P*). It consists of quartz with large spangles of mica. The joint planes run at a steep angle to each other, and between the planes in two or three places a deposit of brown powdery limonite occurs, in one case as much as a foot thick, but shading off rapidly upwards. This is bounded further in the quarry by several faults with quartz and microgranite between them. These faults are also full of limonite. The mass of microgranite next shown is a fine granite very similar to the normal microgranite dykes associated with the granite. It is in parts stained by infiltrated limonite and hæmatite along the joints which make dendritic markings, comparable with those found on Windy Common to the south, mentioned later.

A thick vein of quartz follows with a dip of about 75° to the east. This sends an offshoot into the microgranite. Lastly, there is another quartz vein separated from the former on both sides of the quarry by a wall of granite, but they run together through the granite in the centre. These last two veins of quartz contain little mica, but are much stained by infiltrated iron-bearing water to yellow, brown, and red.

Mr. Harker describes the Foxdale granite thus: "It consists of quartz, microcline, an acid plagioclase, muscovite, subordinate biotite, and little crystals of garnet and zircon. In the marginal part of the intrusion are developed bands and masses of pegmatite, thick veins and bands of greisen, and finally quartz veins containing only local aggregations of white mica or bordered by a narrow seam rich in that

FIG. 2. Diagrammatized Section of quartz veins (Q) in granite (G) exposed in the Foxdale Silica Quarry. (See Map, Plate XVI.)

FIG. 3. Section in Eairy Quarry. (See Map, Plate XVI.)

Q. Quartz veins } including Harker's
P. Pegmatite } 'Greisen'
M. Microgranite (with Dendrites).
G. Granite.

S. Slates (altered).
D. Glacial Drift.
L. Limonite in joints.

mineral. These quartz veins, as at Grainsgill, traverse the other types of rocks.”¹ It is significant that here in the Skiddaw granite quartz-mica pegmatite and small quartz veins occur. The north-eastern trend-line of the Isle of Man strikes into the Lake District, and the Manx slates have been long supposed to be comparable with the Skiddaw slates.

Pegmatite is seen in the Eairy Quarry and marked ‘pegmatite’ on the diagram. Mr. Harker uses ‘greisen’ to denote a rock with felspar in subordinate amount, with a rather coarse-textured mosaic of quartz and the mica in moderately large flakes. No topaz or cassiterite are present. No felspar has been found in the quartz rocks in Eairy Quarry, but rocks consisting simply of a mosaic of quartz and mica are present and here are included among the pegmatite. In only one case was a pegmatite found with felspar. A block of large-grained pegmatite with quartz, muscovite, and kaolinized felspar was found near the Foxdale Silica Quarry, but not *in situ*. In the Eairy Quarry the coarseness of grain of the quartz rocks varies considerably. Some of the pegmatite is very coarse indeed, the quartz grains often too large to trace. In some cases the quartz consists of a mosaic with flakes of mica, and this may possibly correspond with Mr. Harker’s ‘greisen’. It should be added also that there is considerable evidence of dislocation and disturbance in this Eairy Quarry. Besides the limonite-filled joints, pressure effects are seen in the pegmatite, and in one case a large lenticle of quartz covered with a shining film of mica was found. The granite shows a tendency to foliation in thin section.

MODE OF ORIGIN OF THE QUARTZ VEINS.

One cannot help speculating upon the possible ways by which these characteristic pegmatite and quartz rocks can have been formed. The veins of quartz occur, as seen, in the granite itself and also in the surrounding country rock. As far away as Fleshwick Bay, near Port Erin, on South Barrule and on Slieau Whaullian to the north-west, veins of quartz are found in the slates. These last, however, do not appear as dykes; they follow the cleavage of the slates in some cases, and in others cut obliquely across in strings and bands; sometimes they are in irregular lenticles. In Fleshwick Bay thick veins following the cleavage occur in the grits and slates seen there; the grit near the quartz veins is very much hardened by silicification. Here and on Slieau Whaullian sometimes the quartz veins occur in highly contorted slates, and the veins follow the intricate folds more or less closely. In these cases we have, it seems, water-formed veins—veins which have been formed by infiltration. On South Barrule both forms of quartz occur.

In the case of the veins in the granite, and of those ‘dykes’ of quartz in the country rock, the mode of formation seems to be in every way comparable with that of normal igneous rocks. Veins of aplite that occur in association with many of the acid plutonic rocks are often spoken of as representing the mother-liquor of the molten magma after the greater part has crystallized. In the norma-

¹ “Grainsgill Greisen”: Q.J.G.S., vol. li, pp. 143-4.

sequence of crystallization quartz is the final mineral to consolidate. We have seen from the quarry sections that the thick veins of quartz are not so regular as first supposed, and are usually inclined at angles with the vertical. It should be noticed also that sometimes the granite is veined and stringed with small quartz veins from $\frac{1}{4}$ to 3 or 4 inches in width. This is a local phase and occurs a little to the west of the summit of the hill. The evidence seems to warrant the idea that the veins of quartz represent the final consolidation product of the granite magma. If this is the case cooling must indeed have been slow to allow them to crystallize on such a large scale. The selvages found to some of the veins support this theory also. In one case there is a layer half an inch thick of mica in every way similar to the mica of the granite and of the pegmatite. In another case a lining of quartz and orthoclase felspar occurs as above described. It would seem that these linings are due to the mass of the molten silica with impurities being subjected to a process of segregation, the magma being mobile and the cooling so slow as to allow in the one case the mica and in the other the felspar to be separated and gathered together at the sides, and after an interval the silica to crystallize slowly. All the veins at present seen in the Foxdale Quarry show a very coarse structure, but, as stated, in the Eairy Quarry finer-grained quartz veins occur with also pegmatite. The quartz veins outside the granite are usually rather fine-grained.

At the point marked 'Aplite' on the Map (Plate XVI) a quartz rock of doubtful nature occurs. It resembles a dyke in its field relations, but the exposure is not good. It is associated with sheets 3 inches thick running in the slates parallel to the bedding, and though at first taken for a dyke it more probably is an altered grit faulted off on one side. In section it most resembles an impure quartzite.

There is a decided break between the consolidation of the plagioclase and the quartz, and the former occurs always in well-lamellated idiomorphic crystals. In a section of the granite from the Foxdale Silica Quarry all three feldspars are present, and all the feldspars as well as the muscovite include small fragments of quartz. The microcline is always interstitial. Garnet occurs in small irregular grains locally. Apatite is present, but not common. The rock is a soda granite with a rather high silica percentage. A good approximate analysis is as follows:—

Si O ₂	.	.	.	.	.	.	.	72·5
Al ₂ O ₃	.	.	.	.	.	.	.	16·3
Fe ₂ O ₃	}	.	.	.	.	.	.	2·5
Fe O		.	.	.	.	.	.	
Mn O	.	.	.	.	.	.	.	—
Ca O	.	.	.	.	.	.	.	1·1
Mg O	.	.	.	.	.	.	.	0·5
K ₂ O	.	.	.	.	.	.	.	3·2
Na ₂ O	.	.	.	.	.	.	.	3·2
Ti O ₂	.	.	.	.	.	.	.	0·2
P ₂ O ₅	.	.	.	.	.	.	.	trace
Cl	.	.	.	.	.	.	.	trace
H ₂ O	.	.	.	.	.	.	.	0·54

100·04

The granite contains plagioclase and microcline as well as a little orthoclase locally. The dominant mica is muscovite. The order of crystallization of the constituents is as follows:—

Muscovite.
Plagioclase (chiefly albite).
Orthoclase (when present).
Quartz.
Microcline.

The analysis shows the rock to be of a normal soda-granite type with a high silica percentage. The results compare fairly well with the analyses of granites of the Lake District and Ireland, except that aluminium is in higher percentage and the alkalis a little lower.

The condition of affairs seems to have been this—the main mass of the magma cooled to form the acid soda granite of which the analysis is given, but at the last there was a residuum of silica which crystallized out to form the peculiar quartz veins which run through the granite. The veins are igneous in origin, and there is no sign of ‘comb’ or other structure to suggest that water or vapours have helped in the formation.

DENDRITIC MARKINGS IN THE MICROGRANITE DYKES.

On Windy Common, about two miles south of the ‘Granite Mountain’, microgranite dykes occur with also a few quartz ‘dykes’. The latter run north and south, but the former, of which seven could be mapped, all run north-east to south-west. Several of these ‘elvans’ have been quarried, and some are still being worked. In one of the most actively worked dykes peculiar dendritic markings occur. They were first noticed by Professor Boyd Dawkins, who kindly directed me to the locality and placed his specimens at my disposal. The dendritic markings are solid—not marks on one plane on the surface of the rock, but marks due to the actual soakage of solutions depositing oxides of iron in the rock. They always start on a joint plane, the sides of which are stained with the iron oxide, and run varying distances into the microgranite. Broken surfaces parallel to the joint plane give numerous circular dark marks, and sections at right angles to the joint planes give irregular marks, sometimes dendritic, sometimes almost straight. In section under the microscope the rock is seen to be a microgranite with quartz, felspar (plagioclase and orthoclase), and muscovite. The mica usually exhibits a tendency to parallelism and other evidence of pressure is not wanting. The staining in section is seen to be merely infiltrated colouring matter between the grains. The dendritic marks can be wholly dissolved out of pieces of the rock by hydrochloric acid, yielding a yellow solution of ferric oxide and the fragments becoming quite white. As stated above, the dendrites occur also at Eairy Silica Quarry, and here also one gets the typical surface markings, properly dendritic in outline. Specimens of the dendritic microgranite are very striking and the usual character of the rock is hidden by the dark staining. It is a peculiar infiltration effect which seemed worthy of notice in this place.