

ART. XVIII.—*Notes on Granitic Rocks.*—Part III; by T.
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(Continued from vol. i, p. 191.)

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§ 32. It was mentioned at the close of the second part of this paper that the third part would be devoted to the consideration of the granitic veinstones found in Laurentian rocks. The stratified rocks of this ancient gneissic series, as I have elsewhere pointed out, differ considerably from those of the White Moun-

tain series, which, with their veinstones, have been treated of in the second part of this paper, § 16—§ 23.*

The Laurentian series, the Lower Laurentian of Sir William Logan, as studied by him in a region to the north of the Ottawa, the only area in which it has yet been examined in detail, appears to consist of an alternation of conformable gneissic and calcareous formations. The latter are three in number, each from 1000 to 2000 feet or more in thickness, and separated by still more considerable formations of gneiss and quartzite; a mass of gneiss of great but unknown thickness forming the base (Geology of Canada, page 45). The gneissic rocks of the series are very firm and coherent, reddish or grayish in color, often very coarse-grained and granitoid, sometimes with but obscure marks of stratification; and frequently porphyritic from the presence of large cleavable masses of reddish orthoclase, occasionally with a white triclinic feldspar. They are often hornblende, and sometimes contain small quantities of dark-colored mica. A white granitoid gneiss, composed chiefly of orthoclase and quartz, sometimes contains an abundance of red iron-garnet. The latter mineral is often disseminated, or forms subordinate beds in the quartzites of the series.

§ 33. With the crystalline limestones of the calcareous parts of the series are often found strata made up of other minerals to the entire exclusion of carbonate of lime, by an admixture of which, however, they graduate into the adjacent limestones. These beds generally consist of pyroxene, sometimes nearly pure, and at other times mingled with a magnesian mica, or with quartz and orthoclase, often associated with hornblende, serpentine, magnetite, sphene and graphite. These pyroxenite rocks are generally gneissoid or granitoid in structure, and sometimes very coarse-grained. They occasionally assume a great thickness, and are then often interstratified with beds of granitoid orthoclase gneiss, into which the quartzo-feldspathic pyroxenites pass by a gradual disappearance of the pyroxene. The limestones often include serpentine, pyroxene, hornblende, phlogopite, quartz, orthoclase, magnetite and graphite; so that the same minerals are common to them and to the pyroxenic strata, which may be looked upon as marking the transition between the gneissic and the calcareous parts of the series.

* A good example of a large vein of this kind of intersecting rocks, apparently of the White Mountain series, may be seen in the Ramble in the Central Park in the city of New York. Its place is marked by a great erratic block perched directly over the vein.

The banded structure described in § 21 is well shown in a narrow granitic vein which I owe to Prof. Haughton of Trinity College, Dublin, got from Three Rock Mountain near that city. It consists of white orthoclase, with quartz and some mica and garnet, and exhibits near the middle two bands of prisms of black tourmaline pointing towards the centre, which is filled with a coarsely crystalline orthoclase.

These strata, marked by the predominance of calcareous and magnesian silicates, appear, so far as known, to accompany each of the limestone formations of the Laurentian, sometimes, however, developed to a greater and sometimes to a less extent.

§ 34. I have elsewhere called attention to the fact that the highly micaceous schists and the argillites of the Green Mountain and White Mountain series of rocks, are, so far as known, wanting in the Laurentian, and with them the characteristic minerals of the latter series, staurolite, andalusite and cyanite. There are, however, beds of a highly micaceous rock in the Laurentian, which contain an unctuous magnesian mica with a pyroxenic admixture; these are very unlike the mica-schists composed of a non-magnesian mica and quartz, with orthoclase, which abound in the White Mountain rocks. These magnesian beds belong to the calcareous horizons in the Laurentian series, at which also occur the most numerous veins and the principal minerals of economic value. It is also along these horizons, marked by softer rocks, that the valleys and the arable lands of the Laurentian areas are chiefly found, and for this reason, also, the mineralogy of these parts is better known than that of the harder gneissic portions. The above observations on the lithological character of the stratified rocks are important on account of the relations between these and the included veins, in which the characteristic minerals of the gneissic and calcareous rocks are often found associated.

§ 35. The history of these veins, as seen in the Laurentian rocks of the Laurentides in Canada, the Adirondacks of northern New York, and the Highlands of southern New York and New Jersey, has been discussed at length by the author in an essay on *The Mineralogy of the Laurentian Limestones*, in the Report of the Geological Survey of Canada for 1863-69, pages 181-223.* In this essay, which will be frequently referred to in the present paper, the veinstones found in the Laurentian rocks have been noticed under three heads: 1st, Metalliferous veins carrying galenite, blende, pyrite and chalcopryrite in a gangue of calcite, sometimes with barytine and fluorite; these, which are of Paleozoic age or still younger, cut the Potsdam sandstone, the Calciferous sandrock, and probably also the overlying Trenton limestones. 2d, Quartzo-feldspathic veins with muscovite, tourmaline, zircon, etc. These veins I have described as passing by insensible gradations into the third class, in which calcite and apatite, with pyroxene, phlogopite and other calcareous and magnesian silicates predominate, though frequently accompanied by quartz and orthoclase. These veins are older than the

* This essay is reprinted, with some additions, in the Report of the Regents of the University of New York for 1867, Appendix E. The reader's attention is called to the note on the Hastings rocks at the close of this reprint.

Potsdam sandstone, which rests upon their eroded outcrops, and sometimes includes worn fragments of apatite derived from them.

§ 36. It is these last two classes which it is proposed to consider in the present paper under the name of granitic veinstones. In justification of the extension of the term granitic to the whole of this series of veins, it must be repeated that it is not possible to draw a line of distinction between those in which quartz and orthoclase are the characteristic minerals, and those in which calcite, apatite, pyroxene and phlogopite prevail, sometimes to the entire exclusion of quartz and feldspar, both of which minerals are, however, frequently intermixed with the preceding species in the same aggregate. In one example, in Burgess, Ontario, the sides of a large vein are occupied by a mixture of calcite and apatite, while the center is filled by a vertical granite-like layer of reddish orthoclase, with a little quartz and green apatite. Of another vein in the township of Lake in Ontario, one portion was found to consist of calcite with yellow phlogopite, while an adjacent part consisted of quartz, with brown tourmaline, bismuthine, native bismuth, and graphite.

§ 37. The resemblance between the minerals of these Laurentian veinstones and the same species brought from Norway, was noticed so long ago as 1827, by Dr. William Meade (this *Journal* I, xii, 303). Daubrée, in his account of the metalliferous deposits of Scandinavia, published in 1843 (*Ann. des Mines*, IV, iv, 199, 282), has given us a careful description of the veins from which these minerals are derived. From this, together with the observations of Scheerer and Durocher, we are enabled to compare these veinstones with those of the Laurentian rocks in North America, and show, as I have, in the essay referred to, done in detail, and for each principal species, the great similarity which exists between the two. In the so-called Primitive Gneiss formation of Scandinavia, these veins occur either in gneiss or in a gneissoid rock consisting of various admixtures of pyroxene, hornblende, garnet, epidote and mica, the whole associated with crystalline limestones. The veins which abound in the gneiss near the iron mines of Arendal in Norway, according to Daubrée, though occasionally containing calcite, apatite, hornblende and scapolite, are sometimes destitute of all calcareous and magnesian minerals, and become granite-like aggregates of orthoclase and quartz. He hence describes these veins, as a whole, though frequently abounding in lamellar calcite, as essentially granitic in character. As already noticed in § 8, Daubrée agrees with Scheerer in regarding these veinstones as produced by a process of secretion, in opposition to Durocher,

who looked upon them as having been formed by igneous injection.

§ 38. The principal mineral species known in the corresponding veinstones of the Laurentian rocks of North America are the following: *calcite*, *dolomite*, fluorite, *apatite*, *serpentine*, chrysolite, *chondrodite*, *wollastonite*, *hornblende*, *pyroxene*, *pyrallopite*, *gieseckite*, *scapolite*, *petalite*, *orthoclase*, *oligoclase*, *albite*, *muscovite*, *phlogopite*, *seybertite*,* *tourmaline*, *garnet*, *idocrase*, *epidote*, *allanite*, *zircon*, *spinel*, *chrysoberyl*, *corundum*, *quartz*, *sphene*, *rutile*, *menaccanite*, *magnetite*, *hemalite*, *pyrite* and *graphite*. To which may be added some rarer species, such as *tephroite*, *willemite*, *franklinite*, *zincite*, *warwickite*, found in a few localities only, and others of less importance. Of the above list, those species whose names are in italics have been recognized as constituent minerals in the stratified rocks in which the veins occur, as pointed out by me in the essay already noticed.

The most important species in these veinstones are *calcite*, *quartz*, *orthoclase*, *phlogopite*, *pyroxene*, *apatite* and *graphite*, of which some one or more will generally be found to prevail in the veins in question. The greater part of the species named in the first list were observed by Daubr e in the veins near Arendal, and to these he adds *axinite*, *gadolinite*, and more rarely *beryl* and *leucite*; † while in the island of Uto , associated with iron ores, crystalline limestones, and hornblendic rocks passing into gneiss, are similar granitic veinstones containing *orthoclase* and *quartz*, with *tourmaline*, *cassiterite*, and in the middle of the veins, *petalite*, *spodumene* and *lepidolite*. This association is the more worthy of notice, as the only other known locality of *petalite* (if we except the *castor* of Elba) is in the crystalline limestone of Bolton, Massachusetts, where it occurs, probably in a veinstone, with *scapolite*, *hornblende*, *pyroxene*, *chrysolite*, *spinel*, *apatite* and *sphene*.

§ 39. Evidences of the concretionary origin of these granitic veinstones of the Laurentian rocks appear in their banded structure, their drusy cavities, the peculiar incrustations and modes of enclosure often observed in the crystals, and finally

* The species *seybertite* (*clintonite* or *xanthophyllite*) has acquired a new interest from the recent announcement by Jeremejew (*ante* page 57), that the variety found in the Schischimskian Mountains in the Urals is the gangue of diamonds, which are found abundantly in microscopic crystals imbedded in its laminae. The *seybertite* of this region (the *xanthophyllite* of G. Rose) is described as occurring in talcose slate with *serpentine* (which also include diamonds), while in the Laurentian rocks it is only known in calcareous veinstones with *spinel*, *pyroxene*, *graphite*, etc.

† For a notice of the occurrence of *leucite* in these veins, and also in veins in Mexico, see the author's Contributions to Lithology (this Journal, II, xxxvii, 264). According to Garrigou, this rare species occurs both well crystallized and in compact porphyroid masses, in dioritic rocks (*ophites*) at Lusbe in the valley of Asp , in the Pyrenees (Bull. Soc. Geol. de Fr., II, xxv, 727).

in the rounded forms of certain crystals, which show a process of partial solution succeeding that of deposition. A banded arrangement of the materials parallel to the sides of the vein is often well marked. Thus, while the walls may be coated with crystalline hornblende, or with phlogopite, the body of the vein will be filled with apatite, in the midst of which may be found a mass of loganite, or of crystalline orthoclase mixed with quartz, filling the center of the vein, as already noticed in § 36. In other instances portions of the vein will be occupied by crystals of apatite, pyroxene or phlogopite imbedded in calcareous spar, which in some other part of the breadth of the vein, or in its prolongation, will so far predominate as to give to the mass the aspect of a coarsely crystalline lamellar limestone. Prisms of apatite are often observed extending from either side toward the center of the vein, which in some cases may be filled with calcite or another mineral, and in others is a vacant space lined with crystals. Drusy cavities of this kind a foot in breadth and several feet in length and depth, are sometimes met with in these veins in Ontario.

§ 40. Further evidence of concretionary origin is seen in the manner in which the various minerals incrust each other. Thus small prisms of apatite are enclosed in large crystals of phlogopite, in pyroxene, in quartz, and even in massive apatite; crystals or rounded crystalline masses of calcite are imbedded in apatite and in quartz, and well-defined crystals of hornblende (pargasite) in pyroxene. In another example before me, small crystals of hornblende are implanted on a large crystal of pyroxene, and both, in their turn, are incrustated by small crystals of epidote. Crystalline graphite in like manner is enclosed alike in orthoclase, quartz, calcite, phlogopite and pyroxene.

§ 41. Another noticeable evidence of the concretionary origin of these veins is the phenomenon already referred to in § 25, where the external skeleton or frame-work of a crystal is complete, while the space within either remains empty, or is filled with other minerals, often unsymmetrically arranged. This condition of things is rendered intelligible by the formation of similar hollow crystals during the cooling of certain saline solutions, as for example potash-nitrate. Small hollow prisms of red and green tourmaline, closely resembling the hollow niter crystals, are common in the well-known granitic veinstone of Paris, Maine. I have elsewhere referred to the formation of such moulds or skeleton-crystals as having taken place in vein-cavities, and as serving to explain many cases of enclosure of mineral species (Address to the A. A. S., Indianapolis, 1871. *Amer. Naturalist*, vol. v, page 491). In addition to the examples there cited, the Laurentian veinstones afford some curious cases. Thus a prism of yellow

idocrase half an inch in diameter, from a vein in Grenville, Ontario, composed chiefly of orthoclase and pyroxene, is seen when broken across to consist of a thin shell of idocrase filled with a confused crystalline aggregate of orthoclase, which encloses a small crystal of zircon. In like manner large crystals of zircon from similar veins in St. Lawrence County, New York, are sometimes shells filled with calcite.

§ 42. The rounded forms of certain crystals in the Laurentian veinstones, was, I believe, first noticed by Emmons, who observed that crystals of quartz imbedded in carbonate of lime from Rossie, New York, have their angles so much rounded that the crystalline form is nearly or quite effaced, the surface being at the same time smooth and shining. This appearance is occasionally observed in other localities, and is not confined to quartz alone, crystals of calcite and of apatite sometimes exhibiting the same peculiarity. At the same time the orthoclase, scapolite, pyroxene and zircon, which are associated with these rounded crystals, preserve all their sharpness of outline, as was observed by Emmons for the orthoclase in contact with the crystals of quartz just described. He suggested that the rounded outlines of these crystals were due to a partial fusion, although he did not overlook the fact which renders this explanation untenable, that the species presenting rounded angles are much less fusible than those which, in contact with them, preserve their crystalline forms intact (*Geology of the First District of New York*, pages 57-58). These facts are well shown in the apatite-veins of Elmsley and Burgess, Ontario, where the crystals of apatite rarely present sharp or well defined forms; but, whether lining drusy cavities or imbedded in the calcite or other minerals of the veinstone, are most frequently rounded or sub-cylindrical masses, while the pyroxene and sphene, which often accompany them, preserve their distinctness of form. This rounding of the angles of certain crystals appears to me nothing more than a result of the solvent action of the heated watery solutions from which the minerals of these veins were deposited; the crystals previously formed being partially redissolved by some change in the temperature or the chemical constitution of the solution. Heated solutions of alkaline silicate, as shown by Daubrée, are without action on feldspar, as might be expected from the fact observed by him of the production of crystals of feldspar, as well as of pyroxene, in the midst of such solutions. These liquids would, however, doubtless attack and dissolve apatite, which is in like manner decomposed by solutions of alkaline carbonate, and these latter at elevated temperatures dissolve crystallized quartz. That this solvent process has been repeated during the filling of the veins is seen by a specimen in my possession, which shows crystals of calcite

previously rounded and enclosed in a large crystal of quartz, the angles of which are also nearly obliterated. From the alternations in the deposited mineral matters in many veinstones, as well as from what we know of the changing composition of mineral springs, it is evident that the waters circulating in the fissures now occupied by veins, must have been subject to periodical variations in composition.

§ 43. In the *Geology of Canada* (page 729), I have noticed an example of rounded quartz crystals in the veins at the Harvey Hill copper-mine in Leeds, Quebec. Large terminated prisms of limpid colorless quartz are there found imbedded in compact erubescite, their angles being much rounded, while their faces are concave, and have lost their polish, retaining only a somewhat greasy lustre. A thin shining green layer, apparently of a silicate of copper, covers the surfaces of the ore in contact with the crystals. From the mode of their arrangement in certain specimens, it is evident that these prisms of quartz, lining drusy cavities, were partially dissolved previous to the deposition of the metallic sulphide.

§ 44. Some of the more important types of Laurentian veinstones may now be noticed. Those made up of quartz with orthoclase, muscovite and black tourmaline, often with zircon, are not unfrequent in the Laurentian gneiss, though so far as yet observed less abundant than in the gneisses and mica-schists of the White Mountain series. It is true, as already pointed out, that from the greater softness of the enclosing rocks the veins of the latter series are often weathered into relief (§ 20), and are thus rendered more conspicuous than those in the harder Laurentian gneisses. Among other examples of this first type of granitic veins may be mentioned those in Yeo's Island among the Thousand Isles of the St. Lawrence, and the well known vein in Greenfield near Saratoga, remarkable for affording crystals of chrysoberyl. A frequent type among the Laurentian granitic veins is characterized by great cleavable masses of reddish or reddish-brown orthoclase, with quartz and but little mica. With these are sometimes associated equally large masses of white or pale-colored albite; these veins are sometimes of great size, 100 feet or more in breadth. The perthite of Thompson, well known as a cleavable feldspar made up of alternate thin plates of reddish-brown orthoclase and white albite, forms with quartz a large granitic vein; while the peristerite of the same author is an opalescent or chatoyant albite which occurs with quartz in another vein in the same region. Some of the veins of red orthoclase include large cleavable masses of dark green hornblende, occasionally with magnetite. A remarkable vein about eighty feet in width, in Buckingham, Quebec, is composed entirely of reddish-white orthoclase and

cleavable magnetite, the latter in masses sometimes two or three inches in diameter, scattered through the feldspar.

§ 45. The veins hitherto noticed occur in gneiss, but on the river Rouge one consisting of large masses of quartz and albite is found in crystalline limestone. A remarkable vein described by Sir William Logan in Blythefield, Ontario, traverses alternate strata of limestone and gneiss, and has a breadth of not less than 150 feet. It consists in great part of a coarsely cleavable pale green pyroxene (sahlite), with a dark green hornblende, phlogopite and calcite. Portions of the veinstone, however, consist of an admixture of orthoclase, quartz and black tourmaline, showing the transition from the calcareous to the feldspathic type of veins. In Ross, Ontario, a vein holds large isolated crystals of white orthoclase imbedded with black spinel, apatite and fluorite in a base of lamellar pink carbonate of lime. One of the most remarkable of these composite veins is in Grenville, Quebec, and was formerly worked for graphite. It cuts a crystalline limestone, itself holding graphite and phlogopite, and has afforded not less than fourteen distinct mineral species, viz: calcite, apatite, serpentine, wollastonite, pyroxene, scapolite, orthoclase, oligoclase, garnet, idocrase, zircon, quartz, sphene and graphite. An adjacent vein abounds in phlogopite, with pyroxene and zircon. A not less remarkable vein is that described by Blake in Vernon, New Jersey (this Journal, II, xiii, 116), in which calcite, fluorite, chondrodite, phlogopite, margarite, spinel, corundum, zircon, sphene, rutile, menaccanite, pyrite and graphite occur. Some of these contain barytine, and in one case I have observed natrolite, both seemingly filling cavities, and of later origin than the other minerals. The remarkable zinciferous minerals, franklinite, zincite and dysluite, found in the Laurentian limestones of New Jersey, appear from the descriptions of H. D. Rogers to belong to calcareous veinstones. Granitic veins are found traversing the magnetic-iron ore beds of the Laurentian series. I have described one in Moriah, New York, which includes angular fragments of the magnetite which forms its walls, and consists of a cleavable greenish triclinic feldspar, with quartz crystals having rounded angles, octahedrons of magnetite, allanite, and a soft greenish mineral resembling loganite.

§ 46. As regards the order of deposition of minerals in these veins, we find apatite enclosed alike in calcite, in quartz, in phlogopite, in spinel, in graphite and in pyrite. On the other hand, apatite sometimes includes rounded crystals of calcite or of quartz; and graphite, which itself encloses apatite, is found included alike in quartz, in orthoclase, in pyroxene and in calcite, in such a manner as to lead us to conclude that its crystallization was contemporaneous with that of all these

minerals; while from the other facts mentioned it would appear that the order of deposition was subject to variation and to alternations. In a vein in Grenville, large prisms of a white aluminous pyroxene (leucaugite) penetrate great crystals of phlogopite, while at the same time small crystals of a similar mica are completely imbedded in the crystallized pyroxene. Many facts relating to the association of various species in these veinstones will be found in my essay, but the subject is one which still demands careful study. The banded structure of these veins is well shown in some of those which contain graphite. This mineral, though sometimes irregularly disseminated through the veinstone, frequently occurs in sheets or layers alternating with orthoclase, quartz or pyroxene, parallel to the walls of the vein and exhibiting a peculiar structure due to the formation of successive layers of crystalline lamellæ more or less nearly perpendicular to the plane of deposition.

§ 47. The veins hitherto noticed, whether feldspathic or calcareous, are generally vertical, or nearly so, and in most cases traverse the stratification. Of many of them which have been explored to some extent for apatite, mica and graphite, it is noticed that they are subject to great changes in dimension as well as in mineral contents. They often appear to occupy short irregular fissures, and in some cases are to be described as more or less completely filled geode-like cavities rather than veins.

§ 48. In the reprint of my essay, already mentioned, several veins are noticed in the county of Hastings, Ontario, in rocks which were at that time referred by the Geological Survey of Canada to the Laurentian, but have since been found to belong to a younger series. Such are the veins containing argentiferous fahlerz with mispickel, and that holding native gold with a quasi-anthracitic form of carbon, both from Madoc, and also the vein already noticed as occurring in the township of Lake (§ 36), which contains in one part bismuthine with tourmaline, quartz and graphite, and in another part calcite with phlogopite. This latter vein occurs in an impure limestone, associated with quartzite and micaceous schists, and belonging to a series unconformably overlying the Laurentian, and resembling the rocks of the White Mountain series (this Journal, II, 1, 83). It will be noticed that this vein is lithologically similar to those of the Laurentian, which are not improbably of the same age. Calcareous veinstones like those already described, are not unknown in the White Mountain rocks in Maine, where are found on a small scale aggregates of crystallized pyroxene, idocrase and sphene, and others of calcite with hornblende, apatite and graphite (§ 18), closely resembling the Laurentian veinstones of New York and Canada.

§ 49. The various minerals of these calcareous veinstones are generally described as occurring in crystalline limestones, though C. U. Shepard, H. D. Rogers and W. P. Blake have each recognized the fact that these mineral species, with their calcareous gangue, belong to true veins. Emmons, however, failed to distinguish between these veinstones and the stratified limestones of the series, which, as already stated, often contain disseminated many of the same species, though in a less perfectly crystallized condition than in the veinstones. Since the latter are clearly seen like dykes to traverse the gneiss, Emmons was led to look upon them as eruptive; and generalizing from this, he declared that all the crystalline limestones of northern New York were non-stratified rocks of eruptive origin (*Geol. of the First District of New York*, 1842, pages 37-59). This view of Emmons was to a certain extent adopted by Mather, who while maintaining the stratified character of the crystalline limestones of southern New York, admitted the existence of eruptive limestones. Von Leonhard had already, in 1833, asserted that limestones have sometimes come from the interior of the earth in a liquid state, like other igneous rocks, and a similar view was at that time maintained by many other geologists. Among others we find Rozet asserting the eruptive origin of the crystalline limestones which are associated with gneiss in the mountains of the Vosges (*Bull. Soc. Geol. de Fr.*, iii, 215-235). In support of this view could be urged the dyke-like form of the calcareous veinstones, which other observers, like Emmons, confounded with the bedded limestones. The nature and origin of this misconception, were, I believe, first pointed out by me in a communication to the American Association for the Advancement of Science in August, 1866 (*Can. Naturalist*, II, iii, 123), and subsequently more at length in the essay so often referred to (*Report Geol. Survey of Canada*, 1863-69, p. 182). It was there shown that many of these calcareous veinstones are nearly free from foreign minerals, and so closely resemble in lithological characters the stratified limestones, that the different geognostical relations of the two alone enable us, in some examples, to distinguish between them. In this connection I called attention to the great dykes of granular limestones found traversing gneiss near Auerbach in the Bergstrasse, which Bischof has described as true veinstones. These endogenous concretionary limestones are in fact to the stratified limestones, what endogenous granitic veins are to gneiss rocks.