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THE GEOLOGICAL SOCIETY.

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Henry Hussey Vivian, Esq., and Henry Smith, Esq., C.E., were elected Fellows.

The following communications were read :—

1. *On the METAMORPHIC and METALLIFEROUS ROCKS of EASTERN NOVA SCOTIA.* By J. W. DAWSON, Esq.

[Communicated by the President.]

IN those parts of Nova Scotia lying eastward of the Shubenacadie River, and northward of Mines Basin and Channel, about half of the surface is occupied by carboniferous beds, whose arrangement has been noticed in various papers communicated to this Society*. The remainder, with the exception of a few small patches of new red sandstone and unaltered Silurian strata, consists of metamorphic rocks, for the most part older than the carboniferous system. These metamorphic rocks may, by evidence derived from mineral characters, geographical distribution, and associated fossiliferous beds, be divided

* Proceed. Geol. Soc. vol. iii. p. 711 (Mr. Logan); vol. iv. p. 124 (the President's Address); p. 184 (Sir C. Lyell); p. 186 with map (Dr. Gesner). Quart. Journ. Geol. Soc. vol. i. p. 26 with map (Mr. Dawson); p. 322 with map (Mr. Dawson); p. 393 (Sir C. Lyell); vol. ii. p. 133, organic remains (Mr. Dawson and Mr. C. Bunbury); vol. iv. p. 50 with map (Mr. Dawson); vol. v. p. 129 (Dr. Gesner).

into two great groups, which, so far as I am aware, have not hitherto been accurately distinguished by writers on the geology of Nova Scotia. In the present paper I propose to notice the composition, arrangement, and distinctive characters of these groups; and to describe, somewhat in detail, the metalliferous veins which have been discovered in one of them.

I. One of these metamorphic groups is, in the part of the province now under consideration, limited to the Atlantic coast and its vicinity. The prevailing stratified rocks in this group are, compact and flaggy grey quartzite (often weathering white), mica slate, and clay slate; the latter usually of dark colours, and occasionally passing into flinty slate and quartzite. These rocks usually occur in beds of great thickness. The hypogene rocks associated with them are white and flesh-coloured granite, which has penetrated the metamorphic rocks in large irregular bands and masses. The white granite, which is the most abundant, has white potash felspar, translucent slightly purplish quartz, and grey and black mica. I am not aware that any workable metallic deposits have been found in this group, or that any fossil remains are contained in it. As the association with granite is a somewhat characteristic feature, this group may, for the purposes of this paper, be named the *granitic* group of metamorphic rocks. It must not however be confounded with the granitic group of Dr. Gesner's arrangement*, which consists exclusively of hypogene rocks, and includes syenite, porphyry, and trap, belonging in my opinion to a different system.

The granitic group forms a continuous, or nearly continuous belt along the Atlantic coast of the province, narrow at its north-eastern extremity, and apparently attaining its greatest development in the western counties. In the part of the province now under consideration, its southern or coast side has a general direction of S. 68° W.; its inland side, though presenting some broad undulations, has a general direction of about S. 80° W. Its extreme breadth at Cape Canseau, its north-eastern extremity, where it is bounded on one side by the ocean, and on the other by Chedabucto Bay, is only about eight miles. In its extension westward, it gradually increases in width, until at the head of the west branch of the St. Mary's River, eighty miles distant from Cape Canseau, it is about thirty miles in breadth. Westward of this point, it does not increase in breadth within the district to which this paper refers.

In the peninsula of Cape Canseau, mica slate is very abundant and presents many beautiful varieties†; it is associated with quartzite, clay slate, and granite. At the St. Mary's River, the northern side of the belt consists of a great thickness of grey quartzite, often flaggy and micaceous, and occasionally intersected by veins of white quartz. In the centre of the belt great masses of granite appear at a little distance from the river section, and nearer the coast, mica slate and

* Industrial Resources of Nova Scotia, p. 232.

† I am indebted to Mr. Whiteman, of the Railroad Survey, for an interesting suite of specimens from this peninsula.

Fig. 1.

quartzite prevail. Westward of the main stream of the St. Mary's River, clay slate and quartzite with masses of granite are the prevailing rocks.

The surface of this metamorphic belt is rugged and uneven, but not very elevated. The inland side is however somewhat higher than the parts nearer the coast, attaining in some places an elevation of about 600 feet; it abounds in small lakes and streams, and its coast line is much indented.

From the upper part of the west branch of the St. Mary's River to the head of Chedabucto Bay, the granitic group is bounded on the north by a valley occupied by sandstones, conglomerate, and shale, composed of the debris of the hypogene and metamorphic rocks; and containing a few *Calamites* and other fossil plants of the carboniferous system. This belt of carboniferous strata, which I explored and marked on the map of the province for the first time in 1845, separates in its whole length the granitic group from that next to be described. (See Section, fig. 2.)

II. In the second, as in the first metamorphic group, the prevailing rocks are slate and quartzite; these are, however, of much more varied characters. The former varies from greywacke to imperfect micaceous and talcose schists through many intermediate varieties of clay slate, and presents grey, olive, black and reddish colours. The latter is of every variety of texture, and ranges in colour from white to dark grey. These rocks are also more thinly bedded, and present more frequent alternations than those of the granitic group; at some points they are observed to pass into less altered rocks, containing organic remains; and in several localities they are traversed by metalliferous veins. The igneous rocks which have penetrated the strata of this group are very abundant, and exceedingly varied in their composition and characters. Their prevailing composition is feldspatho-hornblendic, a character by which they are in general markedly distinguished from those of the granitic group. Syenite, greenstone of many varieties, compact felspar, claystone, and porphyries with bases of the two latter substances, are the most common of these

hypogene rocks. For our present purpose this group may be named the *syenitic* group of metamorphic rocks.

The most eastern point at which this group appears is Cape Porcupine in the Strait of Canseau, which presents a nucleus of reddish syenite, against which rest hard dark-coloured slates, apparently closely united to, and passing into, the syenitic mass. Cape Porcupine is separated from the eastern extremity of the granitic belt about twenty-four miles distant, by a tract of carboniferous rocks and the waters of Chedabucto Bay.

From Cape Porcupine, the southern margin of the syenitic group extends along the northern side of the carboniferous valley already referred to, for about sixty miles, with a course of S. 70° W. It then meets, and apparently unites with, the northern margin of the granitic group. At Cape Porcupine, the hypogene and metamorphic rocks occupy only three miles of the coast section, and attain an elevation of 500 feet. Westward of that point, they extend in a narrow, and perhaps in some places interrupted band, bounded on each side by carboniferous rocks for about forty miles, when they unite with a broader but very irregular promontory of similar rocks, extending toward Cape St. George. The triangular space intervening between these two metamorphic bands is occupied by carboniferous rocks.

The metamorphic promontory extending to Cape St. George, and including the Antigonish and Merigomish hills, attains a greater elevation than the band connected with Cape Porcupine. At its extremity, however, it becomes divided into a number of detached hills and ridges, separated by lower carboniferous beds, to which in some cases the metamorphic action has extended itself. The Antigonish and Merigomish hills contain large masses of syenite, porphyry, compact felspar, and greenstone, associated with slates and quartzite. On their western side near Arisaig, there is a patch of shale, slate, and thin-bedded limestone, with Silurian fossils.

The northern boundary of the broad band of metamorphic and hypogene rocks, formed by the union of the two promontories already noticed, extends in a westerly direction along the south side of the Pictou carboniferous district, until it reaches the east side of the East River of Pictou, when it suddenly bends to the south, allowing the carboniferous strata to extend far up the valley of that river. Here, as at Arisaig, its margin includes a patch of fossiliferous slates and shales, among which is a thick bed of iron ore including fossil shells. A few of the fossils of these beds are stated by Sir C. Lyell to agree specifically with those of the Hamilton group of the United States geologists. Prof. Hall of Albany, to whom I have sent a small collection of these fossils, chiefly from Arisaig, where most of the species are the same with those of the East River, is of opinion that they belong to the age of the Hamilton and Chemung groups.

Immediately on the east of the East River, the metamorphic band is about fifteen miles in breadth, and includes masses and dykes of syenite and greenstone, and beds of quartzite and slate, the latter of very various colour and texture. Beyond the East River, the metamorphic band again widens; and between the upper part of the Middle River of Pictou and that of the west branch of the St. Mary's River (the

point to which we have already traced its southern boundary), it forms a broad and irregular tract of metamorphic country. Westward of this tract it is again subdivided; one branch extending near the margin of the granitic group, on the south side of the Stewiacke River,

as far as the Shubenacadie River; another extending for a short distance between the Stewiacke and Salmon rivers; and a third, or rather a group of detached masses, extending through Mount Thom to the eastern extremity of the Cobequid range of hills. In the hilly country connected with Mount Thom, and in the vicinity of the upper parts of the Salmon, West, and Middle rivers, considerable breadths of lower carboniferous strata* have been partially metamorphosed, and invaded by greenstone and other igneous rocks. A mass of granite, containing dark grey felspar, abundance of black mica and very little quartz, occurs on the east side of Mount Thom.

The Cobequid hills, extending nearly in an east and west direction for about ninety miles in that part of Nova Scotia lying north of the southern arm of the Bay of Fundy, must be referred to the metamorphic group now under consideration. Both its stratified and hypogene rocks are similar to those of the parts of the syenitic group already described. Fossils are absent or very rare in those parts of it which I have explored. I have found only a few fish-scales, and fragments of a *Productus* or *Orthis* in calcareous bands associated with black slate and brown quartzite, near its eastern extremity. As the boundaries and general characters of the Cobequid range have long since been described by Dr. Gesner and others, and as I have in a former paper† noticed the structure of its eastern part, I shall at present confine myself to a description of the section of its central portion, afforded by the Great Village, Folly, and Wallace rivers, and the roads in their vicinity. (See Section, fig. 3.)

Fig. 3.—Section across the Cobequid Hills from the Mouth of Great Village River to Pugwash.—Distance 20 miles.

On the northern side of the hills, near the post road from Truro

* In the map attached to my paper on the Newer Coal Formation (Quart. Journ. Geol. Soc. 1845, vol. i. p. 322), some spaces in the south of Pictou and Colchester counties, occupied by hypogene and old metamorphic rocks, are coloured as carboniferous. These spaces, being then unexplored, were left uncoloured by me; but the colourist extended the carboniferous tint over them.

† Quart. Journ. Geol. Soc. vol. i. p. 27.

to Amherst, and also on Wallace River, the lowest rocks of the carboniferous system, consisting of reddish-brown conglomerates, are seen at the base of the hills. Their dip is to the northward at a high angle. On ascending the hills, masses of red, flesh-coloured, and grey syenite are seen, and rise rapidly to the height of several hundred feet; the northern side of the range being steeper and more lofty than the southern. The syenite of this part of the hills has often been described as a granite; but wherever I have observed it, it is a true syenite, containing reddish or white felspar, black hornblende, and nearly colourless quartz. Some of the red varieties are large-grained and very beautiful. The grey varieties are often fine-grained, and appear to pass into greenstone. On the summits of some of the highest ridges in this part of the range are numerous angular blocks of brownish sandstone, drifted from the lower carboniferous district lying to the northward.

Penetrating further into the range, we find thick dykes of greenstone, associated with slate and quartzite. The greenstone is of various degrees of coarseness, and at some points is penetrated by a network of syenitic or felspathic veins. The general course of the greenstone dykes coincides with that of the range of hills. Toward the southern side of the hills, grey quartzite, and grey, olive, and black slate prevail, almost to the exclusion of igneous rocks. The strike of these beds is nearly S.W. and N.E., with high dips to the southward. On the south they are bounded and overlaid unconformably by carboniferous conglomerate and sandstone.

The southern slope of the Cobequid hills is traversed by many deep transverse ravines, apparently due in great part to denudation. From the ridges dividing these ravines, as well as from the openings of some of them, extend long and sometimes very regular slopes of debris, made up of the fragments of the rocks of the hills; including the red syenite of their northern side, which was probably denuded in part by the same currents which deposited upon it the blocks of sandstone mentioned above.

The syenitic group of metamorphic rocks includes the most elevated land of eastern Nova Scotia. The Cobequid range, attaining at several points a height of 1000 feet, is probably the most elevated chain of hills in the province; and forms, in its whole length, the watershed dividing the streams flowing into Northumberland Strait and Chignecto Bay from those flowing into Cobequid Bay and Mines Basin and Channel. In like manner, the complicated group of hills extending westward from Cape Porcupine and Cape St. George, though less elevated than the Cobequid hills, contains the sources of all the principal rivers of the counties through which it extends. The largest of these is the St. Mary's River. Its western branch originating in the same elevated ground that gives rise to the Musquodoboit, the Stewiacke, and the Middle River of Pictou, flows for about thirty miles nearly due east along the valley which here separates the granitic and syenitic groups. Its east branch flowing from the hills in the rear of Merigomish, and passing near the lakes from which the principal branch of the East River of Pictou flows, receives

tributary streams from the metamorphic promontory stretching towards Cape Porcupine, and unites with the west branch at the northern margin of the granitic metamorphic band. The united stream then flows through a narrow valley in the granitic group to the Atlantic.

The groups of hills of the syenitic metamorphic system forming so important features in the physical geography of the eastern part of this province, were for the first time delineated with an approach to accuracy in a small geographical map compiled by the writer, and published in 1847. (See Map, fig. 1.)

Some of the facts already stated bear on the question of the relative ages of these metamorphic groups. That the metamorphism of the granitic group is of greater antiquity than the carboniferous period, is proved by the fact that the debris of its igneous and altered rocks is found in the lower carboniferous conglomerates; as, for example, in the valley of the west branch of the St. Mary's River, I have not found any evidence in that group of igneous action of a later date.

In like manner, at Cape Porcupine, Antigonish, Malignant Cove, the East River of Pictou, and along the whole base of the Cobequid hills, the lower carboniferous grits and conglomerates are filled with the debris of the rocks of the syenitic group, on which in many places they are seen to rest unconformably. The connection of this group with strata containing Upper Silurian fossils, renders it probable that a great part of its beds belong to the Silurian system. There is also evidence that igneous and metamorphic action were continued in this group during the carboniferous period. Instances of this have been mentioned above, and a very interesting example, occurring near Arisaig, has been noticed in a former paper*. This late continuance or renewal of igneous action is evidently connected with the very irregular distribution of those parts of the syenitic group in which it has occurred.

Assuming then that the group which I have named the *syenitic*, consists of altered Silurian and carboniferous strata, perhaps with some of Devonian age, though these have not yet been recognized, we may conclude that the beds of the *granitic* group belong either to some of the older members of the Silurian system, or to a still earlier period. In the part of Nova Scotia to which this paper is restricted, I have not been able to observe the actual superposition of the beds of these groups on each other; but in the western part of the province, where the syenitic and granitic groups are frequently found in contact with each other, it is possible that such evidence may be obtained.

Mineral Deposits of the Syenitic Metamorphic Group.

In a number of localities in this series, venigenous deposits of ores of iron and copper have been discovered. Some of these are of economical value; and are also interesting in the associations of minerals which they present, and in the inferences which may be deduced from

* Quart. Journ. Geol. Soc. vol. i. p. 330.

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them in relation to the mode of their formation and the changes of the containing rocks.

The first of these deposits to which I shall refer is a vein of iron ore and ferruginous limestone, extending along the south slope of the Cobequid hills; and which has been most carefully explored in the vicinity of the Folly and Great Village rivers. This deposit appears to have been noticed as early as the time when the land on which it occurs was granted by the Crown; and it received some attention from Mr. Duncan and other gentlemen in Truro, nearly twenty years ago. No steps were however taken toward its scientific exploration until 1845. In the summer of that year I received a specimen of the ore for examination, and in October of the same year I visited and reported on the deposit. In the same autumn it was examined by Dr. Gesner. In 1846 I again visited it, and reported on it to C. D. Archibald, Esq., of London, and other gentlemen associated with him; and in the summer of 1849 I had the pleasure of again going over the ground and examining the vein at some new points, in company with J. L. Hayes, Esq., of Portsmouth, U. S. Since 1845, the extent and economical capabilities of the deposit have been discussed by several writers, both in this province and in Great Britain. In the following remarks I shall confine myself as far as possible to its geological relations, and facts bearing on its origin*.

I shall begin by describing the vein as it occurs on the west branch of the Great Village River, at the site chosen by C. D. Archibald, Esq., for the furnace and buildings of the "Acadia Mine." In the western bank of this stream, at the junction of the carboniferous and metamorphic series, a thick series of grey and brown sandstones and shales, dipping to the south at angles of 65° and 70° , meet black and olive slates, having a nearly vertical position, and with a strike N. 55° E. The dip of these slates, where apparent, is to the southward, and the strike of the slaty cleavage and of the bedding appear to coincide. Near the Falls of the river, a short distance northward of the junction just noticed, the slates give place to grey quartzite, which, with some beds of olive slate, occupies the river-section to, and for some distance beyond, the iron vein.

The vein is well seen in the bed of the stream, and also in excavations in the western bank, which rises abruptly to the height of 327 feet above the river bed. In the bottom of the stream it presents the appearance of a complicated network of fissures, penetrating the quartzite and slate, and filled with a crystalline compound of the carbonates of lime, iron, and magnesia, which, for reasons to be stated in the sequel, I refer to the species *Ankerite*. With this mineral there is a smaller quantity of red ochrey iron ore, and of micaceous specular iron ore.

In ascending the western bank of the stream, the vein appears to increase in width and in the quantity of the ores of iron. In one place, where a trench was cut across it, its breadth was 120 feet.

* The localities referred to in the following paragraphs will be found in the map of the New Red Sandstone district of Nova Scotia, 1847, Quart. Journ. Geol. Soc. vol. iv. p. 50, pl. 5.

Though its walls are very irregular, it has a distinct underlie to the south, apparently coinciding with the dip of the containing rocks. As might have been anticipated from its appearance in the river-bed, it presents the aspect of a wide and very irregular vein, including large angular fragments of quartzite, and of an olivaceous slate with glistening surfaces. These fragments are especially large and abundant in the central part of the vein, where they form a large irregular and interrupted rocky partition.

The ankerite should evidently be considered the veinstone, as it surrounds and includes all the other contents of the vein, and greatly exceeds them in quantity. Where not exposed, it is white and coarsely crystalline. On exposure it becomes yellowish; and near the surface, as well as on the sides of fissures, it is decomposed, leaving a residue of yellow ochrey hydrous peroxide of iron. In some parts of the vein, the ankerite is intimately mixed with crystals and veinlets of yellowish spathose iron. The red ochrey iron ore occurs in minor veins and irregular masses dispersed in the ankerite. Some of these veins are two yards in thickness; and the shapeless masses are often of much larger dimensions. Specular iron ore also occurs in small irregular veins, and in disseminated crystals and nests. At one part of the bank there appears to be a considerable mass of magnetic iron ore, mixed with specular ore; this mass was not, however, uncovered till after I had left the ground.

The whole aspect of the vein as it appears in the excavations in the river bank is extremely irregular and complicated. This arises not only from the broken character of the walls, the included rocky fragments, and the confused intermixture of the materials of the vein; but also from the occurrence of numerous transverse fissures, which appear to have slightly shifted the vein, and whose surfaces usually display the appearance named "slickenside," and are often coated with comminuted slate or iron ore. In some places these are so numerous as to give an appearance of transverse stratification. One of them was observed to be filled with flesh-coloured sulphate of barytes, forming a little subordinate vein about an inch in thickness.

The general course of the vein, deduced from observations made by Mr. Hayes and myself at the Acadia Mine and further to the eastward, is S. 98° W. magnetic, the variation being 21° west. At the Acadia Mine this course deviates about 33° from that of the containing rocks. In other localities, however, the deviation is much smaller; and in general there is an approach to parallelism between the course of the vein and that of the rock formation of the hills, as well as that of the junction of the carboniferous and metamorphic systems. The vein for a space of seven miles along the hills is always found at distances of from 300 yards to one-third of a mile northward of the last carboniferous beds, and always in the same band of slate and quartzite.

Westward of the Acadia Mine, the course of the vein over the high ground is marked by the colour of the soil, as far as Cook's Brook, about a mile distant. The outcrop of the ore is not exposed in this brook, but large fragments of specular ore have been found in its bed,

and a shaft, sunk on the course of the vein, has penetrated more than forty feet through yellow ochre containing a few rounded masses and irregular layers of ankerite. At this point the decomposition of the ankerite and spathic iron has extended to a much greater depth than usual, and is so perfect that a specimen of the yellow ochre was found to contain only '4 per cent. of the carbonates of lime and magnesia; the remainder being hydrous peroxide of iron, alumina, and siliceous matter.

Still further west, in Martin Brook, I have observed indications of the continuation of the vein. Beyond this place I have not traced it; but I have received specimens of specular iron ore and ankerite from the continuation of the same metamorphic district, as far west as the Five Islands, twenty miles distant from Acadia Mine.

On the east side of the west branch of the Great Village River, the ground does not rise so rapidly as on the western bank, and the vein is not so well exposed. On this side, however, a small quantity of copper pyrites has been found in or near the vein, but it does not seem to be of any importance. Indications of the vein can be seen on the surface as far as the east branch of the river. In the east branch, red and grey conglomerates, dipping to the south, and forming the base of the carboniferous system, are seen to rest unconformably on olive, black and brown slates, whose strike is S. 75° W. The continuation of the iron vein has not yet been observed in the bed of this stream.

Further eastward, on the high ground between the Great Village and Folly rivers, indications of the ores of iron have been observed; especially near the latter river, where in two places small excavations have exposed specular and red ores, and where numerous fragments of brown hæmatite are found scattered on the surface. On the elevated ground a short distance westward of the Folly River, on Mr. Fleming's farm, the lower carboniferous conglomerate rises higher on the slope of the hills than at any other place in this vicinity, and approaches within 300 yards of the iron vein. In the banks of a small brook near this place, the conglomerate is well seen, and a good section of the underlying slate and quartzite is exposed; but we could find no other indications of the continuation of the vein, than slender strings of ankerite, with disseminated crystals of specular iron ore.

The ravine of the Folly River affords a good natural section of the quartzite and slate of the hills, as well as of the carboniferous beds of the lower ground. A sketch of this section, as far as the base of the hills, is given in my paper on the New Red Sandstone of Nova Scotia*. The lowest carboniferous bed is a thick, coarse, grey and brownish conglomerate, dipping S. 20° W. It rests unconformably on a bed of slate very similar to that seen in a similar position at the Great Village River, and which differs considerably in appearance from most of the slates of these hills. The strike of the slate is S. 70° W.; and that of the bedding and slaty structure appear to correspond. In a layer of greywacke included in this slate, I observed small and well-

* Quart. Journ. Geol. Soc. vol. iv. pl. 5. sect. 1.

rounded pebbles of light-coloured quartz. This slate is succeeded by thick beds of grey quartzite and hard olivaceous slates. These occupy the river-section for about 700 yards, or as far as the "Falls," where the river is thrown over a ridge of quartzite fifty-five feet in height; a small rill pouring in on the eastern side from a much greater elevation. Between the conglomerate and the waterfall, the quartzite contains a few narrow strings of ankerite, and at the fall there is a group of reticulating veins, some of them six inches in thickness. They contain a little iron pyrites. These are the only indications of the iron vein observed in this section; and as the group of beds in which it should occur is well exposed, it is probable that it is represented here only by these small veinlets distributed over a great breadth of rock. Above the fall the quartzite and slate continue to alternate for a considerable distance; the dip being generally to the southward, in one place at as low an angle as 55° . About a quarter of a mile above the fall, they are traversed by a dyke or mass of fine-grained hornblende igneous rock.

On the elevated ground, east of the Folly River, the vein is again largely developed, and two excavations expose a part of its thickness on the property of the Londonderry Mining Company. The excavation nearest to the river shows a thickness of 190 feet of rock on the south side of the vein. This consists of grey quartzite, olive slate, and about three feet of black slate. These beds are traversed by a few small strings of ankerite, which increase in dimensions on approaching the broken and irregular wall of the vein. About seventeen feet of the south side of the vein consists principally of ankerite. Adjoining this on the north is red iron ore with nests of specular ore, veins and blocks of ankerite decomposed in part to yellow ochre, and fragments of rock. Ten feet in thickness of this red ore is seen without exposing the north wall of the vein.

On the surface in this vicinity are large fragments of brown hæmatite, which mark the course of the vein. In the eastern excavation, this mineral is seen in place near the surface and occupying fissures in a fragment of quartzite. In this second excavation the red ore is more largely mixed with the micaceous specular variety, and also includes large rounded blocks of ankerite and angular fragments of rock. The width exposed here is thirteen feet, and neither wall is seen. The ankerite is decomposed to the depth of eight feet. The same appearance of transverse vertical layers seen at the Acadia Mine is observed here, and is probably due to the same cause.

Still further east, on the property of C. D. Archibald, Esq., and on ground equally elevated, three excavations have shown a still greater development of the vein. A trench fifty-three feet in length, and nearly at right angles to the course of the vein, shows in its whole length a mixture of red and specular ores with ankerite. Another excavation ninety-five feet to the northward of the first, exhibits ankerite tinged of a deep red colour by peroxide of iron, and traversed by reticulating veins of red iron ore. A third opening, 365 feet south-eastward of the first, shows white and grey ankerite, having some of its fissures coated with tabular crystals of white sulphate of barytes.

The walls of the vein are not seen at this place ; but 150 paces south of the first trench, a thick dyke of greenish igneous rock, apparently a very fine grained greenstone, appears, with a course of S. 102° W. This dyke is not seen westward of this place, but it can be traced for a considerable distance to the eastward. In the Mill Brook, two miles east of Folly River, it appears in connection with a bed of black slate near the margin of the metamorphic system, and probably a continuation of that seen in a similar position in the Folly and Great Village rivers. At the Mill Brook, the dyke is about 100 feet in thickness.

In the bed of the Mill Brook, the vein is seen in the form of a network of fissures chiefly filled with ankerite ; and in its eastern bank it attains a great thickness. In the bank of another brook still further to the eastward and in the same line of bearing, it appears to be of large dimensions, and contains abundance of red iron ore and red ankerite. I have not traced it further to the east, but I have no doubt of its continuance to a great distance in that direction.

I shall now present a few facts and inferences bearing on the manner in which this deposit may have been produced.

The ferruginous magnesian limestone which I have named *ankerite*, differs somewhat in composition from the European specimens on which that species was founded. The mean of two analyses which I have made of specimens from the Folly River is,—

Carbonate of lime	54·6
Carbonate of iron	23·2
Carbonate of magnesia	19·5
Silica	2·7
	<hr/>
	100·0

Specimens from other parts of the vein, which I have examined qualitatively, contain the same substances ; the red ankerite having in addition a variable proportion of the peroxide of iron. The specific gravity of a specimen from the Folly River is 2·916, that of a specimen from the Acadia Mine is 2·997. The other external characters of these specimens correspond with those of ankerite. Perfect uniformity of composition in compounds of this kind from different localities can scarcely be expected, and indeed where the constituents are so nearly isomorphous, species founded on chemical characters must graduate into each other. For this reason, although my specimens are destitute of the small percentage of manganese found in European specimens of ankerite, and differ somewhat from these latter in the proportions of their other ingredients, I have thought it advisable to refer them to that species. Even if the absence of manganese, or any external differences which may be found on a comparison with European specimens, should hereafter be considered sufficient to establish a specific distinction, my application of the name ankerite can, with the above explanation, lead to no misconception.

The absence of cavities and ‘combs’ in the ankerite, its pretty uniform coarse granular structure, its perfect penetration of all the

fissures of the containing rock, and its included rocky fragments, render it probable that it is a true injection-vein or dyke. I could not observe that any unusual degree of metamorphism of the containing rock occurred in the vicinity of the ankerite. The walls of the vein, however, and its included fragments often consist of a peculiar olive slate with shining surfaces, and approaching in appearance to a steatite schist. This slate contains silicate of magnesia, though not in large proportion; and possibly its composition and appearance may be due to the eruption of a highly magnesian rock such as the ankerite. As I did not, however, give very particular attention to this circumstance when on the ground, I am not prepared to affirm that this magnesian slate is confined to the vicinity of the vein.

True *spathose iron* is of rare occurrence in the outcrop of the vein. At the Acadia Mine, where it occurs in intimate mixture with the ankerite, it contains about twenty per cent. of carbonate of magnesia, approaching in this respect to the species *Mesitine spar*, though its proportion of magnesia is much smaller. It also contains about six per cent. of carbonate of lime. This *spathose iron* is evidently of contemporaneous origin with the ankerite.

The *yellow ochre* which abounds in the superficial parts of the deposit, and which at Cook's Brook extends to a considerable depth, is evidently a product of the decomposition of the ankerite and *spathose iron*, under the influence of air and moisture. The latter substance being the more easily decomposed of the two, and being found in some places mixed with the ankerite, it is possible that a larger proportion of the yellow ochre has resulted from its decomposition, than would be inferred from the relative proportions of ankerite and *spathose iron* at the surface. No evidence appears that any considerable portion of the yellow ochre can have resulted from the decomposition of metallic sulphurets.

The veinlets, nests, and disseminated crystals of *specular and magnetic iron ore*, which are scattered through the vein, are probably results of segregation and sublimation; and were probably introduced at the same time with the ankerite.

The *red ochrey iron ore*, which abounds in most parts of the vein, is, in reference to its origin, one of the most difficult features of the deposit. In some parts of the vein it is a very pure peroxide of iron. A specimen analysed by me gave 98 per cent. of that substance. By gradual additions of the carbonates of iron, lime, and magnesia, it passes into *spathose iron* or red ankerite. Its earthy and porous texture, its traces of crystalline form, and its connection with the minerals just named, point to the only theory of its origin which I have been able to form—that of metamorphism of carbonate of iron by heat. This substance is in appearance a roasted carbonate of iron; it may be seen to pass by insensible degrees into that mineral, and it often retains traces of its external form and cleavage.

If we suppose that the vein originally contained a considerable quantity of the carbonate of iron, and that after it was filled and its contents consolidated, heat accompanied by access of oxygen was applied, we have the conditions required for the production of

the ochrey red ore. The irregularity of its distribution would result from that of the carbonate of iron, which, where it now occurs in the vein, is seen to be confusedly mixed with the ankerite. It might also happen that the heat would act most powerfully along lines of fissure, and of this there are some evidences in the appearance of the vein. The comparatively unaltered state of the ankerite is explained by the fact, that it is less easily decomposed by heat than the pure carbonate of iron, or even than the spathose iron found at Acadia Mine. If a small fragment of the mixed white ankerite and spathose iron from Acadia Mine be exposed to a low red heat with access of air, the carbonate of iron is completely decomposed, before any other change than a slight discoloration is produced in the ankerite. Hand specimens from the Acadia Mine often present appearances highly illustrative of the relations of the red ore to the other ingredients of the vein, and confirmatory of the above views of its origin. Fig. 4 is a sketch of one surface of a specimen of this kind.

Fig. 4.—*Surface of a Hand-Specimen from Acadia Mine.*

The *brown hæmatite* is apparently confined to the superficial parts of the vein; and indeed appears to have been more abundant in those parts of it which have been removed by denudation, than in any now remaining. It is no doubt a product of the action of water on the carbonate and hydrated oxide of iron, near the outcrop of the vein.

The *sulphate of barytes*, occurring in small quantities in some parts of the vein, must also be a product of aqueous infiltration.

The facts which I have obtained in relation to the age of this de-

posit are few and not very decisive. The character of the fissure in which the vein is contained, leaves little doubt that the metamorphism of the containing rocks was complete or nearly so before its formation. If, as seems most probable, these rocks be of Silurian age, and if, as the lower carboniferous conglomerates testify, their metamorphism occurred before the commencement of the carboniferous deposits, we have a limitation of the age of the vein, at least in one direction. On the principles stated in my paper on the Colouring Matter of Red Sandstones*, the metamorphosed carbonate of iron of this deposit might have produced on aqueous deposits, formed contemporaneously with or subsequent to its metamorphism, effects in relation to colour similar to those which I have supposed to result from the decomposition of sulphuret of iron. The carboniferous beds at the base of the hills, however, do not present any greater amount of the peroxide of iron than the same beds in other localities; and are indeed, in comparison with those of the opposite side of the Bay of Fundy, rather deficient in this respect. The carboniferous beds of the northern side of the hills are indeed more highly coloured by red oxide of iron than those of the south side. Another fact bearing on the age of this deposit, is the occurrence, in other parts of the syenitic metamorphic group, of slender veins of specular iron ore and ankerite in altered lower carboniferous rocks. If these small veins be of the same age with the great vein of the Cobequid hills, the latter must be of later date than the beginning of the carboniferous period. These small veins are, however, at too great a distance from that now under consideration to allow any actual connection to be traced. On the whole, it seems probable that the filling of this vein is of later date than the Silurian period, and it may possibly have been posterior to the carboniferous epoch.

In the eastern extremity of the Cobequid hills, and in the group of hills connected with Mount Thom, small metalliferous veins have been found in various places. From the vicinity of the northern branch of the Salmon River I have received specimens of specular iron and brown hæmatite, contained in quartz-rock similar to that of the Cobequid hills, and similar specimens are found in different parts of Mount Thom. From the south branch of Salmon River I have received, from small veins in slate of the syenitic system, specimens of copper pyrites containing 31·6 per cent. of copper. This pyrites is associated with sulphate of barytes; and in the same locality there are veins of ankerite, containing disseminated crystals of copper pyrites. Near the salt springs at the West River of Pictou, veinlets of specular iron occur in altered lower carboniferous beds. In brooks, emptying into the West River and the upper part of the Middle River, both specular iron and ankerite occur in slender strings. Such appearances are indeed very common in all that tract of metamorphic country lying to the south of the Pictou carboniferous district. In the vicinity of the East River of Pictou, however, there are other deposits of iron ore which must not be confounded with these veins of the metamorphic rocks. One of these is the conformable bed of per-

* 1848. Quart. Journ. Geol. Soc. vol. v. p. 25.

oxide of iron and quartzose sand occurring in the Silurian system, and containing marine shells already mentioned. Others are veins of brown hæmatite, apparently confined to the lower carboniferous beds, near their junction with the Silurian system.

In the promontories of metamorphic and igneous rocks, extending toward Cape St. George and Cape Porcupine, veins similar to those already described occur in many places. In the former, at Malignant Cove and other places in that vicinity, specular iron ore occurs in slender veins, whose walls are sometimes lined with crystals of epidote. In the latter, near the Lochaber Lake, a mineral district of somewhat interesting character has been discovered. At this place the prevailing rocks are olive, black, and grey slates, and grey quartzite, with dykes of greenstone and claystone. The general strikes of the beds are S. 70° W. to S. 20° W. magnetic; and the directions of the bedding and slaty structure correspond. The slates are often very fine-grained and soft, with glistening surfaces, and highly perfect slaty structure. In the slate and quartzite there are innumerable small veins of white quartz and ankerite, with micaceous specular iron and occasionally iron and copper pyrites. The general direction of these veins corresponds with that of the containing beds, though they are often seen to pass from one plane of bedding or cleavage to another. On the south side of Polson's Lake, two miles eastward of the Lochaber Lake, a large vein of iron and copper ore appears to exist. The slate is here decomposed to a great depth, and among its debris are numerous large fragments of ore marking the outcrop of the vein. Some of these fragments are from three to five feet in diameter. They consist of red ochrey iron ore, with many and often large strings and bunches of copper- and iron-pyrites. No specular iron ore has yet been found in this vein, but there are small quantities of greyish crystalline carbonate of iron, which may be observed to pass gradually into the red ochrey ore, the latter retaining, often in great perfection, the rhombohedral crystallization of the carbonate of iron. In this we have probably evidence of a change similar to that already supposed to have produced the red ore of the Cobequid hills. Where the carbonate of iron is exposed to the weather, it is occasionally seen to be changed into yellow and brown hydrous peroxide of iron.

The pyrites found in this deposit contains from 4 to 17 per cent. of copper. The most common variety has 10·8 per cent. It is scattered through the red ore in the most irregular manner; but in general the boundary between the two minerals is marked by a thin crust of hydrous peroxide of iron, perhaps resulting from the decomposition of the surface of the pyrites by water percolating the porous red ore. The larger masses of pyrites occasionally include fragments or crystals of ankerite and carbonate of iron. I confess that the occurrence of minerals so easily altered by heat, as copper and iron pyrites, in association with red ore, is adverse to the view of the origin of that mineral given above; unless we can suppose the pyrites to have been introduced subsequently to the production of the red ore.

I first heard of these deposits in 1845, when exploring the country in the vicinity of the St. Mary's River, but at that time I had not leisure to visit them. I examined them with more care in the spring and summer of 1848; and I believe there is a prospect that mining operations will soon be commenced on the vein near Polson's Lake, which promises to be a valuable deposit of copper pyrites, and is I believe the first workable copper vein discovered in the metamorphic districts of Nova Scotia.

At South River Lake, two miles eastward of Polson's Lake, specular iron ore is said to occur in large quantity. The metamorphic country eastward of this place, and that lying immediately westward of the Lochaber Lake, have been little explored. In the east branch of the St. Mary's River, about seven miles westward of Lochaber Lake, though the rock formations are similar to those eastward of that lake, I saw no metalliferous veins.

The mineral deposits of the metamorphic districts, to which this paper refers, have only recently attracted public attention; and it may be anticipated that every year will extend our knowledge of these deposits. The details of the rock formations themselves still remain to be worked out; and in the present state of these districts this must require much time and labour. It is also evident that the transition from highly metamorphic to unaltered Silurian and carboniferous beds, on the confines of one of these metamorphic groups, must oppose great difficulties to the accurate mapping-out of the limits of those systems in this part of Nova Scotia. In the mean time, the facts contained in this paper may aid in the formation of general views of the geology of this province; and may afford some new terms of comparison with the metamorphic rocks and mineral veins of other countries.

2. *On the STRUCTURE of the CRYSTALLINE ROCKS of the ANDES, and their CLEAVAGE-PLANES.* By EVAN HOPKINS, F.G.S.

It is a well-known fact to those who have traversed large areas of uncovered crystalline rocks, that they present a structure more or less vertical. In North America, Scotland, and Sweden the diversified edges of the crystalline series may be traced for many miles, presenting a north-easterly structural bearing. Where argillaceous sedimentary beds have been deposited on crystalline rocks, having the above vertical structure strongly developed, I have frequently observed the latter, by a slow chemical action, in the course of time obliterate the seams of deposition in the former, and cleave the beds in conformity to the angular position of the primary structure and the disposition of the crystals in the crystalline base.

These cleavage-planes pass through mountains of undulated beds, and preserve throughout the various contorted seams, the geometrical parallelism of the structure of the parent rock below; thus plainly showing the effect of a polar crystallizing force, acting gradually and insensibly on the whole mass in one direction to an indefinite extent.