21. THE GOLD-LEADS *of* NOVA SCOTIA. By HENRY S. POOLE, Esq., M.A., F.G.S., Government Inspector of Mines. (Read March 12, 1879.)

[Abridged.]

THE character of the auriferous rocks of Nova Scotia was a subject of some discussion a few years ago*, when it was suggested that the gold obtained was from "quartz beds of contemporaneous age with the quartzite and the slate with which they are interstratified."

Dr. T. Sterry Hunt, reporting on this province the year before the subject was brought to the attention of this Society, wrote:—"So far as my present observation goes, I think that to describe the gold-lodes otherwise than as interstratified beds would be to give a false notion of their geognostic relations. The laminated structure of many of the lodes, and the intercalation between their layers of thin continuous films or layers of argillite, can hardly be explained in any other way than by supposing these lodes to have been formed by successive deposition at what was, at the time, the surface of the earth."

This description well expresses the appearance of our gold-districts; but the theory that the "leads," as the lodes are locally called, are contemporary beds with the slates and quartzite has not since been generally accepted; nor has it gained ground with the further knowledge derived from working, nor been adopted by any of the miners, among whom are men experienced in other gold-producing countries.

My position having enabled me to visit frequently the several districts and see the leads in their varying stages of exploitation, I have kept in mind the theory in question, and especially examined the relation of the leads to the containing rocks. Some of my observations I have expressed in the following notes.

Surface-geology of the Gold-fields.

The general features of the districts, and the position of the leads in relation to the country and rocks, may be thus briefly sketched. Along the whole Atlantic seaboard of Nova Scotia, from Seaterie to Cape Sable, Palæozoic rocks extend. The lines of stratification have an almost universally east-and-west course, and, generally speaking, are parallel with the coast-line and with the axes of upheaval, not only of the hill-ranges, but likewise of the anticlinal folds that bring the gold-leads to the surface. The leads also conform, with almost unvarying persistency, with the strike of the slates and quartzite-beds, following even the plications of the strata with remarkable regularity, thus giving rise to the idea that they might be contemporaneous beds and not intrusive veins.

* Quart. Journ. Geol. Soc. vol. xxvi. p. 477.

While quartz veins are not confined to the districts where gold is found in paying quantities, those that have been discovered to be auriferous are generally about the axes of anticlinal folds, and present an appearance which may be compared to a series of diversely shaded sheets of paper sharply bent together, tilted at one end, and cut horizontally. The lines of various shade which the sheets would then show approximately represent the position of the leads and the interbedding slates and quartzites. And, further, as that side would be the more highly inclined on which the lateral pressure found the least resistance, so do the strata incline at these anticlinals. In the districts of Sherbrooke and Uniacke, for instance, the strata are vertical on the south and incline to the north at an angle of 45°. In other districts, as Waverley, Renfrew, and Moose River the vertical and inclined dips are reversed. At Sherbrooke the leads on both sides of the anticlinal are auriferous, and are only the width of the main street apart; while at Uniacke the north dip is two miles away from the working-belt. On the top of Laidlaw's Hill, in the district of Waverley, the lead lies so flat that it is worked "longwall." In it the gold is chiefly found where it is crumpled together by the folding of the strata and forms what are called "barrels." These "barrels" or "rolls" have been followed down on both the north and south dips. On the crest they run in the direction of the axis of the anticlinal; and on either side they trend to the north and south, representing, as it were, the resultant of the forces encountered in the upheaval. In the overlying stratum the position of the plication in the quartz is marked merely by a moderate undulation. The quartz having yielded in the greatest degree to the lateral pressure would indicate that, at the time of the upheaval, it was in a more plastic condition than the containing rocks, and the more when it is observed that the rolls contain angular fragments of slate, and send offshoots and tongues of quartz up into the superjacent stratum.

The auriferous rocks are supposed to be contemporaneous with those of the Cambrian; but the horizon of the belts has yet to be determined. It has been suggested by those who consider the leads to be bedded deposits, that only the lowest rocks of the series contain the gold-leads, which the anticlinal folds have brought to the surface. But the lithological characters of the several districts point to the existence rather of three groups in which auriferous leads exist:—the lowest, composed of beds of slate and grits crumpled and contorted and cleaving transversely to the laminæ (in these no paying lead has been found); the middle, of compact beds in which quartzite predominates and the cleavage-planes generally conform to the lines of deposition (strata of this group in the neighbourhood of anticlinals are intercalated with numerous quartz-leads, some of which only are auriferous to an appreciable extent). The upper group, in the extreme western section of the province, consists of olive-green fissile slates associated with beds of micaceous sandstone and at least one plumbagineous bed. Some of the strata are highly chloritic; in the true gold-districts chlorite is a rare mineral.

Mr. Selwyn, Director of the Canadian Geological Survey, states that some of these sandstones contain pebbles of a grey quartzite, and that he is inclined to believe that these rocks will be found to occupy the position of some division of the Quebec group. Of the relative age of the gold-bearing veins that are associated with the rocks of this section there can be no doubt; for when they are exposed by the tide at Gegoggan and Cranberry Head, they are seen to angle across the beds, to swell out into masses 6 and 8 feet wide, to pinch within a distance of a few feet into less than as many inches, and again expand and contract. Such veins have been found to contain a little gold; and one at the Cream-pot, Cranberry Head, while not so irregular as some at Gegoggan, yielded as much as one ounce of gold to the ton of quartz.

Mining Experience.

Mining-operations have not been confined to the bedded leads; for rich streaks of quartz have been worked in cross leads and in the so-called angling leads. The angling leads are true veins, generally very small; they have the general east-and-west course, but break across the strata at slight angles. In depth they gradually steal across a bed of slate, but, on meeting quartzite, break short across to the next stratum of slate, and so on downwards. In nearly all cases the angling leads have been found to contain more gold when they passed through a quartzite bed.

The true cross leads as yet proved are barren, and of later age than the interstratified leads; but besides them there are bands of quartz connecting two parallel leads, and there are offshoots which are often called cross leads. They in some cases appear to affect the productiveness of the regular leads. For instance, at the junction of a cross lead with the belt lead at Montagu some spots gave as high as 40 ounces of gold to the ton. And at Cariboo (area 629, block II.) an offshoot appeared to govern the direction of the richest portions of the lead; the stope which cut it, 40 feet wide and 20 fathoms deep, yielded 12,000 ounces, chiefly from parcels taken on the line of the offshoot. Whether the yield from the bedded leads is in reality affected by the position of cross leads and offshoots may be doubted; for there are many more offshoots, and perhaps cross leads, than there are gold streaks. But it appears to be a rule that the dips of the gold streak and offshoot are in the same direction. One thing is certain, that the contents of the leads are irregularly distributed, and that their metallic minerals are not uniformly mixed, but are aggregated about certain spots and in certain directions. The paying beds are generally small, of a few inches only; many will not average 4 inches in width; and one of 8 inches is regarded as of good size, though some thicker have been worked. Regularly interstratified stringers, threads, and offshoots of quartz may be seen extending from them into the walls. A stringer from the Wellington lead proved rich when it passed through the slate footwall, but barren in the succeeding bed of quartzite. The Murray lead in the same district of Sherbrooke showed at one spot a number of

stringers entering the footwall. The quartz from them collected together yielded 7 ounces of gold.

Sooner or later in the working of the regular "bedded" leads irregularities characteristic of veins are met with. Late operations at Waverley on the Union lead, one of those referred to in proof of the bedded origin of the leads, have shown the quartz to cease, while the line of fracture is seen to continue its regular course. In one stope a large "horse" of quartzite cut off the quartz; in another the quartz formed a compact "roll" 8 feet wide, from which ramified into the footwall a number of suckers.

In the course of working the parallel leads a layer of quartz is sometimes noticed to "take in" in the adjoining bed of slate. One such layer was opened at a depth of 600 feet in the hanging wall of the Wellington lead.

In both slate and quartzite walls of leads, crevices containing little or no quartz occasionally contain gold. One flat-lying crack in the quartzite wall of a strong barren lead at Uniacke gave 3 ounces of gold, where there was only a little iron-rust and no quartz visible. Gold is also found in the slate walls of rich leads; and from some mines more slate than quartz goes to the stamp-mill. It is found associated in the leads with calcite, felsite, mica, chlorite, with common, magnetic, and arsenical pyrites, with copper-pyrites, galena, and zinc blende. Crystals of gold have also been found, and gold imbedded in crystals of quartz, in cavities of leads.

There are yet other characters suggestive of true veins. Often there is a narrow band of crushed slate next the lead, called "gouge," on account of the ease with which it is extracted by a thin long pointed pick. Its fissile nature is probably due to disturbance at the time the lead was formed. Again, these leads are known to taper out, and what may be called their continuation to start in the side slate, and expand to the original thickness from beyond the termination of the quartz at first worked.

While many of the gold-bearing leads are regular and persistent for hundreds of feet and lie parallel with wonderful uniformity, a careful following shows local troubles. Rolls and barrels and offshoots have been mentioned, and also their apparent influence on the productiveness. Breaks and dislocations of the strata are not uncommon; and while many undoubtedly are of later age, some appear to be contemporaneous. A head or fault divides the Sutherland lead at Sherbrooke without shifting the strata; and on one side of it there are more bands and a greater thickness of quartz than on the other.

Another character, unmistakably that of a true vein, is occasionally met with in the "bedded" leads. For example, in the so-called Barton lead at Tangier, at one spot the writer saw in the middle of the quartz a flake of slate about 10 feet long and an inch thick. The flake had rough edges, and had evidently parted from the hanging wall; for a trail of fragments at its ends marked its course from a depression in the wall. Fragments of slate, too, are often found in the leads, lying in every direction; in parts films of

slate give the leads a ribbon-like structure, and suggest a series of expansions of the fissures and successive depositions of quartz marked by the adhering films of slate.

As it is from mining experience that the weightiest arguments against the bedded origin of the leads can be adduced, fuller reference is made to matters that affect the mining than may seem warranted in a geological paper. There are yet a few observations worthy of note. The constituents of the leads are not uniformly mixed: in the Hay lead 60 ounces of gold were aggregated in one spot; and extended workings in the same lead failed to find elsewhere more than a few pennyweights of gold to the ton of quartz and calcite, the latter a principal component of the lead. The working portions of the leads are small, and the yield of gold not uniform. So far, experience does not encourage extended search beyond the limits of a working "streak" by sinking or driving levels; and the writer is not aware of the discovery in depth of a paying streak not known on the surface.

Relative Age of the Leads and Granite.

It has been suggested that the so-called granites which blot large portions of the Palæozoic belt are not intrusive, but are merely highly metamorphic rocks. That in every case they are so seems hardly compatible with structural characters observable, and which may here be briefly noticed. On traversing the country under review, the hill-tops are often seen denuded of all detrital matter save a few isolated boulders, and the junction of the granite with the sedimentary rocks is in many places exposed.

At Mooseland, for instance, exposures show the line of contact as clearly as would wooden models specially designed to do so; and there the following observations may be made:—Granite occupies the highest ground, presenting a curved margin, in part parallel and in part transverse to the strike of the bedded rocks, which are highly inclined and locally broken. Tongues and veins extend from the parent mass of granite between the opened strata; and in one about 2 feet wide there lies obliquely a thin slab of quartzite half an inch thick and 6 feet long, which has evidently fallen away from one of the walls. Another spot shows a larger slab, about 10 feet long and 1 foot thick, which has fallen forward into the body of the granite while the latter was still in a plastic state. Its original site can without doubt be ascertained by measurement. Parallel to a vein of pure quartz a vein of granite only half an inch wide, 200 feet from the main mass, demonstrates the plasticity, if not fluidity, of the granite; but whether it was derived from excessive local metamorphism or injected from below, is open to question. The sharpness of the broken edges and the locally disturbed condition of the beds along the line of contact certainly suggest the latter, while the crystalline structure of the protruding tongues seems to confirm it; for, as in a chilled casting, the crystals are coarse in the centre and fine next the walls, from more rapid cooling. The crystallization of the mass is, in spots, streaked and irregular near the sedimentary rocks;

and fragments of quartzite may be found imbedded in it. That the intense heat of the granitic mass affected the structure of the contiguous strata is evident from the development of andalusite crystals in the quartzite, and of garnets in the slates,—the former at Mooseland and near Fifteen-Mile Stream; and the latter close to the granite of Cochran's Hill, Sherbrooke, in the walls of gold-leads, and even imbedded in the quartz itself.

A most interesting spot bearing on the subject of this note is on the barrens near the west shore of Moose Lake, where a quartz-lead rising somewhat above the level of the containing quartzite is capped by granite and pierced by small tongues of granite, suggestive, if not conclusive, that the leads are of greater age than the granite.

Glaciation and the Leads.

Grooves and striæ on the surface of the rocks protected from further action by a covering of earth are common throughout the region. Glaciers, an ice-sheet, and icebergs have each their advocates to account for them; and the amount of denudation that they have occasioned is variously estimated. The labours of the gold-prospector have supplied some data which should not be overlooked in forming a conclusion on the subject. The experience of the gold-miner leads him, when he finds the "throw" of a vein, as he calls the float or shoadstones, to seek to the northward. He generally expects to find it within 100 feet of where the "throw" comes to the surface—on the hang of a hill, and where the cover is heavy, at a greater distance than where the surface is flat and the soil thin. In exceptional cases, where a rich throw has been found, trenches have been dug for many hundreds of feet, and every inch of the ground examined without discovering the lead. The so-called Rose lead at Montagu is still unknown, though the throw or drift of similar appearance, and supposed to have come from one lead, has been found to extend over 1000 feet of ground*. Another instance occurred this summer (1878) at Cariboo: large boulders of quartz, weighing in all some 40 tons, which were obtained from one spot, yielded largely, and great search was made for the lead from which they had been derived; but the exploring-trenches both to the north and south failed to find a lead. The boulders were found resting on the bed-rock, which at the particular spot where they were found was on a level with the surface, while about it the surface-soil was deep.

Boulders of other rocks have been traced to their source miles away. In the neighbourhood of Halifax the drift contains fragments of limestone from the Lower Carboniferous and of amygdaloidal trap from the Triassic of the Bay of Fundy, some sixty miles distant. A lump of iron-ore was found on digging a well at Hammond's Plains, of similar appearance and composition to that of the nearest known ore, that of Brookfield, thirty miles to the north. These instances are sufficient to show that while the drift has carried

* Since traced 2200 feet in the direction of the striæ, and a rich mine opened.

much of the "throw" or detached pieces of the rocks but a short distance, it has removed some pieces to very great distances. In general the drift is from the north—though, some prospectors say, on some hill-tops it is from the south, indicating the existence of counter-currents in the shallow waters, supposing the drift to have been due to a northern current and not to an ice-sheet. The angular shape and size of the fragments show that the disjointing force was not a comminuting one. It would further appear that the abrasion of the surface due to the drift was not extensive. On the turn of the Oldham anticlinal the surface is serrated, with the tops of the ridges alone planed off, and the general appearance suggests that the present contour was given before the ancient surface, broken by frost and weather, had its fragments torn away and a new surface formed by the attrition of blocks set in ice passing over it. In some cases the very blocks apparently that made the striæ have been turned over and expose their under surfaces fluted in a similar way to the surface of the bed-rock. Close to the Wellington railway-station a narrow band of rock may be seen slightly elevated above the general level and transversely crossed by striæ evidently of later origin than the displacement of the band; for the striæ are deeper in the band, and their continuations on the undisturbed surface do not take in for 2 or 3 inches from the elevated edge of the band.

Gold in Carboniferous Conglomerate.

At Gay's River the Carboniferous conglomerate is worked in a small way for the gold which is found mixed with the lower portion of the bed. In the "runs" or hollows of the slate the bed-rock is also removed to a depth of 3 or 4 feet for the gold contained in the backs or crevices of the slate. The gold is not very fine; and pieces weighing over a pennyweight are only occasionally found. Usually the surface of the grains is rough, not as though it were fresh from a lead, but rather as if each grain or piece of gold had been first smoothed by attrition and afterwards had fine particles attached to it.

The Total Yield.

Although of interest to the geologist and miner, the gold-fields of Nova Scotia are not of great importance. The annual yield of late years has only been about 13,000 ounces; the largest produce of any one year was 27,000 ounces. The gold obtained is noted for its fineness.

DISCUSSION.

Mr. J. A. PHILLIPS confirmed the views of the author as to the leads of Nova Scotia being true mineral veins.

Mr. W. W. SMYTH stated that he thought the author of the paper had rendered a most useful service to geology in completely upsetting the theory (based on imperfect observation) of the bedded origin of the leads.