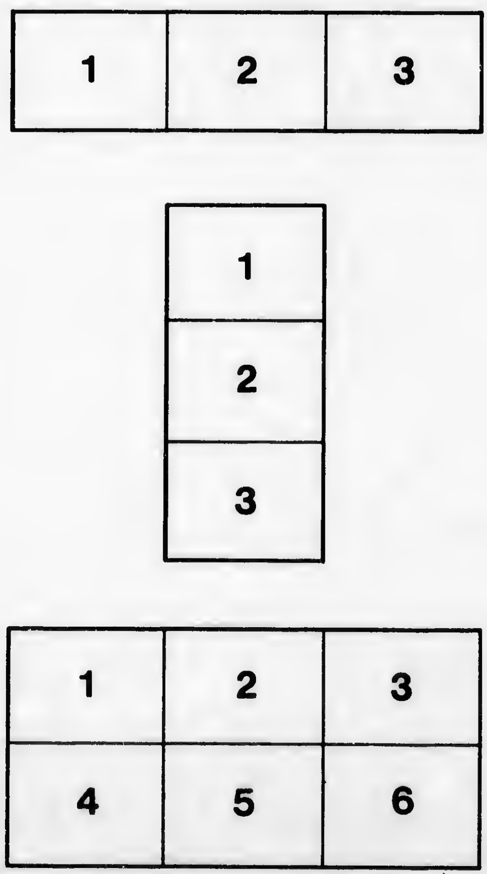
IMAGE EVALUATION TEST TARGET (MT-3)


1 2 3
1
2
3
1 2 3
4 5 6

PUBLISHED BY
THE MINING SOCIETY OF NOVA SCOTIA.

The Gold Measures of Nova Scotia and Deep Mining

(PAPER READ BEFORE THE CANADIAN MINING INSTITUTE, MARCH, 1899)

By E. R. FARIBAULT, C.E.,
Geological Survey of Canada.

OTTAWA:
THE MORTIMER CO., PRINTERS
1899.

On the Gold Measures of Nova Scotia and Deep Mining.

By Mr. E. R. Faribault, B.A.Sc., Geological Survey of Canada.

The gold measures of Nova Scotia became known about the year 1860. The earliest discovery was followed by so many others, that it was believed that the whole of the Province was auriferous. Gradually, however, it became evident that the workable deposits of free gold were confined to the metamorphic rocks of the Atlantic coast, along which they form a continuous belt, from one end of the province to the other, a distance of some 260 miles, varying in width from ten to seventy-five miles.

They cover about half the superficies of the province, exclusive of Cape Breton Island, and their extent may be roughly estimated at 8,500 square miles. Of this area, probably 3,500 square miles are occupied by granitic masses, barren of gold, leaving an area of about 5,000 square miles of gold-measures.

The granite intersects the stratified gold-bearing rocks, in many places, in large masses or dykes, but for the most part it forms a prominent ridge, almost unbroken, from one end of the province to the other. Its intrusion took place at the close of the Silurian period, probably about Oriskany, and was accompanied and followed by disturbances, faults and much local metamorphism of the stratified rocks. It occurred after the folding of the gold-measures and the deposition of the quartz veins; for granite dykes and veins have been observed to always cut the interstratified quartz veins wherever they come in contact with them. The granite has thus no relation to the auriferous character of the veins, and need not again be referred to.

Although, no well defined fossils have so far been found in the sedimentary rocks constituting the gold-measures, most geologists agree to classify them, provisionally, as Lower Cambrian.

They certainly, in many respects, resemble the auriferous Cambrian of the Eastern Townships of Quebec, and knowledge gained in the

Nova Scotia gold-fields may prove of the greatest practical importance in prospecting for veins below the alluvial deposits of Quebec.

The gold-measures of Nova Scotia fall naturally into two well defined and distinct groups, viz., a lower or "quartzite group" and an upper or "slate group."

The mapping of the eastern part of the province, by the Geological Survey, places the thickness of the quartzite group, as far as denudation has exposed these rocks to view, at about three miles, and the thickness of the upper or slate group at about two miles, giving a total known thickness of strata of over five miles.

The lower division or quartzite group is mostly composed of thick-bedded, bluish and greenish grey felspathic quartzite, locally named by miners "whin," a term used in Scotland for an igneous rock or greenstone. Interstratified with the quartzite are numerous bands of slates, of different varieties and colors, from a fraction of a foot to several feet in thickness. The upper division or slate group is mostly composed, east of Halifax, of bluish-black slate, often graphitic and pyritous, rusty-weathering, with occasional layers of flinty quartzose rock. The lower part of this group is characterized by greenish, argillaceous and chloritic, soft slate, of but little thickness at the east end of the province, but increasing to a great thickness at the west end. A few layers of magnesian, siliceous limestone have also been noticed at different places, at the base of the group, overlying conformably the quartzite of the lower division. The line of division between the two groups is thus well defined by characteristic bands, which form valuable data to work out the sequence and structure of these rocks, at any point, with certainty.

The beds of quartzite and slate, forming the gold-measures, were originally deposited in the sea, and therefore horizontally. These horizontal beds were then subjected, during a long period of time, to forces that have produced prodigious results. A close study of the present structure of these rocks shows that they have been slowly moved by a powerful and uniform pressure, which has folded them into a series of huge, sharp undulations, roughly parallel with the sea coast. They have indeed been buckled, bent and folded to such a degree that they occupy only one-half of their former width, measured at right angles to the strike.

Since these rocks were deposited and folded they have been under the unceasing influences that tend to level the hills and fill up the valleys, and, at more recent date, the greater part of the surface was subject to glacial erosion. Extensive denudation has worn away the folded measures to the present level. Some of the sharpest and highest folds have been truncated to a depth, as far as we know, of over eight miles, exposing at the surface a section of gold measures of over five miles in thickness.

The map (Fig. 2) is a reduction of map-sheets published by the Geological Survey on the scale of one mile to one inch. It represents a portion of the gold-measures, thirty-five miles wide and sixty miles long, east of Halifax, between Musquodoboit Harbour and Sherbrooke. The black lines show the anticlinal axes of eleven folds, into which the measures have been plicated ; the narrow, dark shaded bands indicate remnants of the upper slate group, left undenuded along the deepest troughs or synclinal axes of the folds, the other areas indicate the granite masses.

A diagram (Fig. 3), gives a section of thirty-five miles in length, drawn across the whole belt of the gold-measures, along the line of section A B in the plan (Fig. 2).

Below (Fig. 3) is given, for comparison, a diagrammatic section of the Bendigo gold fields of Australia, on a scale ten times as large as the one above. The heavy black lines indicate gold mines on four different anticlinals, worked on the line of section.

The amplitude of the folds, or the distance between the different main anticlinal axes in these two gold fields respectively, varies considerably. The Nova Scotia section of thirty-five miles gives eleven anticlines, or an average distance of three miles between each anticline, and a maximum distance of nearly five miles ; while in Bendigo g district, it ranges from 300 to 1.300 feet. So that in Nova Scotia, the amplitude of the folds, is nearly twenty times greater than in Bendigo.

The mapping of the gold-measures by the Geological Survey during the last fifteen years, has been extended, under my charge, as far west as Lunenburg. The study of the structure of these rocks, over that region, has afforded an opportunity of acquiring many important facts and data by means of which gold mining may be carried on with more confidence, under more exact conditions, and with greater economy.

The most important feature disclosed, is that all the rich veins and the large bodies of low grade quartz worked in Nova Scotia, with few exceptions, follow the lines of stratification, and occur at well defined points along the anticlinal axes of the folds.

It was during the progress of the slow folding of the measures, that the rich quartz veins and large saddle-lodes of quartz were formed, at favourable places, along the planes of bedding on the anticlinal domes of the folds

Thus a thorough knowledge of the structure of the anticlinal folds becomes necessary, to locate the auriferous quartz deposits on the surface, and to develop them in depth.

In tracing the axes of the folds at the surface, the dip of the rocks is the chief guide. If the strata are found to dip towards each other, it is clear they form a synclinal axis or trough; while, if they dip in opposite directions they form an anticlinal axis or ridge.

The rocks, on opposite sides of anticlinal axes, generally dip at angles varying between forty-five and ninety degrees from the horizon, seldom lower than forty-five degrees, and overturned dips are frequently noted.

The deviation of any bed from the horizontal, along the axial line, is its "pitch." A longitudinal section, made east and west along the axis of an anticlinal fold, will show the strata and the fold to pitch either to the east or west, at low angles, seldom over thirty degrees from the horizon.

Owing to the pitch, the outcrop-edges of the beds, on each side of an anticline, are not parallel to the axial line; if they converge towards the east, the anticlinal fold dips east, and if to the west, it dips to the west.

When the pitch inclines both ways from a central point, that point is the centre of an elliptical "dome," and marks the position of one of the most favourable points on the main anticlines for the occurrence of quartz veins.

The average distance between one dome and the next, along the same anticlinal axis, varies from ten to twenty-five miles.

It has been thought by some, that these domes were caused by gentle north and south undulations, crossing the sharp east and west folds. Such does not, however, appear to be the case, generally, as it can clearly be seen by looking over the geological maps of the region, that the pitch at corresponding points on the various main anticlines is often quite different.

It will be seen that most, if not all, of the gold mining centres operated are situated on these domes.

Moreover, it has been observed that most of the anticlinal domes, upon which mines are not in operation, show indications of gold, and many will eventually prove to be important auriferous centres, only a few of them being without the structure necessary for the formation of quartz veins.

Of the twenty-one domes, in the region covered by this map (Fig. 2) fourteen have been worked more or less, six have shown auriferous quartz in situ or in float, and the remaining one has not yet been proved.

The gold districts operated to the east of Halifax are here given, together with their horizon or the distance of their strata below (and in one case above) the base of the upper slate group.

Moose River ....about	3¼	miles.
Tangier .... "	2¾	"
Fifteen-mile Stream and Beaver Dam................	2½	"
Lawrencetown	2	"
Goldenville, Harrigan Cove, Gold Lake and Forest Hill	1½	"
Waverley and Renfrew.	1¼	"
Mooseland, Killag, Liscomb Mill, Richardson, Lower Isaac's Harbour, Wine Harbour and Montague ..	1	"
Ecum Secum, Middle Isaac's Harbour, Cochran Hill, Lake Catcha, and Oldham,.....	¾	"
Salmon River....................................	½	"

Caribou at the base of the Slate group.
Stewiacke about ¾ mile above the base of the Slate group.

There is no doubt that certain kinds of slate are more favourable to the segregation of gold than others, and that the prevalence or absence of the former, at certain horizons, will necessarily give zones of different richness.

The fact that important mines have already been worked at different horizons, from the top of the series to the bottom, is sufficient proof that strata favourable to the formation of auriferous veins are met with throughout the whole thickness of the lower quartzite group, and perhaps also in the upper slate group, though apparently less frequently. This is an important fact with regard to deep mining on the domes of anticlines.

The manner in which the strata are bent over the axial lines is worthy of note. The strata in folding do not bend round a centre, to form circular curves, but their curves are more like parabolas, superimposed upon one another. This is due to the immense lateral pressure which has compressed these beds, especially the slate bands, on either side of the fold, producing a thickening of the strata and openings between them on the apex of the folds.

In a certain thickness of sheets of paper or cloth, bent into an anticlinal fold, a "slipping" of the several layers on each other will take place ; the sides of the fold will be tightly compressed, while, on top, openings will be formed.. In the same manner in the folding of this great thickness of strata, the beds separated along the planes of stratification, and moved along these planes, the upper bed sliding upward on the lower inclined bed.

This slipping is clearly proved by the striations and slickensides that are to be seen in most mines on opposite bedding planes, and by a certain thickness of crushed black slates or gouge between the walls.

Such movements naturally took place between strata, where the cohesion was slightest, and thus, we find quartz veins following layers of slate, especially when the state is intercalated between thick beds of hard quartzite.

These slips may be considered as fault-fissures along bedding planes, and it is along these fissures that the quartz began to be deposited, and as, usually, these movements were very slow and intermittent and extended over the whole period of folding, the quartz was also deposited very slowly, usually in thin coatings accumulating one over the other, as the fissures widened, until veins of different thickness and extent were formed. The quartz often holds minute scales of slate, peeled off the walls, and subsequently covered over by other layers of silica, giving a banded structure to the veins; while the gold also often occurs in streaks parallel with the banded structure.

The large-scale plans made during the last two summers by the Geological Survey, including the most important districts to the east of Halifax, have brought to light important facts bearing on the relations of the structure of the anticlinal domes to the thickness, extent and auriferous streaks of the quartz veins.

In the case of sharp anticlinal domes, such as those of Salmon River, Mooseland, the Richardson mine, Fifteen-mile Stream and others, where the dip of both legs of the anticline forms an angle of less than forty or forty-five degrees, large bodies of quartz, called "saddle reefs" in Victoria, are found to occur along the anticlinal axes, and to bend conformably with the bedding.

On the course of the anticlinal axes, the saddle reefs generally keep their size for a great distance, pitching with the strata both ways from the centre of the dome, and eventually pinch out at a certain limit, which may be called the limit of the formation of quartz on the axial line.

They also curve sharply and follow the strata on the north and south dips, but generally thin out much more rapidly on the legs than on the pitch Many legs have been mined in Nova Scotia to the depth of several hundred feet, and the quartz has still been found of a fair width. In Bendigo, where the folds are on an average, twenty times smaller than in Nova Scotia, the legs of quartz are said to very seldom extend to greater depth than one hundred feet below the cap of the saddle reefs; which would correspond proportionately to 2,000 feet in Nova Scotia.

These saddle reefs in Bendigo, are not only of great size and of remarkable persistence in length, but are also notable for recurring in depth, one below the other.

At the Lazarus mine, Bendigo, there are from the surface to the 2,200 foot level, no less than twenty-four of these saddle reefs, thirteen of which are auriferous to a payable degree, and some of great size.

At Bendigo, on the 31st Dec., 1897, six mines were worked over 3,000 feet in depth, and twelve over 2,700 feet; the deepest, the

Landell's 180 mine, was down 3,352 feet, and these were all worked on anticlinal folds.

No operation has yet been carried to any depth, through the arch-core of the folds in Nova Scotia, but the important developments done along the anticlinal axes at Salmon River, the Richardson mine, Waverley, Oldham and Mooseland, should be sufficient to convince the most sceptical, that quartz saddle-reefs and legs may be found underneath one another, to even a greater depth than in Bendigo.

The Montreal-London Gold and Silver Development Co., largely composed of Montreal capitalists, which acquired lately the Dufferin mine at Salmon River, is at present sinking on the dome of the anticlinal fold a vertical shaft, with cross-cuts and levels, which has reached a depth of over 300 feet. I am glad to call the attention of the meeting to this development, which may be considered the first important step in the introduction of a new system of mining and will, no doubt, be the inauguration of a new era of extensive and permanent deep mining in Nova Scotia.

Few reliable data can be obtained regarding the relative richness of the different parts of the saddle reefs and legs on a sharp fold, but many veins, worked on the apex of the fold, such as the Richardson lead at Isaac's Harbor, the Dufferin lodes at Salmon River, and the Bismarck lead at Mooseland, show that the vein is richer or can be worked with more profit on the saddle than on the legs.

In the case of a broad fold, when the angle formed by the dips on both sides of the anticline is over forty-five degrees, the veins do not acquire any great development along the axial lines, and the enlargements are found rather at a certain distance from the axis.

The thickness of the strata denuded, chiefly since the folding, has already been shown to be very great, reaching on some anticlines eight miles. This superincumbent mass of rock exerted a powerful pressure which has to be taken into account in the folding process. It is evident, that in the sharp folds this pressure has been completely overcome by the lateral pressure, but it has had undoubtedly much influence on the shape of the broad folds and the development of quartz.

This pressure accounts, no doubt, for the fact that large veins are seldom found between strata dipping at lower angles than forty or fifty degrees.

Moreover, on a broad fold, at the surface, important veins are found only at a certain distance from the anticlinal axis, and within a limited zone of strata, AB varying between 200 and 1,000 feet. That is to say, quartz veins were formed on a part CD of the fold, where the combined forces of the lateral and of the downward pressure have determined the greatest strain and have produced most sliding and fissures. The outer limit of the zone A, corresponds generally to a point at which the strata begin to dip at an angle which remains constant for some distance.

Likewise, in depth, quartz veins were formed on that part of the fold which was subjected to the same conditions, and is similarly situated. As the structure of a fold will not change much for some distance in depth, the extreme limits C, D, of the zone of quartz veins will be found at about the same distances from the anticlinal axis of the fold, that is to say, parallel with the axial line EF.

If the fold gets sharper in depth, the zone of quartz veins will approach the axial lines EF downward, and if it gets broader, the zone will recede from the axial line. The distance B E of the zone of quartz veins varies considerably in the different districts according to the flatness of the fold. The axial line E F may also coincide with B D, in a sharper fold, and in a still sharper fold it may come half way between A and B, and we have then the typical saddle-reef fold.

Again, at the surface, in the same district, as at Goldenville, the fold may be sharper at one end and broader towards the other end, and in that case the zone of quartz veins will recede from the anticlinal axis, towards the broader end.

The quartz veins are sometimes very numerous on both sides of the anticlinal domes. On the Goldenville anticlinal dome, where developments have, perhaps, been more extensive than on any other districts in the province, some fifty-five different veins have been worked or uncovered, in a width of strata of 1,300 feet on the north side of the anticline, dipping north at forty-three degrees, and some fifty veins in a width of 500 feet on the south vertical dip of the anticline.

They extend in many cases on the surface for thousands of feet and they have been mined to depths of 700 feet in their vertical extension

The thickness of the veins varies considerably. The saddle-reef deposits are by far the heaviest bodies; those worked at Salmon River, Richardson and Mooseland mines attaining fifteen to twenty-five feet in thickness, and others not operated, at Fifteen-mile Stream, Cameron dam, &c., are probably larger.

The veins along the legs of the folds are much smaller, averaging from four inches to one foot, but often larger.

Many quartz veins are also found cutting the stratification at various angles; some are of great thickness, many are auriferous, and a few have been operated with notable profits. They are of later origin generally, than the interstratified veins, and some of them may be roughly contemporaneous with the intrusion of granite. Their richness is generally influenced by the nature of the adjacent strata.

In the interstratified veins the gold is sometimes distributed uniformly over considerable areas; usually, however, it is more or less concentrated within certain limits, leaving spaces on each side, comparatively barren. These enrichments are known as pay-streaks, and have hitherto been the principal source of the gold production

Most pay-streaks are well defined enrichments of twenty to sixty feet in breadth, often accompanied by enlargement in the size of the vein. They dip at low, constant angles, parallel generally with the well defined lines of schistosity of the rocks, and often with striations and corrugations on the walls, giving the veins a crumpled structure, locally called "barrel-quartz."

These corrugations and crumplings are more pronounced in the slate and quartz, and owe their origin to the sliding of thick beds of quartzite over one another, between which the softer bands curve and buckle in a wonderful manner. The pay-streaks lie at right angles to the sliding movement, that is to say, approximately parallel to the anticlinal axis.

Many of the pay-streaks have been proved very rich and some have been traced from the surface along a gentle incline for as much as 1,800 feet, with extraordinary uniformity. In many instances, two or three pay-streaks have been determined in the same vein lying parallel under one another for some distance. This mode of occurrence is necessarily limited to the portion of that vein situated in the pay-zone.

The laws governing the position and extent of the pay-ground or pay-streaks are intimately connected with the structure of the anticlinal folds and are similar to those already laid down for the position and extent of the zones of quartz veins. The data necessary to explain their many peculiarities in the different gold districts are difficult to obtain with any degree of precision, as few plans or records have been kept or are obtainable. As a general rule, the best pay-ground, in most districts, is situated at about the middle of the zone of quartz veins A B, where fissures with angular-veins are most numerous. These small angular-veins or "angulars" which run into the walls at different angles, and sometimes connect one vein with the next, play an important part in the concentration or segregation of gold from the adjacent auriferous rocks, and, causing an enrichment or impoverishment of the main veins, they are well called locally "feeders" or "robbers."

In depth also, the zone of pay-ground G G, should be situated at about the middle of the zone of quartz veins G, parallel with the axial line E F.

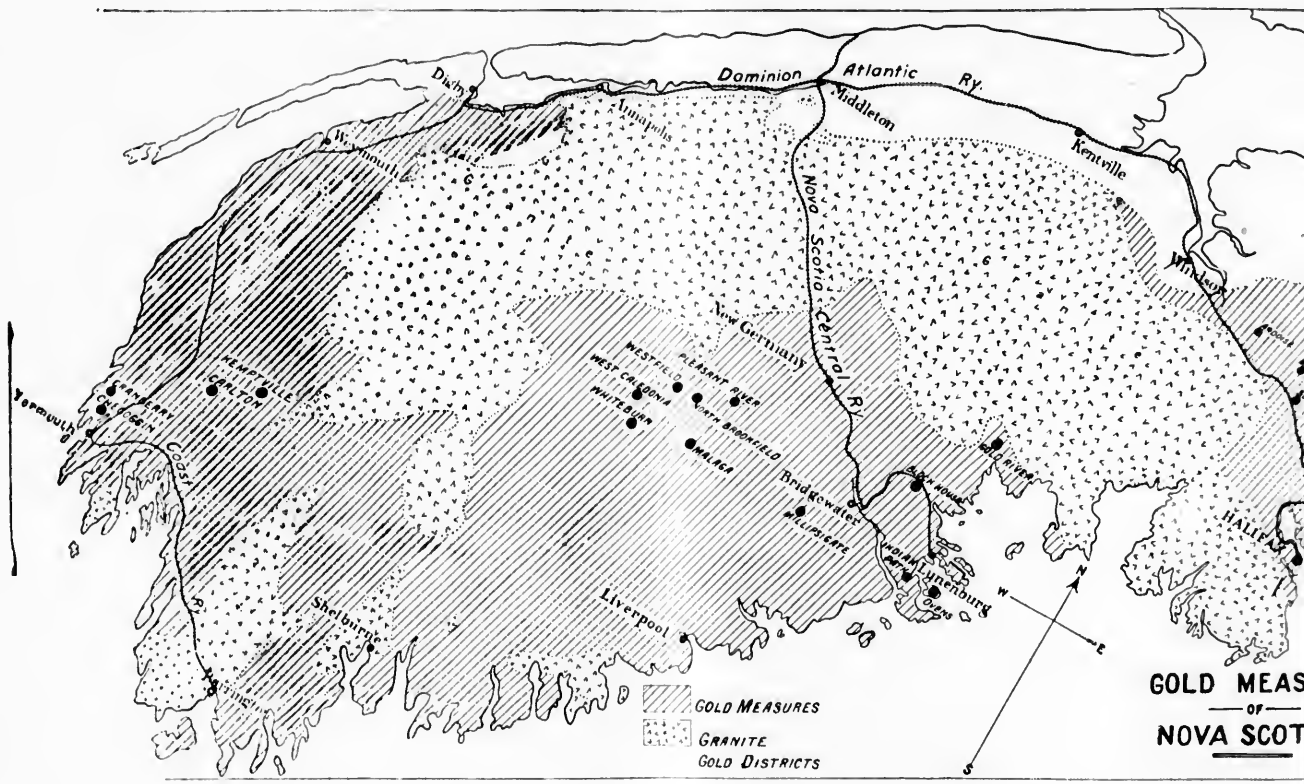
It will then be readily understood, that one individual vein, if it cannot hold gold in paying quantity to a great depth, may nevertheless, be sufficiently rich to be worked with profit for a great length along certain lines parallel with the anticlinal axis; that a vein barren at the surface B may be rich in depth in the pay zone, and that a vein which does not come to the surface B, may also be found payable on that pay zone G′.

The problem then consists of developing a zone of pay ground or portions of veins included within certain limits, along a plane G G, parallel with the axis E F, and that to depths practically unlimited.

This problem will, I am sure, prove interesting to mining engineers, and it only awaits their skill and knowledge to be put in practical operation and place the Nova Scotia gold-fields among the most productive in the world.

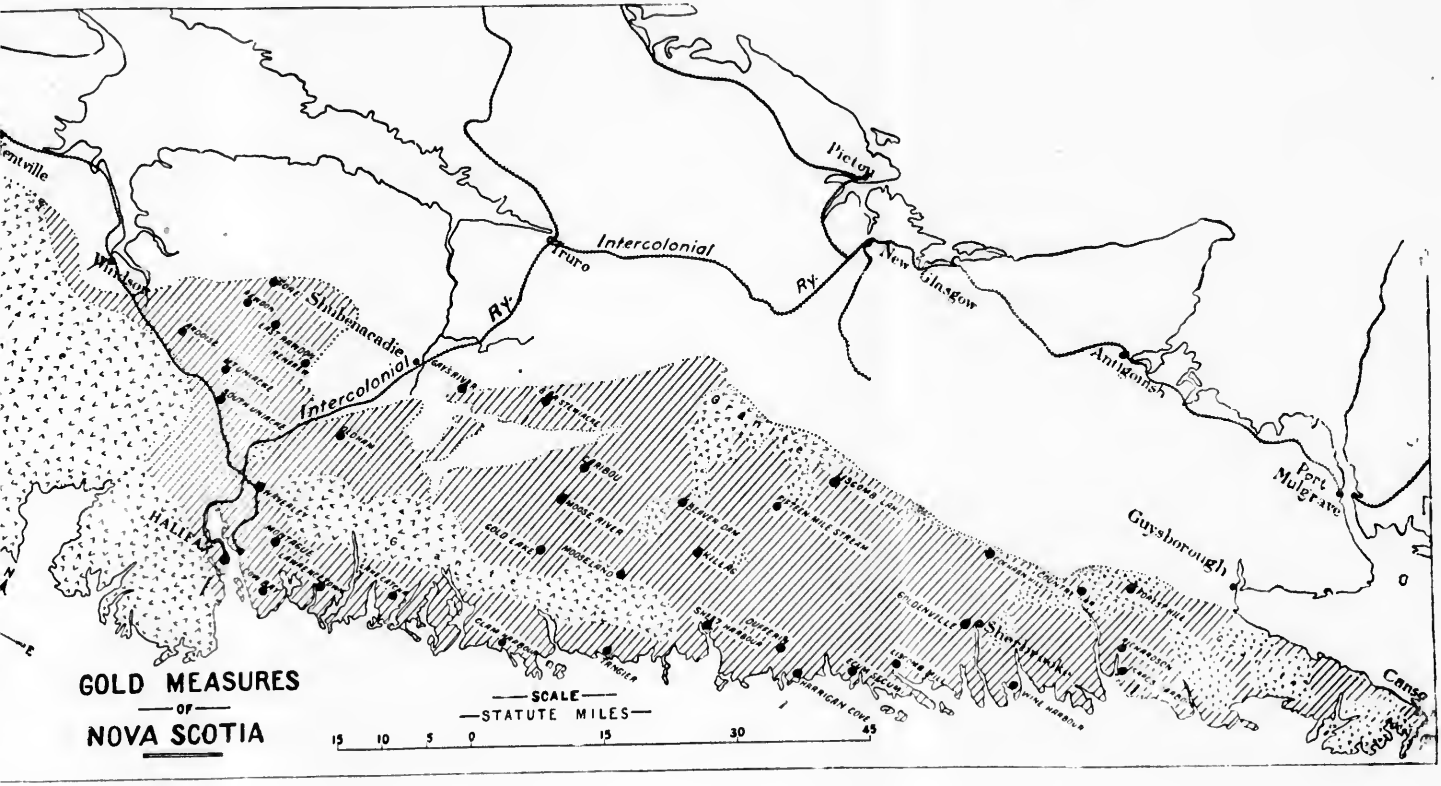
The Gold Measures of Nova

PLATE I



s of Nova Scotia and Deep Mining.

PLATE I.



The Gold Measures of Nova Scotia

PLATE II.

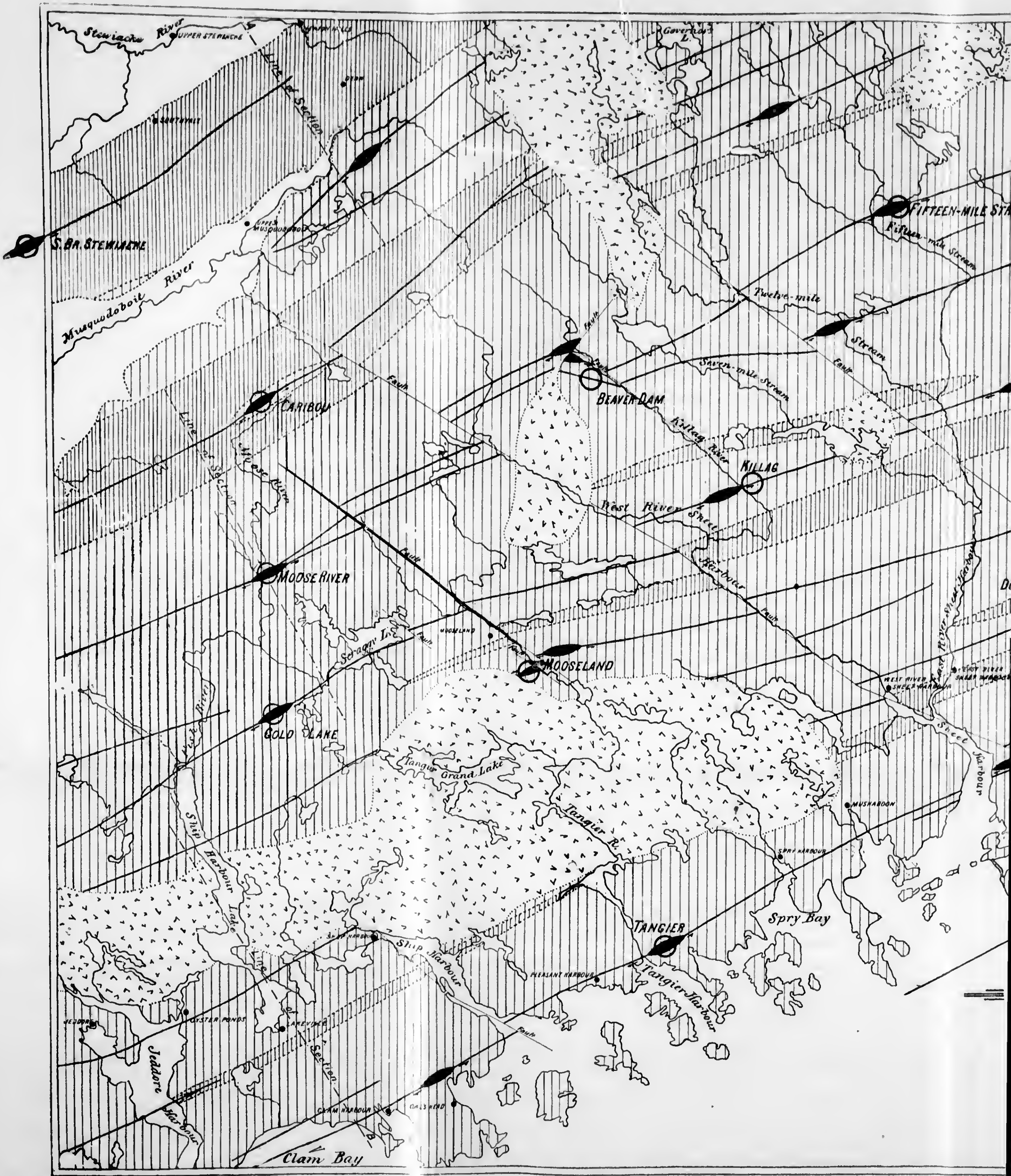
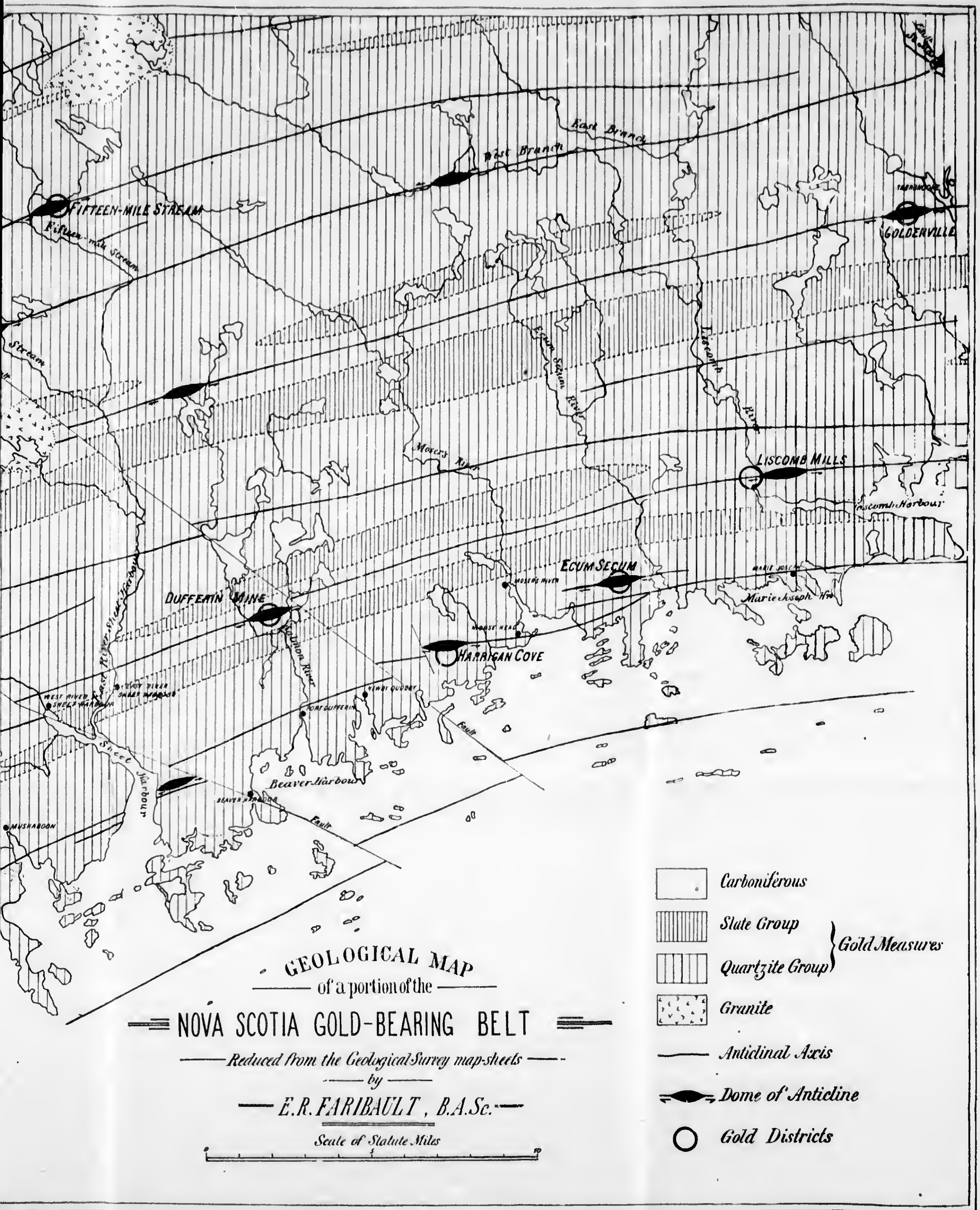
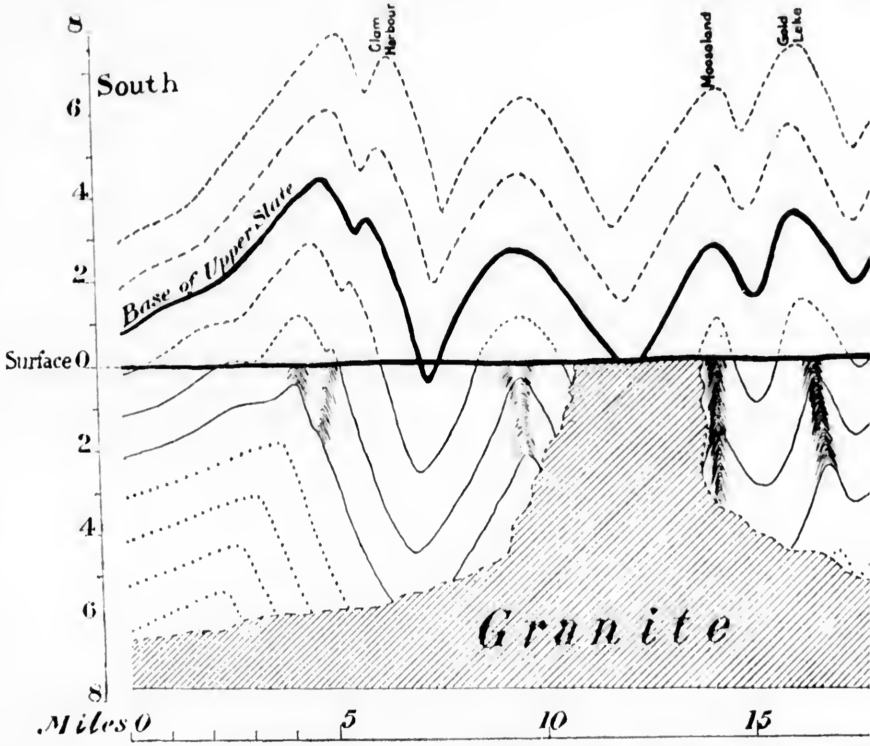


PLATE II.

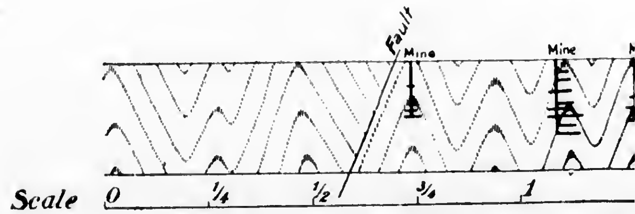

FIFTEEN-MILE STREAM
Fifteen mile Stream
West Branch
East Branch
GOLDENVILLE
Stream
Ecum Secum River
Liscomb River
Moser's River
LISCOMB MILLS
Liscomb Harbour
ECUM SECUM
Marie Joseph Hr.
DUFFERIN MINE
HARRIGAN COVE
East River Sheet Harbour
Salmon River
Sheet Harbour
Fault
Beaver Harbour
MUSHABOON
Carboniferous
Slate Group
Quartzite Group
Gold Measures
Granite
Anticlinal Axis
Dome of Anticline
Gold Districts
GEOLOGICAL MAP
of a portion of the
NOVA SCOTIA GOLD-BEARING BELT
Reduced from the Geological Survey map-sheets
by
E.R. FARIBAULT, B.A.Sc.
Scale of Statute Miles
0
5
10

The Gold Measures of Nova S

PLATE III.



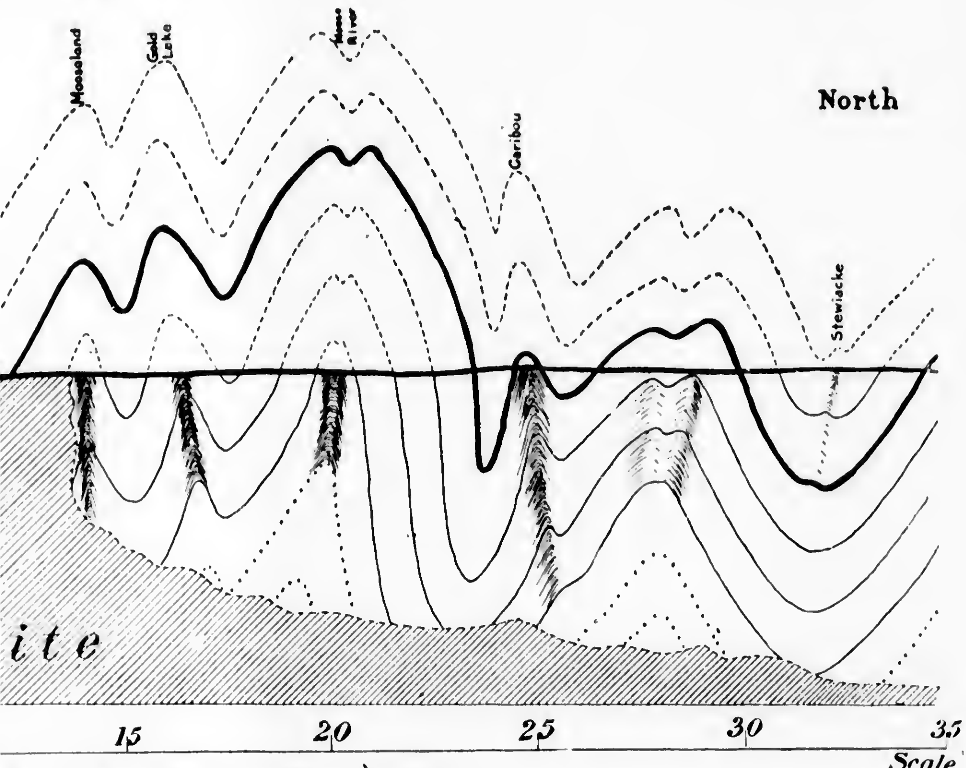
SECTION OF GOLD MEASURES



SECTION OF BENDIGO GOLD-FI

# of Nova Scotia and Deep Mining.

PLATE III.



GOLD MEASURES IN NOVA SCOTIA.

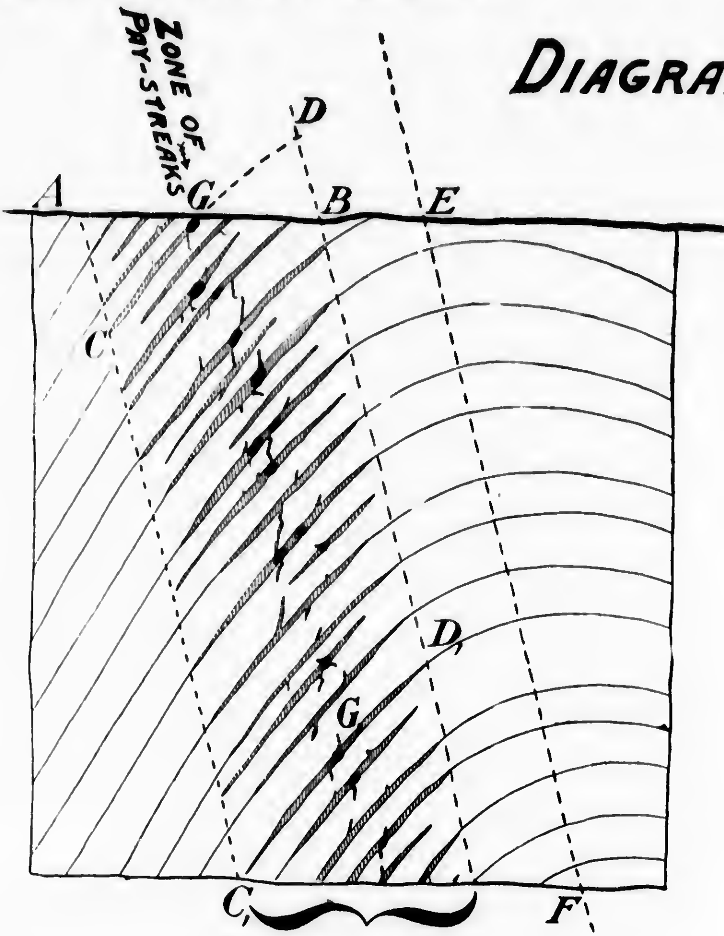
BENDIGO GOLD-FIELD, AUSTRALIA.

The Gold Measures of Nova S

PLATES IV and

SECTION ON BROAD FOLD

DIAGRAMS

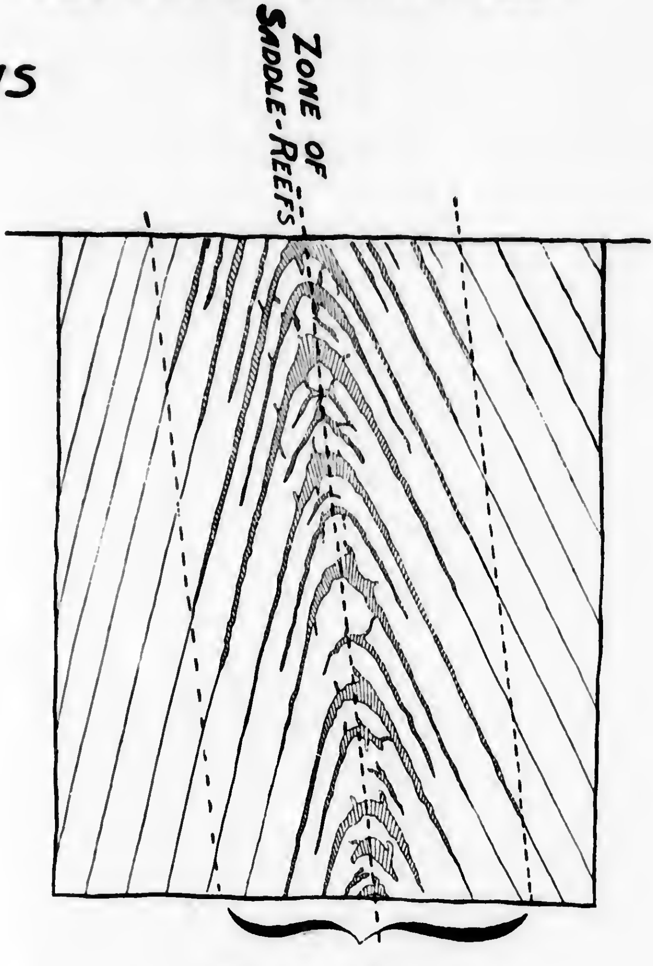


f Nova Scotia and Deep Mining.

PLATES IV and V.

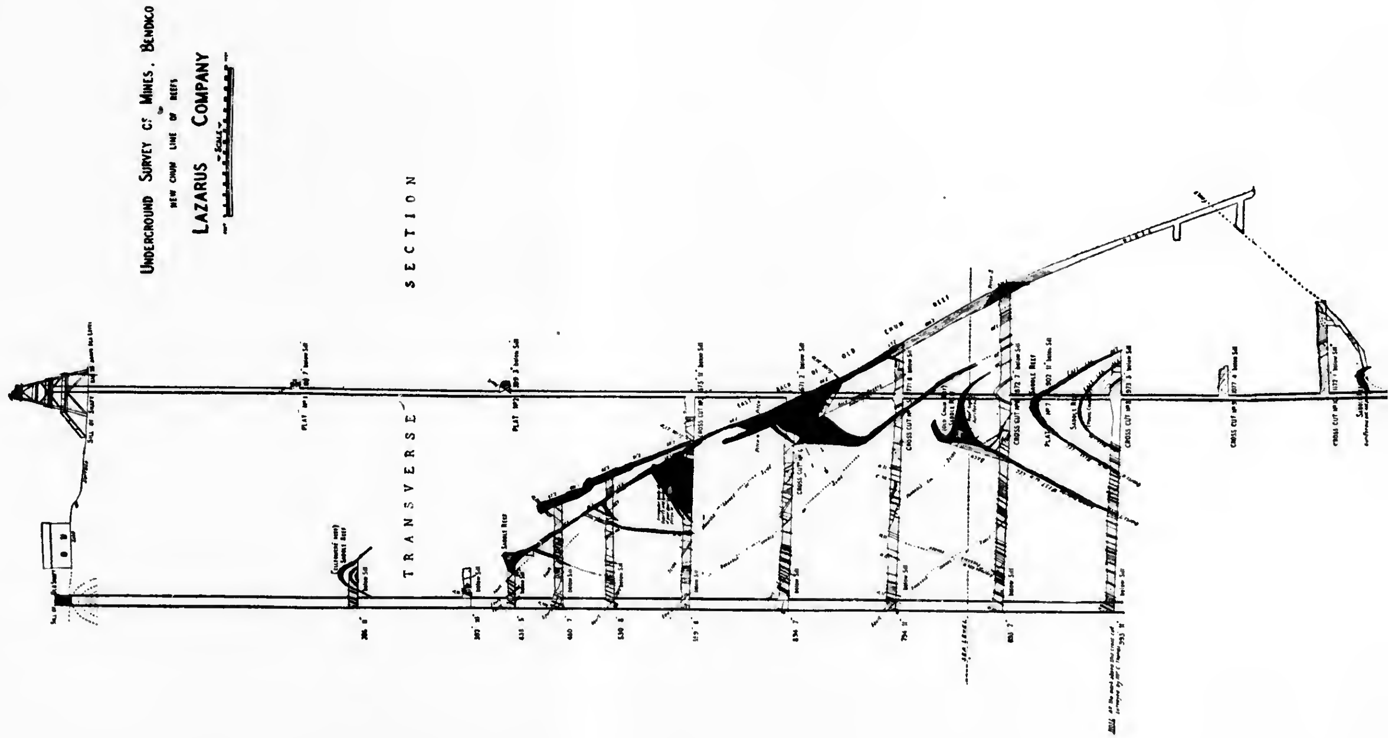
IAGRAMS

SECTION ON SHARP FOLD



The Gold Measures of Nova Sco

PLATE VI.



f Nova Scotia and Deep Mining.

PLATE VI.