

GEOLOGY OF THE MOOSE RIVER GOLD DISTRICT, HALIFAX
COUNTY, NOVA SCOTIA.*—BY PROF. J. EDMUND WOOD-
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*The third of a series of papers on the gold-bearing rocks of Nova Scotia; extracted and altered from a thesis accepted for the Doctorate of Science at Harvard University in 1902, entitled "Geology of the Moose River district, Halifax county, Nova Scotia; together with the pre-Carboniferous history of the Meguma series." The first two papers appeared in the *American Geologist*, 1904, vol. xxxiii.

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INTRODUCTION.

Location.—The settlement of Moose River Mines lies in lat. 44° 58' 55" N., long. 62° 56' 40" W.; and is 37.5 miles northeast (true meridian) from Halifax. Its rocks form a portion of the upland, or Cretaceous peneplain, here very flat. The surface over many square miles of this region is so even that Sphagnum abounds, with moist soil below; and for long distances a well-driven pick will strike bedrock anywhere. On the north barrens extend for several miles; to the other side lies more timbered country, becoming swampy toward the Tangier granite, with numerous lakes. Natural exposures are few, and the true structure is discoverable only by means of underground workings or surface trenches.

The settlement was made, as many others have been, merely by clearing the timber off the level land and damming up a small stream, Moose river, for power. Mining has been carried on in a small way for many years, but no shafts have been sunk below 500 feet. In the course of exploration, numerous shallow pits and trenches have been cut, exposing the bedrock across the strike of the strata. Many hundreds of feet of trenches were opened for me in 1899, in the course of economic development. A few quarries, located as they all are in rather critical parts of the field, afford excellent opportunities for study. The surrounding country is evenly covered with drift, nowhere very

thick and in many places less than a foot deep; and outcrops for several miles are no more abundant than within the limits of the settlement itself.

Extent and topography.—The main settlement extends rather more than half a mile east and west, and a third of a mile north and south (pl. 1, fig. a). One mile west a district locally called "West Mine," (pl. 1, figs. a, b), has been opened superficially for economic purposes; and here also it has been possible to do some detailed work, which has aided in interpreting the structure of the main field. Little could be made of the intimate structure in either part of the district without the aid of subsurface workings, which range from shallow trenches and larger quarries to shafts three hundred feet deep. No really deep sinking has ever been done here.

The topography of the region is that of a plain with very slight relief. The drainage is weak, although low falls are numerous. Lakes abound. The general direction of the main streams is northwest to southeast. Moose river, from which the settlement takes its name, runs roughly south from Caribou, seven miles north-northeast of the Moose River mines, where it has expanded into several lakes. Between the two localities it has a wandering course, often broadening into linear lakes, and in places almost lost in swamps. At the northwest corner of the settlement the river has been dammed to supply one of the crushers, and again at the north for a similar purpose.

From the pond first mentioned, west for a mile or more the surface is fairly even, rising to a height of twenty-five feet above the river, but for the most part without distinct hills or ridges. The disposition of the drift accounts for much of the slight irregularity. East of the river the land rises twenty-five feet in five hundred, then very gradually for a mile. The south side of the district, however, was largely a swamp until 1898.

Division into units of area.—Like most of the proclaimed gold districts of the province, Moose River has been divided by the Department of Works and Mines into *blocks*, composed of

areas; each of the latter being 250 feet north and south by 150 feet east and west. Thus each of the six blocks composing this district contains 1,000 areas, and measures 7,500 feet east and west in fifty areas' width, and 5,000 feet north and south in twenty areas' length. The main settlement comprises a few areas in blocks 1 on the north and 4 on the south (pl. 1, fig. a, and pl. 2). "West Mine" is in block 6 on the north, and south of it lies block 5 (pl. 1, fig. a).

Much trouble has arisen in the study and economic development of gold-bearing properties in various parts of the province, because the early surveys were carelessly made, and always by magnetic meridian; and in many cases either the date or the declination has been omitted from the map. The declination has changed steadily, and in many districts resurveys have detected errors in the older work, and the present area lines may follow neither magnetic nor true meridians. This discrepancy is especially marked where the lines have been run parallel and perpendicular to the general strike of the rocks, as here. The declination at Moose River in 1897 was approximately $22^{\circ} 15' W$. The north-south lines run 5° west of this, or about $27^{\circ} 15'$ west of true north. In this paper all bearings are referred to magnetic north.

Method of approach to subject.—The survey of the Moose River district formed part of an investigation into the pre-Carboniferous history of the gold-bearing series. The spot was selected for detailed study, partly because it appeared to be typical of the series as a whole in many ways, and yet unique in a few features—and in just those features favorable to the study of the veins. I recognize that certain large problems in Nova Scotian geology can never be solved until close, painstaking, detailed work has been done on critical sections; and while the detail in this paper may at first appear excessive, the study has been made deliberately, in the hope that it may lead to more detailed work elsewhere in the series.

The field studies occupied parts of several seasons. When the first survey was made, in 1897, no maps of the district had been published; but within a few months the mining map by Mr. E. R. Faribault appeared [Geol. surv. Can., doc. no. 646; scale 1 : 6,000]. I am much indebted to this for the positions of certain veins which have not been worked since the present study began, and for checks upon certain other features. The map in this paper is more detailed than is customary, even in large-scale mining maps, in its attempt to locate the axes of the several folds; and has the benefit of a number of excavations which were unfortunately not opened when the earlier plan was published. It is a pleasure to note that, while pl. 2 differs in many details from the government map, the later work confirms in the main the general results of Mr. Faribault's survey. This last is to be expected; as his painstaking work has invariably resulted in valuable maps of the anticlinal domes.

Inasmuch as this is a field study, petrographic and chemical aids have been employed only as far as was necessary for the main purposes of the paper; and many interesting problems involving their use have been neglected. It will be noticed also that the larger theoretical questions are not included in the following pages, except for a partial summary at the end. This is because the length of the paper would be increased unduly, were they treated in full; and the alternative is to be followed of presenting a discussion of the general problems arising from the study, in subsequent detached papers.

Nomenclature.—Throughout more than a half-century of study of the gold-bearing series, no distinct geological names have been used for it and its subdivisions. Almost simultaneously with this paper another has been published, proposing a remedy (Am. Geol, vol. xxxiii); and the nomenclature of that paper will be employed by me in this and subsequent contributions to the geology of the series. The gold-bearing series as a whole is there called the *Meguma series*; the lower, quartzite, or gold-

bearing division is named the *Goldenville formation*; and the upper or black slate division, the *Halifax formation*.

Below is a list of terms used in the present paper, which might otherwise be misunderstood by some, because of newness or the local meaning employed.

Angular—(1) An irregular spur from a stratified vein, or (2) a vein striking nearly or quite with the strata, but intersecting them in dip. The first meaning is in part local, as in some other places these veins are called “feeders” or “robbers.”

Barrel—A corrugation of stratified veins, and of strata adjacent to them, usually on the plunge of a domed anticline.

Break—Fault.

Lead—Stratified vein.

Pocket—A restricted portion of a lead or other vein, locally highly enriched.

Regular—In the plane of stratification.

Roll—Generally a synonym for “barrel.”

Surface—Glacial drift.

Whin—Sandstone or quartzite in this series.

:00 or :01.—1900, or 1901, dates.

Acknowledgments.—This research had its beginning in a small study made for and with Professor N. S. Shaler of Harvard University; and throughout the continuance of this and of other studies arising from it, he has aided it in every way, so that my indebtedness to him is greater than to anyone else.

The help derived from Mr. Faribault's map has been mentioned. Thanks are due also to Mr. B. F. Pearson and Mr. J. K. Pearson, upon whose property much of the detailed work was done, and who gave every facility for it; and to owners and workers of the other properties in the district.

PART I.—STRUCTURE.

DATA FOR STRUCTURAL INTERPRETATION.

Absence of fossils.—No fossil remains of any description have been discovered in the rocks of Moose River. The only appearances suggestive of them are some concretions which protrude from the surface of a quartzite ledge on area 132, block 1. These have weathered less than the rest of the rock, through the possession of a firmer cement. They appear as ovoid projections ranging up to three inches in length, two in width and three-quarters in height. Frequently stratification bands can be seen to pass through them, but these are faint. The weathering has left the surface of the concretions rough.

In the slide they show no trace of organic origin. Their appearance differs little from that of the other quartzites of the district, except in a slightly coarser texture and more abundant cement; characteristics which decrease outward from a center, and doubtless the concretionary growth is a function of them. Two thin sections show grains of quartz cemented by silica and calcite, with the usual secondary minerals, described later. The grains are so situated as to leave no room for an organic nucleus, now perhaps lost, but both specimens show an inorganic nucleus. The cementation has centered around a few coarse grains of sand, about twice the diameter of the other grains. In the vicinity of these is a comparatively dense network of secondary minerals, chiefly dark ones such as chlorite, biotite, and particularly a dense amorphous iron oxide. Wherever the grains of quartz are unusually large, there is a tendency to this increased density; but it centers chiefly around one spot.

Lithological horizons.—Of rock horizons, only one can be found which, by reason of its distinctness and continuity, might be used throughout the region as a datum plane. This is the slate belt containing the Jo. Taylor belt of leads. Unfortunately the structure is such that this one is not visibly repeated across

the strike; and furthermore, the outcrops and artificial exposures are not so placed as to make the exact delimitation of this horizon easy.

Interbedded veins, and distribution of strikes and dips.—Most of the interpretation of structure rests, then, upon two series of data—the attitude of the stratified veins, and the distribution of strikes and dips in the sediments. In small areas and for short distances, recognition of definite horizons in the strata is also possible. The distribution, attitude and characteristics of the bedded veins serve well within certain limits; but beyond a fault these criteria may occasionally fail, especially if the displacement be large, or the veins near a point where they die out or cut across the strata to another horizon, as they do in a few places. Yet veins are frequently the only horizon markers available in measuring a fault. Taken in connection with the distribution of strikes and dips of the sediments, and the lithological character of the strata on the hanging and foot-walls of vein belts, they form part of a fairly secure group of data.

SEDIMENTS.

General distribution.—North of the settlement, beginning two or three areas beyond the Copper lead, the rocks are chiefly quartzite for nearly three miles. Here and there thin slate strata are intercalated, but the proportion of argillaceous material is small. South of the mines, starting at the third or fourth tier of areas south of block 1, quartzite again stretches for several miles. The exact proximal limits of these whin* zones cannot be given, on account of the few natural outcrops and the absence of artificial openings; but the margin of error is small.

Between these limiting whin areas is a broad belt characterized by lustrous black slate, often somewhat schistose; essentially

*This quartzite is called "whin" by miners throughout the province. The term, used throughout the gold mining part of the province for sandstones, arenaceous slates and quartzites, was originally employed by Hutton in Scotland, to designate certain sheets of trap, and in Cornwall still has a similar meaning.

different from the slate of the Halifax formation, which is well exposed on the road north from the mines. There are quartzite strata within this zone, but they are comparatively few and narrow. In them, as in the more abundant ones to the north slate lenses with rounded edges are occasionally found. It is the extent of this slate belt, at least 1,500 feet wide across the strike, which constitutes one of the unique features of the district. All the ore-bearing veins are situated in it, even though many of them lie at the contact of slate with thin strata of quartzite.

The plunging of the folds east and west is not sufficient to bring the bordering quartzites of the north and south around the ends of the anticlines—at least, within the limits of the survey.

Characteristics: slates.—The argillaceous material varies from a soft lustrous slate to one that is as hard and dense as the best roofing slates. In both the composition is chiefly kaolin, finer in the former, and somewhat lighter colored in the slide. Most of the characteristics seen in thin section are metamorphic. The color in the field is due largely to the same cause, but the firmness has for its primary source the texture of the mass, allowing the metamorphic changes to act differently in different cases. On the whole, the coarser the slate the less it has been shattered by cleavage.

Characteristics: quartzites.—The coarser sediments grade imperceptibly into the pelites in places, but in the slide a sharper line of demarcation is usually present than would be expected. The quartzites have as their chief constituent fine and well rounded grains of quartz. The cement is partly secondary silica, but so much calcite is present that it is difficult to see in some specimens what can be the origin of the granular gleam characteristic of fresh quartzite surfaces, and highly developed in the psammites of Moose River.

No distinctly feldspathic material was seen in the slides, and little kaolin in any but the finer whin. There is, however, a considerable amount of muscovite and biotite. While some of

the mica is evidently secondary, other pieces, especially of biotite, show by their rounded outline and their relation to the quartz grains that they are clastic.

Contacts of strata.—The discontinuity of strata has been mentioned. This is as marked in a small as in a large way; for there are many lenticles of slate in the whin, from a few inches in length to less than one, the ends of which are sometimes well defined and rounded, but more often vague and serrate. In no case has the microscope shown a local deposit of slate thinning out to an edge. The upper and lower contacts are smoother where not folded; but even these are frequently sinuous, merely from almost microscopic differences in deposition. Under the influence of folding and cleavage, the strata and laminæ have assumed very complex relations.

FOLDS.

Position of the two main anticlines.—One of the features in which Moose River differs from other gold districts of Nova Scotia is in being situated, not on one dome, but on three. It has been stated that the rocks of the Meguma series lie in persistent and roughly parallel folds, the axes of which run northeast to east. Two of the anticlines pass through this field (pl. 1, fig. a, and pl. 2). The more northerly has a direction of N. 60° E. (true) at the east end of the main settlement, and N. 69° E. (true) at its west end. The other runs N. 65° E. (true) on the east, and N. 74° E. (true) on the west. Thus both are converging westward at an angle of 5°.

Union of anticlinal axes westward.—The north axis can be traced eastward through Fifteen Mile Stream settlement, apparently dying out five miles northwest of Goldenville. The south axis passes eastward through Beaver Dam and Ragged Falls gold districts, running parallel with the other at a distance of two to two and a half miles from it, and continues farther east through Stillwater to Country Harbor. There it is lost in a fault of large horizontal displacement, although the Seal Harbor anti-

cline is almost certainly a continuation of it. The eastward course of the two folds does not come further into this study. Westward, however, they are of special interest, on account of their continued convergence and final union a mile west of the settlement (pl. 1, figs. a, b). The combined anticline stretches westward through Mt. Tom, probably to Waverley. Its point of bifurcation is partly a matter of estimate, as outcrops are few and little trenching has been done; but enough observations are possible to give reasonable accuracy.

Stratigraphic position of Moose River district.—The only datum plane in the series available for broad structural study is the contact between the Goldenville and Halifax formations. North of Moose River lies a broad zone of the latter, and many observations can be made between the two. South of the mines there is no belt of black slate north of the Tangier granite, in such line that a section through Moose River would intersect it.

On the road north from the settlement, although outcrops are numerous at the roadside and in the surrounding barrens, it is difficult to get the structure with certainty. All the exposures are of quartzite, and the weathered faces and superficial parts easily reached with a hammer rarely show slate laminæ. The whin itself is too uniform to have visible stratification planes. Such observations as are possible give steep north dips up to the edge of the upper formation. Two miles west of the mines a traverse north is possible under better conditions. Here the dips vary somewhat, averaging 75° N., and giving a thickness of 16,730 feet. The Moose River anticline plunges westward throughout this region, and to the eastward lower and lower strata lie against its axis at the surface. If 75° N. be assumed for the average dip of the Goldenville beds north of the mines, as seems reasonable in view of observations at the traverse to the west and three miles to the east of the settlement, the lowest exposed strata on the main north anticline lie 16,900 feet below the base of the Halifax formation.

South from Moose River, at least one anticline intervenes between the mines and the edge of the upper formation; and calculation based upon that traverse is rendered still more uncertain by the scattered distribution of such outcrops as are structurally valuable.

Details at "West Mine."—It is at "West Mine" that the union of the two anticlines occurs. This region contains, besides two or three natural exposures, two trenches and several shallow shafts. The location of the axis before and after branching, and of the openings, is shown in pl. 1, fig. b. On areas 187 and 188 the rocks show no sign of a double axis, where visible. By estimate, the farthest point west at which the two axes should be in the least separate, is 64 feet west of the east side of area 189, and 156 feet south of its north end. As a matter of fact, there must be a zone eastward for some hundreds of feet, in which the division is accomplished, and before it can be said that there are two distinct axes. The few natural exposures are somewhat disturbed, but farther east two axes are plain.

The data at West Mine are not so full as in the settlement. The only sources of continuous observation would be trenching across the strike and cross-cutting underground. The two trenches already referred to were in disuse at the time of my study, and gave only intermittent views of the bedrock. The "surface" or drift varies in depth from one foot up to eight or ten. The north end of the northern trench lies in area 214, six feet east and 94 south from its northwest corner. The rocks here have a high north dip, but were not well exposed in 1899. The cut runs 77 feet S. 25° E., to a lead. South of this lie two or three feet of compact quartzite, with a smooth contact; then fourteen feet of dark slate interspersed with siliceous layers, ending against more whin with a "rolling" or corrugated foot-wall contact. These last strata strike N. 80° E. and dip 64° N. The same attitude is found 29 feet south, where the rock has been trenched for many feet along the strike to expose a bedded vein. Thirty-three feet south again is the north end of an eight-

foot belt of slate, on which a shaft has been sunk. Between these stations the rock appears to be quartzite, and south of the slate three feet is the hanging wall of another narrow band of slate. In area 187, next south of 214, the shaft which has been mapped lies over a six-foot belt of veins, the belt being crumpled slate. The strike here is N. 87° E., the dip 84° N. The trench shown on the map runs S. 42° E. Along this 175 feet south is the first vein with a south dip. Thirty-three feet farther is a second, and thirty-one feet south of it a third. The exposures were in such condition in 1899 that the degrees of dip could not be measured accurately, but they were high. The bedrock was only obscurely visible anywhere along this trench. From such indications as could be found, and from questioning those who had dug the ditch, the estimate was made that the axis lies about 125 feet from the north end of the trench. It strikes east and west, and the estimate here agrees almost exactly with that given earlier, from data a mile to the eastward. Throughout the traverse of the region the rocks show a local crumpling and contortion unlike anything seen in most of the districts, but such as might be expected to accompany the division of an anticlinal axis, in alternating competent and incompetent strata. For a considerable distance north and south, such outcrops or prospect holes as have been found from year to year show dips away from the axis.

The minute details of this commercially unimportant field have been given, because they throw light upon some problems in the main settlement. For the location of the strata, veins and structures in the main part of the field, pl. 2 can be used throughout the remainder of the discussion of structure.

Location of axes in main district.—In the eastern part of the region the structure, reduced to its lowest terms, is that of two east and west anticlines, slightly diverging eastward, the north fold plunging west and the south one east. Between them, owing to the abundance and peculiar distribution of the slate strata, there has been developed a local anticline, which

appears to die out westward almost within the limits of the field; and which quite certainly ends on the east within a short distance, although another has been found seven miles from the mines. This is one of the unique features of the area, because of the opportunity it offers for the study of the growth of folds; and is made possible by the presence of the broad horizon of slate instead of the alternation of narrow well-defined bands of slate and quartzite characteristic of the other domes.

The more northerly of the two main anticlines starts east from West Mine with its axis taking a probable direction of N. 86° E. Where it crosses Moose river it has a strike of N. 89° W. The more southerly fold starts east with a strike of N. 87° W., and at the west end of the main field lies N. 84° W. This gives an eastward divergence of 5° to the axes. Where they cross the stream they are approximately 525 feet apart. The vicissitudes of faulting are described elsewhere. It may be recorded here, however, that east of the westernmost main fault the north anticlinal axis does not change its strike; east of the middle fault it lies for most of its way N. 86° W., probably turning northeast somewhat, as do the beds to the north; and east of the third main fault it starts N. 88° E., but soon turns to N. 82° E. The directions of this and the other six axes, at the extreme east end of the district, are estimates based upon observations immediately west and some distance east. The south anticline starts directly east from the west fault; but runs northward somewhat, influenced but not intersected by the middle fault, then strikes S. 87° E., to the east fault. Beyond this the axis is sinuous for nearly 500 feet, finally straightening out in a direction N. 87° E. Thus the axes diverge eastward at 5° here, also. The distance between them is the same as at the west end—525 feet.

Lack of outcrops makes the position of the synclinal axis between these folds problematical, west of the west fault. Inasmuch, however, as it is very definitely located everywhere else, the position assigned, based upon data immediately to the east,

cannot be far wrong. East of this fault the nearest outcrops of opposite dips are only twelve feet apart, so that the axial line can be given with great accuracy. East of the middle fault the axis is estimated with reference to a definite horizon which appears on both sides of the break,—the Jo. Taylor belt of leads—combined with certain other less definite data. East of the east fault, also, exposures define the position of the line closely. It will be noticed that here the distance to the south anticlinal axis is much less—45 feet—than in any place to the west.

To understand the growth of the middle fold, it will be necessary to state in detail the data available for determining the structure. For this purpose, the rocks will be considered in four divisions—*i*, west of the west fault; *ii*, between this and the middle fault; *iii*, west of the east fault; and *iv*, including the east end of the field.

Division i: attitude and character of strata.—Exposures in division *i* are few, compared with the rest of the region. West of the river the only shaft is that on area 66, supposed to be on a continuation of the Britannia belt. The dip of the skids is about 50° S. The rock on the dump consists largely of an argillaceous quartzite, grayish green in color and highly lustrous. Mingled with this is a compact, shiny black slate. It was impossible to descend the shafts at any of the visits. North to the bend of the river is a continuous outcrop along the stream bed. It is all quartzite, having only here and there laminæ by which to get the attitude. The two records on pl. 2 sum up all the knowledge that can be gained without excavation. The strata at the more southerly station strike from N. 85° E. to E.—W., according to the precise spot of observation.

East of the stream the land is low and somewhat swampy toward the north. On areas 133 and 168 is a ledge of much weathered quartzite, but it is impossible to be sure of its attitude. It lies along the line of probable westward continuation of the north anticline, and doubtful evidence points to a north

dip on the north side, and a south dip on the south; but this was not considered in plotting the axis on the map. Several outcrops lie a few feet north of the Alex. Taylor lead, all but two, which have been recorded, being of doubtful value for structure. These two exposures are quartzite, so that there is no slate on or near the surface north of the lead just mentioned; but this is not surprising, as the slate rarely stands out well under erosion. Northeast of the shaft near the center of area 132, is a ledge from which the concretionary "fossils," already described, were collected. This is also whin, coarse in places and with an indeterminate but distinctly low south dip. The Alex. Taylor lead is important because, although the deepest shaft is only forty feet down on a 35° surface dip, the lead flattens out considerably in that depth. The next data come from the Britannia, which gives an average dip of 45° S. A small trench on area 69 showed in 1899 six belts of leads, all with a fairly steep south dip, one measured as 67° . In 1901 a belt of rather erratic veins had been opened on areas 68 and 69, to a depth of 170 feet. The dip of the sediments varies considerably in that distance, through irregular "rolling" of the beds; but it is safe to call it on the average 70° S.

No other exposures are met north of the Touquoy crusher except a number of leads in a drain on the east side of area 32, observable only in 1899. They all have steep north dips, some probably vertical; but the depth open to observation was too slight to make sure of that. These leads, on account of similarity in attitude, interval and composition, are taken to correspond to the Moleskin and leads south of it in the trench on area 30; and to the south, leads with a south dip, very like the Smith and those near it, have been seen when the drain was fresh. Finally, a bedded vein occurs at the south corner of the Touquoy crusher, vertical and in vertical strata; and south of this are three south dips, on area 33.

Division i: interpretation of structure.—The obvious interpretation of these data is given in the section on pl. 3. The

north side of the north anticline is fairly to be inferred from observable steep dips east of the fault. South of this axis the dips are low for some feet, increase to 35° at the surface in the Alex. Taylor lead but are still low below; then steepen steadily to 70° , with an average of about 60° . South of the synclinal axis the dips are known to be steep; and from veins in the trench on area 32, and known east of the fault, in divisions ii and iii, a probable average of 70° is obtained. South of the south anticlinal axis, the dips begin at 90° and run out to at least 70° . Farther east they are lower.

Two interesting features are shown in this section. First, the folds are all unsymmetrical, but irregularly so. The axial plane of the north anticline dips 60° S., that of the other two folds 85° S., giving an overturn to the north in all. Second, the north anticline is not normal and simple, but compound, having on the south side very low central dips, and a distinct bulge about one-third of the distance to the synclinal axis. How far west this bulge extends there is no means of knowing, because the country is undeveloped; but eastward it grows into a distinct third anticline, clearly defined, but evidently lying on the side of the north fold. Although not fully developed in division i, this bulge is divisible into an anticline with an axis dipping 53° N., and a syncline whose axis dips 64° N.

Division ii: north anticline.—In division ii the most northern dip visible is that of No. 7 lead, between 70° and 75° . The slate belt extends at least a hundred feet farther north, according to those who worked this part of the district in earlier years; and by estimate some distance beyond. Between No. 7 and the Little North, the rock is still largely quartzite, slate increasing in proportion southward. Even as far as the Big North whin is found to some extent. The dips north of the axis are sufficiently represented on the map—low near the center and increasing outward. The anticline has a comparatively flat top, as can be seen well in the quarry on area 131.

Division ii: westward pitch of north anticline.—Many years ago the Big North was stoped out on the crest of the fold westward on a plunge, the work going somewhat farther than the shaft at the north end of area 132, or about 200 feet. Later the crown was broken down in part, and the present quarry made. This plunge, characteristic of most of the gold districts of Nova Scotia, begins on the east side of area 131 at 9.5° W., and becomes 12° on the west side of the same area. How much higher the angle grows it is impossible to say; for the west fault cuts off both the Big North and Serpent leads, and it has never been proved that the leads west of the break are the same.

Division ii: subsidiary fold, pitching east.—South of the anticlinal axis in areas 130 and 131, the only dip except on the plunge comes from a trial shaft in the center of area 130. Here slate was encountered, almost flat, but dipping south enough to give an average of 5° S. According to this, the axial plane dips 70° S. in this part of the fold. At the south end of these areas is the Archibald vein. This dips 48° S. at the surface; but it does not lie directly in the bedding, as witness the discordance of its strike with all the others near. The Bruce is, however, "regular" or interstratified. From it to the south end of areas 70 and 71 the structure, revealed only by the quarry, gives folds merely foreshadowed in division i. The dips are south for sixty to eighty feet south of the Bruce belt (pl. 7 fig. c); but the strike is erratic, varying from the normal—almost east and west—at the north, to N. 20° E. in one place at the south. For thirty feet farther the dips are slightly northward, the strikes varying from N. 10° W. to N. 30° W. Here, then, is a local syncline, apparently dying out westward, and running east to the fault. That part of division i (pl. 3) to which it corresponds, is the flattening out of the south dips in the Alex. Taylor lead and vicinity. The best estimate of the dip of the axial plane makes it 83° N.

The anticline south of this trough corresponds to the change from low to high dips toward the Britannia, in division i. It

plunges eastward, as shown by the curved strike of the Jo. Taylor belt, and of the strata at the east end of the quarry, immediately north of the anticlinal axis. The Taylor belt is found on that side also, but does not reach the surface in the unexcavated part. The angle of pitch is difficult to measure or estimate, but is about 15° E. All this part of the field is slate, except here and there a stratum of quartzite, such as overlies the Jo. Taylor belt to a thickness of four or five feet. This belt of leads takes part in the synclinal folding immediately to the north. The axial plane of the anticline appears to dip 85° N.

Division ii: south main fold.—The synclinal axis south of the quarry is measurable to within a few feet, for the two nearest outcrops of opposite dip are scarcely twelve feet apart, measured directly across the strike. This axis is continued from west of the west fault, and its plane dips 83° S. The rocks to the south dip much as in the corresponding zone on areas 30 and 171, east of the middle fault. The angles are all high to the south anticlinal axis, whose plane dips 82° S. Thence as far south as the Root Hog the dips vary from 50° S. near the axis to 70° at the lead just mentioned. The rock is slate from the Jo. Taylor belt to the south end of the trench on area 970, block 4, except for a few quartzite strata of no importance. Indeed the small exposure south of the trench, and one near the south end of area 930, block 4, indicate that the slate belt extends at least 650 or 700 feet south of the south anticlinal axis. This trench is one cut in 1899 expressly to develop the structure of the rocks and the distribution of the leads.

Division ii: relation to division i.—A comparison of the cross sections of these two divisions (pls. 3, 4), shows that in ii there is beginning to form a distinct subsidiary anticline on the flat side of the northern fold. It is probable, judging from the distribution of dips in and near the quarry on area 70, that the local syncline does not extend to the fault on the west, and its axis has been drawn with this belief. West of the fault there is no syncline, and this one begins as a definite sag fifty or one

hundred feet east of the break, becoming more marked eastward. It will be noticed that the axes of the local folds dip in opposite directions from those of the main ones; as is to be expected if division ii is a development of division i.

Division iii: north anticline.—In division iii, the northernmost outcrop is a vein on areas 227 and 228. It is doubtful whether this is parallel with the stratification; and as it is some distance beyond the main field, it will not be considered either in map or section. Leads east of the middle fault which have always been regarded as continuations of the Copper and Little North have been worked, in some cases to a depth of 200 feet. From the character of the gangue, and the adjacent sediments, there is little doubt that those two and the Big North are represented in this division. The dips become noticeably lower toward the axis, as is characteristic of the north anticline, which has everywhere a full top and rounded north side. Between the Big North, called the North Sutherland at its east end, and the quarry on areas 73 and 74, there is only one exposure. This is a small pit on the line between areas 126 and 127, where the rock is slate, lying flat. As far as can be learned from those who prospected this zone in earlier years, the strata are almost entirely slate, resembling that of division ii north of the Jo. Taylor belt.

Division iii: subsidiary compound fold.—In the quarry on areas 73 and 74 is a horizon corresponding to part of the larger quarry to the west. On the south the hanging wall lead of the Jo. Taylor belt outcrops, overlain by the usual whin stratum. The foot-wall lead of this belt forms much of the floor of the excavation. On the north side the strata dip north at angles varying from 20° to nearly 40°. On the south the dip is 30° to 45° S. Between is a small but distinct synclinal sag (pl. 8, fig. a). This, then, is the perfection of the fold prophesied in division i and shown in an incomplete form in division ii. Not only has an anticline been formed on the side

of the large one, but this has itself been made compound by the sinking of a syncline on its summit. On area 75 a small quarry shows this puckering to a slight extent. In this case, however, the dips on the north side are very low, not over 10° . The same condition obtains in a tunnel which runs from the floor of this quarry, eastward under the road to a new quarry on area 76.

Division iii: south anticline.—South of the Jo. Taylor belt, the dips vary on the same horizons, steepening westward and becoming lower eastward. Thus the Dreadnaught slate belt, which has a dip of 45° S., south of the quarry, has only 20° one area to the east. The Dry belt, which dips 80° N. at the north end of area 30, declines to 50° and 35° eastward. The Moleskin changes from 70° to 35° at the extremities of its developed portion. The bearing of this may be seen by comparing with these dips the distribution of dips along the horizon of the Jo. Taylor belt east and west of the middle fault. From such comparisons it appears that both the middle and south anticlines plunge eastward steadily, the former rapidly, the latter at a lower angle.

Little is to be said of the south dips on the south anticline. The Comstock has 60° S. near the east end, becoming somewhat steeper westward. The Root Hog was opened in 1899, and has not been developed far enough to show a diminution of dip.

Division iii: details from trenches.—The best data for parts of this division have been obtained from two trenches cut in 1899 on areas 30 and 71, to develop the structure. The Jo. Taylor belt consists of several leads, of which the hanging and foot-wall ones are easily distinguishable. The belt averages seven feet in thickness. The hanging wall lead is exposed east of the middle fault in a small pit at the end of the east embayment of the quarry, area 71; in the smaller circular pit to the north, and again at the south end of the north trench (pl. 7, fig. a). Near the north end of this trench the foot-wall lead has a dip of 60° S. South of the axis of the small synclinal sag, it appar-

ently rises slowly, for in one place slate lies horizontal; and at the axis of the anticline the lead comes up at an angle of 30° , over a thin stratum of whin which underlies the belt. At the trench this is narrow, and the lead is seen descending the south side at an average angle of 10° but "rolling" heavily. Near the south end of the trench the hanging wall lead has a dip of 5° S., but becomes steeper within a few feet. It is overlain by the same quartzite which is seen in the quarry to the west, and above this lies the Ferguson, a lead which at the south edge of the quarry occupies a similar position. A feature of these exposures is the easterly pitch of the beds, continued from the area west of the fault. The foot-wall lead plunges east 10° , and the hanging wall 5° , where seen.

The south trench gives an almost continuous series of dips. The greater steepness of the rocks, compared with observations farther east, has already been noted. The axis of the south anticline is determinable in this trench precisely. At a distance 152 feet south of the north end of the trench, a ledge appeared in 1899 to give both north and south dips. Although only two and one-half feet broad at the base, it had a dip of 50° N. on the north, and a steep south dip on the south side. Blasting revealed an arched lead, showing the exact position of the axis (pl. 11, fig. i).

Division iii: interpretation, and correlation with div. ii.— In interpreting the data in this block in terms of a structural section, two points must be emphasized. One is that in 300 feet north from the quarry on areas 73 and 74, there is but one exposure: the other relates to the interpretation of division ii. There, upon what appear to be safe and adequate grounds, a structure is worked out which makes the Taylor belt a horizon equivalent to the Copper belt, or strata very close to it. The former is found again in division iii; and if the interpretation is correct, the equivalence must be continued. This shows a change of shape to have taken place in the north anticline, and in the position of the subsidiary fold with reference to it (pl. 5).

The latter is low, instead of resting high on the bulging side of the former; and the main fold is therefore much steeper on its south side. The south anticline remains nearly the same as in the other two divisions, its axis here dipping 85° S. The syncline to the north of it apparently dips 80° S.

The subsidiary fold is better developed than in division ii. Its axes all dip 85° N. Since the bulge on the south side of the north anticline is hypothetical to some extent, having only one exposure for direct evidence, it is difficult to give its axial dip. The structure is best explained, however, by an inclination of 70° N. for the axis of the syncline south of the bulge. Had the section been made near the eastern side of the block instead of the western, the south anticline would be found to have pitched down to a somewhat lower level, with reference to the others. The axial plane of the north anticline dips 85° S.

Division iv.—In many ways division iv is not so well known as the two to the west. The openings are fewer, shallower, and for the most part in disuse. At the critical portion, however, a large quarry has been opened, and two smaller ones to the east. North of the Little North there has been almost no prospecting. Between this and the North Sutherland the rock is largely slate, and south of the latter is practically all slate to the Miller lead.

Division iv: subsidiary and south anticlines.—The only dips north of the axis of the north anticline are the three leads given on the map, and considered by those who worked them in earlier years to be the equivalents of leads of the same name west of the fault. South from the axis are, or have been, a number of exposures with leads, now for the most part abandoned. All were cut very shallow, and information regarding them is hard to get. The new quarry on areas 76 and 77, lying along the middle anticline, gives the same structure as in corresponding parts of division iii; but the southernmost of the axes is farther from the center of the sag. The rock here is a black lustrous slate with a few green bands. To the south

it is noticeable that the south syncline is one of low dips on the whole, instead of the high dips prevailing to the west. The south anticline has dips much like those in similar situations to the west.

Division iv: axial dips and plunges.—The southern and subsidiary anticlines are still pitching east. The former plunges steeply immediately east of the fault, but flattens out after two hundred feet are passed. The latter pitches 15° E. in the large quarry, 6° in the cut at the north of area 78, and 10° in the square quarry to the south. Hence it too is rapidly flattening. The axis of the north anticline dips 85° S. The axes of the compound subsidiary fold have not changed their attitude. That of the syncline north of this fold dips 75° N., having steepened somewhat. The axes of the south anticline and syncline dip 78° S. and 82° S., respectively.

Division iv: correlation with division iii.—Despite the presence of the eastward plunge in the two southern anticlines, which should bring newer beds to the surface eastward, the only feasible interpretation of the structure, as represented by cross-section (pl. 6), gives older strata at the surface. This is on the basis (1) of the distribution of dips in the field, (2) of the approximate equivalence of the Copper horizon with the Jo. Taylor belt. There is so much change that on the subsidiary fold the Jo. Taylor belt would be 260 to 270 feet above the present surface.

The folds have not changed their character materially, but their relative positions are altered. The north anticline is still broad, and the local anticline is still close to the sharp south main fold. But the distribution of dips in the field places the north synclinal axis much nearer the north anticline, so that, although the dips on the south side of the syncline are low, the strata rise considerably upward. It is this that brings the horizon of the Copper lead, or its equivalent the Jo. Taylor belt, so far above the present surface at the crest of the south main anticline.

Summary of Moose River folding.—The theoretical considerations regarding these and other folds in the Meguma will be given in a subsequent paper on the structure of the series. It is sufficient here to recapitulate the conditions found in the field.

The simplest structure of this type is the elliptical dome striking roughly east and west. The modifications in Moose River are such as to distinguish the region from all others :—(1) two main axes instead of one, giving two anticlines, both of great extent along the strike and prominent in the structure of the series ; (2) their convergence westward and final union within the limits of the district ; (3) the presence of a thick slate horizon, included in both folds and overlain by massive beds of quartzite, instead of the alternate whin and slate strata of other domes. This makes possible (4) the puckering up of part of this slate belt into an intermediate anticline, itself compound, and probably dying out east and west within a comparatively short distance ; (5) the plunging of the axes of the main folds, not at both ends as in an ideal case, but one eastward, the other westward ; and (6) the plunging of the intermediate fold eastward, or in the direction of divergence of the axes of the main anticlines. It probably broadens and flattens out until gradually lost ; yet there is some evidence that it, or another in its place, exists six miles east, near Otter lake, where the two main folds are half a mile apart.

The vertical thickness of sediments involved, between No. 7 on the north and the veins in the center of area 970 block 4, on the south, is only about 370 feet.

FAULTS.

Classes of movements.—The faults of the Meguma series fall for the most part into two large types—cross faults, cutting across the strike of the long folds at high angles, and often extending for miles ; and radial faults, striking outward on the plunging ends of domes. There are some that are outside

this classification, but it includes by far the larger number. Of the radial type Moose River has none. Of the other class it has several, three of some size. The evidence for these, and the character of the dislocations, are detailed below.

The direction of motion along the fault plane, and the position of each block with reference to the adjacent ones, are difficult problems because the data are not at first glance always consistent. The simple possibilities in any case may be grouped under four heads:—(1) vertical motion, the east side rising or falling with reference to the west; (2) horizontal motion, the east going north or south; (3) oblique sliding, the east going up or down and north or south. These are all motions of mere translation. There may have been (4) a shearing, upon a fulcrum within or without the field. More than one of these possibilities may be fulfilled in a single fault, and the whole may be complicated by compression of the strata, equalized or differential. These conditions must be examined for each fault in the light of the distribution of dips shown by strata, leads, and axes of folds.

West fault: course.—This fault has been visible in the west stope of the Big North lead, and obscurely at the west end of the quarry to the north. In tracing out the Big North lead it was lost at the break, and was thought to have been recovered on the west side, twelve feet south. I do not think, however, that it has been found, and this opinion is shared by most of those who have worked the lead. At this point, therefore, the horizontal displacement is an unknown distance, quite certainly not much beyond twelve feet. In the west stope of the Big North, the fracture dipped 85° E. Whether this is characteristic of the fault as a whole there are no data for discovering. From the Bruce belt, which was tunnelled west to the break, a cross-cut was driven fourteen feet south, beyond the fault, but without success. Hence the displacement here is at least that amount. From the fault as exposed in the Big North to the west end of the Bruce tunnel is S. 5° E. The position of

the fault at the south side of the field is inferred. The leads in the drain on area 32 all have high north dips, as far as seen by me, and correspond closely to leads in the trench on area 30. Directly east along the strike of the former, however, the leads dip south. Hence the fault must run east of the drain; and probably not far east, because of the considerable change in strike of the fault involved. Taking this into account, I have plotted this portion S. 8° E.

West fault: details of displacements.—The horizontal displacement at the north end of the section is believed to be small, because the Alex. Taylor has dips which would be expected in a lead at the distance south of the anticlinal axis here represented. Were this axis much nearer, the surface dips should be less. At the south end the positions of the synclinal and anticlinal axes in division ii are known with great exactness. That of the anticlinal axis in division i is known quite closely, by reason of the strata at the Touquoy crusher and the leads in the trench. From these data the horizontal displacement of the southernmost axis is calculated to be 50 feet. This gives a positive overlap of 10 feet, and offset of 47.5 feet to the left. These functions have not been computed for the northern anticline, because so small and so problematical.

West fault: direction of motion.—The determination of the direction of motion along the fracture receives little aid from the exposures in the open quarry on area 169 and the west slope of the Big North; for here the fault is a zone, the gouge of which is composed of pieces that have moved in various directions. Dips must be used as far as they give evidence.

(1) In a vertical motion of translation, if the east side rose, the axes of the main anticlines east of the fault would, upon denudation to the present level, migrate southward. Such evidently is not the case. If the east side fell, the axes would migrate southward on the west. On account of the obvious difference in inclination of these axes the northern one, having a lower dip, would migrate the farther, and the two axes would be

nearer together west of the break. The opposite condition obtains. Finally, if not aided by some other movement, a vertical one would leave the dips of the axes unchanged.

(2) A horizontal motion of translation, unaccompanied by any other change, would keep the axes equidistant on either side of the fault, and would not alter their dips. Here the axes on the east, according to the best data obtainable, are forty feet nearer together than on the west; and their dips are altered.

(3) An oblique motion of translation appears at first sight to meet the conditions. By calculation, if the axes east of the fault hold their dip, a movement of the east side up and north 118 feet at an angle of 60° from the horizontal would, upon erosion to a level, give the axes of division ii the position which they now occupy. But there are two other criteria. After an upthrow and subsequent denudation, any horizon is farther from the axis of an anticline than before. As no strata or leads in the two divisions have been proved identical, this test cannot be used. But, second, east of the break the dips of the axial planes are different from those to the west. Unless disturbed by some other movement, they should remain unchanged.

(4) A shearing might make the south end of division ii rise or fall with respect to division i, on a fulcrum within the zone of leads or north or south of it. Consider first the case of a fulcrum between No. 7 on the north and the Root Hog on the south. If the south side fell, the axes of the two anticlines would be brought nearer together; the north migrating south for a considerable distance because of its low dip, unless the fulcrum were near it, and the south axis lying a very short distance north or south of its present position, depending upon the position of the fulcrum. This obviously has not happened. If the south rose, the axes would be farther apart, and the north one would dip less than 60° , which is not true. Second, if the fulcrum were beyond the axis of the north anticline, and the south fell, a shearing of such sort as would place the north axis in division ii where it is and give it a dip of 70° S., would make

the south axis dip 85° N., instead of 82° S., and would not bring the two into their present distance relations. If the south rose, the axes would migrate south, and they did not. Similar objections hold, upon the supposition of a fulcrum south of the field. Thus it appears that no one of the possible classes of movements can account unaided for the present conditions; and a combination of two or more would fail as surely.

If, however, the effect is considered of a compression of the folds, acting in conjunction with the faulting, it is found that any one of the four methods is available. But only two are quantitatively probable:—(1) horizontal movement of the east block northward with reference to the other; and (2) an oblique motion on the east side up and northward, with compression from the south. It is at present impossible to state positively which of the two is correct, because we have not, as in comparing divisions ii and iii, definite horizons by which vertical change can be computed. If (2) be accepted, the proportion of oblique motion to compression is hard to determine, because the latter has altered the dip of the axial planes. In the case of (1), the amount of direct sliding of the whole mass depends upon the position in the north anticline of the fulcrum upon which that axis has turned from 60° to 70° . If this fulcrum lay at the present surface of the ground, the east mass as a whole moved north the whole distance of the offset of the north axis. If the fulcrum lay below the surface, the movement of the whole east block was greater than this; if above the surface, it was less, and may theoretically have been negative, or southward. In any of these cases, compression horizontally accounts for all the motion represented by the difference between the motion of translation and the offset of the south anticline.

But steepening the dip of an axis in the course of compression inevitably alters the dip of the strata, on one side adding to the increase of dip of the beds accomplished by the compression itself. The steepening will occur on the side of the fold towards which the axis dips; and will be least, perhaps almost nothing,

at the level of the fulcrum and near the axis, increasing outward and above and below it. Such evidence as we have indicates that the south dips of the north anticline were not steepened appreciably in the change from 60° to 70° axial dip; hence if (1) is to be accepted, the direct sliding must have been nearly the distance of the offset of the north axis, or about ten feet, the axis steepening 10° about a fulcrum placed close to the present surface of the ground. Of the southern part of the section, all that can be said is that in addition to the ten feet absolute movement north, there was a farther one caused by compression, less northward and greater southward, amounting at the southern axis to 37.5 feet at the most. This appears, of the two, the more plausible explanation. In the course of compression, the south anticlinal axis was decreased in dip from 85° S. to 82° S.

Middle fault: course and attitude.—The evidence as to the functions of this fault are far clearer than of the one just described. Its direction throughout its observed length is N. 19° E. At the north end it has been met in working the Copper and Little North on the west, and these and the Little South on the east. The last has not been opened west of the break because, such is the lack of system in the development of these districts, no cross-cut has ever been made for it. The workings on these leads were abandoned in 1897 or 1898, and I have seen the fault below ground but once. There it appeared as a zone of fractured material, with a breadth not measurable at the time, and dipping east at a very slight angle from the vertical. Indeed, experience seems to show that most of the north-south faults in this series, where their dip is measurable, incline east.

Middle fault: displacements.—If the Copper and Little North had kept their strike eastward to this fault, their horizontal displacement would be 95 feet. But instead, they turn strongly northeast. In other parts of the district, some turn thus in the direction of motion, and some do not. The former cases are probably in the nature of a drag, except where the axis of the

fold plunges. In view of this, even though the turn extends westward for a considerable distance, it has been thought best to neglect it and to base the measurement of displacement upon the general strike. But the south end of division iii is not faulted at all, being merely dragged. Hence the axis of the north anticline is plotted as displaced 70 feet, an amount proportional to its distance from the south end of the faulted area. At the Copper lead, a total displacement of 95 feet gives a negative overlap of 20 feet, and an offset of 92.5 feet. The north anticlinal axis has a negative overlap of 17.5 feet and an offset of 66.75 feet left.

At and near the eastern end of the quarry, area 71, the fault could be seen in three places in 1899. The most northern was a small pit nearly in the centre of area 71, where it dips 68° E. (pl. 9, fig. b). The strata east of the fault are here nearly horizontal, for the more southerly of the two anticlines which form the large subsidiary one broadens and flattens westward. The second exposure of the fault was in a circular pit east of the large quarry, and topographically several feet lower than the first. Here it is essentially perpendicular. Its direction changes erratically in the fifteen feet of section, being at the south end of the pit N. 60° E., and at the north end E.-W. (pl. 11, fig. h). At the east end of the quarry itself, or rather in a short cave excavated eastward from it, the break is again visible. In the second pit just mentioned, the hanging wall lead of the Jo. Taylor belt comes up on the east at a high angle (pl. 9, fig. a). It is said to have been tunnelled east to the small fault on area 72, meeting underground workings east of that point. The total horizontal displacement at this point is 37.5 feet. The overlap and offset are difficult to measure, on account of the curved strike of the Taylor belt west of the fault. If this were due merely to drag, the problem would be simple; but north of the local anticlinal axis west of the break the strike is northwest, showing that the strata really plunge downward toward the east (pl. 18.)

Middle fault: southern limit of dislocation.—That the fault

extends south of the quarry admits of no doubt. But in tunneling the Smith belt east, it was not met, although the works crossed the strike of the break. Instead of faulting to the north, the belt departs from the normal strike, turning northeast, as though dragged severely but not fractured. It appears, then, that the fault stops short of this belt, probably close to it on the north, and becomes at that horizon a very local cross fold.

Middle fault: essential unity of divisions ii and iii.—In deciding what is the character of the movement which division iii has suffered in its faulting, it will not be necessary to go so fully into the theoretical possibilities as in the preceding case. Divisions ii and iii are in some respects a single structural unit. They are the only ones showing the Jo. Taylor belt. Both were shoved north by the west fault, and the difference in attitude is the result merely of a rupture within the block, at one end not extending to the limit of the field.

Middle fault: direction and character of movement.—It is evident at once that a mere motion of translation, horizontal, vertical or oblique, will not account for the growth of the fault. It is equally evident, when tested quantitatively, that the only shearing possible under the conditions—the east side going up toward the north on a fulcrum at or few feet south of the south anticlinal axis—would violate two conditions found in the field. If the north end rose upon a fulcrum at the present outcropping of the Jo. Taylor belt, so as to leave the latter where it is found in division iii, the Copper lead might lie at its present position east of the fault, but probably would be farther north. This is upon the supposition that the axis of the north anticline has been tilted from a dip of 70° S. to 85° S., which has occurred. But the axis of the south anticline would change its dip from 82° S. to 83° N., instead of 85° S., its present angle; and finally, the movement would not account for the changes in the character of the north anticline and the subsidiary folds south of it.

Again, owing to the downward convergence of the main anticlinal axes in division ii, a shearing of the north end upward

would bring these axes closer together after denudation to the present surface, whereas in this division they are farther apart than to the west. From the axis of the main syncline to that of the north anticline, the distances average nearly the same in both blocks. It is noticeable also that the distances between the two anticlinal axes in divisions iii and i are practically the same; and that the horizontal displacement of the south anticlinal axis at the west fault, added to the amount of flexing northward which it received south of the end of the middle fault, is equal to the total horizontal displacement of the north anticlinal axis by the latter fault.

Appeal must be made, then, to some other movement, influencing shearing, to account for the structure of this division. It seems clear that the force which produced the chief faulting of the district, first broke off as a single block all the rock between the west and east faults, shoving it north nearly fifty feet. In the western part of the block, resistance from the north compressed the folds to the extent of 37.5 feet. The eastern part of the block, not meeting with so much resistance, largely broke away from the western, along the line of the middle fault. This break began at the north end, and died out before it reached the axis of the southern anticline, because the rock of division ii took up the compression so that it was slightly felt so far south. There was, then, relatively no compression of this eastern portion, the block moving north as a whole. This explains the distance relations referred to above.

There was, however, a bulging upward of the northern half, due possibly to resistance on the north which was unable to compress the strata as in division ii. This bulge had its southern limit an undetermined but short distance north of the quarry on areas 73 and 74. Thence northward the dips steepened to the axis of the north anticline, which was tilted from 70° S. to 85° S. The north end of this bulge must have been a considerable distance beyond the field of the map, for the north anticline was not compressed to an appreciable degree. Moreover, the angle

between the average dip of the strata on the north and on the south sides of the axis is the same in divisions ii and iii. Thus there is little distortion of the anticline by differential movement.

East fault: course; aspect at east quarry.—The east fault runs N. 22° E. It is visible in the west end of the quarry on areas 76 and 77, nearly perpendicular, with a very slight inclination to the east. It is inconspicuous, as slate lies on both sides. The fracture is a narrow zone, occupied by soft gouge and bounded by well slickensided walls. The testimony of these slickensides is conflicting, because of the various directions in which solid masses in the gouge moved in different places, under the influence of the crushing and slipping strains. In the Comstock and Big South leads, the fault was met in earlier years underground.

East fault: displacements in southern part of field.—Beginning at the south end in division iii, the position of the axis of the south anticline is by continuation from a known point in the western part of the block. It probably is not dragged north by the east fault; for the south anticline is evidently pitching east in the eastern part of division iii, as shown by the converging dips on both sides of the axis, and the curve of the Comstock lead is sufficiently explained by this. East of the fault the axis has been displaced 192.5 feet north. Its position is closely defined by a lead lately uncovered, west of the large abandoned crusher; and one somewhat similarly situated south of the axis. Their convergence indicates the continued eastward plunge of the fold. The offset of this axis is 185 feet left, and its overlap 62.5 feet negative. This is the largest displacement in the district, and northward the distances become steadily less.

The position of the main synclinal axis is indicated very closely, the nearest exposures of opposite dip being only a few feet apart. North of the large quarry only two exposures of any kind are visible, till the North Sutherland is reached.

These both show low dips. The displacements of the north anticlinal and synclinal axes are plotted as intermediate between 192.5 feet on the south, and 110 on the north, the amount being reckoned with reference to the observations farthest north and south. This gives for the anticlinal axis a horizontal displacement of 142.5 feet, an offset of 127.5 left, and an overlap of 57.5 feet negative.

East fault: explanation of movements, and present attitude of division iv.—The structure of division iv cannot be explained by either horizontal or vertical sliding, or by shearing, unaided; for the present relations of the parts, compared with similar ones west of the fault, are not such as should be found after any of these classes of movements. The Little North is in division iv farther from the axis than in the cross-section drawn for division iii. If the axis continues parallel to the leads eastward to the fault, since the dip of the axis has not changed, it may be fair to consider that the difference in distance has resulted from a vertical movement. This could be made by a rise of 52.5 feet on the east, in this part of the block. But if such were the case, the axis east of the break would now be south of that part to the west, because of its migration down the dip. It is probable, in view especially of the divergence of strikes between the north of the district and the remainder, in divisions iii and iv, that the north anticlinal axis takes an intermediate course, as plotted. On this basis, the north leads are so situated in division iv with reference to the axis, as not to require an upward motion to explain their position. The alternative is a northward horizontal sliding of the whole block to the extent of 129.5 feet, the offset of the fault at the north axis; and a compression of the north side of the fold to an extent of 29.5, measured at the Little North.

The changed attitude of the southern part of the field in this block, relative to the northern anticline, is such that only a bulging upward could account for it. The northern limit of this movement was at the center of that fold. The action did not

turn back the north anticline, else it would have steepened the leads to the north, and lowered the dip of the axis. But the leads on the whole are lower than to the west. The southern limit of the bulge is probably not far south of the district. An upthrust of which the south anticline were the center would leave the axial dip unchanged. If this fold were not the center, the dip would be made higher or lower according as the fold were south or north of the center. The axial change is 3° to a lower dip. Hence the southern limit of the bulge should be sought south of the axis of the south anticline somewhat farther than the distance of that axis to the axis of the north anticline, which is 425 feet. There must also have been a compression of the southern part of the block, accounting for the increased displacement at that end. The amount recorded is 85 feet horizontally. But the vertical upthrust of 260 to 270 feet, on an axis dipping 85° N., would cause the south anticlinal axis to migrate 50 feet south when eroded to the present level. Hence the total transverse compression here amounts to 135 feet, becoming less northward. To produce this result there must have been a strong resistance on the north.

Minor faults.—In the underground workings, minute faults are constantly being found. These are in every conceivable attitude, some in the stratification, some in the cleavage, but most with strikes transverse to both. They are identifiable by slight displacements of known horizons and by slickensides. They exercise a compensating rather than a cumulative effect, and thus do not alter the structure of any portion of the district to an appreciable extent. Certain effects of slipping along cleavage will be considered later.

Of the smaller faults shown on the map, none are important. All are nearly or quite transverse, none radiating from the noses of plunging anticlines, and none striking parallel with the sediments. Many follow joint planes. The one on areas 173 and 174 is one which does not displace the beds horizontally, but at which

they turn from their former strike ; and another on areas 126 and 175 is of the same kind. These were met in the old underground workings, and have not been visible during the progress of this study. On area 72 is a very local fault cutting the Jo. Taylor belt, and met in tunnelling in earlier years. On area 73, at the west end of the quarry, a fault with a horizontal displacement of scarcely four feet is visible. Here, as along most of the faults, the east side has gone north with reference to the west. On the south side of the quarry is a small break with a strike N. 73° E., and a dip 87° S. Slickensides show the south to have gone east horizontally. The whole is, like many others, too minute to plot on the map. It is the nearest to a strike fault of any in the district. At the northeast corner of the quarry a slight dislocation runs northwest. On area 75, at the west end of the quarry which occupies its center, slickensides show a slight perpendicular fault or series of parallel ones, running about northwest. The direction of motion cannot be made out. On area 177 a fault has cut off the leads which come from the west. The displacement is unknown, because no development work has been done immediately to the east ; but it must be small. A fault of some length, which appears to die out at both ends, runs through areas 77, 124 and 123. It does not influence the south anticlinal axis. It is visible at the east end of the quarry on area 77, as a perpendicular slickensided fissure. The displacements of the axes of the local fold are reckoned from the distribution of dips in the immediate vicinity. On area 123 the flat-lying lead is cut off by a break which must, however, be very local. On areas 24 and 77 is a fault which has a displacement of four feet at the south end, and hardly so much at the north, where the Cowan lead is visibly dislocated by it. There are probably many more faults, covered by the drift, which more extensive development may bring to light.

JOINTS.

It is a marked characteristic of the district, and apparently of the series throughout, to have many local joints but no great

systems. Perhaps the most abundant run about north and south magnetic, but they are not persistent for more than a few yards. For the most part they neither aid nor retard open or underground development. One of the best joint planes forms the face of the westward spur in the east side of the quarry on area 74 (pl. 8, fig. a). No veining or mineralization has been seen along most of these fractures, except a few cases of pyrite incrustations of a crystalline nature.

METAMORPHISM.

Dynamic character.—No intrusives are exposed in or near Moose River, the nearest granite—the Tangier massif—lying some miles south; and all the metamorphism in this field is of the dynamic type. In brief, it consists of the microscopic redistribution of material in both types of sediments, the alteration of shales into clay slates by cleavage, and of sandstones into quartzites, and later into arenaceous slates by cleavage; and finally, further local change of slates of both kinds into schists. These alterations are not uniformly distributed geographically, even in the same stratum. This may have a very direct bearing upon the interpretation of the highly metamorphosed rocks at the western end of the province.

Secondary minerals.—The cement of the quartzites is partly secondary silica, partly calcite, with a small amount of iron oxide in rocks taken from near the surface. The larger part appears to be calcite. It is probable, from the appearance of the slides, that all the cement, as it is at present, is secondary. Biotite and muscovite are abundant in some slides; and a part, perhaps most, of the mica is secondary. None of the quartz grains show a direct elongation in the direction of cleavage.

The clay slates do not normally show any of these minerals. On the other hand, chlorite is found to a much greater extent than in the quartzites. The color of the slates depends in part upon this, but yet more upon original conditions of deposition. The rocks have, abundantly distributed in the direction of cleav-

age, knots of some light colored mineral. This is either calcite, or quartz grains, or indeterminate masses looking like almost decomposed felspar.

Arsenopyrite is not found in slides of slate, to any extent, but is present in those cut from quartzites; and fails to show stretching. Pyrite is abundant in both rocks. Usually it is elongated with the cleavage; but in some cases the crystalline shape is unaltered, and in others it has a ramified margin and cellular interior, because of having crystallized in the massive form and adapted itself to its surroundings. This variety often encloses bits of biotite and chlorite. Most of the cellular nature, however, results from the presence of quartz grains.

Cleavage and schistosity.—All the sediments are heavily cleaved. The planes of fissility are parallel to the general strike of the rocks; and in highly inclined strata, or those in which original division planes are poorly marked, cleavage is readily mistaken for bedding. The quartzite is poorly cleaved as a rule; but near the surface, weathering has in many places brought out the incipient fissility so as to give a tolerably good sandstone slate. The pelite has taken the cleavage well; but no such perfection is reached as in roofing slate, for the necessary uniformity of texture is wanting. In places even the slates show little cleavage to the eye underground, but blasting brings out the greater weakness along these planes, and the circulation of shallow under-water has increased fissility near the surface to a high degree.

The cleavage is everywhere highly inclined, but often several degrees from vertical. In the quarry at the center of area 75, it strikes N. 80° W., and dips 79° to 80° S. On area 132, at the exposure from which the "fossils" were taken, the direction is N. 87° W., dip 52° S. At the west end of the quarry on area 131, where the Serpent lead was exposed in 1897, it lies N. 80° W., with a dip 67° S. North of the district half a mile to a mile, several observations show it to be nearly vertical.

Slickensides along cleavage planes are abundant, usually taking the form of a smooth deposit of chlorite. In some openings there is a distinct serration of the contact of horizontal or low-lying strata. Examination has shown it to be due in a few instances to crenulation of the laminæ, developed so far as to give strain-slip cleavage. But this is only in slate. Between slate and whin, as in the quarry on areas 73 and 74 (pl. 8, fig. a; and 11, fig. b), it is the result of slipping along ordinary cleavage planes which happen to be nearly or quite perpendicular to the stratification. In this quarry the quartzite does not show cleavage well, except at the east end. This applies especially to the stratum overlying the Jo. Taylor belt. In general through the zone occupied by the subsidiary anticline, the preponderance of pelite has allowed a good fissility to be developed.

In the quarry on areas 76 and 77, the same stratum appears in different places as a well cleaved slate and as a fine knotted schist. As a whole the cleavage in this district ignores the small crenulations of the slate. When, however, it comes down on top of a corrugation in a quartz vein encased in slate, it often curves, sometimes parting to one side and the other, because the slate yields readily while the quartz is brittle (pl. 8, fig. b, and 15). This curving was well shown in 1897 in the west end of the quarry on area 131, on a large scale.

In many specimens pyrite is seen lying in the cleavage planes, but quartz veins never. This pyrite is not crystalline or massive granular, however, but always stretched into a thin plate, or at least so far as much to distort the shape of the original crystal. This proves conclusively the later date of the cleavage than any of the sulphide concentrations. Indeed, cleavage and jointing were the last great dynamic changes in the sediments. Arsenopyrite has resisted stretching, for the most part.

In thin section the quartzites show little appearance of cleavage. The quartz grains not only are not elongated, but when

irregular in shape generally have their longer axes parallel with the stratification. This was noted in all the slides in which the latter was visible. The secondary minerals in these rocks do not appear to form distinct bands giving cleavage or schistosity; and altogether the quartzites are quite massive when viewed under the microscope.

But the slates are strongly cleaved, as well as slate laminæ in the whin. The fissility results chiefly from a rearrangement of the kaolin, so that it lies in the cleavage bands rather than in those of stratification. It is aided, but probably not formed, by secondary minerals. Those rocks which in the hand specimen appear most schistose, even the fine knotted schists mentioned above, have only a slightly larger amount of secondary material, the schistosity being due to a microscopical wavy cleavage that seems to be crenulated without much regard to the knots of quartz or other minerals. It is this crenulation which, in part at least, gives the lustrous and silky appearance to the schists. Pyrite never influences cleavage.

Glacial pressure affected that part of the cleavage lying near the surface in many places. The best example is along the trenches in areas 30 and 71. Here all the top of the rock is in places crushed into a mass of small cleavage plates, which were gradually worked into the glacial gravel by the onward motion of the ice. Where this breaking up was not so complete, an overturning of the cleavage from a south to a north dip has taken place, accompanied by a great increase in the fissility of the rock; due in part to the ice strain, and in part to a later water circulation.

RECENT WEATHERING.

The weathering of the sediments consists largely of changes in the sulphides. The pyrite and arsenopyrite alter, in some cases giving sulphates, and in others not. As a whole the rocks stain little by this process. In some places the angular cavities left by the crystals are quite abundant.

The fissility of both slates and quartzites becomes more marked, the cleavage laminae separating with increasing ease, the slates turning a paler color, and the quartzites whitening much from the grayish green so common in the unaltered condition. Where pyrite lies in abundance along stratification planes, its weathering aids in separating the strata and causing the appearing of open spaces between them.

PART II.—VEINS.

COMPOSITION.

Constituents.—The gangue in the veins of Moose River is chiefly quartz, with some calcite. Most of the leads have shown only quartz, and the cross veins appear to have no other gangue. The Little North has much calcite, and a few others have large amounts erratically distributed; but in no case does it form the main part of the lead. It is mixed with the quartz without apparent system, sometimes occupying the whole width of the vein, again next the country rock, often in the center; or in a few instances interbanded with quartz in distinct layers. It is surprising to find its cleavage planes often curved, giving a resemblance to a light colored siderite. Tests, however, have shown it to be calcite. The curving is gentle, but in a few cases quite sharp monoclinical folds half an inch high have been found. It is evident from a study of the adjacent rock that the curving is a result of dynamic action subsequent to the formation of the veins.

Arrangement of minerals.—The quartz is rarely cellular or drusy. A few druses show very distinct crystal faces on the walls. The cellular portions of the gangue are especially white, or are rusted by decomposition of a sulphide. Normally, however, the gangue is dark and ribbony, and uniformly dense. The gold is associated with this type, on the whole, more than with the other.

The leads never show a distinct comb structure. When druses occur at all, they are in the interior of masses which are,

as a whole, nearly or quite homogeneous; and quartz crystals appear never to have been found in layers, each with its longest axis perpendicular to the vein walls. The ribbony type referred to is the most abundant, and is best seen where, as often happens, thin laminæ of slate are included in the gangue, lying parallel to the mains walls.

The data relative to the ores will be considered under a separate head.

DISTRIBUTION.

Stratified leads.—The veins of Moose River belong to two groups, as regards their relation to the country rock—stratified, called “leads” throughout the province, and “cross” or unstratified veins. Connected with the former are the “angulars” (sometimes contracted to “anglers”). The distribution of the leads and angulars is erratic, the only system being their confinement within a zone represented by the width of the mining district north and south. This is because the whole field is a unit of slate, inclosed on either side by the overlying thick quartzite. There is whin within this zone, but it is not so abundant or important as in most districts in the series.

The nearest approach to a system is the scarcity of leads of any size on the subsidiary anticline, below the Jo. Taylor belt. Instead, the slate is full of minute stratified veinlets and seams of pyrite and arsenopyrite. These are present more or less throughout the whole thickness of rocks exposed in the district, but are especially characteristic of this part.

It was early thought that the veins were more numerous on the margins of the field, especially at the north, and decreased in abundance toward the center; but recent developments show that this apparent distribution was due in part to the chance order of opening.

Erratic veins.—The erratic veins belong to no particular series or age. They are unsystematically distributed, cut the bedded leads at all angles, and cross each other. It may be remarked here that in no case do veins which belong distinctly

to this class show signs of having been folded or disturbed to any extent since deposition.

ATTITUDE.

In a large way, the leads are chiefly parallel with the stratification of the country rock, thus partaking of all the structural peculiarities of the sediments. They are folded with the latter, and have been affected by faults as they have. This has caused it to be possible, in interpreting the structure of the region, to use these veins where the slate and quartzite were for the most part hidden.

Relation to belts of strata.—In position, the leads may lie in or between slate strata, or at the contact of slate and whin. While in most districts the latter situation is the more common, here it is not so. At many horizons there is no quartzite for a wall, yet leads occur in the slate in well-defined belts. This being the case, it is surprising to find the proportion of veins that break across from one bed to another small—fully as small as in other gold districts in the series. Where such irregularity does occur, it is always within narrow limits, as from the hanging to foot-wall sides, or vice versa, in a single horizon of slate backed up by whin. Where no quartzite is present, the distance of cross fracture is no greater. In the unstratified section of such vein, the wall is usually slightly more irregular than that of a bedded lead. Frequently only part of a lead has thus broken across, the rest continuing conformable with the sediments. Such bifurcations have not, in this district, been especially rich in gold.

Angulars.—Closely related to these is the class of veins called “angulars” or “anglers”. These are usually branches of the main stratified lead, cutting irregularly across all structures, and dying out at a greater or less distance from the parent mass. They occupy fissures in the form often of irregular rents, which are widest near the main vein and decrease in size away from it, and evidently originated from the stratified lead. The char-

acter of the gangue does not differ from that in the parent vein. In some instances, in a distinct belt there is no single lead that is strictly interstratified; and the whole belt is a series of intermeshing veins which run parallel to the strike of the country rock, but across the dip. Such are the Dreadnaught and Kaulback belts. In Moose River, angulars of this class have no great length on the strike, but in some other districts a belt of them occasionally reaches a length of 2000 feet. Where an angular of either type meets a main lead, pockets of ore are sometimes found. Spurs from the stratified leads never, so far as observed, break up vertically or across horizontally through several strata, but are virtually confined to a single belt, whether in slate alone or in slate between whin walls. They occur, however, indiscriminately on hanging and foot-wall sides of leads and belts.

The best example of a belt of angulars is the Kaulback belt, opened in 1901, and cut to the 170-foot level by August of that year. The leads here have the strike of the sediments—N. 85° E.—but there is no vein among those occupying the belt that is strictly conformable in dip for more than a few yards vertically.

Confinement to one side of a fold.—Although continuous along the strike, and generally in depth as far as worked, the leads of Moose River are, with two exceptions, not found on both sides of a fold. Local miners often express belief that a certain lead is the same as some other on the opposite side of an axis; but there is nothing to warrant this here except an occasional general similarity between the two. One of the exceptions is the case of the Great North (pl. 14) and the Serpent, which, when the west stope on areas 131 and 132 was open, could be seen turning from the north dip to the west and slightly to the south. Lack of exploration prevents knowledge as to how far it extends on the south. The second case is that of the Jo. Taylor belt, the hanging wall lead of which turns from a south to a north dip on the plunge in the quarry on area 71, and has also been excavated on the north dip at the east end of the quarry on areas 73 and 74. In the former, it is found only as

far north as the north side of the subsidiary syncline. In the latter, it extends to the north side of the subsidiary anticline, and appears to be pinching out at the north side of the quarry. None of the leads first worked, on the north dip of the north main anticline, have been found on the intermediate or south anticlines.

Crenulations: relation to stratification.—Two detailed features of the attitude of the veins are crinkling and “rolling” The former is very characteristic of this district, and is found in both stratified and cross veins. It consists in a corrugation of the whole width of the vein, coarse or fine according to the thickness of the latter, and in strict conformity with the bedding in the stratified ones. The lamination of the slates follows the crenulations of the lead, exactly when near it, less faithfully when farther away.

Crenulations: variation in size and shape.—The amplitude and interval of the curves vary greatly, apparently depending upon the size of the vein and the proportion of arenaceous material in the country rock adjacent. The west side of the quarry on area 76 shows this feature. Here, bounded only by slate, are very many stratified veinlets of quartz. In some there is a thinning of the vein from half an inch down to one-quarter or one-eighth of an inch in thickness. Accompanying this is a gradual and proportionate diminution in the size of the corrugations made by the veins. A few inches above and below, the slate laminæ are undisturbed; and all gradations are found between this state and that close to the quartz, in which the minutest crenulations of the latter are reproduced in the slate. Another case is shown in pl. 11, fig. a, in which the vein is half an inch thick on the south, decreasing to a mere film on the north, the crenulations becoming smaller also in that direction. A still better one was visible in 1901 at the 60-foot level of the Kaulback belt, in the north tunnel, where the strata dip 60° S. The vein in question is one of the belt of angulars, and at this point cuts across the bedding for a few feet, then turns upward

parallel to it. It dies out completely before reaching the surface. The laminæ of slate close to the lead curve with it, but the general stratification is unchanged (pl. 11, fig. c).

In shape, the crinkling varies from broad open folds to close and overturned ones. The latter, in inclined strata, are overturned uphill, as in pl. 13. The curves may or may not be rhythmic. When even in interval they usually are uniform in amplitude. When uneven in either way, there often is some system in their irregularity, a rhythmic change such as in pl. 11, figs. e, f, being common. In a larger way most of the leads show the same thing. Thus the Jo. Taylor, especially the foot-wall lead in the quarry on areas 73 and 74, is corrugated evenly and steadily for many feet across the strike. Those show it best, perhaps, that lie in belts bounded on one or both sides by whin. Here the veins are crenulated strongly, the size of the folds being still proportional to the breadth of quartz. The sharpness of curvature is inversely as the thickness of the veins. In these cases the slate is folded to a thickness depending upon the size of the vein and violence of its contortion, and the proximity of whin. Sympathetic folding of the country rock rarely extends more than two feet away from the lead, on either side. If whin bounds the belt within the distance to which this folding would tend to extend, the latter is arrested, never affecting the whin. When, as often happens, the lead lies along one wall of the belt, the adjacent whin prevents rolling of the strata on that side. It is never strictly true, however, that the vein lies next the wall. A thin band or rind of slate intervenes, and is frequently closely folded, slickensided and crushed by the intense strains to which it has been subjected. This is not especially well shown at Moose River, because whin walls are rare.

Crenulations: Kaulback belt of angulars.—A special case is found in that class of angulars which run parallel to the strike of the strata, but break across the dip. Some belts are composed entirely of a network of such veins, instead of having bedded leads. In these instances the belt as a whole follows the

stratification, while no one member of it does. In the best parts of the Kaulback belt, several veins run parallel to the bedding for a short distance, then oblique to the dip, then parallel again, and so on. The stringer described earlier as a thinning stratified vein, is part of this system (pl. 11, fig. c). Its upper edge stops 60 feet below the surface where cut in the north tunnel; and this terminus is lower and lower as one goes west, the line of limit having a plunge of 40° W. There are probably many such blind veins.

Six feet below the top of the drift in the level mentioned above, this vein cuts across the strata, and continues this relation from there down, receding from the axis of the anticline on the side of which the strata lie, more rapidly in depth than do the sediments. That is, the dip measured over a considerable section is less than that of the strata. With all its cross-cutting the vein retains its corrugation. On the whole the waves may be slightly larger where not parallel to the bedding. This may be due to the fact that in these portions the vein is considerably thicker than when conformable. In such places it breaks up into several stringers, which reunite later (pl. 12, figs. b, d). This occurs at the south tunnel in the 60-foot level, in a section in which bedding and cleavage are clearly shown. It is noticeable everywhere that veins do not as a rule break upward into overlying beds, but rather break upward into underlying strata, as in pl. 12, figs. a, c. The exceptions are angulars starting definitely upward from a bedded lead.

Crenulations: effects upon secondary structures.—Both joints and cleavage are turned out of their course by the sharp curving of resistant quartz veins, where the structures reach the crest of a fold. Joints are but broadly curved, cleavage sharply; and some of the planes of fissility are deflected past one side of the obstructing corrugation, some past the other, making a curved divergence of the fractures (pls. 8, fig. b, and 14, 15, 16).

Crenulations: cross veins.—Cross veins are in some cases corrugated, but not so frequently as the stratified leads. These curves have no relation to folds in the country rock, except in angulars parallel to the strike but not the dip of the sediments. They are more likely to be uneven in size and irregular in amplitude and interval; and rarely become progressively smaller with a thinning of the vein (pl. 11, fig. d). They are exposed particularly well in the new openings of the Kaulback belt, in the quarry on areas 73 and 74, and in that on areas 76 and 77.

Where the veins have a strike perpendicular or parallel to that of the cleavage, it might be expected that slipping along those planes, or the corrugation of the sediments close enough to give strain-slip cleavage, would account for the phenomenon. Instances of veins parallel with the strike of the cleavage (which is close to that of the strata except where folds plunge), but cutting the sediments in their dip, are confined to certain angulars. Those veins which run perpendicular to the strike of the cleavage must have two accompanying features, to be explicable by the method just mentioned. If they have slipped along ordinary cleavage planes, the strata enclosing them must also have slipped; but I have never found this to be the case, where such veins have been visible. Furthermore, where the strata are serrated, the serrations are small as compared with the corrugations in veins, and fairly uniform, with no irregularity comparable to that shown by the cross veins. If strain-slip cleavage caused the corrugations, we should find some sign of it also in the sediments, either cleavage or acute small-scale folding; but do not. The best cases in the veins occur where there are no corrugations in the strata, and where the major planes of division between the beds, which must be made uneven if slipping has taken place along any cleavage, are perfectly even in their dip. There is not the slightest deviation in the dip of the laminæ in proximity to the veins.

The more numerous instances of veins oblique to the strike of cleavage and stratification cannot be explained by any theory

of slipping or corrugation of the sediments; because either would produce structures diagonal to the vein, giving corrugations which would not be persistent in the vein for more than a few inches or feet, and which would appear to start on one side of the vein, pass through it obliquely, and come out on the opposite side at a distance along the strike of the vein. This has never been observed. The only explanation remaining, therefore, is that the cross veins lie in fissures which had their present sinuous course at the beginning of occupancy by the vein material. It is noticeable that this crenulation is not found in quartzite, unmixed with slate; but is confined to slate and alternations of the two. It is best developed where no quartzite is present. It appears, then, that in the thinly laminated pelites, at the time of intrusion of the cross veins, the rock broke under strain most easily across the strata squarely or diagonally in places, with the bedding in others, and in some backward or downward rather than upward.

Rolls.—In the stratified leads, most of the corrugations run horizontally or with a low dip. Where the anticlines plunge downward, however, these corrugations, instead of following the strike of the strata horizontally around the nose, take a course intermediate between the dip and strike of the rocks. Thus they may converge on the two sides of the nose of the fold and in the direction of its plunge, but not so sharply as the strike lines; and they dip, but not so steeply as the strata, nor in divergent directions like them. To such corrugations the term "roll" is applicable. It should be restricted to this phase, but is loosely used for large crenulations of any kind in leads. The true rolls are not well shown at Moose River, perhaps because of the scarcity of well-defined rock belts.

Pinching and swelling, so often mistaken for rolling, are not common at Moose River. Indeed, they are less abundant in this series as a whole than in other countries; and never due, as often there, to the sliding of one side of a sinuous vein upon the other, or to the chemical enlargement of the vein by solution of its walls.

Details of contacts.—It is chiefly in connection with corrugations that we often find the leads very laminated, the layers consisting of alternate bands of slate and quartz. Usually the layers of the latter are thick, of the former thin; but occasionally the reverse is true. The quartz in these laminæ is never cellular, and is generally dark and translucent. It is noticeable that the crenulation and rolling are accompanied by many fractures, upward from the crests and downward from the troughs; and that very rarely are these occupied by gangue, or by pyrite.

In close detail, the margins of the leads are seen not to follow the stratification, either in portions that are straight or in rolls. Some of these contacts are shown in photograph on pl. 14. Frequently in detail the vein breaks up into two or more stringers, or dies out and is replaced by another *en echelon*. In many specimens laminæ of slate are seen, wholly or partially detached, and thinning out rapidly to an edge. Several of these slivers may lie in close proximity in the lead. On the outside of the curve of rolls and other corrugations, the country rock gapes more or less, and into these fissures the vein material has penetrated; but this occurs also where the stratification is not curved.

In the slides all these features, and indeed several more, are shown in a very minute way, proving that in the finest detail the contacts have the same characters as on a larger scale.

RATIO OF VEIN MATERIAL TO SEDIMENTS.

In most fields and most parts of this field, isolated outcrops give a minimum amount of vein material in sight, across the strike of the folds. In the central belt here, in which the three trenches and large quarry were cut in or near 1899, continuous exposures give a maximum of quartz, under exceptionally favorable conditions for the formation of veins. In this zone, south of the north anticlinal axis, I have counted and measured 70 leads, in a distance of 750 feet, aggregating 300 inches in breadth of vein material. This gives 1 to 30 in cross-section—an extremely small amount. Yet this is higher than any

estimate I have been able to make elsewhere, and it is probably fair to consider it as near a maximum for any considerable breadth of rock. It is perhaps exceeded by two or three cases near the Isaac's Harbour district.

It is interesting to note, also, that in a portion where slate appears at first sight to be the only sediment, a large amount of arenaceous material is present. In the north trench it amounts to 33%, in the second trench to about 45%, and in the quarry on areas 71 and 72, where the slate is unusually abundant and clear, to 15%, in cross-section.

PART III. METALLIC CONTENTS OF THE ROCKS.

PYRITE

Relation to stratification planes.—Pyrite is the most important sulphide, and the most abundant. In connection with it and the arsenopyrite much of the gold occurs, in large part intimately associated. The pyrite is here chiefly in small cubes and granules, rarely in clusters of crystals or large granular masses. In the veins, however, granular accumulations are not uncommon. Reference has already been made to the presence of pyrite along the major planes of division of the strata. This is its most characteristic attitude in slates, or between slate and whin, even when much folded. These major planes of separation mark the greater changes in conditions of sedimentation, resulting in greater textural alternations; and the contiguous strata have comparatively little cohesion. Hence, with the rusting of the pyrites, fracture is easy along them. The minor planes divide strata of greater similarity and cohesion. Within quartzite, or between adjacent beds of it, the distribution of the mineral is irregular for the most part, and the crystals lie in all attitudes. Occasionally they occupy stratification planes in the whin; but rarely, for the rock is dense and homogeneous.

In the slate, the sulphide lies irregularly in the stratum, or more often is found along minor or major planes of separation.

It is most abundant in the last named situation, belonging very evidently to the upper of the two layers, and becoming gradually less abundant upward. Often at the top and immediately below the division plane, crystals are entirely absent. This is well shown in the quarry on areas 73 and 74, especially along the south side. In the small quarry on area 75, some of the strata have the greatest accumulation of pyrite along a medial plane, decreasing upward and somewhat less downward, with still a layer between the beds. The grouping of pyrite along the stratification planes is so constant in the slate, that in many other parts of the country, where layers are too similar to give the usual criteria of color and texture, and where bedding is obscured by strong cleavage, it has been possible to use planes of pyrite crystals with complete success in interpreting structure.

Attitude in leads and cross veins.—In the veins the mineral is abundant but often erratic in distribution, in places protruding into the quartz from the sediments. Within the vein it is irregular, and never occupies a definite central position. Its most important place, and commonest, is on the margins of the veins in sheets. While these are found on both sides, they are much more abundant on the hanging walls. This is brought out well in the zone of oxidation, by the rusting of the iron; below it is as real, but less apparent. The hanging wall lead of the Jo. Taylor belt, on areas 73 and 74, shows this. The rule does not hold in the irregular cross veins.

ARSENOPYRITE.

This occurs sparingly in the slate, abundantly in the whin, and in the veins is erratic in distribution but present in spots in considerable quantities. In the two first mentioned it is crystallized; in the last, massive except in a few instances. Very rarely a short vein is found composed entirely of a mixture of pyrite and arsenopyrite, but in Moose River these are of small size. In the sediments it is so rare in the slates as to be unimportant. Where present it is either in the stratum, or in a few

instances along the margin. In numerous cases a crystal has been seen lying directly across the plane of separation, partly in the upper and partly in the lower layer. In the quartzite its distribution is without system. The mineral is here always crystalline; and its striated prisms, up to half an inch in length, lie at all angles to the stratification planes, usually without arrangement. In a few places the crystals line the parting planes sparingly, but in general their position has no reference to them. In one or two cases the longest axis of the crystal crosses one of the major planes of division.

The distribution of arsenopyrite appears to have no relation to the proximity of veins, except in a few instances. The vicinity of the Britannia belt is thickly studded with coarse crystals, largely within the belt, and to a decreasing extent outward from it on either side. The veins themselves contain pyrite and arsenopyrite in massive and granular lumps, and the latter mineral somewhat crystallized locally. The gold in this belt is very pockety; and appears to have no present relation to the proximity of the sulphides, which by assay are shown to contain almost none of the metal. The habit of this belt is so peculiar as to give local miners the idea that it could be identified to the east, with one or more faults intervening. Thus in the south entrance to the quarry on area 73, the large lead in the south of the trench was thought by some to be the main Britannia, partly from expectation, partly because of the large amount of arsenopyrite near it. In this case, however, the lead itself contains none, and practically none is found on the south; while to the north the mineral extends throughout the length of the trench. At the east end of the district the Cowan lead has been called the Britannia, because of the accumulations of crystalline arsenopyrite. There is no probability that either of these represents the real Britannia.

The unsystematic arrangement, difference in crystallization in veins and country rock, and apparent lack of connection with the pyrite for the most part, are the most important character-

istics of this sulphide. It has already been mentioned that this mineral is never distorted by cleavage, while pyrite often is. Also, the former never occurs on cleavage and slickenside planes, while the latter frequently does.

MINOR SULPHIDES.

Pyrrhotite has been found very sparingly in the slate, but there is too little of it to assign it a definite distribution. Galena occurs in the bedded leads, and has been reported from slate in immediate proximity in two cases. It is uncommon. Where present it occupies the interior of the lead, in both quartz and calcite, and is never more than an eighth of an inch broad in single masses. It does not appear to influence the distribution of gold. Chalcopyrite has been found in irregular masses in both veins and sediments. In the latter, in several instances it has been stretched along the cleavage planes into thin plates, or else was deposited originally in that attitude. The former is more probable, in view of the polished surfaces of these thin sheets. I have never seen it in joint or fault planes.

GOLD.

In sediments.—Gold occurs in both sediments and veins. In the former it is held most in the slates, and often as much is found at a distance from the veins as near them; but it is not uniform in distribution, as shown by a large number of assays made in 1899. The quartzite is not barren as a whole, however, although it carries on the average much less than the slate. A sufficient number of tests has never been made to prove any distinct relation between the run of gold in the whin and the proximity of leads. All the assays for this district were taken within the general slate zone. It has not yet been determined that the great mass of whin to the north carries any gold. In the sediments as a whole, little of the metal is free. Almost all is locked up in sulphides, even near the surface.

In veins: special enrichment.—In the veins, however, a large proportion is free within the zone of oxidation, and a small

amount below it, the percentage decreasing for some depth. In the free state it takes the form of filaments or wires, leaves and nuggety masses, small or large, and may be so fine as to be entirely invisible. In some cases the free gold is accompanied by sulphides, in others not. The larger masses are found usually, but not always, in "pockets" or local spots of enrichment. These are in some veins situated at or near the junction of angulars, particularly from the hanging wall, and the bedded leads. In other cases the metal is closely related to the presence of rolls, lying most often in the swell on the hanging wall. A considerable extent, either a whole vein or parts of several, may be characterized by the presence of these enriched spots, the spaces between being wholly or comparatively barren. In this district such accumulations are too discontinuous to form pay streaks, and distinct ore chutes are not so common here as on the more perfect domes. Wherever they do exist, they follow the dip of rolls. The Copper lead has one, with a very low west dip, in division ii. The Little North has two, perhaps three, with the same dip. These leads plunge west, and their rolls dip west, the ore chimneys following these closely. The Big North has one streak, on the west plunge, which was followed west to the west fault and lost.

Relations to vein walls.—In some belts the gold is so finely disseminated as to be invisible. Such concentrations as can be seen, yet not sufficiently high to call pockets, are often found in sheets of irregular thickness, lining the vein wall and projecting thence into the gangue. Rarely they tongue into the country rock. More often the sheets are smooth on that side, their irregularity being entirely toward the gangue. Where the gold lines the sides of rolls, it usually is bounded outwardly by a rusted zone when near the surface. From this lining wiry stringers, irregular masses and leaves project into the vein, often along distinct fractures.

Britannia and Kaulback belts.—These are two of the most instructive belts for the study of visible gold. In the former,

the only large accumulations were a series of pockets on a roll in the main vein. Here the metal occurred chiefly close to the hanging wall, running thence into the quartz. In this it lay as interlacing stringers, leafy expansions, and knotty bunches. Leaves were rare. In places the quartz was so intersected by wires that it could not readily be separated from the gold without fine crushing.

The Kaulback belt is composed entirely of angulars; but these are in the main parallel to the strike of the sediments, and are interstratified in parts. Evidently their origin is the same as the bedded leads. As a belt they follow the sediments; as individuals they do this only occasionally. In these veins the gold is more often on the margin than elsewhere, but in some places is abundant in the center. Certain characteristic appearances are reproduced in pl. 17, figs. c, d, e, f, g. Figs. c and d are typical of many cases, the gold lining the side of the vein, extremely smooth toward the country rock, rarely standing out into the slate, but serrated irregularly by projections on the vein side. These projections are usually small stringers, but occasionally too thick and obtuse to bear that name. The main part of the leaf is so thin that it can readily be peeled off from the quartz. These two figures are from a small mammillary bulge on the side of the vein. Such bulges are abundant. A little pyrite and arsenopyrite were in the quartz, but the gold appeared to bear no definite relation to them. In some instances, as in fig. g, the gold leaves the vein margin entirely, and runs some distance into the slate.

The gold of this belt is often closely associated with a steel colored mineral, which may be slightly altered arsenopyrite but does not have all of its superficial characters. The surface of the gold leaves is pitted with it, and it usually has a vesicular character itself. Inability to take away any of the specimens in which it was seen has made positive identification impossible. Both pyrite and arsenopyrite are abundant in the veins of this belt, in crystalline as well as massive form. This applies par-

ticularly to the latter mineral. Where bunches of these sulphides lie within the quartz, the gold sometimes occupies the margins and strings into the interior, sometimes is in leaves in the interior. In this case it always has connection with the margin. It is never seen against the side of a crystal of either sulphide. Both pyrite and arsenopyrite have drusy cavities when massive, but these are unoccupied, and give no evidence of having ever been filled.

PART IV.—SUMMARY OF GEOLOGICAL HISTORY.

The theoretical problems regarding structure of the rocks, origin of the veins and the ores, metamorphism, and other phenomena of the Meguma series as a whole, are being considered in separate papers, and will not be touched upon here. Certain events, such as the intrusion of the granites, have left no effect in this district, and their study must of necessity be pursued elsewhere. All that is intended in these paragraphs is an outline statement, without elaboration or defence, of certain important events in the history of the series, evidence for which can be obtained in Moose River.

The sediments were deposited in comparatively shallow water, in which currents distributed the detritus irregularly, giving a marked discontinuity of strata. In this way, here and there over the sea bottom and at different times, larger amounts of pelite were formed; either alternating with sands regularly, or more rarely having little sand dropped with the mud. Moose River represents the latter type of what elsewhere in this series of papers is called a "horizon of more abundant slate." Between these, geographically and stratigraphically, little but sand of various textures was laid down. Thus such a dome as Moose River has very definite limits, not only north and south by the overlying whin, but east and west; and its veins cannot be expected to extend indefinitely in any direction, nor to reappear on any other dome. The slate and vein-bearing horizons are also definitely limited in depth as well as in extent.

The accumulation was on a sinking sea bottom, in a syncline of deposition. The sediments at Moose River were among the first of which we have knowledge, but evidently not actually lowest in the series. The water may have contained lowly organized life in some form, as shown by the slight amounts of graphitic material in the rocks.

With the great accumulation of strata came gradual lithification, from pressure of overlying rocks and rise of the isogeothermal planes induced by the continual blanketing. It allowed considerable secondary alteration of the shales and sandstones, through increase in the solvency of the water of sedimentation, and showing itself especially in the deposition of secondary minerals.

Increased lateral pressure of necessity accompanied increased sinking of the sea bottom. There ensued more chemical action, and the beginning of the east and west folding. Simultaneously came the earliest deposition of vein material, along planes of weakness, which were stratification planes. At last the folds became marked in height, and greatest where plastic shale strata were abundant; and in the interstices between layers, and occasional radial gashes upward from the folds, the veins and ore had been gradually deposited, the latter in part remaining in the adjacent country rock.

Later, the greater rigidity of the rocks under pressure allowed jointing and faulting. Pressure kept the fracture planes tightly closed for the most part. Cleavage had been begun earlier, in an incipient way; but it had not developed into a mechanical fissility until all the vein concentration had ceased.

Denudation had been active on overlying beds, and finally reached the horizon of Moose River. Evidence elsewhere shows that by far the larger part of the denudation, which was the last great event in the history, took place before the close of lower Carboniferous times.

APPENDIX. DETAILED DESCRIPTION OF LEADS.

In the following description of the gold-bearing leads, the data are given by divisions, as in the discussion of folds above. The statements are not intended to be complete; for, in a district mined in so desultory and fragmentary a manner as this has been, it is impossible to get reliable data in sufficient quantity regarding leads long idle. No mention of value is given; and, indeed, all statements of a pecuniary nature have been rigidly excluded from the paper. The information has been gained from every available source that is reliable—personal observation, Mr. Faribault's excellent map, and miners who have worked the leads in question in former years. The use of pl. 2 will be necessary throughout the description.

Division i.—This territory is much less opened up than that to the east. The Alex. Taylor lead is three inches thick where seen. At the north end of area 67 are two leads on the surface, which have never been opened; the northern five, the southern two inches wide. The Britannia is a belt of two leads, with a foot-wall of whin and no distinct hanging wall. The larger of these veins is six inches wide west of the river, and very white, and five inches thick in the main opening. The smaller lead averages four inches. Both roll heavily.

The Kaulback belt consists chiefly of two veins at the surface, two feet apart and stratified. At a depth of twelve to fifteen feet they break gently southward across the bedding, diverging somewhat, so that at 170 feet down on the slope they are five to six feet apart. They also turn slightly northwestward across the strike of the country rock. At various points they break up into stringers, sometimes reuniting again. South from the more southerly of the two leads 23 feet, at the 170-foot level, is a six-inch bedded lead, rolling strongly.

The vertical lead under the south corner of the Touquoy crusher is very uneven in thickness, running from a few inches up to nearly two and a half feet. Southeast of it, on the west

side of area 33, is a four-inch lead. Farther south a lead of three inches has a shaft over it, and within a few feet comes the South lead, of two inches.

There is little doubt but that many times this number of leads outcrop on the surface of the bedrock. All the trenches in this and other divisions, tend to emphasize this probability. On the west side of area 69 a cut 55.3 feet long was opened in 1899, in a search for the Britannia belt. It has since caved in. The first five feet from the south end is in slate, with a steep but undeterminable south dip. From five to twelve feet the rock is occupied by a belt of angulars. At the latter station is a two-inch lead. At 21.5 feet and 23.5 feet is a belt occupied by two very small leads; at 39 feet is the north side of a whin belt, and three feet farther is a narrow lead. At 52 feet is a lead of three to four inches thickness, and at 55 feet a small vein heavily corrugated. The Kaulback belt of angulars has already been described. It is difficult to estimate the thickness of quartz represented, on account of the many bifurcations of the veins. On area 32, in a drain which begins at the north end of the area, a number of leads were visible in 1899 after cleaning the excavation, and more were seen in earlier years. South from the north end 54 and 56 feet, the first leads are two which are thought to be the Moleskin belt, from similiarity in the appearance and relations of the quartz. No. 1 is one-fourth inch, and No. 2 is two inches thick. The third lead is 78 feet from the north end, six inches broad; the fourth 83 feet, 8.5 inches broad; the fifth 87 feet, four inches across; the sixth 90 feet south, two inches thick; and the seventh is 9 feet south of the area line, and 1.5 to 2 inches thick. They all have steep north dips.

Division ii: north anticline.—Beginning at the north of this division is No. 7, six to eight and sometimes ten inches thick, rolling heavily westward. The rock is largely quartzite to the Copper (pl. 13), which has two leads, three and four inches on the average. A slate belt of several feet was available also.

for crushing. There are said to be three leads between the Copper and No. 7; but I have never seen them, as they were met only in an old cross-cut, long since abandoned. Somewhat more slate is found in the country rock to the Little North. This again is really a belt of two leads, with two feet between them, in which some whin occurs with the slate. Altogether there are about four inches of quartz, rolling west at a very low dip. Some little whin is to be found between the Little North and Big North; but the rock is chiefly slate, with many veinlets of quartz interstratified. The Big North (pl. 14) is in a belt, with a whin hanging wall. The main lead lies on this wall, and averages four inches thick; is very curly, and has west-dipping rolls. The Serpent is perhaps the most irregular lead in the district, in places as low as two inches or somewhat less, in others as high as eighteen. It is extremely well corrugated, but unevenly, the thickest parts giving the largest and roundest curves (pls. 15, 16). It is remarkable for the clearness with which the relation between the crenulation, cleavage and jointing are shown in the sediments. This lead, better than any other, brings out the manner of breaking of the vein parallel with the laminæ of the slate.

Division ii: comparison with "West Mine."—It may be well to turn aside here, although not in the geographical order of treatment, to describe the leads at West Mine; for they are stated by their prospectors to be equivalent, in part at least to leads just described in the main settlement. At the head of the north trench (pl. 1, fig. b) is a four-inch lead. In the fourteen-foot belt a few feet south of it is a ten-inch vein on the foot-wall, and many stringers north of it through the slate to the limit of the belt. This is thought to be No. 7. The lead in the east-west trench, with a steep rolling north dip, is regarded as the Copper. The shaft south of this cut is over the Little North belt, eight feet wide with three leads—one on each wall and one in the belt. Southeast of this shaft is the vein thought to be the Big North. Here is a six-foot belt with a

three-inch lead on the foot-wall, and a small one on the hanging wall. Both roll heavily, as do also the rather rough walls, the foot-wall rolling ten inches deep.

Comparing these, lead for lead, with those described from farther east, we have little ground for belief in their identity. The northern ones have about the right intervals between each other, and are at equivalent distances from the probable position of the anticlinal axis. But the distance from the Little North to the Big North is far out of proportion. There is also a dissimilarity of belts, most marked in the two just mentioned. Altogether, I see no ground for classing them as identical with the eastern veins. The distance between the localities is greater than these leads are ever carried by direct observation. More than this, no lead or group of leads has ever been proved to descend the nose of a plunging fold and rise to the surface farther along the strike; and the most plausible theories of the origin of such veins render it improbable that they would do this. Finally, the rocks at West Mine are pitching west, as in the main district; and no proof has been found as yet, of an eastward plunge between the two places. Unless one exists, the former strata are structurally higher than the latter, and not their equivalents.

Division ii: subsidiary anticline.—Returning to division ii once more, no leads are found south of the Serpent and north of the Bruce belt, except a few filaments at the center of the anticline in the quarry on area 131, most of which do not outcrop at the surface. The Archibald vein I have no personal knowledge about, as its openings have been full of water for a number of years. The Bruce belt consists of several thin leads, occupying about a foot in width. In the quarry, no leads are met north of the Jo. Taylor belt (pl. 18) which was in early years tunnelled under the western two-thirds of the quarry. The belt is seven to eight feet thick, overlain by four feet of whin, and contains six leads. The hanging wall lead is exposed here better than farther east, the foot-wall one not so well. The corrugations of

the hanging wall lead are chiefly on the east plunge, and are continued east of the fault. The foot-wall lead is not crenulated here so much as in the quarry on areas 73 and 74. The total breadth of quartz in the belt is eight to ten inches.

Above the whin stratum mentioned lies the Ferguson, three inches thick, dipping 60° S. From this a shallow trench was cut in 1899 in the south entrance to the quarry, to expose any leads present. Five feet south of the Ferguson it brought to light a strongly corrugated lead, one and one-half inches thick, pinching perceptibly eastward. Six and a half feet from the first lead is another, one-quarter inch thick. At seven and one-half feet lies a half-inch vein, which may be an angular; at nine and one-half a one-inch corrugated lead; at ten and one-half a three-inch one; and at eleven a lead one and one-quarter inches thick, with some stringers on its hanging wall. The last four are all rolled closely together and in sympathy. At sixteen feet is a one-inch lead which rolls so heavily as to reverse its normal south dip in places. At 21 feet lies a quarter-inch lead, and at 25.5 feet a three-quarter-inch one. At 32 feet from the Ferguson is a large lead, six to twelve inches thick, with a strike N. 87° W. and a surface dip of 63° S., becoming somewhat less downward; and claimed by some to be the Britannia. It is very white, and lies in black graphitic slate; but has little or none of the arsenopyrite characteristic of that lead farther west. The slate for 30 feet north, however, has much of it in crystalline form. On the southeast side of this entrance to the quarry are several thin leads. East of the trench, on the excavated bank, is a narrow one, striking N. 87° W. and dipping 60° S. Probably it is identical with the one in the trench next south of the proposed Britannia.

Division ii: south anticline.—Three leads lie immediately south of the synclinal axis. In a hole at the north end of area 31 is the Bigelow, sometimes called the Big White, sixteen to 24 inches thick; and two and a half feet south of it a nine-inch lead, both very dense and white. Their attitude is nearly or

quite perpendicular. The Smith belt contains two leads, and an angular on the foot-wall of the northernmost, in the shaft. This is the belt which, when worked east, was found to curve around the south end of the middle fault. A few feet south lies the South Flat lead, five inches thick, parallel with the Smith. It has been exposed for several yards in a shallow cut, and curves on the strike, parallel to the former. Its eastern exposure, where it was possible to get the dip accurately in 1899, is really in division iii.

Division iii: north anticline.—On the east side of this fault block, a few feet north of the Copper, is a four-inch lead which does not, however, appear to be equivalent to No. 7. The Copper still has two leads, giving a foot of crushing material, including the slate which bounds it. The Little North has two feet of crushing material in the west, and one foot in the eastern half of the block. The Little South is a thin curly lead, with soft slate adjacent to it, giving a foot of good crushing rock. The Big North does not roll so much as at the west plunge, and averages about eight inches in thickness. At the east end of the block it is called the North Sutherland, although there is no reason to regard it as a different lead. It thins somewhat to the east, being only five inches across, east of the road. On area 28 is a one-inch lead.

Division iii: subsidiary anticline.—Between this lead and the large quarry, no veins are exposed. Here the hanging wall lead of the Jo. Taylor belt comes up steeply from the south on the south side; and on the east end where it plunges, it runs under the whin cap shown in pl. 8, fig. a. There it was gouged out for nearly 200 feet east, with a small part of the belt under it, leaving the rest of the belt and the whin cap. The foot-wall lead forms the floor of the quarry over about two-thirds of its width northward, thence sinking steeply southward on the south side and gently northward on the north. It does not sag in the syncline so much as the hanging wall lead. It is strikingly corrugated, in waves of four inches amplitude and less. The

belt contains only five leads in this quarry, and the overlying whin has thickened to nearly eight feet. The hanging wall lead dips 40° N. on the north side of the quarry, and is thinning out fast to a stringy film of quartz. Outside the whin cap on the south the Ferguson is found, two inches thick where seen.

Division iii: south anticline.—The Dreadnaught is a four-inch lead on the west, twelve inches wide eastward, breaking up more or less into angulars, and enclosed by slate. The Dry belt, sometimes called the Tripe belt, is a slate band seven to eight feet wide, with about a foot of angulars. The Moleskin is a belt of two leads, three and four inches thick, with a whin hanging wall. The Comstock, where opened on the east side of the block, is five to seven inches. South of it is a four-inch lead.

Division iii: three trenches.—Three surface cuts have been made in this block (pls. 7, 18). The attitude of the beds in them has been stated in the earlier part of this paper. In trench No. 1 (pl. 7, fig. a) only the Jo. Taylor belt is exposed. A portion of the foot-wall lead is figured in pl. 9, fig. c, to show the character of its irregularity in the western part of the division. This lead pitches east 10° , the hanging wall lead 5° . The latter is very dark and ribbony; the former is white and cellular, with much iron rust. It is here two inches thick. Immediately south of the whin overlying this belt, the Ferguson comes up at the end of the trench, very much crenulated, and averaging one and one-half to two inches thick.

In trench No. 2 (pl. 7, fig. b) the first lead lies 32 feet south of the north end, and is one inch thick, lying in a three-foot belt of slate with a dip 72° N. Lead No. 2 is at 56 feet, two inches thick, dipping 80° N. No. 3 is at 75 feet. It is a belt of two, the north one two and one-half inches, the other a zone of veinlets; the two sets being six inches apart. It is probably the Dry belt. Whin lies on the hanging wall. No. 4 is at 79 feet, one-fourth inch thick, with a high north dip. No. 5 is a belt of three, the north one 84 feet 4 inches south, the middle

85 feet, and the south one 86 feet 3 inches. The first has a thickness of one-half inch, the second one-half to one, and the third one inch. They dip 50° N. No. 6 is the Moleskin belt. It is composed of two leads, the higher 90 feet from the north end of the trench, one-half inch thick, with a hanging wall of whin; the lower, two feet farther south, one-fourth inch thick. They dip 70° N. No. 7 is a perpendicular lead, at 96 feet, one-half to one inch thick. No. 8 is at 99 feet, a three-quarter-inch lead. No. 9 is at 100 feet, one inch thick, and appearing in places to be two leads very closely associated. No. 10 is 147 feet south, a quarter-inch curly lead, already referred to as having a double dip, lying as it does exactly on the anticlinal axis. No. 11 is at 166 feet, a large white lead, twelve to fifteen inches thick, dipping 50° S. South of the trench is the S. O. B. lead, five inches thick.

Trench No. 3 (pl. 7, fig. d), on areas 31 and 970 (block 4), was cut to overlap No. 2. South of its south end 37 feet are two two-inch leads. North from its south end 21 feet is the Hen Miller lead, six inches; at 85 feet is the Root Hog belt, with leads one, two, four and six inches thick. At 110 feet is a large lead of twelve to fifteen inches; at 131 feet a belt of two leads, three and two inches. At 154 feet is an eight-foot belt, giving leads of one, six, one, and four inches. At 172 feet is the S. O. B., six inches; and at 202 feet a large angular. At 215 feet is an eight- to ten-foot belt of slate, with leads of six and two inches. Beyond the trench, in the drain, is a three-inch lead, the South Flat; and beyond this the Smith belt, a three-inch and a two-inch lead.

Division iv.—In this division the Copper and No. 7 have never been prospected for. The Little North is here more like its condition on the west side of division iii, giving two feet of good crushing. The North Sutherland (Big North) is five inches thick on the average. South of this, owing to the structure, there are no leads which have been found to the west; and since many of the workings have been in disuse for years, or have

been poorly made, I have not data for all. The Flat lead, area 124, is three inches thick. The more northerly of the two in the center of area 77, east of the fault, is two inches thick. The Big South (wrongly called Comstock by some) is a foot thick. Two leads, six and one inch respectively, lie a few feet south of its east end. The Miller lead is three inches across. The Cowan is an erratic vein, probably not strictly in the stratification of the sediments. It varies much in thickness, running up to two feet in swells. A six-inch vein lies so close as to be included practically in the same belt. The former has a south dip, but in places appears to dip north, owing to its large corrugations. It and its belt contain much striated arsenopyrite like that in the Britannia belt, and miners have considered them equivalent; but there is no possibility that they are.

DESCRIPTION OF PLATES.

Plate 1. *Fig. a.*—Outline map of the Moose River gold district; to show general geography, location of blocks, axes of main folds, and situation of detailed map (pl. 2). Adapted from Geol. Surv. Can., doc. 624.

Fig. b.—Detailed map of "West Mine," showing the natural outcrops and artificial exposures, and the position of the anticlinal axis.

Plate 2. Detailed map of the main part of Moose River gold district; showing positions of shafts, quarries, leads, exposures of country rock, and anticlinal axes, with the attitudes of determinable strata and veins. Scale 1 : 2100, 1 inch to 175 feet.

Plate 3. Detailed cross section of division i.

Plate 4. Cross section of division ii.

Plate 5. Cross section of division iii.

Plate 6. Cross section of division iv.

Plate 7. Detailed sections from trenches and quarry on areas 30, 31, 70, 71 Block 1, and 97 Block 4. *Fig. a.*, trench 1; *fig. b.*, trench 2; *fig. c.*, quarry; *fig. d.*, trench 3.

Plate 8. *Fig. a.*—View in quarry on areas 73, 74; looking east, showing synclinal sag on the subsidiary anticline. Above the opening is the hanging wall whin overlying the Jo. Taylor belt. The opening was made in excavating the hanging wall lead, and below this lies the slate holding the other veins of that group. The foot-wall lead forms the floor of the quarry. The face is a joint plane. The cleavage, and the serration made by its intersection with stratification, are also shown.

Fig. b.—Crenulated lead; showing curving of cleavage around the arch, and inward toward the center of a trough. The white spots in the country rock are crystals of arsenopyrite. About natural size.

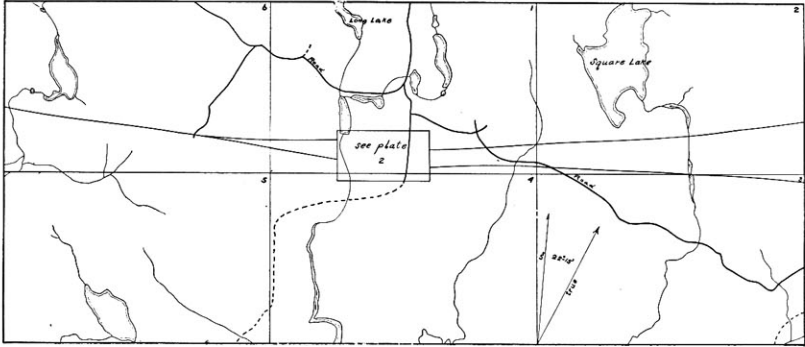


Fig. a.

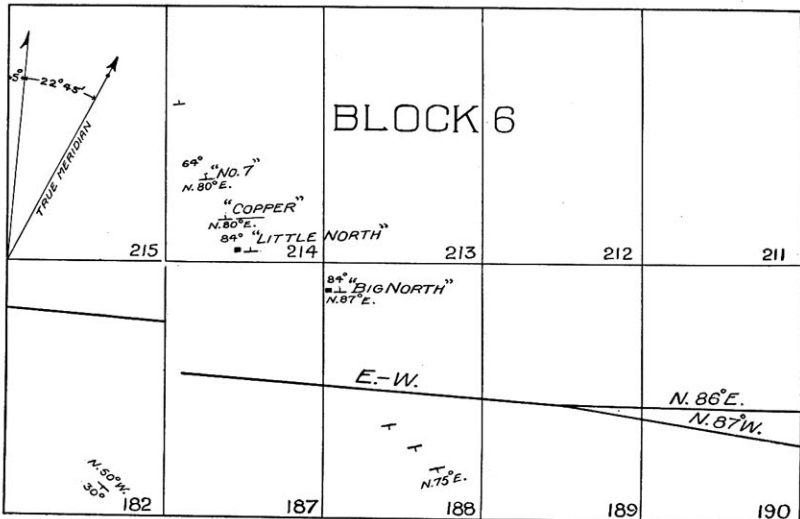
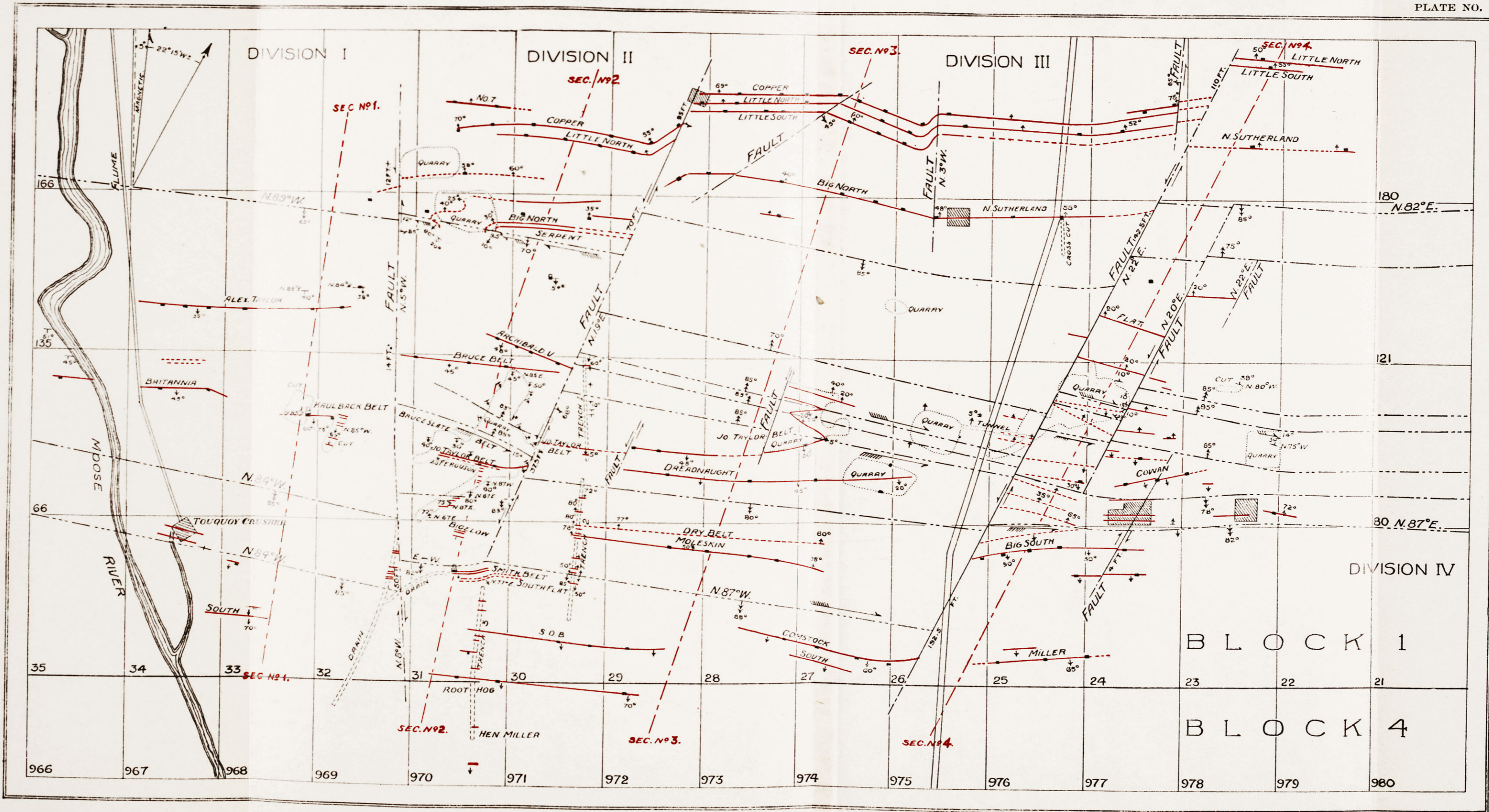
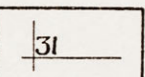
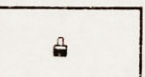
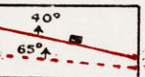
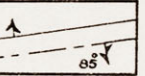
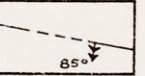
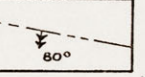
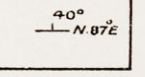
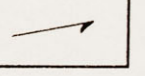
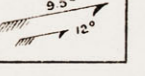
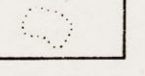
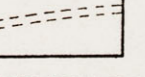
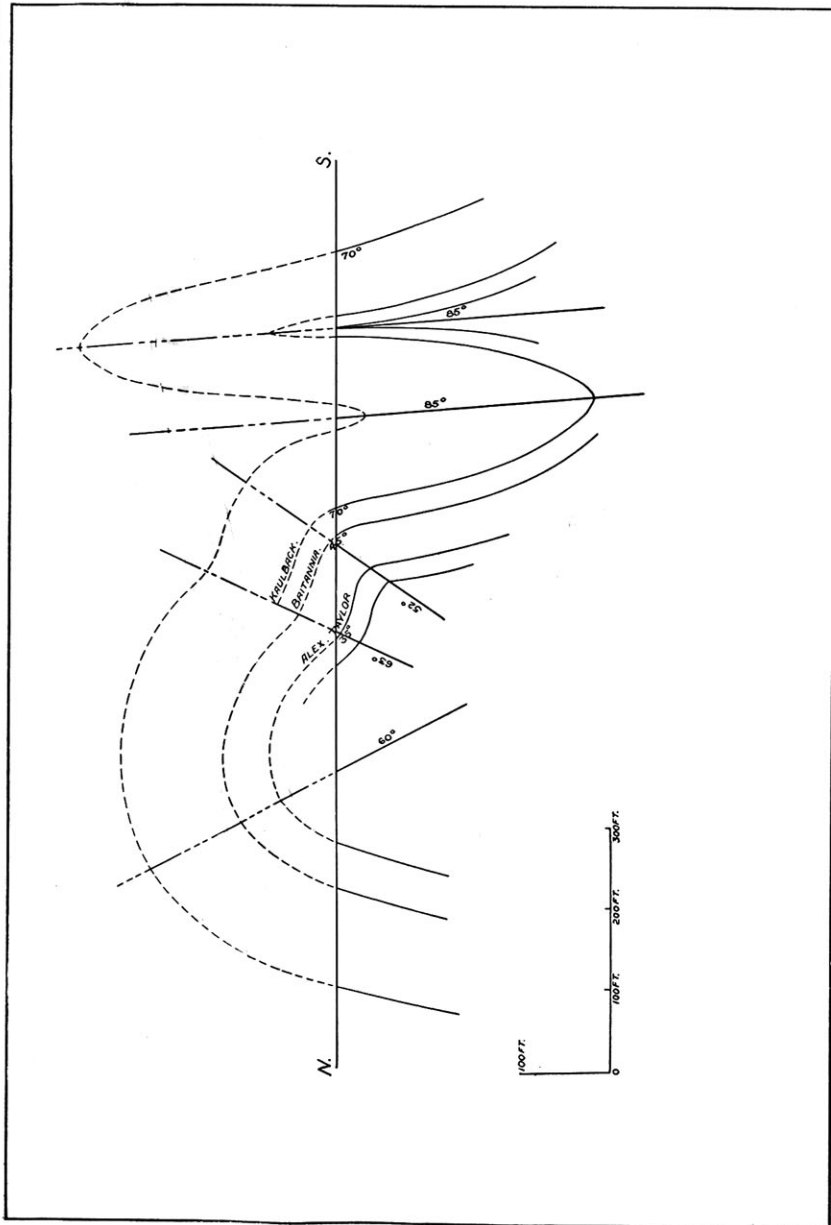


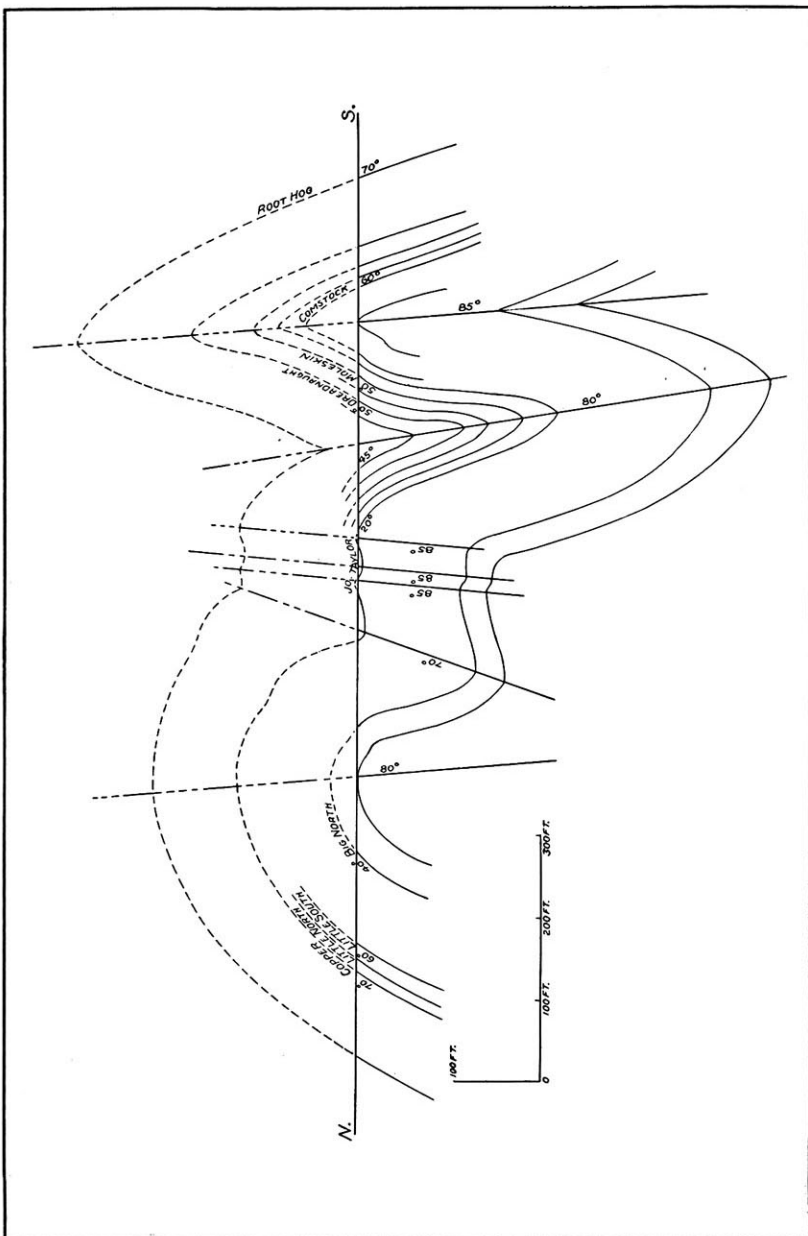
Fig. b.

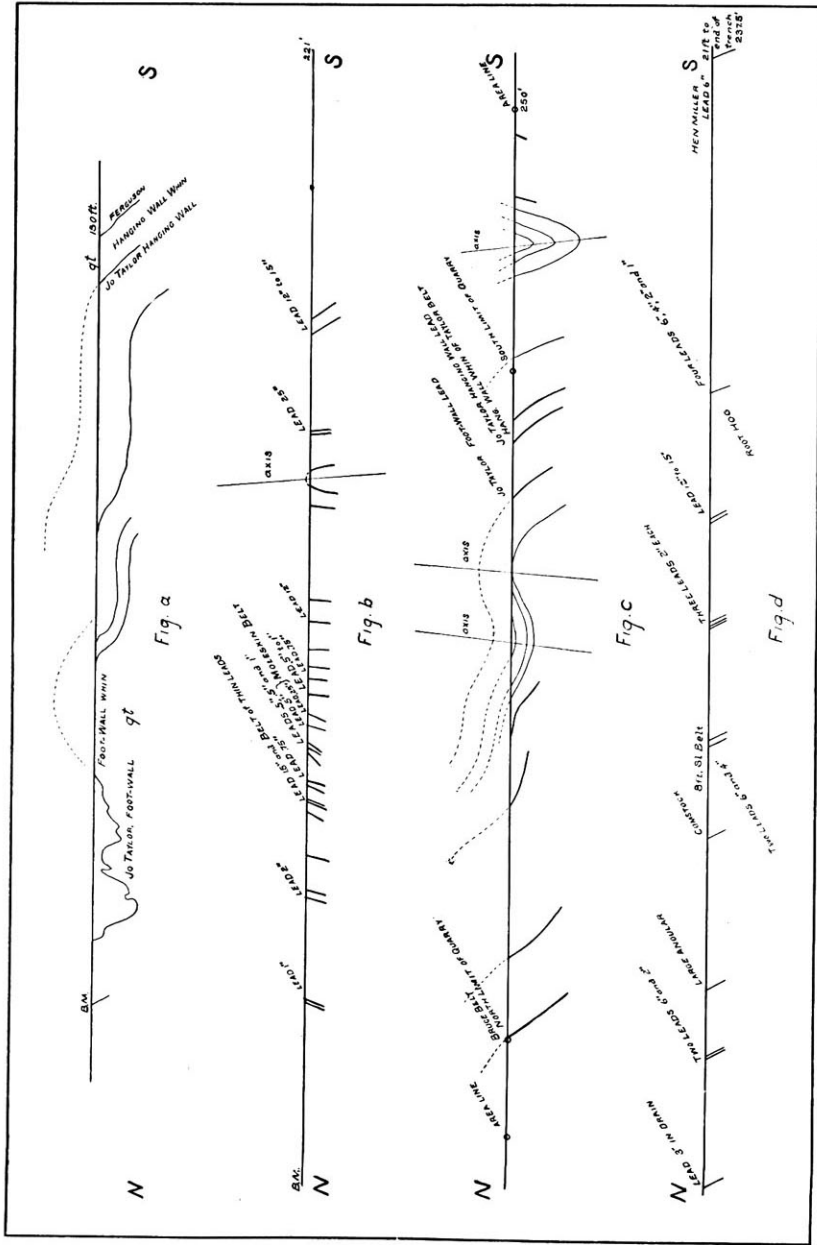


LEGEND.

-  NUMBERS OF MINING AREAS.
-  SHAFT AND POWERHOUSE.
-  LEDGES AND VEINS WITH DIP; SHAFT.
-  FAULT WITH DIP.
-  ANTICLINAL AXIS WITH DIP.
-  SYNCLINAL AXIS WITH DIP.
-  STRIKE AND DIP OF STRATA.
-  HORIZONTAL DISPLACEMENT OF FAULT.
-  PLUNGE OF AXIS OF FOLD.
-  CUT OR QUARRY.
-  TRENCH OR CROSS-CUT.







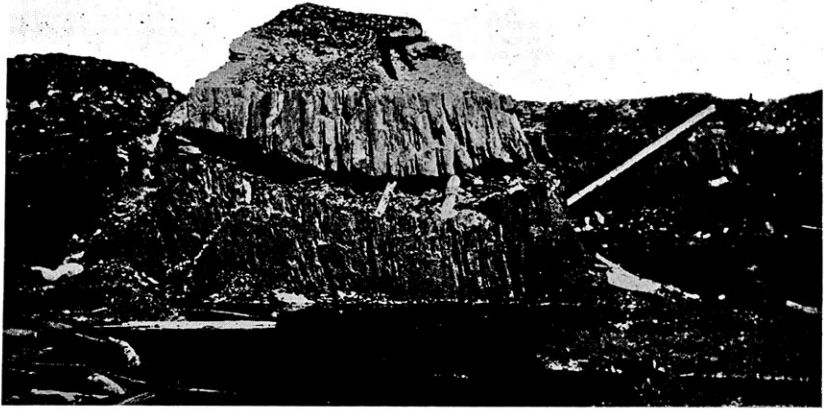


Fig a.



Fig. b.

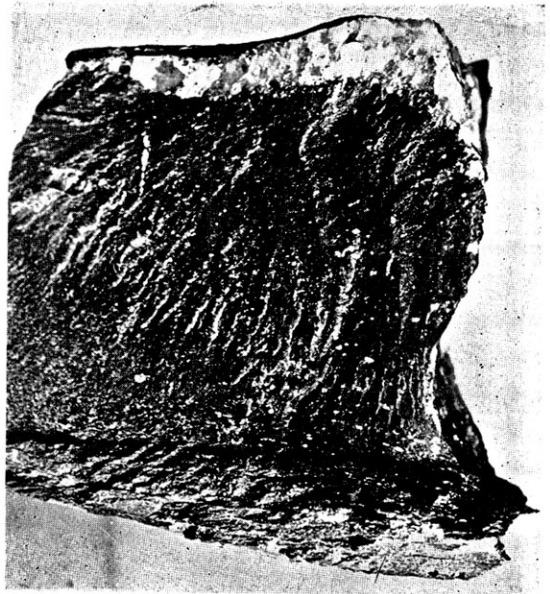


Fig. c.

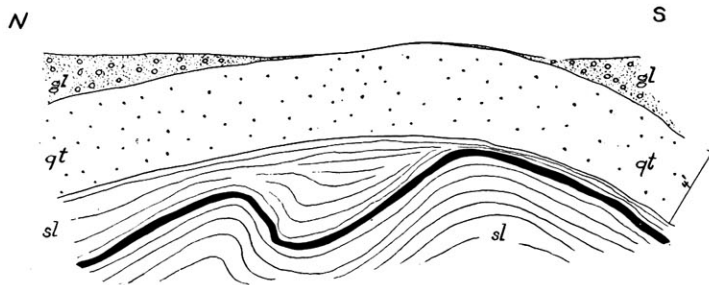


FIG. a

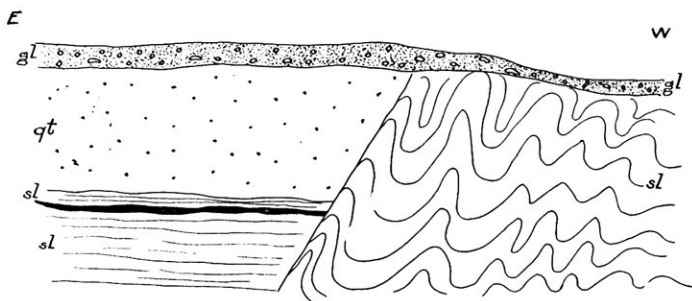


FIG. b

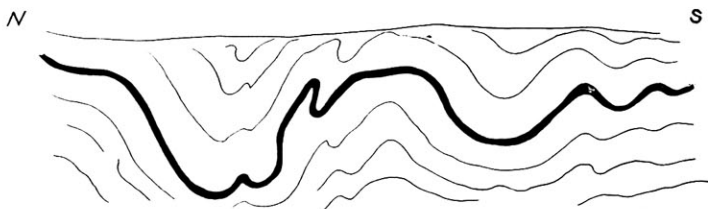
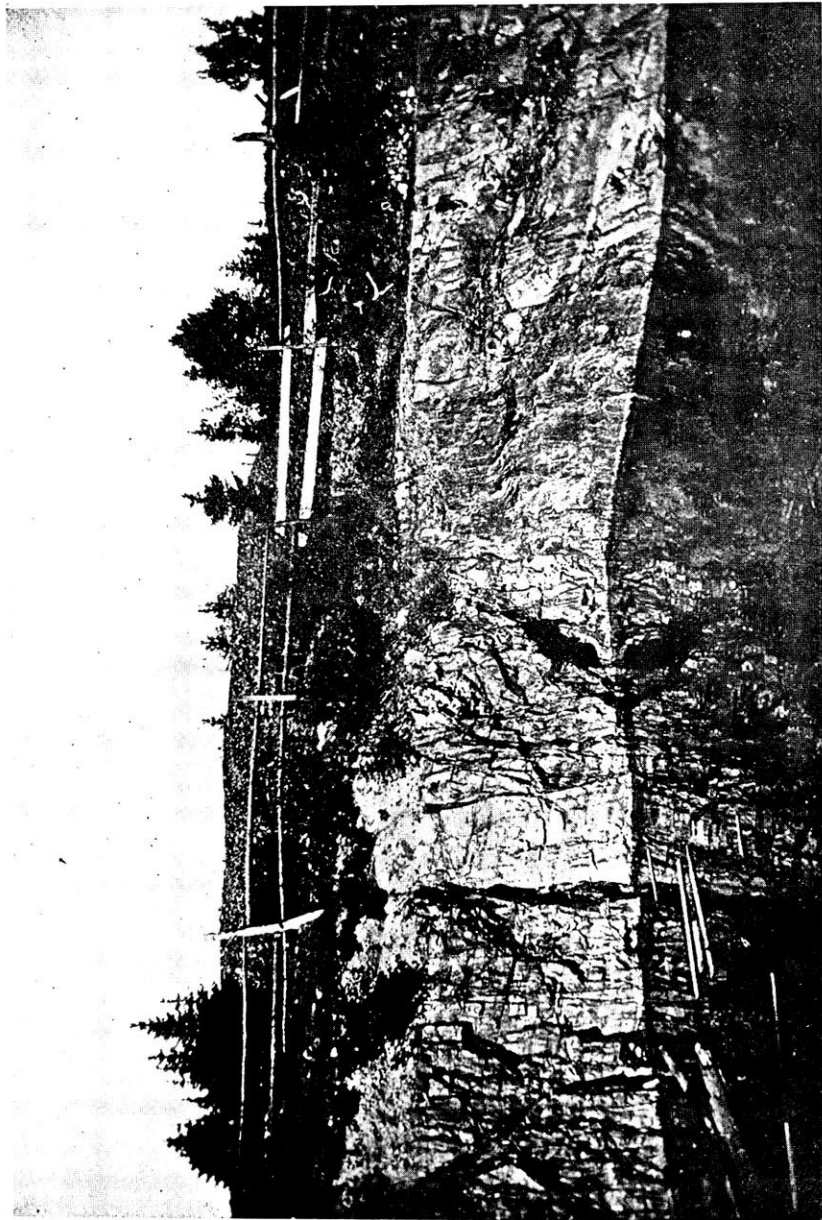
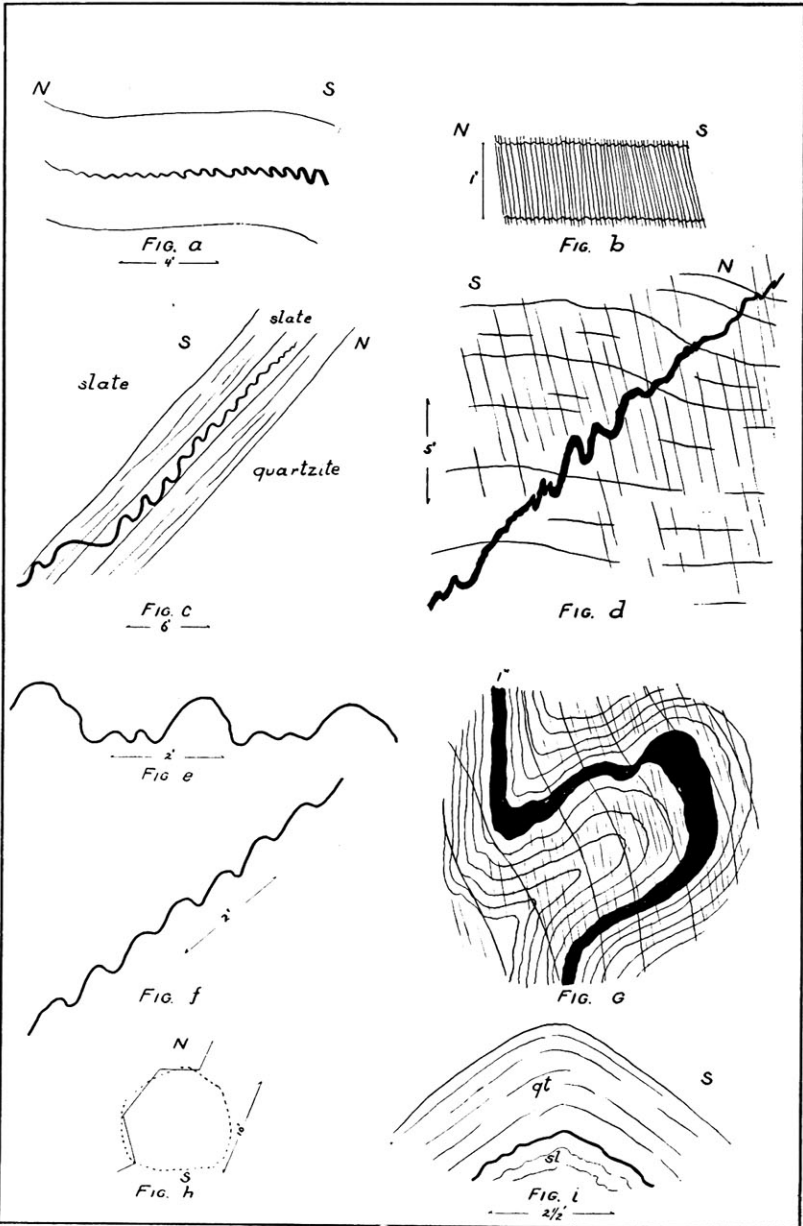
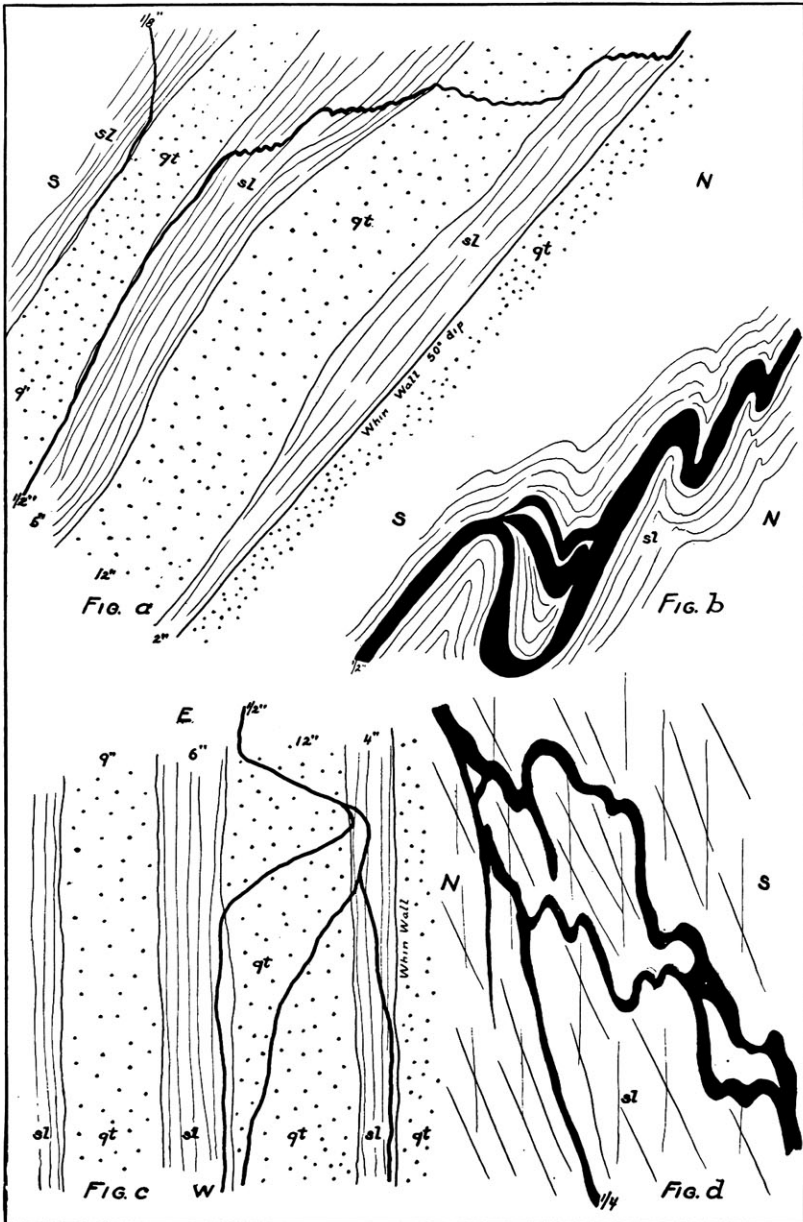


FIG. c















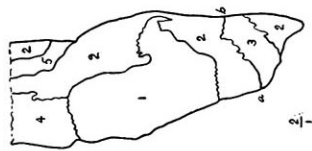


Fig. a

$\frac{2}{1}$

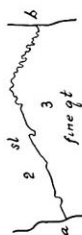


Fig. b

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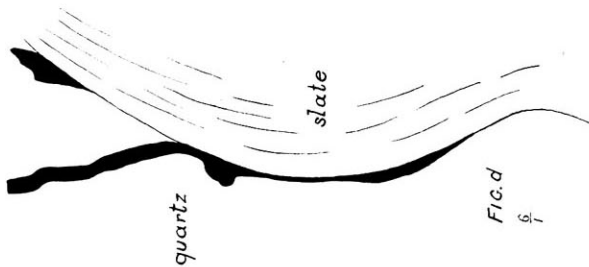


Fig. d

$\frac{6}{1}$

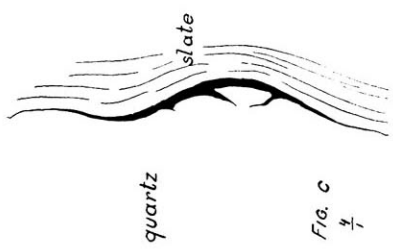


Fig. c

$\frac{4}{1}$

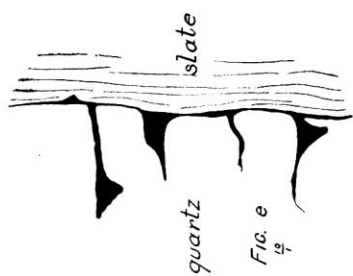


Fig. e

$\frac{10}{1}$

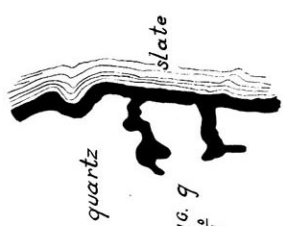


Fig. g

$\frac{20}{1}$

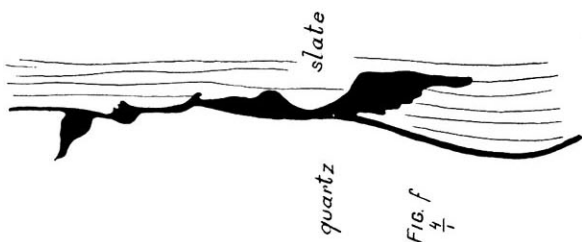


Fig. f

$\frac{7}{1}$

Fig. c.—Specimen taken from the roll of a vein; showing the stratification curving beneath the roll, and approximately parallel with it. About natural size.

Plate 9. *Fig. a.*—Section at intersection of middle fault with south anticlinal axis of the subsidiary anticline; on east side of fault, in a small pit on area 71. Black band represents the hanging wall lead of Jo. Taylor belt, changing from a south dip, and leaving the hanging wall whin.

Fig. b.—In the same pit as *fig. a.*; section showing fault. The lead is viewed along the strike, but has little dip at this point. In these two figures, *gl* = glacial drift, *qt* = quartzite, *sl* = slate.

Fig. c.—Section at the north end of trench 1; showing crenulations in foot-wall lead of the Jo. Taylor belt (vid. pl. 7, *fig. a.*, north end of section).

Plate 10. View in quarry on area 77, looking northeast; showing on north side of quarry the eastward pitch of the strata, and on the east wall a fault plane (cf. pl. 2)

Plate 11. Structural details.

Fig. a.—Crenulated lead, just below Jo. Taylor belt; to show relation between size of vein and amplitude of corrugation, and lack of sympathy of adjacent strata.

Fig. b.—Serration of stratification by cleavage; quarry, area 74.

Fig. c.—Crenulated angular, Kaulback belt (cf. *fig. a.*).

Fig. d.—Irregular vein; west wall of quarry, area 73. Inclined lines show cleavage, horizontal lines stratification.

Figs. e, f.—Details of rhythmic crenulation of a lead.

Fig. g.—Diagrammatic section, to show the relation between stratification, jointing, and cleavage, in the country rock adjacent to a roll. The first follows the vein closely, in full lines; the second is broadly curved, in full lines; the third is but slightly curved, in broken lines.

Fig. h.—Map of the middle fault, in the small pit at east end of quarry, area 71.

Fig. i.—Detail of crest of the south anticline in trench.

2. The heavy line indicates a lead, capped by whin and underlain by slate.

Plate 12. Details of Kaulback angulars.

Fig. a.—Section at 60-foot level, north tunnel; showing relations of angulars to stratification.

Fig. b.—Map of part of the same angulars, taken at approximately the same place; looking *up* at the roof of the tunnel.

Fig. c.—Details of rolling and splitting of a stratified portion of an angular.

Fig. d.—Details of a portion which follows the stratification approximately. Vertical lines represent cleavage.

Plate 13. Copper belt, here composed of two leads, symmetrically crenulated; looking east.

Plate 14. Big North or Great North lead, looking west in the stope on the west plunge; showing crenulation, and relations of stratification and cleavage to the lead.

Plate 15. Serpent lead, looking west on the west plunge; showing in the lead extreme contortion with crushing, and parallel banding, and twisting of cleavage under the influence of rolls.

Plate 16. Serpent lead; showing details of a thick portion.

Plate 17. *Fig. a.*—Contacts of irregular lenticles of slate in quartzite.

Fig. b.—Enlargement along line a-b.

Figs. c-g—Sections of vein margins, from Kaulback angulars; showing relations of gold to gangue and country rock. *Fig. e*, a portion of *fig. c* enlarged; *fig. g*, a portion of *fig. e* enlarged.

Plate 18. Map of areas 30, 31, 70 and 71, enlarged from the original of pl. 2.