ART. XVI.—*The Geology of the Reefton Gold-veins.*

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Communicated by Dr. Marshall.

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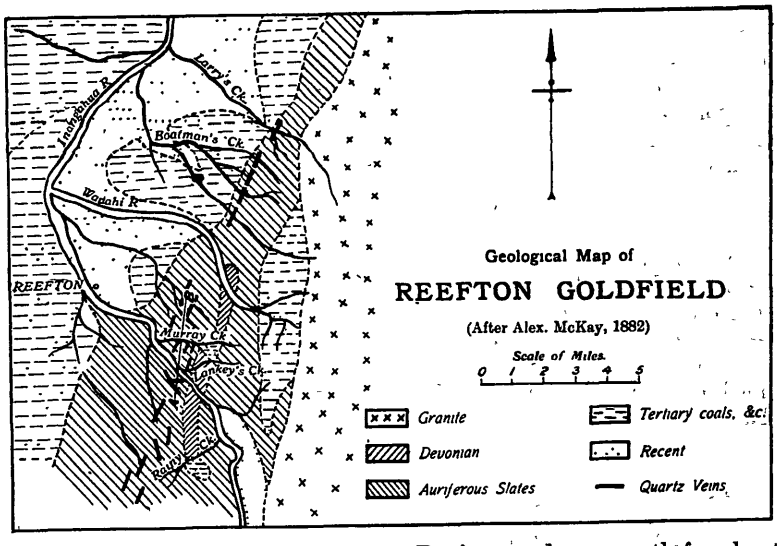
INTRODUCTION.

THE quartz-mining district of Reefton has many claims to distinction among the mining camps of the Dominion. Although late in development, the mines when opened up made rapid strides, and the goldfield has survived alike the wild-cat period and the period of booms and crashes. The Town of Reefton was the first in New Zealand to be lit with electric light, by power from the Inangahua River, and, although none of the mines compare with Waihi for magnitude of operations, the field offers good opportunities for studying the cyanidation of low-grade ores. The veins themselves are interesting from the point of view of structural features rather than of genesis.

I wish here to express my great indebtedness to Mr. A. Spencer, surveyor for the Consolidated Company, for the great assistance he rendered me by giving me access to the mines and to the mine-plans.

GENERAL DESCRIPTION OF THE DISTRICT.

The district of which Reefton, a town of two thousand inhabitants, is the commercial centre, occupies the valley of the lower Inangahua River,



which emerges from the gorge, flows past Reefton, and runs north for about twenty miles to join the Buller River where the old Township of Lyell is

situated. The upper Inangahua flows north-west, and crosses in its gorge the best-known part of the gold-belt. This latter further extends some distance to the south, passing over a low saddle into the watershed of the Grey River.

The district thus indicated lies in a valley between two granitic ranges—the Paparoa Range on the west, and the Victoria-Brunner Range on the east. The Inangahua River receives in its course several tributaries, the most important being on its right, or east, bank. The largest are the Waitahu River, which joins it a few miles below Reefton, then Boatman's and Larry's Creeks. In the gorge it receives on its right bank Lankey's and Murray Creeks, and on its left Rainy and Devil's Creeks. These are small mountain-streams, whose names are closely linked with the early history of the goldfield.

The mountain-slopes from the 3,000 ft. level to the valley have been for the most part heavily timbered, and still are in the less settled parts of the district. But the forests are being rapidly destroyed to supply timber for the mines and for other purposes, and to clear the land for grazing.

The district is well watered by its numerous streams, and, in common with other parts of the West Coast, it has an abundant rainfall. There is more than sufficient water for mining purposes, and the available water may still be turned to account as a source of power. The climate is mild for the most part, though somewhat cold in winter, and the town during that season is frequently enveloped for days at a time in a thick low-lying fog.

The district is connected with Greymouth by a forty-mile train service, and with Westport by a coach *via* the Lyell. Nearly all of the Reefton traffic goes by the former route.

Previous Geological Work.

The veins themselves have never been systematically examined since their exploitation, which is a matter for regret both from an economic and from a scientific standpoint. The geology of the district has, however, received some attention from Hector,* Cox,† and notably McKay.‡ The last named also has some incidental references to the veins. Murray, in a report on deep quartz-mining in New Zealand,§ has also some notes on the Reefton mines. The only other available information is contained from year to year in the annual reports of the Mines Department.

Geology.

The district is bounded on both sides by granite massifs, in the Paparoa Range and the Victoria and Brunner Ranges. The space between is occupied by a belt of slates—the gold-bearing series, considered by Hector's Geological Survey to be the equivalents of the Maitai series.‖ These slates are much folded into a series of sharp anticlines and synclines, and also much disturbed by faulting. The age of the slates is not definitely known. They have been referred to the Carboniferous, but may be much younger.

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* J. Hector, Reps. N.Z.G.S., 1873–74, p. 85.

† S. H. Cox, "Geology of Westland," Reps. N.Z.G.S., 1875–76.

‡ A. McKay, "Geology of Reefton District," Reps. N.Z.G.S., 1882, p. 91.

§ R. A. F. Murray, "Report on Deep Quartz-mining in New Zealand," parliamentary paper C.–6, 1894.

‖ A. McKay, "Geology of Reefton District," Reps. N.Z.G.S., 1882, p. 132.

The belt of quartz veins runs through them in a north-and-south direction along their strike.

Erosion along an anticline in the slates has exposed beneath them in places a series of cherts, slates, and limestones containing fossils of Devonian age.

As regards the relations of these three formations, the granites on both sides are intrusive into the slates, as seen by the intense local contact-effects in Larry's Creek and elsewhere, and to their intrusion is doubtless due the intense folding and crushing of the included belt of slates. These latter are claimed by Hector and McKay to rest with pronounced unconformity on the Devonian rocks,* and from other considerations this is probably the case, but good sections showing the junction between the two formations are difficult to obtain owing to the faulting and disturbance that the rocks have undergone. McKay has described in some detail the Devonian sequence exposed in the Inangahua Gorge, Lankey's Gully, Waitahu River, and Rainy Creek.† North and south of these limits the Devonian rocks have not been recorded.

Next in age comes the early or middle Tertiary series of coal-bearing rocks, well developed at Boatman's and at the head of Murray Creek. In these localities good seams of high-grade bituminous coal occur, from which over 100,000 tons of coal has been won. This coal is a valuable asset to the district, and is in high favour for household purposes. Accompanying the coal-bearing rocks are auriferous gravels and cements (which have been worked in places), sandstones, and, further north, limestones. The base of the series is occupied by coarse greywacke breccias, well exposed in the Buller Gorge, on the east flanks of the Paparoa Range. The rock series thus described as exposed in the Reefton district is typical of the great coal-bearing series of the West Coast, whose age is still a matter of doubt. They have been classed by Hector and McKay as Cretaceo-tertiary,‡ but the limestone fossils indicate a much younger age. Whatever their age, they rest with marked discordance on the older rocks, and are also deeply involved in the structure of the ranges on which they occur, as is well seen in Murray Creek.

The Inangahua Valley is occupied by gravel terraces of Pliocene or Pleistocene age, and by recent gravel-deposits. The gravels, both in the main valley and in the tributary streams, have yielded a considerable quantity of alluvial gold, and are even yet in places profitably worked by small parties.

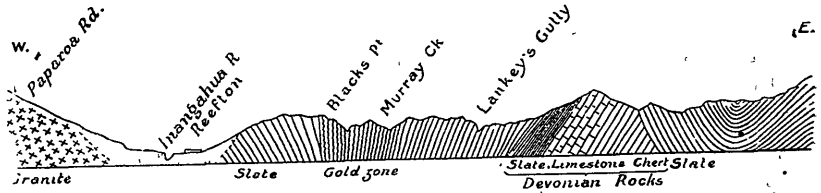


FIG. 1.—SKETCH SECTION ACROSS REEFTON GOLDFIELD.

The above sketch section across the district from west to east indicates the geological structure.

* A. McKay, "Geology of Reefton District," Reps. N.Z.G.S., 1882, p. 130.
† *Loc. cit.*, p. 108.
‡ *Loc. cit.*, p. 140.

Dykes.

The granitic rocks are penetrated here, as elsewhere on the Coast, by numerous basic and semibasic dykes, including varieties of diorite, porphyrite, camptonite, and similar types.

The slates are also intruded by a series of dykes which, so far as yet known, are exclusively of diabase. The outcrops are difficult to locate, owing to the extensive alteration which the dykes have undergone, some of them being slightly schistose. They have generally been exposed in mine-workings only, and, as many of the mines are now closed down, observations cannot readily be made. They have been found in the Specimen Hill, Inglewood, and Keep It Dark Mines, but the only one that I saw was in the last-named, and its occurrence is described under the description of that mine.

It is notable that these dykes seem confined to the gold-bearing belt, but their intrusion seems to antedate the vein-formation. Their intense alteration is probably due to solutions acting at this period, and their occasional schistosity indicates that they have been subjected to considerable pressure, probably during the period of folding of the slates. There is thus evidence for assuming that they are the oldest known intrusives in the district.

Petrography of Diabase.

Megascopically the diabase is a rather soft dark-green rock, full of black cleavage-faces of small augite crystals.

Under the microscope the rock, when fresh, has the typical ophitic structure of a diabase. It is composed of twinned laths of andesine-feldspar containing some secondary sericite and calcite arranged evenly along the centre of the crystals. Augite is fairly fresh and pale in colour, the crystals filling up interspaces between the feldspars, or occurring as small detached crystals. The individuals are occasionally twinned. The relative proportions of augite and feldspar vary somewhat; at times augite predominates, with the local disappearance of other constituents. It is then coarse and in better-outlined crystals. Olivine is occasionally seen in some quantity, but very largely replaced by a mesh of serpentine, without the separation of much iron-oxide. It is probably not a highly ferriferous variety. Of other constituents, a good deal of magnetite (both primary and secondary), a little basaltic hornblende (often chloritized), and needles of apatite are present.

The alteration of this rock close to the vein is well shown under the microscope. In the first stage the feldspars become more and more replaced by carbonates till the twinning is indistinguishable, and they practically consist of sericite-calcite pseudomorphs. Olivine is replaced by chlorite and serpentine, augite by magnetite (or ilmenite) and a leek-green serpentine. The ophitic structure can, however, still be traced.

With further alteration all structure is lost, even the outlines of crystals being obliterated. The rock becomes an aggregate of carbonates and sericite, with a good deal of opaque iron-oxide, and a little quartz, probably introduced. Strings and patches of pale-green chlorite are present at first, but these are eventually altered to sericitic matter. Pyrite crystals are also frequently present.

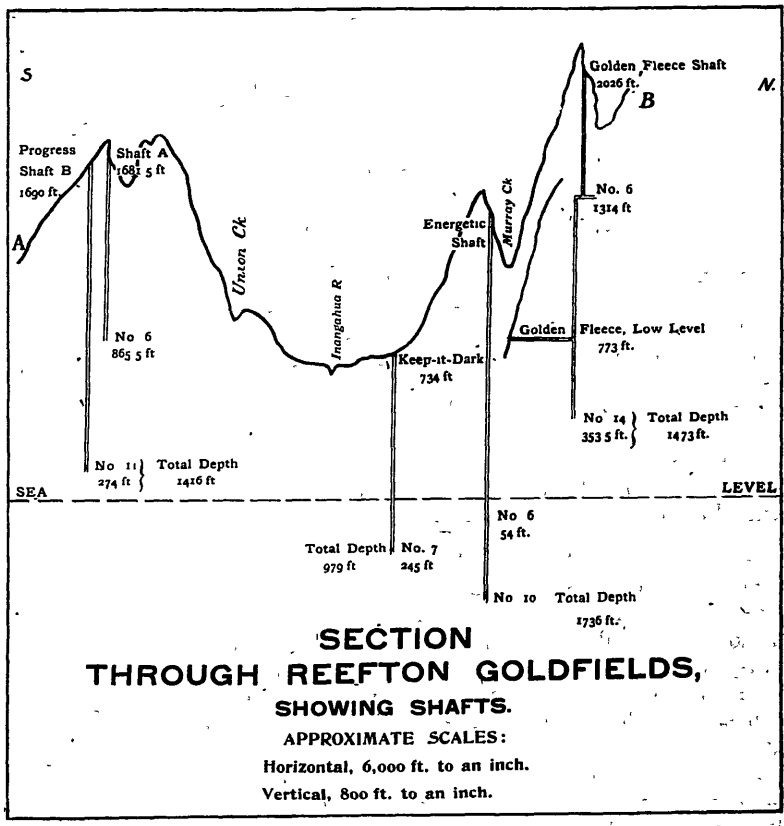
Thus we are able to trace the progressive steps of alteration. The lime-soda feldspar is changed to carbonates and sericite; the augite and olivine first to transitional chlorite and serpentine, with separation of iron-oxides,

and finally to the same end-products, these two minerals composing in the end the mass of the altered rock.

THE VEIN-SYSTEM.

The gold-belt, which occupies a zone running nearly north and south, passes through the broken foothill country of the Victoria and Brunner Ranges, on the east side of the Inangahua Valley. It extends almost continuously from the Lyell to Black's Point, near Reefton, in the Inangahua Gorge, and, crossing the river, passes south as far as Snowy and Blackwater Creeks, in the Grey River watershed.

The belt thus indicated is, in its broader aspect, merely a portion of the continuous reef-bearing zone of the West Coast. Thus, passing northwards, we come to the reefs at Mokihinui and on the Owen Goldfield, and



SECTION
THROUGH REEFTON GOLDFIELDS,
SHOWING SHAFTS.
APPROXIMATE SCALES:
Horizontal, 6,000 ft. to an inch.
Vertical, 800 ft. to an inch.

finally to the Golden Ridge district, near Collingwood. To the south, wherever the belt of slates appears, we find reefs in the same line—in the Taipo River and the Wilberforce. This belt of reefs is certainly irregular in its course, but it cannot be geologically subdivided, as all the veins have the same features, which will be described in detail under the next heading.

On the Reefton Goldfield, commencing at the north end, we find first the Alpine Consols and other lesser-known claims at the Lyell. Passing south we reach Larry's, where the Caledonian Mine is situated. Next, at

Boatman's, occur a group of small but well-known mines—the Specimen Hill, Welcome, Fiery Cross, Hopeful, and Just in Time. Approaching Reefton, the belt has apparently a much greater width, probably due to the wider exposure of slates, while the veins are larger and have been more extensively developed. On the west side occur Anderson's and the Invincible, two properties on which little has been done. Then occurs the Energetic-Wealth of Nations-Keep It Dark group, the most productive on the field. The Ulster, Ajax, Golden Fleece, and Royal occur in a line to the east of these, and lastly come the Inglewood, Victoria, and Golden Treasure Mines. Fig. 2 shows the distribution of mines in the Murray Creek district.

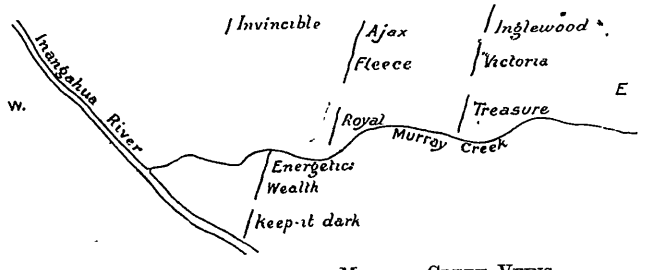


FIG. 2.—SKETCH-PLAN OF MURRAY CREEK VEINS.

Crossing the gorge of the Inangahua River, we reach the well-known Globe-Progress Mine, the vein in which runs almost east and west, deviating widely from the usual north-and-south course. A few old properties, including an antimony-mine described by McKay,* occur to the west of this vein. Following south, we pass in succession the Inkerman, Sir Francis Drake, Cumberland, Golden Lead, and A1 Mines, the last situated at the head of Rainy Creek, in the Merrijigs district.

Still further south, on the Big River, lies the Big River Mine, about twenty miles from Reefton; and lastly, near it, the lately developed Blackwater Mine, in the Snowy Creek watershed.

CHARACTERISTICS OF THE VEINS.

The auriferous belt consists of a zone of crushed and fissured slate of varying width (maximum, about two miles), and it is to be observed that this zone lies parallel with the line of strike of the slates, with the granitic intrusions on either side of it, and with the observed outcrops of the older Devonian rocks to the east, while it practically corresponds with the line of occurrence of the altered diabases. These coincidences have a structural significance.

If the intrusion of diabases was the first phenomenon, it is probable that they caused a line of weakness along the strike of the slates. Later, with the granitic intrusions and the intense crumpling of the slates between, this line of weakness would be the locus where crushing and faulting would be concentrated. The junction between the soft slates and the hard Devonian cherts would also be a line along which movement would readily take place—in fact, the belt of resistant Devonian rocks, which were indurated and folded prior to the deposition of the slates, would evidently act as a central buffer during the later folding movements, and would

* A. McKay, "On an Antimony Lode at Reefton," Reps. N.Z.G.S., 1882, p. 88.

further concentrate movement and shattering into a comparatively narrow zone in the slates.

The absence of veins in the Devonian rocks is not surprising, as they would not be amenable to extensive fissuring, more especially as the relief of strains would be readily effected by faulting of the weaker slates. Moreover, fissuring and faulting would take place where the stress due to folding was greatest—that is, in the apex of the main syncline of the slates.

Throughout the width of the zone of disturbance there are places where more defined fissuring has taken place, giving access to thermal solutions. It is in these places that the veins proper occur, and the position of the chief veins is indicated by the position of the mining claims.

Turning to the individual veins, if they can be so regarded, a vein consists of a series of lenses of quartz, with constriction of the vein-walls between. The lenses follow each other more or less continuously to considerable depths, with short barren patches of "vein-formation" between the lenses. The vein, as indicated by its walls and the included band of crushed slate which contains the lenses, conforms as a rule to the bedding of the country rock, though frequently it may cut across it.

The lenses vary considerably in dimensions in different parts of the field, the smallest occurring at Boatman's and the largest in the Inkerman Mine. In most cases they show a steep pitch to the north along the strike of the vein. The gold, of fineness 960, and worth over £4 an ounce, is free-milling, and varies from coarse to fine. The former is caught on the battery-tables, and the latter recovered by cyaniding the tailings. It is scattered for the most part through the lenses, though occasionally it lies in shoots on the walls. Of sulphides, auriferous pyrite is always present, the pyritic concentrates being worth approximately £20 per ton. Stibnite is also very frequently present, some veins carrying a notable proportion of it. It is mostly low grade, and mingled with quartz. When present in quantity it occurs in seams and bunches. As an accessory it is scattered sporadically through the stone, and greatly increases the consumption of cyanide. To remedy this, the Keep It Dark Company now treat their tailings with a solution of caustic soda previous to cyaniding.

Metasomatic Action.—The results of analyses made of the fresh and altered slates show a considerable loss of silica and alkalies; the effect of the ore-bearing solutions on the slate has been sericitization, with a decrease of specific gravity. The effects are thus quite analogous to those which I have described in the case of the veins of Otago.* Both Reefton and Otago, it may be noted, carry a very similar class of vein and ore throughout, although most of the Otago veins cut across the bedding of their country rock.

FEATURES OF THE MINES.

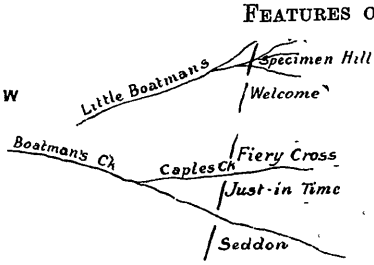


FIG. 3.—SKETCH-PLAN OF BOATMAN'S VEINS.

(1.) *Boatman's Group.*

The veins of this group were characterized by quartz blocks of small size and high value, but at greater depths they became less frequent and too small to extract with profit. The position of the different mines is shown in the sketch-plan.

* This volume, p. 82.

The following section (fig. 4) shows how the groups of quartz lenses pitched strongly to the north along the strike of the vein.

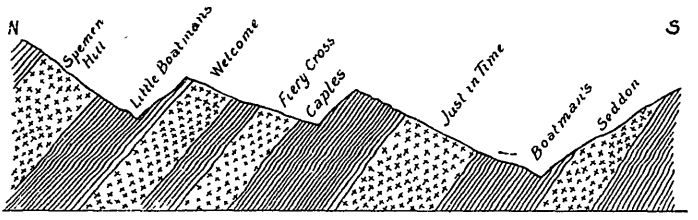


FIG. 4.—SECTION AT BOATMAN'S.

The quartz-zones shown were the points of attack of the several companies that operated in the district, each zone consisting of a series of more or less disconnected blocks or lenses of quartz. The vein dipped uniformly to the east, except in the Specimen Hill lease, where the dip was very irregular. This was also the poorest part of the ground. The Welcome, which was for many years the best dividend-payer of the group, was worked immediately below the Specimen Hill, but apparently on a different belt of quartz. A good deal of antimony-ore occurred in this mine, and gold film or "paint" on clay selvages was frequently met with, doubtless indicating secondary enrichment. Mining at Boatman's has declined very much, and work is now limited to intermittent tributers and occasional prospectors.

(2.) *Murray Creek Group.*

Energetic-Wealth of Nations Mine.—This mine is worked on a main or hanging-wall line of blocks, with a subordinate line of quartz on the foot-wall of the formation or zone, about 200 ft. to the east. This latter has been worked in former times in Nos. 6, 7, and 8 levels. Both lines are practically vertical, with local irregularities, but the hanging-wall line shows a slight westerly dip in the northern workings. Further, this hanging-wall line appears to carry two more or less definite seams of quartz, about 20 ft. apart, with a belt of altered rock between (fig. 5).

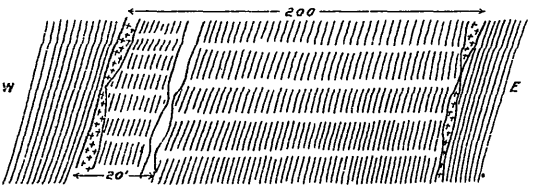


FIG. 5.—SECTION OF WEALTH OF NATIONS VEIN.

The blocks generally run in a continuous line from the surface downwards, with frequent pinches in their course, and a fairly uniform northerly dip along the strike (fig. 6).

FIG. 6.—QUARTZ LENSES, WEALTH OF NATIONS MINE.

The blocks show great variations and irregularities, and are becoming smaller in the deeper levels. They are frequently split by "horses," and the stone is generally mottled and seamy.

The gold may occur on a foot-wall (of a block), on a hanging-wall, or right across in even value, and the appearance of the stone is little guide to its quality. A block has never been barren throughout, but the good blocks are more uniform in value, and the inferior blocks more patchy. Some very good gold was taken from the foot-wall seam of a block in No. 8 level. Its habit is illustrated in fig. 7.

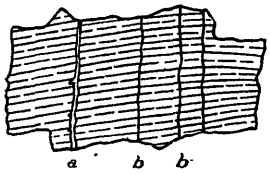


FIG. 7.—OCCURRENCE OF GOLD, WEALTH OF NATIONS MINE.
a. Seam of gold. *b*. Seams of pyrite.

Keep It Dark Mine.—This lies to the south of the last, and its vein is practically a continuation of it, though there is evidence of a patch of barren ground between the two. This one also dips to the west for the most part, though with much irregularity, and with local changes in strike. Like the Wealth, it lies steeper (practically vertical) in the deep levels. It contains a number of blocks which vary in width, and are generally short. They wedge out very quickly, passing into mullock or "formation." The accompanying figure (8) illustrates this change:

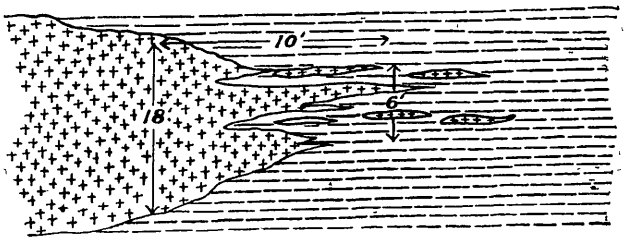


FIG. 8.—PLAN OF QUARTZ BLOCK, KEEP IT DARK MINE.

The blocks pitch to the north and are similar in all respects to those in the Wealth. The gold is free and generally fine, and the ore is poorer in the deeper levels. Auriferous pyrite runs generally in seams and strings through the ore. Stibnite occurs in patches throughout the mine, sometimes accompanying good gold, sometimes the reverse. As a rule, the gold is evenly distributed, though sometimes it clings to the walls of blocks. In the accompanying section of a face at the north end of No. 7 level good visible gold occurred right across, quite independent of the nature of the stone. It is generally found that coarse gold indicates good ore; where the gold is not visible the ore is poor.

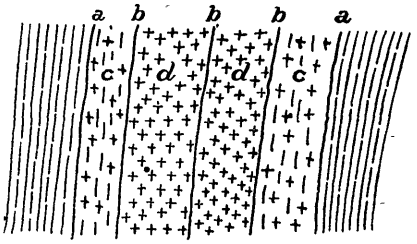


FIG. 9.—SECTION OF FACE, KEEP IT DARK MINE.
a Walls *b*. Pug seams. *c*. Seamy ore.
d. White glassy ore.

In No. 5 level (800 ft.) a dyke of altered diabase was encountered at one spot on the hanging-wall of the vein (fig. 10).

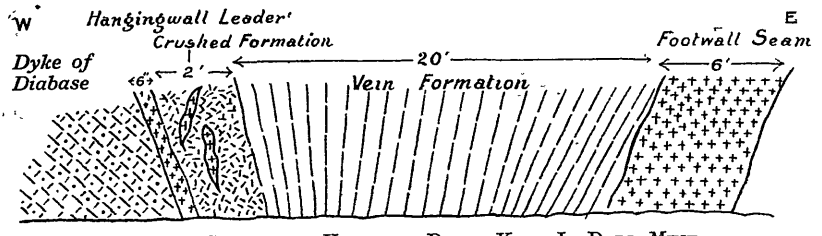


FIG. 10.—SECTION OF VEIN AND DYKE, KEEP IT DARK MINE.

The dyke is cut off from the hanging-wall leader shown by a defined pug or clay face. Small quartz veins ramify into and through the diabase from the leader, varying from mere threads up to 2 in. thick, and the larger ones show a very fine comb-structure. These facts strengthen the view that the diabase is older than the period of vein-formation. It has not, as far as can be ascertained, influenced the gold-content in its vicinity.

Golden Fleece.—This mine was formerly worked by Kit Mace (of Macetown, Otago) and others, on Ajax Hill. The first five levels were driven before the mine was taken over by the Consolidated Company, in 1897. Then the low-level crosscut, which had been started by Government subsidy, was pushed on, and ultimately struck the vein after a mile and a half of driving. In its course it struck no stone and no indication of a vein, although it was only about 500 ft. below the level of Anderson's prospecting drive. The crosscut leads into No. 10. level.

The vein strikes north-east and dips north-west. The blocks of ore are irregular, and the vein in the deeper northern levels shows a tendency to turn to the east, while the blocks generally have a northerly pitch along the strike.

The vein stands nearly vertical on Ajax Hill, but in the deeper levels it becomes gradually much flatter. The average width of blocks is 2 ft. From No. 6 down to No. 14 level the blocks became much smaller, although their value was maintained. Thus during the last few years all the levels from 6 to 14 had to be stoped to supply sufficient ore, and working became expensive.

The remaining line of Murray Creek veins—the Golden Treasure and Inglewood—were of good value, but their blocks were rather small. The Golden Treasure carried in places a good deal of stibnite

(3.) *Globe-Progress Group.*

This property comprises two older claims, both worked on the one vein, which strikes approximately east and west.

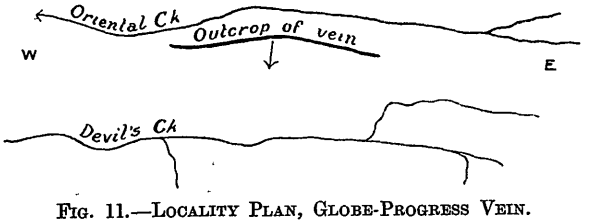


FIG. 11.—LOCALITY PLAN, GLOBE-PROGRESS VEIN.

The vein lies in a zone of soft crushed slate, surrounded by harder sandstone. Down to No. 6 level it has a dip of 60° to the south; below that it flattens out, and from No. 8 to No. 11 level—a distance of 400 ft. vertical—it made 1,500 ft. of base. It is worked by two shafts—one, the eastern, opens up 5 and 6 levels; the other, the western, opens up the deeper levels. The shaft-head is 1,600 ft. above sea-level, and No. 11 is 1,460 ft. deep.

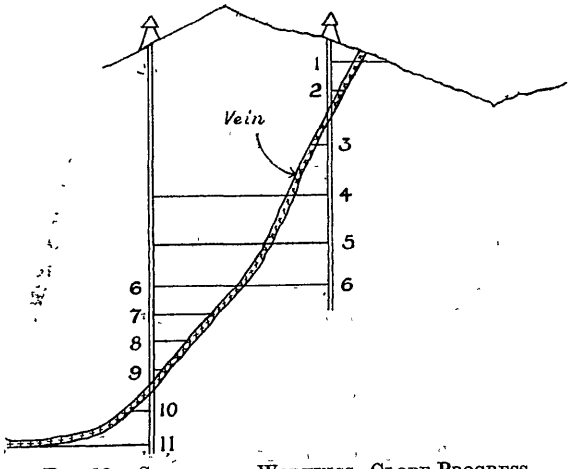


FIG. 12.—SECTION OF WORKINGS, GLOBE-PROGRESS.

Except in the harder sandstone some distance from the reef, the country is soft, and stands badly. The estimated annual cost of timber in this mine during the last ten years has been £3,000. The walls are generally poorly defined, and rarely do a foot-wall and hanging-wall occur together; they are often obscured, while quartz merges gradually into slate.

The quartz occurs in lenses of varying size and value, frequently much disturbed by small faults. The following varieties of ore are met with:—

(1.) Seamy: The most characteristic form. It is seamed with strings of pyrite and mullock, and is nearly always gold-bearing.

(2.) Brecciated: This is only occasionally found.

(3.) White glassy or "dog's-tooth" quartz: This varies in its gold-content. In blocks of this quartz which have been regarded as poor or barren, gold is frequently found in good payable patches. Miners claim that it is possible to distinguish good and poor ore in this mine by means of its appearance to the naked eye; but this is very doubtful. Frequently quartz set down as poor has been found to give good returns.

The difference between the seamy and white glassy varieties seems to be largely due to processes of replacement in the former case, and to simple deposition without replacement in the latter.

The quartz blocks are in the main low-grade throughout, and poorer in the lower than in the upper levels. The gold is patchy in its distribution, does not run in shoots, and is very fine. This vein carries the finest gold on the field. It occurs both free and involved with pyrite, which is the common sulphide.

Stibnite occurs, frequently and patchy. In places it has been found in seams up to 30 ft. thick, but of low-grade (30 per cent.) ore. In this mine antimony-ore is found generally to accompany poor values in gold.

The blocks or lenses of quartz follow in the main three roughly distinct shoots, which all show a certain pitch to the south-west. They are all fairly continuous, though with frequent pinches and makes.

The main shoot has been worked right down to No. 11 level. Between 8 and 11 it flattened considerably, as shown in figure, and in No. 11 it lies practically horizontal. This is the most peculiar feature in this mine.

The vein thus appears to occupy the limb of a syncline; but further development is required to test whether the other limb exists, and whether it carries ore. Owing to the great confusion of strike and dip of the slate I was unable to find evidence of a synclinal arrangement from surface observations. The flattening observed may, indeed, be only a local phenomenon, or an irregularity in the course of the vein. At any rate, the evidence in favour of a syncline is not yet conclusive.

In the development of this mine the diamond drill has played a considerable part, sometimes with much success. Much care has, however, been found necessary in interpreting its indications. Thus, in veins of this interrupted type a bore may be put in and may miss a block altogether. Again, it may pass through a block at such an angle as to give a very exaggerated idea of its thickness. A bore was put down from a point near the shaft-chamber in No. 11 level for a depth of 1,000 ft., or 2,500 ft. below the surface: no promising indications were found, but the bore is interesting as being the greatest depth reached in a New Zealand mine. The results of other bores made have given no indication of the existence of a synclinal vein.

The deeper levels of the mine, as of all others in the district, are conspicuously dry and dusty, except for surface-drainage in the vicinity of the shaft.

(4.) *Rainy Creek or Merrijigs Group.*

The Rainy Creek group, particularly the Inkerman, is noted for the large size and low value of its quartz blocks. One block in the Inkerman reached a width of 130 ft., but averaged less than 2½ dwt. to the ton. The strike of the vein is north-east, and it dips steeply to the south-east. It contained several large blocks—the Big Blow, the Antimony Block, and the Balaclava Block—which all showed a slight pitch to the north-east along the strike. Antimony-ore is common in the Inkerman and in adjacent claims.

The zone of reefs in this part of the district follows an irregular north-and-south line, with frequent divergences and irregularities in strike and dip. Of the others, the Al and Golden Lead were worked for some time, but returns were never encouraging, and mining at Merrijigs is now at a standstill.

(5.) *Big River Group.*

New Big River.—This lies near the head of the Big River, about twenty miles south of Reefton. It strikes north and south, and the main block or series of blocks pitches to the north. Fig. 13 shows the disposition of quartz in the vein.

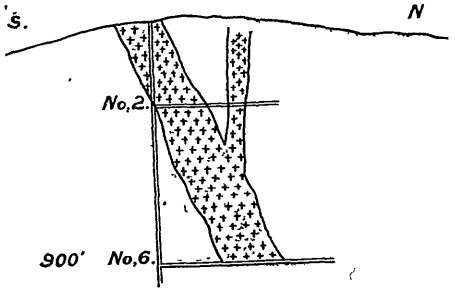


Fig. 13.—Section, Big River Vein.

Blackwater.—This is a narrow type of vein. It strikes north and south, and dips to the west at about 70°. The direction of dip of the quartz blocks has not yet been definitely ascertained, as the mine is only being developed. The gold is free, evenly distributed, and often coarse. There are frequent blocks of stone, mostly of uniform value, but a few patchy. The blocks have an

average width of from 2 ft. to 4 ft. It is probable that, as at Boatman's, the values here have been improved by secondary enrichment.

This is the most thriving portion of the district. The Big River mine is undergoing vigorous development, and both mines promise to be good dividend-payers for some time to come.

GENESIS OF THE VEINS.

The period of vein-formation probably followed closely on the intrusion of the granite masses and the folding of the belt of slates. A zone of slate was highly crushed and fractured (a shear-zone) along the axis of a synclinal fold, and this gave access to thermal solutions, arising presumably as after-effects of the granitic intrusions.

The character and occurrence of the quartz, as well as the great loss of material suffered by the altered rock, indicate that the quartz lenses which comprise the workable portions of the veins are due largely to replacement of rock and segregation of silica. Further, the manner in which the quartz gradually peters out into the lode-formation also strongly suggests replacement.

McKay is inclined to believe that the period of vein-formation was prior to the folding of the slates.* The evidence I have collected leads me, as I have stated, to the opposite conclusion.

As regards the dip of the quartz blocks, this feature appears to have originated as follows: When fissuring took place differential movement between the walls of the fissures would be in a direction slightly inclined to the vertical, if there was a combination of vertical gravitation forces and more or less horizontal minor shearing-forces. Thus, where pressure was greatest crushing would presumably be concentrated along inclined lines in the fissure-zone. Subsequently, with the ascent of the mineralising solutions, deposition and replacement would naturally follow those lines along which crushing and comminution of the rock had been most intense. The fact that the dip of quartz blocks is practically the same throughout the district, indicating a uniform direction of resultant movement, seems to support this explanation, and it is also, I believe, applicable to explain the similar dipping quartz shoots in the various groups of Otago veins

HISTORY OF MINING AT REEFTON.

Quartz-mining at Reefton dates from 1870, when Anderson discovered the Invincible line, Shiel the Ajax and Golden Fleece line, and Adam Smith the appropriately named Wealth of Nations line. Boatman's and Rainy Creek districts were prospected in 1872, and the Globe Mine was first opened up in 1882. The poorest of these was the Rainy Creek, which has never given good returns, although a good deal of desultory work has been done. The various companies at Boatman's got high returns for some years, and the best of them—the Welcome—has only just lately closed down. The early workers had many difficulties to contend with, owing to the absence of roads and tracks, but a good deal of work was done till about 1896, when quartz-mining reached a low ebb. About this time Mr. David Ziman took over a large number of claims on behalf of an English company, and formed the Consolidated Goldfields of New Zealand (Limited), which held the Wealth, Fleece, Welcome, Inkerman, and several others, as well as a large

* A. McKay, "Geology of Reefton District," Reps. N.Z.G.S., 1882, p. 134.

interest in the Globe-Progress Mine. Since that date the yield of quartz has rapidly increased, and reached its height about 1904.

The mines at present in operation are the Wealth, Progress, Big River, Blackwater (Consolidated Company's mine), and Keep It Dark (dating from 1873). Their statistics, operations, and plants are fully described in the New Zealand Mining Handbook for 1906.

The section accompanying this paper shows the position and depth of the principal shafts and workings in the different mines.

Future Prospects.

Any future developments will occur, as indicated, along the auriferous zone, and prospecting is rendered difficult by the fact that reefs are not readily located except when blocks of quartz happen to outcrop. There can be no doubt that a great deal of payable ore still exists in many parts of the field, but the difficulty of locating it is an obstacle which demands considerable initial outlay in prospecting.

In regard to the prospects of deep mining, we have seen that at about sea-level the blocks of quartz are notably smaller in all the mines, although the gold-content is generally still payable. As the blocks get smaller the expenses of working increase, and it seems very probable that the limit of profitable mining will be reached not many hundred feet below the present deepest workings. In other words, the blocks will become too few and too scarce to justify further development in depth.

Lastly, the very high returns secured in the early days (2 oz. to 4 oz. per ton) from the upper levels indicate secondary enrichment, and it is therefore obvious that in any future work the upper levels will be the most remunerative.

Art. XVII.—*Geology of Rarotonga and Aitutaki.*

By Dr. P. Marshall, M.A., D.Sc., F.G.S., University of Otago.

[*Read before the Otago Institute, 10th November,* 1908.]

Rarotonga.

But few statements have hitherto been made as to the geological nature of this island, and they are very general. Mr. Percy Brown has lately been good enough to forward me specimens of rock from several localities on the island, and from the study of these, as well as the statements of Mr. Brown, Mr. James Allen, M.P., and those in the Government Year-book, the following description has been compiled.

Relatively few soundings have been made near Rarotonga, but there is at present no reason to doubt that it is surrounded on all sides by water between 2,000 and 3,000 fathoms in depth. It is situated to the east of the deep trench which extends from New Zealand almost to Samoa.

The volcanic rock appears to rise directly from the ocean-shore without any intervening fringe of raised coral rock, though the island is surrounded with a fringing reef of coral. This appears to prove that no change in elevation has taken place since the volcanic action ceased.

In the neighbouring island of Tonga Mr. Lister has proved an elevation of 1,000 ft., while the atoll of Palmerston and others seem to prove consider-