1894.

NEW ZEALAND.

OLDER AURIFEROUS DRIFTS OF CENTRAL OTAGO.

Presented to both Houses of the General Assembly by Command of His Excellency.

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GEOLOGICAL REPORTS ON OLDER AURIFEROUS DRIFTS OF CENTRAL OTAGO.

BY ALEXANDER McKAY, F.G.S., MINING GEOLOGIST.

Presented to both Houses of the General Assembly by command of His Excellency.

Mr. A. McKay to the Under-Secretary for Mines.

Sir,— Mines Department, Wellington, 15th May, 1894.

I have the honour to forward to you my report on the district in which I have been engaged during the year ending the 31st March last. The principal work of the season was an investigation and study of the older auriferous drifts of Central Otago, the report on which is divided into several heads, as under:—

1. Localities examined.
2. Description of the Auriferous Drifts according to the Localities where they occur.
3. Classification and Sectional Relationship of the Strata examined.
4. The Auriferous Drifts considered in relation to the Changes of Level and Disturbances by Faulting that have taken place since their Deposition.
5. Conclusion.

Localities examined.

The examinations for the year were begun within the Waitaki Valley, in the Maraewhenua District, and thence were continued along the eastern flanks of the Kakanui Range to the watershed of the Shag River. This north-eastern district of Otago as an auriferous field is cut off from the goldfields of Central Otago by the Kakanui Range, Mount Domett, and the Kurow Mountains. Its auriferous deposits consist chiefly of quartz grits underlying marine strata, associated with or taking the place of the coal-measures of Cretaceo-tertiary date.

Within Shag Valley, not far from Palmerston, two localities on the downs between the river and the foot of the Horse Range were visited, gold having been recently discovered at those places.

Proceeding by way of Dunback, Macrae's was visited, and from that place different examinations were made in various directions. Next, Hyde and Hamilton's were visited; and, after making the necessary examinations at these places, from Hamilton's by way of the Taieri Bridge and Ewe Burn, Naseby was reached.

Several days were spent examining the eastern and northern borders of the Maniototo Plain from the Upper Kye Burn to the Wether Burn. From the Wether Burn the line of quartz-drift or made hills was followed along the base of the Mount Ida and Hawkdun Ranges to near the head of the Mount Ida Water-race.

Returning from the Upper Manuherikia, the district around Hill's Creek and St. Bathan's was examined, and also Vinegar Hill, which with the Two-mile forms the north-eastern end of a long line of deeply-involved gold-bearing strata that extends through Cambrian's, Drybread, Tinker's, Devonshire Diggings, and Waikerikeri to the Molyneux River at Clyde.

From Clyde, Cromwell and Bannockburn were reached, from which places various examinations were made, more particularly the area of quartz drifts on the western slopes of Cairnmuir Range. From Bannockburn, by way of the Carrick Range, the Nevis Valley was visited, and, returning thence to Cromwell, the Clutha Valley was followed to the junction of the Luggate Burn with the river.

From the Luggate, Criffel Diggings, Fat Boy, Frenchman's, and Mid Run were visited, and, after these, the Cardrona Valley was examined from the junction of the Cardrona with the Clutha to its source. Next, Arrowtown was reached; and thence Arthur's Point and Maori Point, on the Shotover, were visited. Returning from Maori Point to Clyde, thence Bald Hill Flat was visited, and from the latter place examinations were made to some distance down the Molyneux Valley. From Bald Hill Flat to Ophir and the Pool Burn Valley was the next journey undertaken; and from Black's No. 3, German Hill was reached, and the Rough Ridge followed to the Clyde–Naseby Road. Reaching and leaving Naseby, on the road to Palmerston, Shag Valley was examined. From Palmerston, by way of Dunedin, Lawrence was reached, and from that place Blue Spur, Weatherstone's, Waitahuna, and Waipori were examined. From Lawrence the Molyneux Valley was followed as far as Coal Creek, five miles above Roxburgh; and from Lawrence, in the opposite direction, Clinton, Waipahi, Tapanui, Kelso, and Heriot were visited, and, in the district further to the west and north-west, Waikaka and Switzers.

Returning from Switzer's to Dunedin, the Taieri Valley to Middlemarch, at the foot of Strath-Taieri, was the field over which the last examinations for the purposes of this report were made.

During the latter part of February and the early part of March, 1894, while accompanying Messrs. R. A. F. Murray, Government Geologist of Victoria, and H. A. Gordon, Inspecting Engineer of the Mines Department, on a trip over Central and Northern Otago, opportunity was afforded for further examinations that have been useful in making this report. Reports of previous surveys by various workers, and my acquaintance with a number of localities that on this occasion were not visited, enable me to deal with and describe the beds at those places.

These examinations were chiefly made for the purpose of determining the origin, mode of occurrence, and distribution of the auriferous quartz-drifts that are found throughout Central and Eastern Otago and over a considerable part of the Southland District. At many places these beds are richly auriferous, and for a long time there has been an uncertainty as to their identity in different parts, their mutual relationship, and their position in the scale of geological formations. As the work progressed it became apparent that beds very similar to each other were not always of the same age, and that in many cases the older alluvial auriferous drifts, on being denuded, had yielded to the younger deposits a portion of their gold. Therefore, in order to show fully the importance of the more ancient deposits, it is necessary to describe those which contain gold derived from the older beds, and this involves generally a description of all the beds of Cretaceous or Post-cretaceous age occurring within the district examined.

Description of the Beds at Localities examined.

Gabriel's Gully and Evans's Flat.—Below the Township of Lawrence, Gabriel's Gully gradually widens, until it opens out on that part of the Tuapeka Valley called Evans's Flat. The surface alluviums of the river valley, which alone were worked in the early days of the rush, where they spread over a greater breadth, were less rich in gold than above Lawrence, where the valley is much narrowed, and where, from side to side, the width of the alluvial deposit was often not more than from 2 to 3 chains. Above a certain point (the Blue Spur) the gravels of Gabriel's Gully did not yield payable gold, and the lesser gullies, which, below the Blue Spur, are few and unimportant, were also poor in gold. The workings along Gabriel's Gully showed distinctly that the source of the gold lay in the Blue Spur, and, in due course, the southern margin of the Blue Spur deposit was prospected and proved gold-bearing.

Blue Spur.—The Blue Spur lies between the upper parts of Gabriel's and Monro's Gullies, and consists of a massive accumulation of breccias, gravels, sand, soft sandstone, and sandy clay, the latter often crowded with plant-remains and approaching the character of an impure lignite. From west to east this deposit fills what appears as a depression in the line of hills that bounds the right or northern side of Gabriel's Gully, and forms the water-parting between it and Monro's Gully.

The earliest detailed geological description of the cements of Blue Spur, Weatherstone's, and Waitahuna that has come under my notice is contained in a report on the Tuapeka Cements, dated 25th May, 1879,* by S. Herbert Cox, F.C.S., F.G.S., from which the following extract has been taken:—

"The deposits of cement which are at present known, and of which some are worked, follow a north-west and south-east line, the Blue Spur being the furthest to the north-west at present known. Between the Blue Spur, which is situated at the head of Gabriel's Gully and Weatherstone's, the next deposit to the south-east is a narrow ridge of the Kakanui schists, and it is here that the quartz reef mentioned above occurred.

"The next deposit of importance is Waitahuna, although a few patches of cement do occur between these points, and have received a certain amount of attention from prospectors. After passing Waitahuna in a south-easterly direction, no work of importance has been done on these beds.

"At the Blue Spur the cements are enclosed in a trough, or, perhaps, more correctly, a basin, as, in addition to the bed-rock on which they rest as in a trough, the schists to the north-west and south-east respectively rise to form hills of greater elevation than the cements themselves assume at the present time. The bed-rock on the north-east side of the basin or trough is very steep, while on the south-west side it is more shelving; the total thickness of the cement being certainly not less than 300ft.

"An enormous quantity of this spur has now been removed, and what is left is now cut by steep gutters, from which stone has been taken from time to time. Where the sluicing and other claims have been regularly at work great masses of the hill have been removed; so that the spur, which must in the old days have possessed a similar configuration to the rest of the surrounding country, presents now a series of pinnacles and steep cañons, bearing testimony to the large amount of work which has been done. . . . Although so much of the Blue Spur has been removed there yet remains many years' work before the place will be worked out; and if Weatherstone's deposit should prove as valuable as this has done, Lawrence will again be one of the most successful and thriving townships in the colony."

The deposit is carefully described by Mr. T. A. Rickard, in a paper on the Goldfields of Otago and the Geological Formation of the Blue Spur, read before the American Institute of Mining Engineers at Plattsburgh in June, 1892, an extract from which appears in the Goldfields and Mining Report of New Zealand, 1893, pp. 109–111, from which latter work the following description of the Blue Spur deposit has been taken, the original not being available:—

"The Blue Spur is perhaps the best-known and most interesting alluvial deposit in New Zealand. It is situated near the head of Gabriel's Gully, about two miles east of the Town of

* Geological Reports, 1878–79, p. 42.

Lawrence. The deposit consists of a mass of cement and conglomerate, occupying a cup-shaped hollow in a ridge or spur which divides two nearly parallel gullies. The mass of cemented conglomerate has been variously estimated at from eight to ten million cubic yards; but the present manager, whose opinion is of the most value, puts it at from eleven to twelve millions. The area covered is 45 acres.

"A nearer view of the deposit presents the following features: On the Lawrence [or western] side the rock forming the rim of the cup-shaped hollow presents a very uneven surface, and the folia of the schist are much disturbed and fractured. The pebbles of the conglomerate are imbedded in the soft, crushed country, there being no distinct boundary or line of demarcation between the deposit and the surrounding country-rock. There are longitudinal furrows in the schist parallel to the strike of the country and the longer axis of the deposit. Reddish layers of oxidized material form marked lines through the general faint-blue tinge of the cement, and indicate the dip of the deposit, which is seen to be at a low angle towards Gabriel's Gully, or south-eastward.

"Descending among the masses of conglomerate one can observe the structure of the material. Fractures cut through the included fragments of the more fissile schist, but they do not pass through the harder pebbles. These last are of varying size up to boulders 2ft. in diameter. The wash shows a large proportion of schist fragments, held together by a light greenish-blue fine-grained cement. Of the remaining portions of the material large jasperoid boulders are the most prominent.

"Going to the further side of the deposit it is seen at once that the rim-rock has an altogether different appearance from that noted on the Lawrence side. The bounding wall is perfectly straight and even, with a dip of 25° 30′ to the south-west. It shows incrustations of alum. The schist of the country, which dips with the face of the rim-rock, shows no signs of having been crushed or dislocated. When first uncovered, the face of the wall is said to have been (and its present appearance suggests it) wonderfully straight and smooth. Exposure to the weather has induced the slow shaling-off of its surface, which is now littered with thin sherd-like fragments broken off by frost and rain. Originally the rim-rock was covered with a thin layer of clay, which protected it, but the clay first hardened and then cracked, to be subsequently removed by the rain; and the underlying country-rock is being rapidly eroded.

"Coming towards Gabriel's Gully a pink layer containing lignite is seen. Near the gully, mining operations have partially uncovered the bed-rock. At the present time the edge of the rim-rock is laid bare, but the bed-rock of the gutter is under water. It is seen that the gutter comes abruptly against a ridge over 60ft. high; from the foot of this it rises gently towards Monro's Gully, but soon meets with another interruption in the form of a wall of rock over 20ft. high, beyond which it slopes away again before taking its regular rise. Numerous irregular crevices found in the bed-rock of the gutter generally contained a great deal of gold. Above this the cement was very variable in its gold contents, which were usually arranged along certain red bands. Some of the material was absolutely non-auriferous, while other portions would form a pudding-stone of golden wash, the gold of which, as distinguished from the fine flaky character it usually had, was of the size of beans.

"While the rim-rock arising from the gutter on the north-east side was, as we have seen, smooth and regular, that of the Lawrence side was rendered remarkable by 'crab-holes,' as they were called by the miners. These were irregular corrugations, not parallel or straight, but narrowing or opening out at intervals. The cavities were as much as 15ft. deep; they were covered with a casing of cement as regular as plaster, and the material which filled them was a different-looking cement from that of the main body, the line of division between the two being so marked as to be of assistance in blasting.

"*The north-east wall continues under the Lawrence rim-rock.* [The italics are mine.] In working along the smooth face of the north-east rim, a party of miners followed it and were working their way underneath the south-western 'reef' before they discovered their mistake by hearing the blasting of those above them.

"To recapitulate its main features; it [the Blue Spur] consists of a mass of cement and conglomerate, lying in a depression formed in the quartzose mica-schists of the Wanaka series, and transverse to the present watershed of the district. The country has a dip of 15° to 20° south-west, the inclination increasing near this deposit. The rock on the north-east side conforms in dip to the bounding-wall of the deposit on that side. On the Lawrence side there is no conformity; the schist is disordered; and the boundary between the conglomerate and the country-rock is almost obliterated. On the north-east side the bounding-wall, when first uncovered, had a smooth polished surface. On the Lawrence side corrugations and irregular holes were common in the rim-rock. The north-east wall continues under the face of the opposite side. The gutter itself is in places very irregular; it has one particular break of 20ft. in height; it is separated from Gabriel's Gully by a rocky ridge, and has a general rise towards Munro's Gully.

"The deposit has a roughly-bedded structure, indicating a gentle dip south-eastward, or towards Gabriel's Gully. The wash at the north-west, or towards the Munro's Gully end, is the coarsest. Along its shorter axis the dip is scarcely noticeable, save near the edges. It is more flat on the Lawrence side.

"Beds of lignite occur, confined to an upper horizon of the deposit. The dip of the gutter would bring the conglomerate above the present surface as we go north-west. It is therefore not surprising that no traces of it are found in that direction beyond Munro's Gully, for erosion has removed it."

This description of the Blue Spur deposit is the best and most exhaustive that has come under my notice. When the examinations detailed above were being made, some of the facts mentioned could not be verified, hence the fulness of this extract; and it remains but to add to Mr. Rickard's description some facts that appear to have escaped his notice. As to the "Genesis of the Blue

Spur Deposit," some remark will be made further on. In his conception of the origin of the deposit Mr. Rickard generally agrees with the views put forward by Professor Hutton, and I will therefore quote what the latter says descriptive of this deposit :—

"Blue Spur, Tuapeka: In this locality a small patch of conglomerates are found occupying the top of the ridge between Munro's and Gabriel's Gully. These conglomerates are formed of pebbles of quartz, purple jasperoid slate, and fragments of schist, bound together in a blue clayey matrix. They occupy a cup-shaped depression in the schist rocks, and dip to the east.*

"Seated on the top of the saddle that divides Monro's from Gabriel's Gully is a deep cup-shaped hollow in the schist rocks which has been filled up much higher than the present lips of the cup by gravels cemented into a hard blue conglomerate. This is the Blue Spur, famous for the immense quantities of gold that have been derived from it. On close inspection this hollow is seen to have been an old mountain-tarn with smooth polished sides, which have, however, now decomposed into a blue clay to a variable depth of from 2in. to 6in. Although I could detect no striæ on the sides of the hollow I have no doubt but that it was excavated by a glacier. This old rock-basin is filled up with beds of conglomerate that dip to the east, and as a rule the stones get smaller towards the east, which, together with the direction of the dip, prove that the old tarn was filled up from the west. The conglomerates consist in great part of pebbles and subangular blocks of green quartzite, and a dark purple jasperoid slate with quartz veins, which rocks do not exist nearer than the Tapanui Mountains, west of the Clutha River."†

To these descriptions there has to be added the results of the recent examinations made. It was noted that on the western or Lawrence side there is an undoubted dip of the Blue Spur deposit to the eastward, but perhaps on account of the lapse of time, and the denudation that has taken place since the schist rock was laid bare, the extreme irregularity in the surface of the older rocks that has been described by Mr. Rickard was not noticed. At the lowest level at which workings are now carried on silt and water prevent the bed-rock from being seen, and at no point could the eastern slide-wall be observed to the level where it comes in contact with the schists directly underlying the conglomerates west of the smooth wall or surface of the slide. Therefore the descriptions given have to be accepted in so far as they apply to the condition of the under-surface west of the slide, and in the gutter where the slide undercuts the schist rock. Thus all except the lowest part of the conglomerate cement could be examined, and this consisted, immediately above the bottom, of an angular schistose breccia, such as might very well have been derived from the neighbouring country. The higher part of this was described as being relatively poor in, or devoid of, gold. Above this were rounded and subangular conglomerates extending upwards to the lignite seam. Against these, sluicing operations were being directed with, as was understood, paying results. Greyish-greenish sandy beds followed, and over these was an impure seam of lignite, the total thickness from the lowest gravels to this point being perhaps 120ft. All the beds below the lignite seam are purely or mainly formed of schistose material. In an estimate of the whole, sandstones occupy a very subordinate position, and in the lower or schistose part are found the great bulk of the jasperoid or dark-purple boulders that are so conspicuous in the tailings after the bulk of the lighter material has been washed away. These purple jasperoids have a crystalline structure, and abound in magnetite. It is very unlikely that they have been derived from the Tapanui Mountains, as they belong to the deeper-seated rocks of the crystalline axis running from Lake Wanaka to the Lower Waipori. As the beds are seen to dip both to the north-east, towards the smooth wall or slide, and to the south-east, or from Monro's to Gabriel's Gully, the true dip is between these points; but, in any case, there is a rise of the floor of the deposit from Gabriel's towards Munro's Gully. Following in this direction, and on the present greater height of the eastern part of the deposit being reached, coarse material, apparently belonging to an horizon below the lignite, is seen at the surface. Sluicing is carried on in these, the tailings being discharged into Monro's Gully. Between these and the deeper working discharging into Gabriel's Gully, and towards the western side, an old working-face exposes the higher beds of the deposit. The conglomerates here are well rounded, and consist mainly of sandstones, and there is at this place a comparative absence of jasperoid boulders, showing, as has already been hinted, that these have not been derived from a sandstone area. Mr. Rickard mentions a jump of 20ft. in the schist-floor in passing from Gabriel's to Monro's Gully, by which it is understood that the wall of rock faces the Gabriel's Gully side. There is also, between the present deeper workings and the part of Gabriel's Gully opposite, a ridge of underlying rock, which, from the westward, continues till it abuts against the slide. These may merely be irregularities of the old surface existing before any part of the Blue Spur deposit had been laid down, or they may be due to cross-faulting prior to the formation of the principal slide.

The great structural feature of the Blue Spur is the limitation of the conglomerate deposit on its north-east side by a remarkably well-defined fault, which is of such a character that it should be capable of being traced to considerable distances, both to the north-west and to the south-east, inducing the very decided plunge of the deposit to the south-east. The probable existence of cross-slides anterior to the formation of the main eastern slide has been mentioned. The 20ft. wall of rock indicated by Mr. Rickard, or the ridge separating the deeper ground from Gabriel's Gully, may of themselves not be evidences of this cross-faulting; but, as along Gabriel's Gully there is a yet deeper depression, and the schist rises high on to the hill-slopes to the south-east before reaching the Weatherstone area, having regard to the general dip of the beds, it seems almost a necessity that these peculiarities are best explained by supposing a fault or faults to be present. The schist-floor rising to the north-west, no auriferous breccia conglomerates have been traced on the northern side of Monro's Gully. Although, with other rocks, quartz is moderately abundant in the Blue Spur deposit, nowhere can this breccia conglomerate be said to approach the character of the auriferous-quartz drifts as seen at Mount Buster, Hamilton's, St. Bathan's, and Criffel, in which localities

* "Geology of Otago": Dunedin, 1875, p. 49. † "Geology of Otago": Dunedin, 1875, p. 93.

the quartz drifts may be considered typical. As noticed by Mr. Rickard, the gold is coarse or fine in different parts of the deposits, and from some of the bands it is absent altogether. There are no means of estimating what amount of gold has been obtained from the Blue Spur since work was first commenced in the breccia conglomerate, but relatively the quantity has been very great. To this, as the proceeds of the conglomerates at the Blue Spur and Weatherstone's, has to be added most of the gold obtained from Gabriel's and Monro's Gullies, Weatherstone's Flat, and the Tuapeka River.

Weatherstone's.—Weatherstone's Diggings lie south-east from the Blue Spur, and are separated from Gabriel's Gully by a ridge of hills 300ft. to 400ft. in height. In what is nearly the line of the eastern wall or slide bounding the Blue Spur deposits, breccia conglomerates begin near, but south of, the saddle leading into the watershed of Weatherstone's Creek. The auriferous gravels in the basin of Weatherstone's Creek are practically of the same nature as those of Blue Spur. Like the latter, they to the eastward are cut off by a fault, and they have also a dip to the south-east, and in this direction are like the Blue Spur deposits, limited by the uprising of the underlying schists.

The beds begin near the saddle between Weatherstone's and Gabriel's Gully, and, with a greater width of exposure, dip under the lower grounds of Weatherstone's Flat and also towards the slide or fault-line on the eastern side of the deposit. At some places, beds of sandy clay are more pronounced than at the Blue Spur, and there is an absence, or comparative rarity, of the purple jasperoid boulders. Over the lower grounds, and on Weatherstone's Flat, a rewash of the deposit overlies it. In this the gold occurs in a concentrated condition compared with the yield from the main body of the cement, which is not nearly so rich as at the Blue Spur, or, at all events, the rich strata have yet to be discovered.

Deep sinking on Weatherstone's Flat has shown that the deposit here approaches 500ft. in thickness,* and, as it must be assumed that as great a thickness of the upper strata has been removed by ordinary denudation, it will not be too much to say that originally the beds must have been from 700ft. to 800ft. thick. The Blue Spur has in like manner been reduced by denudation by an equal or greater amount. Apparently no attempts have been made to trace the south-eastern limit of the cement-area at Weatherstone's, and therefore no cross-fault has been proved. It was assumed, and it is evident, that there is deeper ground to the south-east of the prospecting-shafts, and, however the auriferous area is terminated, the northerly dip of the bottom under the cement must be very abrupt. The results of prospecting the deep ground proved that the wash was not rich enough to induce those engaged in it to continue the work. Gold is, however, being obtained from the cements in the western side of the area, and one or two parties are engaged sluicing the old tailings and the rewash of the cement itself; but on the whole Weatherstone's as a field for mining appears to be in a very backward state.

Quoting from Mr. Cox's report on the cement deposit at Weatherstone's already cited, he says,—

"Passing over the ridge between Gabriel's Gully and Weatherstone's no cements are met with until after crossing the summit, but, on the spurs falling into Weatherstone's, beds or benches of cement have been found which yielded in some cases a considerable quantity of gold, while in the gullies below them no gold was to be found. This fact would point to more than one rearrangement of the beds since the gold was originally deposited in the cements. At Weatherstone's the cements appear again, covering a considerable area of ground, but lying much lower than the Blue Spur; and, although a large amount of work has been expended by different prospectors in sinking shafts on the various claims, there would seem to be a tendency to wait until Messrs. Brown and Gascoigne's claim, which is further on than any other, has been proved before any large expense is undertaken by the others in erecting crushing machinery.

"At the claim above cited a battery has been erected, and the mine prospected by several shafts sunk at intervals from the edge of the flat, where the cement commences, up to the battery, it being only a very short distance beyond this, in the direction of the Blue Spur, before the schists make their appearance, rising into a spur, which separates Weatherstone's from Gabriel's Gully.

"The result of these shafts has been to show that the cement at this point runs in a trough, the first shaft bottoming at 10ft., and the others at various depths up to 60ft.; and Mr. Gascoigne informs me that in all probability the greatest depth reached in this claim will be 100ft. . . .

"The cement has been traced all through the flat towards Lawrence, and at a place called the Mound a shaft has been sunk to a depth of 500ft. through these cements, but has not received further attention since the bottom was reached, so I infer the results obtained were not so satisfactory as could be wished. . . . At places the prospects of the wash-dirt are very rich, some that I assayed last September returning 2oz. 17dwt. of gold per ton, and doubtless there is some richer even than this. It has, however, been ascertained by experience that the gold is by no means evenly distributed, but runs in patches, without apparently any set rules; so that any estimate as to the richness of the deposit from mere assays is nearly, if not entirely, useless. The blue cements of Weatherstone's are capped by red ones, which, however, are only due to the oxidation of the pyrites which has taken place near the surface, as they partake of all the characteristics of the true cements, varying only in colour, and most assuredly not being a rewash of these beds. The same remarks apply equally well to the cements of Blue Spur and Waitahuna."

Forsyth.—This locality lies within the watershed of the Waitahuna River, and the beds to be described are exposed in the railway-cuttings from the saddle by which the line passes from the Tuapeka watershed to near Waitahuna Railway-station. The beds as seen in the railway cuttings are slaty breccias of schistose material, similar in character to, if not so coarse as, those at Blue Spur. The limits of the area which includes these beds were not determined, and but little could be learned respecting them. It appears that the breccias here have been recognised as a continuation of the Blue Spur deposit, and have been prospected, but found not payable. Nevertheless it is evident

* See extract from Cox's report.

that the deposit is gold-bearing, as shown by the old workings in the creek leading to the Waitahuna, opposite the township. This has been worked right up to the breccias, and as far as they extend along the creek. Many localities like this cannot be fairly prospected on account of the lack of a sufficient water-supply.

Waitahuna Gully.—This trends north-east and south-west, making junction with the main valley of the Waitahuna about a mile and a half above the Township of Havelock. The valley is nearly straight, and lies along a line of fault which is a continuation of that seen at the Blue Spur and at Weatherstone's. The hill-slopes are very abrupt on the eastern but more moderate on the western side of the valley. Towards the lower end the width of the valley is inconsiderable, being from side to side a few chains only; it is filled, to the point where the stream divides, with tailings from claims on its western side, and the line of fault is continued along the lesser branch to and along the Scandinavian Claim.

A quarter of a mile before reaching the store and post-office an extensive sluicing claim is situated on the east side of the valley. This is being worked in breccia-conglomerate cements, evidently the same in age, and mode of their formation, as those of the Blue Spur. Here, as at the Blue Spur, the deposit dips to the south-east, and forms a basin of deep ground in that direction to the point where the valley is again narrowed. The shallow ground within the present workings shows the surface of the underlying slates plunging at a steeper angle than it does between Monro's and Gabriel's Gully, in the Blue Spur. The material of the conglomerates, though recognisably similar to that of the Blue Spur, is yet somewhat different, there being a greater number of sandstone boulders present in the lower part, while the jasperoid rocks, though plentiful, are not so abundant. The condition of the deposit is also different. It has been subjected to greater pressure, causing a movement of the mass within itself, which has resulted in the polishing and slickensiding of almost every boulder of any size in the lower part of it. Iron or manganese seems to form a slight coating on the surface of these polished boulders, and they shine as though an artist in boot-blacking had devoted his utmost skill to their burnishment. In the middle part of the deposit this is less apparent, and for some 15ft. or 20ft. from the surface the gravels, through the partial decomposition of this cement and their own substance, are of a rusty-brown colour. The ground has been worked from the outcrop towards the south and south-east till the gravels show a face of from 40ft. to 50ft. in height, beyond which it is not followed,—whether on account of the lessening fall of the tail-race or other difficulties, was not ascertained. The area covered by the conglomerate at this place is less than at Weatherstone's, or at the Blue Spur, but the higher dip of the bottom, which, at its least, is from 15° to 20°, must give a great depth of deposit in the middle of the little basin. Washing-up was going on at the time the locality was examined, and the claim-holders appeared to be satisfied with the results. Here, as at the Blue Spur, there is a considerable quantity of free iron-pyrites found in the boxes and tail-race on cleaning up. Part of this may be liberated from the material of the cement, due to the pounding-up of pyritous boulders; but unquestionably the greater part of the pyrites have formed in the sandy or clayey parts of the deposit since it was laid down. To the eastward the conglomerates are clearly limited by the line of fault, already mentioned as running along that side of the valley. To the south and south-west the beds rest upon and rise on to the higher grounds to the north-east and north.

It has been mentioned that, especially in the lower part, sandstone boulders, of moderate or large size, are more abundant here than in the lower beds at Blue Spur. These sandstone boulders appear to have been derived from the near neighbourhood, as on the ridge of hills immediately to the west rocks of identical composition are found *in situ*.

Scandinavian Claim.—This is situated near the head of the south-western branch of the creek and in the line of the lower part of the valley. The area of conglomerate deposit is small. All of it cannot be seen, but apparently the whole may not be more than 7 or 8 acres in extent. The breccia conglomerates appear at the surface over less than half that area, and the exposure is made at the southern end of their development. The fault-line on the eastern side of the deposit is as clearly exposed as at Blue Spur, and in every particular is a counterpart of the slide at that place. At the southern end the workings are limited by the uprising of the older rock, which forms a comparatively even face, trending nearly east-and-west, and with the fault-line forming an angle of about 80°. The general character of the conglomerates is similar to those last described. The conglomerates once occupying the angle described at the southern end of the claim have been washed away to a depth of 50ft., or thereabouts, as measured along the sloping wall of the fault-line, and they have also been removed from the opposite steep slope down to the working-level of the tail-race, which had to be cut through a high barrier of the conglomerates to the north, that, for some reason, has not been removed. The claim is not now working, and there was no one on the ground from whom information could be obtained as to the cause of the suspension of the works. The conglomerates within this area sit upon a ledge, or in a small basin considerably above their level in the deepest part of the area last described. The manner in which this area is closed at the southern end indicates that, as on the north-western side of Monro's Gully, though the line of fault may be, and most certainly is, continued, no breccia gravels come in contact with it for some distance.

Of the cements at Waitahuna Mr. Cox says, "At Waitahuna the cements are, to all intents and purposes, the same as those before described [at Weatherstone's and at the Blue Spur]. On the north-east side of the cement the bed-rock is very steep [the presence of a fault seems to have escaped Mr. Cox's notice], but more shelving on the south-west side. The cement narrows to the east, away from the Whim Claim, but widens out westward, stretching up into the spurs above Maori Gully. At Barr's Sluicing Claim, at the head of the gully, the whole body of the cement down to the main bottom is being removed, while at the Whim Claim they are working on a false bottom, and are only sluicing and not crushing, although it is now proposed to erect a battery in connection with these works. The Somerset Claim is sinking a shaft, which, at the time of my visit,

was 120ft. deep, a colour of gold being got. The character of the cements in this shaft is very different from that of those in other parts of the field, being very brown, and the schists much decomposed."

Glenore.—There is no visible exposure of breccia conglomerate at this place, but it was reported to me that breccias similar to those of Blue Spur underlaid the superficial gold-bearing wash of the creek-bed, as far east as this has been worked. It appears also that the breccias are met with to the south-west, on Adams's Flat, as shown by the above quotation from Mr. Cox's report. Slaty breccias of schistose material occur at various places over the area of the Kaitangata Coalfield.

Speaking of the breccia conglomerates at this place, Mr. Cox says, "At Adams's Flat, near Mount Stuart, the cements occur again, but have only been worked as the bottom for the alluvial diggings of this district. A few shallow pits have, however, been sunk at different places, and all of these, when tested, showed a colour of gold, but never very much. Since none of these shafts, however, have bottomed, there is practically nothing known of the cement there. . . . From Adams's Flat the best idea can be obtained of the flow of the glacier which deposited these beds, for from here a distinct depression in the country can be seen in the direction of Waitahuna and Weatherstone's. Moreover, the character of the beds is so identical along this line as to leave no doubt in my mind that the rocks constituting the cements have travelled in this direction—namely, from north-west to south-east, and also that the means of transport has been glacier-ice." *

Tuapeka River.—A patch of Blue Spur conglomerate, it is said, occurs about two miles up the Tuapeka from the bridge on the road to the Beaumont, but this was not examined, and it is possible that the workings carried on there may be in another class of deposit.

The breccia-conglomerate deposits of this part of the district have been described consecutively, disregarding for the time being another class of auriferous strata which in other parts of Otago are, as gold-bearing deposits, of as much importance as the breccia conglomerates of the Blue Spur. Reference is thus made to the auriferous quartzose gravels and grits that are widespread over the greater part of Otago, and which have yielded by natural processes to younger deposits, or at the instance of man directly, perhaps the greater portion of all the gold hitherto raised on the Otago goldfields. Such gravels occur in the district around Lawrence, and, strangely enough, in the close neighbourhood of the breccia conglomerates, but never (in this district at least), except it may be in the Waitahuna River bed at Havelock, directly associated with them. This is indeed surprising, since, collectively, they will have to be considered as belonging to the same formation, and in the general sequence will have to be considered as being the next following beds to the breccia conglomerates. In other parts of the Otago district this association is seen, and actual interlamination of the two kinds of deposit takes place, as for instance within the Kaitangata Coalfield. Nevertheless, within the Tuapeka district they are ever apart, and hold a vertical relationship that is sufficiently puzzling. Their lower beds are usually formed of quartz detritus, more or less, sometimes completely, rounded, over which are more quartz drift or beds of clay and dark shales with seams of lignite or brown coal, usually again followed by quartzose sands of finer grain, sometimes by an upper conglomerate mainly composed of quartz pebbles.

Beaumont Hill.—On the road from Lawrence to the crossing of the Molyneux River at the Beaumont, after crossing from the watershed of the Tuapeka River, about a mile from the saddle, there is a development of quartz gravels, forming a hill of some height, and they also fill the valley to the eastward. The underlying slate rocks are so placed that the lowest or any horizon of the gravels forming the hill might easily be prospected. A pit for road-metal has been made in the side of the hill, and from the material thus taken it is said gold, but not in paying quantity, was obtained. Elsewhere in these beds no signs of prospecting can be seen; and where the underlying rock appears, near the road, exposing the lower strata of grit, the beds have not been prospected. This area of quartz grits extends south in the direction of the lower valley of the Tuapeka River, between which and the Molyneux there appears to be a considerable development of the same gravels, generally occurring as isolated patches on the higher lands.

Monro's Farm.—There is an area of quartz drift associated with beds of lignite present between the lower part of Monro's Gully and the saddle by which the main road leads to Evans's Flat. The grits, &c., show in the road-side near the farmhouse, but nothing could be learned respecting the prospecting of the beds. They appear to extend some distance along the south-east of Monro's Gully.

Lawrence Racecourse.—The depression west of the Town of Lawrence, where is a racecourse, and once was a coal-mine, brick-field, &c., has quartzose gravels underlying the lignite seam, which may or may not prove auriferous, but which should be tried, as all such deposits are worth prospecting, more especially those that are resting on gold-producing rocks like the schists of this part and Central Otago. Further removed from the source of the gold there are great bodies of quartz drift and sand which are not likely to yield, yet sometimes do contain, payable gold, and it is therefore reasonable to expect gold in the same beds when they lie near to or on the rocks yielding gold, and from which the quartz drifts have been derived.

Coghill's Hill, Waitahuna.—This is 800ft. above the level of Waitahuna Railway-station. The lower and middle parts of the hill are formed of schist. On the top there is a deposit of quartz gravel and grit about 20ft. thick. The lower half of this is a free-working deposit that may easily be pulled down with the pick; the upper part is cemented into a hard rock that would have to be removed by blasting. These sands are gold-bearing. They are said to have been rich enough to pay highly if water could have been got to sluice them *in situ*, but, this being impossible, the material had to be carted to the Waitahuna River, and the cost of carting rendered the working of the deposit unprofitable. No work was being done when the place was visited, and clearly, unless

* It seems to me that Mr. Cox has overlooked the occurrence of what at Coombe's claim may be described as coal-grit, which beds are stated to be younger than the cements: hence these deposits are not identical with, nor of the age of, the lower breccia conglomerates of supposed glacier origin, yet lie in the line indicated.

the ground be very rich, without water being brought on to the ground the method adopted of working was not likely to pay. The area of the deposit is also too small to warrant the construction of costly works for the purpose of bringing water on to the place.

Sutherland's Hill.—This lies to the east of Coghill's Hill, and is divided from it by a deep gully. It is also capped by quartz gravels and cements, but so far as could be seen no prospecting for gold has been done on it. The area of quartz gravels is greater than on Coghill's Hill, and should they prove auriferous, which is likely, water could be got on to some parts of the deposit, or the wash could be shot down the hill to the Waitahuna River.

Hills East of Waitahuna Gully.—There are several patches of quartz grits lying on the hills immediately to the eastward of Waitahuna Gully. Gold is reported to have been found in these gravels, but, all the water that could be brought on to the ground being employed elsewhere, nothing appears to have been done in the way of testing them.

Waitahuna Flat.—Above and below the Township of Havelock, beneath the superficial gravels deposited by the river, lie beds of clay, lignite, and quartz drift, of which the latter, it is generally supposed, may be gold-bearing. No serious attempt has been made to reach through this false bottom to the bed-rock, on which it may be expected the more auriferous gravels will rest.

Manukau Hill.—This lies on the left or east side of the railway-line from Lawrence to Milton, and nearly opposite Mount Stewart. As seen from the railway there appears to be a small area of quartz grits on the top of the hill. These have been worked with highly paying results, but the deposit is isolated and apart from any extensive tract of the same material; and where similar beds are present, as is the case to the south and east, they are either not prospected, or, being prospected, have proved not sufficiently auriferous. Mr. Cox says, "At Coombe's claim, between Adams's Flat and Waitahuna, grits occur which resemble the coal-grits as developed at Pascall's. As far as I can judge, these beds are younger than the cements themselves, since the coal at Pascall's no doubt overlies the cements, and the grits rise into hills in the surrounding district (quartz hills) between Adams's Flat and the Tokomairiro Plain."

Glenore Railway-station.—Half a mile above the railway-station at this place the tops of the hills are covered with a deposit of quartz grit, loose, or cemented into a hard rock. The beds strike away to the south-west in the direction of Stony Creek and Stirling, and gradually dip under the Tokomairiro Plain and its continuation as low ground to the Molyneux River between Stirling and Kaitangata. The low hills and downs between the Tokomairiro Plain and Kaitangata Lake are composed of quartzose sands and grits, with beds of shale and brown coal, all of which may be seen in the numerous railway cuttings or in natural exposures over this part of the country. These may possibly be gold-bearing, but there is less likelihood of their being so than are the similar beds that lie farther among the hills to the north and north-west. Yet it is not to be denied that payable gold is found in similar beds much farther removed from the source whence the quartz grits have been derived than are the beds skirting the Tokomairiro Plain, and forming the low hills and downs at its western end. The same remarks apply to the whole area of the Kaitangata Coalfield, and to the slopes of the hills to the north of the Tokomairiro Plain as far as the Waihola Gorge or thence to the Waipori River. Further on, when other facts have been brought to bear on it, this subject will have due consideration.

Upper Waitahuna.—The road from Lawrence to Waipori crosses the sources of two branches of the Waitahuna River in which there are recent alluvial deposits that deserve some notice. It is not my intention, as it would serve no purpose, to describe in detail modern river- and creek-gravels, wherever these may chance to be gold-bearing, but there are instances of more than ordinary interest, illustrating in what manner some of the older drifts have been formed; and the deposits along the source branches of the Waitahuna River is a case in point. On the road from Lawrence to Waipori the schist rock is at many places so crowded with thin laminæ of quartz that sometimes from a fifth to a third of the whole may be said to be quartz. The slate in such cases very easily decomposes, and readily falls into a micaceous clay, speedily removed by the agency of water, while the harder quartz is left or carried along to where it forms beds of nearly pure quartz gravel or angular grit, in the gully-bottoms and along the banks of the different creeks. This is seen notably at two places on the road from Lawrence to Waipori, and in both cases the quartz gravels have been turned over in search of gold. From Lawrence to Waipori there are no reefs or reef-quartz to be seen along the road, yet the gold of the valleys has evidently been derived from the adjoining hills. This is shown by the manner in which the workings have followed the lesser gullies to their heads, or, it may be, on to a spur, along which the last efforts of prospecting have been made. Clearly the gold has been obtained, not from distinctive reefs, but from bunches and formations of quartz in the schist rock. The considerable body and the purity of the quartz shingle formed as above described showed distinctly how in a more extensive watershed much larger masses of quartz drift might be formed; nor was such an illustration far to seek.

Upper Waipori Valley.—The low grounds of this part of the Waipori Valley may be divided as follows: First, the Jutland Flat and river-valley, above the township; second, the river-flat below the township to Post Office Creek; third, Lammerlaw Creek.

The Upper Waipori Valley and Jutland Flat to the junction of Lammerlaw Creek is filled with detrital matter, mainly quartz and beds of clay in two divisions, an upper and a lower. At the base of the upper division, 10ft. to 20ft. from the surface, there is over the Jutland Flat a deposit of clay and lignite which constitutes a false bottom, to which level early mining operations were carried, and beyond which dredging operations are not carried at the present time. Shallow old workings extend up the valley some considerable distance, all of them apparently on this false bottom, as are the workings on the south side of the valley, opposite the township. Where the clay and lignite beds were absent, in such workings as were examined by me, it was very hard to distinguish between the upper and the lower series of quartz gravels, although this appears to be easily done by the miners. The underlying beds, below the lignite, appear to be mainly composed

of quartz sands of coarser or finer grain. Their thickness has not been ascertained, except it may be in the vicinity of the present hydraulic workings of the deep lead close to the bank of the river. The lower flat, from the township down stream to where the river-bed is seen to be schist rock, is, like the upper flat, covered by a superficial wash, having clay and lignite as a false bottom, or simply, as higher up the stream, there is a parting, often obscure, which limits the superficial gold-bearing drifts, and separates them from the lower. Together, the upper and the lower flat may have an area of some two square miles, extended along the river-valley a distance of some six miles.

What is singular and distinctive of this Waipori drift-deposit is that it is confined to the low grounds of the valley, and, unlike the similar deposits of the Tuapeka and Waitahuna watersheds, there is not a trace of it on the higher grounds. It is also distinguished by the total absence of cement-stones, which have formed elsewhere in similar deposits, although these abundantly occur to the north-east and the south-west, where the quartz grits occur on high ground. Weighing all things together, the conclusion is that these Waipori quartz drifts have originated much in the same manner as, but on a larger scale than, those described as present in the Upper Waitahuna Valley.

Deep-lead, Lower End of Lammerlaw Creek.—A little above the junction of Lammerlaw Creek a deep and narrow run of quartz drift trends nearly parallel with the creek, and has been traced across the valley of a small tributary stream to a distance of a quarter of a mile, when it divides, becomes tortuous, and shallows out to the surface. This narrow run of deep ground (some 30ft. to 60ft. in depth) is thought, on entering the valley of the main stream, to be continued in a south-east direction, or at an angle across the flat opposite the township; but this is unlikely to be the case, as on joining the main body of drift its distinctive character as a specially rich run or lead would be lost, due to the greater power of the main stream in comparison with Lammerlaw Creek. There can be no doubt that the ravine of the Deep Lead was once the bed of Lammerlaw Creek.

Island Block, Old River Channel.—From the Beaumont to five miles beyond Rae's Junction the main road along the west side of the Molyneux Valley is some distance from the river. The river runs along a narrow valley, rock-bound, and closely backed by hills on each hand—hardly a gorge, but something like a gorge is thus formed. Island Block constitutes a range of hills of moderate elevation, which, with the hill-slopes on the opposite side of the river, confine the Molyneux within the limits of a comparatively narrow channel with steep banks, perhaps correctly enough called a gorge. On the western side of the Island Block Range an old channel of the Molyneux separates it from the Spylaw Range to the west. Near the southern end of this old channel of the Molyneux the extensive hydraulic-sluicing operations of the Island Block Company have for some time been in progress.

Mr. Gordon, in his report of last year,* says, "This company has done a considerable amount of work, and have expended over £21,000 on the plant and claim. The place where they carry on their operations has been known for many years as the Island Block, on account of a rocky ridge running alongside the river on the western side for a distance of about three miles and a half; and on the western side of this ridge is a wide low valley between it and the main range. This ridge is termed the island: hence the name of the Island Block. Judging from the topographical features of the country, there seems no doubt that the Clutha River at some time flowed at the western foot of this island, as a distinct channel can be traced out of the present river-bed where the low ground on the southern end of the island or rocky ridge joins the low valley previously referred to and the river. After the company commenced operations, near the side of the river on the southern end of the island, they got into a deep gorge full of rough rounded river-wash, in the bottom; and on the southern side of this deep gut, on the shelving reef, very rich auriferous drift was found. But there was very little gold found in the bottom of the deep gut, the best layers being higher, amongst the drift. On taking a cut up from the river towards the main range they got off the run of gold, and after working over twelve months, sinking paddocks here and there, they came on rich auriferous drift in the low valley on the western side of the island at the southern end; but it is really very questionable if they have got the original river-bed yet. The valley is from 20 chains to 35 chains in width, and it takes some time to get a cut put across this. Judging by the curves of the main range on the western side of the island, the river has at one time flowed close to the foot of the range, and wherever a gentle curve inwards is found in the course of a stream the water follows that curve. Hence, it seems to me that probably the deep ground will yet be found between the present workings and the main range; although there is little doubt but that the river must have had different channels from time to time along the valley, and that the present workings are in one of these. The ground is about 40ft. in depth. At the time of my visit there was in the centre of the paddock a deep gut. The rich layers were a considerable distance above the bottom, from which very good prospects were being obtained by washing a little of the drift on a shovel."

Under the loamy subsoil the drift is moderately coarse, well-rounded river-wash, consisting mainly of the harder parts of the schistose rocks of the river-valley from this point to the upper end of the Dunstan Gorge, mixed with a proportion of sandstones and quartz pebbles. There are no clay banks dividing the drifts into different parts, and the whole is just what might be expected as the deposit of a large and moderately-swift running stream. If this is to be taken as illustrative of the action of a considerable river, and comparison made between the deposits at this place and some or many of the supposed old river-channels, the results, it will be found, do not always agree, and there would be some difficulty in understanding such deposits as are found at the Blue Spur, Weatherstone's, the Bannockburn, the Nevis, and the Cardrona if they were strictly to be compared by this standard. But this is not actually necessary, and the deposits of the old channel of the Clutha at Island Block may be typical of but one phase only of the river's action, and the slightly different though generally agreeing type may yet be discovered.

* Goldfields and Mining Report of New Zealand, 1893. Report by Mr. H. A. Gordon, Inspecting Engineer, page 112.

Moa Flat, Miller's Flat, and Anderson's Flat.—These are different parts of a rather extensive area of flat land which have resulted from the infilling of an old lake-basin, the southern rim of which, and its bed, has been deeply excavated to form the present channel of the river. The flat is almost level, and there are no series of descending terraces to the level of the river, but between the high banks it looks as though the river had at once selected its course and rapidly cut this down to the level at which it now flows. Toward the northern end and on the west side of the river there are some high terraces resting against the southern slopes of the Mount Benger Range, which indicate that the lake-basin has been filled to the level of their upper surface. Whether the entire area of the old lake-basin was at any time filled with gravels to this level seems doubtful. The nature of the lowest deposits in the Moa Flat lake-basin could not be definitely determined, but beds of lignite are exposed in the bed of the river opposite Ettrick, and along the foot of the hills on the opposite eastern bank of the river there are many white quartz cement boulders, the bed-stone of which has been formed in the quartz drifts of older date. A low saddle leads from Moa Flat by way of Moa Flat Station into the Pomahaka Valley, and it is evident that there has been a connection between this part of the Molyneux Valley and the low country west of the Tapanui Mountains, over which quartz drifts and lignites are spread as far as the Mataura River and the Southland Plains.

Coal Creek, Five Miles above Roxburgh.—Between Roxburgh and the entrance to the gorge of the Molyneux, a little above the junction of Coal Creek, the valley expands to a width of two miles, this wider portion having a length of five miles. At and near the mouth of Coal Creek quartz grits and sands are seen on the banks of the Molyneux and in the banks of the creek at intervals, to where they are overlain by a very thick bed of lignite, or brown coal. The grit-beds apparently strike across the river to the southern bank, but are not exposed to view, on account of the heavy terraces of river-shingle on that side. It is noticeable, however, that to the point where the grits should be on the southern side the banks of the river have been worked for gold, but for some distance above this point there is no working of any consequence. This may be interpreted as meaning that the quartz drifts that have been washed away were gold-bearing to such a degree that whatever gold they yielded to the ordinary gravels of the river-bank made the latter worth working. Coal Creek brings down from the southern spur of the Old Man Range very coarse *débris*, often large blocks of schist. These, forming terraces, to a large extent obscure the area over which would otherwise be exposed the quartz drifts underlying the coal. Their possible area at the surface is also lessened by the brown coal and other beds overlying the grits.

Noisy Creek.—From Coal Creek the road rises along hilly country on the right bank of the river till at Noisy Creek the difference in elevation is some 1,200ft. Grits and quartz sands show at many places along this part of the valley, and at places on the descent into Gorge Creek. At the crossing of Gorge Creek there is a small patch of sands and indications of lignite, and on the roadside between Gorge Creek and Coal Creek (Bald Hill Flat) quartz grit occurs at several places. These drifts have been prospected, but yield nothing more than the colour of gold.

Bald Hill Flat.—A number of sluicing-claims are being worked on Bald Hill Flat, and along the bed of Coal Creek to the bridge on the main road. The wash is modern schistose *débris* carried down from the slopes of the Obelisk or Old Man Range, and therefore requires no special description. This wash, varying from 10ft. to 20ft. thick, rests on a bottom of white clay and quartz grit, or yellowish quartz sands, that are chiefly seen in the southern end and towards the west side of the basin. The surface of the schist rock on the east side slopes at a moderate angle to the west underneath these sands, &c., but on the west side the younger beds terminate abruptly against a wall of schist rock. Where the junction is laid bare there are no very distinct indications of faulting; but more to the south, in the same line, the spur from the high range separating Coal Creek from Gorge Creek, there is strong evidence of the existence of a fault. In the middle of the northern broader part of Bald Hill Flat (sometimes called Spear-grass Flat) are two isolated hills rising from 100ft. to 150ft. above the general level. These are capped by coarse river-gravels which on the western or lower hill have been to a considerable extent worked for gold, without, however, yielding sufficiently, as at the time the ground was visited work was suspended. These gravels are distinct from and older than the slaty schistose gravels of the southern end of the flat, and evidently are due to the action of the Molyneux at a time ere it had cut the deep gorge which it now follows from the Manuherikia Junction to and beyond the junction of Gorge Creek. These coarse river-gravels must at one time have been present over the whole area of Bald Hill Flat.

On the southern point of the range between Bald Hill Flat and the Molyneux there is a small area of well-washed sandstone gravels. These are decomposed so far as to assume the usual light-brown colour of what is known in the Upper Manuherikia and Naseby districts as Maori bottom. They are easily recognised as a fragment of the extensive sandstone gravels that fill or are found in all the valleys and old lake-basins to the north and north-east of this point. At the place here referred to the gravels are at an elevation of about 1,700ft. above sea-level. A small patch of white cement-stones and traces of quartz grit occur at the same place.

Butcher's Gully.—Remnants of a once widespread formation of quartz drift are found from the northern end of Bald Hill Flat, across and along Butcher's Gully, to beyond the junction of the road from Conroy's Gully with the main road leading to Alexandra. Generally the grits have been removed from the higher grounds, and there remain only the hard blocks of grey cement to attest the former presence of the sands; but in the creek-bed, a little south of the road junction spoken of, holes have been sunk to a considerable depth in white quartz grit, which showed all the evidences of being the original deposit, and not a rewash of this into the gully.

Conroy's Gully.—This is reputed to have been, in gold, one of the richest gullies in the whole of Otago. Conroy's Creek takes its rise from the Old Man Range, near the Obelisk—a solitary rock 80ft. in height and less in diameter, having the appearance of a column or pillar, and to be seen

from far and wide over the country to the east and south. In its lower part the bed at Conroy's Creek forms a narrow gorge or cañon, and it was along this part that the richest deposits of alluvial gold were found. Along the south-east side of the narrow valley runs a line of quartz drift deposit about one-third up the slope on that side. This quartz drift is exposed in the road-cuttings, and traceable as outcrops of white gravel for some distance higher up the gully. It is seen to be highly disturbed, and dipping to the south-east under the schists that form the hills bounding that side of the valley. It is stated that good prospects of gold have been obtained from these quartz gravels, and it is evident that they have contributed towards the enriching of the creek-channel along Conroy's Gully. This line of quartz drift from the foot of the gully should follow the margin of the plain on the west side of the Molyneux to Alexandra, but it has not been traced by me in that direction.

Bannock Burn.—At its junction with the Kawarau, the Bannock Burn exposes in its banks quartz drifts and sands; and these, with beds of clay and lignite seams, extend along both banks for a distance of about two miles from the main river. The same beds extend down both banks of the Kawarau for a mile below the bridge above the Bannock Burn Junction. The Bannock Burn lower valley is separated from the township and diggings of that name by a ridge of hills broken by the gorge of two or three small creeks (Fork Burn) that thus find a way, from the western part of the watershed across a valley depression one to two miles wide, to join the main stream. This valley is considerably above the level of the Cromwell Flat and the valley of the Clutha above the junction of the Kawarau; yet it is clearly an extension south of the Clutha-Lindis old lake-basin prior to the formation of the Dunstan Gorge and the lowering of the waters of the old lake. The Kawarau River now separates this southern portion from the Cromwell Flat. On the southern bank of the Kawarau, and below the level of the Cromwell Flat, there is a variable breadth of river-terrace, due to the action of the Kawarau in recent times. In some parts the gravels there are being worked for gold. At higher levels, under and surrounding the upper township, there is what is called the "mountain-wash," a thick deposit of coarse gravels evidently derived from the eastern slopes of the northern part of the Carrick Range. This mountain-wash is gold-bearing; and a number of sluicing-claims dealing with this are now in operation. Farther east, and at a lower level, the flat between Horne's store and the rocky gorge below Mrs. Robinson's hotel was covered by a lesser thickness of river-shingle and a rewash of this mountain-wash, the whole of the middle and eastern parts of which has now been worked. River- or lake-gravels extend south to the Kawarau Station, and the point where the new road to the Nevis begins to ascend the Carrick Range. Under all these beds there is a development of sands, clays, and lignite or brown coal, and beneath these a variable thickness of sands and pebbly quartz grit. At places these latter beds are highly inclined—almost vertical; while at other places not far distant they are nearly in a horizontal position. A little to the north of Angel's Hotel a line of highly-inclined quartz grit is seen in some of the claims. This crosses the road, and is continued in a south direction along a ridge of low hills that trend parallel to the lower slopes of the Carrick Range. Some of these quartz grit bands are so likely for gold that it is surprising no attempt has been made to prove whether they are auriferous or not. A patch of these gravels lies to the east of the Bannock Burn, about one-third up the side of Carnmuir Range. What of this is now left consists mainly of masses of cement; but at places there are loose quartz gravels, in which a few holes have been sunk, but not recently; and it could not be ascertained by whom nor with what result. These beds in Cairnmuir are 700ft. or 800ft. above the level of the grit-beds in the Lower Bannock Burn, and are completely isolated from them. At Pryde's Coal-mine, two miles south of Bannockburn Township, the beds dip at moderately low angles to the west and south. The quartz grits are exposed in the coal workings and along the banks of the creek. The first terrace-level shows river-gravels, and the higher terraces towards the foot of the Carrick Range mountain-wash. The quartz gravel runs along the western depression into the Upper Bannock Burn (Duffers' Gully), where its course is nearly west. There is also an isolated area of white quartz gravel on the old Nevis Road between the Bannock Burn and the descent of the range on the Dunstan Gorge side. Neither of these two last places was closely examined, though they could be recognised for what they are from the road across the Carrick Range.

The general arrangement of these lower beds in the Bannockburn Basin in the line of section through the township and principal diggings shows the lower beds on the west side as being vertical, or as strata dipping at high angles to the east. Followed to the east the beds show a lessening dip, and the higher beds have more clay banks and sandstone gravels. Near Horne's the dip changes, and beds of lignite and quartz grit appear between the road-line and the rocky gorge breaking through the range of hills separating the broader valley to the west from that of the Lower Bannock Burn. In the Lower Bannock Burn the beds are again represented under the same arrangement, only the higher beds above the coal are absent, and the lower beds abutting against the lower slopes of Cairnmuir are not seen on account of heavy deposits of terrace-gravels.

Nevis Valley.—At the bridge, six miles below the Nevis Township, on the right bank of the river, there is a patch of white quartz gravel. River-terrace gravels overlie this, and the action of the river has to a large extent broken up the cement bands and carried away the underlying grits and sands. Large blocks and well-rounded boulders of the cemented quartz grit are now mixed with the river-wash, and these still overlie and protect the looser and more easily denuded quartz grits. The ground has been worked for gold; and it is evident from the workings that gold was to some extent obtained from the lower beds of quartz grit resting on an irregular surface of schist rock. The Nevis Valley from the foot of the second gorge has a width of about two miles. Near the junction of Coal Creek, and again at the township, considerable areas of the lower flats along the river-bank have been, as shallow workings, turned over in search of gold; but there is little being done in these at the present time. There are a number of claims being worked along the foot of the high terraces and lower hills on this, the west, side of the valley, or in the vicinity of Stewart's Creek. There being an abundant water-supply during the summer months, hydraulic slucing is here

carried on, a superficial coarse gravel overlying quartz grit and beds of breccia conglomerate being operated upon. The underlying beds involved along a line of fault have their west limit along this line. The fault limiting the breccia conglomerate and quartz drift beds can be traced to the foot of the gorge above the township, and in the other direction followed to Gibbston on the Kawarau.

At the township, the shallow workings of the river-flat laid bare banks of clay, gravel, and quartz grit apparently dipping at high angles to the eastward. These beds in the hill-borders at the back of the township are a strange mixture of schistose and sandstone gravels, banks of clay, and beds of white quartz grit. The workings on the flat extended back to the foot of the hills as shallow surface-workings; and, in some cases, on to the hill-slope. Then it was discovered that the underlying highly-inclined conglomerates and quartz grits were auriferous, and ordinary sluicing operations were directed against these. Next, an elevating plant was erected, which has worked to lower levels than was possible with previous appliances. On the opposite side of the creek, MacKersie and party have brought in a race, and are preparing to commence operations—first, by washing away the old workings and recent gravels to the foot of the spur, and, next, the hill-slopes themselves. Ordinary ground-sluicing has effected already the removal of part of the spur on MacKersie's side of the creek; and these works have exposed breccias and heavy conglomerate beds similar to those of Blue Spur and Waitahuna. The conglomerates at this place particularly resemble the slickensided and polished conglomerate deposit described as showing on the west side of Waitahuna Gully.

The junction of these beds with the schist on the west side of the valley may or may not be along a line of fault; but the lower beds of the younger series are here vertical, indicating such movements as might very well imply faulting. In Nevis Burn, along the contact line between the younger beds and the schist, to the westward, the evidence of faulting is more apparent; and in following the line across Dootan's Creek and the saddle-divide between this watershed and the Kawarau at Gibbston, it is clear that the beds are preserved only by being deeply involved between the schist rocks to the east and west, and that on the western side they are suddenly terminated by a line of fault. This line of fault probably runs along the whole of the Nevis Valley from the upper end of the lower gorge to the saddle leading into the Nokomai Creek and the Mataura watershed. North of Stewart's Creek the general dip of the quartz grits is to the west. Further up the valley the coal appears on the east bank of the river, while the quartz grits and breccia conglomerates which also belong to the lower part of the same series dip to the eastward.

Upper Nevis and Roaring Lion Creek.—On the occasion of a visit to the Upper Nevis some years ago nothing was observed that indicated the presence of the quartz grits in this part, and, in spite of descriptions of beds intended to convey the idea that these or the breccia conglomerates are present just above the second gorge, there are doubts that such is the case. The beds described probably are heavy deposits of modern creek-gravel and slope-deposit, which, whatever else is, are there present. At the junction of the two main branches of the Roaring Lion Creek, and at a considerable altitude above the bed of the Nevis, white quartz gravels are present, and extend north and south along the valley of the streams indicated. Gravels of the same type also occur as isolated patches on the higher parts of the range up to about 5,000ft. These particulars regarding the Roaring Lion deposit were furnished by Mr. James Carson, of the Lower Nevis.

Gibbston to the Saddle leading into the Watershed of Dootan's Creek.—At Gibbston there are beds of gritty sandstone and shales with a thick deposit of lignite or brown coal. In the lower grounds heavy traces of river-gravels obscure these deposits, and higher on the range schistose *débris*, as slope-deposit, also to a large extent hides the junction of these rocks with the schists to the west. The coal is worked at about 500ft. above the level of Gibbston, and at a second mine 300ft. to 400ft. higher, or near the saddle leading into the Nevis watershed. Though thus obscure at the surface, the different levels at which the coal-measures are found show that deep involvement of the beds has taken place, and that the formation as a narrow belt of younger rocks runs through the range from Gibbston to Dootan's Creek and the Lower Nevis Valley. At Gibbston there is no development of grits, gravels, or breccia conglomerates that are likely to prove gold-bearing, and the beds at this locality are of interest, chiefly as showing the manner in which the involved and faulted beds are brought in contact with the older rocks along the opposing side of the fracture.

Cardrona Saddle.—About 800ft. below the Cardrona Saddle, on the side of the steep slope to the Kawarau, there is a patch of white sand and some traces of coal. This indicates the continuation of the line of fracture across the river to Gibbston from whence it crosses the saddle into the Upper Cardrona in the direction of the coal-mine on the left side of the valley, under the higher part of the Crown Range, six miles above the Township of Cardrona.

Crown Terrace.—This lies along the east or left bank of the Arrow, at a height of from 500ft. to 800ft. above the river. The Crown Terrace constitutes an old shore of Lake Wakatipu at a time when an extension of the lake filled the valley between the northern end of the Remarkables and the Crown Range to the height above mentioned. Gold-workings are being prosecuted at the northern end of the terrace, above and below the line of Tobin's Road, which leads along the face of the Terrace to Arrowtown. The gold found in this part is probably due to the action of the Arrow River at a time when it discharged into this arm of Lake Wakatipu.

Millar's Flat.—This lies between Arrowtown and Arthur's Point, and is bounded on the north by the southern slopes of the range between the Arrow River and the Shotover, and on the south by a ridge of low hills running from the Shotover below Arthur's Point to Lake Hayes. Clearly Millar's Flat is an old channel of the Shotover, and a very legitimate field for prospecting. There are no traces of glacier-action to be found on the higher levels of the Crown Terrace, but at a lower level at the head of Millar's Flat a small moraine extends across the valley, and the outlet of the river is clearly seen to have been close under the hill-slope on the northern side. The road from Queenstown to Arrowtown has been cut through this old moraine, thus exposing to view the

material of which it is composed, and exhibiting its structure. It lies at about the same height above the sea as does the terminal moraine between the Kingston arm of Lake Wakatipu and the Matarua Valley. Speaking of Millar's Flat as a probable gold-bearing area, Professor Hutton says, "As some of the places which I consider very promising, and certainly deserving of the special attention of the drift miner, I may mention the part of the old Clutha lake-basin in the angle where the Bendigo Creek enters, and along the foot of the range on which the Bendigo reefs occur. Also the extensive so-called Millar's Flat, between Arrow and Queenstown, which, to all appearances, represents an old channel of the Shotover River, and should, as such, be very rich, judging from the splendid yields obtained from the river-workings higher up. Mr. Warden Beetham first drew my attention to this dormant field, the high prospective mining value of which is believed in by many miners in the district."* Most, if not the whole, of Millar's Flat is now freehold land in several holdings, and this might interfere with the ready prospecting and working of the gold-bearing drifts it may contain. It certainly appears to be as promising a field as the old bed of the Molyneux, at Island Block, and could as readily be worked either by dredger or by elevator.

Valley between Arthur's Point and Queenstown.—That the Shotover did at one time pass between the hill at the back of Queenstown and the range to the north is certain, river-gravels being traceable all the way till the lake-shingle of the old beach is encountered. The shallower ground lies towards the north-eastern end of this old channel of the Shotover, but in this no trace of former prospecting can now be discovered. In going from Arthur's Point to Queenstown, after passing the highest level at which lake-shingle is found, a hole has been sunk to a considerable depth in the narrowest part of the valley, but, from what could be learned, this, owing to the influx of water, could not be bottomed. I do not think in any case that river-gravels would have been met with; more probably glacier morainic matter would have been encountered. But certainly the saddle and fall to the Shotover should be further prospected.

Bob's Cove, or Twelve-mile, Lake Wakatipu.—Gold has been worked here since the early days of the rush to the Lake district. Shallow alluvial recent deposits along the bed of the creek have hitherto been worked, but as it is possible that other gold-bearing deposits of greater geological age are present it becomes necessary to deal with and describe these older beds that may chance to be gold-bearing. Professor Hutton describes the beds at this place as follows: "At Fews, or the Twelve-mile Creek, on the east side [north side of the cross reach] of Lake Wakatipu, there is a small patch of Tertiary rocks belonging to this [the Oamaru] formation. The lowest bed is blue shale, covered by green sandstone, which is again followed by calcareous sandstones with bands of conglomerate, the whole being capped by a hard grey limestone containing 90½ per cent. of carbonate of lime and about 3 per cent. of carbonate of magnesia. These beds are about 600ft. thick, and dip 15° S.E. towards the lake. They have, however, been a good deal undermined, and large masses of limestone have fallen into the lake, giving the western portions a very broken appearance. I have also been informed that other outliers of this formation exist on the north side of Aftonburn, on the west side of the lake, and up the Shotover, in Stony Creek."† From the locality last mentioned to the head of Skipper's Creek, immediately under the peak of Mount Arum, there is a line of fault, on the east side of which these deposits lie. There is involved along this line a variety of rocks, and frequently quartz grits, possibly auriferous.

During the early part of 1880 the writer made an examination of a large part of the Lake County, and in the report which followed dealing with the geology of that district the beds at Bob's Cove and their continuation to the north-east were described as follows: Both Tertiary and Cretaceo-tertiary rocks are developed on the north side of the middle part of Lake Wakatipu, and thence extend as a narrow strip, included as by a fault between the older rocks, along the eastern slopes of the Richardson Mountains to Stony Creek, north of Mount Gilbert. With these Cretaceo-tertiary rocks aphanite breccias belonging to the unaltered Palæzoic series are included along the same line, but have not been traced north of Butcher's Gully, on the south side of the Moonlight Gorge. These rocks embrace the coal sequence and overlying beds to the lower members of the Pareora series.

On the shores of Lake Wakatipu the beds dip to the west, and the sequence begins with a breccia conglomerate resting on the older rocks belonging to the Te Anau series. For a short distance the section of the immediately overlying beds is obscured, and the next rocks seen are mottled marly greensands, between which and the underlying breccia conglomerates coal-seams, if present, should occur. The prospects of finding coal-seams in these beds is, however, somewhat remote. The greensands are overlain by blue sandy marls with marine fossils. The fossils are very similar to those from other parts of Otago where marine formations immediately overlie the coal. Concretionary boulders occur in the sandy marls above the greensands, and some of these contain remains of vertebrate animals, cetacean or reptilian. The blue fossiliferous beds are overlain by a second band of green rock (green sandstone), and these are followed by a hard compact coralline limestone, alternating with marly strata, in which fossils are abundant, but very obscure. This limestone may be fully 150ft. thick, but its thickness cannot be exactly determined, as the whole is not clearly seen, and, on account of a change in the strike of the rock, looking from the shore, it appears to be much thicker than it really is. It is in many places so hard and compact as to show not the least trace of fossils, and these are only to be detected on fragments of the rock which have been weathered under the atmosphere or polished as beach-stones on the shore of the lake. Such specimens show that this limestone is composed almost wholly of minute branching corals very similar to those that form the limestone at Brighton, on the west coast of Nelson. The limestones are overlain by conglomerates and brown and green sandstones, the latter marly.

* "Geology of Otago": Dunedin, 1875, p. 181. † "Geology of Otago," p. 48.

From beds of the light-brown sandstone the building-stone so much prized, and used for various ornamental purposes in the district, is obtained. This is a highly indurated rock, traversed by a system of joints which cut the bedding-planes at an angle of nearly 45°. The stone is lifted along these joints, and blocks of almost any size can be obtained.

In Moke Creek and Poverty Gully, a branch of Moke Creek, the lower part of the sequence only is present. The rocks here consist of conglomerates and red or black shales, with sandstone. Occasionally thin streaks of coaly matter are present in these beds, and a badly-preserved dicotyledonous leaf may here and there be found; but otherwise than from the peculiarity of their position these rocks are of little interest or importance in an economic sense. They are deeply involved where continued across the eastern spurs of Benmore and where they cross Moonlight Creek, about the middle of the gorge. Further on they cross Jones's Creek, and thence extend into the watershed of Stony Creek; and more recently the same beds have been traced to the sources of Skipper's Creek, in the upper part of the Shotover Valley. There are associated with these beds bodies of quartzose cement, which, resulting from the destruction of the neighbouring schistose rocks, may in places prove to be auriferous, and as these are present in or across the valleys of such creeks as Few's Creek, Moke Creek, and Jones's Creek, all of which have proved richly auriferous, some part of the gold obtained from these may possibly be derived from this source. There is with the limestones at the head of Butcher's Gully, between Moke and Moonlight Creeks, a considerable development of these quartz grits, and, although these do not appear in the gorge of Moonlight Creek, they are again found in the upper part of Jones's Creek. More recently further exploration of this line has been made during a recent visit to the Shotover Valley, and the involved rocks have been traced into the upper part of Skipper's Creek. At Maori Point the valley of the Shotover widens somewhat, and heavy terraces of river-gravel lie upon the sides of the comparatively narrow valley. There are in these gravels numerous blocks and boulders of argillaceous limestone, fine-grained fossiliferous sandstone, and masses of quartz grit cemented into a hard rock.

Stony Creek.—The valley of Stony Creek is very gorgy and, to those not acquainted with it, difficult to explore. From information received it would appear that the fossiliferous rocks, cements, &c., cross the valley about three miles west of where the creek joins the Shotover. The beds were described as constituting a very large reef, by which is to be understood that, in their exposure as a narrow belt of country, these beds are included and deeply involved between schist rocks on each hand. In the large sluicing-claims at the mouth of Stony Creek there is a very considerable proportion of the wash derived from these younger rocks. In that part of Johnston's claim which has been worked one-sixth of the boulders left on the ground belong to these rocks, and a very considerable collection of fossils might be made from the gritty brown sandstones and fine-grained argillaceous sandstones. Considerable quantities of quartz grit are also present.

Skipper's Creek.—It is not easy to trace the line of these beds across the mountains between Stony Creek and Skipper's Creek, but that the beds are continuous there can be little doubt. Much material, and often blocks of large size, derived from these Cretaceo-tertiary rocks are to be found along the bed of the lower part of Skipper's Creek. In Butcher's Gully, a branch of Skipper's Creek, a great number of large blocks of white cement stone or quartz grit are seen near its junction; and in like manner the same rocks are to be met with in the west or right-hand branch of Skipper's. These rocks appear to be absent from the northern branches of Skipper's Creek, and it is just possible that they do not reach further to the north-east than the southern or left-hand branch of this creek. All the quartz grits and pebbly conglomerates met with in the Shotover Valley are so strongly cemented that they form a hard rock, and thus, though they might be comparatively rich in gold, they would not pay to work. Apart from their possible productiveness in gold, these rocks, and the line of fracture along which they lie, are highly interesting and otherwise of great importance, as leading to a solution of some of the more difficult problems in connection with the geology of the district.

Coal-mine, Upper Cardrona.—The strata in connection with this lie about a mile east of the bed of the Cardrona, at an elevation of somewhere about 2,500ft. above the sea, on its south-east slope and close under the higher part of the Crown Range, and about six miles up stream from the Cardrona Township. Speaking of these beds, Professor Hutton remarks, "In the Cardrona Valley the lignite beds, according to Mr. Wright, are perpendicular, and interstratified with yellow clay and green sandstone." I have not seen the beds at the coal-mine, but, as quartz grits and sands associated with lignite appear on both banks of the stream between the shepherd's hut and the township, these and the beds at the coal-mine must be regarded as belonging to the same series and formation; and, as on the Kawarau side of the Cardrona Saddle the same or similar sands appear in connection with a seam of lignite, these sands also should be represented at the coal-mine. To my mind there is little doubt that these beds are in direct continuation of the line worked at Gibbston, and thence traceable into the Nevis Valley, and, as just stated, the same in age as the beds found farther down the Cardrona Valley to within two miles of the township. The occurrence of green sandstone is perhaps the only puzzling feature in connection with these beds, and from this circumstance it might be inferred that they belong to the marine series, as developed at Bob's Cove, on the north shore of Lake Wakatipu. Probably the green colour of the so-called sandstone is due not to glauconite, but to a mere coloration of the beds by some other form of iron-silicate.

The Cardrona Valley from the Junction of Coal Creek to the Township.—The creek-bed has generally been worked for gold, but the gold-bearing wash is restricted to the bottom of the valley, which is narrow and confined by the descending spurs of mountains of considerable elevation. A mile below Coal Creek there are white sands on the left bank of the main creek, and again at the junction of a small stream coming from the east. At this latter place the sands and coarser grits form the point of the spur on the down side of the junction referred to. This bluff, undercut by the action of the stream, has in part slipped away and exposed the beds clearly to view, showing

them to have a thickness of about 30ft. at least. Their area at this place is small; yet they deserve some attention, as being possibly gold-bearing. Lower down there are sands and shales on the right bank of the stream, and with these traces of coal.

Cardrona Valley near the Township.—Above the township for a mile or better the hill-slopes from the south-east spurs of Mount Cardrona narrow the valley, and confine the creek within a very rough bouldery bed. The immediate slopes on the north-west side are covered with like material, forming a fan-shaped talus slope which covers terraces formed on this bank of the stream. Further to the north-east, on the same side, beds of greater age appear at a higher elevation, and on the right bank of the stream, underneath the coarse bouldery wash mentioned, are heavy beds of slaty schistose shingle, and yellow sandy beds of finer grain derived from the same source. These beds of coarser material have yielded the great bulk of the gold found in the bed and banks of the river near the township. A short distance below the township they lose their character as very coarse material, and are spread over the low flats as ordinary river-shingle. Opposite the upper part of the township is, or rather was, Robinson's claim, the wash in which was coarse river-gravel resting on the schistose shingle and fine sands already alluded to. This claim yielded a large quantity of gold, and very rich samples were found embedded in the surface of the soft sands on which the gold-bearing wash rested, leading to the belief that these sands were rich in gold, though such actually was not the case. The relation of these sands and shingle-beds of schistose material to another great series of sandstone gravels in the Cardrona Valley is somewhat difficult to make out, and will have to be discussed in another part of this report.

Criffel Face, Upper End.—Opposite the lower part of Cardrona Township, on the east side of the valley, and some 800ft. to 1,000ft. above the valley, there is a line of auriferous drifts running along the steep slope of the mountain-range known as Criffel Face. The beds dip eastward at high angles, and thus appear to pass under the schist rocks of the higher part of the range. The auriferous beds undoubtedly lie at the base of the series of strata to which they belong, but by a series of disturbances they have become inverted and thrown back upon the higher beds of the series, and their junction with the schists along the line of Criffel Face must be regarded as a line of fault, or, at all events, of acute inversion of the strata, both old and young, such as can hardly have occurred without vertical displacement.

To the westward, on the lower slopes of Criffel Face, the rocks are coarse sandstone gravels (Maori bottom), dipping at low angles, or almost horizontal, at the level of the river, but on the middle part of the range having a high dip to the eastward. These are apparently followed (but in reality underlain) by blue clays with thin seams of impure lignite, and these again by slaty schistose breccias and gravel-beds formed of the harder material of the schistose rocks and a proportion of sandstone. Further up the range, and consequently lower in the sequence, beds of quartz gravel appear, either independently or alternating with the breccias and conglomerates already mentioned. What the beds more to the eastward and higher on the range are, has not yet been proved, and this at the surface (owing to the presence of schistose *débris* from the higher part of the range) is difficult to determine. These deposits contain cement stones derived from an older formation of quartz grits, and therefore in age are younger than those in the upper part of the Manuherikia, those bordering the Maniototo Basin, or in the Waitaki Valley, or the Tuapeka district. They are gold-bearing, and at this, their south-western, end have been prospected with such good results that a water-supply has been brought from the high lands above Criffel Face to work the deposit. When the ground was last visited by Messrs. Fraser (M.H.R. for the district), Gordon, Murray, and myself, sluicing was being carried on in the most southerly of the claims opened out, and the prospects shown us from the solid ground were such as should pay well, unless the wash has to be followed to great depth, involving danger from the instability of the ground on the upper side of the workings. As shown in the claims already opened out, while the beds generally have a trend along the range parallel to the Cardrona Valley and the upper part of Criffel Face, they are yet so much crushed and disturbed that frequently blocks of wash are found lying and trending at various angles to the general line of strike. So far as examined, and proved by the work already done, there seems to be no reason to doubt that a valuable discovery has been made, and that further prospecting will demonstrate the continuance of this auriferous belt to some distance along the range to the north-east.

Criffel Face, opposite the Middle Part of the Cardrona Valley.—Four miles to the north-east of the locality last described, on the same line, and about the same height above the low grounds of the Cardrona Valley, some prospecting in deep ground has been carried on. From what could be gathered respecting this from the prospector, the schistose wall on the eastern side of the auriferous beds was nearly vertical, while the auriferous-quartz gravels in contact with it dipped south-east at an angle of about 45°. The quartz-gravel outcrop was described as being about 4 chains in width, and on the north-west, or down-hill side, the beds rested on the sandstone gravels of the slope of the range and the low grounds of this part of the valley. Gold was obtained by the prospector, but not in quantity that was considered payable, and a mistake was made in continuing to sink in the highly-inclined strata in the hope of reaching the bottom of the quartz grits. If driving or trenching across the up-turned edges of the strata had been done the beds might thus have been proved from the Maori bottom to the schist rock at a comparatively small cost. As it is, the ground for the present has been abandoned, though possibly the success attending prospecting in the same beds at the south-west end of Criffel Face may induce further trial at this place.

Criffel Face, near Mount Barker.—The line of junction between the younger auriferous drifts and the schist rocks of the higher part of Criffel Face gradually, as it is followed to the north-east, descends to a lower level, and at the mouth of the valley, near Mount Barker, the junction is not more than 200ft. above the river. Here there are gold-workings on the lower slope of the range, the material of the wash being, apparently, sandstone gravels—at least, the greater bulk of what is being washed away is of this character.

Cardrona Valley from the Township to Mount Barker.—A mile below the township the river-bed and bordering flats have an average width of half a mile, perhaps a little more, but the valley itself, between Criffel Face on the south-east and the Mount Cardrona Range on the north-west, has a greatest width of from two and a half to three miles. The river and lower grounds throughout keep to the south-east side along the foot of Criffel Face. On its north-west side the valley is filled by a series of hills reaching to about 2,000ft. above sea-level. These hills are formed of sandstone gravels, and are evidently due to the filling-in of an old lake. These gravels, as has been stated, rise on to Creffel Face to a height of 700ft. to 800ft. above the level of the valley, and on this side they have suffered great disturbance. On the north-west side the beds are resting in a nearly horizontal position, and hence present the appearance of deposits in the Cardona Valley after it had acquired or assumed its present general outlines. In these sandstone gravels one or two sluicing-claims have been worked on the north-west side of the valley. These are not now being worked. Towards the lower end of the valley there are heavy terraces of schistose shingle resting against the southern spurs of Roy's Range. These are clearly younger than the sandstone gravels on the same side, and further up the valley. It is a curious fact in connection with these sandstone gravels that not only have they been accumulated in a valley where the only rocks *in situ* of such date as could yield them are schist, but also that to the south-west and the north-east the only openings by which foreign material could enter the valley, the deposits, younger or older, as the case may be, are of schistose material.

Lower Cardrona to its Junction with the Clutha.—An old moraine, stretching from Mount Iron to the southern end of Roy's Range, lies between the Lower Cardrona and Lake Wanaka at Pembroke; and morainic matter also lies on the right-hand bank at the junction with the Clutha, this latter forming the inner part of the great Wanaka-Hawea moraine which stretches across the valley from the slopes of Mount Criffel to Grandview, on the opposite side of the Clutha. South of the Cardrona, and west of the road to Cromwell, the moraine has been destroyed, and its material reassorted by the action of running water, leaving still at frequent intervals the larger blocks showing through the shingle on the surface of the plain. Under these partly-destroyed moraines, at the junction of the Cardrona, and seen for some distance down the right bank of the Clutha, are beds of clay and sands that, with traces of lignite, should be the continuation of the beds running above the mid slope of Criffel Face.

North-east Slopes of Mount Criffel.—At 2,600ft. above the level of the sea, or 1,600ft. above the level of Lake Wanaka, there rests on the slopes of Mount Criffel, and at lower levels, a series of terrace deposits, which lie against the side of the range as far as Frenchman's and Luggate Burn. These gravels clearly indicate the height to which the waters of the old lake at one time stood; and on the track to Mount Criffel Diggings there is a considerable number of dyke-stone boulders which have been derived from Black Peak or Mount Alta. These gravels have been worked for gold at Frenchman's, and thence to Luggate Burn, and the greater part of the gravels worked on Mid Run belong to the same series. The beds here described are in no sense of glacier origin, all glacier-deposits lying at a much lower level; and from this it would appear that the lake-basins were filled with water prior to the advance of the glaciers. At all events, the evidence everywhere is that water reached to a greater elevation than did, whatever its date, the glacier-ice.

Mount Criffel Diggings.—On Mount Criffel proper the gold-bearing wash occurs at a height of 3,550ft. above the level of the sea. The wash consists of quartz, sands, and grits, sometimes a moderately fine quartz gravel, but as a rule the material is comparatively fine in grain. Towards the south-west part of the field, west of Luggate Burn, some tributaries of the main creek were very rich in gold. The wash in these was common slaty rubble or mountain-creek wash, and, though part of the gold obtained from this may have been derived directly from the rocks of the vicinity, the great richness, in part, seems to have been due to the destruction of the quartz drifts once present, but of which there now only remains the cement boulders scattered over the surface. These cement boulders are found over the greater part of the Criffel Range and over the flat grounds of the upper part of the Roaring Meg watershed, and indicate the former much larger area over which the quartz gravels were once spread.

The earliest official notice of the Mount Criffel goldfield is to be met with in the Mines Statement by the Minister of Mines, the Hon. W. J. M. Larnach, C.M.G., 24th July, 1885. Referring to Mount Criffel, the Statement proceeds thus: "On arrival at Wanaka or Pembroke I learned during the evening that a discovery, recently announced, of a promising alluvial goldfield had been made near the summit of Mount Pisa, overlooking the Cardrona River, Lakes Wanaka and Hawea, nearly 4,000ft. above the river, distant about nine miles from Pembroke. The diggings are known as 'Criffel.' I determined to visit the locality, and accordingly started next morning on horseback with Mr. Hamer, of the Mines Department, and Messrs. McDougall and Thompson as our guides. After three hours' climbing we reached several of the workings, and found the miners at first disinclined to part with information; however, knowing the general run of their frank and honest dispositions, I interviewed them straightforwardly, and told them the purpose of my visit. We were not long in getting upon good terms with one another, until I was taken from claim to claim, over a distance of nearly two miles, and shown good sized bags of fine gold, the results of a few weeks' work. I learned that there were about fifty miners on the field prospecting, about thirty of whom were on payable gold. One veteran miner, well and favourably known on the southern mines, who has had many ups and downs, and was again on for another 'up,' in reply to my question, 'Are you satisfied with what you are doing?' called his son and told him to 'throw a shovelful of earth into the dish and wash it before Mr. Larnach.' The son did this, showing a result of over 1dwt. of fine gold, which my friend insisted upon my carrying away as a memento of my visit to Criffel. The drawbacks to the progress of the field are want of tracks and water. Up to the time of my visit only water for half an hour's washing per day could be stored during the night previous by damming up a small spring; but an enterprising party—the discoverers, I believe, of the field, Messrs. Wilson and Hollo-

way and Co.—are engaged in constructing a race fifteen miles long, to bring in six heads of water for their own use, at a cost at from £1,200 to £1,500. I predict that a big rush will be made to this field in spring, as I am aware that parties at work there last summer netted handsome returns."

In his report for the same year (1885) Mr. H. A. Gordon, Inspecting Engineer, Mines Department, at page 11, has the following: "Criffel Diggings.—This is a field that has only recently become generally known. It is situated on the top of the range, between the Cardrona River and Luggate Creek, about 4,000ft. above the sea-level. A party consisting of three miners has been working there for about two years, but it was only during the last year that rich auriferous ground was discovered. From its high elevation it can only be worked during the summer months; but from the rich deposits that have been found, and the apparent extent of auriferous country there is in the locality, it is likely to support a considerable mining population next summer, when fresh discoveries will probably be made. There were about fifty miners on the ground during the latter portion of last season, and the amount of gold that has been purchased from this field is about 1,000oz., of which amount the three prospectors obtained 300oz.; but this was principally from ground that they had worked the previous season and had stacked ready for washing when the snow melted, which gave them a supply of water. They have about 1,700 loads of washdirt again stacked ready for washing next spring. The great drawback to this field is the want of a plentiful supply of water, as it is ground specially adapted for sluicing. A water-race is at present being constructed from the Luggate Creek, but the parties that are constructing it do not anticipate being able to supply any other claimholders with water, as they consider it will be more advantageous to use the whole of it themselves. There is likewise no passable road to get timber and supplies upon the ground at present; pack-horses manage to get up on the top of the range with provisions, but the track is a very bad one." In a further report—"Reports on the Mining Industry in New Zealand, 1890"—at page 82, Mr. Gordon remarks, "The run of auriferous wash-drift found on the top of this range cannot be traced for any great distance. The wash-drift is also of two different characters—one description of it is formed similar to that found in the low terraces near Cardrona, while the other is an old quartz-gravel wash similar to that found in the vicinity of St. Bathan's and Mount Buster, having large trees lying amongst it, with branches complete, all silicified. The gold found in this quartz drift also seems to be more ground up than that found in the other wash-drift. It is only here and there where this old quartz-drift deposit occurs; it seems to come from the direction of Mount Pisa, but the top of the range has been greatly worn down since this deposit has been made, and only a few places remain to mark the course of an ancient current, which must have carried this material for a considerable distance."

At the time of my visit only two parties of miners were on the ground, and these were sluicing towards the southern end of the workings. Criffel proper is confined to the western bank of Luggate Burn. On the east side the area of quartz drifts and auriferous ground is known as Fat Boy.

Fat Boy.—The diggings known by this name include an area of quartz drifts commencing near Luggate Burn, a quarter of a mile below Halliday's camp, and the principal quartz-drift workings on the Criffel side of the creek. At its lowest point this eastern run of auriferous quartz drift has an elevation of 3,250ft. above sea-level, and here the last of the drifts, barred by a narrow rim of schist rock, overlooks by some 300ft. to 400ft. the bed of Luggate Burn. This gives great facilities for draining this northern part of the quartz-drift area on the east side of the creek. On the Criffel side the quartz drifts are not deeply involved amongst the older rocks, but cap, or lie in depressions of, the schist rocks. It is otherwise on the Fat Boy side. The width of the formation varies from 4 to 15 chains, and this runs south-south-west a distance of about four miles to the northern foot of the ridge of rocky heights that separates the watershed of Luggate Burn from that of the Roaring Meg before the former turns to the east to drain the higher part of Mount Pisa. The quartz drifts along this line dip to the westward, and on that side are suddenly terminated along a line of fault, while on the western side, towards Alice Burn, they dip at moderate or high angles from the schist rock on that side towards the northern end, but are said to be deeply involved on that side also in the southern part of the line. At its southern termination the Fat Boy line of quartz drifts attains an elevation of about 4,000ft. above the sea. My examinations were confined to about a mile of the northern part, but the line of drifts could be traced by the eye as far as stated, and shown to be present by a line of prospecting-holes made in white gravel for a considerable distance farther to the southward; and, as regards the south end of the line, Mr. Halliday informed me that the presence of the gravels had been proved to the foot of the rocky spur already described.

A party of miners—Newman and party—hold a lease of the northern end of the line, and for the past three years have been prospecting the ground during the summer months. Various trial cuts in the eastern shallow ground have been made, but these appear not to have yielded satisfactorily, and a shaft bottomed at a considerable depth gave gold, but not in paying quantities. In yet deeper ground two boreholes have been put down, but these, so far as could be learned, did not reach the lower beds of the deposit. At the extreme northern end of the white quartz drifts a tail-race has been cut partly into the rocky rim that borders the deposit. This tail-race has enabled the sluicing-away of less than 2 chains in length by 1 chain in breadth to the level of, or a little below, the rocky ledge at the northern end, but as the gravels dipped rapidly to the south, as well as to the west, in the upper half of the cut they could not be bottomed otherwise than by sinking a shaft, which was done, and from this a drive was put in westward to the schistose wall on that side. As none of the party had arrived on the ground at the time of my visit, during the second week of November last, full particulars with respect to what had been done could not be obtained. From the northern limit of the line of drift the ground rises to the south to the top of the first ridge some 200ft., and this northern slope is strewn with large boulders of cement stone, such as has already been frequently described as resulting from the sands themselves being cemented into a hard quartz-like rock, the cementing medium evidently being silica. These blocks of cement are very numerous

towards the northern part of the claim, and have caused no little trouble in the workings. As they all lie upon the surface it would be easy to remove them to one side before working the deeper part of the ground. Slowly, indeed, has this eastern side of the Criffel field been developed, but it must be admitted that the difficulties in the way have been very considerable; and, as Newman and party have but a poor supply of water, this lack of water has also retarded the development of the field. Yet it is evident that there are great possibilities along this, the Fat Boy, line of quartz drifts.

Mid Run, Luggate Burn.—This forms a ridge of hills between Luggate Burn and the northern slopes of Mount Pisa. Here, as at the Frenchman's, and on the north-east slope of Criffel itself, the wash is a coarse sandstone or schistose gravel which at one time has formed the beach of an extensive lake. The auriferous ground being situated at a lower level than at Criffel and Fat Boy, work can be started earlier in the spring and longer continued during the autumn months. At the time of my visit to Criffel there were eight or ten parties at work on Mid Run, and by report they were well satisfied with their earnings. The deposits of gravel are lodged along the side of the range, at a considerable elevation above the level of the creek, and gravels again appear on a level terrace-like plateau, and are developed at this height round the north-eastern end of Mount Criffel Range, past Frenchman's, to the track leading from Mount Barker to Criffel diggings.

Lower Luggate Burn.—There is little to be noticed in this part, and I may but mention the high terraces at the back of the schoolhouse and hotel, which close under the spurs of Mount Pisa appear to be promising ground for prospecting.

Tarras Creek and the Lower Lindis.—Heavy terraces of gravel are developed within the area of the Lower Lindis and Tarras Creek. It was reported to me that the white quartz drifts are present in Tarras Creek, but they were not noticed when the district was examined by me during 1880; and during my last examination this part of the district was not visited, because old lake-deposits must necessarily hide from view over all the lower grounds the lower beds of quartz drift, &c., as is the case along the western side of the Clutha Valley from the Kawarau Gorge to Lochar Burn. Subsequently, while accompanying Messrs. Murray and Gordon to the Cromwell Reef, Bendigo, on the northern slope of the Dunstan Mountains, much could be noted proving an extensive destruction of the quartzose grits, cement boulders derived from them being scattered over the hill-slopes to 1,000ft. above the valley, but there was little evidence favouring the likelihood of the drifts being met with at the surface in the lower part of the Lindis Valley.

Clutha Valley along the Base of Mount Pisa Range.—As shown at Bannockburn, and thence to the northern bank of the Kawarau, there is a line of quartz drift continued to the north-east along the foot of the Mount Pisa Range across Low Burn, Park Burn, Tinwald Burn, &c., to the point where a secondary ridge of schist terminates the direct continuation of this line; but, as this part of the Clutha Valley is filled with heavy terraces of lake-gravels that cover the area between the points mentioned back to the foot of the range, the creeks cutting across these have not yet exposed the grit, &c., underlying the lake-gravels, except it be at the extremities of the line described. I am convinced as to the existence of these rocks, but have not shown their probable limits on the map accompanying, though they may be traceable over a part of the line described.

Clyde.—At Clyde there are none of the auriferous quartz drifts to be seen on the banks of the river, but that they cross the valley at this point is scarcely to be doubted. How far they have been a factor towards the enrichment of the recent gravels on the banks of the Molyneux at and below Clyde need not be here inquired into (since their highly auriferous character will appear when describing another locality), but with respect to their actual existence, and also their extensive destruction during the formation and cutting-down of the Dunstan Gorge, Professor Hutton remarks, "In the first place, the abruptness and narrowness of the entrance to the gorge at Cromwell shows that it has never been the outlet of a large body of ice; and in the second place, the lignite deposits under the township at Clyde must have been formed in still, shallow water, which could not have been the case if the Clutha then rolled through the gorge in the way it does now."*

Waikerikeri Creek rises on the Dunstan Mountains, near the Leaning Rock, and falls into the Molyneux a little below the Township of Clyde, north of the main road to Ophir and the upper part of the Manuherikia Valley. At first the valley of the creek is bounded by high gravel terraces, the upper parts of which show a great number of large angular blocks of schist, leading to the belief that the material of the higher part of these terraces has been deposited by glacier-action as morainic matter. Higher up, these terraces are confined to the east side of the valley, while rolling downs and higher hills slope from the western end of the Dunstan Mountains. These downs and lower hills are formed of well-rolled gravels in the lower grounds; and at greater heights, resting on the schist rocks, there is a development of clay, shales, lignite beds, and quartz grits. The visible western end of this line of grits, shales, &c., is at the coal-mine a mile inside the entrance to the Dunstan Gorge. The occurrence of lignite in the middle part of the Waikerikeri Valley has not been proved; but there is here, between the coarser sandstone gravels and the schists to the north, a development of quartz gravels, tilted so that it dips nearly vertical; and these beds it is that deserve special notice here. For a long time gold-workings have been carried on in the beds of the creeks, and on the sides of the lesser gullies intersecting the lower downs on the north side of the main stream, and at the time of my visit two or three parties were still at work sluicing the beds of the creeks formerly worked, or the heavy, but comparatively poor, wash formed by the sandstone gravels. Mr. Lindsay, an old resident miner, gave me what information he could, and accompanied me over the downs and hills to the foot of the slate range, thus necessarily passing over the outcrop of the quartz drifts. From what could be seen it was evident that much gold had been liberated from these, and had been entangled amongst the coarser wash of the creek-bottoms. Having expressed this opinion—my surprise that no prospecting had been done in the quartz-drift

* "Geology of Otago," p. 91.

deposit—and pointed out that, so far as appearances went, the drifts here were fully as likely to contain gold as at Cambrian's, Vinegar Hill, or at St. Bathan's, Mr. Lindsay promised to do something in the way of prospecting the quartz drift in his neighbourhood, and, as we were on a very promising outcrop of the beds, direction was given where and in what manner prospecting should be carried on. More recently it was reported that Mr. Lindsay had found gold, and was supposed to be making wages, but was very reticent as to the nature of the find that had been made. If with the means available Mr. Lindsay thought it worth while to work the beds, with a fuller supply of water the quartz grits at this place would pay well. The drifts here belong to the older series of quartz gravels, and do not contain slaty breccias nor white cement boulders, as is the case where younger, though somewhat similar, auriferous beds are found in other parts of the Manuherikia Valley. The quartz drifts should cross Waikerikeri Creek between four and five miles above the main road, and, if continued in a direct line as set out between Clyde and Waikerikeri, this line continued would coincide with that which connects the Devonshire Diggings, Tinker's, Drybread, and all the auriferous localities along the base of the Dunstan Mountains.

Lower Manuherikia to Chatto Creek.—Mention has already been made of the line of quartz drifts present in Conroy's Gully, and of that which from Butcher's Gully is continued along the main road towards Alexandra. The line along the south-east side of Conroy's Creek, when it reaches the broader valley of the Molyneux, either passes under the more recent deposits of the alluvial plain, or changes its direction and follows the rocky ground, bordering the plain at its southern end, to Alexandra. But, whether continuous or not, the same beds are proved by dredging to occur in the bed of the river at Alexandra, and they are present in the bed and banks of the Manuherikia above the junction, where they occur on both sides of the river. On the right bank clays and quartzose gravels are traceable, sometimes at the surface and sometimes sectionally exposed under younger sandstone gravels to Chatto Creek, along the lower part of which the quartz sands are clearly seen. Between Chatto Creek and the Manuherikia a low but rugged range of schist rock interposes, and beyond Chatto Creek there is a valley depression between this range to the south and the Chatto Hills on the north side of the road.

Chatto Creek.—Above the bridge on the main road Chatto Creek has cut deeply into the sandstone conglomerates and underlying clays, thus forming a deep narrow gorge. Although the schist rock is seen at the bridge, the quartz drifts appear to be absent, and the clays mentioned rest hard on the older rocks, while the sandstone gravels form the tops of the hills, which slope north into lower grounds covered with recent shingle. Towards the north-east the beds forming the Chatto Hills have a dip to the north-west, and beds of quartz drift are likely to appear at the bottom of the series in that quarter.

Devonshire Diggings.—These are on the line of deep involvement along the base of the Dunstan Mountains. The superficial gravels at present being worked for gold form a coarse creek-wash of considerable thickness, which has been brought down from the mountains to the north-west. Underneath this, of older date, and highly unconformable thereto, there is a slaty schistose wash, dipping towards the range. This could be seen in one claim only, and, though this lower wash was reckoned gold-bearing, it was not being worked. So far as could be made out, the Devonshire Diggings are not likely to afford much deep ground, like that at Tinker's and Drybread—not, at least, until the superficial gravels have been worked over, thus laying bare and affording means for the prospecting of the lower beds.

Tinker's.—Tinker's is an important mining locality. Formerly mining was carried on chiefly in the more modern drifts of the creek-beds, and terraces formed of recent or comparatively young material, but since the comparative exhaustion of the superficial deposits, and the discovery of deep and very rich ground striking along the foot of the Dunstan Mountains, the energies of the miners have been mainly directed to this. Writing in 1890, Mr. Gordon remarks, Tinker's "is the richest field for its size there is in the colony, and the area of the rich auriferous deposit is not yet defined, as the area of auriferous ground that can be worked is entirely dependent on the available water-supply on the field. There is apparently a run of old quartz-gravel drift, or what is known as the granite-wash, going along the foot of the range and extending to near Clyde in the one direction, and will no doubt be traced to Cambrian's, Vinegar Hill, St. Bathan's, Naseby, Mount Buster, and on to Maraewhenua. At Tinker's it seems to be confined to a comparatively narrow run, which lies at a considerable angle against the Maori bottom, or Old Man Reef, on the side next the flat, and dips on the other at a corresponding angle underneath the schist rock in the main range. The bottom of this quartz has never been reached. A shaft was put down near the boundary of the Mountain Race Company, the Undaunted Company, and Reid and party's claims to a depth of 240ft., and showed that the whole of this wash-drift contains sufficient gold to pay for working by hydraulic sluicing and hydraulic elevators. The Mountain Race Company has sluiced off to such a level as the tail-races will admit, except the portion underlying the schist rocks at the foot of the main range, in order to get the whole of the wash-drift here. The schist rock overhanging the wash-drift comes down in slides, and interferes with the sluicing operations considerably."* In his report for 1891 Mr. Gordon further remarks, "Near the foot of the range there are four claims—namely, Reid and party's (known as the Sugar-pot Claim), the Mountain Race, Ewing's, and Symes and Morgan's. These claims have a rich run of quartz grit wash-drift going through them. This seems to be comparatively a narrow run of ground following the foot of the range, and at the time it was deposited the range must have been steeper than at present, as it is now partly underlying the foot of the range. This means that slips have come from time to time as the quartz drift was being deposited, and kept extending over the deposit further every time a slip occurred. This makes the drift difficult to take out of the underlying position in which it is now found, as in doing so a large quantity of

* Report on the Mining Industry of New Zealand, 1890, p. 76.

débris from these old slips has to be removed at the same time. The depth of this character of wash-drift, which is of a much older formation than the gravel-drifts further out on the flat, has never yet been ascertained, neither here nor at any place where it has been worked in the district." The "shaft sunk near the boundary of the Mountain Race Company's ground and the Sugar-pot Claim to a depth of 240ft.," showing "no indication of being near the bottom," yielded "about the same" prospect "of gold all through; but the question of being able to work to this depth is a problem not yet solved, but there is no doubt that it will yet be worked by several hydraulic elevators, one below the other, to a considerable depth. The wash in the shaft does not appear to be rich enough to drive out, but will give good returns for working by hydraulic elevators and sluicing. How far this run of ground may traverse the foot of the range has not been ascertained, and, indeed, it is of very little use for any one to go prospecting for sluicing-ground in this locality, as all the available water that can be brought on the ground is taken up and utilised."* The wash-drifts constituting the deep ground at Tinker's consists of partly-rounded slaty schistose breccias, containing sandstones and cement boulders from the older quartz drifts. Towards the line of contact with the older rocks to the north-west beds of quartz gravel or grit alternate with the more slaty material, and in Ewing and McConochie's claim the lowest bed seen is a massive development of quartz, sand, and grit. Mr. Gordon, in the above extracts which I have made from his reports of 1890–91, describes how the beds dip so as to pass at a varying but always high angle under the schist rocks forming the lower spurs of the Dunstan Mountains. In the eastern end of Ewing and McConochie's claim the beds are nearly vertical, while the sandstone gravels of the "Maori bottom," although younger, seem to be pushed underneath the more auriferous beds. Looking, however, at the section shown in the south-west end of the claim, it is seen that the beds throughout are exceedingly disturbed, and that, except in a general way, little is to be learned from the mere dip and apparent relative position of the different beds. In the Blue Duck Claim the auriferous beds are nearly vertical or inverted, the lower beds resting on those higher in the sequence and passing under the schist rock with a high dip to the north-west. There is less quartz drift showing in this than in Ewing and McConochie's claim, next to the south-west, but the reason of this appears to be that the works have not so closely approached the fault-line as they do in the other. There is again in this claim the appearance of the "Maori bottom," the beds forming it being unconformable to the auriferous bands. In the Sugar-pot Claim the wash is sometimes very coarse, and all the beds are standing nearly vertical. Making here careful inquiries as to the occurrence of the white cement stones derived from the older grits, several examples embedded in the solid wash 30ft. or 40ft. from the surface of the ground were shown to me, also specimens said to come from the lower part of the 240ft. prospecting-shaft; and it was also stated that a great number of "Chinamen," or "white Maoris," as these boulders are called by the miners, were met in sinking the shaft. As to the dip of the strata met with at this the greatest depth reached in this neighbourhood, no definite information on this point could be obtained, but the probabilities are that the beds return to the vertical and then dip to the east under the higher beds of the same series and the "Maori bottom" where this latter is present.

Drybread, or Matakanui.—This locality shows a continuation to the north-east of the auriferous deep ground of Tinker's. The strata consist of thick banks of clay with beds of slaty schistose shingle and quartz grit dipping to the north-west, but at a lower angle than the dip of the same beds at Tinker's. The auriferous bands may not be as rich as they are at Tinker's, but there is certainly more material favourably placed for sluicing than at that place. The formation also shows a considerably greater thickness of beds, and there seem to be several bands of gold-bearing wash. As some of these lie at a greater distance from the fault-line and schist rock than do the auriferous bands at Tinker's, there will thus be avoided the danger and cost that threaten future works in the latter locality. The downs east of Drybread are formed of sandstone gravels, while the lower terraces and flats extending to the main road along the Manuherikia Valley show at most places a preponderance of schistose shingle.

Lauder Creek.—This is the principal stream coming from the Dunstan Mountains between Drybread and Cambrian's. Though there is no place between Drybread and Cambrian's where extensive mining has been carried on in the line of deep country along the foot of the Dunstan Mountains, it is the general opinion that the deep ground is continuous; but whether it be that the beds of Tinker's and Drybread are continued to the north-east, or those of Vinegar Hill and Cambrian's to the south-west, remains to be seen. The auriferous beds constituting the deep ground in the areas indicated are not of the same age. Why neither series appears along the valley of the Lauder Creek appears to be owing to the fact that the terrace-gravels of younger date reach back to the schist rock of the lower part of the Dunstan Mountains, and are nowhere cut through by the creeks deep enough to lay bare the underlying deeply-involved drifts. As an instance of the depth to which these older gravels have been covered up by the sandstone gravels of the "Maori bottom" may be mentioned the fact that the hydraulic head of the Mountain Race Company's supply at Drybread is from the top of a spur some 400ft. above the workings, and that at this height there are gravel-beds of "Maori bottom" resting on the schist rock in a horizontal position. The extension of these beds to the east had to be denuded away in order to expose the slaty and quartzose auriferous drifts underlying. These and younger beds occupy a lower level in Lauder Creek, and thus hide the older beds from view.

Cambrian's.—The first workings at Cambrian's were in the coarse shingle of the creek-bed, and on its banks, but prospecting soon led to the discovery of gold in the white quartz gravel similar to that of Kildare Hill at St. Bathan's. Together, these sources of gold-supply have maintained Cambrian's as a mining township from the earlier days of the rush to the present time. In 1892, Mr. Gordon, speaking of Cambrian's, reported as follows: "There has been a considerable quantity

* Reports on the Mining Industry of New Zealand, 1891, p. 70.

of gold obtained at this place, but the best portion of the ground is no doubt worked out. At the same time it is believed by a number of miners that there is a considerable area of good ground that would pay well for hydraulic sluicing if properly carried on. . . . The same quartz-drift wash occurs here as at Tinker's, Matakanui, and St. Bathan's."

Vinegar Hill.—The importance of this place, apart from the presence of gold, is due to the enterprise and energy of Mr. John Ewing. Gold appears to have been discovered here during 1879 or the early part of 1880. Mr. Warden Robinson, reporting on the 31st March, 1880, in dealing with the fresh discoveries made in his district during the previous twelve months, says, "The principal item of interest in mining affairs has been the continued development of the rich ground at Vinegar Hill and Shepherd's Hut Flat, near Cambrian's, where a new goldfield equal to the famed Welshman's Gully may be said to be proved to exist. . . . This discovery comes in very opportunely, at a time when the Welshman's Gully, which has been continuously worked for the last sixteen years, may be reasonably expected to have yielded up the best of its treasures." Reporting for the year 1892, Mr. Gordon says, "The only claim being worked here [Vinegar Hill] is that of Mr. John Ewing. . . . The ground he is working is about 70ft. in depth, consisting of a greenish clay mud, full of small spiral shells and vertebræ of fishes. It is an exceedingly tough substance when first broken down, but after lying exposed to the atmosphere for some time it crumbles and melts away with the water. The whole of this 70ft. of overlying deposit on the auriferous wash-drift has to be removed before any gold is obtained, the wash-dirt consisting of from 6in. to 1ft. of quartz gravel."* Reporting for the year 1893, Mr. Gordon remarks that "the character of the ground worked last season is similar to that mentioned in my last report, the depth of the face being from 50ft. to 70ft. The uniform layer of wash is only from 1ft. to 2ft. thick, consisting of quartz gravel lying on top of the schist rock. The sedimentary deposit lying on the top of this wash has the appearance of a highly-consolidated glacier-mud. It is formed in bands, having only a slight inclination to the horizontal. Last season he had taken a cut in towards the range, and found a fault in the sedimentary deposits, which shows that the side next the range has been lifted up about 12ft. since the material was consolidated, every band being distinctly seen, corresponding with those at the 12ft. deeper level. The most interesting discovery made in this claim is on the end of the cut next the mountain-range. The old quartz drift is found to join on to the schist rock, dipping away into the range at a high inclination. This shows that the deep run of quartz drift is between these workings and the range, and this deposit has never been tested in this locality. There is a little gold through the drift, as far as it has been tested, below the level of the schist rock, and in all probability a rich run of this ground will be found between the present cut and the range. . . . Hughes and Morgan's claim . . . is closely adjoining Mr. Ewing's, and on the side of the hill facing Vinegar Flat. The quartz drift here is formed in bands, highly contorted, and lying at a steep inclination. . . . The depth of face where Morgan and Hughes are working is about 90ft."

Between the principal workings on Vinegar Hill and Welshman's Gully (Cambrian's) there is a line of quartz drift which, resting on the schist rock to the east, dips at a moderately high angle to the north-west in the south-west part, but at Vinegar Hill the younger beds dip off the hill itself at a low angle, and here show a considerable thickness of greenish fresh-water clay, resting on a thin stratum of quartz gravel. This clay, as described by Mr. Gordon, is seen to thicken as the works are carried to the northward, and does so up to the point where the eastern side is let down by a fault, which, with a grade of about 45°, pushes the younger rocks under the wall of schist, and at places so crushes wash and overlying clay together, and through each other, that what can be seen here is a splendid example of what may be supposed to have happened along the main line of fault here at Drybread and at Tinker's. Beyond the fault the clay-beds continue dipping at a low angle towards the north-west for a distance of some 3 chains, showing but little improvement in the thickness of the wash underlying, but at the furthest point reached in the workings the floor of schist rock dips suddenly, and the wash thickens, this line of dip in the floor trending away to the eastward. The cover of non-auriferous material not lessening, work has in the meantime been suspended in this direction, and a fresh working opened out at the north-eastern end of Vinegar Hill, near Mr. Ewing's house. This is in a continuation of the deep ground mentioned as occurring at the north-west end of the workings just described, and a heavy body of white quartz drift has been exposed, showing a very rich prospect of gold. The wash in the face was not bottomed at the time of my visit, but several highly satisfactory prospects washed by Mr. Ewing from an horizon about 8ft. from the upper surface of the drift, and a prospect taken by myself from what appeared the least likely part, some distance above and away from where Mr. Ewing had been trying, though not equal to the others, was yet a highly-paying prospect. There is little doubt but that, as indicated in Mr. Gordon's report of last year, this is the eastern margin of a deep run of quartz drift lying between the old workings and the foot of the mountain-range, and the thickness and richness of the wash in this promise to surpass what was anticipated of it. From the old workings to the foot of the pipe-line spur the width of this depression, filled with auriferous quartz gravel, is from 200 to 300 yards. It is probable that it narrows to the south-west, and, confined to a narrow channel, the wash will dip at high angles towards the range. To the north-east, on the right bank of the creek passing Mr. Ewing's house, the width of the run of quartz drift is about a quarter of a mile or more, and necessarily here the beds are lying at a lower angle. Over this north-eastern part Mr. Ewing has had some prospecting done, but as yet with no very remarkable results.

St. Bathan's Basin.—The rush at the Dunstan was reached by a great number of miners who followed the Shag Valley, and thence, crossing the Maniototo Plain, arrived at the Dunstan by way of the Manuherikia Valley. The result was many discoveries along the line of travel, of which Dunstan Creek and St. Bathan's are instances. The Basin of St. Bathan's and Kildare Hill has a peculiar

* Reports on the Mining Industry in New Zealand, 1892, p. 88.

situation. The basin lies on the western side of a long spur running south from Mount St. Bathan's, having Muddy Creek and the Manuherikia River at its eastern foot, and Dunstan Creek on the opposite side. The crest of this spur as far as St. Bathan's is formed of indurated sandstones and shales belonging to the Te Anau series (Devonian). To the east the ridge of older rocks is flanked by the auriferous quartz drifts of Muddy Creek, and to the south a short distance beyond St. Bathan's the continuation of the spur to its termination shows heavy beds of the sandstone gravels known in the district, and here described, as "Maori bottom." These sandstone gravels are continued north along the west side of the spur to the outlet of the St. Bathan's basin, and form the ridge between the township and Dunstan Creek. These gravels thus form one side of the basin. The basin is triangular in outline, gradually widening from south to north, towards which it is bounded by a steep slope running east-and-west. The greatest length is short of three-quarters of a mile, and the greatest width about a quarter of a mile. Resting on the older rocks of the east side of the basin are beds of quartz drift dipping at considerable angles to the westward in the southern part of the basin, but lessening in amount and altering in direction (*i.e.*, more to the west and south) as the northern part is reached. In the centre of the basin the strata of drift "dip at varying angles, sometimes reaching 35° S.W." (Hutton); but towards the southern end of the basin the dip is at higher angles. The richest gold-bearing stratum lies near the base of the quartz-drift series, and always under the lignite or leaf-bed. The wash being elevated from the deepest ground in Mr. Ewing's claim is about 12ft. in thickness, and this is seen 70ft. below the level of the old working, or, in all, about 130ft. to 140ft. below the level of the original surface. The face and sections of the works at this level show moderately fine-grained quartz gravel, with a sprinkling of slaty schistose material through it. The colour of the wash is bluish-grey, but on exposure to the atmosphere the surfaces of the parts not being worked become coated with an efflorescence of sulphur, and where long exposed the sands become light-grey or white.

In the deeper ground of the centre of the basin the dip shows no appearance of lessening in amount; but this must eventually be at a lower angle, since towards the north the basin is limited by a bar of hard rock belonging to the Palæozoic series, seen in the cuttings of the road from the township to Dunstan Creek; and also to the west of the township the drifts underlying the "Maori bottom" show in the banks of the Dunstan Creek. In the northern end of the basin the dip is flatter and more to the south, and along the sludge-channel brought in from Dunstan Creek the upper sands are seen to be overlain by beds of grey or bluish-green marly clays corresponding in character with the beds that overlie the stratum of gold-bearing wash at Vinegar Hill. These clay-beds form the floor of the present workings to the north of the deeper part of the race, and do not anywhere appear inside the basin. In the broader northern part of the basin a considerable amount of work has been done, but towards the western side in this part a block of country has not been worked down to the lower level. In the face of this can be seen a stratum of the cement stone, "Chinaman," or "white Maori," as boulders of it are called indifferently by the miners in different parts. The cement band occurs at a considerable distance above the richest gold-bearing stratum, and when, as is often the case, scattered boulders of this rock appear without gravels between them and the bed-rock, in almost every case the sheet has been broken up and the underlying gravels removed. A curious instance of this is to be seen between Butcher's Creek (Bald Hill Flat) and Conroy's Gully, where a large mass of cement stone is poised on a pillar of schist little more than one-third the diameter of the cement-stone flag.

In his report of last year Mr. Gordon says, "Although this goldfield has been worked for the last twenty years there is still a large quantity of gold being got from the old quartz drift, or what is locally known as the granite-wash. . . . There is a layer about 5ft. in thickness, composed of a bed of leaves, amongst the quartz drift at St. Bathan's, and this layer lies at about the same inclination as the face of the schist rock against which the quartz drift is lying. This shows conclusively that the leaves at the time they were deposited had a horizontal bed, and that there could not have been a rapid current near the place where such deposition took place. The manner in which the layers have been tilted up shows that an upheaval took place which altered the topographical features of the country. . . . There is only a very small area of gold-workings in the vicinity of St. Bathan's, but a very large quantity of gold has been obtained. Over 100,000oz. have been purchased by one of the banks there, and the quantity of gold in the quartz drift does not appear to diminish as it gets down. The deepest workings yield about as much as those near the surface, and the way that it is being traced has the appearance of its being continued along the foot of the range between Vinegar Hill and the main range." In the St. Bathan's Sludge-channel Company's claim "the character of the ground is quite different from that in the claims in St. Bathan's basin, and to a great extent resembles the consolidated clay found in Mr. Ewing's claim at Vinegar Hill. This material seems to abut on the old quartz-drift wash which is seen higher up [to the north] on the face of the terrace, and gives one the impression that there is a deep run of this drift between the place where they are working and the terrace; and very likely a great portion of the ground that has been stripped by the company will be worked again to a greater depth when the tail-race or channel is constructed to the proper level," * which was intended to admit of working water free to a further depth of 75ft.

Muddy Creek.—Quartz drifts lie on the eastern slope of the St. Bathan's ridge from the junction of Muddy Creek with the Manuherikia to the Scandinavian Company's claim, and the point where the creek leaves the higher part of the St. Bathan's Range and assumes a southerly course. On the eastern bank, terraces and terrace-flats of sandstone gravel are present, between Muddy Creek and the Manuherikia, above the gorge; and beyond Muddy Creek, between a continuation of these terraces and the foot of the St. Bathan's Range, lies a narrow strip of quartz gravels

* Reports on the Goldfields of New Zealand, 1893, pp. 119, 120.

which show at one or two places on the road to Rocky Creek. It is, however, within the middle part of Muddy Creek that along this line the quartz drifts have any special interest. In the Scandinavian Claim they are nearly horizontal in position, and in the sands are found large trunks of trees, while beds of clay and lignite are also present. Near the mouth of the creek the quartz drifts disappear under the sandstone gravels terminating the St. Bathan's spur, and they appear in the bed of the Manuherikia, and on its right bank, up to the entrance to the gorge, here also overlain by "Maori bottom." The quartz drifts cross above the gorge, and on the east side of the river run along the eastern slopes of the Hawkdun Home Hills, but are not again seen higher up the valley on the right bank of the river.

Manuherikia River to Saddle between the Hawkdun Home Hills and East End of Blackstone Hill.—Quartz grits, clays, and lignite beds from the foot of the Manuherikia Gorge skirt the western base of the Hawkdun Home Hills, and, dipping westward, disappear below the river-gravels of the flat on the south side of the Manuherikia. At the spring of the saddle leading to Hill's Creek these beds alter their direction, and trend to the westward, and, gradually acquiring a high angle of dip, follow the northern base of Blackstone Hill to the river-crossing near Blackstone Hill Station. Gold is found in Pennyweight Gully and other gullies draining from the Hawkdun Home Hills, but, as the wash is a coarse gravel, it is, though not certain, possible that the gold has been derived from the quartz grits. The Hawkdun Home Hills are, however, formed of slates and sandstones such as are found in the Mount Ida and Hawkdun Ranges. These are not gold-bearing, and it is therefore unlikely that they have yielded the gold that rests upon them.

Pipeclay Gully and Downs to the North-west.—The road from Blackstone Hill Saddle to Clyde follows these downs as a flat ridge between Pipeclay Gully and the Manuherikia. The quartz grits are seen to be present till opposite the workings in Pipeclay, beyond which they are overlain by sandstone gravels ("Maori bottom") on the higher ground to the west, and dip under the more recent river-gravels to the north; but they are continued along Pipeclay Gully, at first on both sides, but finally on the left bank only, to the point where the creek joins the river. Cliffs and isolated masses of hard cement appear in the upper part of Pipeclay and on the downs opposite, but these appear to have been but little regarded as a possible repository of gold. Between the highly-inclined banks of white clay and the schist rock forming the slopes of Blackstone Hill are bands of quartz gravel that have been and still are being worked, but as these are followed to the westward the gravels die out and the clays rest directly on the schist rock, still, however, maintaining a high dip to the north.

Hill's Creek.—On the east side of Blackstone Hill Saddle there are clay-bands with lignite-seams, and underlying these quartz grits, the latter being very much disturbed, due to the action of a fault, which can by surface-indications be traced running north-and-south along the line that limits towards the east the quartz drifts. The quartz drifts at this place have been worked to a considerable extent; and also, on the southern slopes of the Hawkdun Home Hills, both quartz drifts and rough sandstone-wash have been worked since the early days of the Otago diggings. Followed east along the southern slopes of these hills most of the workings appear in coarse sandstone gravels, which must be regarded as "Maori bottom." Beds of white quartz cement stone occur here, and also nodules of clay iron-ore in connection with the wash and lignite beds. Of these workings, formerly known as Blackstone Hill Diggings, writing last year, Mr. Gordon says, "Some very rich patches of ground were worked on the saddle of the range where the old quartz drift appears, but as this drift gets further into the ranges it is covered over with a more recent deposit, or it may be said that since the quartz drift was deposited here the rocks have been tilted up, and are now positively overlying the quartz-drift deposit. Underneath the quartz drift there is a bluish-black puggy bottom, or, at least, when exposed to the action of water and the atmosphere it gets soft and swells up, so that the superincumbent weight of material above the auriferous layers in the quartz drift has the effect of causing the bottom to bulge up, and very little of the auriferous layers can now be got at. The drift has been worked along the foot of the hill for a considerable distance, but it has not so far proved remunerative; but Mr. Johnstone is still continuing a cut-up through the ground with the hope that it will improve."*

Marion Burn.—Marion Burn, in its lower part, runs along the northern base of the Hawkdun Home Hills. In the creek-bed the slate rock is exposed, but higher on the hill-slopes the quartz drift covers the slate rock to a considerable extent, and rises to a height of 2,500ft. above sea-level. The bed of Marion Burn has been worked for gold in its lower part, but not above the point where it is crossed by the most easterly line of quartz drift; and to either, or both, of the lines of quartz drift—that on the Home Hills, and that running along the foot of the Hawkdun Mountains—must the gold found in Marion Burn be referred. The gold found in the Marion Burn is reported as being of a coarse description, and, as usually the quartz drifts contain moderately fine gold, it may be assumed that on the northern slopes of these hills it is coarser than usual. Very little prospecting has been done in these quartz drifts. Only two prospecting-holes were noticed, though it may be that others exist.

Western Base of the Hawkdun Range.—From the northern base of Little Mount Ida a line of quartz drift runs along the foot of the Hawkdun Range to near the head-lift of the Mount Ida Water-race. About three miles above the junction of Spencer Burn with the west branch of the Manuherikia River quartz drift occurs on the slope of the range at some height above the level of the Mount Ida Water-race. Some years ago a rush took place to this locality, it having been reported that a second St. Bathan's had been discovered there; but after what may be regarded as a fair trial the place was abandoned, but not before it was shown that with abundance of water and in a less remote place the ground might have been made to pay for working. From the junction of Spencer Burn for some considerable distance the line of drifts is below the level of the water-

* Goldfields Reports, 1893, p. 118.

race, but along this part clays and lignite-seams are chiefly developed, and the quartz drifts are not well exposed if they are present under the other beds of the series. Within five miles of the Marion Burn the beds have assumed a high dip eastward, or towards the range, and near McDonald's Hut, on the water-race, both the lignites and the quartz drifts are well exposed. On the south side of the gully from McDonald's the quartz drifts are standing nearly vertical, and some work has been done in the way of prospecting the beds. Some little gold was found, but this was followed instead of making a cut across the highly-inclined beds to the older rocks on which the lower beds of the series would be found resting, and near which it was probable the best gold would be found. At various places the beds show in positions favourable for prospecting—from McDonald's to Kennedy's Hut in Marion Burn, more especially towards the Marion Burn end of the line. Between the upper end of the gorge of Marion Burn and the foot of the range the beds are exposed over a breadth of nearly half a mile; and at one place there is a hill covered with white cement boulders, beneath which there is a very promising development of quartz drifts. On the banks of Marion Burn itself the grits and lignite-seams show at several places, but towards the upper part, where it leaves the Hawkdun Range, the broad gravel plain of the upper part of the valley of Ida Burn overlies and obscures the beds for some distance; but they again appear to the south in the saddle that lies between this and the source of Gorge Creek and the south branch of Ida Burn. On the northern side of this saddle there are a great number of very large cement blocks strewed over the surface, but on the south side of the saddle, and thence across the hills to the Mount Ida Water-race, the cement masses are absent, and the quartz grits, as good-looking well-rounded quartz-wash is loose, and easily prospected with the pick and shovel.

Gorge Creek.—In the head of Gorge Creek the beds have been well exposed in making the water-race which passes this point; and somewhat higher up than the shoulder of the low spur round which the race is taken, a party of miners have opened out the ground and are preparing to work the drifts, after having worked a rewash of the same beds filling up the narrow valley of a blind gully coming from the quartz hills to the north and north-east. Accompanied by one of the party I examined the immediate vicinity of these workings with some care, and pointed out the evidence tending to prove that the gold they had hitherto been getting in the superficial deposit was probably—indeed, beyond question—derived from the quartz-drift deposits occurring higher up the ridge. We followed the gully, and found old prospecting-holes right to the higher part, and right on the crest of the ridge, one or two in the quartz drift itself. These holes had been put down many years ago, and at a time when what would now be considered a good prospect would not be considered sufficient to work the ground. On this place, in his report of last year (Goldfields Report, 1893, p. 118), Mr. Gordon remarks, "There are considerable areas of apparently auriferous drifts between Naseby and Blackstone Hill, and also on a terrace on the upper side of Pearce's Gorge, where very little prospecting has ever been done; and breaks in the Mount Ida Water-race, washing away portions of the drift gravel in the vicinity of the latter place, have disclosed the fact that it is auriferous. A few years ago claims were worked at the Little Ida Burn, and close adjoining this the deep run of quartz drift comes through, but nothing has been done to prospect this deposit in any place between Mount Buster and Blackstone Hill." The beds run west along the valley of Gorge Creek for fully a mile below the point where they are exposed in the Mount Ida Water-race, but it is not clear that they make direct connection with the beds of the same series near to where the coal-mine is worked on the banks of the south branch of Ida Burn.

The Woolshed, Blackstone Hill.—Mining has, for the want of water apparently, been discontinued at this place, which lies about from two to three miles westward of Hill's Creek Township, at the foot of Blackstone Hill Range. A very considerable amount of work has been done in the white quartz drift at this place, a line of which runs along the foot of the range and the northern side of Ida Valley to the Pool Burn Gorge. It appears that the wet character of the ground along the line of quartz drift towards Pool Burn Gorge prevented this part from being prospected, and this also may be said of the continuation of the same line beyond the Pool Burn Gorge in the direction of Black's No. 3. There is a general opinion amongst the miners that this line of drift is rich in gold, and a scheme has been mooted of driving a tunnel from the Manuherikia Valley through the western spur of Blackstone Hill to reach and drain this line of drift. This would be a costly work; while, from the incoherent character of the beds and their high dip, the auriferous drifts would also be costly to work if they had to be mined otherwise than by open workings. The gold also is not evenly distributed, as the results of prospecting at Black's No. 3 have shown.

Black's No. 3.—"The deep lead, or, more appropriately, deep workings at this [Pool Burn] valley, formerly known as Black's No. 3 Diggings, are situated on the eastern slopes of Raggedy Ridge. The sequence of the lacustrine deposits, at the base of which the auriferous wash occurs, is well exposed at the old workings, which follow in a north-and-south line the outcrop of the wash. In the mode of their deposition, origin, and character the strata here are in every respect similar to those found at Hill's Creek, Naseby, St. Bathan's, Tinker's, Drybread, and all the other localities on the margins of the old lake-basins where they have escaped denudation. They were deposited contemporaneously, and, the same causes being in operation all over this area, their sequence is always the same. But the character of the sediments was subject to several outside influences, such as the velocity and set of currents, the inflow of streams from the adjoining mountains, and the nature of the rocks where the material was originally derived. Allowing for the local variations caused by these, it is found that the general character, as well as the sequence, is the same at all places situated on the margins of the old basins.

"At the deep workings at Ida [Pool Burn] Valley the deposits consist of the following members, in descending order: 1. Blue and grey bedded sands and clays. 2. Rusty ferruginous quartz grits. 3. Black carbonaceous quartz sand. 4. Grey quartz sand (very local). 5. White clay (very local). 6. Auriferous wash. 7. White clay. These beds have been subjected to considerable local disturb-

ances, and dip in different directions within short distances. At the workings farthest up the Pool Burn they dip west—that is, towards the schists—at an angle of 45°. At this place the auriferous wash was worked along the outcrop as deep, open-trench workings to a depth of 15ft. to 20ft.; and, when this system could no longer be pursued with safety, shafts were sunk on the wash, which was raised in buckets. The shafts were of various depths, according to the dip of the wash and the appliances available for sinking. The greatest depth reached was 200ft., but most of the shafts were much shallower than this.

"At the point where the road to the German Hills diggings leaves the slopes of Raggedy there is an isolated patch of the schists, on the gorge side of which the strata dip to the east—that is, towards the Pool-Burn Stream. As a result of this direction of dip the auriferous wash rises into shallow ground, lying on stiff white clays close to the underlying felsitic schists, which are here as much decomposed as at Green's Reef. The same system of open-trench working has been adopted here as at the diggings higher up the flat, but very little attempt appears to have been made to follow the wash to the dip, probably on account of the inflow from the Pool Burn.

"With respect to the future prospects of the deep workings in the Ida Valley, it is obvious that three main conditions are necessary to insure success—viz., an auriferous wash yielding payable results; an extended area of payable ground; and last, but not least important, skilful mining. With regard to the first condition, the payable character of the wash is admitted by all those who have worked on the field, and their evidence is confirmed by the nature of the old workings, which would not have been undertaken unless the results were worth the risks incurred. Next, with respect to the extent of the auriferous wash, it is probable that most of the shallow ground has already been worked, so that future workings would be confined to the deep ground. The lacustrine strata extend along the flanks of Raggedy Ridge from the head of the Pool Burn to the gorge, and there can be little doubt that the auriferous wash which is always at the base of this series is also present; but there is less certainty as to its payable character along the whole length of this extended lake-margin. The presence of the wash, if not its auriferous nature, could easily be ascertained by boring at well-selected points. The black carbonaceous quartz sand, which is the equivalent of the lignite found at other places in this area, overlies the wash, and, being a characteristic and well-marked horizon, always present in the Ida Valley, affords an effective check and guide as to the progress of the boring. The wash is a rough, subangular gravel, composed of quartz sand, pebbles, and fragments of mica-schist. It varies in thickness from 5ft. to 30ft., and is said to carry gold wherever it is touched.

"The principal and, in fact, the only reason given for discontinuing the digging at this place is the depth of the ground and the danger attending the mining operations. The wash is inclined at high angles, and is enclosed in loose, porous strata, in which it is difficult to sink by the ordinary means adopted in mining. The loose quartz sand, known to the diggers as drift, when wet is little better than a quicksand, and precautions would have to be taken to keep it out of the workings."*

German Hill.—Mr. Park also reported on the workings at this place. He says,—

"The German Hills are situated on the east side of the Pool-Burn Valley, under the slopes of Rough Ridge. As at the other diggings on the margin of the old lake-basin, there are but three formations represented here—namely, the foliated mica-schists, the lacustrine series, and recent alluvium. The latter occurs under such peculiar and exceptional circumstances that it cannot with propriety be termed a true alluvial deposit, although at the same time the gold it contains is a rewash from the lake-deposits. In order to convey a clear idea of its character and occurrence it will be necessary to first describe the sequence of the lacustrine series, of which but two members now remain. The upper is a hard quartz sand and gravel rock, and the lower a yellow quartz wash, often interbedded with bands of clay. The latter rests directly on the schists, and varies in thickness from 10ft. to 20ft. The upper consists of fine quartz sand false-bedded with quartz gravel or wash that has been cemented by the infiltration of siliceous waters into an intensely hard, compact rock, varying in texture from fine-grained to coarse according to the nature of the material forming the original deposit. At Sebastopol (the name by which the higher rocky ground is known to the diggers) this stratum of cemented rock is about 8ft. thick, and in some places it is even more than this. By the gradual denudation of the softer clays and loose lake-wash upon which it rests it has become broken and shattered into innumerable detached tabular-shaped blocks of great size, which completely cover the ground, and render it impossible, by manual labour alone, to reach the auriferous wash underlying them, and the yellow lake-wash on which this in turn rests.

"The recent auriferous dirt is a rewash of all the lake-deposits that formerly overlay the rocky stratum, the broken and fissured surface of which was admirably adapted to catch the gold. The dirt is said to be very rich, and in past years many attempts were made to work it—in some instances by tunnelling below the blocks of rock, in others by sluicing at points where the blocks were smaller. By the former method the risks incurred were very great, from the danger of the detached rocks breaking into the workings; while in sluicing there was the additional danger caused by rocks falling into the paddocks as the dirt was being removed. The old lake-wash contains payable gold, and has been extensively worked along the flanks of the range.

"The amount of auriferous ground at Sebastopol is about 150 acres, of which 75 or 80 acres on the west and north-west slopes of the hill, where the rocky stratum is thinnest, are available for working. The difficulties that have prevented the successful development of this field in the past have been—first, the scarcity of water, and, second, the heavy character of the rocks covering the auriferous dirt. With regard to the first, I think it is probable, judging from the synclinal arrangement of the lacustrine strata in the Pool Burn Valley, that a supply of artesian water could be obtained by boring on the flats a short distance from Sebastopol. Next, with regard to the nature of the work, it is quite evident that, in order to successfully work the ground, the

* Park: Geological Reports, 1888-89, pp. 21, 22.

rocks must first be removed; and this is simply a mechanical problem, the solution of which seems to be solely a question of sufficient power. The blocks of rock are of all sizes, ranging from a few pounds to a hundred tons in weight, with occasional masses of even greater dimensions."*

From German Hill along the same side of Pool-Burn and Ida-Burn Valleys the quartz drift is nearly continuous all along the foot of the Rough Ridge to its eastern termination. At several places work is, or has lately been, carried on, and there are many localities at which the beds could be easily prospected; they have not, however, been prospected. It seems that in but few instances have the beds been prospected independently, but in most cases, the rough rubble of the nearly adjoining creeks being found to be gold-bearing, the following-up of this would lead to the discovery of gold in the quartz drifts.

Wether Burn.—Between the south branch of Ida Burn and Wether Burn there is a considerable development of the quartz drifts associated with white clays and beds of lignite. The lower beds crop out east of the road-line on the saddle at the end of Rough Ridge, and up to the road-line masses of white cement stone are scattered over the flat terrace-lands; and it is also apparent that the beds extended at one time along the White Sow Valley to the Gimmer Burn. The schist appears in the bed of the Wether Burn, a little below the crossing of the Clyde–Naseby Road, and forms a rocky ridge between this part of the Wether Burn and the White Sow Valley. The presence of gold has been ascertained in the white quartz drifts near the Wether-burn Hotel, but, as remarked above, since the rough mountain-shingle of the creek-bed has not yielded to the gold-miner, the quartz-drifts lie unprospected.

Gimmer Burn and Garibaldi Diggings.—The line of quartz drift along the eastern foot of the Rough Ridge from the White Sow Valley is continued to, and past, the foot of the Gimmer-Burn Gorge, and for some unknown distance up the Upper Taieri Valley. "On the summit of Rough Ridge, some few miles south of the Otago Central Mine, lies the Garibaldi Diggings, from whence some rich yields have been taken in times past, but there has always been a lack of water, which has usually to be stored, always an expensive operation. The shallow ground has been worked by means of sluicing, but the auriferous deposits are becoming deeper, necessitating heavy expenditure in constructing deep tail-races through hard metamorphic rock. An attempt is now being made to do this, and it may be some time before the result can be made known. The ore is all heavy reef gold, and cannot have travelled far, as its surface has not been much abraded by the action of water."†

The gold found in the gorge of the Gimmer Burn, said to be of a coarse description, probably in part has been directly derived from the schist rocks of the Rough Ridge; in part, however, it may have been derived from a development of quartz drift in the upper part of the valley known as the Garibaldi Diggings. The Garibaldi Diggings are, in the material of the wash and associated beds, similar to the German Hill workings, Mr. Park's description of which has just been quoted. At present the Garibaldi Diggings are almost abandoned; formerly a good deal of gold was obtained from this place.

Sowburn Diggings.—On the opposite south-eastern side of the Taieri Valley a line of quartz drift runs along the north-western base of the Rock and Pillar Range, from Patearoa Ford by way of the Sow Burn to Hamilton's. These have principally been worked at the Sowburn and Hamilton's, but they are present along the line indicated at many places, and certainly deserve to be further prospected. The Sowburn Diggings were opened shortly after Hamilton's (in 1863), and work has been carried on ever since that date.

Patearoa.—"In December last [1888] portions of the Taieri River-bed and adjacent terraces, near Patearoa Ford—in all, about 100 acres—were taken up by a number of miners, who amalgamated and jointly prospected the ground with boring-rods and tubes. The depth of auriferous wash was found to average 20ft., and to be of a quartz-drift nature, similar to the drift now being worked at St. Bathan's. The prospects obtained showed a result of from ½dwt. to 1dwt. of gold to the load. This was considered quite ample to justify a more systematic and costly scale of operations."‡ The Upper Taieri was not visited, but the evidence of the presence of the quartz drifts is sufficient. So far it has not been ascertained that quartz drift occurs at any place in the Serpentine Valley.

Hamilton's.—The gold-workings at Hamilton's have been almost wholly in quartz drifts. On the northern slope of the Rock and Pillar Range the drifts form a kind of basin, which shallows to both ends and to the north, but on the side towards the range the beds of drift are crushed under the spur, or overridden by it, and this margin of the basin is consequently somewhat irregular. Hamilton's is 1,800ft. above sea-level, and consequently about the same level as Naseby, on the opposite side of the Maniototo Plain, the Wetherburn Saddle, &c. For a number of years Hamilton's was a very rich diggings, but gradually the ground got exhausted, or too poor to pay for driving out, and, the supply of water that can be brought on to the ground being very limited, hydraulic sluicing is only carried on during a few months of the year, and then not on a large scale. On the north side the basin is bounded by a low ridge of slate, to the north of which there is another line of quartz drifts. This, trending nearly east-and-west across the creek, to the westward passes through the high terrace close to the schoolhouse, and thus reaches the western base of that terrace in the gully that bounds it on that side. From the lip of the basin to some distance below the schoolhouse the bed of the creek and its banks have been worked for gold. These workings in ordinary mountain-creek wash showed the presence of the quartz drifts as a false bottom, and in this rich gold was found and traced to the eastward beyond the immediate banks of the creek. The same line of drifts was followed between the outcrop of the slate rock and the cap of volcanic rocks that to the north-west overlies and obscures these sands. Open workings along

* Geological Report, 1888–89, pp. 24–26.
† Warden Hickson, reporting to the Under-Secretary of Mines, 7th May, 1885.
‡ Warden Dalgleish to the Under-Secretary of Mines, 31st May, 1890.

this line have been carried to a depth of 40ft. from the surface over a distance of some 300 yards; and from what could be gathered it was the difficulty of contending and dealing with water, not the lack of gold, that prevented the continuance of mining along this line. No one was working on any part of the line at the time of my visit; but a miner who had been on Hamilton's for many years acted as guide over the ground, and informed me that in the deeper part of the cut prospects of ½dwt. to the dish could be obtained when the ground was abandoned on account of water. If it be as above stated there is yet a large area of ground that would pay to work, and which could easily be drained by tunnelling from the creek to the westward. The quartz drifts pass underneath the basalt sheet that lies between Hamilton's and Taieri Lake and the river to the bridge on the road to Naseby. As this area of basaltic rock has a synclinal arrangement, and terminates before reaching the Taieri River, the white clays and quartz drifts again make their appearance between the edge of the basaltic sheet and the river. This lower outcrop is at some 500ft. to 600ft. below the upper, and, should it prove that throughout gold in paying quantities is present, there could be no difficulty in working the ground under the basaltic sheet.

Shepherd's Hut, Hamilton's.—This is a basin-like area similar to Hamilton's, and lying about a mile east, at nearly the same level above the sea. The grits shelve on to shallow ground to the north, but on the south side the ground is deep, and to drain this a tunnel has been driven from the creek to the westward. The ground at moderate depths was driven out, but at the present time the deeper ground is worked by hydraulic sluicing. The ground is said to have paid well. Further to the eastward, on the saddle leading to the Taieri River, near its junction with the Hound Burn, auriferous quartz drifts have been worked, but the results have not equalled anticipations, and work is now at a standstill. The northern lower slopes of the Rock and Pillar Range, from the foot of the Taieri Lake to the bridge on the Hamilton's–Naseby Road, are largely covered with basaltic rocks, partly resting on slate rock and partly on white clays and quartz drift, the latter undoubtedly auriferous at many places. Wherever, therefore, these grits can be easily reached they constitute a promising field to the prospector.

Taieri Bridge above the Lake.—It has been noted that the white clays and quartz drifts appear from underneath the sheet of volcanic rocks near the Taieri Bridge, and on the upper side of the bridge the clays are exposed in a cliff on the bank of the river, and the grits are present in the downs that lie to the westward between the Hamilton's Road and the river.

Maniototo Plain between the Lower Parts of the Hog Burn and Ewe Burn.—After crossing the Hog Burn, on the road from the Taieri Bridge to Ewe Burn and Naseby, the road follows a low ridge exposing quartz drifts at the surface. These lie at low angles, and spread over a considerable breadth of country. To the south-east they pass under the basaltic sheet developed in the middle of the Maniototo Plain, while to the north-west they are overlain by the recent sandstone gravels of Ewe-Burn Creek. Along the double ridge striking in the direction of Ewe-Burn Schoolhouse they extend four or five miles, and these beds are so disposed and situated that they might be prospected to very considerable depths without encountering water. The borehole put down at the Ewe Burn for the purpose of proving the existence of artesian water in its deeper part passed through these beds, and gold was found in the material brought up from a considerable depth in this borehole. Much lower beds would be met with at the surface within a mile or so of the Taieri Bridge. This area is well worth prospecting, even though the quartz drifts could not be passed through or bottomed, because gold in paying quantities does occur at different horizons in these quartz drifts. No prospecting has been done over this area other than one or two shallow holes put down to prove the rewash deposit on the sides of the low spurs within a short distance of the junction of the Hog Burn with the Taieri.

Ewe Burn above the Clyde–Naseby Road.—Little gold has ever been obtained from the Ewe-Burn creek-bed, but the line of quartz drift traced east from the Wether Burn is returned considerably to the north, and crosses the Ewe-Burn Valley in the line of Butcher's Gully, where some workings, now abandoned, have been carried on; also in the bed of the Ewe Burn, at about where the quartz drifts cross, gold-workings once were, though no one is working there at present. The rocks of the Mount Ida Range are not gold-bearing, and it is from this source that the recent gravels of the Eweburn Valley are supplied: hence their non-auriferous character, except near the point where the line of quartz drift crosses the creek.

Government Dam, Naseby.—The quartz drifts on the east side of the Ewe-Burn Valley trend round the spur of the isolated schist hill north of the Government dam, beyond the southern spur of which they again strike to the north-east towardst he head of Hog Burn. In the terrace west of the dam the grits lie close to the spur of the range, and are overlain by gritty and finer-grained greensands, with marine shells (*Pecten*, &c.). In the lower grounds the quartz drifts and impure lignite-beds are exposed. North and east of the dam several prospecting-holes have been put down in the quartz drifts, but they do not appear to have passed through gold-bearing drifts.

Hog-Burn Valley, near Naseby.—"This is a field where there is a large area of auriferous ground, but in many places the wash-drift is shallow, and the claims are quickly worked out. This, together with the ground containing very little gold, prevents many of the miners placing a good hydraulic plant on their claims, they being content to follow the methods of sluicing used in the early days—namely, a canvas hose with very little head, the ground being broken with picks before turning on the water. . . . There is no doubt that there is a large area of drift-wash containing a little gold, but it requires a constant supply of water and all the improved hydraulic appliances to make this character of ground pay for working." Mr. Gordon is here speaking of the surface-wash and more superficial gravel deposits that constitute the shallow ground in the vicinity of Naseby. There is deeper ground in the terraces on both sides of the Hog-Burn Valley, and there is, besides, the run of deep quartz-drift country which it is my more especial purpose to describe. Of this Mr. Gordon says, "There is a large extent of country between St. Bathan's and Naseby, and the run of the old quartz drift which is successfully worked at Mount Buster

apparently traverses the country towards St. Bathan's, and follows on round the foot of the high range to near Clyde. Some portions of this quartz drift give high returns of gold for sluicing, and most probably a fresh discovery will yet be made between the Manuherikia River and Naseby. A prospecting shaft at the upper end of the Hog-Burn Valley was put down several years ago to a depth of about 120ft., which got into the quartz-drift wash containing a little gold, but this shaft was never bottomed. The same run of ground is found at Mount Buster."*

During 1893 Sir James Hector reported "On the Deep-sinking at Naseby," carried on under the auspices of the Naseby Deep-lead Prospecting Association, the aim of which "has been to discover auriferous layers in the white quartz drifts which skirt the northern margin of the Maniototo Plains, being part of the shore-deposit of an ancient lake-basin. A shaft has been sunk to a depth of 300ft. at a point in the Hog-Burn Creek about a mile above the Township of Naseby. For the first 200ft. this shaft passed through beds of the Upper Tertiary gravel, sand, and silt derived from the disintegration of sandstone rocks, while the last 100ft. sunk passed through white quartz drift of a moderately fine grain, and somewhat subangular character, and evidently derived from the mica-schists. In these—the lower drifts—some of the quartz gravel near the bottom of the shaft was proved to be gold-bearing, but the percentage of gold obtained was so small that it was hopeless to think of working such deposits, and the association has endeavoured to continue sinking in order to test the white drifts where they rest on the main bottom. . . . There are sound reasons, founded on experience obtained elsewhere, for believing that the quartz drifts are sufficiently auriferous to warrant a considerable expenditure in prospecting them; but there are localities in the vicinity of the present shaft where this object could have been attained at much less cost, as there is very little chance of the main bottom being reached by the prospecting-shaft in less than 400ft. At the same time it may fairly be urged that, as in these quartz drifts the gold does not always lie on the main bottom, a bed of payable gravel might be struck not far below the depth already reached. Moreover, were it rendered certain that payable gold-wash does exist, the position of the shaft has been judiciously chosen, being at a point whence the strata rise to the north and north-west, thus commanding the drainage of a considerable area of the drifts in these directions, as shown by the dips observed. . . . At the same time . . . the quartz drifts could have been quite as effectively prospected at the surface, where they crop out both to the north and west, and are exposed on the Hog-Burn Creek 240 yards up stream from the point where the shaft is being put down. At this place the quartz-drift layers are seen to dip at considerable angles, and where they rest on the schistose rocks or true bottom are almost vertical. Here, therefore, there is every facility for testing at the surface-outcrop the same beds attempted to be reached in the shaft; and equal facilities are afforded along the eastern outcrop of the area surrounding the distributing-dam of the Mount Ida Water-race. In the latter locality it is not certain that the drifts are all of the same age, those west and north of the dam being little more than gritty greensands, which contain fossils of Upper Cretaceous age, being the same as those which occur elsewhere in the roof of the upper coal-formation. To the east and south the beds are overlain by white clays with beds of lignite, the latter being in turn overlain by quartz drifts having the same character and position as the quartz drifts in the Hog Burn. No effective prospecting has been done in these quartz drifts [in the vicinity of Naseby], which is very remarkable, the examination of the old surface-workings proving that, with few exceptions, the creeks have become comparatively poor in gold above the point where they intersect the quartz drifts, evidently pointing to these as the source of the gold. These drifts should, therefore, be carefully prospected by ground-sluicing where they are exposed along the west side of the creek, and there seems every reason to believe that the prospecting shaft should have been located somewhere within the outcrop of the quartz drifts, in order to avoid the 200ft. of the upper sandstone drifts, or 'Maori bottom' as it is locally termed, which it has been necessary to sink through to reach the auriferous beds, which could have been examined and tested on the surface at a distance of 240 yards from the prospecting-shaft."†

Foot of Mount Ida Range, Hog Burn to Little Kye Burn.—The quartz drifts continue from the Hog Burn across the upper part of One-spec Gully to the Little Kye Burn, and the beds are being worked in at least one claim within the Kyeburn watershed, near the foot of the mountain-road leading to Clark's Diggings, on the saddle between Mount Buster and Kyeburn Peak.

Clark's, or Mount Buster, Diggings.—In 1884 a report was published on the auriferous-quartz drifts on the saddle between Mount Buster and Kyeburn Peak, and which thence extend some distance to the northward; and here may be reproduced such parts as describe the position and character of the auriferous drifts:—

"Auriferous quartz drifts are not rare in central and eastern Otago, and on these grounds alone the deposit at Clark's merits no special consideration. Its claim to such rests on the peculiarity and great height of the situation, coupled with the fact that what evidently are the same beds are now found at much lower levels, and this within such short distances as to show that, since the period of their deposition, considerable displacements of strata have taken place, whereby some parts of the district were elevated to a height of 2,000ft. or more, over and above the amount of elevation which has affected the same beds but a few miles distant. There being a double series of auriferous quartz drifts in the district, it is of interest to know to which of these the deposit at Clark's should be referred, whether to the Miocene quartzose grits or to those of Cretaceo-tertiary age. As a continuous mountain-range the Kakanui Mountains terminate on the south side of the Kye Burn, north of which to the southern end of the Kurow Mountains the higher peaks are not linear in arrangement, but form a central knot from which three mountain-ranges—the Kakanui, the Kurow, and the eastern part of the Mount Ida Range—appear to radiate. Of the central cluster of mountains Kyeburn Peak is the most westerly. It is separated from Mount Buster at the

* Report on the Mining Industry of New Zealand, 1891, p. 71. † Geological Reports, 1883–84, pp. 44 and 45.

eastern end of the Mount Ida Range by the high saddle on the summit and northern fall of which Clark's Diggings are situated. The southern slopes of the Mount Ida Range are very abrupt. On the northern side the slope is gradual, and, but for the presence of a number of narrow and deeply-excavated valleys, this presents all the characters of an elevated table-land sloping gently to the north. Along the eastern edge of this sloping table-land the Kurow Mountains rise abruptly, south of which the higher part of the table-land is insensibly lost in the western part of the cluster of peaks surrounding Mount Domett. The Little Kyeburn drains the southern slopes of the saddle, and the diggings are reached by a track cut round a shoulder of Mount Buster, west of the saddle.

"The quartz drifts and other Tertiary strata filling the north-east corner of the Maniototo basin scarcely reach to a height of 2,500ft. on the line of track, and are here at a higher elevation than elsewhere east of Mount Ida or within the Maniototo basin. Above this point the rocks seen are blue slates, sandstones, and coarse breccia conglomerates that are probably of Upper Devonian age. The fall to the north being reached on the eastern slope of Mount Buster, the quartz drifts, commencing at the lowest part of the saddle a little to the eastward of the road, stretch as a line of rounded hills northward a distance of four miles in the direction of the southern end of the Kurow Mountains. East and west this belt of quartz hills is irregular in width, and often formed of isolated knolls and ridges, in the gullies between which the old Palæozoic rocks show at the surface. Everywhere they are formed exclusively of quartzose materials, with the exception of a few feet at the base of the deposit, which is sometimes made up of local rocks occurring as highly-decomposed breccia conglomerate, occasional boulders of which are sometimes met with in the quartz sands, and called 'dough-boys' by the miners. Being necessarily much denuded, the thickness of the quartz drift is variable, but in most of the hills it is yet from 40ft. to 100ft. thick. The upper part is usually fine sands; the middle beds are slightly coarser in grain, and often false-bedded; while the last 6ft. or 8ft. may be either fine sands, or a wash carrying quartz boulders of all sizes up to a diameter of 10in. It is in this coarser wash that the richest deposits of gold are found. If, however, this coarser wash be absent, the finer sands resting on the main bottom frequently carry good gold. Distinct lines of stratification are difficult to make out, but it is abundantly manifest that the beds yet lie in a horizontal position. The coarser wash at the bottom, and patches of silt in the upper beds, show this to be the case. Gold is known to occur in what are considered paying quantities at many points along the belt of made hills to its northern extremity, but work is at present being done only near its southern end. The difficulties in the way of developing the field are the lack of a sufficient and continuous supply of water, coupled with the fact that at an elevation of 4,000ft. work can only be carried on during the summer months. Three companies were at work when I visited the place. These are in possession of all the available water which can, without great cost, be brought on to the field, and practically have a monopoly of whatever their water can command. The method employed is hydraulicking, which is conducted on as large a scale as possible while the abundant supply of water which is to be had during the spring and early summer months is available. After the new year there is generally a scarcity of water, and after the end of April all work is suspended on account of the severe conditions which prevail at that season of the year, work not being resumed, as a rule, till the following October. . . . At Clark's there are no agglomerated masses of quartz cement; the gravels of the lower part of the deposits are completely rounded, and mostly flat, pitcher-shaped pieces, indicating wave-action. There are no lignite-seams nor shales carrying fossil leaves."*

On this field Mr. Gordon remarks, "Gold was first discovered here in 1863 in a small creek-bed known as Clark's Creek, which runs into Deep Creek, forming a tributary of the Waitaki River. The ground was very shallow and easily worked, and in some parts of this creek-bed the auriferous-wash drift was found to be very rich. As soon as the shallow ground got exhausted attention was directed to the higher ground on the east side of the creek, where a deep run of fine quartz-drift gravel was found, similar to that at St. Bathan's basin, having a little gold through it in layers of concentrated material, showing that at one time this drift had been brought down by the action of a large river or stream, and that the work of concentration had been carried on from time to time, leaving the material of greater density in thin layers or bands before another deposit was brought down to undergo a similar process—namely, by washing away the lighter sands and material, while particles of greater density remained behind."†

Kye-Burn Diggings.—Near the upper township mining has mostly been carried on in the recent alluvial deposits of the river-bed and its banks, and more recently in the heavy gravels of the "Maori bottom," forming a range of hills between the Little Kye Burn and the main stream. The quartz drifts are developed to a considerable extent along the western base of the Kakanui Mountains, and the section across the river near the coal-mine seems to expose a double series of quartz drifts with fossiliferous greensands associated with the upper drifts. The range of hills between the Little Kye Burn and the foot of the mountains to the eastward is somewhat remarkable on account of the vast number of blocks of white quartz cement that lie scattered over its surface. These lead to the supposition that there is in this range a great development of the quartz drifts; but, so far as could be determined, the cement blocks are resting either on "Maori bottom" or on a slaty breccia deposit not unlike the finer parts of the lower deposit at the Blue Spur, Gabriel's Gully. From the Upper Kye Burn along the foot of Mount Pisgah to the Swin Burn the quartz drifts are not well exposed, being overlain and obscured by fan deposits brought down from the higher part of the range, and deposited by the creeks along the margin of the plain. A small area of quartz drift was described to me as occurring in the valley of the Kye Burn, two or three miles above the Upper Kyeburn Township, thus indicating the possible connection of the drifts of the Maniototo area with those of the Maraewhenua and the Waitaki Valley.

Swin Burn and Hound Burn.—Sands and shales are developed in the Swin-Burn Valley, and

* Geological Reports, 1883-84, p. 91. † Goldfields Report, 1893, p. 116.

thence extend south into the upper part of Shag Valley. The same beds, overlain by volcanic rocks, extend south-west along the ridge of Little Puketapu Hill, and to the west in the Hound Burn they again descend to the level of the Taieri River, and show as sands and fine grit on the left bank one mile below Ryan's Hotel. In the Hound-Burn Valley prospecting has been carried on for a very long time. The locality is always spoken of as being a very promising one, and yet no mining population has ever been attracted to it. One or two parties may be found within the Hound-Burn Valley or its neighbourhood, or for a time the place may be abandoned. Apparently, from what could be learned, prospecting is confined to the shallow rubbly wash of the creek-bed, and but little attention is paid to the quartz drifts, which undoubtedly afford the gold found in the more recent deposits of the creek.

Hyde.—Gold was first discovered at Hyde in the coarse mountain-wash brought down by the creek from the Rock and Pillar Range, but it was soon ascertained that the gold extended up the creek but a short distance above the outcrop of the quartz drifts. The quartz drifts, at their junction with the slates in the bed of the creek, were very rich in gold; and, the line of outcrop crossing the creek at nearly right-angles, the gold was followed along the outcrop into the next creek to the south. Since the place was opened, early in 1864, a great amount of white quartz drifts has been removed, and but for the scarcity of water there would have been much more.

Fullerton's and Mare Burn.—Fullerton's, like Hyde, has its gold chiefly confined to the quartz drifts, any gold got in the rubbly wash of the creek being clearly derived from the adjoining drifts. In the Upper Mare Burn this was also the case, although the workings along the creek were chiefly in coarse gravels; but between the Upper Mare Burn and the road from Hyde to Macrae's there are quartz drifts, the drainage from which is by way of the Mare Burn.

Station Hill.—This is to the north of the road, and on the top of the Taieri Ridge, overlooking Horse Flat and Deep Dell. Here the only wash is quartz grits, which have been worked by cradling or with a water-supply totally insufficient to prove the ground. It is evident from what has been done at this place that with a good supply of water the quartz drifts could be made to pay handsomely.

Horse Flat.—The claims being worked towards the eastern end of the flat are wholly in coarse creek or terrace-wash. In the middle part, close under the slopes of Taieri Ridge, the workings show coarse rubbly wash, mixed with cement boulders from the quartz drifts, while towards the southern end of the flat, and near Deep Dell Station, the quartz drifts are at present under the terrace-wash.

Macrae's.—By far the greater area of ground worked at Macrae's shows coarse, shingly wash, derived from the neighbouring slopes on each side of, and towards the head of, the valley. On the north-west side of the flat, however, quartz drifts are present, and towards the eastern end of the township these have been worked, and gave good returns. West of the township the same beds can be traced along the margin of the flat, and they also near the margin of the flat form an isolated hill covered with cement blocks. At this place the grits have been prospected and proved gold-bearing, but, owing to the presence of water and the loose nature of the wash, they have not hitherto been worked. At Macrae's there are said to be two varieties of gold—one rough and raggedy, evidently derived from the slates of the neighbourhood; the other a smooth, plump, or scaly gold, as clearly derived from the quartz drifts developed along the north-west side of the flat.

Nenthorn.—Quartz drifts occur in the lower part of Nenthorn Creek, and in an isolated ridge of hills lying about five miles south-east of the township. In the latter locality some gold-working has been carried on in the valley south-east of these hills, which has led to the conclusion that the gold came from the neighbouring quartz drifts. This led to their being prospected, but this was done in an insufficient manner, and without success.

Green Valley and Waihemo, Shag Valley.—Quartz grits are seen at two or three places on the road from Waihemo Hotel to Green Valley, and on the northern side of Waihemo Hill. Judging from appearances, these may contain gold.

Dunback to Taieri Peak.—From Dunback to the upper part of Pleasant River, near Taieri Peak, the slopes bounding Shag Valley are at many places covered with cement boulders, but the quartz drifts have generally been removed.

Pleasant River.—From Taieri Peak to Mount Watkins, and thence east to the main road and railway-line from Palmerston to Dunedin, there is a great development of quartz drifts underlying brown quartz sands and rusty greensands. Gold is found in small quantities over this area, but not so plentifully as to lead to the inference that the grits themselves would pay to work. On the east bank of Pleasant River, at the base of Smyler's Peak, the quartz wash is of an unusually coarse description.

Macgregor's Creek, Road from Palmerston to Foot of the Horse Range.—Between the foot of the Horse Range and Macgregor's farm the road-cuttings show a narrow ridge of slate and sandstone of probably Devonian age. On both sides of it, and in the hills to the south-east, mantling over this older rock, are beds of schistose breccia, breccia conglomerate, and quartz grits. These are auriferous, and are probably so to an extent that renders them payable to work, but, besides being on freehold land, there is no water that, short of very great cost, could be brought on to the ground. In a blind gully south-east of the road-line, where the older rock shows, the gradual breaking-down of the cements and the removal of the lighter and finer parts has resulted in the concentration of the gold along the creek-banks and in the semicircular basin at the upper end of the gully. This concentrated material proved so rich in gold that one man, with but a cradle and such water as he could retain on the ground, got for one week's work gold to the value of £60. This rich ground was necessarily limited, and at the time of my visit small wages only were being made. This gold was thus unquestionably derived from the grits and breccia conglomerates at the base of the coal-bearing series of Shag Point and the Horse Range.

South-west Slopes of the Horse Range.—There are two gullies on the north-west side of the road crossing the Horse Range from Shag Valley. These have been long known as being auriferous, and have been worked intermittently from the early days of the Otago goldfields. A few years

ago some one did better than usual, and the consequence was a rush. The ground is now supposed to be completely worked out. These two gullies derived their gold from the coarse breccia conglomerate that lies at the base of the coal-bearing series, and which lies on the saddle at the head of these creeks, and forms in part the spur between the two gullies referred to.

Trotter's Creek.—From the crest of the Horse Range north to the mouth of the gorge of Trotter's Creek, breccias and breccia conglomerate, that are not easily distinguished from those of the lower part of Blue Spur, are developed as the lower beds of the Cretaceo-tertiary coal-bearing series. Upwards, these beds pass into quartz grits and limonitic sandstones to be seen in the lower part of Trotter's Creek Gorge. Trotter's Creek has been worked for gold nearly as far as the breccia conglomerates extend, and there cannot be a doubt that the gold found in the bed and banks of the creek has been derived from the quartz drifts and breccia conglomerates of the Horse Range and the north side of the gorge.

Kartigi Beach.—The gold found at the mouth of Trotter's Creek and on the sea-beach to the north and south has clearly been derived from the quartz grits and breccia conglomerates towards the source of the creek.

Moeraki Beach.—The source of the gold found on Moeraki and Onekakara Beaches is similar to that found at, and north and south of the mouth of Trotter's Creek. Between South Peak and the gorge of the Otepopo River the front hills and eastern slopes of the Kakanui Mountains show the older rocks in the deep ravines and gullies overlain by limonitic sandstones and shales of the coal-bearing series, and at places by moderately coarse well-rounded quartz drifts. These latter are seen on the higher part of North Peak, and again under the coal in the higher part of Government Hill, between the Rookery River and the main branch of the Waianakarua or Otepopo River.

Kauroo Creek to the Gorge of the Kakanui.—Between the Otepopo River and Island Stream the quartz grits at the base of the coal-bearing series are confined to a narrow belt on the slopes of the front hills, a few stray patches of grit or volcanic rocks being found farther inland. The southern base of Kauroo Hill is formed of Palæozoic rock, and the higher part of volcanic rock covering up the thin edge of the denuded quartz drifts, which make rapidly to the north-west, north, and north-east, and cover a considerable extent of country between the Kauroo Creek and the gorge of the Kakanui River. The quartz drifts over this part (Balruddry Run) are known to be auriferous, but the owner objects to mining. On the neighbouring runs, where permission to prospect has been given, it seems that the gold was not sufficient to pay, though the miners still believe that rich ground exists. There is, in fact, a considerable area of ground, including parts of several runs on the north-east slopes of the Kakanui Mountains, respecting which there is thus some doubt, the miners asserting that they are debarred from prospecting, while, on the other hand, it is said that prospecting has not been a success. These grounds are at a considerable elevation above any permanent source of water-supply, unless this be brought from higher parts towards the source of the principal creeks, and the value of the field will not be determined till a sluicing-test on a moderately large scale has been made. With a good supply of water, there is little doubt that parts of this area would pay to work.

Windsor, Ngapara, and Upper Part of Waireka Creek.—In this part of the district there is a considerable development of the quartz drifts, and at some places payable gold is said to be found, but, as the land is freehold and under cultivation, no workings are being carried on. In some of the cuttings along the Oamaru–Livingstone railway-line the quartz grits show largely. To the westward of the railway, on the heights north of the Kakanui Gorge, the quartz drifts are found over the high land to a distance of four or five miles south-west of Livingstone.

Livingstone.—Gold was discovered here about the time of the rush from Naseby through Dansie's Pass to the Waitaki. The gold was first found in the creek-wash of Golden Gully, which proved comparatively rich in the precious metal. The bed of the upper part of Awamoko Creek was also auriferous, and some gold was got on the banks of the Maraewhenua River. Soon, however, prospecting led to the discovery of gold in the white quartz drift that, resting on the slate rock, passes under the terraces and table-lands to the east and south, or lay as scattered patches of coarser grit on the high lands to the west and south. To the eastward the quartz drifts are overlain by a thin stratum of greensand with fossil shells and sharks' teeth. These beds also proved auriferous, and this, with the first foot or so of the quartz drift, is the horizon that is, for the most part, being worked at the present time. Brown sands, sometimes containing hard bands full of fossil shells, overlie the greensands, and following these is a sheet of basalt, followed by other sands, grey or green, till the sequence is finally closed by the Maraewhenua limestone, which, on the south side of the river, is the highest member of the Cretaceo-tertiary series.

North Side of the Maraewhenua Valley, opposite Livingstone.—The rocks here are practically the same as at Livingstone, on the south side of the river, excepting that there is on this side a greater development of high-level river-gravels, which in places are worked for gold. Most of the claims on this side of the river are working the greensand stratum and the first few feet of the quartz drift. The quartz drifts extend north-west on to the slope of the range between the Otekaike and the Maraewhenua, and in the gullies cut through this into the sub-schistose bed-rock coarse pieces of gold are often found. There are about thirteen parties of miners at work on this side of the field, and a somewhat greater number on the Livingstone side. Their average earnings do not exceed £2 a week per man, and this estimate applies only to the times when work is in progress, scarcity of water causing frequent interruptions, especially during the summer months.

Otekaike Valley.—From the northern bank of the Maraewhenua River the belt of auriferous quartz drifts strikes north and north-east into the Otekaike Valley, and then bends more to the east, and is continued along the valley of the Waikura to the main road up the Waitaki Valley. There are no gold-workings north of Sheepwash Creek, although gold supposed to be payable is known to exist over a considerable area in this direction.

Otiake River to Kurow.—The line of quartz drifts should appear along the eastern lower slopes of Little Domett and Big Ben Mountains, as the limestone and higher members of the formation are exposed near the Otekaike Station; but immediately higher up the Waitaki Valley heavy terraces of sandstone gravels are present, and are specially developed between the Otiake and Kurow Rivers.

These extend back to the foot of the mountains, and obscure the northern continuation of the quartz drifts. These sandstone gravels correspond to the "Maori bottom" in the Maniototo basin and the Manuherikia Valley.

Awakino Valley.—Beneath the coal-measures stretching from the Kurow River to the Little Awakino there are at places a considerable development of quartz drifts. These, with the other strata belonging to the same series, form a syncline where they cross the valley of the Big Awakino, and, a larger area of grits being exposed than is in the Kurow or the Little Awakino, the partial destruction of these has yielded gold to the recent gravels of the stream. Gold was found, and a rush to the Awakino took place, but the amount of gold in the creek-gravels was not considered payable, and soon the place was deserted, without giving the quartz drifts and rusty cements anything like a fair trial.

Switzer's.—At Switzer's the bulk of the gold-workings are in coarse gravels that resemble the "Maori bottom" of the interior, but underneath these are beds of brown sands quartz drifts, clays, and lignite-seams that correspond with the similar rocks of the Upper Manuherikia and Maniototo basins. A ridge of older rocks on the east bank of the Wakaia River, above the township, confines the quartz drifts to the valley between this ridge and the western slopes of the Argyle Hill Range, but both to the north and the south the grits extend beyond the barrier of older rocks, and consequently dip into the main valley. Towards the northern end of this exposure of the quartz drifts several claims have been worked in them, but it would appear that either a patch has been worked out or that the ground was too poor to pay for working. Further south, near the middle of the valley, is situated another considerable working in the quartz drifts, and towards the southern end the beds have been worked in some four or five claims, and were still being worked by Chinamen at the time of my last visit. As both the upper sandstone gravels and these, the lower or quartz-drift series, are auriferous at Switzer's, it seems to me that the main requirement of this field, to make it again prosperous, is an abundant supply of water, capable of commanding the drifts at the higher levels.

Muddy Creek.—This lies on the opposite or western side of the valley from Switzer's, and scarcely deserves to be considered apart, other than to note that in the beds associated with the quartz drifts concretionary masses of lime cement-stone are found containing large shells (oysters) and a considerable variety of smaller size, which thus will aid in proving the age of the beds at both places and in this part of the district generally.

Waikaka.—The diggings at this place are of great interest, since there are no sandstone gravels or rubbly creek-wash covering the quartz drifts. The denudation of these has afforded the material of the superficial wash in the low grounds along the creek and on the terraces on each side. Quartz detritus is, therefore, the only wash; along the creek flats this is free from earthy matter, and occurs as a well-rolled gravel. On the terraces a variable depth of loam, from 3ft. to 10ft., overlies the auriferous wash, which also contained earthy matter. Highly-inclined strata of quartz, gravel and banks of white clay underlies the upper wash. These lower quartz-drifts, it was ascertained, are gold-bearing; and at the back of the township a deep prospecting shaft was put down in the gravel-beds. It could not be learned what the depth of this shaft really is, but it has been sunk to considerably more than 100ft. from the surface. A gold-bearing layer was struck, or, at least, a good-looking quartz wash, and a quantity of this was sluiced, since which work has, for lack of funds, been discontinued. In the east branch of the creek a considerable area of ground has been worked under like conditions, proving that the gold in the superficial wash was not derived from the ranges towards the source of the Waikaka, but from the quartz drifts adjoining and underfoot.

Mackenzie.—The line of quartz-drift outcrops along a range of hills forming the water-parting between the Wakaka and Pomahaka Rivers, and on this line Mackenzie is situated. Gold-workings to some extent have been carried on at this place, but the locality was not visited.

Landslip Hill.—Here also the quartz drifts are developed. They are overlain by hard quartz cement stone, in which are numerous finely-preserved imprints of dicotyledonous leaves and ferns. Gold was found here by Gabriel Reid during the time he was prospecting for the Otago Government; but it does not appear that then or since then has payable ground been found.

Knapdale (McNab's Run).—Gold is found at many places amongst the hills between the Mataura and the Waikaka Valley, on McNab's Run, and at places within the Waikaka watershed a considerable amount of work has been done. Generally the gold is found in a rewash of the quartz drifts, under conditions similar to those obtaining at Waikaka Diggings.

Classification and Sectional Relationship of the Strata examined.

The map accompanying shows the different formations that are present within the Otago goldfields. The scale of the map prevents the minuter subdivisions of the Tertiary and Cretaceo-tertiary formations being shown, and for the purposes of this report it has not been considered necessary nor advisable to subdivide the schists or the unaltered Palæozoic formations. For the map, therefore, the following classification has been adopted:—

1. Recent and Post Pliocene.
2. Pliocene and Upper Miocene.
2A. Auriferous breccias and quartz drifts of probable Upper Miocene age, lower part of 2.
3. Lower Miocene and Upper Eocene. (The area of the Upper Eocene is so small that this, occurring only near Oamaru and in the Waitaki Valley, has not been distinguished.)
4. Cretaceo-tertiary: Upper beds.
4A. Cretaceo-tertiary: Middle and lower beds.
5. Carboniferous and Devonian formations.
6. Metamorphic schists, probably of Silurian age.
7. Basic volcanic rocks.

As this report professes to deal only with those formations that yield alluvial gold, the older Secondary, Palæozoic, and schistose formations will be dealt with in the shortest manner possible. Some of them, it may be, contain alluvial gold, but this has yet to be proved. There are thick strata of indurated conglomerates and pebble-beds in the Hawkdun Mountains, and indurated angular breccias at the eastern end of the Mount Ida Range, both of which might contain gold; but no one has as yet thought of testing these deposits, and they would require a considerable percentage of the metal to pay for working, as the material would have to be crushed in a battery mill to set the gold free.

Oolitic, Liassic, and Permian conglomerates of a granitic character occur immediately to the south and west of the district reported on. These are likely to contain gold, and on more than one occasion gold has been reported as occurring in these rocks. Mr. John Buchanan, late Botanist and Draughtsman to the Geological Department, informed the writer many years ago that he had obtained gold from the conglomerates occurring between the Kaihiku Range and the Lower Mataura. To the south-west these rocks do not occur within the area mapped. Trias or Permian beds are possibly present in some parts of the Horse Range, on the north-east side of the great anticline, and hence their appearance in the extended classification, although not shown on the map nor in the sections, unaltered rocks older than the Cretaceous period being taken together as "old rocks."

The following scheme of classification includes all the rock-formations known to occur within the boundaries of the Otago goldfields, as on the map:—

Table of Formations occurring within the Otago Goldfields.

Formation.	Name of Series.	Character of Beds.	Principal Localities.
Recent	Recent	Sand- and gravel-beds, fresh water or marine	Widespread throughout the district.
Pleistocene and Upper Pliocene	Glacier-deposits ..	Angular detritus ..	Glacier-deposits, confined to the west and north-west parts of district.
	Old lake deposits ..	Well-rolled shingle, usually sandstone	Sandstone gravels forming terraces, and shore-deposits within the old lake-basins of the interior.
Lower Pliocene ..	Maori or terrace bottom	Sandstone gravels, clays and lignite at places	Old lake-basins; Switzer's; Kaitangata Coalfield, &c.
" " ..	Newer breccia conglomerate and quartz drift	Slaty breccias and gravels, apparently a river-deposit, quartz drifts, &c.	Criffel Face, Cardrona Valley; Devonshire Diggings, Tinker's and Drybread, Manuherikia Valley; Little Kyeburn, Maniototo Basin.
Miocene	Fresh water series ..	Light-coloured shales, greenish clays, quartz drifts with beds of lignite	Kawarau Gorge; Cardrona, Nevis, and Manuherikia Valleys; Ida Valley, and in part the Maniototo Basin.
Lower Miocene ..	Pareora series ..	Fossiliferous greensands underlain by quartz grits	Kyeburn River, Upper Kyeburn at coal-mine.
Cretaceo-tertiary ..	Upper series	Limestones and calcareous sands	Along the coast from Oamaru to Waihola.
" ..	Middle series	Marly clays, volcanic tufas, and greensands	Oamaru and Waitaki district, and the coast-line to mouth of the Molyneux; Skipper's; Naseby; Switzer's, and Lake Wakatipu.
" ..	Lower series	Shales and quartz sandstones with coal-seams; quartz grits and breccia conglomerates	Along the coast north of mouth of the Molyneux; inland from Naseby to Tuapeka; Switzer's; Bob's Cove to Skipper's, &c.; Lake Wakatipu district.
Trias-Carboniferous	Wairoa, Kaihiku, Maitai series	Sandstones and indurated shales	Kakanui Mountains; Kaihiku Range.
Devonian ..	Te Anau series ..	Indurated coarse breccias, sandstones and pebble-beds, shales, &c.	The Kakanui Mountains; Mount Ida and Hawkdun Mountains; Mount St. Bathan's, &c.
Metamorphic ..	Upper schists ..	Grey flaggy arenaceous schists, sometimes with quartz foliæ, but these not characteristic of the rocks	From Hamilton's to the upper part of Shag Valley; Silver Peak to Chain Hills, Dunedin; Taieri Gorge (lower) by way of Mount Stuart, across the Molyneux to the Pomahaka Valley and Switzer's, thence to the southern and central part of the Eyre Mountains.
" ..	Middle schists ..	Soft silky mica-schists with or without their somewhat regular laminæ of quartz	Lindis Valley; Arrow and Shotover Valleys; between Lawrence and Waipori.
" ..	Lower schists ..	Mica-schists, calcareous, strongly foliated with elliptic masses of quartz; siliceous and chloritic schists, with an abundance of magnetite, in crystals or massive	East slopes of the Richardson Mountains; greater part of interior Otago to the northern boundary of the provincial district; the eastern and southern limit is that of the upper schist in these directions.
Volcanic ..	Miocene volcanic rocks	Sheet and columnar basaltic rocks	Neighbourhood of Dunedin; Waihola.
" ..	Cretaceo-tertiary volcanic rocks	Sheet and columnar basaltic rocks	From the Maraewhenua River along the coast-line to Waihola Gorge; Upper Shag Valley, and south side of the Maniototo Plain; Taieri Gorge; Mount Highlay; Moonlight and Nenthorn Creeks, &c.

In the different localities which have been described, seven, at least—perhaps eight—varieties of auriferous wash drift have been noted. These are,—

(*a.*) The older breccia conglomerates.
(*b.*) The older quartz drifts.
(*c.*) The newer quartz drifts.
(*d.*) The newer breccia conglomerates.
(*e.*) The sandstone conglomerates (" Maori bottom ").
(*f.*) Old lake-margins—Wanaka, Wakatipu, &c.
(*g.*) Recent alluvium.
(*h.*) Sea-beach deposits.

(*a.*) *The Older Breccia Conglomerate* is found forming the Blue Spur between the upper parts of Gabriel's and Monro's Gullies; at Weatherstone's; Forsyth; Waitahuna Gully; Scandinavian Claim, at the head of Waitahuna Gully; Glenore, or the Woolshed, Diggings; at Adam's Flat, on the borders of the Tokomairiro Plain; at the Nevis Township; Bob's Cove, Lake Wakatipu; Macgregor's Creek, Lower Shag Valley; on the south-west slopes of the Horse Range; and on the north side of the Horse Range, along the gorge of Trotter's Creek.

(*b.*) *The Older Quartz Drifts* are found at Beaumont Hill; Tuapeka River; Monro's Farm; Racecourse, Lawrence; Coghill's Hill; Sutherland's Hill; hills east of Waitahuna Gully; Waitahuna Flat; Manukau Hill; Glenore Railway-station, hills west of; Coal Creek, Roxburgh; Noisy Creek; Bald Hill Flat; Butcher's Gully, Bald Hill Flat; Conroy's Gully; Bannockburn; Cairnmuir Range; Nevis Valley; Roaring Lion Creek; Gibbston; Cardrona Saddle; Bob's Cove, Lake Wakatipu; Stony Creek, Shotover Valley; Skipper's Creek, Shotover Valley; coal-mine, Upper Cardrona; Cardrona Valley, coal-mine to township; Criffel Diggings, Mount Criffel; Fat Boy, Mount Criffel; Clyde; Waikerikeri Creek; Lower Manuherikia and Chatto Creek; Cambrian's; Vinegar Hill; St. Bathan's; Muddy Creek; Hawkdun Home Hills, west face; Pipeclay Gully, Blackstone Hill; Hill's Creek; Marion Burn; western base of Hawkdun Mountains; Gorge Creek; the Woolshed; Blackstone Hill; Black's No. 3; German Hill; Wether Burn; Garibaldi Diggings; Sowburn Diggings; Hamilton Diggings; Shepherd's Hut, Hamilton; Taieri Bridge, Hamilton to Naseby Road; Maniototo Plain, Taieri Bridge to Ewe Burn; Ewe Burn, above the Clyde–Naseby Road; Government dam, Naseby; Hogburn Valley, near Naseby; foot of Mount Ida Range, Hog Burn to Little Kye-Burn Creek; Clark's, or Mount Buster, Diggings; Upper Kye Burn; Swin-Burn and Hound-Burn Valleys; Hyde; Fullerton's and Mare Burn; Station Hill; Horse Flat, Deepdell; Macrae's Flat; Nenthorn; Green Valley and Waihemo, Shag Valley; Dunback to Taieri Peak, Shag Valley; Pleasant River; Macgregor's Creek, Lower Shag Valley; south-west slopes of Horse Range; Trotter's Creek; Kauroo Creek, Kakanui Gorge; Windsor and Ngapara; Livingstone Diggings; north side of the Maraewhenua River; Otekaike Valley; Awakino Valley; Switzer's; Muddy Creek, Switzer's; Waikaka Diggings; Mackenzie; Landslip Hill; and Knapdale Run.

At forty of these eighty localities where the older quartz drifts occur, so far as has yet been ascertained, gold is found as the colour only. At the other forty localities, whether at present working or abandoned, payable gold has been found; and it can hardly be doubted that many localities might be worked with profit could a better or sufficient water-supply be brought on to the ground.

(*c.*) *The Newer Quartz Drifts.*—These beds are contemporaneous with the newer breccia conglomerates, and, with them, occur at the following places: Upper Waipori Valley; Deep Lead, junction of Lammerlaw Creek with the Waipori (possibly these beds are younger than the others which are found at Tinker's); Drybread, in the Manuherikia Valley; and also on Criffel Face, in the middle of the line of fault, and at its western end.

(*d.*) *Newer Breccia Conglomerates.*—These beds occur at Criffel Face, upper end, and on Criffel Face, opposite the middle part of the Cardrona Valley; at the Devonshire Diggings, Tinker's, and Drybread, Manuherikia Valley; and are distinguished from the older by containing the proceeds of the denudation of the older quartz drifts.

(*e.*) *" Maori Bottom " (Sandstone Gravels).*—These beds are auriferous, and have been worked in the Cardrona Valley, below the township. It is hard to distinguish between these and the gravels worked at Frenchman's and Mid Run, in the watershed of Luggate Creek, though the latter more properly belong to the old shore-line of the great lake of which Lake Wanaka and Lake Hawea are but the remaining deeper parts.

Tarras Creek and the Lower Lindis show a development of these beds, though here they are not known to be auriferous—at least, no gold-workings are or have been carried on at these localities. These beds are not clearly defined at the Bannockburn, but they form high terrace-hills in the lower part of the Manuherikia Valley, and reach down the Molyneux Valley as far as the junction of Gorge Creek. They are also seen on both sides of the gorge of Chatto Creek, at Tinker's and Drybread, and at St. Bathan's, between the lower part of Dunstan and the Manuherikia. They form high terraces between Muddy Creek and the Manuherikia, and occur between the Manuherikia and Pipeclay Gully, Blackstone Hill. So far as known, these beds are not auriferous in the Manuherikia Valley, except it be on the right bank of the Waikerikeri. Within the watershed of Ida Burn the beds are largely developed, and occur throughout the central and eastern parts of the Maniototo Basin, but it is only at the Upper Kye Burn, and possibly on the left bank of the Hog Burn, below Naseby, that the beds are worked for gold. In the southern part of the district they are worked for gold at Switzer's, and perhaps at Muddy Creek in the same watershed. The higher terraces along the foot of the Mount Pisa Range to nearly abreast of Cromwell are not of the same age as the beds filling the middle part of the Cardrona Valley.

(*f.*) *Old Lake Margins (Lakes Wanaka, Hawea, and Wakatipu).*—Beds of this description are found on the north-east end of Mount Criffel, at the Cromwell Reef, on the north slope of the

Dunstan Mountains; and the mountain-wash at Bannockburn should also be referred to deposits of this class. Bald Hill, on Bald Hill Flat, may have been a deposit near the outlet of the Manuherikia Lake. Unless Frenchman's and Mid Run be considered as belonging to the same beds, these are not known to be auriferous in the Clutha Valley north of the Kawarau Junction; at Bannockburn and Bald Hill Flat they are. The Crown Terrace, at the old infall of the Arrow, at the eastern end of the pre-glacier extension of Lake Wakatipu, has also to be considered as coming under this head.

(*g.*) *Recent Alluviums.*—In the localities described, recent auriferous alluviums are present at Gabriel's Gully, Weatherstone's, Forsyth, Waitahuna Gully, Glenore, Tuapeka River, Waitahuna Flat, Upper Waitahuna River, Upper Waipori Valley; Island Block, Moa Flat, Bald Hill Flat, Butchers' Gully, Conroy's Gully, Bannockburn, Nevis Valley, and Miller's Flat; Arthur's Point to Queenstown, Bob's Cove (Lake Wakatipu); Clutha Valley along the base of Mount Pisa Range, Waikerikeri Creek, Devonshire Diggings, Tinker's, and Drybread, Hill's Creek, Hog Burn, Upper Kye Burn, Hyde, Horse Flat, Macrae's, Nenthorn; Macgregor's Creek (Lower Shag Valley), south-west slopes of the Horse Range, Trotter's Creek; Livingstone; North side of Maraewhenua River; Switzer's, Muddy Creek (Switzer's), Waikaka Diggings, and Knapdale.

With the exception of Island Block, and, perhaps, Bald Hill Flat, the recent auriferous drifts in all these localities may have derived their gold from contiguous quartz drifts or breccia conglomerates, and there can hardly be a doubt that they did so in the great majority of instances.

(*h.*) *Sea-beach Deposits.*—Gold is found near the mouth of the Mataura River, and thence along the coast-line to the eastward, on the beach of Molyneux Bay, and in small quantities at Coal Point, on Kartigi and Moeraki Beaches north of the mouth of Shag River, and at the mouth of the Kakanui River. North of the mouth of the Shag River the beach-gold has been derived from the breccia conglomerates and quartz drifts at the base of the coal-bearing series, the older rocks of the Horse Range, and eastern slopes of the Kakanui Mountains not being gold-bearing.

The Quartz Drifts and Breccia Conglomerates a Source of Gold to more Modern and Recent Deposits.

The amount of gold raised from the quartz-mines of Otago cannot be readily determined, but it is certainly short of one-seventy-fifth of the total gold raised in Otago since 1862. At the present time, with the exception of two small mines on the slopes of the Old Man Range above Bald Hill Flat, some fossicking at Nenthorn, and some prospecting at Waipori, the auriferous lodes being worked are confined to the Arrow and Shotover Valleys and the northern slope of the Dunstan Mountains. East of the Molyneux there is not at the present time a single quartz lode being worked on anything like a scale that would seem to give promise of a great future for this form of gold-mining in Otago. With the exception of the Cromwell Mine, at Bendigo Creek, on the north slopes of the Dunstan Mountains, and the mines now working in the Arrow and Shotover Valleys, perhaps also two small mines on the slopes of the Old Man's Range opposite Bald Hill Flat, all those that have been worked have proved too poor to pay at the prices then paid for labour, and with the machinery and appliances at the time in use.

That auriferous quartz-mining in Otago has been of very slow development is beyond dispute, and the reason appears to lie in the low-grade character of the stone and the comparative thinness of the quartz reefs. There can be no doubt that, when new and improved methods of extracting the gold have considerably cheapened the cost of treatment, reefs now abandoned, or in abeyance, will again be worked; but a poor reef, to pay, must show a large and constant body of auriferous quartz.

While thus, in the past, reef-mining has not flourished, the district east of the Remarkables and the Cardrona Valley has yielded an amount of alluvial gold such as might fairly lead to the inference that the auriferous quartz reefs within that area must be numerous, massive, and rich.

The reefs not bearing out this conclusion, we have to look to the older and newer breccia conglomerates and quartz drifts as being the immediate source of the greater part of the alluvial gold that has hitherto been raised in the Otago District.

These accumulations are so disposed that they are in a large measure, what remains of them, protected from being destroyed by ordinary denuding agents, being either overlain by younger deposits or involved between older or younger strata, so that the same result is effected. That their area in past times was much greater than at the present there is abundant evidence in the disjointed scattered patches that are preserved, and in the great abundance of cement stones over surfaces considerably distant from any deposit of loose quartz drift, and the quantities also of this particular kind of rock in the newer drifts and recent gravel-deposits of interior Otago.

As regards the time and mode of origin of these accumulations, there may in some cases be a difficulty in arriving at the truth. In the majority of instances the manner of deposition and the relative age of the beds can be fairly well determined.

During the latter part of the Permian period and older and middle Mesozoic times the New Zealand area was greatly depressed, and a succession of deposits were laid down amounting in the aggregate to fully 30,000ft. of strata. This is shown in the succession of Permian and Secondary deposits displayed in the Hokonui Hills, and in the district between the Mataura and Molyneux Rivers, south of the main road from Dunedin to Invercargill. In the middle and northern parts of the South Island, if the amount of deposit during the same period was somewhat less, it was still very great, and there is yet preserved in the Canterbury and Nelson Districts from 8,000ft. to 10,000ft. of Permian and older Secondary strata.

Widespread as these formations were over the South Island, it can hardly be supposed that they were absent from the central interior district or the goldfields of Otago, or that, at a later period, they had wholly to be removed in order to admit of the great denudation of the schistose

rocks that took place during the latter part of the Cretaceous period, the ultimate residue of which has been preserved in the shape of great accumulations of quartzose sands and gravels that are to be found over almost all parts of the Otago goldfields.

From the Hokonui Hills, in Southland, to the Kakanui Ranges, in north-eastern Otago, these rocks have been totally removed, nor in the line at right-angles to this, from Popotuna Gorge in the south to the mountains on the northern boundary of the provincial district, is left a single outlier of this great series of formations.

The Otago District further shows the presence of a great series of rocks of older date that are interposed between those mentioned and the schistose rocks of the central goldfields. These embrace the deposits of Carboniferous and Devonian age represented by the Maitai and Te Anau series. With respect to these, the evidence is equally in favour of their having once extended over the whole of the goldfields area, but, as there was a period of erosion and denudation between the deposit of the Maitai and Kaihiku series, it may have been that during this the Carboniferous and Devonian rocks were largely denuded away from the area of the goldfields. But that they were removed in part only is shown by their inclusion with younger Secondary and Tertiary rocks along the line of fault extending from Bob's Cove on the northern shore of Lake Wakatipu, along the eastern slopes of the Richardson Mountains, to Skipper's Creek and Mount Aurum in the Upper Shotover Valley. Also, an extensive outlier of the same beds is to be met with in the Hunter Valley, at the head of Lake Hawea. There being no outliers of Secondary rocks favours the assumption that during the period of their deposition the schists were not exposed.

It is thus evident that denudation equal to the removal of many thousand feet of strata must have preceded the laying-bare of the schists, or any considerable area of them, and that by the time the lower beds of the Cretaceo-tertiary series began to be laid down the unaltered enveloping strata of older date had been removed almost to the extent that now appears. The proceeds of such denudation must have consisted largely of sandstone gravels, but these appear to have been wholly removed to beyond the limits of the Otago District. Naturally, it was to be expected that the lowest beds of the next succeeding formation would be largely composed of materials derived from the unaltered Secondary and Palæozoic rocks; but such is not the case, schistose rocks clearly supplying the greater bulk of the material. There is another curious point in connection with this subject of the denudation of the unaltered older rocks from Central Otago, which is, that the younger deposits of late Miocene or early Pliocene date are almost wholly composed of sandstone gravels, brought from a distance and deposited on a schistose area. So that in the one case we have sandstones denuded, but over the denuded area schistose gravels are deposited; while in the other case schists are denuded, and the deposits over the area are exclusively sandstone.

After the deposition of the Mataura series (Upper Jurassic) the land was upheaved, and the denudation of the newly-laid-down deposits was begun; but we may vainly speculate as to the limits of the land, or the culminating point and axis that determined the direction of the different watersheds: all that can be said is, that the New Zealand of that day did not greatly resemble the New Zealand of the present time, and just as likely as not its mountain-ranges trended in a direction different from what they now do. Therefore, in giving by sketch section an illustration of the present outlines as they appear from the Hokonui Hills in the south-west to the outer slopes of the Kakanui Mountains in the north-east, the dotted lines do no more than indicate the previous continuity of the beds to the south-west and north-east (see fig. 1), in which 1 represents the deeper-seated metamorphic rocks, 2 the Devonian and Carboniferous formations, and 3 the Permian and Secondary sequence.

The first deposits belonging to the Cretaceo-tertiary period indicate the operation of an energetic form of denudation. This is shown by the breccia deposits of Trotter's Creek and the Horse Range, and the breccia conglomerates of Blue Spur, Weatherstone's, and Waitahuna, and the same line continued south-east into the basin of the Kaitangata Coalfield.

Lower Breccia Conglomerates.—These constitute the Horse Range and Trotter's Creek breccias, lying at the base of the sequence of strata forming the Shag Point coalfield, within which are to be found the most complete sections illustrating the sequence of this lower part of the Cretaceo-tertiary series and its relation to the higher parts. Fig. 2 shows the arrangement of the beds from west to east, from the main road across the Horse Range to the Shag Point Hills, near Allandale. On this, A is the Horse Range; B, Puke Iwaiti Hill; C, the railway-line and valley from the Shag River to the sea, near Shag Point Railway-station; E, Allandale; X, old rock; 4, breccia conglomerate; 5, lower quartz drifts, with shales and coal-seams; 6, middle division of the Cretaceo-tertiary series.

Fig. 3 shows the section at right angles to the last, or from the slopes of the Horse Range, across Macgregor's Farm, to near the Shag River opposite Palmerston, in which A indicates the south-west slopes of the Horse Range; B, Woolshed Creek; C, Macgregor's Gully; and X, old rock; 4, breccia conglomerate; 5, older quartz drift, with coal-seam; 12, Recent deposits. The beds on Figs. 2 and 3 correspond in position with the breccia-conglomerate deposits of Blue Spur, Weatherstone's, and Waitahuna, &c., and, like these, are auriferous. The lower part of the Blue Spur deposit is remarkably like the breccias of Trotter's Creek Gorge.

The sequence and arrangement of the different beds forming the Blue Spur deposit is shown in Fig. 4, the line of section being taken from south-west across the deposit to the fault or boundary of the deposit on the north-east side. 1, metamorphic rock schist; 4*a*, the lower, more angular, and schistose part of the deposit; 4*b*, finer-grained sandy beds, containing leaves of trees, &c.; 4*c*, second thick band of breccia conglomerate, material less angular than the lower band; 4*d*, higher breccia conglomerate, separated from the middle by sandy clays and an impure seam of lignite. North of the line of section the upper part of this, or a distinct stratum overlying, is composed largely of sandstone as well-rolled conglomerates.

Fig. 5 shows the same beds along a line from north to south, or from Monro's Gully, A, to

Gabriel's Gully, B. On this, 1 represents the schist rock; 4*a*, the lower part of the auriferous breccia conglomerate; and 4*e*, the higher sandstone part, also auriferous.

The deposits at Weatherstone's and at Waitahuna are practically the same as at Blue Spur, and consequently do not require to be illustrated by sections.

The section Fig. 6 shows the manner of the occurrence of the breccia conglomerates in the Scandinavian Claim, at the head of the west branch of Waitahuna Gully. In the actual line of section the breccia conglomerates have been removed by hydraulic sluicing: 1 represents schist; 4, the breccia conglomerates.

Fig. 7 shows the different small patches of breccia conglomerate and older quartz drifts along a line north-west to south-east, from Monro's Gully to the Tokomairiro Plain: A, Monro's Gully; B, Blue Spur; C, Gabriel's Gully; D, Weatherstone's; E, Forsyth; G, Coghill's Hill; H, Waitahuna; K, Waitahuna Gully; L, Scandinavian Claim, head of Waitahuna Gully; M, Manuka Hill; N, Glenore; O, Adams's Flat; P, downs west of Tokomairiro Plain; X, old rock; 1, schist; 4, breccia conglomerate; 5, older quartz drift.

Without taking into consideration whether or not it be that breccia conglomerates of this age are present in the Nevis Valley, it is apparent that the older breccia conglomerates have at one time extended over a large part of eastern and central Otago. Material, both local and derived from a distance, is to be found in the various patches along the line from Blue Spur to the low grounds of the Tokomairiro Plain, and this is doubtless the case also in the Horse Range. These breccia conglomerates have to be considered as the product of denudation carried by rivers and lesser streams into hollows and inequalities of the land-surface at the time of their deposit. The Blue Spur deposit, and its continuation to the south-east, is, without question, due to the action of a considerable river draining first a schistose area and latterly bringing down a greater amount of sandstone detritus. This is shown by the character of the material in the upper and lower parts of the deposit at Blue Spur itself. At Waitahuna Gully the material is to a considerable extent derived from rocks that are locally developed. Within the Kaitangata Coalfield the coarser schistose and sandstone conglomerates alternate with beds of finer-grained quartz grit and quartz sand, the latter indicating the action of the sea in more completely reducing a portion of the breccia conglomerates, so as to leave only the harder material, consisting of quartz, &c. Professor Hutton clearly indicates his belief that the depression containing the breccia conglomerates at Blue Spur "was excavated by a glacier, and afterwards filled with conglomerates by the agency of a river";* but it has been shown that, at least, one side of this basin had no existence till long after the deposition of the conglomerates. Mr. Rickard, on the other hand, while contending that the material is "the rocky freight of a glacier," yet explains the existence of the basin in which this now rests as being partly due to faulting on the north-east side, and crushing of the slates on the western side of the area covered by the conglomerates.† Mr. Rickard, however, adds the following: "The line of fault is not parallel to the course of the lead; the two meet between Monro's and Gabriel's Gully, and so explain the enlargement at that point of the receptacle of the ore-deposit. This explains the natural selection of this particular place as the *locus* of the deposit. To proceed further, the glacier in its slow downward progress to the sea is temporarily arrested by the softer rock, which it here encounters much in the same way as a runner is retarded in crossing a ploughed field. This arrest allowed the accumulation of a terminal moraine, which, protecting the rock on which it lay, assisted the tendency of the ice to erode the softer schist; where the terminal moraine at one time lay we now find the rocky bar [at the Gabriel's Gully end of the deposit]. A hollow was scooped out. This was in early Eocene days. A little later, that subsidence took place which preceded the deposition of the Oamaru series. This caused the retirement of the glacier, or, more accurately, the melting-away of its lower portion. The rocky basin which had been scooped out by the ice now became a fresh-water lake, with its upper end still guarded by the glacier. The ice which broke away from the foot of the glacier bore with it large boulders of jasperoid which had been brought down from Tapanui. This and other material was borne across the lake, to fall eventually upon its bottom as the ice-floes melted. In the meantime, up above, the glacier continued to plough through the soft quartzose schists, and send down a golden tribute, derived from the lode-formations which it cut through. The fine flakes of gold were accompanied with micaceous mud and angular bits of quartz, all to be deposited in the capacious hollow of the lake. Thus the rocky basin became gradually filled up with confused layers of big jasperoid boulders, quartz gravel, and bluish mud, the gold sifting its way to the lower portions. The subsidence continuing, and with it the slow retirement of the glacier, and the lake being nearly full of detritus, it became a morass. Vegetation took root, and flourished for a brief period. A time of flood, due to excessive thaw, brought down a volume of water, bearing the sand and gravel, which covered the vegetation. Being thus protected from the air, the reeds of the morass became the lignite of to-day. A river linking a series of small lakes, of which the Blue Spur was one, now flowed along the course of the present alluvial lead. Additional material was deposited in some places, while material was removed in others. In the middle of the Eocene period, the elevation of the land culminated and changed the drainage system of the district. In Miocene times, the Clutha and its tributaries began to flow across the line of the Blue Spur lead. That erosion then commenced which, in the cutting-out of Monro's, Gabriel's, and Weatherstone's Gullies, left the gravel-deposit as part of a dividing-ridge";‡ and thus Mr. Rickard as strongly contends for the excavation-by-ice theory as does Professor Hutton.

Nowhere can the evidence of ice-action be seen at the Blue Spur, Weatherstone's, or at Waitahuna, and there is no need for such an hypothesis. The so-called basin has not been "scooped out," and the material filling it, though angular, being locally derived in the lower part, is not of morainic origin. The writer has travelled a good deal amongst the New Zealand Alps, and

* "Geology of Otago," p. 93. † Goldfields Reports, 1893, p. 111. ‡ *Ibid.*

seen many moraines in progress of formation; but the Blue Spur deposit does not resemble any of them. The partly or fully water-worn shingle in the beds of the larger rivers of Westland, from the Teremakau to the Haast, will show the manner in which the Blue Spur deposit was formed. The Horse Range deposit, being of greater extent, thickness, and generally of coarser material as respects the more angular detritus forming the greater bulk of the deposit, has a far better claim to be regarded as having been due to glacier-action or deposited as a moraine; but the material is somewhat regular in its occurrence, and never of great size, and might, all of it, have been brought from the neighbouring schistose area west of the Shag Valley by the action of a considerable and powerful torrential river.

These gravels, therefore, are nothing more than old river-gravels, more or less rounded, of the period to which they belong, and, as part of a great system of gravel-deposits, the portions which have been described have escaped denudation and rearrangement owing to their peculiar position, and the rate at which the sea invaded the land during the subsidence which followed the formation of the coal-bearing part of the Cretaceo-tertiary series.

It has been mentioned that there are in the Nevis Valley schistose breccias resembling the Blue Spur deposit; but there are doubts as to the actual age of these, and notice of them will be deferred till dealing with the "newer breccia conglomerate."

Quartz Drifts.—Towards the production of these the first stage would necessarily be the formation of rough schistose shingle resembling the mountain-creek rubble, and the river-gravels of the present time, and, without question, the quartz drifts have largely resulted from the further pounding of the breccia conglomerates. This result, as may be seen in the great accumulations of quartz sands and coarser drifts, has undoubtedly been effected by the agency of wave-action, either of the sea or on the shores of extensive inland lakes, there being no rivers in New Zealand at the present time that do, or apparently can, produce pure quartz gravel by current-action along its bed. Having this possibility in view, the writer carefully noted the gravels of the Molyneux, from the Beaumont to the outlets from Lakes Hawea, Wanaka, and Wakatipu, and nowhere was anything noted leading to the belief that the quartz grits have been so produced. Quartz sands and quartz drifts are, however, found on the shores of Molyneux Bay, where no local stream carries rubbly material from a near distance or readily-denuded cliffs at present capable of producing quartz drifts. Subangular quartz drifts may, however, be formed in the manner already described in this report (see page 8), where it is stated that such drifts are forming on a small scale along some of the tributaries of the Upper Waitahuna, and also where it is stated that the quartz drifts of the Upper Waipori Valley may have been formed in the same way. However, owing to the peculiar conditions, deposits of quartz drift so formed can have but a limited extent and importance.

Along the entire eastern and southern seaboard of Otago, and for a considerable distance inland, the quartz drifts have been formed by the action of the sea. The rivers conveyed the unsorted mixture of slate and quartz to the shore-line, where it was reduced to nearly pure quartz.

From fifty miles up the Waitaki Valley, along the foot of the Kurow and Mount Domett Ranges to the Livingstone Goldfield, all the quartz sands are directly followed by marine fossiliferous beds; and from the same dish of stuff taken from the greensands overlying the quartz drifts of the Maraewhenua Goldfield, sharks' teeth, sea-shells, and gold can be obtained. The same conditions obtain between Big Hill and the gorge of the Kakanui River, and along the whole eastern flanks of the Kakanui Range to Trotter's Creek and the Horse Range. South of Palmerston, almost the whole of the upper watershed of Pleasant River is covered by quartz drift, in the higher beds of which marine fossils are to be found; and from Hummock Side, westward and southward, the quartz drifts are marine to Nenthorn Creek and Taieri Ridge on the one hand, and to Silverstream and Mullocky Gully on the other. In the northern part of eastern Otago the quartz drifts are marine to a little west of Naseby, probably to the water-divide between the Ewe Burn and Wether Burn. At the Government dam—the distributing dam of the Mount Ida Water-race—an abundance of marine fossils are to be obtained from beds immediately overlying the quartz drifts, and the deposits at Hamilton's are regarded as being of the same age and of like origin. Hyde, Fullerton's, and Station Hill should also, with some other localities, be included with the drifts that were immediately followed by marine beds. There is a possibility that within Strath Taieri, and also along the Taieri River, near the mouth of Nenthorn Creek, the grits are overlain by, or otherwise associated with, beds of shale and lignite-seams that have originated on land and in fresh-water lakes. South of the Taieri the western limit of the marine beds may never have reached beyond Fortification Hill, and thence it would extend into what is now the Tuapeka watershed, and, in the southern part of the district, reach as far north as Tapanui, Waikaka, and Switzer's. The second area of quartz drifts, occupying central Otago, must be regarded as of fresh-water origin. This occupies the Wether Burn, Ida Burn, and Pool Burn Valleys, and the whole of Manuherikia Valley; and the Molyneux Valley, from the foot of the gorge near Coal Creek, Roxburgh, to Lakes Hawea and Wanaka, including in this the valleys of the lesser streams, such as the Fraser River and the Bannock Burn. The western limit of this area of fresh-water deposit is the western sides of the Nevis and Cardrona Valleys. West of the Nevis and Cardrona watersheds there are no quartz drifts till the line from Bob's Cove, on Lake Wakatipu, to Skipper's Creek, on the Shotover, is reached. This, again, gives evidence of having been laid down in such a position that it was immediately and conformably followed by marine beds. From the beds immediately overlying the quartz drifts in this line abundant evidence of marine life is to be obtained. There is thus a central northern area of fresh-water deposits surrounded by a much larger area to the east, south, and west, which is undoubtedly, in the beds that immediately follow the quartz grit or drift, of marine origin.

The section from Livingstone to the limestone table-land on the south side of the Maraewhenua River may be taken as sufficient to show the age of the beds and their relationship to other

members of the Cretaceo-tertiary series. See Fig. 8: A, Livingstone; B, limestone table-land on the southern side of the Maraewhenua; X, old rock; 5, older quartz drift; 6, middle part of the Cretaceo-tertiary series—the lower bed of this division, resting on the quartz drifts, is gold-bearing; 6*a*, volcanic rocks, as basaltic lava-floes, associated with middle division of the Cretaceo-tertiary formation; 7, upper part of the Cretaceo-tertiary formation.

No other section on the eastern side of the Kakanui Mountains adds to the information contained in the above, which makes perfectly clear the relation of the quartz drifts to the fossiliferous greensands that overlie the coal, and of the greensands to the volcanic rocks which further south are thought to be of Miocene age, and of all the underlying strata to the limestones. This section, along the southern side of the Maraewhenua, from Duntroon to Livingstone, was first examined by me during 1877, and in my report on that district the following remarks are made: "In the upper part of Awamoko Creek the coal-beds are not yet known to be present; but a considerable extent of country near the Maraewhenua gold-workings is covered with coal-grits and the overlying greensands, which, striking across the Maraewhenua River, reach as far as the Otekaike River, west of the limestone table-lands. The grits in this latter district are of great interest, as they form the matrix from which most of the gold on this field has been obtained, all the claims which were examined being opened in the grit, and in not a few of them the grit is directly overlain by fossiliferous greensands and sandy calcareous beds full of marine shells. From what could be learned, paying gold-workings have not been found in this district in any other deposit than this quartz grit, which, dipping away to the east, is overlain by a thick bed of columnar basalt, followed by the representatives of the greensands, and again by the Maraewhenua limestones."* At Black Point, on the Waitaki River, four miles below the Maraewhenua junction, the lower beds of the Cretaceo-tertiary series are of great interest, from the fact that they are here composed of coarse conglomerates of sandstone and other rocks, overlain by the usual quartz grits. The coal horizon overlying these is represented by a carbonaceous shale, followed by white clays, similar to those met with in the Maniototo Basin, and these pass into a mixture of yellow and green sands, with hard concretions full of fossil shells overlain by greensands, the latter being followed by the Maraewhenua limestone.

Numerous sections, all of them showing the same relation of the quartz drifts to the middle and higher parts of the Cretaceo-tertiary series, are to be met with in the country north-west and west of Oamaru, but to cite further examples would be needless. South of Shag Valley, to Waikouaiti and Blueskin, the same evidences appear, the quartz drifts overlain by the coal-beds and greensands passing under limestones of the age of the Ototara limestone or Oamaru building-stone.

In the neighbourhood of Dunedin the sands and quartz drifts of Green Island, with their accompanying coal-seams, pass under greensand strata, and these are overlain by the Caversham (calcareous) sandstones. At Mullocky Gully, and on both sides of the upper part of Silverstream, the quartz drifts with coal-seams are strongly developed. Between Saddle Hill and the lower gorge of the Taieri this is also the case, and in Waihola Gorge and at Millburn the sequence is again closed by limestones. Over the Kaitangata Coalfield fossiliferous greensands appear to be the highest beds. In the Pomahaka Valley, beds containing marine fossils, apparently of Miocene age, close the sequence beginning with the auriferous quartz drifts, while in the vicinity of Switzer's the grits and coal-beds are overlain by beds containing concretionary masses full of sea-shells such as are found on the Kaitangata Coalfield. At Bob's Cove, Lake Wakatipu, Moke Creek, Stony Creek, and Skipper's, the quartz drifts are everywhere followed by fossiliferous beds containing marine shells.

As the breccia conglomerates of Adam's Flat and the west branch of the Tokomairiro River, below Glenore, lie at the base of the coal-bearing series, in the low ground further to the east and south the quartz drifts overlie these, their relative position to each other being thus made clear. Thus, also, may be determined the true position of the beds west of Glenore Railway-station, on Manukau Hill, and at other places where the beds are isolated from the other members of the sequence. At Waitahuna and near Lawrence the relation of the older quartz drifts to the breccia conglomerates is not so clear, the two never appearing in actual contact, although occurring in the close vicinity of each other. The two sets of beds, as seen in the section across Waitahuna Gully, are illustrated by Fig. 9: A, Waitahuna Gully; B, heights to the east of Waitahuna Gully; 1, schist rocks of the Otago goldfields; 4, breccia conglomerates; 5, older quartz drifts.

The apparent discordance between the breccia conglomerates and the quartz drifts may be explained under the supposition of the absence or removal of the lower beds and the overlapping of the quartz drifts, these latter having since been removed from the areas where the breccia conglomerates are now found. The apparent weakness of this theory is the absence of the quartz drifts as the higher beds included along the line of fault; but, as there can be no doubt that the quartz drifts, whether conformable or unconformable, are the younger of the two sets of beds, it is equally probable that they once overlaid the breccia conglomerates.

Between Coghill's Hill and Waitahuna Flat, opposite the Railway-station and Township of Havelock, the difference in the levels is 800ft., in a horizontal distance of less than half a mile; yet the same beds are present at both localities, and show no signs of disturbance other than the different altitudes at which they occur. Fig. 10 shows the beds in the line of section above indicated: A, Coghill's Hill; B, Waitahuna Flat; 1, schist rocks; 5, the older quartz drifts. In the low grounds of the river-valley a band of lignite occurs between the higher and lower beds of 5, and it has to be supposed that the auriferous beds on the top of Coghill's Hill correspond to a horizon underlying the lignite-seam.

The quartz drifts in the vicinity of Lawrence, at Evans's Flat, Monro's Farm, Beaumont Hill and thence extending towards the Lower Tuapeka, not having been proved to contain gold in paying quantities, and showing nothing remarkable in their composition, or in the position they occupy, require no special comment or illustration in this place.

* Geological Reports, 1876–77, pp. 64, 65.

The description already given should be sufficient to give a clear idea of the mode of the occurrence of the beds at Waikaka, the creek- and terrace-gravels there resting on the upturned edges of the quartz drifts being all that could be shown in section. At Switzer's the section there seen between the hills bordering the river-bank, on the east side of the valley, and the western slopes of the Argyle Hill Range, is illustrated by Fig. 11, in which A is the position of the Wakaia River; B, Round Hill; X, old rock; 5, the older quartz drifts, containing thick seams of lignite; 10, "Maori bottom," forming the principal gold-wash at Switzer's; 12, Recent.

Gold-workings have been carried on in the quartz drifts near the northern end of the middle part, and at the southern end of the auriferous area east of the Wakaia shown on the map, and illustrated by section in Fig. 11. The beds (10), however, are, and have been, the principal source of gold at Switzer's. These beds, from the saddle between the southern spurs of Argyle Hill and Round Hill, extend down the hill-slopes to within a short distance of the river-bank near to the township.

Fig. 12 is a sketch of the beds shown in section as they appear on the shore of the cross arm of Lake Wakatipu at Bob's Cove: 1, schist rocks of the Otago goldfields; 2, Devonian rocks, belonging to the Te Anau series; 4, breccia conglomerates; 5, older quartz drifts; 6, middle part of the Cretaceo-tertiary formation; 7, upper part of the Cretaceo-tertiary formation; 8, Pareora beds (Lower Miocene). At Moke Creek, and thence across the slopes of Ben More Mountain to the Moonlight Gorge, beds 4, 5, and 6 are seen deeply involved; and in the Moonlight Gorge the limestones (7) are also present.

Fig. 13 shows the mode of occurrence of these beds on the eastern slopes of Ben More between Moke and Moonlight Creeks: A, Ben More, B, Moke Creek; 1, schist; 5, old quartz drift; 6, middle beds of the Cretaceo-tertiary formation; 7, upper part of the Cretaceo-tertiary formation; 12, Recent.

Neither at Stony nor at Skipper's Creek were these beds examined *in situ*, the line of fault on the east side of which they occur running along rough and inaccessible country towards the sources of those streams. From prospectors and old residents the information was gleaned that the limestone forms a big reef like a quartz reef where it is seen to cross Stony Creek, three to four miles above the junction of the creek with the Shotover. Between Stony Creek and the different branches of Skipper's, the limestone and associated beds do not appear to have been traced, but masses of quartz grit and cement stone are brought down every tributary of Skipper's Creek that rises on the southern slopes of Mount Aurum. As Stony Creek has cut deep into the slopes of the Richardson Mountains where the limestone is seen to cross its bed, the position of the limestone above sea is not higher than the terraces at Maori Point, or from 1,600ft. to 1,800ft. At the head of the right-hand branch of Skipper's, and across the intervening spurs to the south-west, the beds involved along the fault must reach to a height of nearly 4,000ft. It would have taken longer time than, under the circumstances, could be afforded to examine closely this line of grits, limestones, &c., and that it existed was considered sufficient for the present purpose.

Returning to the eastern part of the district. At Macrae's the quartz drifts lie at a lower level than they appear at on Station Hill, and this difference of level is considerably greater in the intermediate space where the drifts appear at the surface, near Deep Dell Station. There is also a considerable difference of the levels between the upper part of Mare Burn and Fullerton's, and also between the higher and lower levels at Hyde; but, although the flexures are considerable, there is no evidence of actual faulting. In the upper part of Shag Valley, and from the Swin Burn along the foot of Mount Pisgah, the beds dip towards the range, and are suddenly terminated against the older rocks.

At the Upper Kyeburn the lowest grits are nearly vertical, and are followed by greensands, with Miocene fossils, which, associated with quartz drifts, are overlain by white clays and heavy beds of lignite. Younger Miocene or older Pliocene gravels overlying the lignite series form hills between the Kye Burn main stream and the lower part of the Little Kye Burn. The lower quartz drifts are found at the foot of Mount Buster and Kyeburn Peak, at elevations about 2,000ft. above the sea; while on the high saddle to the north, at Clark's, the height is not less than 4,000ft. This difference of level takes place within a horizontal distance of less than two miles. At the Hogburn the quartz drifts dip to the south at high angles, and are, south of their outcrop, shortly obscured by "Maori bottom" and beds of recent wash, derived in part from the "Maori bottom" and in part from the quartz drifts. Fig. 14 shows the relation of the different beds to each other: X, old rock; 5, older quartz drift; 10, "Maori bottom" (sandstone gravels); 12, Recent gravels, formed of a mixture of quartz drift, schist fragments, and sandstone gravels, with many large boulders of cement stone, derived from the older quartz drifts.

As the superficial gravels are to a considerable extent formed of detritus from the quartz drift, either as well-rolled pebbles of quartz, or as boulders of white or yellowish-brown quartz cement, the probabilities are that a large part of the gold obtained from the surface-wash in the vicinity of Naseby has been derived from the destruction of quartz drifts existing in the neighbourhood.

At the Government dam the gritty fossiliferous greensands are overlain by white clays and lignite, and associated with these are beds of quartz drift, which, as at the Kyeburn, may belong to the freshwater series, which would thus seem to have been present over the area of the Maniototo Basin.

The section from Hamilton's to the Taieri Bridge is of interest as showing the possibility of gold-bearing quartz drifts under the basaltic sheet. Fig. 15 shows the disposition of the different rocks: A, Taieri River; B, Hamilton's Diggings; 1, schist old rock; 5, older quartz drift; *5a*, white clays overlying the quartz drifts; *5b*, thick sheet of basaltic rock; 12, Recent deposits near the banks of the Taieri River.

The quartz drifts at the Sow Burn, and as far as the Taieri River, at Patearoa, evidently belong to the line of outcrop on which Hyde and Hamilton's are situated, and to the lower series of quartz drifts.

Newer or Fresh-water Series of Quartz Drifts.—These are found throughout the areas regarded as forming the old lake-basins of central Otago, but the deposits to be described have not been deposited in lake-basins the outlines of which can now be traced. During Pliocene times extensive lakes did exist, filling the valleys of the Upper Taieri, Ida Burn, and Manuherikia, and from the junction of the Manuherikia extending down the Molyneux Valley probably as far as the vicinity of Bald Hill Flat. At the same time, above the Dunstan Gorge a very extensive lake, the waters of which stood at a height of 1,600ft. above the present level of Lake Wanaka, occupied the low grounds of the watershed, and extended up the Lindis and Cardrona Valleys, and further mountain-valleys, as far as then excavated. The deposits in and around the margins of these lake-basins are still in a horizontal position, and the old shore-lines can be traced with tolerable accuracy. It is, however, different with the lake-basins of Miocene times. The boundaries of these can no longer be traced, and their marginal deposits are now to be found at all elevations from 400ft. to 4,000ft. above sea-level.

The quartz-drift deposits in the Wether Burn, and thence extending north into the Ida Burn watershed, form the southern end of a long line of deposits that dip to the east, and are suddenly brought to a close along the foot of Mount Ida and the Hawkdun Mountains. This line of drift has not yet been proved to be payable, except it may be in Gorge Creek, where a party are now at work; but at several places the beds are of interest as illustrating movements that have affected the formation, and also as to the character of the strata.

On the north side of Marion Burn heavy beds of quartz cement stone, such as have been described as being fine quartz sand or grit, cemented into a hard flinty rock, cover the top and south-east side of a low hill; clays and loose quartz drifts underlying. A portion of this sheet of cement stone is still undisturbed, and this is therefore the most easterly example of the occurrence of this rock *in situ*. See Fig. 16: A, Hawkdun Home Hills; B, Marion Burn; C, western slope of the Hawkdun Range; 2, Devonian or Carboniferous rocks; 5, older quartz drift; 5*a*, white clays and beds of hardened quartz sand forming cement stone.

Some prospecting has been done in beds 5 on both sides of Marion Burn, and a little gold obtained, but not sufficient to warrant the further working of the quartz drifts at this place. At Macdonald's Hut, four miles further north, the beds are standing nearly vertical, and at one place where a little gold was found some work has been done, but this also did not give encouraging results. Close to Macdonald's Hut, on the northern side of the creek, an opening has been made in the lignite-seam, showing that here the beds are standing vertical.

Further along the line of the Mount Ida Water-race the dip of the beds is at lower angles, sometimes nearly horizontal, but the general tendency of the younger strata is to dip towards the high range, and suddenly to terminate at or close to the foot of the range.

At Hill's Creek, and the Woolshed, Blackstone Hill, the quartz drifts are greatly disturbed, and dip at high angles towards the range. Near the road-line, on the saddle leading to the Manuherikia, the grits are partially pushed under the older rocks, and as vertical beds appear, striking at right-angles to the line of fracture, and the west boundary of the old rock.

The beds at German Hill and at Black's No. 3 have been sufficiently described by Mr. Park. Sectionally the quartz drifts at the two places would appear to be connected, and underlie the superficial deposits of this part of Pool-Burn Valley; but this is a matter of no practical importance at the present time.

At St. Bathan's the section across the southern end of the basin shows the quartz drifts as having but a narrow exposure, as shown in section. See Fig. 17: A, St. Bathan's; B, Dunstan Creek; 1, schist rock; 2, Devonian or Carboniferous; 5, quartz drift; 10, "Maori bottom."

Fig. 18 shows the section across the middle part of St. Bathan's Basin, in which line, 2 represents the Devonian rocks of St. Bathan's Spur, 5 the older quartz drifts below the leaf-bed. It is from this horizon that the greater amount of gold won has been obtained; 5*a* represents the leaf-bed and numerous alternations of grit-bands and beds of white clay; 10, "Maori bottom."

Fig. 19 represents the section across the north-western outlet of St. Bathan's Basin: A, sludge-channel leading to Dunstan Creek; 2, Devonian rocks belonging to the Te Anau series; 5, the older quartz drifts; 5*a*, white or greenish marly clays; 10, "Maori bottom," consisting of sandstone gravels; 12, Recent. There are no indications of the presence of a fault in the St. Bathan's Basin, but the beds dip at different angles and in different directions in the opposite ends of the area occupied by the quartz drifts.

At Vinegar Hill the beds are unquestionably the same as those exposed in the St. Bathan's Basin, but the sandstone gravels forming the western rim of the basin are absent, and a thick deposit of clearly stratified greenish marly clay forms the highest beds in the sequence of the auriferous quartz drifts.

Fig. 20 illustrates the section from the higher part of Vinegar Hill in a line north-west to the lower slope of the Dunstan Mountains: A, Vinegar Hill; B, slopes of the Dunstan Mountains; 1, schist rock; 5, older quartz drift; 5*a*, greenish marly clay; 12, Recent.

More to the eastward the section, along a parallel line, Fig. 21, shows an increased thickness of auriferous quartz drifts: A, Vinegar Hill; B, Dunstan Mountains; 1, schist rock; 5, older quartz drifts; 5*a*, greenish marly clays; 12, Recent.

The beds at Vinegar Hill extend south-west along the base of the Dunstan Mountains, but have not been worked beyond the watershed of Cambrian's. As already explained, more to the south-west, younger terrace gravels reach back to the foot of the range, and so hide the quartz drifts from observation.

In the Molyneux Valley quartz drifts of this age occur at Coal Creek, where the north-west part of section, see Fig. 22, is clearly exposed: A, Molyneux River; 1, schist rock; 5, older quartz drifts; 5*a*, clays overlying lignite.

There are no gold-workings in the quartz drifts at Coal Creek, or where they appear on the

banks of the river at the junction of the creek; nor are the quartz drifts seen on the opposite south-east bank of the river; but they can scarcely fail to be present as shown in the section. In this connection it is somewhat remarkable that the banks of the river have been worked to a considerable extent at and below the point where the quartz drift is supposed to cross to the left bank, while higher up, to the foot of the gorge, there have been scarcely any workings—at least, in the higher banks of the river.

At Bald Hill Flat the sections of the quartz drifts show no peculiar feature, and at Butcher's Gully, where they are deeply involved, they are so in the manner that appears along the south side of Conroy's Gully. The position of the drifts at the latter place is represented in Fig. 23: A, Conroy's Gully; 1, schists; 5, older quartz drifts.

At Bannockburn the general section from Quartzville east to the slopes of Cairnmuir Range is as shown in Fig. 24: A, Cairnmuir Range; B, Bannock Burn; C, Lower Flat, Bannockburn; D, Upper Flat; E, Carrick Range; 1, schist rock; 5, older quartz drifts; 5*a*, clays, lignite, and quartz drifts overlying 5; 10, "Maori bottom"; 12, Recent.

From the Bannockburn the line of highly-tilted strata runs north-east along the base of the Mount Pisa Range, but, being for the most part covered by gravels of more recent date, no important exposures of the quartz drifts are seen north-east of the Kawarau Gorge.

The section from Mount Pisa through Mount Criffel to the lower part of the Cardrona Valley shows the quartz drifts on both sides of Luggate Creek somewhat as rendered in Fig. 25: 1, schist rocks; 5, older quartz drifts; 9, newer quartz drifts and breccia conglomerate; 10, "Maori bottom" (sandstone gravels), with clays and thin seams of lignite at the base; 12, Recent.

These sketches will serve to show the manner of occurrence of the marine and fresh-water quartz drifts throughout the district examined, and will make it abundantly clear that, whether old sea-beach or lake-margin be sought for, these are difficult of recognition, and, when found, in nothing do they indicate the limits of the sea or the extent and outlines of the ancient lake-basins in which the beds were laid down.

Newer Breccias and Newer Quartz Drifts.—The deposit of the breccia conglomerates, marine and fresh-water quartz drifts, may have been in progress contemporaneously. Even the overlap of the fresh-water beds from the Manuherikia and Ida Burn Valleys into the Maniototo Basin does not imply more than a slight elevation of the land and the formation of low-lying lakes, where once the sea had been; but it is evident that prior to the production of the newer breccias and quartz drifts considerable elevation of the land had taken place. The deposits under this head must be considered as of Upper Miocene age, since they are intimately connected with the sandstone conglomerates that close the Miocene or form the earlier deposits of the Pliocene period in this part of New Zealand. At Tinker's and Drybread it is not everywhere quite clear which of the two—the newer breccias and quartz drifts, or the sandstones of the "Maori bottom"—are the older. On Criffel Face there is no doubt that the "Maori bottom" conglomerate is the superior rock; and this must be taken to be the general relation of the beds. The beds are found only at Drybread, Tinker's, and along Criffel Face, from Mount Barker to the Cardrona Township; but with these have been included the quartz drifts of the Upper Waipori, not that there is any certainty that these latter are of the age of the beds at the other localities mentioned, but mainly as a matter of convenience.

Fig. 26 shows the arrangement of the beds at Drybread, in the Manuherikia Valley: A, Pipe-line spur, Dunstan Mountains; B, Drybread Flat; 9, strong bands of quartz drift and breccia conglomerates; 9*a*, bands of clay alternating with 9; 10, "Maori bottom"; 12, Recent.

The beds 9 contain washed and well-rounded boulders, derived from the cement bands in the older quartz drifts present *in situ* at St. Bathan's, German Hill, Marion Burn, and elsewhere. The beds have a good deal of subangular or partly-rounded schistose material mixed with the quartz gravel. The lower beds of quartz drift, close to the fault-line F, are composed mainly of pure quartz.

There is no doubt that the beds are present along the foot of the range as far as Tinker's; but recent gravels at Thompson's Creek break their continuity as a surface exposure. They however reappear in the Sugar-pot, the Wild Duck, and in Ewing's and in McConochie's claim at Tinker's, and continue in the same line as far as the Devonshire Diggings. See Fig. 27: Section across the gold-workings in Ewing's and McConochie's claim, Tinker's, Manuherikia Valley: A, Dunstan Mountains; B, terrace between Tinker's Township and the claims; 1, schist; 9, breccia conglomerates and newer quartz drifts; 10, "Maori bottom" (sandstone conglomerate); 12, Recent; 13, slip-deposit or wreckage of the spur, due to working of the claim.

At the Devonshire Diggings, where also the slaty breccias are seen to underlie the surface-shingle, no clear section or contact with the older rock is exposed.

Whether any of the rocks of the Nevis Valley belong to the series under consideration is uncertain; but the bulk of the quartz drifts, &c., there belong to the older series.

In the Cardrona Valley the whole line of the involved rocks on Criffel Face belong to this division. At the south-west end of Criffel Face, where three or four claims are being prospected, the beds appear in section, as in Fig. 28: A, slopes of Criffel Face; B, Cardrona Valley; C, slopes of Mount Cardrona; 1, schist rock; 9, newer breccia conglomerate and quartz drift; 10, "Maori bottom" (sandstone conglomerate); 12, Recent. Throughout the sections illustrating this report, F indicates faults, and inversions of younger beds in contact with the older rocks.

"Maori Bottom" (Sandstone Gravels).—These, as has been shown in the preceding sections, are, at places, involved with the younger breccias and quartz drifts, and therefore have to be considered in connection with deep alluvial mining in Otago. They are worked for gold at the Upper Kyeburn, and have been at Tinker's, though the workings there are now abandoned. They have also been worked in the west side of the Cardrona Valley, below the township, and largely at Switzer's, the greater part of the gold obtained from the higher levels at Switzer's having come from the sandstone gravels of the "Maori bottom." The beds *f*, old lake-margins, and *g*, recent alluviums, also *h*, sea-beach deposits, require no special description in this section.

According to the theory entertained as to what was the origin of these different auriferous deposits, and partly to recapitulate what has already been stated at pages 35 and 36, after the deposit of the higher beds of the Old and Middle Mesozoic formations, the area of what is now Otago became dry land, and for a long time denuding agents were active in the reduction of the great anticline between the south-west slopes of the Hokonui Hills to the south-west, and the Kakanui Mountains, on the north-east borders, of the goldfields. Gradually the higher formations were removed, and ultimately a large area of schistose rock was exposed and extensively denuded before the commencement of the deposition of even the lowest beds of the Cretaceo-tertiary formation. What is now the seaboard of Otago, and for a considerable distance inland of the present coastline, must then have been loaded and burdened with enormous quantities of shingle- and gravel-deposits derived from the gold-bearing rocks. During the slow submergence of the land which followed, the sea reduced the greater part of this to the condition of a quartz gravel, effecting this by a process of grinding and removal of the softer parts, and thus originated the quartz drifts, grits, and sands lying east of a line drawn from Naseby to Blue Spur and from Blue Spur to Switzer's. North-west and north of this line the sea does not appear to have covered any part of central Otago, but a vast extent of fresh water seems to have occupied the area between Moa Flat and the foot of Lake Wanaka in a north-and-south line, and between Mount Cardrona and the Remarkables and the eastern borders of the Maniototo Plain in an east-and-west direction. Whether it be within the borders of the Maniototo, in the Pool-Burn, or Ida-Burn Valleys, at the source of the Manuherikia, at Coal Creek, in the Upper Nevis, at Bannockburn, at Gibbston, or within the Cardrona Valley, or on the highest elevation of Mount Criffel, the beds betray everywhere the same sequence, exhibit the same character, and indicate not a number of comparatively small lakes, but a vast inland sea capable of simulating the greater ocean in the mode of treatment and deposit of the residue brought into it. Within both the marine and fresh-water areas of deposit, beds of hard cement stone were formed.

During Miocene times, alterations took place whereby the great inland lake was partly drained, the deposits in it denuded, and the new breccias and quartz drifts, as also the sandstone gravels known as "Maori bottom," were deposited. At the close of the Miocene period, the inland lake occupying the greater part of central Otago was largely filled up with material brought into it, latterly from the north and north-east. It is not necessary to suppose that this great lake was completely drained of its waters, since during Middle Pliocene times great changes in the configuration of the land began to take place. Along lines of faulting, constituting great earth-fractures, unequal movements took place, whereby in one place the beds affected were elevated, while at other places they were depressed. These movements have affected all strata of the age of, and older than, the "Maori bottom," and, as a consequence, the breccia conglomerates and quartz drifts, whether fluviatile, lacustrine, or marine, are in a majority of instances found standing at high angles, and not unfrequently in an inverted position. Their present outcrops, therefore, show beds under such circumstances that it is impossible to conclude here was the limit of the lake or sea, or that the existing hill-slopes and mountain-heights ever formed such shore-line.

Faults.

Faults have undoubtedly exercised a very great influence upon the physical outlines of Otago since the beginning or middle part of the Pliocene period. Twelve great faults are known to intersect different parts of the North and South Islands, and several of these pass through the area of the Otago goldfields. In a previous report a map is given showing how far these have been traced, and their supposed extension through parts of the country over which they have not actually been traced.* Of these, Nos. 2, 3, 8, 10, 11, and 12 intersect different parts of the Otago District. Nos. 13 and 14 were at the time considered of minor importance, but 13, it would appear, is a gigantic fault, ranking with the others as regards its lineal extension and vertical displacement, and of great interest as being, perhaps, the one in Otago most recently initiated, and, it may be, still active. A number of additional faults have been discovered during the progress of the examinations lately made, but it has not been ascertained how far some of these are great earth-fractures extending to other parts of the South Island outside the Otago District. Fault No. 10, described in the report above cited as the "Moke Creek Fault," extends from the south-west across the middle arm or cross-reach of Lake Wakatipu to Bob's Cove on the northern shore of the lake. To the south of the lake the line of fault has not been explored. To the north-east from Bob's Cove the line of fault runs along the south-east flank of the Richardson Mountains as far as the upper part of Skipper's Creek and the east spurs of Mount Aurum. Further information obtained during the past season necessitates a slight variation of the line of direction as drawn on the map upon which this fault was first shown, and the modified line is coincident with some remarkable features in the Upper Matukituki Valley, which may, in part, be due to the presence of the fault-line. To the south the correct line also coincides with some remarkable features which its presence may serve to explain.

Near the middle of the east-and-west reach of Lake Wakatipu this line intersects the south-west extension of No. 2 (the Great Clarence) Fault, and jointly the effects of the two have been the principal cause of the great depth of this part of the lake, which is 1,350ft. deep, or its bottom is 300ft. below sea-level. To this fault is due the preservation of Tertiary, Cretaceo-tertiary, and unaltered rocks of the Palæozoic series at Bob's Cove, and of the Cretaceo-tertiary rocks that are found along the line as far as it has been traced.

Fault No. 2 (the Great Clarence Fault).—This runs through the South Island from one end of it to the other. It enters the Otago District to the east of Lake Hawea, and is continued along part of the Cardrona Valley to Arthur's Point on the Shotover, and Bob's Cove on Lake Wakatipu. That part of its course which runs along the Cardrona Valley may, and probably does, correspond with the fault showing along Criffel Face; and in drawing the sections which cross from Mount

* Geological Reports, 1890–91, p. 1.

Criffel to the west side of the valley this has been assumed to be the case. As the breccia conglomerate and newer quartz drift along Criffel Face is auriferous, and promises to afford payable ground, that part of the fault-line which runs through Otago is thus of economic importance. The Awatere Fault (Fault No. 3) runs coincident with No. 2 in the south-west part of its course, and within Otago is no longer to be distinguished. A fault appears to be present along the Cardrona Valley, above the township, as small patches of involved quartz drifts are to be found along that line; but for the present this can hardly be considered as a line of great fracture, and therefore has not been distinguished by a number and a name.

Fault No. 14 (the Nevis Valley Fault).—This is quite evident along the eastern lower slopes of the Remarkables, and from Nevis Burn and Coal Creek across the ranges to the Kawarau River near Gibbston. The line along the Nevis Valley, from the township to the bridge, six miles further down the valley, is not in line with that part which crosses the ranges to the Kawarau; but there can be little doubt that the fault is the same throughout. On the north side of the Kawarau Gorge the line crosses the saddle at the source of the Cardrona, and is probably continued as far to the north-west as the coal-mine in the upper part of the Cardrona Valley.

Fault No. 15 (Mount Pisa Fault).—Between Mount Pisa and Criffel, and from opposite the highest point of the former, a line of fault involves and bounds the western part of the "Fat Boy" line of quartz-drift deposit. This fault is nearly parallel with that on Criffel Face. Southward it is probably continued into the watershed of the Roaring Meg. To the northward the line continued runs along the depression of Lake Hawea and the valley of the Hunter River. Its importance in the present case is, that what are likely to prove valuable auriferous deposits are preserved along the east side of the fault-line. These have not been sufficiently explored to show their true value, but, being contiguous to the rich auriferous quartz-drifts of Criffel Diggings, the Fat Boy line of drifts warrant extensive prospecting, and their greater area will give them an importance, if sufficiently auriferous, which the Criffel deposit could not lay claim to.

Fault No. 16 (Clutha Valley Fault).—This runs along the eastern base of the Mount Pisa Range. It crosses the Kawarau a little below the east end of the Kawarau Gorge, and is continued to the south-west along the eastern base of the Carrick Range to the upper part of the Bannockburn Valley, and thence probably into the watershed of the Fraser River. The evidences of faulting along the north-eastern part of this line are more to be inferred than actually seen, as the beds faulted are for the most part obscured by deposits more recent than the formation of the fault. South of Bannockburn Diggings such evidences are sufficiently plain. Lesser faults occur along the lower course of the Bannock Burn, but these cannot be traced to any great distance, and may be overlooked in this place. Auriferous deposits and important gold-workings lie along the main line of fault, but the upper beds, consisting of "mountain wash" have not been affected by the fault, and the lower quartz-drift deposit has been but little, if at all, prospected.

Fault No. 13 (the Tuapeka Fault).—This is one of the greater fault-lines which, though perhaps, structurally considered, it be of less importance than the Great Clarence Fault and the Moke Creek Fault running along the base of the Richardson Mountains, is yet in other respects more important than they. It is apparently the most recent of all the great fractures crossing the goldfields of Otago. First discovered at the Blue Spur, Gabriel's Gully, it has, as it there appears, been described by Mr. Rickard in the paper from which an extract has been made at page 2. The fault, at the suggestion of Sir James Hector, is also shown on the map facing page 1 of the Geological Reports for 1890–91. This year's examination proved that the direction of the line of fracture was not exactly as shown the map illustrating Part II. of my report on the geology of Marlborough and south-east Nelson. From Monro's Gully the line of fault is distinctly traceable into the watershed of Weatherstone's Gully, and thence less clearly it may be followed into the Waitahuna watershed. Waitahuna Gully lies along the line of fracture, and it is as clearly and characteristically displayed on the east side of the Scandinavian Claim, at the head of the left branch of Waitahuna Gully (see Section No. 6), as it is at Blue Spur itself. Setting out the line of fault as between the east side of Blue Spur and this point, and continuing the line to the south-east, the same passes remarkably close to the quartz-drift gold-workings of Manukau Hill and the breccia-beds at Glenore Railway-station. The distance between Glenore Railway-station and Blue Spur is so considerable that the line continued in the opposite direction may fairly indicate the true course of the fault. Continuing the line of fault as thus set out, and making some —and that but little—allowance for deviation from the straight line, the fault passes not far to the westward of the junction of the Manuherikia with the Molyneux at Alexandra, and is but a little to the west of the average course of the river through the Dunstan Gorge. Perhaps there is no warrant to suppose that this line of fault is continued farther to the north-west or to the south-east, but continued to the north-west it would cross two or more lines in the vicinity of the lower end of Lake Wanaka, and would thus confirm what has been noted—namely, that where two or more of these fault-lines intersect within a limited space there is at that place, relatively, an area of depression.*

Fault No. 17 (Conroy's Gully Fault).—This runs along the southern side of Conroy's Gully. It is indicated by a line of quartz drift which, dipping at high angles to the south-east, or standing nearly vertical, is suddenly terminated against the schists forming the higher slopes on the southern side of the valley. The quartz drifts thus involved are said to be auriferous, but they do not seem to have been much prospected. From the fact that the creek-bed of Conroy's Gully was very rich in gold opposite to where this line of quartz drift occurs, it is reasonable to suppose that a large part of the gold in the modern creek-bed was derived from the quartz drifts. Another line of quartz drift deeply involved along a fault runs from Butcher's Gully in the direction of Alexandra and the lower part of the Manuherikia Valley. Which of these two it is that is continued along the Lower Manuherikia to Chatto Creek it is not easy to determine. Probably the two unite, and therefore, for convenience' sake, as far as to Chatto Creek this line of quartz drift preserved by faulting shall be considered as belonging to, and a continuation of, Conroy's Gully fault.

* Geological Reports, 1890–91, page 25.

Fault No. 18 (the Manuherikia Fault).—This line of fault runs along the base of the Dunstan Mountains from the Molyneux Valley at Clyde to the Dunstan Creek near St. Bathan's, in the upper part of the Manuherikia Valley. The line of fault is usually very well marked, and the involved beds are commonly in a vertical or an inverted position. There are many localities along this line whereat gold-workings have been and are in progress. To the tilting and denudation of the newer breccias and auriferous quartz drifts along this line are due the diggings at Waikerikeri, Devonshire Diggings, Tinker's, Cambrian's, Vinegar Hill, &c. Had the auriferous beds along the fault not been tilted, they must have been so buried beneath the "Maori bottom" and younger gravels that even to the present time they would have been hidden from view. The inversion of the beds along the fault-line causing the schist to overhang the loose auriferous gravels renders the working of the drifts a matter of difficulty and some danger, especially in those claims where the auriferous drifts have been washed away to a considerable depth.

Fault No. 19 (Hill's Creek Fault).—This line of fault is very clearly seen on the north-east side of the saddle between Blackstone Hill Range and the south-western part of the Hawkdun Home Hills. The fault is of very modern date, and the latest displacements can still be traced at the surface. At some places the younger strata strike in an easterly direction towards the fault, and are suddenly terminated at the line of fault, the opposite wall being schist. At some places, as described by Mr. Gordon, the schist is quite overturned, and found resting on the quartz drift. The north-west and south-east extension of this line has not been traced, but it or another fault passes to the eastward of the coal-mine east of the main road across Ida Valley, and thence across the saddle at the north-eastern end of Rough Ridge into the Wetherburn watershed. The line between these two points, if prolonged to the north-west, passes close to St. Bathan's gold-workings, and, following generally the line of Dunstan Creek, crosses the Dunstan Pass into the Lindis watershed. The same line continued to the south-east passes close to Hamilton's and Hyde, and, south-east of the Taieri, passes close to Horse Flat, Deep Dell, and Macrae's, at all of which places quartz drifts are present, more or less involved amongst the older rocks. It is not maintained that the Hill's Creek line of fault can be traced to the extremities of the line described, but it is something more than a coincidence that so many features indicating the probable presence of a fault are to be found along the line.

Fault No. 20 (Blackstone Hill Fault).—The manner in which the quartz drifts lie in against the south-east lower slopes of Blackstone Hill Range is sufficiently indicative of the presence of a fault from the vicinity of Hill's Creek Township to the Pool-Burn Gorge, and at Black's No. 3 the evidence of a continuation south-west of the same line is not to be doubted. This line runs nearly parallel to that along the south-east base of the Dunstan Mountains, and both lines have on the opposite side of the valley an outcrop of quartz drifts dipping at a lower angle in a north-west direction, or away from the range that bounds the valley on the south-east side. The Pipeclay line, on the north-west side of Blackstone Hill, is an exception, the beds there standing at high angles.

Fault No. 21 (Hawkdun Fault).—This line runs along the whole length of the Hawkdun Mountains, or from the head of the Mount Ida Water-race to the upper part of the Wether Burn, the line being apparently terminated at the foot of Little Mount Ida. Clear sections, showing the contact of the younger series with the old rocks of the Hawkdun Mountains, are not of frequent occurrence, but the dip of the quartz drifts and associated rocks is generally towards the mountain, and at a few places it is seen that the junction of the two formations must be along a line of fault.

Fault No. 11 (the Kyeburn Fault).—This runs along the east side of the Maniototo Plain, from the Swin Burn to the western base of Kyeburn Peak and the east end of the Mount Ida Range. Along this line auriferous quartz drifts are found at 1,300ft. along the bed of the Kye Burn, and at 4,000ft. above the sea five or six miles further to the north. To the north the rocks on both sides of the fracture have been elevated, but south of the Upper Kyeburn Township and diggings the displacement has been a downthrow on the western side. This line can be traced as far to the north as the gorge of the Ahuriri, above where that river joins the Waitaki. Continued to the south the line passes near to Macrae's Diggings, along the Upper Stone Burn and Silver Peak Range to Blueskin Bay, involving Cretaceo-tertiary rocks at various places along this part of the line.

Fault No. 12 (Waihemo Fault).—This runs along Shag Valley and the south-western slopes of the Kakanui Mountains and the Horse Range to the sea at Shag Point. The fault-line runs out to sea immediately to the south of the mouth of the Shag River, and along the lower part of Shag Valley the amount of displacement can be ascertained by comparing different strata of Cretaceo-tertiary age on the opposing sides of the fault-line. Near the sea there must be a displacement of not less than 2,000ft., but this amount is considerably lessened as the line is followed up Shag Valley.

The Auriferous Drifts considered in Relation to the Changes of Level and Disturbances by Faulting that have taken place since their Deposition.

Whether on Manukau Hill or Mount Criffel, at Waikaka, or on Mount Buster, one and the same is the character of the older quartz drift; and the many localities of occurrence which have been cited show that at one time the drifts were all but universal over the surface of south-eastern, interior, and north-eastern Otago. Both the breccia conglomerates and the older quartz drifts, having resulted from the causes indicated and in the manner described, appear to have remained comparatively undisturbed up to and during Middle Miocene times. During later Miocene times they were denuded to a considerable extent, and in the neighbourhood of areas where schist was exposed there was a mingling of detritus from the older quartz drifts, with less rounded material, derived from the schists, &c. These materials now form the newer breccia conglomerate found along Criffel Face, in the Cardrona watershed; at Devonshire Diggings, Tinker's, and Drybread, in the Manuherikia Valley; and probably in the northern end of the range of hills east of Little Kye-Burn.

The newer quartz drifts are intimately associated with these, and in the Manuherikia and Cardrona Valleys the beds appear to be for the most part river-bed deposits: perhaps at Drybread and the Little Kye Burn they are, in the higher beds, deltaic or lacustrine. Succeeding these, the next beds are the heavy sandstone conglomerates, which in Otago are usually called "Maori bottom." In the Cardrona Valley these beds are at least 500ft. thick. In the Manuherikia Valley and in the Maniototo Basin their actual thickness is not so easily determined, but it is less than within the Cardrona watershed. At Switzer's the thickness of the beds is considerable, though far short of the maximum above stated. Before the deposit of the "Maori bottom" beds, all central Otago had been denuded of the rocks capable of yielding the sandstone gravels of which the "Maori bottom" is composed, and it seems almost a necessary conclusion that at this time the area of the goldfields of Otago be regarded as having been depressed below the general level of the surrounding regions, over which sandstone and slaty rocks were present. One very large or several smaller lakes there probably were, and into this or these were carried the sandstone gravels from the exterior regions. The eastern area now comprising the Maniototo Basin could easily have been supplied from the Kakanui and Mount Ida Ranges, and the Manuherikia Valley from the unaltered rocks of the Mount St. Bathan's and Hawkdun Ranges; but there is a difference in the case of the "Maori bottom" in the Cardrona Valley. The gravels there present can have come from nowhere but the Hunter Valley, above Lake Hawea, although at the present time the rearranged glacier-moraines and gravel-plains below the lakes to the Luggate Burn show few signs of the presence of sandstone.

The older quartz drifts and breccia conglomerates and the beds belonging to the same series that overlie them appear to have been denuded to a considerable extent before the deposition of the lower beds of the next succeeding series. The newer breccia conglomerates and quartz drifts, like the older, rest generally on schist rocks, and appear to be the product of river-action, as seen on Criffel Face, at Tinker's, and Devonshire Diggings. At Drybread the higher beds appear to be more of a lacustrine character. To some extent, therefore, the extensive lacustrine area, which was characteristic of the period of the older drifts, had been broken up, and parts of it brought under the influence of the denudation then in progress; but there is no evidence that the country was being rapidly modified by the elevation and depression of the land on opposite sides of great fault-lines traversing the whole length of the provincial district. It was not till after the deposit of the sandstone gravels known as "Maori bottom" that this took place. In the Waitaki Valley, Maniototo Basin, and generally in eastern Otago it is not quite clear that the great disturbance took place after the deposit of the "Maori bottom" gravels; but in the Manuherikia and Clutha Valleys the evidences that it was subsequent are decisive. Subsequent to the deposit of these, the several fault-lines which have been described began to be formed, and up till the present time vertical and thrust movements have been and are in progress. The result was that the Maniototo Basin was separated from the coastward tract by the appearance of the Horse Range and Kakanui Mountains; was also cut off from the Poolburn and Ida Burn Basin by the Rough Ridge and the Wetherburn Range. Ida Valley and the Poolburn Valley, likewise an old lake-basin, shut off, as described, from connection with the Maniototo Basin, was likewise separated from the lake-basin of the Manuherikia Valley by the Raggedy Ridge, Blackstone Hill Range, and the Hawkdun Home Hills. These, and the Hawkdun Mountains to the north-east, limited to the south-east the Manuherikia lake-basin, which the Mount St. Bathan's Range and the Dunstan Mountains limit on its north-west side. The Mount Pisa and Carrick Ranges limit in the same way the lower portion of the Clutha lake-basin, the waters of which filled the lower part of the Lindis Valley, and, in the neighbourhood of the present lakes, Lake Hawea and Lake Wanaka extended some distance up the Cardrona Valley. The Nevis Valley probably has not been a lake since the deposit of the "Maori bottom." While these different lake-basins were being formed in the central and northern parts of Otago, more to the west the same thing was going on in the Lake Wakatipu district; and while depression of the country to the east of the line of the Moke Creek and Great Clarence faults was going on, resulting in a yet further deepening of the lake, the schist formation of the Richardson Mountains, due to lateral pressure from the eastward, was gradually overriding the Tertiary and Cretaceo-tertiary rocks along the eastern foot of that range.

Between these newer lake-basins portions of the deposit in the older were raised high on to the mountains, as is shown by what remains on Criffel and Mount Buster even at the present time. Several fault-lines intersecting each other in the vicinity of the lower ends of Lakes Wanaka and Hawea, the depression where these crossed being greater than elsewhere, the present lakes now lie in that portion; but the united Lakes Wanaka and Hawea extended along the Clutha Valley to Cromwell and Bannockburn, and were of large area compared with the combined extent of the present lakes. The level at which the waters stood in these newer Pliocene lake-basins was, in the case of Lake Wakatipu, nearly 1,000ft. above the present level of the lake; in the case of the united Hawea and Wanaka, 1,600ft. above the present level of Lake Wanaka. In the case of the Manuherikia and Maniototo Basins—these being now totally drained, or almost filled in—such comparison may not be made; but on the eastern side of the Maniototo the highest superficial gravel exceeds somewhat 2,000ft., while the level of the Taieri Lake is 1,100ft. above the sea. There is no proof that since the deposit of the "Maori bottom" the waters of the lake in the Maniototo Basin reached the level of Hamilton's or Naseby, and the superficial alluvial drifts at high levels between the Upper Hogburn and Eweburn may wholly be due to the action of those streams before they had cut down to their present level. In time glacier-ice invaded the upper valleys, and filled the depressions now occupied by Lakes Wakatipu, Wanaka, and Hawea. Glacier-moraines reach to Franktown and the foot of the Remarkables, and choke the former outlet of Lake Wakatipu, and lie against the lower slopes of Ben Lomond opposite Queenstown; but the highest terraces on the side of the Ben Lomond Range and on the Crown Terrace, on the left bank of the Arrow, opposite Arrowtown, are old lake-beaches. Therefore the lake had been lowered considerably from its highest level before the advance into it of the glaciers of the Dart and Rees Valleys.

The same thing happened in the Wanaka district. The high-level terraces of the old lake are 1,600ft. above the present level of Lake Wanaka, as seen on the north-east slopes of Mount Criffel, at Frenchman's, and at Mid Run; but no morainic matter reaches within 500ft. of this level. The moraines lie in comparatively low ground around Mount Iron, and in the peninsular area between the Lower Cardrona, the lake, and the Clutha River. The Hawea side of the depression was not so fully explored, but the evidence there must be of the same character. A distinct moraine lies on the left bank of the Clutha, between Tarras Creek and Long Gully. This is in comparatively low ground, and, so far as noted, is the furthest extended and lowest moraine connected with the Wanaka-Hawea former extension of glacier-ice. Further down the valley there is no evidence of the presence of glaciers till reaching the Kawarau Gorge, at which place the evidence in favour of the presence of glaciers, such as it is, is not more than what might be expected as having come through the gorge from snow-fields on the neighbouring mountains. There are no evidences of the presence of glaciers at the Bannockburn Diggings, nor anywhere within the Bannockburn Valley. The high-level terraces proving that the waters of the united and greatly extended Wanaka-Hawea Lake stood far above the level to which glacier-ice at any time attained is shown by the presence of the old beach-gravels still resting on the northern slope of the Dunstan Mountains, at a height of 1,000ft. above the level of the Clutha Valley, below the Lindis Junction.

The high terraces opposite Cromwell, on the western side of the valley, appear to be lake-terraces such as are met with along the Lower Lindis. At Bannockburn the middle and lower terraces are river-gravels. The "mountain wash" is a rough creek-rubble or slope-deposit, and could not be referred to the action of ice as glacier-ice. Terrace-gravels rest on the slopes of the Dunstan Mountains at the upper end of the Dunstan Gorge, directly opposite the Township of Cromwell. These are some 500ft. above the level of the junction of the Clutha and Kawarau branches of the Molyneux, and may indicate the height of the old rim or lip-barrier that prevented the waters of the Molyneux making their way through the Dunstan Gorge, though probably the barrier was at a greater height than this. Before the cutting-down of the Dunstan Gorge it is perfectly evident that the Molyneux found its way into the lower valley below Clyde by way of the Bannockburn Valley, and thence into that of what is now the Fraser River, at what different levels may be judged by a study of the contours of hill and valley as these are at the present time. Professor Hutton is of the opinion here expressed, that the Molyneux escaped from the Upper Clutha Valley by way of the valley of the Bannockburn and the Fraser River.* It has already been pointed out that the Dunstan Gorge lies nearly in the line of the north-west extension of the Tuapeka fault (Fault No. 13), and it may fairly be inferred that due to action along that line the Wanaka-Hawea Lake was first tapped, so as to drain through the Dunstan Gorge. The fall of the bed of the river, which in thirteen miles is only 65ft.,† would be ten times greater, or nearly so, while the volume of water would probably be very much larger than at present, the cutting-down of the gorge and the gradual tapping of a very large lake adding not a little to the volume of water passing through the gorge. This great volume of water must have cleared every obstruction in its way that was not solid rock, and hence the terraces of large angular blocks and river-shingle on the left bank of the river at Clyde and thence extending to and beyond Waikerikeri Creek. This was probably the last great alteration in the course of the Molyneux River. If ever it passed from Moa Flat west of Spylaw into the Pomahaka and Mataura watersheds the change to its present course was probably effected at a date prior to the cutting-down of the Dunstan Gorge.

The high-level lake-terraces of the united Wanaka-Hawea Lake in its extension to Cromwell and Bannockburn have been worked at several places, as, for instance, at Bannockburn and along the high terraces on the north-west side of the Clutha Valley to Lochar Burn; also on the opposite side of the valley to nearly as far. Mid Run and Frenchman's, on the Luggate Burn, are the only other important localities where goldmining is carried on in these beds within the Upper Clutha Valley. In the Kawarau-Wakatipu district the Crown Terrace is the most important, if not the only, locality.

Conclusion.

A perusal of the foregoing parts of this report will show that, with respect to the older breccia-conglomerate beds, these are not confined to the neighbourhood of Gabriel's Gully, Weatherstone's, and Waitahuna,—that they may be looked for, and prove auriferous, along the lower hill-slopes to the south-east, along the borders of the Tokomairiro Plain and over parts of the Kaitangata Coal-field, where the lower beds of the Cretaceo-tertiary series are exposed. Also, as has been shown, there is a large development of the same beds in the Horse Range, from the downs on the south-west side of the range to South Peak, north-east of the gorge of Trotter's Creek. The same beds also appear in Mount Vulcan, on the north side of the Shag River, at its mouth. At Blue Spur, Weatherstone's, and Waitahuna the beds are known to be auriferous, and also in the Horse Range. They should be prospected wherever prospecting can be carried on at a moderate cost, since it can hardly be that the three localities which have been worked are the only places where these beds are auriferous.

With respect to the older quartz drifts, they have been the great source from which gold was set free to enrich the more modern gravels at a great number of places on the Otago goldfields. An endeavour has been made to make it clear that these beds have not their auriferous parts arranged like leads along an old river-bed, nor in fan-shaped deposits, such as might have accumulated at the mouths of rivers or lesser streams falling into a lake. It has been shown that the gold is found in a particular stratum or strata, which, as in the case of the Maraewhenua goldfield, extends over its entire area, or the gold may be more concentrated in particular areas of lesser extent; but, still, in every case it has to be considered that we are dealing with a gold-bearing stratum which has to be prospected after the manner of a coal-seam. Where the beds are tilted so as to stand

* "Geology of Otago," p. 91. † *Ibid.*

at considerable, or high, angles, and are not overlain by younger deposits, they can be easily prospected by trenching along the surface of the ground; and even when the dip is at moderate angles, as in the Maraewhenua goldfield, the outcrop of the auriferous stratum is usually easily to be found.

Further prospecting should be carried on in these beds in the hilly country between Pigroot and Hyde, at Hamilton's; under the basaltic sheet and along the line of outcropping drifts to the Sow Burn, and along the different lines that appear round the borders of the Maniototo Basin, Ida-Burn and Pool-Burn Valleys, and in the Manuherikia Valley, and wherever the beds are met with east of the Molyneux River. The newer quartz drifts and breccia conglomerates of Tinker's, Drybread, and some other places along the south-east base of the Dunstan Mountains should be further prospected in the same way.

The great difficulty in the way of the further development of alluvial mining in Otago is the scarcity of water, and the difficulty of bringing an abundant supply on to many places where hydraulic sluicing could be carried on profitably. The measure of the water available is, therefore, that which must determine the rate of progress and increase of this form of gold-mining in the district examined. At Fullerton's, Hyde, Hamilton's, Black's No. 3, St. Bathan's, and several other places very rich driving-ground was met with in the quartz drifts, but it was never, apparently, rightly understood under what conditions the gold stratum had been deposited, and, as a consequence, prospecting by shafts in the deeper ground was usually adopted, when the gold-bearing stratum might have been followed at the surface. It is hoped that this report has thrown some light on the subject, and that future prospecting will be carried on for driving or sluicing ground, not by the costly method of deep-shaft sinking, but by following the outcrop of the auriferous gravels where these have been proved, and by trenches cut across the belt of drift country where the gold-bearing stratum has not been determined.

Of the newer quartz drifts and breccia conglomerates on Criffel Face, Cardrona Valley, much cannot as yet be said, but it is a field that is very well worth prospecting, since it may prove to be continuously auriferous from opposite the Cardrona Township to the mouth of the valley near Mount Barker. Of the newer Miocene or older Pliocene conglomerates, locally known as "Maori bottom," these may not at many places be rich in gold, but they are at the present time being worked at several places—notably at Switzer's—and indicate a source of gold that is practically inexhaustible.

The old high-level lake terraces at the Crown Terrace, Arrowtown, Frenchman's, and Mid Run, in the Upper Clutha Valley, show that at similar levels at other localities like deposits of an auriferous character may be found.

The illustrations accompanying this report comprise geological map of the goldfields of Otago, and six sheets of sketch sections, Nos. 1–28.

ALEXANDER McKAY.

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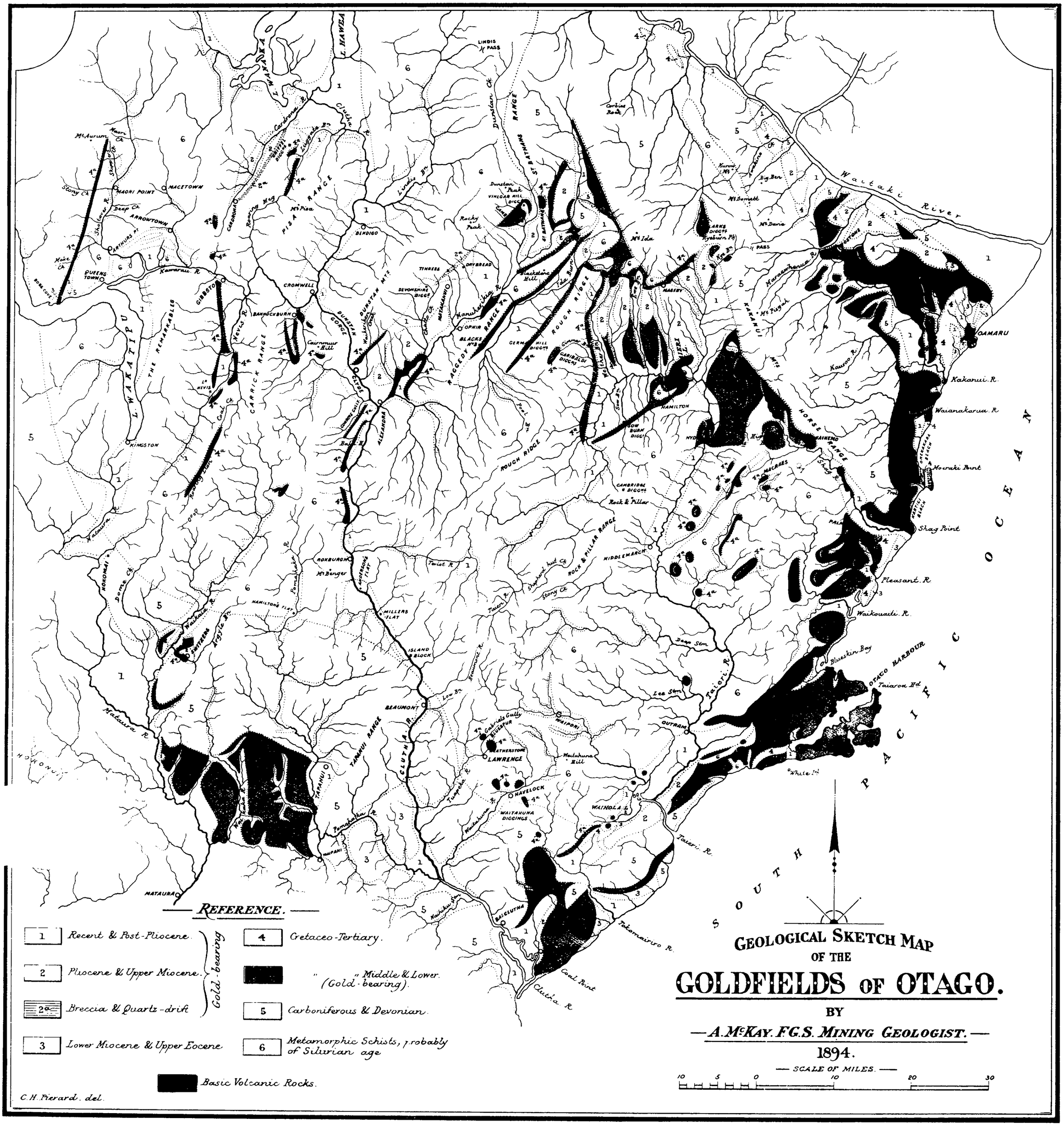

REFERENCE.

1	Recent & Post-Pliocene.	4	Cretaceo-Tertiary.
2	Pliocene & Upper Miocene.		" " Middle & Lower. (Gold-bearing).
2a	Breccia & Quartz-drift	5	Carboniferous & Devonian.
3	Lower Miocene & Upper Eocene	6	Metamorphic Schists, probably of Silurian age

Gold-bearing

Basic Volcanic Rocks.

C.H. Pierard. del.

GEOLOGICAL SKETCH MAP OF THE GOLDFIELDS OF OTAGO.

BY

—A. McKAY. F.G.S. MINING GEOLOGIST.—

1894.

— SCALE OF MILES. —

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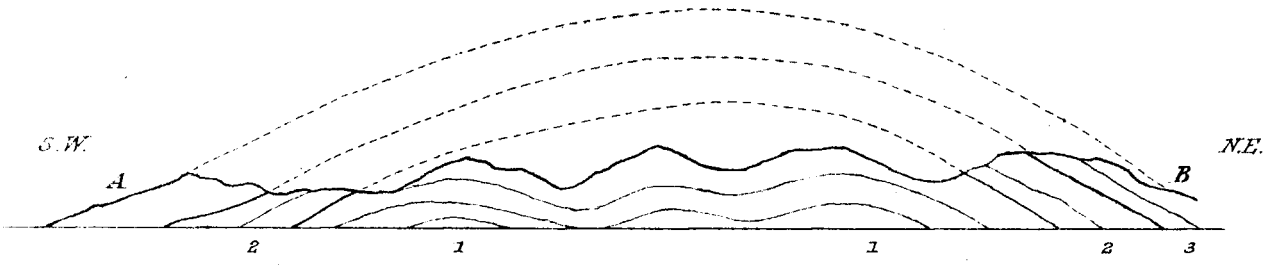

Fig 1. Sketch Section from Hokonui Hills N.E. across the Goldfields of Otago to the Kakanui Mountains.

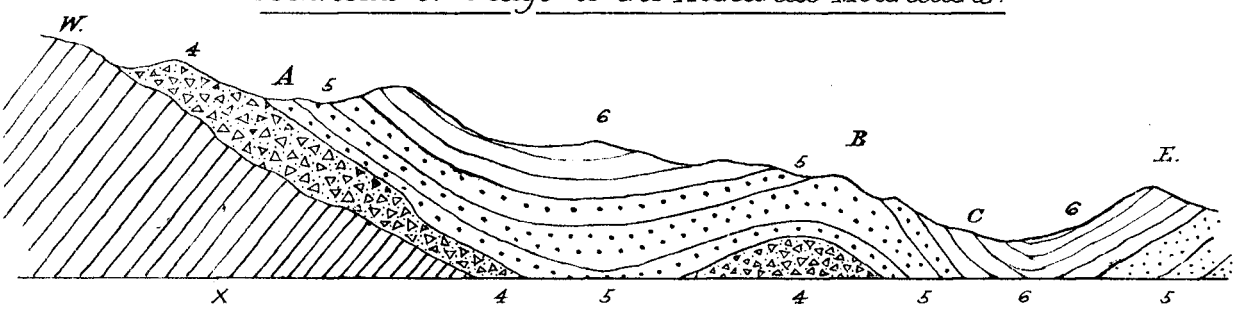

Fig 2. Sketch Section showing the beds from the Road over the Horse Range E. to Alandale Shag Point Hills.

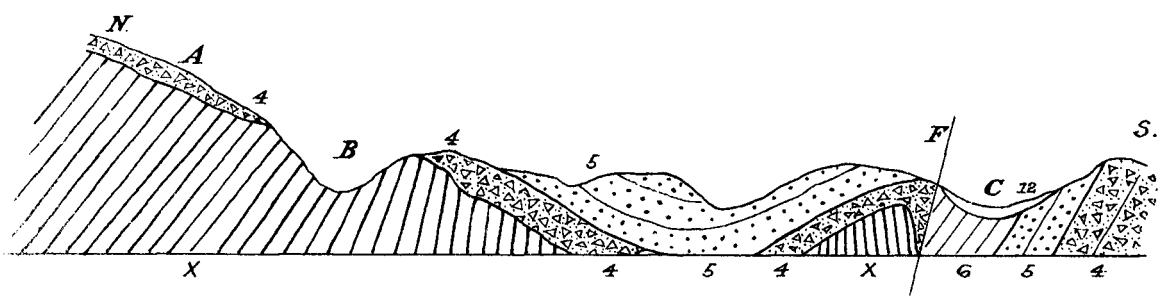

Fig 3. Sketch Section showing the beds present in the line from the southern slopes of the Horse Range South across Macgregor's Farm in the direction of Palmerston.

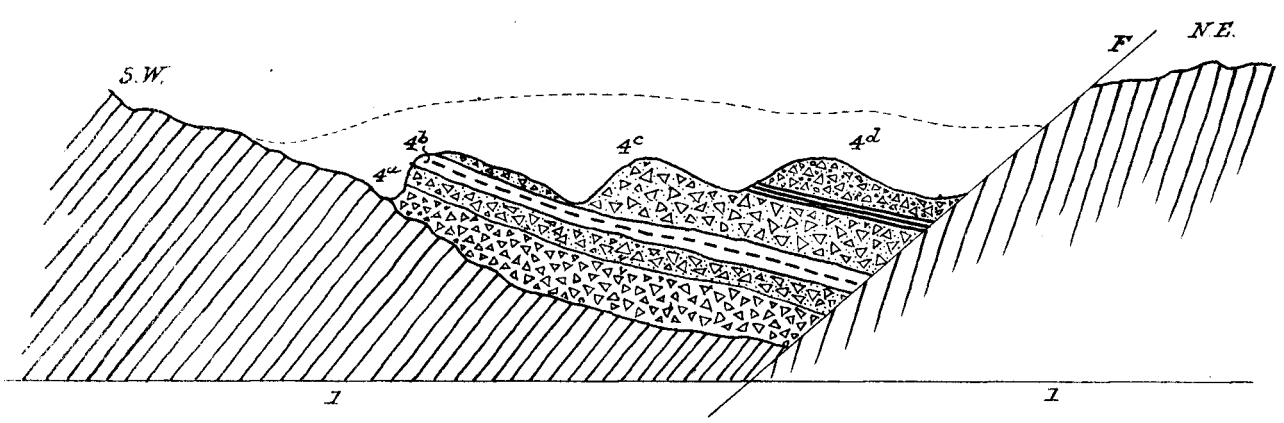

Fig 4. Sketch Section across the Blue Spur Deposit, from South-west to North-east.

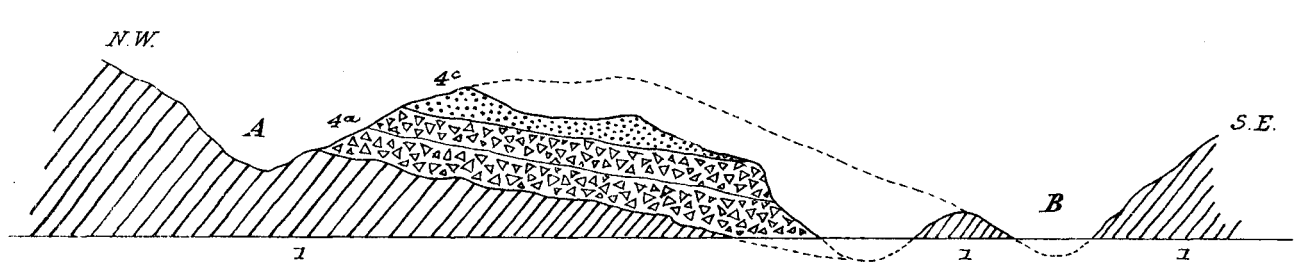

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Fig 5. Sketch Section from Northern side of Monro's Gully to Gabriel's Gully, showing the arrangement of the Blue Spur Deposit; in a North-west and South-east line.

Sections to illustrate Report by A. McKay. F.G.S. Mining Geologist.

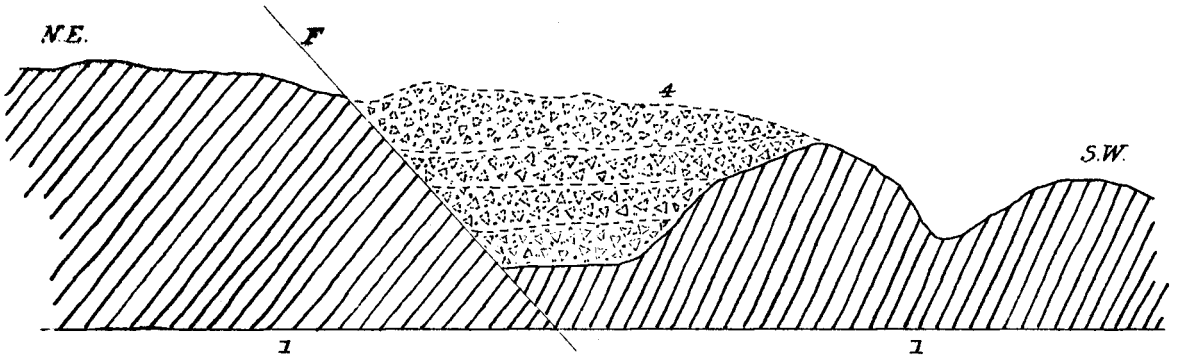

Fig 6. Sketch Section North-east - South-west, across Scandinavian Claim. Waitahuna Gully. ——

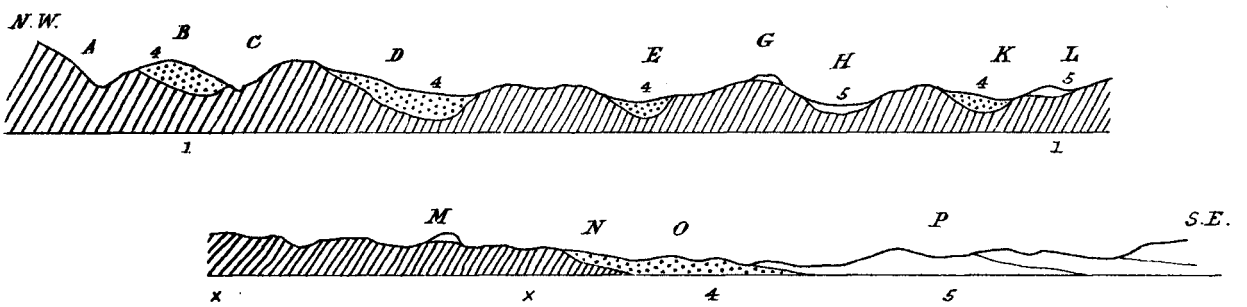

Fig 7. Sketch Section from Monro's Gully S.E. along line of Breccia Conglomerate deposits to vicinity of Tokomairiro. ———

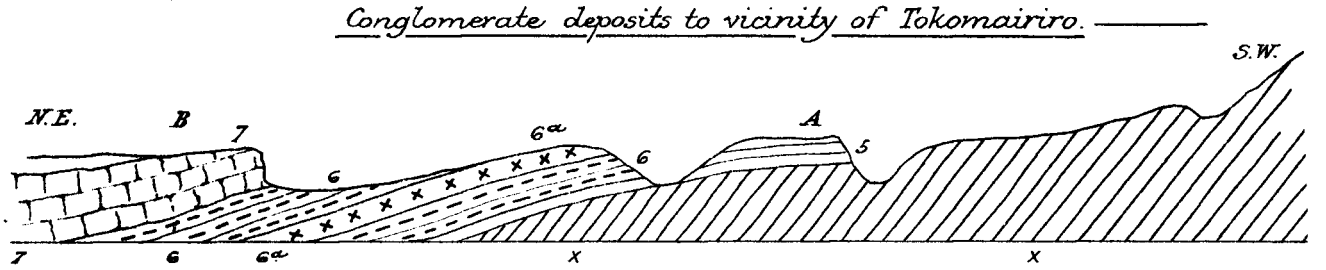

Fig 8. Sketch Section from Limestone South side of Maraewhenua River to Livingstone, showing position of the Auriferous Quartz Drifts relative to the Middle & Upper Parts of the Cretaceo-Tertiary Formn.

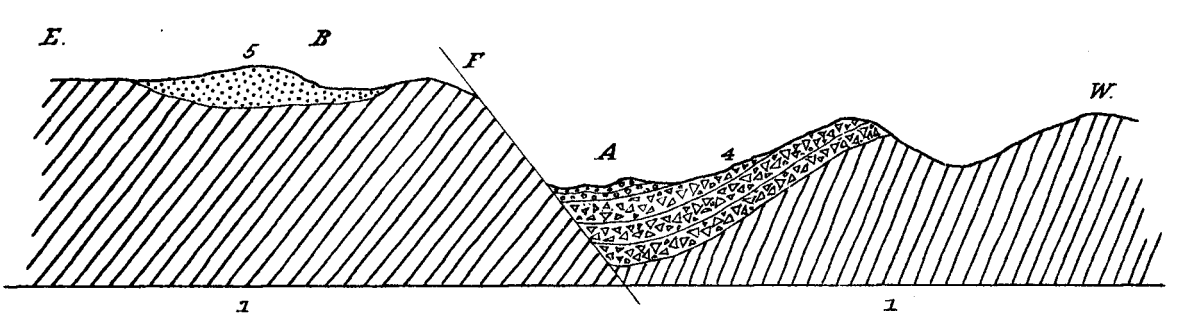

Fig 9. Sketch Section across Waitahuna Gully.

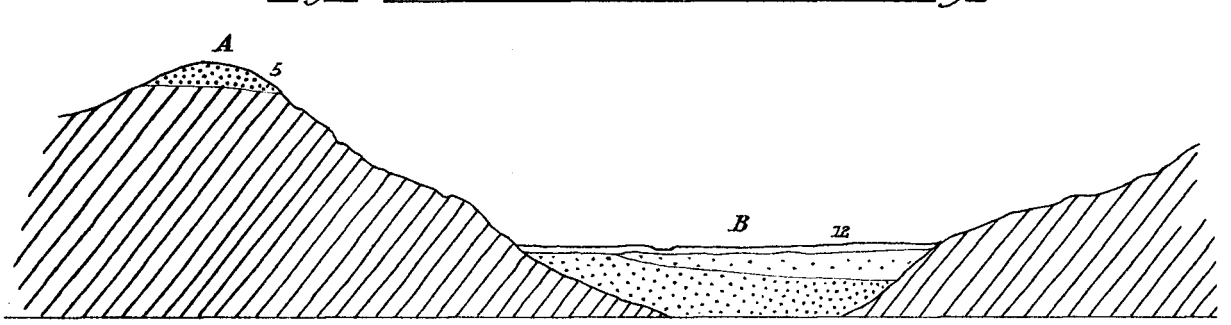

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Fig 10. Sketch Section N-S. from Cogill's Hill to Waitahuna Flat showing the older Quartz-Drifts at different elevations. ———

—— Sections to illustrate Report by A. McKay. F.G.S. Mining Geologist. ——

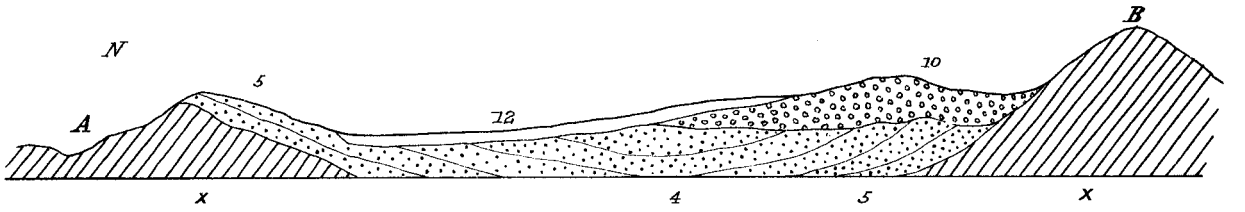

Fig 11. Sketch Section showing the position and relations of the Auriferous beds at Switzers to the underlying Quartz drifts, and of these to the Old Rocks.

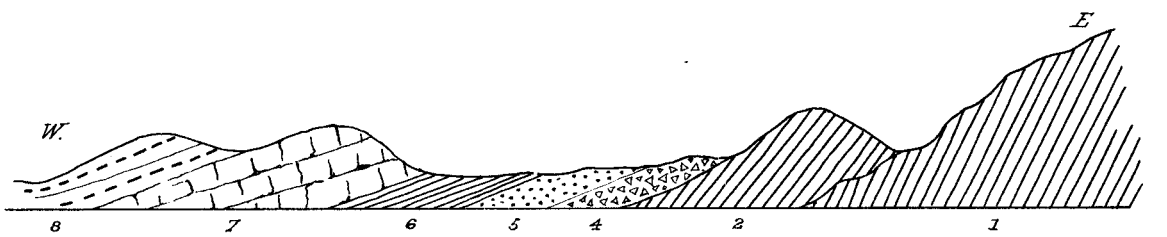

Fig 12. Sketch of Section seen at Bob's Cove Lake Wakatipu.

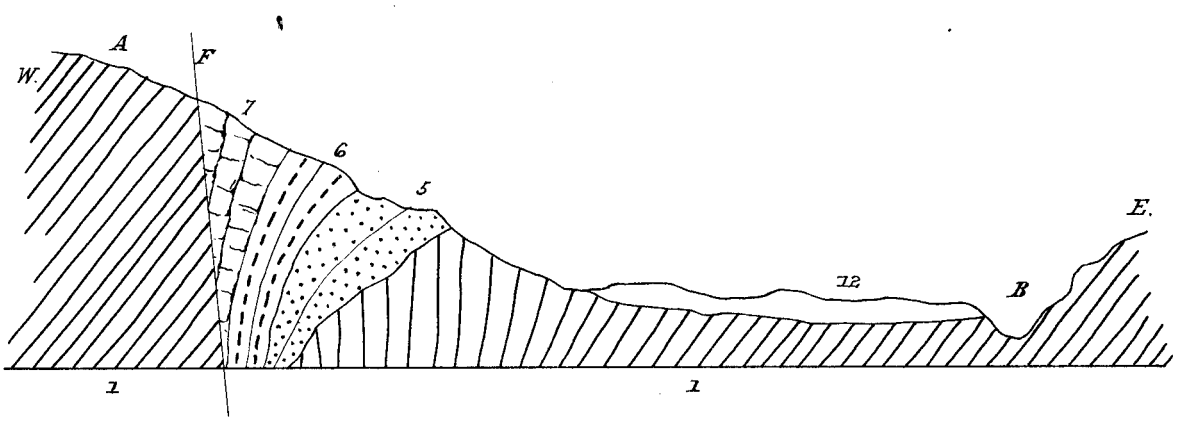

Fig 13. Sketch Section showing the manner of involvement of the Quartz-drifts on the slopes of Ben More, between Moke and Moonlight Creeks. Lake Wakatipu.

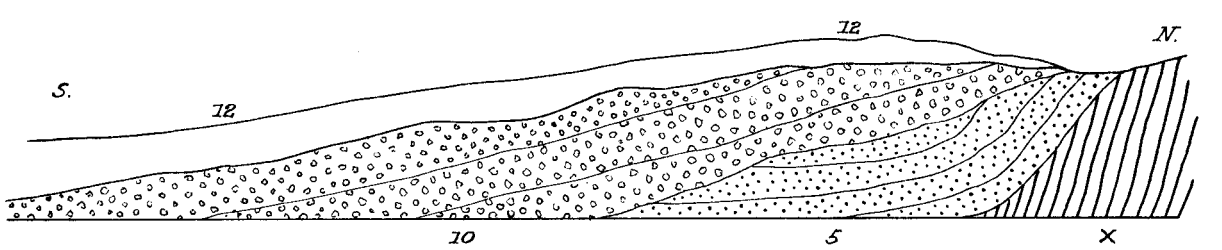

Fig 14. Sketch Section showing the beds along the right bank of the Hog Burn, near Naseby.

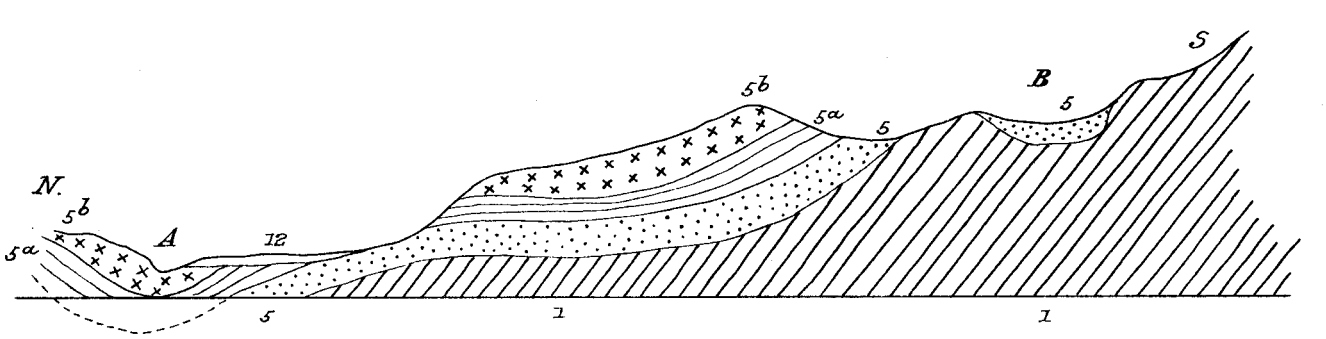

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Fig 15. Sketch Section from Taieri Bridge to Hamilton's Diggings. Maniototo Basin.

Sections to illustrate Report by A. McKay. F.G.S. Mining Geologist.

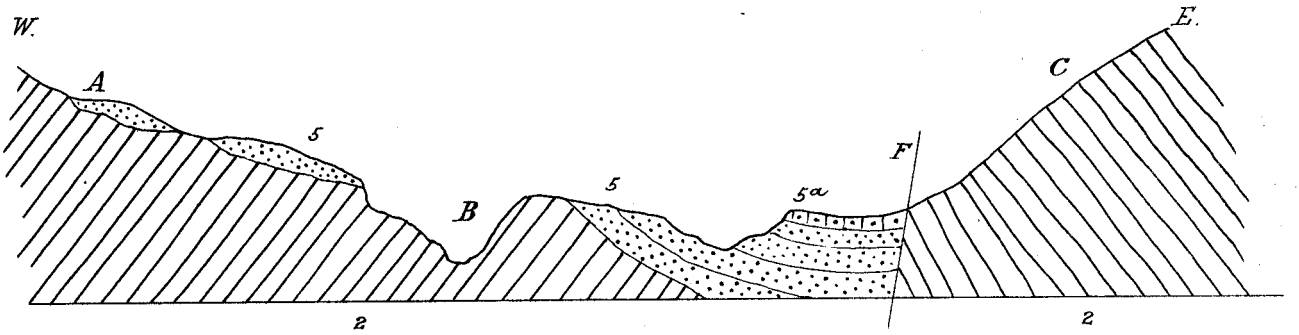

Fig 16. Sketch Section showing the Beds from Hawkdun Home Hills, East across Marion Burn to the Hawkdun Range.

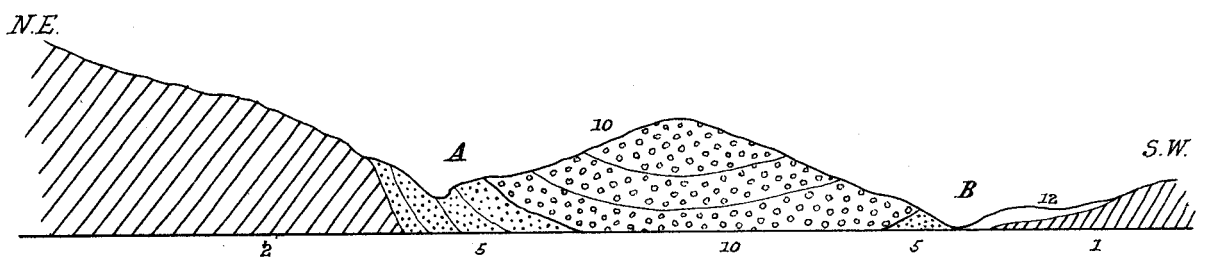

Fig 17. Sketch Section N.E. to S.W. across the Southern end of St Bathan's Basin.

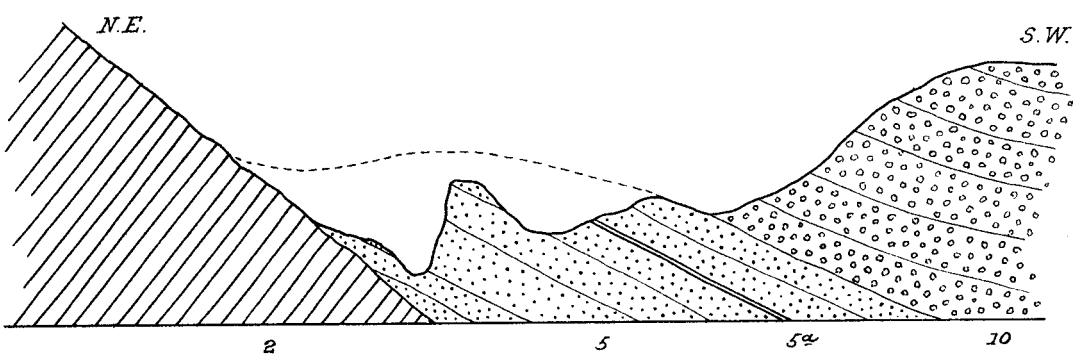

Fig 18. Sketch Section across the Middle part of St Bathan's Basin.

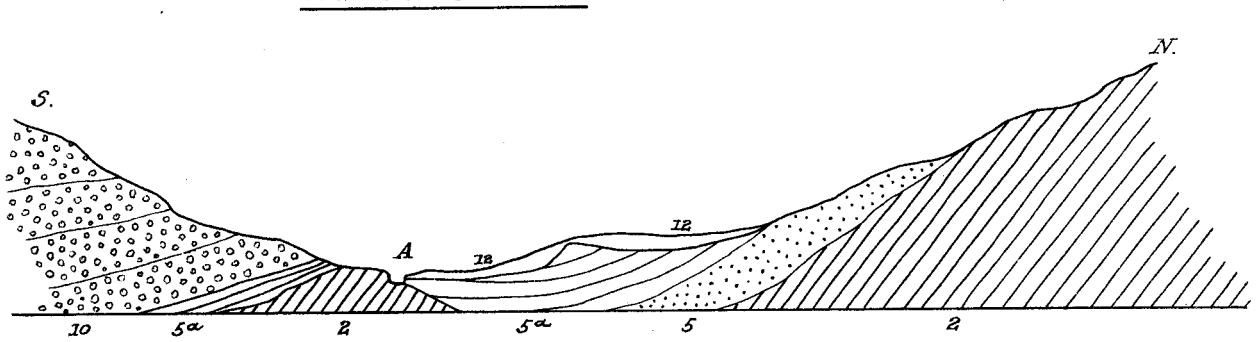

Fig 19. Sketch Section South to North, across the outlet of St Bathan's Basin in the direction of Dunstan Creek.

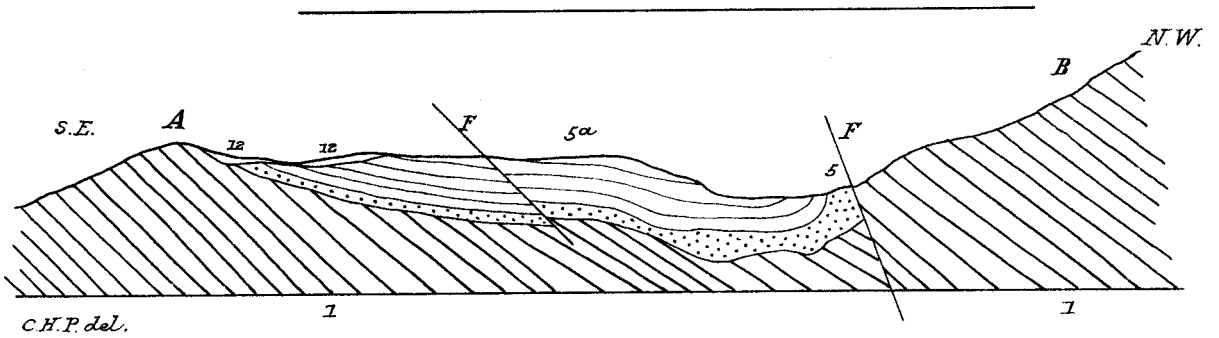

Fig 20. Sketch Section from Vinegar Hill North-west to the slopes of the Dunstan Mountains.

Sections to illustrate Report by A. McKay. F.G.S. Mining Geologist.

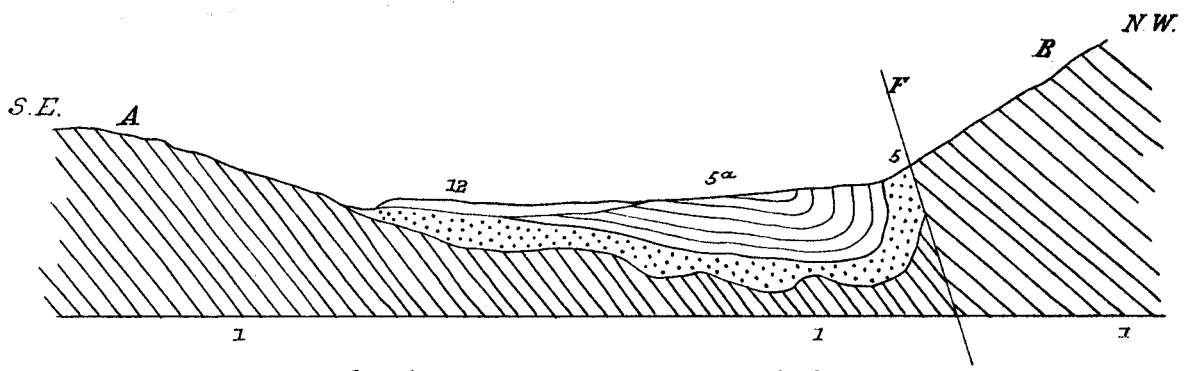

Fig 21. Sketch Section at Vinegar Hill, from Mr Ewing's House North-west to slopes of the Dunstan Mountains.

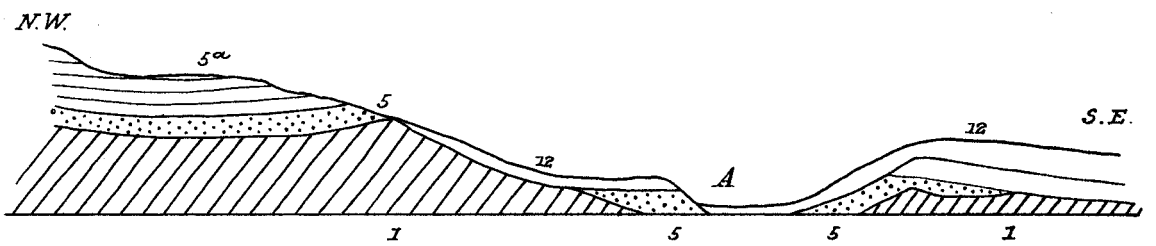

Fig 22. Sketch Section from N.E – S.E across the Molyneux River near the junction of Coal Creek, 5 miles above Roxburgh.

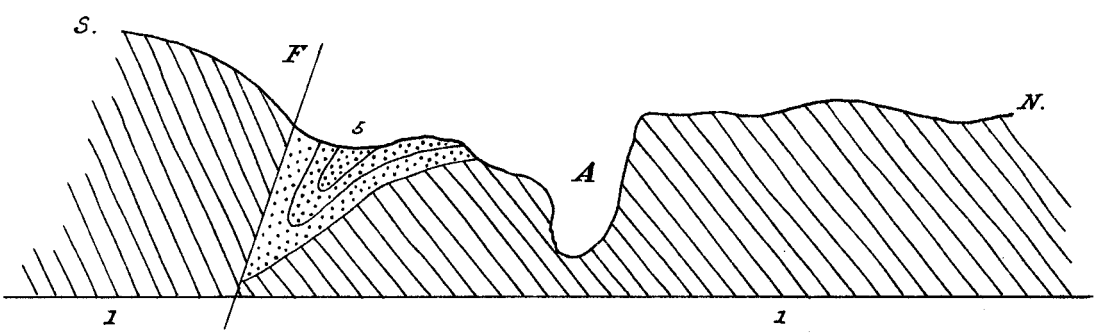

Fig 23. Sketch Section across Conroy's Gully showing the Quartz-drifts involved along line of Fault.

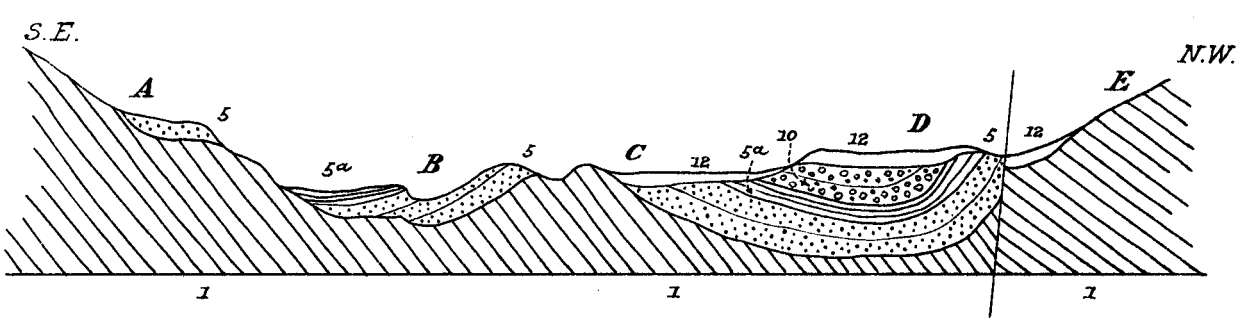

Fig 24. Sketch Section from slopes of Cairnmuir North-west to Northern end of the Carrick Range.

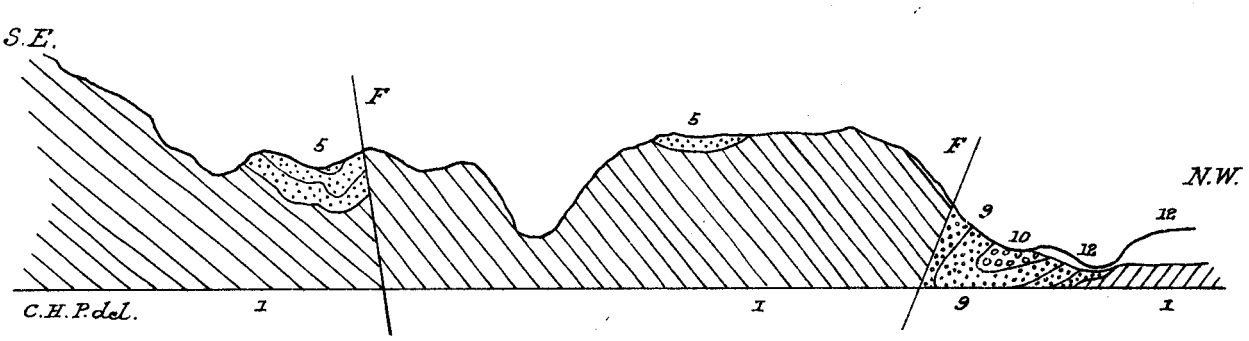

Fig 25. Sketch Section from slopes of Mount Pisa across Fat Boy & Griffel Diggings to the Cardrona Valley, near Mount Barker.

Sections to illustrate Report by A.McKay. F.G.S. Mining Geologist.

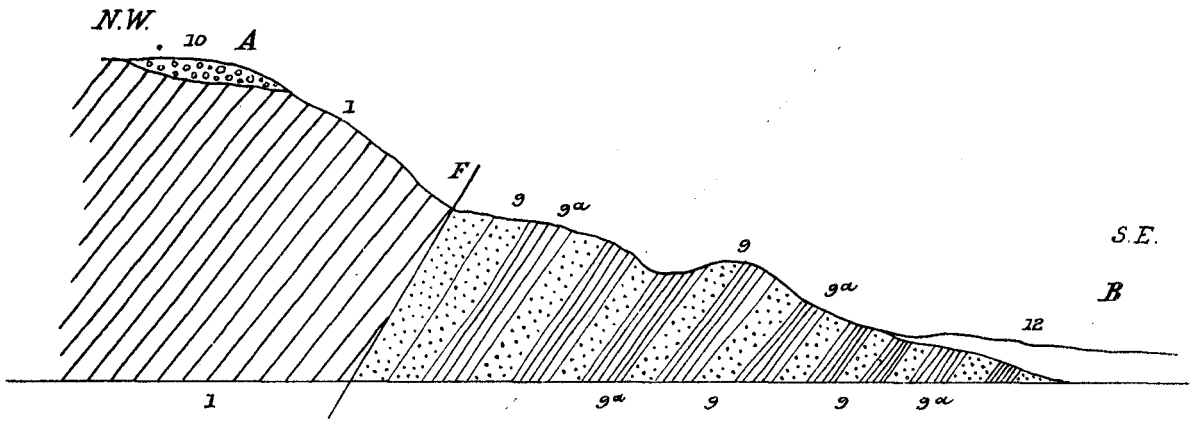

Fig 26. Sketch Section across the Outcrop of Auriferous Quartz-drifts and Breccia-conglomerates at Drybread. Manuherikia Valley.

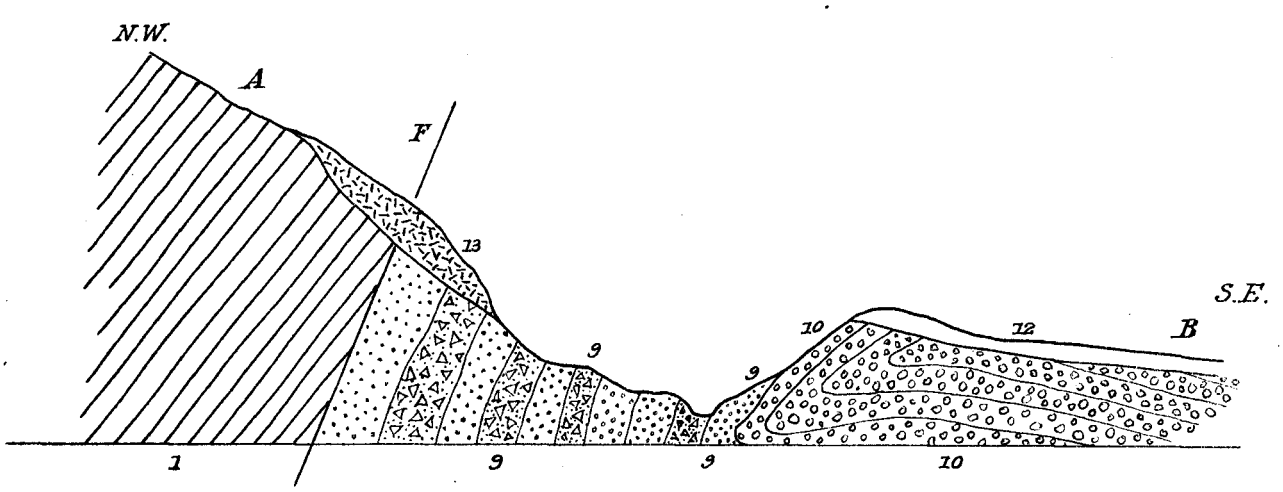

Fig 27. Sketch Section across the Gold-workings in Ewing & Maconochie's Claim. Tinkers.

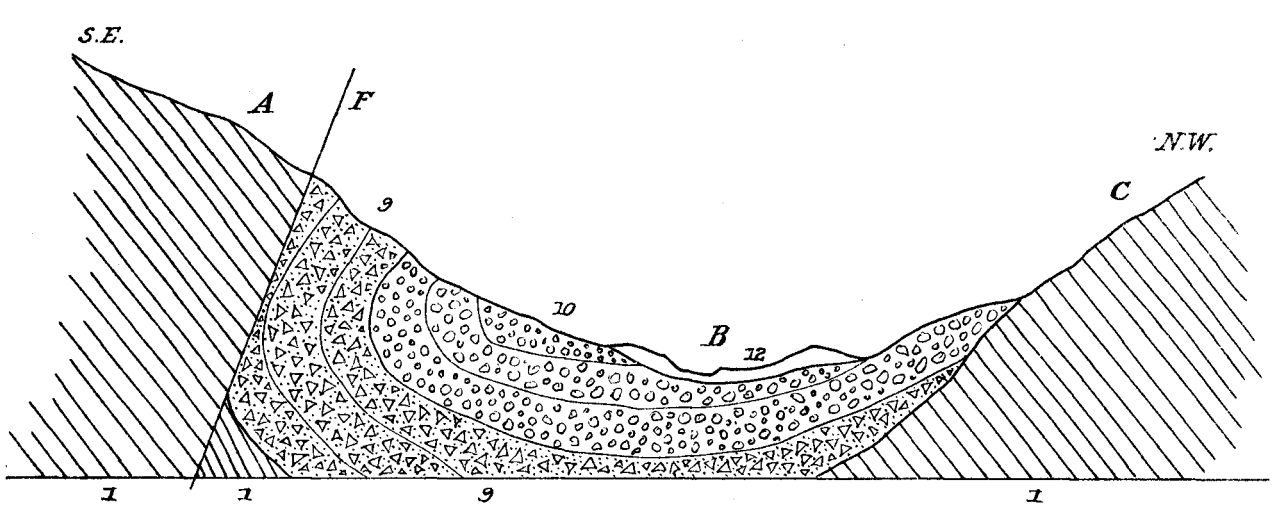

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Fig 28. Sketch Section from Griffel Face, North-west across the Cardrona Valley.

Sections to illustrate Report by A. McKay. Mining Geologist.