PRINCIPAL RESULTS OF THE YEAR'S FIELD OPERATIONS.

The operations of the Department during the last calendar year have as usual been confined to those which have a direct bearing upon the economic aspects of geology, and it is hoped that in the results therefrom expectations have been fully realised. The following is an account of the year's work:—

KALGOORLIE.—The importance of Kalgoorlie, and the vast interests connected therewith, rendered it imperative that a detailed geological survey should be carried out. The survey was undertaken with the object of furnishing an accurate basis upon which the work of the prospector and the mining engineer might be founded, for universal experience has shown that many mining failures have been due rather to a want of knowledge of structural geology than to a lack of engineering training.

When this work was commenced, it was found that there was no topographical map upon which the areas of the different formations, the geological boundaries, and the underground workings could be laid down, for as a rule any surveys carried out by the different State Departments are designed to meet the immediate demands of the public for land, no attempt, unless under exceptional circumstances, being made to delineate the relief of the ground. As a preliminary step towards remedying this, it was found necessary to prepare a topographical map designed to be issued as a basis for the geological and mining details. This survey was entirely carried out by means of the tacheometer, the efficacy of which for work of this special nature has been amply demonstrated. A great deal of time and labour was involved in this preparatory work, which could have been more profitably expended by the geological staff in other directions. The whole of this work is now virtually complete and ready for publication.

As the examination of all the mines will occupy some considerable time, it is intended to publish in the meantime a first edition of the map of the district giving the topographical details, and subsequently an edition showing the actual or inferred trend of the lodes, together with all the geological information acquired in the course of that examination. When finally complete the work will comprise:—

(*a.*) A two-sheet map, on the scale of 4 chains per inch, of what is known as "The Golden Mile," showing all the underground workings, the trend of the lodes, the area covered by the different geological formations, and other cognate points.

(*b.*) A four-sheet map, on the scale of 10 chains per inch, of the country between Hannan's Lake and a point about a mile North of Kalgoorlie, thus embracing the whole of the productive area of the goldfield.

In addition to these, there will be a sheet of vertical sections, upon a suitable scale, depicting the structural relations of the ore bodies, and the enclosing rock-masses.

The geological map of Kalgoorlie will mark a great advance on any official plan yet issued of the goldfields of the State. In addition to geological and mining information, all the prominent land marks, such as hills, shafts, batteries, etc., are shown, as these are of far greater value for purposes of location than lease pegs, and imaginary boundary lines which can never be regarded as permanent. The map should thus prove of use not only to the mining community, but to the public at large. The carrying out of similar work at other important mining centres, when opportunity offers, is in contemplation. A full report upon the geology of the area embraced by the field work is in course of preparation, but as this involves the completion of many chemical analyses, and much microscopic work which, owing to the increasing demands upon the time of the staff, cannot readily be undertaken during usual official hours, some little time must necessarily elapse before the work is complete, and ready for the

printer. The following is a *résumé* of the salient geological features, so far as they are at present understood.

The geological structure of Kalgoorlie is not, as has been anticipated, of extreme simplicity. The staple formation of the field consists largely of certain schistose rocks, some of which are distinctly of sedimentary origin. The sedimentary rocks are now represented by black and pyritous shales, slates, hæmatite-bearing and jaspery quartzites, greywacke, and sandstone. Associated with these beds are amphibolites, and derivatives therefrom, which in all probability represent igneous rocks; but whether these occur in the form of lava flows or are of intrusive nature has not yet been determined. In addition, certain undoubtedly intrusive igneous rocks of both a basic and acidic type are met with. The structural relations of these different rocks are being exhaustively worked out.

So far as observations have at present been carried, almost all the rocks would appear to have been highly altered both chemically and dynamically, and it is by no means improbable that the mechanical movements to which they have been subjected have been repeated more than once. The alteration produced has not been uniformly distributed, for black pyritous shales with barely any trace of metamorphism occur in intimate association with the more highly altered beds. A pseudo-conglomerate and breccia form a prominent feature underground in a portion of the field. From present observations, it does not appear to be of littoral origin, but rather to be due to the mechanical deformation of the surrounding rocks *in situ*, in reality a crush-conglomerate of breccia. The lodes are for the most part bands of the basic rocks, which are characterised by a strong foliation, the alteration of the amphibole into chlorite and carbonates of iron, lime, manganese, and magnesia, and finally the development of secondary silica, mica, pyrites, gold, tellurides of gold, etc. There are no grounds for believing that the mines of Kalgoorlie have reached the limit of ore deposition, or that the lodes will not prove productive in depth.

Mr. E. S. Simpson is engaged upon a series of quantitative analyses of the rocks of Kalgoorlie, and has submitted to me the following preliminary *résumé* of the results of his researches:—

The chemical examination of the rocks of the Kalgoorlie district has been so far chiefly confined to those from the immediate vicinity of the more important mines of the Boulder belt. The rocks consist of amphibolites and their derivatives, acid eruptive rocks, ultra-basic eruptive rocks, and a series of sedimentary rocks.

Amphibolites and their Derivatives.—The rock mainly developed within this area is a *Greenstone*, or Diabase, the product of chemical alteration of a basic rock, which appears in an undecomposed state on G.M.L. 1219E. On this lease the rock (2117*) is a coarse-grained light green *Amphibolite*, consisting mainly of amphibole, with a little plagioclase and alteration products. It is of too basic a character to be looked upon as a true diorite; its chief constituents being: Silica, 44 per cent.; ferrous oxide, 14 per cent.; alumina, 11 per cent.; lime, 10 per cent.; magnesia, 11 per cent. A massive rock of similar character occurs also close to the junction of the Kanowna and Menzies railway on the North, at Mt. Hunt on the South, and at one or two intermediate points.

Alteration products of this rock compose, however, the greater part of this field. At Mt. Hunt a foliated but otherwise unaltered form (598) appears. Towards the centre of the field chemical changes have been very marked, being first in the direction of the absorption of water with consequent development of chlorite, and in some cases epidote, and also of a little carbonic acid with consequent formation of carbonates of lime and magnesia. The latter are readily removed by underground waters so that we find the greater alteration the rock has undergone the less lime and magnesia does it contain. The average of a number of samples of a Greenstone or Diabase of this nature was: Silica, 45·5 per cent.; carbonic acid, 9·1 per cent.; ferrous oxide, 12·4 per cent.; alumina, 10·8 per cent.; lime, 7·8 per cent.; magnesia, 3·5 per cent. By the further action of carbonated water the whole of the chlorite of this rock is decomposed, and we have as the result a very compact pale grey *Siderite-rock*, in which practically all the iron, manganese, lime, and magnesia are present as carbonates. A rock of this nature (1751) in the Ivanhoe mine, having the outward appearance of a quartz porphyry, was found to contain: Silica, 42 per cent.; alumina, 8 per cent.; ferrous carbonate, 24 per cent.; calcium carbonate, 10 per cent.; magnesium carbonate, 3 per cent.; manganese carbonate, 1 per cent. A second example (1828) from Chaffer's mine was still further altered by the formation of a considerable amount of magnetite, at the expense of the ferrous carbonate. By foliation and the development of a little sericite, this rock passes (in the Golden Horseshoe Mine) into a *Siderite Schist* (1796) containing 22 per cent. of ferrous carbonate.

* The numbers in parentheses are those of the Geological Survey Collection Register.

Returning to the greenstones: by strong foliation these become *Chlorite schists*, varying in colour from dark green to greenish grey. The mean composition of two samples, one (1730) from the Imperial Boulder G.M., the other (1750) from the Oroya G.M. was: Silica, 43·1 per cent.; carbonic acid, 11·5 per cent.; ferrous oxide, 12·8 per cent.; lime, 11·1 per cent.; magnesia, 3·4 per cent.

These chlorite schists being more easily permeated by water than the more massive rocks are still more liable to suffer metasomatic change, and so, especially on the Eastern side of the Boulder belt, there is a large area of schists varying in nature from a dark green highly chloritic rock to a pale grey or pink carbonated rock.

It would appear that in the extreme stage of alteration of the chlorite schists, a rock is reached in which a considerable amount of the carbonates has been removed in solution with a consequent enrichment in silica up to 62 per cent., and in alumina up to 14 per cent. The study of the gradations between this supposed extreme type and the original chlorite schists is yet to be undertaken.

The surface weathering of the amphibolites and other highly ferruginous rocks results in the formation of cappings of *Laterite* consisting of massive, cellular or nodular ironstone. Remarkably pure iron ores are common in these deposits: one sample (1937) from the Thunderbolt Lease, containing 57·6 metallic iron, only 1·6 per cent. silica, and 8·6 per cent. water. These rocks also require further investigation.

Acid Eruptives.—The only two undoubted acid eruptives recognised within the area under review are *Felspar porphyries*. A foliated white rock (1435) of this nature forms a narrow dyke which has been traced from the South Kalgurli Lease (1208E) to the Eleanor Lease (921E). A dyke of grey felspar porphyry (1743) occurs on the Lake View Consols No. 2 Lease (1064E), which may be only the Southern extension of the first-mentioned dyke.

Ultra-Basic Eruptives.—An outcrop of *Peridotite* occurs on the South shore of a well marked bay* on the Western side of Hannan's Lake, as well as on two adjacent small islands. On the mainland this rock is very much weathered, but in places is found altered into a serpentine (248). On the island near the South headland of the bay the alteration has been into a granular crystalline carbonate rock containing: Silica, 31 per cent.; carbonic acid, 27 per cent.; ferrous oxide, 8 per cent.; lime, 5 per cent.; magnesia, 17 per cent. A less highly altered portion of this peridotite outcrops on a second island 12 chains West-South-West of the first.

A single specimen (274) of a serpentinous nature was collected from the Black Cat lease (3862E), North-East of Kalgoorlie townsite. This may be portion of a second ultra-basic intrusion.

Sedimentary Rocks.—Highly-inclined rocks of undoubted sedimentary origin extend from one end of the field to the other in comparatively narrow bands, bounded on either side by amphibolites or their alteration products. These rocks range in character from a soft grey *Sandstone* (369) to a compact flinty *Quartzite* (2226), or a strongly foliated *Siliceous schist* (1739), in which almost all trace of its original structure has been obliterated; and from soft grey or black *Shale* to a hard grey or graphitic *Slate*, or *Jasperoid claystone* (1475). A *Sericite schist* (597) occurs on the Madge lease (1638E). *Breccias* (159, 1726) composed mostly of fragments of slate are also known.

Only three examples of sedimentary rocks have been analysed, and these do not differ in any marked way from those of other parts of the globe. It is interesting, however, to note that whereas the quartzites of most other districts in central Western Australia are characterised by numerous interbedded bands of hæmatite, those of Kalgoorlie are almost without exception entirely free from them.

More recent *Sands*, *Clays*, and *Gravels* of the usual type cover a large portion of the surface of the field. Between Boulder and Hannan's Lake there is a bed of *Siliceous sinter*.

Auriferous Lodes.—The "lodes" of the Southern portion of the field are for the most part bands of foliated greenstone or of chlorite or carbonate schists derived therefrom, which have been impregnated with gold, gold and silver tellurides, etc., and which pass insensibly on either side into non-auriferous greenstone. They are frequently interlaced in every direction with small veins of quartz. In the Ivanhoe, and some other adjacent mines, some of the ore bodies are composed mainly of quartz, being either quartz reefs or beds of quartzite. A grey sandstone (1732) from the Forrest King Lease (917E) was found to carry 1·688oz. gold per ton, whilst flake gold has been found in slate in the Lake View Consols Mine.

The full details of these investigations will appear in the report on the Kalgoorlie Goldfield, which can only be undertaken on the completion of the field work.

PHILLIPS RIVER GOLDFIELD.—In the early part of the year, an examination of the Phillips River Goldfield was made by Mr. Blatchford, the Assistant Geologist. From this officer's researches it appears that the staple formation consists of crystalline and metamorphic rocks, covered with those nodular ironstone (? laterite) deposits, which form such a striking feature in many parts of the State.

The granitic rocks of the district naturally vary considerably both in composition and form. Both the mica and the felspar occur in places in large masses, in some cases of such a size as to make the exploitation of the former upon a commercial scale possible. In one portion of the field about two miles South of Cocanarup Station, is a

* This is just within the North-West corner of Water Lease 9.