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# REPORT ON THE GENERAL GEOLOGY OF THE MT. LYELL MINING FIELD.

## INTRODUCTION

The following brief preliminary report upon the Mt. Lyell copper field and neighbouring country is presented to give a concise account of the geological survey just completed. It is prepared in anticipation of a more complete report, and the statements contained herein must be regarded as provisional and subject to any alteration that may be deemed necessary upon closer investigation. It is intended to accompany a report on the Economic Geology of the field. The greater part of the general geology was investigated by Messrs. F. Blake, Field Geologist, who spent five weeks on the field, and Q.J. Henderson Jr. Assistant Geologist, who spent nine weeks on the field, while P.B. Nye, Government Geologist, spent five months investigating the economic geology.

## PHYSIOGRAPHY

### (a) General Description

The area under review embraces one of the most rugged and precipitous portions of Tasmania. It consists of a range of high mountains (the West Coast Range) rising abruptly from the coastal peneplain, which is broken by deep ravines and gorges. The most prominent mountains are due to being wholly or partly crowned by the erosion-resisting West Coast Range conglomerates; and to the bold configuration resulting from the corroding effect of the King and Queen Rivers. In Pleistocene time glaciers invaded the district, accentuating the topographic relief and widening and deepening existing valleys, although these were later largely filled with glacial deposits.

### (b) Mountains.

The West Coast Range is represented by three large and distinct mountains, having a meridional trend and all connected by low saddles. The most northerly being Mt. Sedgwick which is connected to Mt. Lyell (lying immediately to the south) by the Comstock Gap, a low divide which separates the waters of Comstock Creek, flowing east to the King River on the east side, from head waters of the East Queen on the west side.

Mt. Sedgwick presents a characteristic feature in that the northern slopes are gradual, while to the south and south-west the massive conglomerates and quartzites form great escarpments hundreds of feet high, with more gently sloping foothills which consist of massive and schistose igneous rocks.

Another divide known as the Gormanston Gap connects Mts. Lyell and Owen; this separates the east flowing Linda Creek and the west flowing Conglomerate Creek which flow into the King and Queen Rivers respectively.

Mt. Lyell is smaller and not so high as either Sedgwick or Owen. It has a general east-west trend with steep cliffs at the western end, while all other slopes are fairly steep.

Mt. Owen, to the south of Mt. Lyell, reaches a height of approximately 3600 feet. It has a general southerly trend and presents steep, bare faces, often in the form of cliffs, westerly to Queen River basin and easterly to the valley of King River. The northern fall towards Linda Creek is less steep.

(c) Rivers and Valleys

The drainage of the eastern slopes of the West Coast Range falls into the King River, the main tributaries being the Linda and Comstock Creeks which flow in an easterly direction through large transverse valleys.

The Queen River with its two main branches - the West and East Queen - drains the area west of Mt. Lyell and north of Queenstown as far as the Comstock Gap. It is noteworthy to mention that there exists here an example of possible river capture; the East Queen River by headward erosion in the glacial material having captured some of the headwaters of the Comstock Creek. Another feature worthy of mention is the U-valley, due to glacial action, in which Comstock Creek flows and which is probably one of the finest examples to be seen in Tasmania.

The north-west and western portion of the field is drained by the Yolande River which collects the waters of Pearl and Diamond Creeks.

The drainage of the western slopes of Mt. Owen is carried into effect by means of Conglomerate, Reservoir, Roaring Meg and Lynch Creeks, all of which are west flowing affluents of Queen River.

(d) Plains

The only plain worthy of description is that termed by Gregory the Henty Peneplain. It stretches from the foot of the West Coast Range westerly to the coast and has a gradual slope seaward. The excellent views obtained from Mt. Lyell suggest that it was related to the ancestor of the Henty River and its tributaries, the drainage of some of which has been captured and destroyed by the Queen River.

## THE SEDIMENTARY ROCKS

(a) Cambro-Ordovician

### King River Slates and Quartzites

For several miles along the Hobart-Queenstown road, east of the King River bridge, hard fissile slates are exposed in road-cuttings and creek beds. To the South of the King River, east of the One Mile Peg on the old Kelly Basin line there are two isolated outcrops, one being slates and the other quartzites.

The outcropping of the slate indicates a thickness of many hundred feet. The cleavage planes strike at 145° and dip south-west at a high inclination. . Apparent bedding planes have a bearing of 110°. The contact of the slates and quartzites is not observable as only one isolated outcrop of the quartzite occurs.

The slates vary in colour from grey to bluish-black, with an abundant development of white mica, muscovite, and have a marked laminated structure.

No fossils were observed anywhere in this series, although a more thorough search might reveal some.

This series may be in faulted relation with the rocks on the western side of the King River, but it has been placed tentatively in the Cambro-Ordovisian System. This is based purely on lithological grounds, as the rocks differ from the Queen River series and appear to be older. With this assumption they would underlie the West Coast Range series, which can be reasonably anticipated from the field occurrence.

(b) Silurian

(i) West Coast Range Conglomerates.

This is a series of thickly bedded conglomerates, quartzites and sandstones. The conglomerate is a quartzose rock of white, reddish, or purplish colour, composed of quartz, quartzite and quartz schist pebbles in a very hard siliceous cement, which constitutes only a small proportion of the whole. The quartzites and sandstones are generally coarse-grained and have the same tints. The conglomerates are coarsest near the base of the series, and become finer towards the top.

The complete section of the series is nowhere exposed, and the total thickness must approach 2000 feet. The series was not examined in detail, but close examination would enable a number of stages to be defined. The colouration would greatly assist in this direction as certain beds up to hundreds of feet in thickness have characteristic tints.

The series occupies a north and south tract of country corresponding to the West Coast Range from which it has derived its name. In fact the conglomerates cap these mountains, their resistant nature being partly the cause of the mountains existing in their present form. Each mountain is occupied by a more or less isolated block of conglomerates.

Numerous crags, detached masses of conglomerate, notably the Tharsis mass, north east of the Comstock Mine and north of the Linda Creek bridge on the Queenstown-Hobart road, indicate the intensity of the faulting contemporaneous or preceding the intrusion of the porphyries.

Strikes and dips have a considerable range in direction and amount. On Mt. Sedgwick the strike is generally north and south with a westerly dip of 30° to 60°; small local faults and foldings are to be observed in many places. On the western end of Mt. Lyell the beds are horizontal, but on all other parts of the mountain the strikes are in many different directions and the dips are high. This is due to the fact that heavy and closely spaced faulting has resulted in the formation of numerous blocks, striking and dipping in different directions. East of Gormanston-Lynchford track, on the western fall of Mt. Owen the strike of the series ranges between 120° and 185°. Viewed from the track a large anticlinal fold with a north-south strike is observable. One limb is dipping to the west at 30° and the other to the east at 35°.

Along the track also are several outcrops of slates in association with conglomerates and quartzites which appear to conformably underlie the latter series. Generally, the series is unfossiliferous but one occurrence of probable worm tracks is worthy of mention; these tracks consist of a double row of impressions such as would be made by the parapodia of a worm resembling the sand-worm Nereis. Five "tracks" are observable on the rock exposed, one of which is strongly curved. In size they greatly exceed any recorded species but, owing to the nature of the matrix, no details of structures are available.

The series is in contact with several others at different localities. Its base is not visible and, as indicated above, the King River series may underlie it, but they are not in direct contact. The summit of the series was not definitely located within the district, but the sandstones and limestones around the northern island in Lake Margaret are probably part of the Queen River series, so that the latter conformably overlies the West Coast Range series.

Along the west side of the West Coast Range, the series is in contact with porphyries, schists (derived from porphyries), and "breccia conglomerates". Along the eastern side of the range, the conglomerates are in contact with "breccia conglomerates". The relations with these rocks will be discussed later. In the Linda Valley the series is in faulted relation to the Queen River series.

The series is regarded as being the base of the Silurian system. It underlies the Queen River series which from palaeontological evidence belongs to the Silurian system.

(ii) Queen River Slates, Sandstones and Limestones

This series is essentially composed of sandstones and quartzites with beds of slates, shales, limestones, and fine grained breccias, intercalated. No sharp line divides the sandstones and quartzites; they shade imperceptably into one another. Lithologically, the rocks are similar to Silurian ones occurring elsewhere in Tasmania. The slates are normal, buff to black in colour, The best development being exposed in cuttings etc. along the Lake Margaret Tram.

In places metamorphism has not completed the transformation of clays to slates, and gives rise to shales which are exposed in the valley of Raggety Creek where is situated the old quarry used in obtaining material for brick making purposes. The sandstones range in type, from fine grained argillaceous rocks to coarse sandstones with siliceous cement. The predominant colour is white, with frequent variations to buff or grey.

The limestones of average quality occur as intercalations; the most important economically for many years was the old flux quarry, situated on the west side of the road to the Company's Offices, about 20 chains north of the Queen River bridge. Other isolated outcrops of insignificent sizes occur, notably at Fossil

Bluff, east of the above quarry and in the beds of Mt. Owen Creek and a small creek near the one mile peg on the Old Comstock Tram, both tributaries of Linda Creek.

A possible easterly extension of the Fossil Bluff limestone outcrops in a small north-west flowing tributary of Conglomerate Creek, about 20 chains north-east of Queenstown. South of Conglomerate Creek and east of Queen River, the series is represented mainly by intercalated bands of slates, quartzites and felspathic sandstones or fine grained breccias. White siliceous sandstones do occur, but are chiefly confined to the south-east portion of the belt. Slates, sandstones and limestones differing in no way from the above occur in Linda Valley.

A complete section of the series is not exposed within the district. From its areal distribution and uniform strike in the region west of the Queen River, the series must be a thick one and be several thousand feet in thickness. Detailed work would probably enable a number of zones to be separated, but such was not attempted.

The rocks of this series as indicated above occupy a large area to the west of the Queen River. They are also fairly extensive to the south of Queenstown and in the Linda Valley. Throughout the porphyry intrusions they exist as a number of small isolated areas. These blocks represent remnants of the original continuous area of sedimentary rocks, caught up and undigested by the intruding rocks. West of the Queen River, the rocks have a general strike of 110°, and a vertical dip. To the south of Conglomerate Creek, the average strike of the rocks is 139° with dips ranging from 50° to 80° both towards the north east and south west.

The changing dips with fairly constant strikes suggest some local folding in this area so thoroughly intruded by igneous rocks.

The limestone to the south of Fossil Bluff strikes at 110° and is almost vertical with a possible high dip to the south-west.

In two places along Queenstown-Lynchford road, at 5 and 10 chains respectively north of Lynch Creek, limestones are exposed in beds from 100 to 180 feet in thickness. They dip to the east at 70° with interbedded quartzites and have a strike of 195°. Fossils generally are not abundant in the series. At Fossil Bluff on the east side of Queen River, about 20 chains north of Queenstown, numbers of indeterminate fossil casts are visible in limestone. Again, in a cutting at the small siding alongside Lake Margaret tram, near where the track to Zeehan crosses the line, numerous brachippod fossils are imbedded in sandstone. Fossils have also been obtained from Linda Valley and other places within the district. These are identical with similar fossils near Zeehan and elsewhere, which have been ascribed to the Silurian system.

On the most northern island in Lake Margaret, north of the mapped area, fine grained sandstones contain brachiopod fossils which resemble Silurian types. Interbedded with the sandstones is a thin bed of dark bluish limestone and conformably underlying these to the east are fine grained quartzites, fine grained conglomerates, pink quartzites and coarse conglomerates in that order. The whole are dipping at 33° to the west.

If, as it would appear, the sandstones, limestone and quartzites belong to the Queen River series then it is established that they conformably overlie the West Coast Range conglomerate series.

In the Linda valley, they are in faulted relation with the West Coast Range series. Elsewhere the series is in contact with the various porphyries. In the north-western part of the district, it is bounded by intrusive porphyries (evidence of the intrusive nature of the porphyries will be discussed later) on the eastern side in a most irregular manner from Hunn's Siding on the Lake Margaret Tram in a south south-westerly direction to Queenstown, where the boundary becomes more complicated.

North of the Howard Plains haulage, a number of porphyry dykes traverse the series in a general north-westerly direction; these connect with another body of porphyries which trends in a south-westerly direction from Davies Hill in the north to Diamond Hill in the south and form the western boundary of the area under discussion. To the south of Conglomerate Creek, the series is intruded by numerous small dykes, tongues and larger masses of various types of porphyry which have caused the sedimentary rocks to have an unusually irregular-shaped outline. In numbers of places different sized blocks of slates and quartzites are included within the areas occupied by porphyries and schists.

### (c) Permo-Carboniferous

No rocks of this age outcrop within the area, and as pointed out above, those rocks forming the islands in the north-eastern portion of Lake Margaret, formerly regarded as belonging to this system should be, in the opinions of the writers, regarded as the base of the Queen River slates and sandstones series, conformably underlain by the West Coast Range conglomerates etc.

Fossiliferous sandstone specimens containing casts of Aviculopecten, Spirifera etc., collected by Mr. W. Morris of the Survey Staff of the Comstock Mine, are, almost without doubt, referable to the Permo-Carboniferous. These rocks are reported to be situated on the north-eastern end of Mt. Sedgwick and are intruded by dolerite, a relationship almost invariably found associated with such rocks.

### (d) Pleistocene

From Queenstown southwards almost to Lynch Creek some of the low hill tops immediately east of Queen River are capped by waterworn gravels consisting of quartz and quartzite. At Spion Kop, Hospital Hill and other places a thickness in excess of 50 feet of gravels is attained.

These gravels may represent a higher horizon of the Pleistocene fluvio-glacial deposits northwards from Queenstown. They are however more typical of ordinary stream deposits, and as the remnants parallel Queen River it is probable that the gravels are terrace remains of an older high level representative of Queen River, and may date back to early Tertiary times.

The typical Pleistocene deposits consist of morainal material, tillite, interglacial fluvio-glacial or fluviatile sands and clays etc.

The evidences of glaciation, established in the field, correspond with observations in other portions of the West Coast Range. Generally these deposits occur on the flat country east of Mt. Owen, in the transverse valleys of the Linda and Comstock Creeks and elsewhere, smaller remnants remain.

The best developments of glacial till occur between the townships of Gormanston and Linda and north of the Comstock Mine at the head of Comstock Creek. This till consists of a heterogeneous accumulation of rounded and partly rounded to sub-angular masses of rocks (chiefly conglomerate and quartzite and occasionally porphyries etc.) varying in size from three or more feet in diameter down to a few inches. Associated with this till are beds of sand and clay in the nature of varved deposits, that is, showing seasonal deposition, and representing inter-glacial epochs.

Huge erratics of conglomerate can be seen on the King River Plain, east of Mt. Owen, near the two mile peg on the Kelly Basin Line, and also on the northern side of the Comstock Gap.

Striated rocks are observable near the King River bridge on the Hobart-Queenstown road. A particularly fine example is to be seen upon the outcrop of West Coast Range fine grained conglomerate, on which the retaining wall of the Lake Margaret Dam has been built; here is a large bare surface on which the glacier, moving down the valley now occupied by the Yolande River, has ploughed deep furrows.

These glacial deposits have been eroded to some considerable extent and as a result the plains and valley floors are now covered with a coarse alluvial deposit, which has been laid down by the streams which have cut their way down through the true glacial deposits until they have reached their present base-levelled condition relative to the King River.

These glacial deposits are to be correlated with the Pleistocene ones elsewhere in the State. The glaciers originated on the mountains and moved down existing valleys etc., probably enlarging them and later filling them up to a considerable extent. The deposits are more wide-spread on the Sedgwick plateau and while suggesting an ice-cap phase, are more or less restricted to the lower levels.

(e) Recent

Queen River below its two main upper branches is at present depositing sediment in the form of gravels and alluvium over its open flood plain.

The main tributaries of the river flowing westerly from Mt. Owen are also forming similar deposits along their lower courses adjacent to Queen River.

Alluvial deposits have also been extensively formed along the King River.

## IGNEOUS ROCKS

(a) Devonian Porphyries

The dominant geological feature of the Mt. Lyell field is a complex suite of intrusive porphyries.

The belt of porphyries has a general meridional trend throughout the middle portion of the district.

Along their eastern periphery the porphyries grade imperceptably into igneous schists.

The western boundary is represented by a most irregular line along its contact with Silurian slates, sandstones, etc.

The porphyry group is divisible into four main types the distinctions between the types being sometimes somewhat arbitary, since the change from one type to another is transitional.

Owing to the fact that the porphyries change insensibly from one type to another, it is established that they represent differentiation products of the one parent magma.

In describing the porphyries, it is thought advisable to adopt the field names for the purpose of this report, as some of the types have not yet been sectioned for microscopical examination.

(i) Felspar Porphyry

These rocks show at least two distinct varieties when examined in hand specimens. One is a white, finely crystalline rock with few or no phenocrysts and gives but slight indications to the unaided eye of their actual mineralogical composition. The other is the more common variety and contains abundant and easily recognisable phenocrysts of felspar. These varieties alternate with great frequency in the cuttings along the Comstock Tram from about 10 chains south of the "deviation" to the second zig-zag.

About 25 chains north of where the deviation joins the main line, a curious phenomenon has developed giving rise to an apparent dyke of conglomerate in the porphyries. Upon closer examination, it is seen to be due to partial silicification of the porphyry.

In the region east of the East Queen River and between Comstock Gap and Conglomerate Creek, the common type is similar to the above.

The felspar porphyry south of Comglomerate Creek is a massive to slightly schistose type trending in a southerly direction, and extending beyond Roaring Meg Creek.

In hand specimens, the common variety is a grey to greenish-grey rock with phenocrysts of felspar (white to pink) in a fine ground mass. Occasionally dark green chloritic spots are visible and probably represent altered augite. The rock is well-jointed, and often appears to be sheared or schistose. This feature is probably a lesser effect of the earth-movements which deformed the eastern portion of the intrusion into the schistose porphyries and Lyell schists.

The felspar porphyry (and the deformed portions) occurs as a fairly wide dyke-like body extending in a north and south direction through the centre of the district.

Along its eastern boundary, it grades insensibly into the schistose porphyries and Lyell schists. In certain places the porphyry extends close to the conglomerates of the West Coast Range.

In the schist belt to the east of the main felspar porphyry body some small irregular areas of schistose porphyry have been mapped with the schists. Along its western boundary, for the most part, the felspar porphyry is in contact with the Queen River slates, sandstones quartzites and breccias. From this boundary, in the vicinity of Queenstown, several narrow dykes of felspar porphyry extend north-westerly and intrude slates and quartzites. Other small isolated dykes of similar rock occur to the south of Queenstown. In the north-western parts the continuity of the contact is broken by a number of dykes given off in a general north-westerly direction; these dykes differ in mineralogical composition and will be, therefore, discussed under appropriate headings.

At its northern end, in the vicinity of the Comstock Gap, the felspar porphyry is in contact with quartz-felspar porphyries. Near the Smelters, and included within the boundaries of this rock, is an area of augite porphyrite; it is also in contact with similar porphyries.

(ii)A <u>Quartz Felspar Porphyry</u>

The quartz felspar porphyries occurs differently to the felspar porphyry in that it is present as a number of smaller bodies throughout the porphyry belt. The principal localities are Lynchford, Southern Slopes of Sedgwick, West Queen River and Comstock Gap. One of the largest intrusions is to the east of Queenstown-Lynchford road, south of Roaring Meg Creek. The trend of this area is N.N.E. to S.S.W., the widest portion being in the north while the width of the rock decreases towards the south.

The southern extension of this rock has not been mapped but the western, northern and north-eastern boundaries are in contact with Silurian sedimentaries, except where masked by gravels along the course of Queen River. The south-eastern part of the intrusion grades into quartz porphyry and augite porphyrite.

A good soil is formed from this quartz-felspar porphyry and grass lands have been developed over the area for grazing purposes.

Two small dykes of quartz-felspar porphyry occur in close proximity to Gormanston-Lynchford track on the east side of the main area. Another dyke is exposed in a cutting on Queenstown-Lynchford road while east of the latter are three more dykes which junction with and grade into the large area of quartz porphyry.

All of these several dykes intrude the Silurian slates and sandstone series.

The typical quartz-felspar porphyry south of Queenstown is a dark grey-green type of medium grain size, showing small phenocrysts of quartz and felspar in a finer mass of the same minerals together with chlorite and possibly some augite.

A specimen of the rock from Lynch Creek previously examined under the microscope contains orthoclase felspar predominating over plagioclase in hypidiomorphic crystals with occasional quartz crystals. Augite occurs as small irregular grains in chlorite. The latter is scattered abundantly throughout the rock in grains, flakes and large irregular patches. The rock was described as syenite porphyry, but might be more correctly termed an augite-syenite porphyry.

Quartz felspar porphyry also outcrops extensively on the south and south eastern slopes of Mt. Sedgwick. This mass has not been mapped in its entirety. Along the western edge the rock is in contact with Silurian conglomerates and appears to be intrusive into them. The general rock type has a pinkish colour, is of coarser grain than the quartz-felspar porphyry south of Queenstown, and no augite or chlorite is visible to the unaided eye.

An extensive belt of this rock occurs along the West Queen River, where a deep gorge has been cut, a distance of approximately three quarters of a mile, south of No. 1 Dam site 1022/W 40 acres. It is exposed on both sides of the river, extending nearly half a mile in an east-west direction, about 5 chains to the east and 20 to 40 chains to the west. The outcrop is roughly lenticular in shape, with the longer axis north and south.

In the hand specimen, it appears to be a coarse-grained plutonic rock, composed of pink felspar, a green ferro-magnesian mineral and quartz.

At the Sedgwick Gap a very persistent dyke of quartz felspar porphyry, about six to eight chains wide and striking north west and south east, can be traced at the surface from a point, about twenty chains south east from the north eastern corner of mineral section No. 2556/93M 71 acres, to within three chains of the Comstock Mine. Underground it can be picked up on the Nos. 4 and 7 levels, where it is in contact with the West Coast Range conglomerates and turns in a south-westerly direction to follow along the contact.

(ii)B "Breccia Conglomerates"

This group of rocks although showing no apparent relationship in the field must be discussed under the heading of quartz felspar porphyry from many considerations, the most forceful being microscopical. In the field the group falls readily into two main types:-

(a) A "coarse conglomerate" in which pebbles of various sizes are plentiful, the major portion of them being quartz felspar porphyries while smaller pebbles of quartz porphyry are abundant, pebbles of quartzite and reef quartz are also present. The matrix is apparently of igneous origin and resembles the quartz-felspar porphyries.

(b) Similar to above and differs only in being finer in texture while pebbles are a rarity.

They occur in three widely separated localities, and in one place only are both types represented viz., the east end of Mt. Lyell extending north from Linda creek to the south side Comstock Creek. In this locality they also reach their greatest development. The other occurrences are situated on the eastern side of Mt. Owen in the south and at the head of the Comstock valley, on the south-western slopes of Mt. Sedgwick, in the north.

A most striking and significant feature in regard to these rocks is that they occur in almost an identical structural relationship in all three localities, that is in a position where they might appear to be under-lying the conglomerates and quartzites of the West Coast Range series, and in each case are in contact with the coarse member of the series in which boulders of quartzites etc. from six to eighteen inches are abundant. At times there appears to be a rudely-stratified structure, which gains recognition only on account of the alteration of bands of "coarse conglomerate" with bands of finer material in which pebbles are a rarity.

At the east end of Mt. Lyell and on the slopes of Mt. Sedgwick, quartz felspar porphyries are associated closely with these "breccia conglomerates". At the east end of Mt. Lyell there is also a small area of sheared porphyries and schists similar to the Lyell schists and thus forming a correlation with the porphyries and schists to the west of Mr. Lyell.

These rocks have been referred to previously as sedimentary ones forming the base of the West Coast Range series. The evidence, however, suggests that they occur between the quartz felspar porphyries and the coarse members of the West Coast Range series, and are the result of the intrusion of the former into the latter. This might be considered a rather unusual product of intrusion, but it must be pointed out that the whole of the porphyry intrusions are somewhat unusual. It has already been seen that the intrusions contain numerous large and small blocks of the West Coast Range conglomerates and the rocks of the Queen River series. Further small pieces of quartzites and pebbles of same are contained in the porphyries and the schist at quite a number of places. It is the writer's opinion that the quartz felspar porphyry magma was of such a composition and nature that it could intrude conglomerates, partly assimilating and replacing them, thus giving pebbles of quartz felspar porphyry in a ground mass of similar character. The presence of pebbles of quartz porphyry and granite pebbles and pieces of slate is very interesting as these types do not outcrop in the immediate vicinity, and therefore must have been derived from underlying formations and brought up with the rising magma. The pebbles of quartzite, reef quartz etc. are probably unassimilated pebbles in the original conglomerate, though they may possibly have been transported a short distance.

A somewhat analogous occurrence is the formation of the "pebble" dykes occurring at Tintic, Utah described in Economic Geology Vol. 29 No. 4, 1934. by Rollin Farmin, who concludes that "the pebbles were not of surficial origin, nor were they formed by faulting nor by hot springs. They were broken from underlying formations by fluids of magmatic origin and were injected upwards into the country rock". Basalt dykes often bring up pieces of intruded rock from depth.

* Hills, speaking of an outcrop of similar rocks at South Darwin, states "that when traced still further south the lithological character changes completely to normal conglomerates by the gradual elimination of the porphyroid pebbles", which can also be interpreted as further evidence in support of the theory of replacement during intrusion.

The opinion is therefore expressed that the "breccia conglomerates" have been formed by peculiar actions and replacements of the conglomerates by the intruding quartz porphyry magma. The writers realise that it forms an unusual occurrence and put forth their views with some hesitation. However, the field evidence tends to support the above views which are tentatively brought forward pending further field work in adjacent districts. They realise that there are difficulties to be encountered in the reported field occurrences in the adjacent districts and as stated above the views are only tentative though they give explanations of the occurrences in the Lyell district.

(iii) <u>Quartz Porphyry</u>

The largest body of quartz porphyry extends in irregular form from Queenstown South across Roaring Meg Creek to some distance south of Gormanston-Lynchford track.

It is in contact with Silurian sediments on all sides except on the extreme eastern edge where it

* Geo. Survey Bulletin No. 16. The Jukes Darwin Mining Field by Loftus Hills M.Sc. Assistant Govt. Geologist.

gives place to felspar porphyry.

In the vicinity of Roaring Meg Creek several small areas of quartz felspary porphyry appear within the quartz porphyry body. The change is transitional and the quartz felspar porphyry does not appear to be a separate intrusion. They have been omitted on the plan. To the north and south of Roaring Meg Creek and west of the main body several small areas of quartz porphyry are isolated within slates and sandstone. Quartz porphyry also outcrops to a limited extent to the west of Gormanston-Lynchford track, north of Lynch Creek. It is here in contact with slates on the east and grades into quartz felspar porphyry to the west.

Fresh specimens of the quartz porphyry consist of a hard, light grey coloured rock containing a felspathic ground mass in which are set porphyritic crystals of quartz and occasional patches of white mica.

Usually the rock is seen only in its weathered state, in which condition it is represented by a white kaolinised mass dotted with quartz blebs.

In some of the prophyry dykes in the north-western part of the area, small patches of this rock are developed, particularly between the point where they cross the Lake Margaret Transmission Line and the main body of quartz felspar and felspar-porphyries to the east.

(iv) Augite Porphyrite

This rock is developed to a great extent in the locality of Lynch Creek where it is transitional along the western side into Quartz felspar porphyry. The extension of the rock southwards has not yet been mapped but the northern and eastern boundaries are irregularly dispersed with slates and sandstones.

Another area of augite-porphyrite outcrops about the head of Reservoir Creek in the vicinity of Gormanston-Lynchford track where it is surrounded by schists and schistose felspar porphyry.

Within the felspar-porphyry mass, half a mile east of Queenstown, is a smaller area of a similar rock type.

In hand specimens the augite-porphyrite is fine grained and dark grey-green in colour. Small augite crystals stand out in a ground mass of what appears to be felspar and chlorite.

In some specimens, from north of Lynch Creek, olivine is present in occasional patches and calcite filled amygdules are showing.

In the north western part of the area these rocks occur as dykes trending roughly north west and south east and range in texture from a very fine grained type, in which abound lath-shaped phenocrysts of augite, set in a ground mass indeterminate to the unaided eye, to a much coarser gabbroid type.

The dyke of the coarse gabbroid rock trends in a south westerly direction after it crosses the Zeehan-Queenstown track some five chains west of the Lake Margaret tram; to the east, it trends east and west and becomes very much finer grained.

The dykes, with the exception of the one just described, connect a roughly meridional body of porphyrites and porphyries, west of Diamond Creek, to the Queen River prophyries eastward. In the western body of porphyrites, extending south-south-west from Davies Hill, near Hunn's Siding on the Lake Margaret tram, almost to Diamond Hill, are included small areas of quartz felspar porphyry which pass by insensible gradations into the normal augite porphyrites. A narrow band of Silurian sediments separates the main body from Diamond Hill through which passes a dyke of quartz porphyry. The dykes are not confined to the Silurian sedimentaries as two augite porphyrite dykes traverse in a north-west south-east direction the Queen River felspar porphyries in the vicinity of Crown Hill and the most northern one can be traced to within 15 chains of the second zig-zag on the Comstock tram.

These rocks are regarded as complementary, that is, they accompany large "acid" intrusions and "complement" in the chemical sense.

(v) Evidence for intrusive nature of porphyries

A. Numerous porphyry dykes of all the types described above penetrate the Silurian sediments notably at East Queenstown, south of Queenstown and along the southern portion of Lake Margaret tram. In most cases these dykes junction at one end with the main bodies of the porphyries.

B. Scattered blocks of Silurian sediments included within all types of the porphyries and schists are common occurrences, as can be seen from the geological map.

One of the best examples of this type of inclusion is that of the Tharsis conglomerate which is a large body of West Coast Range conglomerate situated between the Royal Tharsis and North Lyell orebodies. This body is included with-in an area of igneous schists.

In other places as at Roaring Meg Creek xenolith-like blocks of slates and quartzites are embraced within porphyries. In many places the porphyries contain angular fragments of slate ranging from a few inches up to several feet in size. The latter is particularly noticeable around the edges of larger included blocks.

There appears to be no doubt that these occurrences represent material caught up by the porphyries during their intrusion i.e. unassimilated remnants of the intruded rocks.

C. Several instances of transgressive contacts of porphyries with Silurian sediments occur.

In Roaring Meg Creek, along the western edge of the quartz porphyry body at its contact with slates and quartzites, a definite vertical contact is in evidence. The line of contact cuts sharply across the bedding planes of the sediments for a depth of at least fifty feet.

D. Some of the sedimentary blocks included within the porphyries are traversed by veins and tongues of porphyry. Instances of this occur in the valleys of Roaring Meg Creek and Lynch Creek, where the igneous rocks are quartz porphyry and augite porphyrite respectively. On Gormanston-Lynchford track, at the head of Conglomerate Creek, where inclusions of slates and quartzites occur in schistose felspar porphyry, veins of similar porphyry, up to 12 inches wide, traverse the sediments.

E. Metamorphism of sedimentary rocks at the contact with porphyries. East of Queenstown, and along the western boundary of the felspar porphyry the adjoining rocks to a distance of one foot from the boundary have been converted into cherts.

Along the conglomerate-porphyry contact on the southern slopes of Mt. Sedgwick, the porphyry is fine-grained close to the contact indicating a chilled margin of the intrusion.

The above evidence proves definitely that the various types of porphyries are intrusive into the Silurian rocks and more particularly the Queen River series. The evidence is not so abundant in the case of the West Coast Range series, because the Lyell schists are generally in contact with this series. However, the schists, representing schistose and mineralised prophyries, also present evidence that the original porphyries were intrusive into the West Coast Range series. The evidence is based on included blocks of conglomerate e.g. Tharsis conglomerate,and that west of Moore Creek waterfall. Further at numerous places off the south end of the Tharsis conglomerate, and north of the Razorback conglomerate, the schists contain pieces of red quartzite up to several feet in size, typical of the beds interbedded with the conglomerate. These pieces could not be explained otherwise then by unassimilated fragments of an intruded rock in an intrusive one. The whole nature of the schist conglomerate contact is strongly suggestive of an intrusive one and not a faulted one, although it is not unlikely that some later faulting does occur.

From the above evidence it is concluded that the whole of the porphyry bodies are intrusive into the Silurian rocks. They are, therefore, post-Silurian, and while no closer determination of age is possible (pending on examination of the Permo-Carboniferous-porphyry relations on Mt. Sedgwick) it is considered that they are hypabssal intrusions from the Devonian granite batholiths of Tasmania.

(vi) The Lyell Schists

These rocks are described in the accompanying report on the Economic Geology and only brief descriptions will be given here.

The schists form a long and narrow belt occurring between the Queen River porphyries on the west and the West Coast Range conglomerate series on the east. Proceeding easterly from the Queen River porphyries, it is found that the porphyries become much jointed, then somewhat schistose, and the felspar phenocrysts gradually begin to disappear until schists are obtained without any trace of the felspars or the original porphyry rocks. The alteration of the porphyries was caused mainly by earth-movements which deformed them, but the final and most complete alteration was due to the action of the mineralising solutions. However, even in the schists in the mineralised zones, microscopical examination reveals relics of former phenocrysts of felspar, thus supporting the evidence of the derivation of the schists from the porphyries.

The schist belt extends from the Comstock mine on the north as far south as mapping was carried out. The widest belt exists between the western end of Mt. Lyell on the north and Conglomerate Creek on the south.

To the south of Conglomerate Creek, the alteration of the porphyries to schists has not been so wide spread or intense and the belt is not so well-defined. It has the same general trend as further north, but contains a number of areas of more or less unaltered porphyry. No attempt was made to map all these in detail and they are included as schists.

(b) <u>Mesozoic Dolerite (Diabase)</u> Although numbers of dolerite boulders occur in Pleistocene glacial material on the Mt. Lyell field, the only known outcrop is that on the top of the eastern portion of Mt. Sedgwick.

In the latter locality the rock is in contact with rocks of the West Coast Range conglomerate series on the north and west, while elsewhere it appears to junction with porphyries, and apparently overlies these rocks as the remnant of a sill. It probably intrudes the reported Permo-Carboniferous rocks of this region. The rock is the typical diabase of central and eastern Tasmania which has been fully described previously in other publications.

## GEOLOGICAL STRUCTURE

The district consists essentially of -

(a) The West Coast Range series occupying the mountains of that range and representing a long north and south tract in the eastern half of the district.

(b) The Queen River series occupying the region west of the West Queen, and Queen Rivers, but in places extending to the east of these general boundaries.

(c) The Queen River porphyries and Lyell schists occupying a north-south tract between the above two series.

The West Coast Range series forms the base of the Silurian and yet it is found on the mountains at considerably higher levels than the stratigraphically higher Queen River series. This cannot be explained by a uniformly westerly dipping system, because the Silurian rocks strike and dip in many directions and do not form a westerly dipping system. The relationship has to be explained by large scale faulting along the western side of the West Coast Range, but its exact position cannot be accurately determined. The included blocks of both Silurian series in the porphyries and in the schists enable however a fairly definite position to be determined. From the geological map it will be seen that the position is a line bearing 340° from the conglomerate near the Duke Lyell to the western end of Mount Lyell. Further north the line bears 45° towards the Comstock mine, and then bears 300° along the south-western flanks of Mt. Sedgwick. At the same time, a narrow down faulted block extends to the north-east towards Mt. Sedgwick proper.

Another down-faulted block occupies the Linda valley, the bedrock of which is the Queen River series. The northern fault of this block is located fairly accurately at a number of places, but for the greater part is obscured by detritus. This fault forms the southern boundary of Mt. Lyell.

It will be noted that the porphyries for the most part intrude the main down-faulted block of the Queen River series to the west of the West Coast Range. The eastern boundary of the porphyry belt is generally along the line of the fault, but the porphyries do extend easterly of it and have intruded the West Coast Range series to the east of the fault. This is quite a common feature in Tasmania and the smaller Devonian intrusions particularly of basic rocks, are found in down-faulted blocks of the Queen River series.

(a) Faulting. The main fault along the western side of the West Coast Range has already been described, as have also a number of others bounding small down-faulted blocks of the Queen River series. These do not represent all the faults and a general examination of Mts. Lyell and Owen shows that the conglomerates on these mountains consist of a number of comparatively small blocks in faulted relation to one another.

Faulting may occur in the Queen River series but it is not apparent to the same extent as in the above.

The porphyries and schists do not appear to have been faulted to any large extent though no doubt small faults are probably present. The boundaries of the intrusions are quite normal and no large scale transverse faults have displaced them.

The above suggests that the faulting is later than the Silurian rocks but prior to the intrusion of the porphyries. This probably also applies to the main fault along the western side of the West Coast Range.

(b) Folding. Folding is apparent in the conglomerates on parts of Mount Owen and Mount Lyell. These folds are near the western boundary of the conglomerates and are connected with the faulting, particularly the main fault.

No folding was observed in the Queen River series, but the widths of the outcrops of the rocks of this series suggests close folding, but sufficient detailed work was not carried out to locate the folds.

(c) Intrusions. The intrusions of porphyry occur as large dyke-like bodies. The felspar porphyry intrusion is the most typical dyke-like one, being long and narrow. The remaining ones are more irregular, and the quartz-felspar porphyry would probably be found to be the most extensive.

The offshoots from the main bodies are in the form of long narrow dykes.

## GEOLOGICAL HISTORY

The geological history can be expressed briefly as follows:-

(a) Cambro-Ordovician sedimentation. This included the deposition of the Cambro-Ordovician rocks such as the Dundas slates and breccias (not exposed in this district) and possibly the King River Series.

(b) Period of Diastrophism. This closed the Cambro-Ordovician sedimentation, probably folded the sediments and elevated them.

(c) Silurian sedimentation. The land again sank beneath the sea and the Silurian sediments were laid down, beginning with the conglomerates under shallow water conditions, and becoming less shallow with formations of sandstones and fine conglomerates, to be followed by deeper and clearer waters with the formations of slates and limestones.

(d) Epi-Silurian Diastrophism. This brought the Silurian sedimentation to a close, folded and faulted the rocks and probably raised them above sea level.

(e) Devonian igneous intrusions. These followed closely upon the diastrophism, if not more or less contemporaneous with same, and gave rise to the granites, porphyries, dolerites, gabbros, serpentines etc.

(f) Period of mineralisation. The end phases of the Devonian intrusions consisted of mineralisation and the formation of the mineral fields of Mt. Lyell, Rosebery and numerous others throughout the State.

(g) Period of Denudation. From the end of the Silurian to the beginning of the Permo-Carboniferous, sedimentation, the State was a land area undergoing erosion.

(h) Permo-Carboniferous sedimentation. This probably took place over the district, but the rocks have been almost entirely removed by subsequent denudation.

(i) Triassic sedimentation. It is doubtful if this occurred in the western districts and these parts of the States may have been a land surface.

(j) Mesozoic intrusions. The intrusions of dolerite (diabase) occurred at the close of the Triassic period. Relics of the diabase exist on Mr. Sedgwick.

(k) Period of denudation. During the latter part of the Mesozoic and practically the whole of the Tertiary eras, the district was probably undergoing continuous erosion.

(l) Pleistocene glacial period. During the Pleistocene, the higher parts of the district were partly under ice, and glaciers moved down into the then existing valleys, at first enlarging them and later depositing morainal material etc. Inter-glacial epochs occurred and resulted in the depositions of sands, clays etc.

(m) Recent. Since the end of the glacial period, the land has been undergoing erosion, with also formation of alluvial deposits along the streams at a number of places.

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