REPORT ON THE STORMONT, BELL MOUNT AND BLACK BLUFF DISTRICT

The object of the visit to this district was to investigate the bismuth and gold deposits, and since these occur mainly in the west of Moina in the vicinity of Stormont and Black Bluff a geological survey of this part of the area was undertaken. The period spent in the field was from 8th January to 16th February, giving a total time of six weeks in the field.

The surveyed area is included in the western half of the Middlesex mining chart.

The Writer desires to express his appreciation of the splendid services rendered by Messrs E. and A.W. Goldsworthy, who acted as his field assistants during the survey.

LOCATION AND ACCESS:

The surveyed area is to the west of the township of Moina, which is 11 miles in a direction S.S.W. from Wilmot. Wilmot can be reached by road either from Sheffield, Devonport or Ulverstone. A road goes as far as Moina, and past there, there is a track which even when perfectly dry is almost impassable for cars, and which becomes exceedingly muddy in the winter months. The track goes as far as the Stormont Bismuth Mine. A track from Nietta goes to Black's Mine on the Lea River, and is quite passable with a pack-horse.

PHYSIOGRAPHY:

Nearly all the area is included in the valley of the Lea, except the part along Ti-tree Creek, which drains into the Iris River. The Lea River is a swift stream with numerous falls and rapids, and especially just before its junction with the Iris it has numerous cliffs along its banks. Stormont forms the southern boundary of the valley and Black Bluff the northern, both these ranges being formed largely of conglomerates and grits of the West Coast Range Conglomerate series.

The streams from Stormont are small and unimportant, but those from Black Bluff are larger and longer. The three main ones, Falls, Devonport, and Deep Creeks were traversed and the branch streams fixed by traverses running more or less around their heads.

The higher parts of the area were largely button grass plains, but around the creeks and river the scrub was often very thick.

Two areas of basalt occur but they seem to have had little effect on the physiography.

GEOLOGY:

Summary - Most of the area consists of sedimentary rocks which belong to the Silurian system, being an older system equivalent to the West Coast Range Conglomerate and a younger Tubicolar Sandstone series. Besides these there is a series of limestones which is probably younger than the other two and equivalent to the Gordon River limestones. Porphyry occurs on the edge of the area on Stormont and at Black Bluff, and basalt occurs in the Lea River valley.

West Coast Range Conglomerate Series - This series is found on top of the ranges of Stormont and Black Bluff, having resisted erosion better than the other series. It consists

of conglomerates, sandstones, and grits, the latter two having a red to chocolate colour which becomes very marked when wet. This suggests a shallow water origin and indicates that the conglomerates are of the nature of basal conglomerates to the Silurian system. This series conformably underlies the tubicolar sandstones and in fact the latter are generally regarded as a late somewhat local facies of the West Coast Range Conglomerate series. The conformable relations are best shown at the top of the cliffs in Deep Creek and at the head of the western branch of Devonport Creek, where the two series are in contact with parallel dips and strikes.

The strike of the rocks is about north and south, but this is only in a general sense, since the individual dips and strikes both of this series and the tubicolar series are very irregular.

Tubicolar Sandstone Series - This series consists of sandstones and shales, the former predominating with a few conglomerates. Many of the sandstones have abundant tubicolar casts which give the series its name. This is the series which occurs throughout most of the surveyed area, being found, except for some basalt, all the way up the Lea River valley as far as Black's Mine. Many of the sandstones show slight mineralisation and in parts become slightly schistose.

The dip is usually small, averaging about 15 degrees, and becoming as high as 45 degrees. The strike, as mentioned before, is very irregular,

At the Stormont Bismuth Mine there is evidence of the conversion of a shale belonging to this series to a garnet rock which contains the bismuth minerals.

Limestone - Limestones occur on the Iris River near the bridge and are interbedded with more siliceous layers. The relations with the other Silurian rocks are not quite clear, but they are probably equivalent to the Gordon River limestones, which are represented in various parts of the country around here, such as Mole Creek and Railton. TheGordon River limestones overlie and are conformable to the Tubicolar Sandstone Series, and it is probable that they bear the same relation here.

Near the mouth of Ti-tree Creek a rock, which may have been a limestone, has been converted to a garnetiferous rock similar to that at the bismuth mine at Stormont. Numerous metallic minerals are present, chiefly pyrite and chalcopyrite.

Tertiary and Recent - Pre-basaltic. These rocks are found immediately underlying the basalt, and consist of angular fragments of older rocks cemented together with siliceous solutions coming from the basalt. The result is a rock consisting of numerous angular pebbles with a hard siliceous base. It was referred to by Twelvetrees and Reid as a member of the Tubicolar Sandstone Series, but everywhere that I observed it it was between the basalt and the older Silurian rocks, and it seems probable that they represent the old detrital land surface over which the basalt flowed. Only one occurrence of this rock is shown on the map in section 10347/M, since the other occurrences are too small in area to be worth showing.

Post-basaltic - Traces of the old bed of the Lea are seen on the southern bank of the river, where rounded boulders occur about thirty or forty feet above the river level. These deposits carry traces of gold, and sometimes a small amount of alluvial work has been carried out at the mouths of small gullies which have crossed this alluvial material and reconcentrated the gold.

IGNEOUS ROCKS:

Quartz Porphyry - This rock occurs near the heads of Falls and Deep Creeks and also on the south side of Stormont The rocks have phenocrysts of quartz and a greenish ground mass; the loose boulders of this rock have a bluish colour which is characteristic of the rock.

The porphyry is intrusive into the Silurian rocks. It becomes schistose near the contact with these rocks, which is strong evidence of its intrusive character. Where this rock occurs at other parts of the West Coast it has been shown to be intrusive into the Silurian rocks, and since these rocks are similar it can be assumed that these also are intrusive.

Numerous quartz-hematite veins are found connected with the porphyry, and are found usually near the edge of the porphyry or in the surrounding rocks.

Basalt - Basalt occurs in two patches, one around the junction of the Falls and Lea Rivers, and the other along the Lea Valley east of the Stormont Mine. The basalt in the latter locality is largely fragmental and consists of large angular pieces of basalt in a fragmental base. The other occurrence consists of solid basalt and was evidently formed as a lava.

The basalt occurred in an older valley of the Lea, since it does not occur on any of the ranges on the side of the valley. It rises to about 500 or 600 feet above the river level between the Lea River and Falls Creek, and since the basalt is fragmental it probably represents a centre of eruption.

The basalt is a dark coloured rock with phenocrysts of felspar, olivine and augite.

Economic Geology - The minerals which are of economic importance in this district are the ores of bismuth and gold. Veins containing galena, sphalerite and copper minerals occur, but they are not of sufficient size or value to be of economic importance. The gold and bismuth deposits will be dealt with separately.

Gold deposits - Practically all the gold from this area has been won from reefs, principally at the Stormont, Devonport, and Black's mines. The gold occurs in quartz as wires along the cracks at the Stormont Mine, and in gossanous material at the Devonport and Black's Mines. This shows the gold to be of secondary occurrence, and the probability is that the reefs will pass down into primary pyrite. At Black's Mine veins of primary hematite occur, so that in this case the gold may be contained in the hematite in the primary state.

The gold occurrences at Black's and Devonport Mines are seen to be practically on the junction of the conglomerates and tubicolar sandstones, and probably have formed in a fracture system due to a faulting movement which has brought these two rocks into contact, giving a faulted instead of a conformable junction at these particular points.

DEVONPORT MINE:

The workings of this mine are shown on the accompanying plan, and consist of a tunnel with a trench on the surface of the hill. There is about 80 feet of backs to the tunnel at the trench.

In the end of the northern branch of the tunnel, there is a more or less north and south fault line filled with quartz and slickensided material from the walls of the fissure. There is not much gold in the reef, and it is very irregular.

In the southern branch of the tunnel some black gossanous material is exposed, some of which is reported to have carried good gold values. At the end of the drive there is a lode 5 inches wide of gossanous material, striking at 340° and dipping to the east. This, again, is very short.

In the surface trench, 80 feet above the tunnel, two veins are exposed about ten feet apart. These strike at 325° and dip 75°E. The east lode is filled with quartz and crushed country rock, and the other is a soft iron-stained lode. Both of them are irregular and somewhat difficult to trace.

The deposits at this mine seem to have formed in a shear zone formed near a fault which has brought the tubicolar sandstones and the conglomerates into sudden contact. The conglomerates are represented by grits and reddish quartzites. The faulting seems to have taken place by means of a number of small irregular fissures instead of a single fracture. These fissures seem to have been formed at different periods, and one set was filled with quartz and the other with pyritic material which gives the gossanous lodes when oxidised. Any gold values found in these lodes are most probably largely due to surface enriching effects and would not be expected to continue downwards.

BLACK'S MINE:

This is situated in the western portion of the surveyed area, about a quarter of a mile up the Lea River from its junction with the Falls River. A plan of the workings has been prepared. Mr. Twelvetrees reported on the mine in 1913, and since his information was obtained when the mine was working, the following particulars are given in an extract from his report.

> "The original workings at this mine were carried out by the well known prospector, B.L.F.J. Thomas, 17 or 18 years ago. An underlay shaft was sunk in pipestem rock to about 25 feet. The occurrence was that of a seam of gossan passing down into pyrite, but specimen gold is said to have been found on the rock-walls.
>
> "Six or 7 chains south of the above is Todd's shaft, (this is the most easterly of the three shafts which are seen on the west of the plan). sunk vertically 60 feet in red quartzite of the conglomerate series. A cross-cut from it was driven west-south-west for 50 feet, but no lode or mineral was met with. Mr. Black unwatered it, but was unable to do anything owing to the presence of foul air.

"Twenty feet west of this is another shaft, which connects with a costean running north-west and then running south-west. These workings expose an irregular formation of quartz in veined and silicified pink quartzite. With this is associated pyrite and slickensided specular iron ore. On the hanging wall of this formation is a main underlay shaft, in which solid veins of specular iron ore were followed. Twenty feet south of this is the most westerly shaft, sunk 55 feet on the formation, with a crosscut driven 26 feet north-north-west, The limits of the ore formation are not well defined. At the surface the silicified portion of the outcrop seems to be about 7 feet, but mineralisation extends to a greater width. The ore-bearing portion will probably be found to be irregular is size.

"The assay records vary a great deal, as might be expected in a formation in which free gold is liberated by the decomposition of specularite and pyrite.. Mr. Black informed me that the samples from the dumps assayed 14 dwt. 13 gr. gold per ton. Other samples assayed at the Mt. Bischoff works yielded 5 dwt., 7 dwt. and 8 dwt.

"Mr.Hartwell Conder, M.A., who examined the mine in 1903 reported the following assay returns from his samples:-

From 120 tons around shallow shaft, 3 dwt. gold per ton.
" 100 " " deeper " , 6 " " " "
" drive: across face, trace only.
" " : along north side, 12 feet to the shaft, 6 dwt. 10 gr. per ton.
" " : south-east end, practically in shaft 3 dwt. 2 gr. per ton.
" specimen of iron oxide, trace only.

"A hundred feet lower down is a tunnel which was driven by Osborn and Hancock for 55 feet across the conglomerate, but without reaching the lode. (This tunnel could not be found on the present survey). One hundred and forty feet lower than this, and 60 feet above the river (170 feet below the surface at the shafts according to my survey), Mr. Black has driven a tunnel 160 feet into the face of the cliff overlooking the Lea. (This length is now 190 feet, which was the length when Mr. Black left the mine to go to the War). The rock passed through is pink quartzite of the conglomerate series, and the direction of the adit is north 55 degrees east. A flat seam of pug accompanies the drive, and the country intersected carries veins of pyrites".

It is seen from this description that the lode is running almost north and south through the two shafts on the west of the plan. It is, however, very irregular, and may not exist as a definite lode.

The other shafts have been sunk principally on alluvial material, and a little fine gold has been found in them. The wash has been cemented by iron-bearing solutions and is now a solid mass of pebbles cemented together by limonitic material. The gold bearing wash occurs on top of this limonitic material, which occurs in a band about two feet wide. The patch which has been shown as worked on the plan contained the only coarse

gold which has been found around here, the gold being rough and did not show signs of having travelled far from its source.

The most easterly shaft shown on the plan was sunk in white sandy material in which pyritic nodules occurred. These nodules consisted entirely of pyritic material, and assayed about 5 dwt. of gold per ton. They may represent pieces of the original lode material, since the gossanous material found near the surface would pass into pyrite in depth.

It is seen from the plan that the reef is near the contact of conglomerates and tubicolar of conglomerate sandstones, and the high dip of the beds observed in the cliffs below the shafts suggest that the reefs may have formed in a shear zone due to a fault which brought these two series into contact at this point.

STORMONT MINE

This mine is situated at the foot of Mt. Stormont on its northern slopes. The following extract is taken from the late Mr. Twelvetrees report of 1913.

> "The Stormont lode was discovered by C.F.D. Adam. Information concerning the work was supplied to the writer by Mr. Adam and Mr. A. Campbell. The mine was floated by the late R. Mitchell, with a moderate amount of capital. The original shaft was sunk 35 feet and a short drive put in. A little underhand stoping was done north and south from the shaft.
>
> "Recently A Campbell and S. York sank small shafts to 14 feet, 22 feet, and 50 feet, and drove about 30 feet at the 50 feet level.
>
> "The work showed some free gold, sometimes in wire and crystallised forms, occurring between thin leaves of quartz in pink pug. Several narrow veins were met with at times - a vein now on the footwall, now on the hanging wall. Pyrite also appeared and this will probably be the characteristic mineral in depth. The lodes strike north and the shoots pitch in the same direction.
>
> "Work proved unremunerative, and was suspended at the end of 1911. An attempt was made to raise capital for it under the name of the Golden Acres Mines but was unsuccessful".

The strike of the reef is actually 330°, and work appears to have been carried out on two reefs about 6 feet apart. Some quartz which is seen at the bend of the water-race belonging to the Bismuth Mine probably represents the continuation of this reef.

REPORT ON THE BELL MOUNT GOLD FIELD

LOCATION AND ACCESS: The field is on the south-west side of Bell Mount, and is not greater than 100 acres in area. It is about half a mile west of the main road from Wilmot to Moina at a point about 3 miles from Moina, and there is a cart track from the road.

PREVIOUS REPORTS: Previous reports dealing with this area are:-

1898: Smith, J. Harcourt - Report on the Bell Mount and Middlesex Tinfields.
OS 132

1901: Waller G.A. - Report on the Mineral Districts of Bell Mount, Dove River, Five Mile Rise, etc.
OS 167

1907: Twelvetrees W.H. - Report on the Bell Mount and Middlesex district.
OS 237

1913: Twelvetrees W.H. - The Middlesex and Mt. Claude Mining field. (Geol. Survey Bull. No .14)

1919: Reid, A. McIntosh - The Mining fields of Moina, Mt. Claude and Lorinna. (Geol. Survey Bull. No.29).

HISTORY: Gold was first discovered by Malcom Campbell in 1892, and during that year and the next, 100 men were actively engaged in mining on the field. After that only occasional prospectors were working on the field, until lately there has been some more work carried out.

TOPOGRAPHY: The field is in the form of a basin, with Bell Mount on the north, the divide between the Wilmot and Forth Rivers on the east and sandstone spurs on the south and west. Four main creeks, Bell, Poverty, Mosquito and Basalt creeks flow through the Main auriferous area, and at the south-west portion of the field these join into the main stream, Bell, Creek, which flows through a gorge into the Wilmot River. Bell, Poverty and Mosquito Creeks are separated by mounds of detrital material about forty feet high, the shaft shown on the plan on the spur between Poverty and Bell Creeks having been sunk 35 feet in detrital material without reaching bedrock.

GEOLOGY: The rocks surrounding the basin are tubicolar sandstones, sandstones and conglomerates. Bell Mount, to the north east of the field, consists of porphyry. Basalt occurs on the south west portion of the field, mainly along Basalt Creek. The bedrock near the junction of Mosquito Creek with Bell Creek consists of limestone, and in other parts of the field it is sandstone. In Bell and Poverty Creeks it is a black puggy material which has been thought to be an old soil, but which is probably decomposed limestone.

WORKINGS: These are shown on the plan of the field, with information concerning the thickness of the wash, size of the gold, and the nature of the wash. It has been reported that only the lower six inches of the wash contain payable values.

The main workings have been on Bell Creek, where 3 oz. nuggets were quite common, and the largest nugget was 22oz. The best gold was obtained from Betts' claim at the confluence of the two branches of the creeks. Just above this claim the ground became very deep and was not bottomed, although attempts were made. This, however, was only a local occurrence. The wash also occurs up on the west spur and has been worked wherever water was available. The wash here is very heavy with several very large boulders. It is reported that a run of gold was found on the top of the spur, the run following a very sinuous course. It was here that a sandstone boulder was broken open and a nugget was found similar to those that were found in the alluvial workings.

A peculiar feature of this field is the shape of the nuggets, which are flat and smooth on one side while the other side is rounded. The shape is said to suggest that the gold had been occupying a space in sandstone, probably along a joint plane.

Considerable work has been carried out along the course of Poverty Creek, and lately the wash on the end of the spur between Poverty Creek and Bell Creek has been worked. In the former only fine gold was obtained, but in the latter both coarse and fine gold is found.

Paddocks have been worked at various parts along the course of Mosquito Creek. The flat on the south of Basalt Creek has lately been prospected and encouraging results have been reported. Some of the ground from this part has lately been worked by sluicing.

Good gold has been obtained from the point where the three latter creeks join.

Sykes' workings are a small patch of worked ground on the south of the field. The wash which I saw was quite angular, although A.M. Reid reported that it was well rounded. The material runs from Bell Creek up a fairly steep bank, and conglomerate bedrock outcrops just above the workings. Although nothing definite was known about these workings, local reports state that good returns were obtained from them.

ORIGIN OF THE GOLD: The problem of the origin of the gold on this field is one which many have attempted to solve, but so far with no success.

The mounds of detrital material show that orinin-ally, before the stream began to cut down into their beds, the whole area was covered by it. Twelvetrees considered that the basin was a swamp or lake at the time of the collection of the material, and that the

gold has been reconcentrated in the stream courses. This seems to be a very reasonable explanation. He also considered that the country to the north and west, especially the west, would be the source of the metal. This is also probable, since the coarse gold has been found entirely on the west side of the basin, which suggests that the gold came from the west, the coarse gold being dropped soon after it entered the basin, and the finer gold being carried over to the east to the Poverty Creek workings.

The shape of the nuggets is an interesting fact to be considered when discussing the origin of the gold. In connection with this, Mr. Sweeney supplied me with some interesting information about an occurrence of gold at Black Bluff about which he had been told. Here a reef narrowed down to a blade-like thread of gold, but sometimes it widened out suddenly into bulbs (see sketch shown with plan). This gives a shape remarkably like the nuggets, being flat and smooth on one side and rounded and rough on the other. While this is only hearsay evidence, it is recorded because it provides a good illustration of a possible manner in which nuggets of such a shape could be formed.

The most probable explanation seems to be, therefore, that the original occurrence of the gold was in small veinlets in sandstone or conglomerate. The gold then came, both free and included in the detrital material, from the west and north and collected in the basin. The gold was then reconcentrated in the stream courses where it was found and worked.

STORMONT BISMUTH MINE

LOCATION: The mine is situated about three miles west of the township of Moina. There is a track leading to it from Moina which is impassable for a car even in the summer, and in the winter it becomes very bad. The track rises about700 feet above Moina in passing over a saddle between the valleys of the Iris and Lea Rivers.

GENERAL GEOLOGY:

(i) Unaltered Sediments: These belong to the Tubicolar Sandstone Series, and consist chiefly of sandstones, some of which show the casts which gives the series its name. The boundary between the snadstones which have the impressions and those which have not, has been mapped, and is shown on the larger scale plan of the mine. These rocks are the normal types occurring in the district, and show a certain amount of alteration in the presence of arsenopyrite.

(ii) Garnet Rock: This rock type has the most economic importance, since it contains all the bismuth values. It is characterised by the development of garnet, which is the red form almandine. Usually the garnets are fairly large, up to about 5mm. but sometimes they become very small and difficult to recognise. The rock can be recognised in this case by

its red colour and its specific gravity, which is considerably higher than the common rock types.

In thin section the rock is seen to have been extremely altered, and indeed it is very difficult to recognise any individual minerals. Garnet is the only mineral which can be recognised with certainty and this is seen forming along cracks in the rock.

(iii) Altered Rocks (non garnetiferous). These are the rocks which occur near the garnet rocks, but which have not been altered to such an extent as the latter. A transition from this type into the garnet rock can be seen in the tunnel leading from the mill into the open cut, the garnet rock occurring in the open cut end of the tunnel. These rocks contain patches which consist mainly of rather a fibrous mineral, probably tremolite.

(iv) Magnetite Garnet Rock. This rock is seen in the track beside the open cut going down to the mill, in the water race, and in various other parts. It has been encountered in the shaft which was sunk to the south of the open cut (No. 4) and large masses of it are seen lying on the mullock heap of this shaft. The only minerals which can be recognised in the hand specimen are magnetite and garnet, and there is enough of the former mineral present to give the rock a black appearance. The garnets occur rather sparingly, and sometimes are not present at all.

(v) Quartz: Two or three masses of quartz occur in the vicinity of the mine, one of which is shown on the large scale plan. Another occurs underneath the flat mass of garnet rock above the falls on Castle Creek. The latter occurrence of quartz contains metallic sulphides, mainly galena, but the other is quite barren of any metallic minerals.

(vi) Basalt: Basalt occurs to the south of the mine, and the mass of garnet rock on which the present workings are being carried out passes underneath the basalt. To the east of the workings the basalt passes down to the Lea River and the older rocks are exposed only in the bed of the stream.

STRUCTURAL GEOLOGY:

1. FAULTING - The only faulting which has been seen in the vicinity of the mine is that which has been revealed by the mine workings, but it has probably played an important part in the geology of the area. The best evidence is a slickensided surface which was seen at the south-east corner of the open cut and along the drive running south from this corner. This slickenside occurs in garnet rock, and bismuthinite can be seen in it, and specks of gold are reported to have been seen on the surface. Although this indicates post-mineralisation movement, it does not exclude the possibility that the fault plane had formed before mineralisation, and perhaps played an important part

in the changes and mineralisation of the rock.

In the large scale plan of the mine there are two short drives shown going from the east side of the open cut. At the ends of these drives, and on the east side of the main south drive, some of the non-tubicolar sandstone is to be seen. The junction between the garnet rock and the sandstone is mineralised. This implies that the two rocks have been brought into contact by faulting, along a line parallel with the occurrence mentioned above. These sandstones occur underneath the tubicolar sandstone, which adjoins the garnet rock on the surface. The mass of quartz which occurs between the garnet rock and the tubicolar sandstone has probably been deposited along this fault plane.

The shaft in the south-west corner of the open cut, No. 2, was flooded when it cut a head which was reported to be running E. - W. and which probably represents an E.-W fault. The magnetite rock near the water-race seems to be occupying a fissure which has this direction.

2. STRUCTURAL RELATIONS OF THE ROCK TYPES

(i) Garnet Rock: The mapping of the garnet rock shows them to be quite irregularly disposed, both in horizontal distribution and altitude. It does not seem possible to connect the various masses to represent a single original bed, except by considerable faulting, of which little evidence was found. Simple folding unaccompanied by faulting could never provide an explanation of the relation, but it is possible that folding accompanied by faulting may explain the relations. The most probable explanation, I consider, is that the garnet rock represents an alteration product of rocks at various horizons, the location of the alteration depending mainly on fracturing and perhaps on certain chemical properties of the original sedimentary rocks.

The two easterly masses of garnet rock occur as flat masses. That which is located on the flat on the east of the mine huts gives a very good section as evidence of its flat horizontal nature. On the slopes above the flat only sandstone is to be seen, while over almost the entire flat only garnet rock is present. At the edge of the flat there are practically cliffs which descend to the river, and here the garnet rock disappears only a few feet below the level of the flat. From this evidence it can be concluded that the garnet rock probably occurs as a flat mass which coincides with the present surface of the ground.

The massof garnet rock in the bed of the river on the east lease is probably of the same nature. It extends only a few feet up on either bank, but persists for nine chains along the course of the river. The size of the garnets becomes greater from the west end of the exposure, where they are of microscopic dimensions, the the east end, where they become in parts about 5 inches in diameter. The bismuth minerals occur in the east end and appear to be closely associated with fracturing, This fracture marks the contact of the garnet rock and sandstone. The formation of the garnets seems to

have been largely controlled by this fracture, since it forms the limit of alteration, and the grain size of the garnets decreases on moving away from it.

The garnet rock upon which the present mine workings are situated seems to occur as a mass of greater vertical than horizontal extent. The open cut is about thirty feet deep, and shaft No. 2 was sunk a further 32 feet in garnet rock. The formation of the garnet rock may therefore be related to the faulting which has been previously described. The mapping of the boundary between the tubicolar and ordinary sandstone shows that the elongation of the garnet mass has practically the same direction as the trend of the sedimentary rocks. The steep slopes, of course, alter the trend of the rocks considerably from their true strike. The fact, however, seems to be a coincidence, when the depth of the garnet rock and its sharp junction with the sandstones on its eastern edge are considered. The garnet rock at the dam does not seem to be flat, since it cannot be traced around the hill-side. In this case it may be related to a fracture with an E.-W. direction, along which magnetite rock now occurs.

The garnet rock thus seems to occur in masses of two types, one having greater horizontal extent than vertical, and vice versa. The horizontal masses are probably related to bedding, which is rather flat in the vicinity. The vertical masses, on the other hand, seem to be related to faulting. The exposure in the bed of the river on the east lease shows that even in the flat masses, the alteration seems to have proceeded outwards from fracutres. The alteration of the original sedimentary to garnet rocks thus seems to have been controlled primarily by fractures, and from these fractures it has proceeded outwards when beds susceptible to alteration have been reached.

(ii) Magnetite-garnet rock: The magnetite-garnet rock occurs on the track on the west of the open cut, and it is separated from the garnet rock by a belt of less altered rock. Although the outlines of the mass are not clear because of mullock having been tipped to the west of the track, it seems to be trending parallel to the garnet rock. The magnetite garnet rock which was met in shaft No. 4 is in the same line, but in this case it was evidently directly against the garnet rock.

The magnetite rock near the dam trends almost E.-W. and as mentioned before, probably was formed along a fracture.

3. GENESES OF THE GARNET ROCK:

In the creek near the north-west corner of the mill there are some soft relatively unaltered shales, and these occur practically on the line of the prolongation of garnet rock. It is probable, then, that the garnet rock was formed by the alteration of these shales. Garnets are usually thought to develop from the alteration of limestone, but since the garnets are the red form, almandine, and therefore probably contain only a little lime, the pre-existence of limestone is not necessary for an explanation of the formation of the mineral.

It is common to find the garnet rock grading

into ordinary sandstone through smooth, highly silicified, fine quartzites, indicating the action of siliceous solutions on the sedimentary rock. The combined action of the siliceous and iron-rich solutions probably formed the garnets, since alumina would be present in sufficient quantity in the original shale. On this hypothesis, the garnet rocks occur near fractures which were open while both siliceous and iron-bearing solutions were being introduced, while the quartz and magnetite rocks occur along fractures which were open at stages when only siliceous or iron-bearing solutions were in circulation.

4. LOCATION OF BISMUTH VALUES:

The thin sections show that the garnet has been formed along seams, and the bismuthinite is interstitial between the garnets. The bismuth was thus deposited in the last stages of alteration of the rock.

Structurally the bismuth values are related to the fracturing. In the mine workings some relation is indicated, but no definite statement can be made. On the east lease workings this is very apparent, since all the bismuth values occur in the following section at the extreme east of the garnet rock. The section from east to west is:- sandstone: 2'9" of garnet rock, bismuth bearing and coarse on the east, grading into fine on the west: 4'2" of dark rock with much arsenopyrite and pyrite: 4'3" of very rich bismuth bearing garnet rock: garnet rock extending upstream. The contacts between these types are quite plain, and it is evident that they are related to a system of parallel fractures.

Bismuth values are reported to occur throughout the garnet rock in the flat to the east of the mine, but these were not investigated since exposures were poor.

ECONOMIC GEOLOGY:

(i) Bismuth: The bismuth occurs mainly in bismuthinite. There is some carbonate, bismutite, and there seems to be a considerable quantity of the oxide, bismite. This latter mineral is not recovered in the gravity separation, since it has almost the same specific gravity as garnet. The deposit is free from other metallic minerals, which raises its commercial value greatly.

(ii) Gold: The gold content of the bismuth concentrates is quite appreciable, and comes to represent an important factor in the value of the ore. The gold evidently occurs in the free state, as coarse colours have been reported to have been seen in the garnet rock. No gold was seen by the writer, who had to rely upon local reports for his information.

(iii) Metallic Sulphides: These do not occur associated with the bismuthinite, but they are found in the quartz veins in the vicinity. These are principally galena, blende and chalcopyrite. Pyrite and arsenopyrite also occur in mineralised country rock. None of these occurrences are of economic importance.

(iv) Non-metallic minerals: These are very numerous, and no detailed study of them was made. Garnet, quartz and magnetite are the most important, and their occurrences have been described. Calcite occurs along planes of parting in the garnet rock, and evidently represents a final stage in its alteration.

CONCLUSIONS: The mineral associations, and the form of the

masses, suggests that the garnet rock has been formed by contact metamorphism. Garnet, magnetite, and tremolite are characteristic minerals under these conditions, and the association of the rock with fracturing and bedding indicates that it was formed by the activity of circulating magmatic solutions which rose up the fracture planes and attacked certain favourable beds. The magmatic solutions presumably come from the quartz porphyry magma. The nearest outcrop of the rock is on the top of Mt. Stormont to the south of the mine, and about 1000 ft. above it. Although this is the nearest outcrop, it is quite probable that the porphyry occurs not far beneath the surface, and sufficiently close to give contact metamorphic effects.

Since the bismuth was introduced in the last stages of activity of the solutions, it is probable that the best values will be obtained near the main fractures. This condition certainly applies in the east lease workings, and seems to apply in the main mine workings.

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