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THE FIVE-MILE COPPER-NICKEL DEPOSITS

Introduction

Plans

Location and Access

Topography

History of the Field

General Geology

Geology of the Cambrian Group

The Basic and Ultrabasic Intrusions

Geological Structure of the Field

The Structure of the Copper-Nickel Lodes

The Mineralogy of the Copper-Nickel Lodes

Comparison with Other Copper-Nickel Fields

The Genesis of the Ore Bodies

The Persistence of ore at Depth

Conclusions

Recommendations

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INTRODUCTION

The history of copper-nickel mining in the Five-mile area dates from 20th June, 1893, on which day a 40 acre lease was marked out by one J. Dixon and subsequently granted as a reward claim for nickel. The field has had a somewhat chequered history and has been worked spasmodically from 1894 to 1949. The detailed history of the field is traced in a subsequent section of this report. Early in 1952, interest in the field was revived by a visit to the district of a representative of Metal Scrap and Byproducts Ltd., of London. This company, a large consumer of nickel, is investigating possible sources of nickel supply from within the British Commonwealth. The English company, through its Australian subsidiary, Eagle Metals and Industrial Products Pty. Ltd., obtained options over the leases of the Five-Mile held by Montana Silver-Lead N.L. and Mr. R. E. Clarke and approached both the State and Commonwealth Governments for assistance in determining the productive capacity of the field. As a result of representations made by the Tasmanian Director of Mines, the Bureau of Mineral Resources agreed to carry out a geophysical investigation of an area 7000 ft. by 1000 ft covering the known workings and portion of the surrounding country at the Five-Mile. Assistance in the field work of this investigation was given by the Zeehan staff of the Mines Department. The survey commenced on 8th May, 1952, but was temporarily abandoned on 5th June owing to bad weather conditions. It is expected that the survey will be resumed later this year. During the survey, a baseline was laid down for 7000 ft on a bearing of 354° (magnetic) to the west of the known lode. From this baseline traverses 100 ft apart extend in an easterly direction for 1000 ft each with pegs at 25 ft intervals. Instrumental readings are taken at each peg.

The Zeehan staff of the Mines Department undertook the task of compiling a geological report on the area. This has been carried out in two related sections.

(a) The regional geology of the country surrounding the copper-nickel deposits. This has been carried out by interpretation of aerial photographs in conjunction with field mapping.

(b) The detailed geology of the area covered by the geophysical grid. Within this area, all outcrops have been inspected, and all workings, tracks and other features plotted using the grid as a survey base.

In addition to this work, the original lease surveys have been consulted and eleven corner pegs re-located. From the positions of these pegs, the lease boundaries have been plotted on the geological plan.

In the preparation of this report reference has been made to the following publications:-

- (1) The Dundas Mineral Field. A.M.Reid. Geological Survey of Tasmania Bulletin No.36 1925.
- (2) Principals and Practice of Geophysical Prospecting, Report of the Imperial Geophysical Experimental Survey, 1931. A.B.Broughton and T.H.Laby P 84 - 90.
- (3) Various Annual Reports of the Secretary and Director of Mines.
- (4) Files of the now extinct "Zeehan and Dundas Herald".
- (5) Mineral Deposits. W.Lindgren (4th Ed.1933)
- (6) Mining Geology. McKinstry. 1948.

- (7) "Nickel" A summary report on nickel compiled by John V. Beall and published in the American publication "Mining Engineering" for August 1951 (Vol 3. No.8)
- (8) A summary report of available information on the Five-Mile field prepared by the Hobart staff of the Mines Department, dated 10th April, 1952. A copy of this summary is appended to the present report.

PLANS

The following plans accompany this report:-

- (1) Regional geological sketch map. This has been compiled from aerial photographs by uncontrolled plot and is on an approximate scale of 20 chains to 1 inch.
- (2) Detailed geological plan. This is based on the surveyed geophysical grid and is on a scale of 100 feet to 1 inch.
- (3) Drilling sections. This plan was prepared in 1940 by R. R. McGhie from drills put down by the Mines Department for Gold Mines of Australia N.L.

LOCATION AND ACCESS

The Five-mile copper-nickel field lies about half-way between Zeehan and Renison Bell, a little south of the Argent Tunnel on the Emu Bay Railway. It is distant from Zeehan five miles (hence the name) by rail and seven miles by road. The Emu Bay Railway runs within 900 ft of the southern shaft (Vaudeau's) and the Zeehan-Renison Bell road runs half a mile further east. The two feet gauge North-East Dundas Tram parallels the EBR from Zeehan to a point close to Vaudeau's shaft and then swings away east to cross the Renison Bell road. From the crossing, a branch line from the tram runs one and a half miles to Griffith's Siding. The tram and branch line have long since been abandoned and the rails and sleepers removed. The formation, however, provides a ready access to the copper-nickel field and it is possible to drive a heavy truck from the Renison Bell road to Griffith's Siding. The tram formation runs close to Vaudeau's shaft which is thus accessible to motor transport. Short tram formations run from the branch line to the South and North-Cuni shafts respectively. These formations are not, however, accessible to motor transport but could readily be renovated.

The H.E.C. Transmission Line (44K.V.A.) from Rosebery to Zeehan parallels the Renison Bell road and at its nearest point is distant three quarters of a mile from Vaudeau's shaft.

The ports of Burnie and Strahan are respectively 88 miles north and 28 miles south of Zeehan by rail. The copper mining centre, Queenstown, is 24 miles south east of Zeehan by road, or 50 miles by rail via Strahan.

TOPOGRAPHY

The copper-nickel deposits occur over a narrow north-south zone at least one and a half miles long located near the centre of a roughly circular topographic basin two to two and a half miles in diameter. The encircling hills rise to 200 to 600 feet above the floor of the basin. The hills to the south are ridges of quartzite forming part of the north-east limb of the

Zeehan syncline. The remaining hills and the basin floor consist of members of the Cambrian group of sediments with an ultrabasic intrusion forming prominent outcrops north-east of the field at Serpentine Hill. The hills do not encircle the basin completely there being four gaps in the perimeter:-

- (1) To the south there is a major fault offsetting the quartzite ridges. Through this gap run the EBR and the NED Tram.
- (2) To the south-east there is a narrow gap between the east limb of the Zeehan syncline and the Cambrian sediments. This gap provides a route for the Zeehan-Renison Bell road.
- (3) To the north-east there occurs the valley of the Melba Creek running as far as Melba siding on the NED Tram two miles from the copper-nickel field.
- (4) To the north-west is a narrow gap along the headwaters of the Little Hentry River.

A little north-east of the field is a saddle over which runs the Renison Bell road and under which is driven the Argent Tunnel on the EBR.

The field is located on the headwaters of the Little Hentry River. From the north-west and west two headwaters flow southwards through the southern gap mentioned above. From the east come the Melba and Nevada Creeks to join the main stream. Just south of the crossing of Nevada Creek by the Renison Bell road is a low saddle. On the southside of this saddle rises Leslie Creek which joins the Little Hentry River two miles south-west of the copper-nickel field.

The southern hills are covered with button grass, low scrub and patches of gums. The ridge between Melba and Nevada Creeks is covered mainly by stringy bark gum while the northern hills are clothed in typical West Coast rain forest consisting of myrtle, sassafras, leatherwood and celery top pine with King William pine on the crests of the ridges. The floor of the basin, to a large extent, marshy especially along the stream courses with low, irregular-shaped ridges between. A number of patches of stringy bark gum occur but the area is mainly covered by dense second-growth manuka and associated scrub at times reaching a height of fifteen feet. On the copper-nickel field itself, the southern portion from the EBR to 1000 ft north of Vaudeau's shaft, is reasonably open. There are a number of grassy patches with low fern, some scrub and a small stand of gum. In general, however, it is reasonably easy to move about this portion of the area. From this point northwards to the rain forest, however, the area is uniformly covered with dense manuka scrub and gum patches and movement over this portion of the area except along the tram formation and cut traverses is extremely difficult.

HISTORY OF THE FIELD

The era of copper-nickel mining at the Five-mile appears to have dawned on 20th June, 1893. On that day four leases were pegged in the vicinity of the present crossing of the NED Tram by the EBR. Lease No. 1925/91M of 80 acres was pegged by G.E. Elburn and granted as a reward claim for copper while lease No. 1926/91M of 80 acres pegged by J. Dixon was granted as

a reward claim for nickel. Leases Nos. 1923/91M of 40 acres and 1924/91M of 78 acres were pegged by E.E. Thomas for copper-nickel. Two days later No. 1927/91M of 80 acres was pegged in the area by R. G. King and on 11th July, 1893 A. Goldstraw and J. Dixon pegged a further lease No. 1956/91M of 80 acres in the same general area. During 1894 the "Nickel Reward" shaft was sunk to an unknown depth, presumably on lease No. 1926/91M. The workings were taken over by G. Beardsley and according to A.M. Reid (1) p.37 this person sank the shaft to 20 feet and several parcels of ore were obtained from the workings. There is no record of any developmental work being carried out on the other leases mentioned and no shafts or workings can now be discovered. Leases Nos. 1923/91M and 1924/91M became void on 11th December, 1894 and Nos. 1925/91M, 1926/91M and 1955/91M became void on 16th August, 1898.

The first period in the development of nickel mining was thus short-lived. At this time, nearly sixty years later, it is difficult to determine why the venture should have been abandoned. It is suggested, however, that there may have been four contributing causes:-

- (1) The prospectors ranging outwards from the newly-established town of Zeehan were searching for silver-lead ore and were not over interested in other ores.
- (2) The difficulty of finding a market for the then-unusual nickel ore.
- (3) The necessity to develop and mine the deposit by shaft rather than by adit.
- (4) The difficulty of transport. At that time neither the road, the EBR, nor the NED Tram were in existence.

No development of the copper-nickel ore-bodies occurred during the ensuing eleven years. During this period, however, silver-lead ore was discovered to the east at the McKimmie Mine and several smaller shows. Also during the period, the EBR line had been put through connecting Zeehan with the port of Burnie on the North-West Coast and the NED Tram had been constructed from Zeehan to Williamsford to service the numerous mines which had been discovered in the North Dundas area. By the time that the second period of development opened in 1909, then, the five-mile area was well served by transport facilities.

The persons responsible for the renewal of interest in the field were the brothers James, George, and William Wallace, William Davie and Thomas H. Vincent. During the latter part of 1909, the Wallace brothers had taken out a prospecting licence over portion of the five-mile area, J. and W. Wallace locating the rich silver-lead lodes of the Lead Blocks which they pegged as lease No. 4350M of 40 acres on 9th November, 1909. On 20th November the same year G. Wallace pegged an adjoining lease No. 4386M. The Lead Blocks area was taken over and developed by T. H. Vincent and subsequently by Zeehan-Dundas Mines Ltd. under the managership of T. H. Vincent. Later the same year, on 18th December, T. H. Vincent and W. Wallace pegged lease No. 4495M of 77 acres east and south of the Lead Blocks. On 20th December G. and J. Wallace pegged lease No.

4496M of 80 acres south and adjoining 4495M. These two leases were subsequently, on 17th May, 1913, transferred to the Dundas-Cuni Mining Co. Ltd. a subsidiary of Zeehan-Dundas Mines Ltd. On 23rd December, 1909 W. Davie pegged lease No. 4514M of 34 acres south of but not adjoining 4496M. On 28th August, 1913, this lease was transferred to the Copper-Nickel Prospecting Syndicate, a subsidiary of the Block 10 Broken Hill Co. It is of interest to note that these three leases were marked out for copper and that no mention is made of nickel in the original lease applications. It is assumed, therefore, that either the presence of nickel was not at first suspected by the discoverers or that they considered it of little value and were concerned only with the copper content.

Also on 23rd December, 1909, G. Wallace marked out a 40 acre lease No. 4603M south of and adjoining Davie's section 4514M and J. Wallace pegged No. 4604M of 40 acres covering the gap between 4514M and 4496M. These two leases were marked out for copper, silver and lead. Apparently the leases did not come up to the expectations of the lessees for both leases became void on 12th December, 1911.

The second stage of development, therefore, begins with the pegging of five leases over the nickel-bearing belt in 1909 and the transfer of three to mining companies in 1913, the remaining two being abandoned. By March, 1911, the branch line from the NED Tramway to Griffith's Siding had been completed to service the then-operating Lead Blocks section. Thus by the time that the two mining companies were ready to commence operations in 1913, rail transport from the area was available.

Although the two mining companies took over their leases during 1913, they had apparently held options for some time previously and had carried out exploration and developmental work. The actual dates of the commencement of operations are uncertain but appear to be during 1911. The following is a survey of the operations of the companies as far as can be ascertained from this time until the cessation of activity in 1914.

The Dundas-Cuni Mining Co. Ltd. (T.H. Vincent, Manager)

The first reference is found in the "Zeehan and Dundas Herald" dated 27th March, 1912. The work done consisted of trenching and the sinking of a small pit (about 8 ft) which later became the North Cuni shaft. The ore was proved to be 3 ft wide, to run north-south and to have an easterly underlay. A bulk sample of ore despatched to England some months previously had assayed 17.00% Ni and 6.45% Cu. At the time there were 30 tons of ore at grass assaying 13.4% Ni and 8.55% Cu. On 25th April, 1913, it was reported in the "Herald" that the company had decided to exercise the options over sections 4495M and 4496M. New developments were to be advanced on a permanent scale and regular shipments of ore made. The transfer was effected on 17th May, 1913.

The Report of the Secretary of Mines 1913 (p. 30) states:- "The trial shipment of ore from the North Mine (North Cuni Shaft) having been disposed of on satisfactory terms it was decided to develop the nickel-copper lode on more comprehensive lines. Surface prospecting by trenching disclosed on Section No. 4496M (i.e. in the vicinity of what was later the South Cuni shaft) an outcrop which, on stripping, proved to have an average thickness of 6 ft. payable ore about 140 ft. long and it was decided to install plant and test the lode at depth. A main shaft (South Cuni Shaft) was sunk to 80 ft. A first level has been sent out at 70 ft and where the

lode is now being driven on it carries 4 feet of payable ore. The production of nickel ore to date is 630 tons (presumably this was from both north and south shafts).

The report of the Secretary for Mines 1914 P. 36 states:- "Owing to the company's inability to dispose of its copper-nickel ores, the mines closed down. The lode has been driven on for 100 feet at the first level (South shaft) and stoping has proceeded above the level. From the main (south) shaft 1100 tons of ore have been raised but with the exception of 300 tons which were shipped the remainder of the ore is held in stock pending the re-opening of the market".

On 4th August, 1914, it was reported in the "Herald" that ore contacts to purchase galena and copper-nickel ore had been indefinitely suspended and operations at the mines were halted. The actual date of closing is not recorded in available reports but local information is to the effect that it occurred shortly after the outbreak of war, perhaps towards the end of August 1914.

There is no recorded information available regarding the depth to which the north shaft was sunk. It is locally, reported, however, that the depth was 70 feet with a plat cut at that depth. As at the time of closedown the south shaft had been sunk 80 feet with a level at 70 feet 100 feet in length. It is not known what amount of this 100 feet was north and south of the shaft.

The Copper-Nickel Prospecting Syndicate (H.A.Vaudeau, Manager).

The first mention in the "Herald" dated 16th July, 1912, states that the lode was struck at the 65 feet level 8 feet from the shaft. On 3rd April 1913 it was reported that diamond drilling contracts had been let. Details of the bores are given in the Summary Report attached pp2 - 3. On 3rd July, 1914, a fairly complete report on the mine appeared in the "Herald" which is summarised as follows:-
 "The No. 1 level has been worked out. It yielded about 2700 tons of ore. A winze has been sunk from No. 1 level and is now down 8 feet. It there proves the ore to be 3½ feet wide. At No. 2 level (120 feet from the surface) the plat has been cut and, on driving 6 feet south, the lode was intersected and found to be 6" wide and 14" in the backs. The drive is now in 10 feet and the lode has been opened out to 15". Fourteen feet above No. 2 level, the lode was passed through in sinking the shaft and 46 tons of ore were won in the operation. What is known as the Blowfly lense of ore situated 660 feet north of the main shaft is practically worked out, 280 tons of marketable ore was won from it and 20 tons remain to be extracted. The dimensions of the Blowfly orebody were 35 feet long at the bottom and 60 feet on the surface. Since starting operations in August 1913 2763 tons of ore have been marketed and 300 tons are at grass".

Reviewing operations of the syndicate for 1914, the report of the Secretary of Mines for 1914 states P. 37:-
 "During the past year, the company sold 3089 tons of copper-nickel ore the price received at the mine being

£15,815, metal values being approximately 10.0% Ni and 4.5% Cu. Nickel contents varied from 8.7% to 10.9% and copper contents from 4.1% to 14.0%. The shoot of ore at the 76 feet level was proved to be 78 feet long; this was beaten out to the surface. The main shaft was sunk to 122 feet and the lode cut and driven on, the south drive being 41 feet from the crosscut. The formation was very much disturbed for some distance but during the last 20 feet looked much better and some nice metal is now showing in the face. Water is very troublesome (30,000 gallons per hour) and a 20" diameter Cornish Lift pump had just been installed when war broke out. The ore contract was suspended and the mine practically shut down only a little prospecting being carried out".

The last recorded reference to the operations of the syndicate is found in the Report of the Secretary of Mines, 1915 p.26 "Beyond a little prospecting, no work was done by the syndicate. No results of any value were obtained".

Nowhere in any available reports is any reference to the Mosquito shaft found. The Summary Report states (p.3) that 52 tons of ore were mined from this shaft during 1914.

Summarising, then, it may be stated that the second period of development of the five-mile deposits occurred during the period 1909-1914. Good access to the area was provided and the two companies apparently proceeded along sound lines. They prospected by trenching and by diamond drilling, despatched trial shipments of ore and developed three areas by shafts and drives. Average metal values were 8 - 11% Ni and 4 - 14% Cu. Rate of water inflow was 20,000 to 30,000 gallons per hour. It appears that during 1914 the companies were in a good position to proceed with production and it was solely on account of loss of markets following the outbreak of war that the enterprises were abandoned.

Following this abandonment of activity in 1914, there ensued a period of fourteen years during which little activity took place. One noteworthy event, however, was the pegging by J.C. Devereaux of a 10 acre lease No. 8851M on 20th April, 1922. The outcrop of copper-nickel ore which was the basis of the application occurs approximately three-quarters of a mile southwest of the nickel reward, i.e. not on the then known line of lode. The lease was abandoned in 1924. In 1927, J.H.S. Munro of Zeehan acquired several leases in the southern portion of the field in the vicinity of Vaudeau's shaft but no prospecting or developmental work was undertaken. During the period, also, several other leases were acquired by various persons but all were later abandoned without, apparently, any significant prospecting.

The third period of active development opens in 1928. The Report of the Secretary of Mines for that year states P.19:- "Considerable activity has been displayed by engineers and miners in the five-mile area and a company has been formed to open and work the northern orebodies. Development at that end of the lode seems satisfactory. At the southern end attention has been confined to exploration at the surface". This company, the Copper-Nickel Mining Company, was a local

company, most of the shareholders being Zeehan residents. On 7th December, 1929, the company acquired consolidated lease No. 10953M of 157 acres which included the old 77 acre lease No. 4495M and a further area of 80 acres north and adjoining. The company continued operations until January 1932 when the venture was abandoned.

The renewed activity on the field was apparently due to the carrying out during the early part of 1928 of a geophysical survey by the I.G.E.S. over the central and northern portions of the field. Details of this survey will be found in Edge and Laby (2) Pp84 - 90. The company's activities were mainly concerned with the old North Cuni shaft workings. The shaft was not deepened but the drives were taken out along the lode from the plat cut at 70 feet. The north drive was 150 feet and the south 80 - 100 feet. To connect to the south drive an underlay winze on the lode which had previously been started was completed. Some stoping was carried out mainly on the south drive. Exact details of the amount of stoping are not now available. In addition to working this shaft, the company also carried out some developmental work on the northern extension of the lode was revealed by the I.G.E.S. Survey. The shallow Genet's Winze was sunk in this area and ore stoped out to a depth of 10 feet for a length of 70 feet.

The following production figures for this company are quoted from the Reports of the Secretary of Mines:-

<u>1929</u>	842 tons ore containing 85 tons Ni and 46 tons Cu
<u>1930</u>	117 tons ore valued at £1999
<u>1931</u>	0.2 tons Nickel valued at £45
<u>1932</u>	0.55 tons Nickel valued at £136.

It is not known what proportion of this production came from each of the areas being worked.

In the North Cuni shaft, difficulties were experienced with water inflow. The Company had limited financial resources and was not able satisfactorily to cope with the trouble. The venture was abandoned in January 1932.

During this third phase of activity, some diamond drilling was carried out by the Mines Department in 1930 as a follow-up to the geophysical survey. Bores Nos 2, 3, and 4 were in the area northeast of Genet's Winze and Nos. 1, 5, 6, 7, and 8 in the vicinity of the South Cuni shaft. Details of these bores are given in a later section of this report.

Following the close of the Copper-Nickel Company in 1932, there ensued a further period of inactivity until 1938 when the fourth period opened. In that year, the Australian Nickel Company reopened the old Vaudeau shaft and raised 277.72 tons of ore containing 19.75 tons of nickel and 11.19 tons of copper. No other details are available regarding the activities of this company and no further mention is made of it in published reports after 1938. Its activities were therefore very brief and confined to the year 1938.

In 1939-40 further drilling in the area was undertaken by the Mines Department for Gold Mines of Australia who were then interested in the deposits. Bores Nos. 9 & 10 were located east of Genet's Winze and Nos. 11 - 17 in the vicinity of Vaudeau's shaft.

Following this, the field was again quiescent until the fifth period of activity commenced in 1946-47 when Lead and Nickel (Zeehan) N.L. made preparations for unwatering the Vaudeau shaft. Production was not commenced until 1948 in which year approximately 750 tons of ore were raised but, as no market could be found for the product, the venture was abandoned. During this period no additional exploration work was undertaken. The company completed the rise connection between the two levels commenced in 1914 and stoped out almost the whole block of ore between the two levels south of the shaft. In addition a small underhand stope was made in the North drive on No. 1 level.

During 1950 the assets of Lead and Nickel (Zeehan) N.L. were taken over by the Montana Silver-Lead N.L. Thus the latter company came to be the holders of leases Nos. 1M/46, 2M/46, 3M/46, 4M/46 and 5M/46 of areas respectively 32 ac., 157 ac., 20 ac., 20 ac., and 20 ac. In addition the company has applied for No. 11M/52 of 30 acres south of 3M/46 and R.E. Clarke has applied for 2M/51 of 34 acres being the original area of 34 acres taken out by W. Davie as No. 4514M.

The following is a summary of the history of working and the details of workings as far as can be ascertained.

Vaudeau Shaft

1913-14 Worked by Copper-Nickel Prospecting Syndicate. Shaft sunk to 122 ft. Levels at 70 ft. and 122 ft.

1938 Some ore extracted by Australian Nickel Company.

1946-48 Rising and stoping by Lead and Nickel (Zeehan) N.L.

Total Production

Approximately 3900 tons ore

Values 8 - 11% Ni 4 - 14% Cu.

Present Extent

of Shaft 122 ft.

Workings No. 1 level at 70 ft. North drive 25 ft, South drive 80 ft. with three rises to surface. No. 2 level at 122 ft. North drive short, South drive 40 - 45 ft. Stopping - almost completely stoped No. 1 level to surface. On No. 2 level stope 35 ft. long from 2 to 1 level. Small underhand stope north drive on No. 1 level.

10.

Blowfly Shaft

1913 - 14 Worked by Copper-Nickel Prospecting Syndicate. Apparently worked out.

Total Production Approximately 300 tons
Values Unknown
Present Extent of Workings Unknown but small

Mosquito Shaft

1913 - 14 (?) Worked by Copper-Nickel Prospecting Syndicate. Not clear whether worked out or not.

Total Production 50 tons
Values Unknown
Present Extent of Workings Unknown but small

South Cuni Shaft

1913 - 14 Worked by Dundas Cuni Mines Ltd. Never re-opened since close-down in 1914.

Total Production 1189 tons (some from surface workings)
Values. Average of six bulk samples taken in drive workings and quoted by Reid gives 8.65% Ni and 4.58% Cu. Average of four parcels of ore totalling 509 tons gives 10.37 - 11.57% Ni and 5.12 - 5.53% Cu.
Present Extent of Workings Shaft 80 ft. No. 1 level with approximately 100 ft. of driving. Stated to be mostly stoped out to surface.

North Cuni Shaft

1913 - 14 Shaft sunk by Dundas Cuni Mines Ltd. to 80 ft. and plat cut at this level.

1919 - 31 Drive opened up north and south by Copper-Nickel Mining Company. Some stoping.

Total Production 1913 - 14 production unknown
 1929 - 31 Approximately 960 tons ore. Some of this came from Genet's Winze.
Values Quoted for 1913 - 14
 (a) 17.00% Ni 6.45% Cu
 (b) 13.4% Ni 8.55% Cu
 1929 - 31 production 10.15% Ni
 5.46% Ni
Present Extent of Workings Shaft 80 ft. deep. No. 1 level at 80 ft. North drive 150 ft. South drive 80 - 100 ft. Underlay winze to south drive 40 ft. south of shaft. Stoping mostly in south drive. Stope 15 ft. long surrounds winze.

11.

Genet's Winze

1929- 31

Opened by Copper-Nickel Mining Company.
Stoped 10 ft deep for 70 ft.

<u>Total Production</u>	Unknown
<u>Values</u>	Unknown
<u>Present Extent of Workings</u>	As above. Shallow workings only.

GENERAL GEOLOGY

The most recent published report on the geology of the copper-nickel field is that due to A.M.Reid (1) P.25. He states:- "The sedimentary rocks and the associated tuffs belong to the Dundas Series of the Cambro-Ordovician. In every respect they are similar to the rocks of this age occurring at Renison Bell and Waratah. They consist of:-

grey and black slates
grey quartz-feldspar tuffs
red slates and red tuffs.

These rocks occur in intercalated beds of varying thickness and have a northwest trend and an easterly dip. Probably the red slates are pyroclastic.

At the close of the Silurian, these sediments and tuffs were intruded by dykes of basic rocks of various kinds but all were derived from one stock magma having been separated by processes of differentiation. Directly following the intrusion of the main body of the basic irruptive numerous narrow subsidiary dykes of gabbro, norite and pyroxenite broke through the sediments and tuffs, completely fissuring them. Several of these narrow dykes are known and probably many more traverse the swamplands but are covered with peat and soil. Along the course of these subsidiary dykes the copper-nickel ore bodies are found and parallel offset lodes of silver-lead ore occur in the slates and tuffs on either side of them".

Since the time when this report was written much more detailed work has been carried out on the general geology of the West Coast area by various workers. At the present time, the following is considered to be the geological sequence:-

Orogeny	(Granite intrusions)	
	(Basic and ultrabasic)	Devonian
	(intrusions)	
	Bell shales)	
	Florence quartzite)	L. Devonian
	(unnamed) shales)	Eldon) to
	Keel quartzite)	Group) Silurian
	Amber shales)	
	Crotty quartzite)	
	Gordon River Limestone)	Junee) Ordovician
	West Coast Range)	Group)
	Conglomerate)	

Orogeny

Pieman Group

Cambrian

Orogeny

Davey Group

Pre-Cambrian

In the above sequence, the Pieman Group is approximately equivalent to the "Dundas Series" as used by Reid. There is some confusion, as to the definition of this latter term, however, and it is considered advisable, at present, to replace it with the more general term "Pieman Group" without attaching precise definition to it.

In the area under review, the whole of the topographic basin and the hills to the north and north-east consist of rocks of the Pieman Group. These extend for many miles northwards at least as far as the Pieman River. The Junee Group appears to be missing from the sequence here. The West Coast Range Conglomerate is certainly missing and no trace of the limestone has been found. If present, it occurs as a very narrow band along the base of the Crotty Quartzite. Being readily eroded material, as compared to the overlying quartzite, the limestone in this district forms flat marshy valleys and frequently does not actually outcrop. If present, it cannot be more than 70 ft in width in the area under review. The hills to the south of the basin consist of Crotty Quartzite followed southwest by Keel quartzite and Florence quartzite ridges separated by valleys of shale. West of the Florence Quartzite, there occurs the broad expanse of Bell Shales, frequently covered by alluvial and glacial material, forming the central feature of the Zeehan syncline.

Intruded into the Group of sediments, are basic and ultrabasic rocks consisting mainly of pyroxenite and gabbro, in places partly serpentinitised. No intrusions of granitic rocks are known in this particular area although a large quartz-porphry dyke occurs near Renison Bell, three miles north. Nowhere, either in this particular area or elsewhere on the West Coast are the ultrabasic intrusives known to penetrate the Junee and Eldon Groups. They appear to be solely confined to the Group.

GEOLOGY OF THE PIEMAN GROUP

The rocks of the Group are the most important sediments in the area as they are the host rocks for ore deposition. Indeed this statement applies generally to the Zeehan-Dundas-Renison Bell area. In the copper-nickel field they consist of shales, argillites and tuffs.

(1) Shales. These are of relatively minor development. They are generally grey to black in colour, thinly bedded and quite fissile. Often there occur thin discontinuous lenses of white, extremely fine grained tuffaceous material. Previous reports have described these rocks as slates but the term is incorrect. Occasionally, where there has been strong folding movements, cleavage has developed and the rocks may properly be termed slates. In most cases, however, the rocks have merely been compacted and split readily along the bedding planes.

(2) Argillites These are finegrained, compacted rocks of the same order of grain size as the shales but have a more massive appearance. Whereas the shales have thin layers of slightly differing grain size, the argillites are of uniform grain size sometimes over many stratigraphic feet. Thus they do not tend to split as readily as do the shales. Like the shales they are, in general, merely compacted although locally cleavage is developed and they are converted to slates. The argillites are usually brownish red to greenish in colour owing to the presence of iron compounds. The red rocks were probably laid down under oxidising and the green under reducing conditions.

(3) Tuffs These are the most characteristic rocks of the Cambrian Group, so much so, in fact, that the presence of tuff is diagnostic of Cambrian age. The tuff fragments occur from the finest particles up to pinhead size. The particles are usually white to greyish white and have indistinct outlines. The coarser material has the superficial appearance of sandstone. Tuffs occur generally throughout the shales and argillites. In the shales they are usually white while in the argillites they have a reddish or greenish groundmass.

This series of shales, argillites and tuffs may be traced many miles north of the copper-nickel field to the Pieman River and beyond. In the Pieman River area, they are found to be conformably overlain by beds showing a series of rhythmical variations from shale to grit to conglomerate to grit and shale with intercalated tuffs. In this latter group, several fossil horizons have recently been discovered showing that the age ranged from Middle Middle Cambrian to Lower Upper Cambrian and perhaps slightly higher. From this evidence, then, it is deduced that the underlying group of shales, argillites and tuffs is of Lower to Lower Middle Cambrian in age. The younger portion of the Cambrian is also known to occur east and south of the copper-nickel field in the Dundas district.

THE BASIC AND ULTRABASIC INTRUSIONS

These materials were injected into the Cambrian sediments during Devonian times following the orogeny which folded the newly-deposited Junee and Eldon sediments and genetically associated with it. Shortly afterwards, the granite massifs elsewhere on the West Coast were intruded, also genetically associated with the orogeny.

Some misconceptions have arisen regarding the nature of the basic and ultrabasic intrusions. In 1909, L. K. Ward (G.S. Bulletin No. 6 "The Tin Field of North Dundas") after noting the location of the various outcrops of these rocks states (P. 24) "The several outcrops of the basic rocks must necessarily be regarded as possessing continuity in depth, and the slate of the greater portion of the field is therefore resting on an igneous foundation the upper portions of which are exposed at the surface here and there". Succeeding workers Hartwell Condor (G.S. Bulletin No. 26 1918) and A.M. Reid (1) 1925 have accepted this view of the batholithic nature of the main masses and Reid (P. 25) writing of the copper-nickel field, states that:- "..... numerous narrow subsidiary dykes of gabbro, norite and pyroxenite broke through the sediments and tuffs....."

thus again implying a discordant relationship between the igneous and sedimentary rocks.

Recent work by the staff of the Mines Department has shown that this view is totally incorrect. The outcrops in the vicinity of Serpentine Hill are the southern end of an arc of ultrabasic material extending for over fifteen miles. East of this, a less well-defined zone of similar material occurs and another is found in the Dundas area. When viewed on a regional basis, it is clearly seen that the boundaries of the main zones of ultrabasic rocks conform in general to the bedding of the intruded sediments. In the particular case of the smaller intrusion on the copper-nickel field, detailed mapping has shown that this, also, parallels closely the strike of the sedimentaries and dips in accordance with them. In places, however, it is possible to find the intrusions locally cutting across the bedding. The intrusions are therefore classified as accordant i.e. they generally lie along the bedding planes but locally show discordant relationships. In this report, therefore, the particular intrusions with which the copper-nickel deposits are associated will be referred to as sills not as dykes. As mentioned by Reid (1) P.25 there are at least two such sills occurring in the field and probably several more thereabouts. A further feature is the fact that the sills are not simple intrusions. Surface mapping has shown that any one sill tends to split. This observation is supported by the drilling sections which show several such splits at depth. It is probable that the ultimate nature of these smaller ultrabasic intrusions is of the lit-par-lit type.

With regard to the compositions of the basic and ultrabasic intrusions no detailed work has been carried out during the present investigation. However, previous work by the writers has shown that both gabbros and pyroxenites are present at Serpentine Hill but no peridotites. The pyroxenite is mostly bronzitite with a minor amount of aluminous pyroxene and a trace of diopside. Some accessory olivine is sometimes present. The gabbros are coarse-grained with irregular patches of feldspar occurring between the ferro-magnesian constituents. The resulting mottled appearance is characteristic. It has been recorded by L.K. Ward (p.19-20) that locally the gabbro grades to norite.

The basic and ultrabasic rocks have suffered considerable alteration since the time of deposition. The most noticeable alteration is the conversion of pyroxenite to serpentine which forms relatively large masses at Serpentine Hill and elsewhere. Some of the serpentine contains chrysotile asbestos. The conversion to serpentine is not usually complete kernels of unaltered rock being found. Some serpentinisation of the gabbro has also occurred.

Thus it will be seen that, as is usual with basic and ultrabasic intrusions, there are a number of related rock types occurring. A detailed study of the types present would involve much petrographic investigation and was not considered warranted in the present instance.

GEOLOGICAL STRUCTURE OF THE FIELD

North of a line drawn westwards from the crossing of Nevada Creek by the Renison Bell road, it is found that the strike of the Cambrian sediments is, in general, a little west of north with dips varying from vertical to steeply east and that the sediments are shales, argillites and tuffs of Lower to Lower Middle Cambrian age. South of this line the strikes are generally east-west varying from a little north of west to a little north of east and the dips are uniformly to the south. The character of the rocks also show a marked change, the typical members being tuffaceous shales and fine conglomerates, comparable with the younger group of Cambrian sediments mentioned above. In particular, one band of fine conglomerate has been traced from the Renison Bell road just south of Nevada Creek for over half a mile westwards almost to the Crotty Quartzite. The wavy outcrop of this marker beds shown on the regional plan.

It is evident from the above evidence that a major fault zone occurs separating these two subgroups of the Cambrian Group. From the fact that the fault does not penetrate into the overlying Junee sediments, it is deduced that it is Pre-Ordovician in age and associated with the orogeny occurring at the close of the Cambrian sedimentation during which the Cambrian sediments were folded and fractured and later eroded before the Junee and Eldon sediments were deposited. It is convenient to refer to this feature as the "Nevada Fault".

Following this orogeny and baselevelling, sedimentation was continuous from the Ordovician to the Lower Devonian. After the deposition of the Bell Shales there occurred a considerable orogeny during which the recently-deposited sediments together with the underlying Cambrian sediments were complexly folded and fractured. The Zeehan syncline is one of the features produced during this orogeny. The fracturing produced during this orogeny was considerable. In the copper-nickel area, the major Little Henty Fault belongs to this period as do several minor parallel faults as shown on the regional plan.

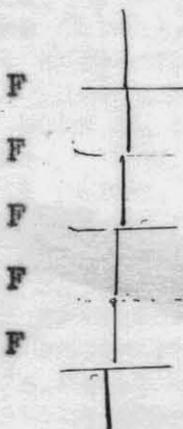
Considering now the detailed structure of the copper-nickel field, it has been shown that the strata strike a little west of north and dip east and that the narrow ultrabasic intrusion with which the deposits are associated is generally accordant with the bedding. In detail, minor variations in the strike occur. In the northern portion of the field there is a change of strike from west of north to east of north indicating a fold in the strata and the intrusion has been shown to follow this change in strike. In the southern portion there are two minor flexures in the strike. On the detailed plan a regional structure line has been drawn to indicate the general course of the strike over the field.

In the vicinity of Vaudeau's shaft three small faults have been observed each offsetting the course of the sill to the east. On the plan these faults are shown striking north of east. Insufficient evidence is available to indicate exactly the true

strike of the faults. However, the important fact is that the offsetting is to the east. Between the Blowfly and the South Cuni shafts and again between the South and North Cuni shafts there are long stretches over which the sill does not outcrop. When, however, the strike of the sill contacts and of the available sedimentary outcrops are carefully examined, it is apparent that the general course of any particular portion of the sill is several degrees west of a line joining the three shafts. From this evidence it is concluded that further small faults paralleling the three observed faults occur between the Blowfly and the North Cuni shafts, each offsetting the lode in an easterly direction. On the detailed plan the term "inferred fault" is shown and is to be interpreted as above.

In the area between the Vaudeau shaft and the EBR, two flexures in the strike of the sedimentaries are shown by the regional structure line. These flexures do indeed occur although it is probable that small offsetting faults also occur in the area associated with the folds.

Reviewing the structure of the intrusion generally, therefore, it is considered that it does not occur as a continuous belt but as a series of parallel steps each step being offset slightly east with respect to the step immediately south by small crossfaults. The generalised picture is as is shown in the diagram below.



The question of the age of this faulting is one of importance but which cannot be answered completely from the available evidence. The orogeny must be considered as occupying a considerable period of time. First there is a folding of the strata followed by intrusion of the magma. There is, however, no clearcut division between the two processes which overlap in time. Thus, during the period of injection, further folding and associated fracturing occur to relieve the stresses built up. It is considered that the major faulting of the area (the Little Henty Fault and others occurring south of the field) were produced during the first period before the magma was injected and that the minor faulting occurred during the later period either co-eval with the injection of magma or slightly later. More exact deductions on this point could be made if underground openings were available. It is probable that the geophysical survey will be able to shed some further light on this question which is of importance in ore location.

There remain two further questions to be considered with regard to the structure of the field. The first is the position of the Devereaux ore-body. At the present time little information can be gained as to the geological conditions in this area. Two shallow shafts and a shallow trench have been cut in flat marshy country. The only outcrops occur in the trench and prove to be highly weathered shales. No outcrops of ultrabasic rocks can be seen. It is therefore impossible to obtain any idea as to how the lode is associated with the ultrabasic or in what direction it is heading. One important feature, however, is the spatial relationship between this occurrence and the main workings. Whereas the latter occur approximately along a line heading a little west of north, the former occurs half a mile west of the known southern end of this line. As noted by A. M. Reid, no trace of this body has been found in the railway cuttings to the north and there are no gossan indications of its occurrence in that direction. It is considered that the Devereaux prospect occurs on the southern side of the Nevada Fault and on a line of lode separate from the known line. It is likely that the lode here will occur in a more or less east-west direction in conformity with the strike of the strata south of the Nevada Fault.

The final point to be mentioned is the occurrence of quartz "blows". In the area south of the EBR three such blows were noted. Northwards, between the EBR and the Renison Bell road three further blows occur, one on the eastern side of a serpentine outcrop. The blows consist of almost pure quartz, often vesicular and the southern ones in particular are stained pink by iron oxide. The most northern one near the EBR has little depth, for a cutting just east shows no quartz but only a barren lode channel. The depth of the remainder is not known. The blows appear to be barren lodes and were formed by the uprise of siliceous solutions along lines of weakness. The three southern ones are located near the line of the Nevada Fault and this fault was almost certainly the migration channel for the solutions. They are of interest in showing the siliceous nature of the mineralising solutions.

THE STRUCTURE OF THE COPPER-NICKEL LODS

At this point it must be stressed that the field work on which this report is based was confined to the surface only. None of the underground workings can be inspected at the present time. The notes given in this and succeeding sections are based, therefore, on previous reports, information gathered locally, and the inspection of surface outcrops and dump heaps.

The most noticeable feature of the ore-bodies is their general occurrence on the footwall side of the basic intrusion. They do not, however, occur solely on the lower contact of the igneous with sedimentary rocks. In the cross-section through the Vaudeau shaft (see Drilling Sections) the ore is shown so to occur near the surface but at depth the body swings away from the contact and for the greater part of the exposed depth is contained entirely within the igneous rock. Again, in Bores 2 and 4 an ore-body

is shown to be contained within the igneous rock. In both these cases, the dip of the bodies conforms in general with that of the intrusion.

Along their courses, the bodies are notoriously variable in width. In the Vaudeau workings the width varies from 10 ft in old No. 1 bore to a few inches in No. 2 level near the shaft. In the drive in the South Cuni workings (see Reid P.32) widths varying from 2 inches to 6 ft are noted. Similar conditions were noted by the miners in the North Cuni workings during 1928 - 31. It has been stated that the width of this lode varied with almost every round fired.

In the Vaudeau workings it has been shown that the ore-body pitches south at a steep angle (Summary Report P. 3 and Reid P. 43). Again it is stated by Reid P.30 with reference to the South Cuni workings that "...the ore shoot is apparently contained between two faults which dip to the southwest and give a southerly pitch to the ore-body".

In general form, then, the lode appears as a series of oreshoots of variable length separated by barren zones of unknown length. The ore shoots, where occurring, are located near the footwall of the intrusion but are not confined to the contact, sometimes occurring wholly within the igneous rock. The width of lode within any one ore-shoot is extremely variable.

THE MINERALOGY OF THE COPPER-NICKEL LODS.

As stated in the Summary Report P. 1, the ore is a massive sulphide containing pyrrhotite, pyrite, chalcopyrite, pentlandite and marcasite. Occasionally the minerals millerite (nickel sulphide) niccolite (Nickel arsenide) and zaratite (nickel carbonate) are found, the latter in relative abundance at the Devereaux prospect. In the outcrops in the vicinity of Genet's winze malachite has been noted in the oxidised zone. It is reported that native copper occurred rarely in the North Cuni workings and a specimen of this measuring 5" x 3" x 3/4" thick was shown to the writer by J. Downing of Zeehan. On the dump heaps of the North Cuni workings a quantity of specimens has been noted containing sphalerite and argentiferous galena of quite coarse grain size. It is reported that these minerals were of frequent occurrence in these workings and, at times, they exceeded the copper-nickel minerals in quantity. It is also reported that the silver-lead-zinc association of minerals was found sporadically in the South Cuni workings. There is no record or report of these minerals occurring in the Vaudeau workings. The ore from the Nickel Reward workings contained, according to Reid P. 37 "... a little silver and a trace of gold". Only in the case of the Devereaux workings has a complete analysis of the total content of the ore apparently been carried out. The following results are quoted from Reid P. 37 from this orebody.

	<u>Sample No. 1</u>	<u>Sample No. 2</u>
Copper	18.1%	14.0%
Nickel	5.5%	6.6%
Iron	27.5%	29.7%
Sulphur	24.8%	-
Cobalt	0.6%	-
Silica	7.9%	-
Zinc	3.2%	-
Lead	Trace	-
Bismuth	Trace	-
Alumina	3.1%	-
Silver	1.4 oz/ton	1.10 oz/ton
Gold	0.02 "	0.04 "
Platinum	0.10 "	0.16 "

These figures show a small but constant content of silver gold and platinum and in one case the presence of cobalt and bismuth which is not reported elsewhere. It is therefore, evident that the lodes are exceedingly complex in character and contain in addition to copper and nickel varying small quantities of cobalt, lead, zinc, bismuth, arsenic, silver, gold and platinum.

A remarkable feature of the lodes is the complete absence of gangue minerals with the exception of quartz. In no case occur such hydrothermal minerals as calcite, sericite, epidote, etc. The ore minerals are associated solely with igneous wallrock, sometimes fragmented, and with quartz. The association with quartz appears to be fairly general particularly at depth. The North Cuni dumpheap shows a quantity of this material which is usually of a cellular nature though sometimes quite massive. Insufficient information is available regarding the relative quantities of quartz and ore minerals and their detailed association.

COMPARISON WITH OTHER COPPER-NICKEL FIELDS.

The chief world production of nickel comes from the Sudbury region of Canada. There a huge lopolith known as the "nickel eruptive" occurs intruded into Pre-Cambrian rocks. In plan the intrusion has an oval shape with diameters of 36 and 16 miles. From the lopolith a number of dykes known as "offsets" extend outwards. The lopolith is highly differentiated ranging from norite at the base to a micropegmatitic granite at the top. The ores occur in two types of deposit.

- (1) Marginal Deposits. These are located in the footwall of the Nickel eruptive. According to Lidgren P.806 "The ore is a breccia or mass of sub-angular to rounded boulders of almost barren norite cemented by the ore minerals which often form a hard crust on the rock". In the Creighton Mines the ore has been followed to a depth of 3500 ft, the ore shoots being a few feet to 150 ft. in width. In the Falconbridge Mine diamond drilling has shown the ore to persist to at least 5700 feet.
- (2) Offset Deposits. These occur along the offset intrusions. Their relation to the basic rocks is similar to that of the marginal deposits although they show the presence of varying amounts of gangue minerals and quartz. The Froid Mine has been opened to a depth of 3000 ft and ore has been proved still deeper by drilling.

The tenor of the larger deposits ranges from 0.8% to 2.0% each of copper and nickel in varying proportions. The richest ores worked are found in the Creighton Mine which contains 3.0% nickel and 1.4% copper.

Approximately 90% of the nickel mined in this district is produced by the International Nickel Co. of Canada and the remainder by Falconbridge Nickel Mines Ltd.

In both marginal and offset deposits the ore minerals are pyrrhotite, pentlandite and chalcopyrite with occasional magnetite, pyrite, sphalerite and sperrylite (PtAs₂). The probable secondary minerals are marcasite, millerite, pyrite, arsenopyrite sphalerite and galena begin to appear in the offset deposits.

Regarding the origin of these ores, Lindgren states P.807" The earlier view of a gravitative settling of the sulphides in a norite sheet has given way to the theory of an injection of sulphide magma more or less charged with mineralisers along certain brecciated or fractured zones. In places the deposits show transition to high temperature veins and to the injected pyrite deposits. In minor part they may have been formed by direct magmatic segregation from the nickel eruptive but, in greater part, they have been formed at the end of the magmatic period by replacement of the silicates by a very liquid melt charged with sulphides and developed by differentiation in a magma reservoir at depth.

In South Africa a deposit of Post-Triassic age occurs at Insizwa. The ore-bodies are found at the contact of a norite sheet with underlying sedimentaries. The ore contains pyrrhotite, chalcopyrite and pentlandite with a little palladium, osmiridium, gold and silver. The nickel content is too low to justify development.

At the northern end of the Bushveld complex at Rustenburg, pyrrhotite, chalcopyrite and pentlandite occur in the Merensky reef in the upper part of the norite sheet. The nickel is obtained as a by-product of platinum mining by Rustenburg Platinum Mines Ltd. No information is available as to the nickel content but an unworked deposit some 40 miles north contains 0.03% nickel.

The only known sulphide deposit comparable in size to a small Sudbury deposit is that at Petsamo in Finland. No information is available regarding the tenor of ore here.

In 1948 copper-nickel ore was discovered near the base of the Duluth Gabbro one of the largest known lopoliths in Minnesota, USA northwest of Lake Superior. This has been reported on by Schwartz and Davidson in "Mining Engineering" July 1952 (Vol. 4 No.7) pp.699 - 702 under the title "The Geologic Setting of the Copper-Nickel Prospects in the Duluth Gabbro, near Ely, Minnesota". Sporadic outcrops of sulphides are found over a distance of five miles along the base of the intrusion opposite its thickest part. The authors state inter alia "Examination of thin sections and polished surfaces of the gabbro indicates that it contains the following minerals in decreasing order of abundance: labradorite, olivene, augite and hypersthene, magnetite, ilmenite,

biotite, chalcopyrite, cubanite, pyrrhotite, pentlandite, apatite and bornite.....A total of 29 chip and grab samples from about 12 localities averaged 0.59% copper and 0.17% nickel....They may be taken as indicating the copper and nickel content in outcrops along the known belt of sulphide occurrences".

The deposit is only in the developmental stage at present but the authors state that "strong evidence of the syngenetic origin of the sulphides and the considerable length over which they occur indicates that there is an excellent geological probability of finding a commercial deposit.

Nickel also occurs in the form of the silicate, garnierite in the deposits of New Caledonia, the Celebes, etc. and as nickel-iron in Japan, the Phillipines, Cuba, etc. As these deposits are of a totally different type to the copper-nickel deposits, they are not considered here.

The parallel between the five-mile copper-nickel deposits and those described briefly above is very close and may be summarised as follows:-

- (1) In all cases the deposits are associated with basic intrusions sills or lopoliths (which differ only in size) usually either of gabbro or norite composition.
- (2) In all cases the deposits occur on the foot-wall side of the intrusion.
- (3) The ore minerals are intimately associated with the rock minerals.
- (4) The five-mile deposits show much variation in width of lode both vertically and horizontally. A similar variation, though on a much larger scale, is shown by the Sudbury deposits.
- (5) The association pyrrhotite, pentlandite, chalcopyrite is of constant occurrence.
- (6) The presence of galena and sphalerite at the five-mile parallels the occurrence of these minerals in the offset deposits of Sudbury.
- (7) The lack of gangue minerals with the exception of quartz at the five-mile indicates a transition between the marginal deposits and the offset deposits of Sudbury.
- (8) The presence of the precious metals gold, silver and platinum appears to be normal to most deposits.

The following points of difference are important:-

- (1) The relative size of the deposits. The Sudbury deposits are of great size and the Petsame deposit somewhat smaller. The Minnesota deposits show promise of being fairly large. The five-mile deposits are quite small by comparison.

(2) This difference is, to a large degree, offset by the relative richness of the five-mile deposits. Whereas the Sudbury ores range from 0.8% to 2.0% each of copper and nickel, the five-mile deposits approximate 5 - 6% copper and 9 - 12% nickel.

THE GENESIS OF THE ORE-BODIES

During the earlier investigation by Reid, the underground workings could not be inspected and the author states P.27 that "On the meagre evidence at hand, authoritative discussion of the problems relating to the origin of the minerals and the processes through which they passed before final deposition would, at this stage, be premature and inconclusive". As the present investigation also was unable to include inspection of underground workings, a detailed account still cannot be given. It is, however, possible to draw some conclusions by comparison with known fields and to indicate some probabilities additional to those given by Reid.

That the nickel ores are connected genetically with the basic rocks admits of no doubt. These rocks are usually strongly differentiated as has been shown and it is logical that the metallic content of the original undifferentiated magma should remain in the liquid state while differentiation proceeds and thus become relatively concentrated in much the same manner as concentration of metallic constituents proceeds during the intrusion and consolidation of acidic magmas.

The injection of the metallic residuum occurs during the final phase along lines of weakness. It is considered that this residuum has limited mobility and thus does not travel far before consolidation commences. Thus the deposits are usually found in physical association with the basic intrusions from which they have been derived. A parallel between this type of deposit and the tin/tungsten type of deposits genetically associated with acidic magmas may thus be drawn. The latter type has low mobility in the liquid state and thus deposits are usually found within or not far beyond the margins of the granitic mass in zones of minimum resistance to circulation.

It is logical to assume that migrating solutions will tend to travel along lines of structural weakness i.e. through zones of minimum resistance to circulation. It does not necessarily follow that the solutions will become consolidated along the whole of their path. We may, therefore, find deposits in certain positions adjacent to their original travelling paths the latter now showing little or no sign of the passage of the solutions.

It is considered that this process has operated in the present instance. In the vicinity of the Vaudeau workings, the association of ore-shoots with cross fractures is quite evident. The cross fractures have provided the original paths along which the solutions migrated. From the fractures, the solutions travelled along the contact of the igneous and sedimentary rocks and there became consolidated. It is likely that the process was an intermittent one,

there being a number of injections of solution, perhaps of slightly differing composition. This would account for the observed banding of the ores, which banding parallels the strike of the lodes.

It has been reported that copper-nickel minerals occur in the adjacent McKimmie silver-lead lode although the reliability of this report is open to doubt. If such be the case, however, the explanation of the occurrence follows logically from the above hypothesis for solutions carrying copper-nickel could have migrated along the cross fractures and thus entered the McKimmie line of lode.

The occurrence of silver/lead/zinc in the North and South Cuni workings is a fact requiring consideration. These metals are derived from acidic magmas and their occurrence in association with basic rocks is apparently anomalous. It must be pointed out at this stage that the copper-nickel field is surrounded with silver/lead/zinc lodes occurring the manner normal to the Zeehan-Dundas areas fissure fillings in Cambrian sediments. These deposits are somewhat younger than the copper-nickel deposits being formed during the closing stage of the granitic injection which succeeded the basic injection in Devonian times. It is considered that portion of the solutions carrying these minerals migrated along the cross fractures and thus entered the copper-nickel lodes. Final resolution of this question would involve detailed study of the lode material at depth which cannot at present be carried out.

THE PERSISTENCE OF ORE AT DEPTH.

The meagre information available appears to indicate that, at a depth of 100 - 200 feet, the copper-nickel orebodies disappear and are replaced by cavernous quartz. Reid P.28 explains that this petering out has been caused by a removal of copper and nickel minerals in solution as soluble sulphates. Unfortunately, no further evidence on this question can be adduced at present but the following points are offered for consideration.

- (1) The apparent petering out is noted in the Vaudeau shaft at approximately 120 feet.
- (2) In the Blowfly and Mosquito shafts it occurred at a much shallower depth.
- (3) It has apparently not occurred at 70 - 80 feet depth in the North and South Cuni shafts.
- (4) It appears to occur between 100 and 150 feet in the vicinity of Bores Nos. 2, 4 and 9.
- (5) The maximum depth at which igneous rock has been intersected in boreholes is 280 ft. in No. 12 bore. In all other cases the intersection has been obtained within 200 feet.
- (6) There is, therefore, very sketchy evidence of what happens below 200 feet.
- (7) The ore is known to occur in shoots along the line of lode. Is it not at least possible, if not probable, that shoots occur in depth also? This feature is of repeated occurrence in the silver-lead lodes of Zeehan. In Sudbury shoots of ore have been traced down to at least 5700 feet. There appears to be no reason why ore should not persist in depth in the five-mile field.

This question is of vital importance when considering the future of the field. It is regretted that a definite answer cannot be given at the present time. It is hoped that the geophysical survey will be able to throw some further light on this question.

CONCLUSIONS

- (1) The general conclusion arrived at during the course of this survey is that the copper-nickel deposits are a proposition well worth further investigation from a commercial point of view.
- (2) The ore is complex carrying besides copper and nickel, lead, zinc, silver, gold and platinum and traces of other metals.
- (3) The ore occurs in shoots along the footwall of a basic intrusion, the shoots being 60 to 150 feet in length with depth varying up to 120 feet.
- (4) The known shoots are located on the south side of cross fractures and it is likely that several more such fractures occur probably with associated ore shoots.
- (5) The width of ore within the shoots is extremely variable.
- (6) There is reason to suppose that the shoots ^{may} reappear at depth. Such boring as has been carried out is quite insufficient to support the statement that ore cuts out below 100 - 200 feet.
- (7) A close parallelism is seen between this deposit and the Sudbury deposits except as regards size.
- (8) The tenor of ore is very high. In fact it appears to be the highest grade copper-nickel ore known.
- (9) From the standpoint of a company interested in relatively small production, the high grade of the ore will offset to a large degree the relative small-ness of the oreshoots.
- (10) Companies which have previously worked the deposits have closed down because of a combination of the factors; loss of market, low financial resources, inability to cope with water with available equipment.
- (11) At the present time there is ample market for nickel ore. Pumps capable of handling the water flow are available and hydro-electric power is close at hand.
- (12) The scattered nature of the known ore shoots would at present require working the field from a number of shafts for a profitable enterprise.
- (13) Were shoots shown to be repeated at depth, profitable working could be carried out from one, or perhaps two shafts. Therefore, the question of repetition in depth is critical.
- (14) Attention should be directed to exploration in depth in the vicinity of the known workings. Following this, particular attention should be paid to the long stretch between the South and North Cuni shafts.

25.

RECOMMENDATIONS

As a geophysical survey is shortly to be carried out over the field, it is considered that detailed recommendations regarding exploration would be premature at the present time. It is strongly recommended that, when this survey is completed, the geological and geophysical data be considered together and recommendations made based on all available information.

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