# REPORT
# ON
# THE DEVELOPMENT OF INDUSTRIES
# IN NORTH CAROLINA
# SECTION 1 AND 11

By

H. A. Brassert & Company

April 27, 1943

This report is preliminary and has not been edited or reviewed for conformity with North Carolina Geological Survey standards and nomenclature.

H. A. BRASSERT & COMPANY
60 East 42nd Street
New York

April 27, 1943

Mr. R. Bruce Etheridge, Director,
Conservation and Development,
Raleigh, North Carolina

Dear Sir:

In accordance with our proposal dated February 4th, accepted by you February 10th, we beg to submit to you herewith Sections I and II of our report covering the first results of our investigation of the iron and coal resources of your State suitable for industrial development.

This report includes the final report by Mr. C. C. Morfit, our Consulting Engineer, on the Sanford coal which is attached hereto. It includes a preliminary report on the iron ores in your State suitable for sponge iron production as a result of the visit and inspection of properties and records by Messrs. Eaton and Nixon. A report by Mr. Ramseyer on the possibilities of magnesium production from the minerals of the State is also included.

Section III of our report will follow shortly after conclusion of the field work. In the meantime we give you herewith a short resume of such conclusions as we are able to reach at this time on the basis of the data contained in the above mentioned reports which are appended.

Sanford Coal

Mr. Morfit has made an intensive field and office study of the Sanford or Deep River coal field. In Mr. Morfit's opinion, in which we fully concur, the so-called Dan River coal field is not of commercial value as the coal seam is too thin to be mined economically under present conditions. The Deep River coal field on the other hand represents an extensive body of good coal suitable for shipment to markets as well as to be used for making coke.

Additional diamond core drilling is necessary in order to accurately determine the extent, thickness and pitch of the coal seam. Mr. Morfit estimates that its average thickness is 40" of clean coal and that the coal can be mined down to at least a level of 2500 ft. below the surface. On this basis, Mr. Morfit shows in tract #1, where mining and drilling have already been done, a reserve of eight and one-half million tons of recoverable coal. This tonnage is sufficient for one mine operating at the rate of 1500 tons per day with a life of 21 years. It justifies the necessary capital expenditure for mine and coke plants. In the same tract an additional eight and one-half million are to be expected but must be drilled to confirm geological evidence. This would double the coal reserve of tract #1. In tract #2 the evidence indicates approximately ten million tons and in tract #3 nineteen million tons, or twenty-nine million tons altogether which could be mined by three additional operations, each producing at the rate of 1500 tons per day. The four mines together would have a reserve of forty-six million tons and a life of 30 years operating at the rate of 6,000 tons per day and furnishing employment to 1200 men.

These tonnages may be increased or decreased by a properly carried out drilling campaign. The cost of such drilling should not exceed $100,000 and might be less. We would strongly advise that such drilling be undertaken immediately and we would suggest that application be made to the Bureau of Mines for this drilling with public funds. We believe that under present conditions coal may be included in the category of critical minerals if produced in fields where labor is available and where the mining of coal will lead to the production of other critical materials, such as iron and steel and chemicals.

The Sanford coal has good coking characteristics and would make an excellent coke, especially in the horizontal Curran-Knowles type of oven. The Sanford coal is a swelling coal which makes it particularly adapted to this type of oven, in which the admixture of low volatile coals is unnecessary. The sulphur in the coal is rather high but if coked in the horizontal oven there will be a substantial elimination so that the coke will not be too high in sulphur for the purposes for which it will be used in our program.

Mr. Morfit sees no unusual mining problems and states that under capable management the mines should operate successfully and show a good earning power. He estimates the cost of production at $2.46 per ton, which based on a sales price of $3.03 at the mine and 390,000 net tons produced annually would indicate an annual profit of $222,300 before federal and state income taxes. The investment per mine would be $1,400,000 and each mine would employ about 300 men.

We recommend the opening at the start of one mine only for the supply of three small coking plants, one to be located at Raleigh, N. C., one in the Winston-Salem and Greensboro area and one at or near Charlotte. The total number of ovens to coke 1500 tons of coal per day would be 62, of which a small number would be required for Raleigh and a larger number for each of the other plants. These plants would produce domestic and industrial coke as well as gas for local consumption. The two larger plants could be increased to produce an additional amount of coke for the manufacture of hydrogen gas for sponge iron plants located in the respective areas. The size of the plants depends largely on the gas consumption of the respective communities. It may be desirable to ship some of the coal.

Each coke plant would produce besides coke and gas, a quantity of medium temperature tars, especially valuable in this emergency, as well as ammonia liquor and ammonium sulphate, a fertilizer much needed by the farmers of North Carolina. Additional by-products can be made, if desired by the WPB, for instance benzol and toluol, Construction and operating costs will be given when size and location of plants and scope of products are determined. Roughly, the cost of a 12 to 36 oven plant without benzol and toluol recovery will, under present conditions, be $50,000 per oven, more or less, according to the size of the installation. The production of coke will be about 16 tons per oven per day. The total gas consumption from the Sanford coal will be 10,000 cu.ft. per net ton of coal, of which 4,500 cu.ft. will be required for heating the ovens, leaving a surplus quantity for sale of 5,000 cu.ft. of 550 BTU heat value per cu.ft. The gross yeild of crude tar per ton of coal will be about 16 gallons.

The possibility of utilizing the black band ore underlying the upper band of the coal seam has been given some consideration and will be studied further. It does not appear to us at this time to have value by itself as a commercial source of iron or as fertilizer. As a by-product of coal mining, however, it might be utilized as a faw material for sponge iron production and it may be valuable as a fertilizer, perhpas mixed with ammonium sulphate.

Iron Ores of North Carolina
for Sponge Iron Production

Our report on the iron ores for sponge iron production is attached. All of the important areas except the magnetite area in Ashe County and the limonite deposits in Cherokee County have been visited and past history and records have been studied.

Our report gives the opinions of Mr. Nixon, who saw all of the deposits which were inspected, and of Mr. Eaton who examined the Cranberry mine and has studied the ores of North Carolina from all the records available. Mr. Eaton and Mr. Nixon will complete the investigation by visiting the remaining districts.

From the work done the most favorable prospects appear to be the magnetites of Lincoln County and Gaston County, especially those at the Big Ore Bank at Iron Station. These magnetites appear to have unusual continuity and the reported width of the ore-zone is great enough for economical mining. Although not all of the ore is magnetite, the ore formation is magnetic, and magnetic surveying should give satisfactory results.

The Cranberry district is next in promise. The Cranberry mine was the largest iron mine in the state, and, although the natural outlet for ore from this mine is through Johnson City, Tenn., and the visible reserves of the mine are largely worked out, it deserves further development by drilling. The lead on which the mine is located is extremely persistent, and the possibility of finding ore in commercial quantities there and farther from the state boundary should not be neglected. Somewhat similar occurrences of magnetite in Ashe County also deserve attention.

The titaniferous magnetites of Guilford and Rockingham counties have the disadvantages of narrow width and high titanium content; but the lead, or ore-zone, in which they occur is remarkably persistent, the iron content of the ore is relatively high, and the titanium oxide may possibly be removed and perhaps recovered by magnetic concentration.

In the light of our present knowledge the hematite and magnetite deposits in Randolph and Chatham counties hold little promise of sufficient tonnage to be interesting.

The deposits of brown ores in Cherokee county have prospects for tonnage as good as, if not better than, any other deposits in the State, but the character of the ore does not admit of concentration before reduction to such a high degree of purity as magnetite and is not as amenable to direct reduction. A more definite statement in regard to the Cherokee county ores will be made after this district has been visited.

The principal problem of the investigation of iron ore resources is to find a large enough tonnage in one district to warrant the capital expenditure required for a steel plant. The old workings, with the exception of the Cranberry Mine, were individually too small to meet the requirements of a modern plant; but in some districts sufficient ore might be found, if the ore-zone is treated as a unit.

Natrually we could not recommend the installation of sponge iron plants anywhere without the assurance of an adequate ore supply behind each plant. There are now no proven reserves anywhere - not even in the Cranberry mine - which would warrant capital expenditure for a commercial sponge iron plant. The smallest size of such a plant to be economically sound is 50 tons daily capacity of iron, requiring approximately 70 tons of magnetic concentrates per day, or 25,000 tons annually. For a life of only 20 years, 500,000 tons of ore would therefore be required. In the Cranberry mine there are only 50,000 tons of proven ore, equivalent to about 20,000 tons of concentrates. This illustrates the necessity of drilling.

We therefore recommend that the work of magnetic surveys, trenching and drilling of the deposits in the Lincolnton and Cranberry districts be undertaken immediately, to be followed by similar exploratory work in Guilford and Rockingham counties. The cost of this work we have estimated at $75,000, as shown in the report. We suggest that an effort be made to have the drilling of the ore bodies, as well as of the coal, done by the U. S. Bureau of Mines. We are prepared to supervise this work on a fee basis.

We are impressed with the probability of the existence of more ore in the Cranberry mine and adjoining territory which might well justify the installation of a 100 ton or even larger sponge iron plant in that area. Only magnetic field work and drilling will make such a development possible. The same applies to the other regions which we have recommended for drilling.

The present cost of a sponge iron plant of 100 tons daily capacity on the basis of low temperature gaseous reduction of magnetic concentrates with hydrogen gas is approximately $750,000. Of this amount $400,000 is for the hydrogen plant and $350,000 for the reduction unit and auxiliaries. Larger plants will cost considerably less per ton capacity and smaller plants more. The cost of sponge iron depends on the cost of concentrates which in turn is predicated on the cost of mining the ore and the ratio of concentration. The cost of hydrogen is an equally important factor and depends on the source and price of the raw material from which it is derived. Available sources for North Carolina plants are coal, oil and propane. The cost of hydrogen per ton of sponge iron can be determined after the location of plants is decided. It appears that the three ore areas indicated above may produce sponge iron at costs comparable to the cost of producing iron and steel in our principal steel centers. The principal object of producing sponge iron in North Carolina should be the manufacture from it of steels of the highest quality. Detailed estimates of costs will be given in the third section of this report, or when the location of plants has been determined.

<u>Development of Industries based on the Olivines of North Carolina</u>

We are attaching a preliminary report by Mr. C. F. Ramseyer which gives a general synopsis of the present state of magnesium manufacture from various raw materials, with special reference to the possibilities in North Carolina.

In addition to the processes mentioned, we are investigating the Gardner process which is entirely new but has not been developed on a commercial scale. The process applies to Olivines which are compounds of magnesia and silica, and spinels which are magnesia and alumina. Dr. Gardner uses a small percentage of sodium carbonate for separation of the silica from magnesia in the Olivine. The sodium silicate results as a salable by-product and part of the sodium is circulated through the process. Dr. Gardner is preparing to make a laboratory demonstration on your Olivines to prove the feasibility of his process and to corroborate the material and heat balances which he is preparing for us. We recommend that this process be given serious consideration as it appears to have economic possibilities, especially for the Olivines for your State. We recommend that you continue to cooperate with the Tennessee Valley authorities in the development of processes for the production of magnesium chloride from Olivine. Other interests have also shown a desire to cooperate, especially the Reynolds Metals Company.

We have given you herewith a condensed summary of our conclusions and recommendations as covered by the investigations we have made to date. The reports on the Sanford coal, the iron ores except Cherokee and the Olivine are attached hereto and made a part hereof.

Respectfully submitted,

H. A. BRASSERT & COMPANY

By

(s) H. A. Brassert

President

# PRELIMINARY REPORT

# ON IRON ORE AND COAL IN

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**H. A. BRASSERT & COMPANY**
**60 East 42nd Street**
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President

# MAGNETITE IN ASHE COUNTY

Although the old maps and records show many occurrences of iron ore in Ashe County, only two, one of which is on the Graybeal property at Lansing and the other on the Ballou and Calloway properties north of Crumpley, are credited in Bayley's report (Bulletin No. 32 of the North Carolina Geological and Economic Survey, by W. S. Bayley, published in 1923 under the title of "Magnetite Iron Ores of East Tennessee and Western North Carolina") with having promise of economic importance.

These two properties were visited on May 6, 1943.

## Graybeal Property

The old workings are of two hills half a mile east of the village of Lansing and north of the stone school-house and Dr. Jones's Infirmary. Most of these old workings have caved in or have been partly filled, but the walls of the veins are still exposed in some of the cuts, and it is possible to approximate from the size and shape of the openings the size and position of the ore that was removed. In some places fragments of ore remain on the dumps and in the pits, and these fragments give some idea of the character and quality of the ore. The strike of the veins is given in Bayley's report as northeast to southwest but I think that this is incorrect, and that the strike is northwest to southeast, basing my opinion on the fact that the cuts run from northwest to southeast, and seem to have followed the ore instead of cutting across barren rock to reach it.

On the hill to the northeast there are four cuts, which apparently followed rich streaks or veins in gneissoid granite. The ore was 3 ft. to 12 ft. wide, standing nearly vertically and striking northwest. It seems to have lacked continuity, because the cuts are not more than 50 ft. long or 15 ft. deep, and the ore in the face, where exposed, is lean. The cuts are approximately parallel, and enter the hill on the northwest side near the top. Apparently the ore did not extend through the hill, for there are no cuts on the southeast side, but an exploration tunnel on this side of the hill is said to have cut the ore. A drill hole put down by the Pulaski Iron Co. on this side of the hill is said also to have cut ore.

On the southwest hill there are three similar cuts on the northwest side near the top. They are parallel and en echelon. The ore was 6 ft. to 10 ft. wide, standing vertically and striking northwest. On the south side of this hill near the road there is a tunnel, which has caved in. It was apparently about 200 ft. long, and, although on page 152 of Bayley's report it is said not to have cut the ore, there is on the dump magnetite of better quality than is seen on top the hill. This may, of course, have come from narrow stringers.

The magnetite occurs with hornblende and epidote as it does at Cranberry, and the "vein" may possible be a basic dike or a basic phase of the granite. There are present also crystals of pyrite, pyrrhotite and calcite, minerals that indicate a probable contact metamorphic origin. Some ore bodies of this origin are large, but as a general rule they are relatively small and irregular. This ore apparently occurs in irregular lenses, more or less parallel, separated by lean material, and it is possible that there are enough enrichments to constitute an ore body rich enough to be mined and concentrated at a profit, but the odds are against it.

The primary ore is magnetite, and could be easily concentrated magnetically; but some of the ore on top of the hill has been oxidized to hematite, and has lost its magnetism. If the ore were mined, it would have to be hauled only half a mile to Little Horse Creek at Lansing, where there would be plenty of water. The Virginia and Carolina branch of the Norfolk and

Western Railway passes through Lansing, but it provides outlet only to the north and west.

Ballou and Calloway Properties

The Ballou Home Place is one mile north of the village of Crumpler. On a hill 200 ft. high in a bend of the north fork of the New River there are a number of old cuts, which were opened on the outcrop of a vein of magnetite, and an old shaft, which was sunk to cut the vein on the dip. All of the old openings have caved in, and it is possible to estimate the width of the vein only by the size of the openings. The ore is reported to have been 22 ft. thick. It strikes northeast and dips southeast at $45^{\circ}$ to $50^{\circ}$.

Apparently there are several veins or lenses overlapping to some extent, and it is possible that there is a fairly wide ore zone with rich spots in it, the pattern of which may be possible to determine by magnetic surveying.

At the foot of the hill on the southwest side a tunnel, called the Pine Tree tunnel, was driven about north-northeast under the road 150 ft. or more into the hillside at a depth of 120 ft. below the upper workings, and it is said to have cut the ore on the dip. The portal of the tunnel has collapsed, but it would be easy to re-open it. One of the local residents says that the ore splits into two branches on the west side, but is in one piece on the east side.

Across the river from the Ballou workings described above, about 1500 ft. to the northeast are more old workings, which have caved in, and there are other old workings near the top of the hill on the Calloway or Sand Bank property 2,000 ft. southwest of the Pine Tree tunnel. These also are caved in. These old workings were not visited, because the river was too high to cross. The three groups of workings are almost on line, and may represent enriched spots along the same zone, but they are quite evidently not connected directly because the ore does not appear in the river.

The ore is magnetite and would have to be concentrated magnetically, although the pieces of ore found on the dumps are much richer than those at the Graybeal property. Very probably only the richest streaks of ore were mined, and there is no way to determine, without further exploration, either the width of the mineralized zone or the analysis of the ore. There is room enough inside the bend of the river for possibly 100,000 tons of ore, if the ore averages 20 ft. wide, and there might be as much more on the other side of the river. The chances of finding as much ore as this are slim, and these figures must be considered only as an outside possibility.

The nearest railroad is the Virginia and Carolina branch of the Norfolk and Western Railway at West Jefferson, which is 10 miles away over a hilly road.

Conclusions

Both the Graybeal and Ballou deposits are in themselves worthy of magnetic surveys and possibly diamond drilling; but it is difficult to see how their exploitation, except for the employment given by mining and concentrating, would add much to the industrial development of the state, because the only railroad serving the district leads out of the state, and their ores could not be used in a steel plant located in the middle part of North Carolina.

# MAGNESIUM

## Magnesium Raw Materials

There are five main sources of magnesium bearing materials from which magnesium is obtained commercially at the present time. These are: salt brines, sea water, magnesite ($MgCO_3$), brucite ($Mg(OH)_2$), and dolomite ($CaCo_3.MgCO_3$). Of these, the supply of sea water is unlimited, and of dolomite virtually so, although only relatively high grade dolomite deposits can be used economically at present. Sea water can only be used if fuel is available at very low cost for the various processing and drying steps required.

Most of the magnesium produced in the world up to the present has been made by the electrolysis of pure fused magnesium chloride (the German-British Elektron or basic magnesium process and the Dow Chemical process). The magnesium chloride is usually made from magnesium oxide (MgO or magnesia) obtained either from brine, sea water, magnesite or brucite. It may also be obtained, at some increase in processing cost, from dolomite; the latter is probably being used as a source of the metal at present in England and some parts of Europe. Of the other two magnesium processes, the carbo-thermal (Hansgirg) requires relatively pure magnesia (MgO), while the ferro-silicon (Pidgeon) process uses straight calcined dolomite.

## North Carolina Sources of Magnesium

Sea water is, of course, available all along the coast of North Carolina; but no cheap fuel, such as the abundant supply of natural gas found on the Texas gulf or California coasts is available.

Workable deposits of magnesite and brucite are unknown, and no deposits of high grade dolomite have as yet been found, but their occurrence is quite possible and further work should be done to develop this possibility.

In its extensive olivine deposits in the western part of the State, North Carolina possesses extremely large reserves of magnesium ore with a high magnesium content. These deposits have recently been reported on in detail by Hunter and Rankin in a Bulletin issued jointly in 1941 by the State Department of Conservation and Development and the T.V.A under the title "Fosterite Olivine Deposits of North Carolina and Georgia". This report, on a conservative basis, shows the existence of nearly a quarter of a billion tons of easily quarried olivine, averaging 48% magnesia, equivalent to 29% magnesium metal, most of which is in North Carolina. General interest in this tremendous natural resource, as shown by the number of publications on the subject, has been increasing during the last few years.

Low cost electric power is a prime requisite for the electrolytic production of magnesium by the fused chloride process and also, to a lesser extent, to make the ferro-silicon required by the Pidgeon process. From the power standpoint these deposits are favorably located, as they are close to the eastern edge of the T.V.A. electric power grid and the Fontana and Hiwassee dams.

While the average percentage of metallic magnesium in North Carolina Olivine is less than that in high grade brucite, it is slightly greater than that in magnesite, and more than twice as great as that in colomite, as shown in the following table:

Magnesium Content of Various Magnesium Ores and Compounds

| Ores | | % Magnesium |
|---|---|---|
| Brucite, $Mg(OH)_2$ or $MgO.H_2O$. 41.7% Mg (hydrated magnesia or natural magnesium hydroxide)..if 90% pure | = | 37.5 |
| Olivine, $2MgO.SiO_2 + 2FeO.SiO_2$ (magnesium silicate contaminated with iron silicate)..average analysis 48% MgO | = | 29.0 |
| Magnesite, $MgCO_3$. 28.8% Mg (magnesium carbonate)..if 95% pure | = | 27.4 |
| Dolomite, $MgCO_3.CaCO_3$. 13.2% Mg..if 95% pure | = | 12.5 |
| Compounds | | |
| $MgCl_2.6H_2O$ | = | 12.0 |
| $MgCl_2.2H_2O$ | = | 18.5 |
| $MgCl_2$ anhydrous | = | 25.5 |
| MgO | = | 60.3 |

There are no theoretical reasons why magnesium chloride cannot be obtained as cheaply from olivine as from any other source, and laboratory scale experimental work by the T.V.A. over a period of several years supports this view. The Authority at the present time is seeking permission from the War Production Board to build a pilot plant in which to work out the technical details of the process on a larger, semi-commercial scale.

Description of Magnesium Processes

All of the magnesium metal now being produced in the United States is made by three general methods. The first, and by far the most important one at present, is the electrolysis of the fused chloride, the latter being derived, as mentioned above, either from sea water, magnesite or brucite. At Midland, Michigan, where production of the metal was first started in this country by the Dow Chemical

Company, magnesium chloride is also derived from brine-well bitterns, a by-product of the production of salt and sodium chloride products. There are no technical reasons why it cannot also be made from dolomite, as it is abroad.

The second process is the Hansgirg process, operated by Mr. Henry Kaiser at Permanente, California, with rather indifferent success up to the present time. This is a carbo-thermal process in which magnesia ($MgO$) is heated electrically in the presence of carbon under a vacuum. The magnesium metal which distills off is quenched in a high velocity stream of natural gas or petroleum vapor to prevent the reoxidation of the metallic magnesium vapor back to magnesium oxide by the carbon monoxide present in the gas. The resultant magnesium powder, contaminated by carbon dust and oxide, is briquetted and redistilled under vacuum to give a metal 99.99% pure.

The third and newest process is the Pidgeon ferro-silicon process. It requires a dolomite of high purity as raw material. The dolomite rock is first crushed and calcined, and then pulverized and mixed with pulverized 75% ferro-silicon. The mixture is briquetted and the briquettes charged into 10" diameter retorts 10' long. A high vacuum, of the order of one ten-thousandth to one one hundred thousandth of an atmosphere, is maintained in the retorts, which are heated externally by any means to a temperature of 2150° F. At this temperature the silicon of the ferro-silicon reacts with the oxygen of the magnesia present in the dolomite to form silica, liberating metallic magnesium.

$$2MgO + Si = 2Mg(vapor) + SiO_2$$

The latter, under the extremely low pressure, sublimes or distills off from the hot briquettes. The silica combines with and is held by the lime present as calcium silicate. The metal is condensed at the external water-cooled end of the retort as a ring or hollow cylinder of metallic magnesium. This magnesium is 99.97% pure. One pound of 75% ferro-silicon makes one pound of metallic magnesium. The production of the ferro-silicon used by Pidgeon's method requires less than half as much electric energy as is used to produce magnesium by electrolysis of the fused chloride.

Whether the Hansgirg process will be able to survive after the war is somewhat doubtful at present. The other two processes will probably be directly competitive. It is too early, however, to state with any certainty which will produce magnesium at the lowest cost. The percentage of magnesium contained in the ore which is converted to pure metal will probably be about the same by either process.

Generally speaking, the fused electrolyte process is more dependent upon both cheap power and cheap fuel than the Pidgeon process. It uses at present over twice the power per pound that the Pidgeon process does, and the production of magnesium chloride by wet methods requires very large amounts of cheap fuel for evaporation and drying. The main reasons for the present high costs of the Pidgeon process are the fact that it operates on a batch basis, and the retorts it has to use to stand the high temperature of 2150° F. at the necessary high vacuum have been extremely expensive and of relatively short life.

If the fused magnesium chloride electrolytic process is used, there is no reason, so far as can be seen at present, why magnesium chloride cannot be made just as cheaply, if not more cheaply, from olivine than from either sea water, brucite, magnesite, or dolomite. However, in this connection it must be remembered that the cost of the magnesium in the original raw material is relatively a very small part of the total cost of magnesium. Present processes produce magnesium for costs ranging from a low of possibly $.15 per pound to a maximum of perhaps $.30 per pound. If we take $.20 per pound as the average cost during war time, the cost per ton amounts to $400. Assuming that olivine, dolomite, magnesite and brucite can all be quarried for approximately $.50 per ton, the raw material cost per ton of magnesium produced will range only from $5.00 per ton, or 1-1/4% in the case of dolomite, down to $1.75 per ton or 1/2% in the case of olivine, magnesite or brucite. It is obvious that the various processing requirements are, and are likely to continue to be, of greater importance than the type of raw material available.

Requirements for the Manufacture of Magnesium

From the above discussion, it can be seen that the ideal place to make magnesium would be at a location where both fuel and electric power were very cheap, and a high grade body of magnesium ores was also available. In North Carolina two or these three requirements are met, at those points where the T.V.A. power lines are close to the olivine deposits. Here, fuel only would have to be imported. The cost of assembling the raw materials and power required by the process in southwestern North Carolina should be competitive with any other part of the country, since in no instance are all three prerequisites obtainable at any one point. The plants in Texas and California have cheap fuel and fairly low cost power, but have to recover their magnesium either from sea water and dolomite, or from magnesite hauled relatively long distances. The Basic Magnesium, Inc. plant near Boulder Dam has cheap electric energy and fairly cheap ore, but has to pay a relatively high price for fuel.

If the Pidgeon process can be made continuous and its high retort cost eliminated, it should be a very economical one. The process itself is very simple, and no extensive ore preparation plant is required, straight calcined dolomite being used without further purification. It takes little fuel, and less than half as much electric energy as any of the fused chloride processes.

Markets and Uses for Magnesium

The prospective uses and market for a new product must always play a very important part in any attempt to establish the commercial feasibility of starting the production of such a product in a new area. At the present time the market for magnesium is a war market, its three main uses being the airplane and automotive transport industries and the production of incendiary bombs. After the war, the latter use will disappear; but if the price of magnesium can be lowered to around ten cents per pound, it will become directly competitive on a cost basis with low carbon steel in many fields. There would seem to be no insurmountable technical reasons why it should not be produced for such a figure, in properly designed and operated large scale units.

Due to the lower quantity of power required for the production of magnesium in comparison with that required for the production of aluminum, together with the one third lighter weight of the latter and the much greater availability of its ores, i.e., sea water, dolomite, magnesite, olivine, etc., it would seem quite probably that magnesium will eventually considerably outstrip aluminum in tonnage, and eventually approach, at least on a volume, i.e. cubic foot basis, that of steel.

Preliminary Recommendations

It is recommended that the State of North Carolina continue to work with the Tennessee Valley Authority as closely as possible in the development of methods for the production of magnesium chloride from olivine at the lowest possible cost. Similar cooperative work should also be carried out with such industrial concerns as show interest in the possibilities of producing magnesium from olivine within the borders of the State.

It is further recommended that further geological survey work be undertaken at once, in order, if possible, to develop reserves of high grade dolomite. Some of the best dolomite used at present by the Pidgeon process is located in northwestern Connecticut and eastern New York State, close to marble occurrences which, in geological structure, do not greatly differ from similar occurrences found in North Carolina.

# NORTH CAROLINA OLIVINE MINING AND DEVELOPMENT

## 1. Foreword

It is impossible to make definite plans, specifications and estimates for mining olivine without a knowledge of conditions at the place where it is to be mined and of the daily tonnage required. Such conditions as the hardness of the rock, the height of benches mined, transportation in the quarry and crushing are fairly uniform, but the depth of stripping, the water supply, the length of the haul to the treatment plant and to the railroad, the cost of bringing in power and the cost of power itself may vary at the different deposits.

## 2. Deposits

As a basis for estimating costs the deposits at Webster in Jackson County have been chosen for study. At Webster there are at least three deposits. Two of them may be parts of one deposit, which has been cut in two by the Tukaseegee River. On the south side of the river is a rounded hill 1400 ft. long and 300 ft. to 500 ft. wide, which rises about 100 ft. above the level of the river. A cut 10 ft. to 12 ft. wide and 12 ft. deep was made across the middle of the hill 30 years ago by the Consolidated Nickel Co. Recently a little excavation has been done by the Olivine Products Company which had a lease on the property until a few weeks ago.

There are probably more than 3,000,000 tons of stone above the level of the river.

On the north side of the river the ground rises rapidly towards the village, and the surface reaches a height of probably 150 ft. above the river. The width is at least 500 ft. The length of the outcrop was not measured, but it is safe to count on at least 5,000,000 tons in the deposit.

Another large outcrop occurs southeast of that first mentioned.

3. Plant Site

The size and position of the plant for treating the ore will determine which of the deposits should be opened first. On the south side of the river there is an excellent site for a plant, from which either deposit would be easily accessible. If the plant is not to be at the quarry, it will be necessary to build a branch railroad half a mile up the river to connect with a logging railroad that connects with the Southern Railway at Sylvan, about 2 miles to the north. The cost of equipping and operating the quarry would be the same, whether the stone was delivered to the railroad or to the plant.

In estimating costs it is assumed that the deposit on the south side of the river has been chosen for development.

4. Power

A power line of the Nantahala Power and Light Company crosses close to the property, and ample power is available.

5. Water

Little water is needed for the quarry. It is assumed that ample water can be obtained from the river, although for the treatment plant storage may be necessary to insure an adequate supply in dry weather.

6. Mapping

The first requirement is an accurate topographical map of the deposit and its vicinity with contours at 5 ft. intervals. From this map the benches can be laid out, and the mode of attack can be planned. Benches 50 ft. high are the most economical, and the hill should probably be mined in two lifts, taking the top off first, but it may be expedient to mine the whole hill in one lift.

7. Diamond Drilling

Before plans are completed, two vertical core-drill holes should be put down to a depth of 100 feet about 500 feet apart on the long axis of the hill to test the quality of the stone. This can probably be done for $1,000.

8. Stripping

There is 1 ft. or 3 ft. of earth on top of the stone, and the surface of the stone is very irregular. The stone has been weathered to a depth of 10 ft. to 12 ft. Inasmuch as the Olivine Products Company used this weathered stone in their operations, it is assumed that it can be used for making magnesium, and will not have to be removed.

On account of the irregular surface of the stone and the difficulty of cleaning it mechanically or by hand, stripping should be done hydraulically. A centrifugal pump delivering 1500 to 2000 gallons per minute against a head of 300 ft., set up by the river and discharging through a 10-in. spiral pipe will prove efficient. The water should be discharged through a No. 1 monitor with a 2-1/2 in. nozzle. By settling out the coarser material behind an earth dam and allowing only the overflow to go into the river, there should be no trouble from contaminating the stream, if stripping is done in periods of high water.

The whole top bench, if not the whole deposit, should be stripped before mining starts.

The volume of material stripped should be less than 1 cu. yd. for every sq. yd. of surface, or .03 cu. yd. per ton of stone in a 50 ft. bench. At 60¢ per sq. yd. of surface, this is only $.02 per ton.

9. Production

The basis for the following estimates and specifications is a production of 1,200 tons a day, or 360,000 tons per year, all operations except drilling being carried on day shift only.

10. Drilling

Drilling for primary blasting, i.e. breaking the stone from the face, will be done with churn drills using bits 9 in. in diameter.

A self-propelling drill, mounted on caterpillar treads, driven by a 25 H.P. motor with a trailing cable should be used. Such a drill is the Bucyrus-Armstrong No. 29. A full set of tools with jars and 5 in. stems is required, and a sharpener should be provided for sharpening the bits. Drilling speed will depend largely on the type of bit used. A Gill bit with cutting edge and reaming surface built up with Stoodite, a hard alloy manufactured by the Stoody Company, will probably give the best results. A drill using 9 in. bits of this kind should put down at least 25 ft. of hole per shift in olivine. The holes should be drilled 25 ft. back from the toe of the face and 20 ft. apart in the row. They should be drilled 5 ft. below the floor of the quarry. In a 50 ft. bench therefore 55 ft. of hole will break 25,000 cu. ft. of stone (1900 tons @ 13 cu. ft.), or 35 tons per foot of hole.

One drill will therefore drill enough hole in a shift to break 875 tons. Allowing 10% for delays, we can count on about 800 tons per drill per shift. Two drills will therefore be needed to produce 1200 tons per day, if drilling is done only on day shift, but one drill will be sufficient, if worked day and night.

For drilling for secondary blasting, i.e. breaking up chunks too large for the shovel to handle, there are needed two 55 lb. jack-hammer drills and accessories, one spare drill, and a portable electrically driven air compressor, having a capacity of 300 cu.f.m. of delivered air. These drills will use detachable bits, and a small grinder for resharpening them will be needed.

11. Blasting

Primary blasting will be done with 60% and 80% gelatin dynamite in 50 lb. sticks, detonated by Primacord. Best results will be obtained by shooting two rows of about 20 holes each simultaneously, breaking 70,000 to 80,000 tons per shot. The rear row of holes will be drilled 20 ft. behind the front row, and the holes will be placed opposite the middle of the spaces between the holes in the front row, i.e. "staggered". Both rows of holes will be fired at the same time.

By following this practice it should be possible to break 4-1/2 tons of stone per pound of powder. Including secondary blasting, the cost of powder, detonators, Primacord, etc. should not exceed 5¢ per ton.

12. Loading

The stone will be loaded by an electric shovel with 2-1/2 yd. or 3 yd. dipper. Such a shovel, if given good truck service, will load 1,000 to 1,200 tons of stone per shift, depending on the size of the dipper. A dipper smaller than 2-1/2 cu. yds. is not recommended, because the stone will break in large pieces and the saving in secondary blasting accomplished by using a large dipper till more than offset the higher cost of the shovel.

The shovel should be equipped with caterpillar treads and trailing cable, should swing in a full circle, and should have Ward Leonard control.

A valuable adjunct to the shovel is a caterpillar tractor and bulldozer, which pushed loose rock back to the face behind the shovel, and makes it unnecessary for the shovel to clean the floor thoroughly. A 5 ton tractor should be large enough. It will be useful also in stripping, in building roads for the drills and trucks and in heavy hauling about the plant. A road-grader, which can be hauled by the tractor, should also be provided.

13. Haulage

The stone will be loaded into trucks and hauled to the crusher. Two Euclid trucks, having 10 yd. end dump bodies and 150 H.P. Diesel engines, will be sufficient for a production of 1200 tons a day, if the haul is less than half a mile. There should be a third truck as a spare.

The plant will also need a 2 ton service truck.

14. Crusher

The coarse crushing plant should contain a 42 in. gyratory crusher driven by a 200 H.P. motor, followed by a conveyor, a grizzly, and two 10 in. reduction crushers or a 5-1/2 ft. Symons cone crusher, a belt conveyor and a storage bin. The reduction crushers will require 100 H.P motors, or the Symons cone a 150 H.P. motor.

This plant will reduce the rock to 1-1/2 inl size. Finer crushing will be done by a fine crushing plant attached to the mill.

15. Shops

The repair shops should include a small machine shop, a garage equipped to repair trucks and tires, a drill sharpening and blacksmith shop, and a small carpenter shop. The shops would serve the treatment plant as well as the quarry, and are not chargeable entirely to the mining operation.

Shops, office and change house should all be under one roof.

16. Power

Transformers will be neededat the substation to reduce the voltage for the different operations. The shovel and the crushers will have 2200 V. motors, and the drills, shops, air compressor and lights will require 220 V.

The total connected load will be about 750 H.P. and the load factor on day shift will be about 50%.

17. Men Employed

| | |
|---|---|
| Office and supervision | 3 |
| Maintenance | 5 |
| Drilling and blasting | 7 |
| Loading | 3 |
| Hauling | 3 |
| Crushing | 3 |
| Miscellaneous | 6 |
| Total | 30 |

Tons per man per day......40

For this small number of men no housing need be provided. They can live in Webster or Sylvan or on nearby farms.

18. Capital Expense

The capital investment other than real estate will be as follows:

| | | | |
|---|---|---|---|
| 1. | Mapping | | $1,000 |
| 2. | Core drilling | | 1,000 |
| 3. | Stripping | | |
| | a. Equipment | 13,000 | |
| | b. Operation | 25,000 | |
| | Total | 38,000 | 38,000 |
| [redacted] | | | [redacted] |
| 4. | Drilling and Blasting | | |
| | a. Blast-hole drill | 11,000 | |
| | b. Block-hole drills | 2,000 | |
| | c. Air compressor | 5,000 | |
| | d. Blasting equipment | 1,000 | |
| | Total | 19,000 | 19,000 |
| 5. | Loading | | |
| | a. Shovel and accessories | 70,000 | |
| | b. Tractor and bulldozer | 5,000 | |
| | Total | 75,000 | 75,000 |

6. Hauling.

| | | | |
|---|---|---|---|
| a. | 3 10 cu.yd. trucks | 45,000 | |
| b. | Garage | 3,000 | |
| c. | Grader | 2,000 | |
| | Total | 50,000 | 50,000 |

7. <u>Crushing</u>

| | | | |
|---|---|---|---|
| a. | Primary crushing | 60,000 | |
| b. | Secondary " | 30,000 | |
| c. | Conveyors | 20,000 | |
| d. | Housing and pocket | 15,000 | |
| | Total | 125,000 | 125,000 |

| | | |
|---|---|---|
| 8. | Shops and equipment, change house, office and warehouse.....9 | 15,000 |
| 9. | Transformers and power line | 10,000 |
| 10. | General expense during construction | 10,000 |
| 11. | Miscellaneous equipment and contingencies | 16,000 |
| | Total | $360,000 |

Cost per ton of annual production....$1.00

Cost per man employed..............$12,000

19. <u>Operating Cost per Ton</u>

| | | |
|---|---|---|
| 1. | Drilling and blasting | $.12 |
| 2. | Loading | .05 |
| 3. | Hauling | .05 |
| 4. | Crushing | .09 |
| 5. | General pit expense | .04 |
| 6. | Supervision and office | .03 |
| 7. | Engineering and analysis | .02 |
| | Total | .40 |
| 8. | Stripping | .02 |
| 9. | Royalty | .10 |
| 10. | General overhead | .05 |
| 11. | Taxes | .05 |
| 12. | Depreciation | .10 |
| | Total | .72 |

H. A. BRASSERT & COMPANY
Consulting Engineers
for the
Iron and Steel Industries

60 East 42nd Street
New York

THE BROWN ORES OF CHEROKEE COUNTY

1. Foreword.

Cherokee County has produced more "brown ores", i.e. limonites and hydrated hematites, than any other county in North Carolina. On account of the geographical position of the deposits the natural market for the ore has been outside the state, and most of it has been sold to furnaces in Tennessee and Alabama.

The greatest activity was during the last war.

2. Geology.

A geological discussion of the origin of the ore and its mode of occurrence is unnecessary. This has been pretty thoroughly described in Bulletin 31 of the North Carolina Geological and Economic Survey, entitled "Deposits of Brown Ores in Western North Carolina" by W. S. Bayley. Suffice it to say that the ores are replacements in a calcareous schist (Andrews Schist) at or near its contact with an overlying quartzite (Nottely Quartzite) or with an underlying marble (Murphy Marble). The geological age of the rocks is Cambrian, but the formation of the ores was much later, following the intense folding that accompanied the Appalachian Uplift, and has probably continued to this day. The deposits were formed by leaching of overlying formations and redeposition below. How many times this concentration took place is a question, but there seems to be little doubt that the concentration of iron oxide bears a close relation to the surface of the ground, and should not be expected to extend to great depth.

The only deposits that so far have had commercial importance are those in the Andrews schist near its contact with the overlying Nottely quartzite. This belt extends from the Fain-Hitchcock Mine, a mile south-west of Murphy, north-east for a distance of 15 miles to the Marvacar Mine, south of Andrews and Valleytown. The structure is a complex syncline, in which for much of the distance the quartzite, which fills the middle of the trough, appears as the capping of a ridge or a series of hills with schist on the lower flanks. All of the important producers between Murphy and Andrews have been on the South-east contact between the schist and quartzite. Ore is found also on the north-west contact, but the deposits are smaller and more irregular than those on the east side. Both contacts are very regular, and are not hard to follow. The presence of a large strike-fault parallel to the eastern contact may have had a strong influence in producing larger ore-bodies on this side.

In most places the ore occurs as a steeply dipping bed or vein with a fairly hard foot-wall and a soft hanging-wall. All of the ore was mined in open pits, and it is said locally that some of the operations were shut down, when the thickness of hanging-wall, that had to be removed, became excessive. In at least two places, however, the ore-formation is nearly parallel to the surface of the ground, and the hanging-wall has been mostly removed by erosion. In some places work was apparently stopped by ground water and in others by exhaustion or deterioration of the ore.

3. Reserves.

The visible reserves in the district are not large, probably not large enough to support a 100-ton steel plant, but exploration should be cheap, and there is a chance of a substantial increase in visible reserves. There also is a good chance to develop and mine a small tonnage of ore with small capital outlay in time to be of help in the war effort. Even though the ore must be sold outside the state, much local benefit will accrue to the district on account of increased employment, if some of the pits are re-opened.

4. Mines and Prospects

1. J. W. Walker Mine.

The Walker Mine is 1½ miles due south of Andrews on the south side of a hill. The old workings consist of a pit about 100 feet long in an east-west direction, 20 feet wide in the bottom at the widest point, and 15 to 20 feet deep. Apparently the bottom of the good ore was reached. A test-pit or churn-drill hole in the bottom of the pit would answer this question, but the chances of finding enough ore to warrant resumption of operations are slim.

2. Marvacar Mine.

The Marvacar Mine adjoins the Walker Mine on the east, and is about 1½ miles south of Andrews. It was much larger than the Walker Mine. There are two pits. The larger pit is about 600 feet long and is 50 feet or more wide in the bottom at its widest point. The strike of the axis of the pit is N 40°E, and the ore pitched downwards towards the north-east. The west half of the pit is dry, but the walls have caved and filled it. The east half of the pit is under water. North of the big pit is a smaller pit, which is above water level. The ore was hauled down grade to a nearby creek, where it was washed. Ore is said to have been found in test-pits at intervals on the strike of the big pit towards the north-east, and it is probable that the ore-body extends in this direction under deeper cover. The mineralization apparently followed roughly the contour of the ground surface.

The chances of finding more ore are good. A few testpits or churn drill holes would supply the information needed.

3. Southern Iron Mining Co.

The Deposit worked by the Southern Iron Mining Co. is 3½ miles south-west of Andrews and 2½ miles east of Marble on the south side of the Valley River.

The deposit is a layer 8 feet to 10 feet or more thick on top of a low rounded hill of pasture-land, the axis of which runs east and west. Stripping is probably nowhere more than 3 feet thick.

The mine was worked from 1916 to 1919, the ore being mined by steam-shovel in a pit, A, 700 feet long and 150 feet to 300 feet wide. The ore was lowered in cars by gravity to a washer 100 feet west of pit A, and, when washed, contained 50% to 60% iron.

150 feet south of the washer is another pit B, about 200 feet long and 80 feet wide, which is now filled with water. The bottom of this pit is said to be ore which contains 6% manganese. Ore of this kind was undesirable in 1919, and the mine was shut down.

The washer has collapsed, but most of the machinery is still on the ground and could be used again. There used to be a short spur from the railroad to the washer.

The hill on which the ore was mined extends beyond the end of pit A for 500 feet. For 200 feet east from the end of the pit the ground is covered with float ore over a width of 350 feet, and for 250 feet farther there are quartzite boulders among the iron, but an old test-pit shows ore. The width gradually decreases to 200 feet.

Ore is said to have been found in the plowed field south of the hill and east of Pit B. It seems quite possible that there is manganiferous ore here.

Total production was approximately 35,000 tons of washed ore, and probably as much more could be mined on the rest of the hill.

This property could be explored easily, quickly and cheaply with a small portable churn-drill, and the washer could be quickly rebuilt. It is close to the railroad and handy to water and electric power. In addition there is the possibility of finding manganese ore or manganiferous iron ore.

The royalty used to be 50¢ per ton of washed ore, but the owners now would be glad to lease it for a royalty of 25¢ per ton and possibly less. The property is controlled by Mr. E. A. Wood of Andrews.

4. Luther Prospect.

About half a mile west of the Southern Iron Mining Co.'s pit and two miles east of Marble is a rounded hill similar in shape to that on which the Southern Iron Mining Co mined its ore. It is on the north side of the road on the right bank of Taylor's Creek. On the south side of the hill is a pit showing 8 feet of ore, similar in appearance to that mined by the Southern Iron Mining Co. Ore is said to outcrop on the north side of this hill also, near the railroad track, but this outcrop could not be found.

This property holds some promise of quick tonnage, easily proved and mined, if the ore is there. If ore should be found, it could be trucked to the washer at the Southern Iron Mining Co. property.

5. Hayes and Hoblitzell Mine.

The old workings of this mine are about a quarter of a mile east of Highway 19 at Marble, and consist mainly of a pit about 300 feet long in the hillside. This pit is reported to have produced more than 30,000 tons of ore. From the records there seems to have been a main vein about 8 feet wide surrounded by a stockwork of ore and sand about 50 feet wide, but little can be seen now.

6. Cooper and Hanks, or Jenkins, Property.

This property, half a mile west of the Hayes mine is reported by Bayley to have a large blanket of ore, possibly alluvial, which could be mined by power shovel and washed, but it is impossible to verify his conclusions without drilling or excavation. If his conclusions are correct, it should be easy to test the property with a churn drill.

7. Heaton and Russell Mine.

The main pit of the Heaton and Russell Mine is on the east side of Route 19 near Maltby, 2½ miles south-west of Marble. The pit is 400 feet long from north-east to south-west, 20 feet to 30 feet wide in the bottom, and 20 feet to 60 feet deep. The

The sides of the pit have caved in so that little can be seen of the mode of occurrence of the ore, but apparently it dipped 45° to the south-east and was about 15 feet thick. Both foot-wall and hanging wall were schist, the latter quite soft on top. The shallow part of the pit is the north-east end and the deep part the south-west end. The ore seems to extend farther into the hill at the south-west end, and operations apparently were discontinued when the cover became too heavy. Old photographs indicate that ore was mined under the hanging-wall before it collapsed.

At this mine there appears to be an opportunity to find more ore in the extension of the vein to the south-east on the dip and to the south-west on the strike. Testing could be done cheaply by churn-drilling.

Bayley estimates, on the evidence of trenches now not open, that the ore extends at least 900 feet east of the big pit, and estimates more than a quarter million tons of "possible" ore. His conclusions could be easily checked by churn-drilling.

8. <u>Savage Bros. Mine.</u>

The Savage Bros. Mine is near the base of the east slope of a quartzite ridge a quarter of a mile west of Route 19 two miles north of Murphy. It consisted of two pits, end to end, 250 feet to 300 feet long over all, 10 feet to 20 feet wide in the bottom, and up to 25 feet deep. Nothing can now be seen of the ore, but, as the bottom of the pits is roughly parallel to the surface of the ground, it is to be expected that the quality, and possibly the quantity, of the ore deteriorated in depth.

There appears to be little chance of finding more ore here.

9. <u>No. 6 Prospect.</u>

No. 6, on Section 6, is about 1½ miles north-east of Murphy and 3/4 of a mile south-west of Savage Bros. mine, but is on the west side of the quartzite ridge on the west contact between the quartzite and the schist. Along the bottom of the ridge ore, possibly float, was mined for use in local forges prior to 1894, but operations ceased when a railroad was built into the district in that year. The old pits extend along the base of the ridge for 500 feet.

About 1,000 feet north-east of these pits and 150 feet above the road is a pit cut into the hillside, from which a few cars were shipped. There are other pits along the hillside, which show ore for a length of 1,000 feet. The thickness of the ore is not clearly shown, but appears to be 10 feet to 15 feet.

This prospect, on account of the steepness of the dip and of the topography, would not be easy to test with a churn drill, and might require a diamond drill or tunneling.

10. Dockery Mine.

The Dockery Mine is a mile north of Murphy on the west side of the ridge a short distance south-west of No. 6. The old workings are filled up and little of interest can be seen there now. The ore is said to have been exhausted.

11. Fain-Hitchcock Mine.

The mine is on lands of two different ownerships, but was operated as one unit. It is 3/4 mile south-west of Murphy on a ridge south of the Hiwassee River.

The old workings consist of a long, narrow pit nearly 1,000 feet long across a spur of the ridge. The depth of the pit is 20 feet to 25 feet, and the bottom appears to be roughly parallel to the surface of the ground, as though the mineralization extended only 25 feet below the surface of the ground. The width of the pit is now only 8 feet to 10 feet, but apparently was 20 feet or more in some places. The ore is said to have become narrower as it was followed down. At the top the width of the pit varies from 20 feet to 60 feet. The strike is N 35° E, and the dip is nearly vertical.

The vein continues for some distance to the north-east but turns a little more to the east. Its presence is attested by several pits and outcrops, but it appears to become narrower as it extends to the east.

According to Bayley the ore from this mone prior to 1920 was screened but not washed. A washer was finally built but was not used long. The mine operated from April 1917 to the summer of 1919 and again in 1920, and produced in all 80,000 tons of ore.

It is to be expected that some wash ore might be found alongside the better grade ore, but the chances of a large tonnage either on the stroke or dip do not appear to be bright.

This is the southernmost mine in the district that produced ore in important quantities.

12. Cooper Prospect.

The Cooper property is about 4 miles south-west of Murphy. On top of a rounded hill in pastureland there are exposures of float ore and apparently ore in place very similar to those at the Southern Iron Mining Co.'s mine near Marble. There are two parallel belts of float, one about 500 feet long and 200 feet wide, and the other 600 feet long and 20 feet wide. They are separated by a belt 200 feet wide in which quartzite boulders predominate. There are no pits and no drilling has been done.

The property would be easy to test with a churn drill and offers a chance to find ore that could be mined cheaply and quickly.

13. Porter Mine.

The Porter Mine is 8 miles southwest of Murphy. It is in an open field west of the highway, and consists of an old pit 200 feet long, 30 feet wide at the bottom, and 12 feet to 14 feet deep. There is 4 feet of overburden and 8 feet to 10 feet of ore. The ore is a yellow limonite, probably lean. The ore strikes N 15° W. and at the south end of the pit dips 45° west. At the north end of the pit the ore is 8 feet thick, and at the south end about 15 feet thick.

The tonnage shipped from this pit was not large, and apparently the quality of the ore was not good enough to warrant stripping off much of the hanging-wall. There is a chance of proving up a small tonnage with a few holes put down on the west side of the pit.

5. Resumé.

Only those properties were visited and investigated which from their record in the past or their prospects in the future held commercial possibilities.

There are other openings or exposures in Cherokee County and the possibilities of the district for the future have not been exhausted, although the cream has probably been skimmed. Most of the operations in the past were carried out on a small scale with inadequate equipment, but were in general financially successful. Since these mines were closed tremendous advances have been made in earth-moving equipment, and it seems highly probable that a profitable mining industry could be built up in the county if ownership of leaseholds were consolidated, so that exploring, stripping and mining equipment could be moved from one property to another, and washing could be done at centrally located plants, to which the ore would be transported by truck.

Most of the drilling could be contracted with well-drillers at $1.00 to $1.50 per foot of hole, and stripping, mining and transport could be contracted also, using men and equipment recently employed in highway construction. There is one second-hand washing plant at the Southern Iron Mining Co. pit, and other second-hand washing machinery can probably be found outside the district.

Cherokee County appears to possess better qualifications for the Federal Government's program of increasing Eastern iron ore supplies quickly through the employment of road contractors and their machinery than any other county in North Carolina. The U. S. Bureau of Mines was given a special appropriation for drilling and testing iron ore deposits having such qualifications, and, if properly approached, the Bureau should be willing to do the necessary drilling without cost to the state.

C. C. MORFIT
Consulting Engineer
11 Broadway
New York

April 24, 1943

H. A. Brassert & Company
60 East 42nd Street
New York, New York

Gentlemen:

Submitted herewith is a report of Investigation No. 1, Sanford Coal Region, based upon field and office studies of the Dan River and Deep River coal fields of North Carolina.

It is our opinion further investigation of the Dan River Coal Field is not warranted as such coal as exists is thin and not possible of economic mining under present conditions.

The study of the Deep River Coal Field of Lee, Chatham and Moore Counties, developed indications of an extensive body of merchantable coal requiring diamond core drill prospecting to accurately determine the extent, thickness and pitch of the seam. Pending such prospecting, we believe it conservative to estimate an average coal thickness of forty inches, pitch of seam 14° or 24.8%, and for the present, 2,500 feet cover as the limit of workability. We consider only the upper bench of what is locally known as the Cumnock seam as merchantable coal, as our investigation of the lower bench under the black band showed a coal too high in inherent ash to lend itself to mechanical or other cleaning.

For the purpose of estimating the virgin coal reserves and the test drilling program necessary, the field was divided into three tracts as shown by the following tabulation. Reference to drill holes by Eavenson refers to five holes drilled under the direction of Howard N. Eavenson and Associates, the information with respect to which has not been released.

| | | | |
|---|---|---|---|
| Tract No. 1, | Proven area | 6,000,000 | Net Tons Recoverable Coal |
| | If logs of drill holes by Eavenson are available and prove coal as reported, | 2,500,000 | " " " " |
| | | 8,500,000 | Net Tons Recoverable Coal |
| | To be proven, | 8,511,560 | " " " " |
| Tract No. 1, | Total, | 17,011,560 | Net Tons Recoverable Coal |
| " " 2, | To be proven, | 9,964,567 | " " " " |
| " " 3, | To be proven, | 19,206,600 | " " " " |
| Total Indicated Territory | | 46,182,727 | Net Tons Recoverable Coal |

No allowance made for dip of seam.

| | | | |
|---|---|---|---|
| Tract No. 1, | 17,011,560 N.T. @ 1500 per day | = 43 years for | one mine |
| Tract Nos. 1 & 2, | 26,976,127 " " " " " | = 34 " " | two mines |
| Tract No. 1,2 & 3, | 46,182,727 " " " " " | = 30 " " | four mines. |

A summary of the estimated cost of diamond core drilling is as follows:

| | | |
|---|---|---|
| Tract No. 1, If records of Eavenson are available, | 8,250 ft @ 2.50 | $20,625 |
| Additional, if " " " not " | 2,500 ft @ 2.50 | 6,250 |
| Tract No. 1, | 10,750 ft @ 2.50 | $26,875 |
| Tract No. 2, | 14,000 ft @ 2.50 | 35,000 |
| Tract No. 3, | 15,000 ft @ 2.50 | 37,500 |
| Estimated Cost of Drilling Campaign to prove Tracts Nos. 1, 2 & 3, | | $99,375 |

Should drilling prove the dip of the seam less than that used for the location of the 2,500 feet cover line, then there will be a considerable increase in the estimate of tonnage reserves shown in the above tabulation.

In addition to the foregoing and depending upon the results obtained in proving the above three Tracts, and depending further upon an intensive geological study of the area in question, there is a possibility that there may be an appreciable acreage of workable thickness of coal in Moore County towards Carthage, west of Lee County line south of Deep River.

The coal in mining is quite friable but not nearly as much as the Sewell coal of the Tug River field of West Virginia. The following analyses show it to be an ideal fuel for domestic, gas, metallurgical and other industrial uses.

| | |
|---|---|
| Moisture | 1.04% |
| Volatile Matter | 34.07 |
| Fixed Carbon | 57.39 |
| Ash | 7.50 |
| Total | 100.00% |
| Sulphur | 1.81 |
| Phosphorus | 0.003 |
| $TiO_2$ | 0.003 |

The coal's coking characteristics makes it an excellent fuel for a Curran-Knowles type of coke oven plant. The commercial possibilities of this added industrial development for North Carolina by the installation of small key plants at points such as Raleigh, Charlotte, Winston-Salem and other similar locations, should be the subject of a separate report.

Regardless of past experience to the contrary, our investigation justifies the conclusion that mining operations properly financed and under capable management can operate successfully in this field and provide an attractive return on the capital invested. There are no insurmountable mining problems involved. With flame-proof equipment and adequate ventilation, mining operations should not be unduly hazardous and operations can be proceeded with under conditions ideal for complete mechanizations. As construction work at the various army camps in the vicinity is rapidly being completed, there should be an ample supply of local labor.

The following estimate of mining costs may conservatively be taken as representative of what costs will actually be. These costs are predicated upon a fully mechanized mine operating two shifts per day, 5 days per week, 260 days per year, producing 1,500 net tons per day or 390,000 net tons per annum. The estimate is based upon present mining and day labor rates and present costs of materials and supplies.

| | | |
|---|---|---|
| Loading cost | $ .80 | per net ton |
| Inside day labor cost | .46 | " " " |
| Total Inside Labor Cost | 1.26 | Per Net Ton |
| Outside Day Labor Cost | .23 | " " " |
| | 1.49 | Per Net Ton |
| Social Security and Workmen's Compensation Taxes | .10 | " " " |
| Total Mine Labor Cost | 1.59 | Per Net Ton |
| Material and Supplies | .30 | " " " |
| Power | .12 | " " " |
| Total Mining Cost | 2.01 | Per Net Ton |
| Office, Overhead & Taxes | .30 | " " " |
| Total Cost of Production | 2.31 | Per Net Ton |
| Depletion & Depreciation | .15 | " " " |
| Total Gross Cost of Production | $ 2.46 | Per Net Ton |

Pending final detail design and mine projections after the drilling campaign of Tract No. 1 is completed, we estimate a typical mine installation to produce the above tonnage to cost approximately $1,400,000 or $3.59 per ton of annual output.

A study of the potential coal market within a radius of 150 miles of the proposed development shows that typical cities within that area have a combined population of over 600,000 and an estimated coal consumption of over 3,300,000 tons per year. With proper preparation and a consistent source of supply, there is not logical reason why the estimated output of the field should no find a ready market. Contributing to this conclusion is the fact that coal shipped from this field to typical North Carolina points carries a freight differential in its favor of $1.24 to $2.41 per net ton as compared with the freight rate on coal from competing fields to the same destinations.

Using a sales price of $3.03 per net ton, based upon Amendment No. 40 to Maximum Price Regulation No. 120 of the Office of Price Administration, the operating possibilities of a single coal mine installation of a capacity of 390,000 net tons of coal per annum, we estimate to be as follows.

| | | |
|---|---|---|
| Sales: | | |
| 390,000 Net Tons | @ $ 3.03 | $ 1,181,700 |
| Cost: | | |
| Total Gross Cost of Production | @ $ 2.46 net ton | 459,400 |
| Indidated Annual Net Operating Profit, subject to Federal and State Income Taxes, | @ $ .57 net | 222,300 |

The installation of the four 1,500 net tons per day mining plants within the area of Tracts Nos. 1, 2 and 3 will protide employment for approximately 1,200 men.

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Due to loss of part of sample in shipment, we have been unable to include an analysis of the commercial possibilities from the mining and preparation of the Black Band ore underlying the upper bench of the coal seam. This phase of the examination should be covered by a supplemental report.

The result of our investigation fully justifies the recommended procedure towards the establishment of a coal mining industry in the State of North Carolina.

Respectfully submitted,

(Sgd) C. C. Morfit

CCM:ef

# MINING AT THE BIG ORE BANK IN LINCOLN COUNTY

The Big Ore Bank, about four miles north of Iron Station and six miles east of Lincolnton, was mined for about 100 years prior to 1882, but the workings were shallow, and the tonnage removed was not large. According to Nitze (Bulletin No. 1, N.C.G.S., p. 90) the old workings were scattered over a length of nearly a mile, and from the map published with the Tenth Census appear to be in two groups, one of which is 600 feet wide, and 2500 feet long. There is a gap of 1000 feet between the two groups. The last work is said to have been done at the "engine shaft", which was 100 feet deep. Nitze reconstructed a cross-section of the ore at the shaft, from verbal information, and showed three bands of ore, 38 feet wide in all, and between the ore-bands two bands of schist, together 7 feet wide, which probably contained a small percentage of magnetite. The ore and the included bands of schist could be mined together economically by sublevel stoping, the schist bands probably producing enough iron in the concentrator to pay for their treatment.

The ore is irregular in length, width and height, and will require close and careful prospecting underground, if no ore-bodies are to be overlooked; but it is likely that average production per unit of area or length on the vein will be fairly uniform. This irregularity of occurrence will increase the cost of mining and development, especially the amount of exploratory drifting.

As the Big Ore Bank is the most promising of the old mines in the magnetite belt that crosses Lincoln County, it has been selected as an example for estimating costs of development, equipment and operation It is assumed that the ore has been mined to a depth of 100 feet, although this is true only in part, and new mining will be done below that depth.

Underground mining will, therefore, be employed, and the ore will be hoisted through a shaft. Probably one hoisting shaft will be enough to serve the whole property, but in this theoretical study only the southern half of the old mine will be considered.

The old engine-shaft was in the hanging wall, but the new shaft should be in the foot-wall, not less than 150 feet from the ore-body. In this preliminary project the shaft will be located about midlength of the ore, drifts extending about 1200 feet northeast and southwest. From these drifts cross-cuts will be driven at intervals across the ore-formation to cut the variousveins shown by diamond drilling from surface. It is probable that diamond drill holes will also have to be drilled underground across the formation from the drift between the cross-cuts in order to obtain information necessary for planning the stopes.

The size and design of the shaft depend on the amount of ore and rock hoisted, and that will depend on the analysis of the ore and the capacity of the furnace. If we assume a concentrating ratio of two to one and a concentrate containing 69% iron, a furnace producing one hundred tons a day of finished product will require approximately three hundred tons of crude ore per day. From development there will be about fifty tons more, mostly waste, making the total amount to be hoisted three hundred and fifty tons per day.

One hoist is capable of handling men, supplies, ore and waste. The arrangement recommended for shallow depth is a skip and a cage in balance for double-shift hoisting. For single-shift hoisting, and for depths greater than five hundred feet there should be two skips in balance with cages above them. In either arrangement the skip is idle when the cage is in use, and vice versa. Consequently the time available for hoisting ore and waste will be about five hours per shift, and the capacity per hour must be seventy tons for single-shift hoisting, or thirtyfive tons for double-shifting hoisting. If a two-ton skip is used and hoisting is done on two shifts, a skip and a cage in balance will have ample capacity down to a depth of five hundred feet.

A shaft 12 ft. 10 in. long and 5 ft. 2 in. wide inside of timbers, with three compartments, will be large enough. There will be two hoisting compartments and a pipe-and-ladder road. It is proposed to sink this shaft to a depth of three hundred and fifty feet at the start, and to open levels at two hundred feet and three hundred feet, leaving a sump and skip-pit fifty feet deep.

The headframe should be about sixty feet high, and should contain two pockets, one for waste and one for ore, into which the skip will dump directly.

Waste will be trammed up a trestle to a dump, ore will be hauled away by truck.

Ore will pass through a primary breaker, and will then be elevated on a belt to a fine crusher, before going to the fine-grinding and separation plant.

It is proposed to house all of the buildings, except the garage and the treatment plant, under one roof. The estimate does not cover the treatment-plant.

<u>General Specifications</u>

1. <u>General expense during construction</u>

Office expense, taxes, royalty, supervision, accident insurance and miscellaneous.

2. <u>Shaft</u> (Drawing)

Vertical, 12 ft. 10 in. long by 5 ft. 2 in. wide inside, with three compartments. Lined with sets of 8 x 8 timber on 5 ft. centers, with

2 in. lagging and 6 x 8 dividers. Depth 350 feet. Levels at -200 feet and -300 feet.

Material: 10 ft. earth. 340 ft. rock, probably schist.

Shaft Plat: (Drawing) 200 ft. long. 2 pockets or chutes.

Air shaft and second outlet; connection through old workings.

3. Underground Development

Mining system: Sublevel stoping

Main drifts and cross-cuts: 3000 feet.

Stope development: (2 stopes) 2200 feet.

Connection to air-shaft: 500 feet.

Underground diamond drilling: 5000 feet.

4. Maintenance of Equipment

Repairs during construction period.

5. Preparing Site

Grading, roads, water supply, etc.

6. Head Frame

Steel or wood. 60 ft. high. A type.

Skip-dump and butterfly gate. 2 pockets for ore and waste. Two 6-ft. head-sheaves.

7. Waste Dump

Trestle 200 feet long. Car and hoist.

8. Hoisting Equipment

Single drum, 5 ft. x 5 ft., grooved for 1-in rope.

Herringbone gears to 50 H.P. slip ring motor.

Rope speed 500 feet per minute.

1 pulley stand.

2 two-ton Kimberley skips, welded.

2 cages, enclosed, with doors, welded. Safety catches.

1400 ft. 1 in. 6 x 19 Plow steel rope and two sockets.

Lilly controller.

9. Main Building

Brick, or corrugated iron insulated with mineral wool, whichever is cheaper. 160 ft. by 30 ft. One story. Concrete floor. To house office, warehouse, shops, boiler and coalbin, engine room, and change-house for sixty men.

10. Air Compressor and Air Pipes

Type 10 Imperial, two stage compressor, capacity

1000 CF. M. delivered air.

150 cu. ft. receiver and piping.

Cooling pond and pump.

650 ft. 6 in. pipe.

1000 ft. 4 in. pipe.

2000 ft. 3 in. pipe.

2000 ft. 2 in. pipe.

1000 ft. 1 in. pipe.

4000 ft. 1/2 in. and 3/4 in. pipe.

Fittings.

11. Rock Drills

6 Drifters

3 Jackhammers

2 Stopers

2 Spares

Hose, steel, etc.

12. <u>Loaders</u>

1 EIMCO No. 12 Loader

2 Scraper hoists and scrapers. Wiring and cable.

13. <u>Haulage</u>

2 2-1/2 -ton S.B. locomotives

2 extra batteries.

1 charging set or converter.

10 2-ton Granby cars.

3000 ft. track. 30 lb. rails.

14. <u>Pumping</u>

Cameron two-stage motor pumps with automatic control.

2000 g.p.m. against 300 ft. head.

Sump pump.

15. <u>Shops</u>

Carpenter shop: bench, saw, borer, joiner, grindstone.

Blacksmith and drill shop: blower, forge, anvil rod-cutter, bit grinder, electric furnace, electric arc welder, cutting torch.

Machine shop: lathes, drill press, pipe machine, bolt cutter, shaper, hacksaw, grinder, air drill, motor and shafting. Bench and vises. Tools.

Electrician Shop: Bench and vise. Testing instruments.

16. <u>Trucks and Tractors</u>

1 2-1/2 ton tractor and bulldozer.

1 two-ton truck

1 wagon. Garage and repair tools.

| | | |
|---|---|---|
| 5. | Prpparing site | 5,000 |
| 6. | Head-frame, skip dump and pockets | 15,000 |
| 7. | Waste-dump and trestle | 5,000 |
| 8. | Hoisting equipment | 10,000 |
| 9. | Main building | 23,000 |
| 10. | Air compressor and air pipes | 12,000 |
| 11. | Rock drills and steel | 12,000 |
| 12. | Loaders | 10,000 |
| 13. | Haulage | 20,000 |
| 14. | Pumping | 5,000 |
| 15. | Shops | 15,000 |
| 16. | Trucks and tractor | 5,000 |
| 17. | Ventilation and connection with old workings | 5,000 |
| 18. | Office and engineering equipment | 4,000 |
| 19. | Change-house equipment and first aid | 3,000 |
| 20. | Preliminary exploration | 20,000 |
| 21. | Transformers and power line | 10,000 |
| 22. | Housing | 40,000 |
| 23. | Contingencies | 11,000 |
| | Total | $400,000 |

The cost of exploring, developing and equipping the mine for a production of three hundred tons of crude ore per day, but not including the magnetic concentrator, is estimated to be $400,000. Thisis roughly $4.50 per ton of annual production, and $6,000 per man employed. To bring the mine to full production will require 18 to 20 months, including six months of surveying and diamond-drilling.

Cost of Production

On the basis of the same assumptions, on which the estimate of the cost of developing and equipping the mine was based, the cost of production has been estimated as follows:

| | |
|---|---|
| Number of men on surface | 25 |
| Number of men underground | 40 |
| Total number of men | 65 |
| Tons per man per day | 4.75 |
| Average wages per day | $6.00 |
| Cost per ton of crude ore: | |
| Labor | $1.25 |
| Supplies | .85 |
| Total | $2.10 |
| Concentrating | .25 |
| Total | $2.35 |
| Concentration ratio: 2 to 1 | |
| Cost per ton of concentrates | $4.70 |
| General overhead | .30 |
| Total | $5.00 |
| Cost per unit of iron | $ .07 1/4 |

17. Ventilation

Old sprays. Fan and tubing. Connections to old workings.

18. Office and Engineering Equipment

Office furniture, calculating machines. typewriters, surveying instruments. Sample preparation.

19. Change House

Lockers, clothes hooks, washing and sanitary conveniences, safety and first aid. Heat.

20. Preliminary exploration

Plane and magnetic surveys.

Diamond drilling. 5,000 feet @ $3.00

21. Transformers and power line

Transformers, meters, lightning arrestors, power line from substation to plant.

22. Housing

Boarding-house, houses for mine foreman, shift-bosses; mechanic, clerk and five families of workmen. Most of the employees will live in Lincolnton or neighboring villages.

Capital Expenditure

| | | | |
|---|---|---|---|
| 1. | General Expense during development | | $55,000 |
| | Mine office | 12,000 | |
| | Taxes and Royalty | 10,000 | |
| | Supervision | 18,000 | |
| | Insurance | 14,000 | |
| | Miscellaneous | 1,000 | |
| | | $ 55,000 | |
| 2. | Shaft and 2 plats (Including sinking equipment) | | 50,000 |
| 3. | Main level development | | 60,000 |
| 4. | Maintenance of equipment | | 5,000 |