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Preliminary report

on

Iron Ore Reserves at Bomi Hills, Liberia

by

W. H. Newhouse, T. P. Thayer, and A. P. Butler, Jr.

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INTRODUCTION

At the request of the Liberian Government made through the Department of State of the United States Government, a party of geologists of the Geological Survey, United States Department of the Interior, was sent to Liberia to examine certain mineral deposits. The party, consisting of Walter H. Newhouse, Thomas P. Thayer, and Arthur P. Butler, Jr., left Washington, D. C., about December 1, 1943, and arrived in Monrovia, Liberia, December 12, 1943. They left Roberts Field, Liberia, May 5, 1944, and returned to Washington May 16, 1944.

The geologists left Monrovia for field work in the interior on January 9, the delay of several weeks being due to difficulties in obtaining porters. Mr. Arthur Sherman, Mining Engineer for the Liberian Government, who accompanied the party into the interior, capably participated in the examination of the iron deposits and otherwise rendered invaluable assistance due to his extensive knowledge of the native tribes and trails.

President Tubman requested that the party first examine the iron deposits at Bomi Hills. At the close of the work there he requested that iron deposits in the Kpandemai Mountains be investigated. The party therefore left Bomi Hills on March 25 and arrived at Jordense Camp in the Kpandemai Mountain region on April 6. Four days were spent at this place examining the iron mineralization in the vicinity of Castle Rock, Sugar Loaf, and Mt. Wutivi of the Kpandemai Mountains. On April 11 Kpandemai village was reached. One day was spent on a long traverse into the Kpandemai Mountains to investigate the iron mineralization.

The party left Kpandemai Village April 15 and arrived at Monrovia April 27.

The iron mineralization in the portions of the Kpandemai Mountains investigated by the party is believed to be too low in grade and too small in amount to be of any present commercial interest and will not be considered further in this report.

LOCATION

The Bomi Hills are approximately 40 miles north of Monrovia. They are reached by motor launch from Monrovia to Brewerville, and thence by trail through the villages of Biegona and Maher. Two and one-half days were required for the trip from Monrovia to the camp at Bomi Hills.

It is reported that an examination of the iron deposits at Bomi Hills had been made by the Holland Syndicate and Noord Europeesche Ertz en Pyriet Maatschappy, the latter organization having done about 4150 feet of diamond drilling. The drill cores were examined for lithology and samples of the high-grade ore and iron formation were taken, but identifying marks relating the core to the holes had been removed before our examination. Representatives of the United States Steel Corporation examined the deposits in 1938-39.

FIELD WORK

The examination of the Bomi Hills deposit, upon which this report and a subsequent comprehensive report to be written later are based, lasted 72 days. A plane table map on a scale of 200 feet to the inch was made, showing topography, location and nature of outcrops, ore deposits, and location of dip needle surveys. Many traverses with a dip needle were run to secure information concerning thickness and location of ore bodies where bed rock was covered by canga and other surficial deposits.

GENERAL GEOLOGY

Metamorphic and igneous rocks predominate in the western part of Liberia and these general types form the country rock in the Bomi Hills. As there observed in surface exposures and in the diamond drill cores, the country rocks include gneisses, schists, iron formation, granite and very minor diabase.

Gneissic rocks abound, with much variation in mineral content. In these a prominent constituent may be any one of the minerals--quartz, feldspar, mica, chlorite, hornblende or epidote. The granitic rocks although usually gneissic, are described in a later paragraph. Mica schist, chlorite schist and minor quartzite are present in the diamond drill cores. The schists are exposed in certain of the trenches and pits but rarely crop out in the Bomi Hills region.

Iron formation consisting mainly of quartz and either magnetite or hematite, or both of these iron oxides, crops out particularly on the northern and eastern parts of Bomi Hill and was intersected in considerable amount by the diamond drill cores. The iron formation is well laminated with alternating layers of medium grained quartz and one or both of the iron oxides. Locally some silicate is interlaminated with the quartz and iron oxides.

Two varieties of granitic rock are present, one light gray, the other pink in color. Although locally these show only slight gneissic structure usually the foliation is pronounced. They are interpreted as later in age than the associated metamorphic rocks and are believed to have been formed by granitization.

Although diabase is widely present near the western coast of Liberia and was seen in a number of hills in the interior, only a few small boulders were found on the surface in the vicinity of the iron deposits.

STRUCTURAL GEOLOGY

The iron-bearing rocks on the Bomi Hills occur as lenticular masses surrounded by gneisses and granites. The smaller lenses in Jupi and West hills are simple, but the larger mass in Bomi Hill probably is a shallow basin-like fold bounded on the north by en echelon asymmetrical anticlines.

West Hill proper may be made up either of a single long narrow body of iron formation which is thinner and bent near the middle, or of two masses, slightly out of line. The deposits strike about N. 70° E. and dip between 50° N. and vertical, the average dip being about 75° N. The iron formation flattens from a dip of 75° N. to nearly horizontal just before it apparently pinches out at the east end of West Hill. The small hill east of West Hill is formed by a lens of iron formation about 450 feet long dipping 25° to 40° N. and striking parallel to, but offset 400 feet south of, the axis of West Hill. No evidence was found suggesting that this body is a faulted portion of the West Hill mass.

The crest of Jupi Hill is covered with large blocks of iron formation, mixed with some iron ore. A 35-foot cliff along the north side at the east end of the summit shows a dip of 75° to the north and a strike almost in line with the magnetite lens 800 feet farther east. Large float boulders and high magnetic readings along the line of strike in the gully 300 feet east of the cliff show that the iron formation extends at least that far, and suggests that the two bodies are continuous.

The narrow eastern end of Bomi Hill is similar in structure to Jupi Hill. The layering in the iron formation dips vertically or steeply to the north where the strike is about west. Toward the east end the strike swings northward parallel to the ridge crest and dips decrease to 45°; and at the east end of the ridge the strike of the iron formation swings past north to about N. 80° W., apparently around the nose of a syncline plunging west.

The structure in the main part of Bomi Hill has many of the aspects of a complex asymmetrical basin. The iron ore along the south side in general dips vertically to 80° northward; steep northward dips in ore body No. 2 and at the base of the high cliff on ore body No. 1 suggest that the dip of the ore flattens toward the north at depth. Fine-grained gneiss and granite are believed to lie immediately south of (below) the iron ore. In the east end of the 821-foot summit the strike of iron formation and iron ore swings from N. 75° E. on the south side around to northwest on the north side; dips decrease from 65° N. to 10° or 15° W. near the center of the structure, and farther north increase again to about 55° S. Granite float was found on the steep east end of this part of the hill, about 100 feet vertically below the iron ore, and there are good exposures farther down, so it seems probable that the granite contact curves with the other structure.

The structure at the west end of the main ore zone, as revealed by iron ore exposures, seems to be more complex. The western part of ore body No. 1 swings from a west strike to N. 35° W. and flattens in dip from vertical to 50° or 55° N. E. This pattern is repeated in the southern half of ore body No. 4, except that in that ore body the dip relations are reversed: the east-west portion dips 60° N., and the part striking NW dips vertically or steeply to the east. The northwest-striking parts of the two ore bodies are in line, and therefore probably are related to the same structure. Between the two exposed parts of ore body No. 4 the structure flattens, and in the northern part it bends down to the north, steepening from 25° to 90° in dip, with the strike averaging about N. 85° W. A few very large blocks and heavy float in the gap between the two parts of this ore body are regarded as evidence that the ore is continuous, though it may be very thin. The west end of ore body No. 4 is directly in line with the magnetite lens in the east end of Jupi Hill.

The relations along the northern margin of Bomi Hill are completely concealed and are not known. Granite float occurs and weathered gneiss is exposed less than 200 feet north of ore body No. 5, but no structure is discernible. Ore body No. 5 has the appearance of an asymmetric anticline, for the layering dips 80° to 90° along the south edge and flattens northward to 55° N. at the west end and 20° N. at the east end. This ore body is in line with the crest of an anticline in banded iron formation exposed 150 to 200 feet farther east. Nearly all of the exposures east of ore body No. 5 along the lower slopes or Bomi Hill are on banded iron formation striking N. 80° to 85° W. anddipping either steeply northward or bent into sharp asymmetric anticlines overturned toward the north.

Layering in iron ore does not everywhere parallel the long dimension of the ore bodies. At the east end of ore body No. 1 layering conspicuously shown by oriented silicates strikes at an angle of about 25° to the trend of the lens, but parallel to the layering in adjacent iron formation. From diamond-drill hole B1 to the end of the exposures west of the Drill Camp, a distance of about 200 feet, the layering strikes consistently about N. 85° E, though the ore body as a whole swings to about N. 65° W. Similar discordance of structures is shown in the southernmost exposure on ore body No. 4, which trends at about 30° to the internal layering. Divergence of layers within massive ore is unusually well shown in one exposure on this ore body, where layers differ by 55° and 30° in strike and dip respectively, within a distance of 20 feet; in this instance the layers parallel the contact and the thickness of the ore changes rapidly along the strike. In the places where gradational relations are shown between iron formation and iron ore the layering in the two rocks is conformable.

In summary, the high-grade ore lenses lie along zones of parallel fractures that appear to be localized mainly on the steep north-dipping flanks of folds. The individual planes of fracture in the rock that has been replaced and that are now represented by layers in the ore, are often approximately parallel to the layering of adjacent iron formation. However, the trend of the zone of fracturing and of several of the larger ore lenses locally forms an angle of 20°-30° with the strike of the individual fracture planes or ore lamellae.

IRON ORES

Two principal types of iron-bearing rocks are present in the Bomi Hills district. One of these is variable, consisting of massive high-grade ore with local transitions to ore with considerable silicate. The other type is the thin layered, quartz-iron oxide rock that is referred to as iron formation.

HIGH-GRADE ORE

Massive ore

The high-grade ore is massive to coarsely layered magnetite with minor silicate. In the outcrops the magnetite of this ore has been oxidized in varying degree to hematite and some of the silicate has been removed by solutio This ore grades into schistose magnetite-silicate ore with a progressively lower percentage of iron as the gangue minerals increase. The silicate minerals present in the ore are anthophyllite and chlorite. In the estimates massive high-grade ore includes all with less than 2 percent silica.

Silicate-bearing ore

In places the percentage of silicate increases near the sides and ends of the high-grade ore lenses. On the cliff or bluff faces, large slabs of such ore break off along the weak silicate bands, leaving only the more massive ore in the center exposed. The type of ore containing more silicates disintegrates by weathering so that outcrops are lacking.

In the estimates high-grade silicate-bearing ore includes all with silica between 2.00 and 13 percent.

MILLING-GRADE ORE

Silicate-bearing ore

With increase in the amount of silicates the percentage of iron decreases and milling would be necessary before shipping. Such ore is present at the Drill Camp on the summit of Bomi Hill and along the ridge trail east of the camp where it is partly covered by canga. The ore at these two places is estimated to contain 40-50 percent Fe.

Iron formation

Fresh unaltered iron formation is a very hard well-layered rock consisting of quartz and hematite or magnetite. The layering is formed by variations in the proportions of the quartz and iron oxides; it is more perfectly developed in the hematite facies because of the platy character and orientation of the hematite grains. The octahedral habit of the magnetite gives the other facies a more granular appearance. The layers range in thickness from almost microscopic dimensions up to about a quarter of an inch.

Microscopic examination of a few specimens indicates that the quartz grains are from 0.05-1.2 mm. in diameter, and the hematite grains and crystals range from 0.2-1.0 mm. in the iron-rich layers, and from 0.02-0.20 mm. in the quartz-rich layers. The magnetite ranges in grain size from about 0.01 to 1.0 mm.

ORIGIN

The iron formation is probably a metamorphosed iron-rich sedimentary rock.

The massive ore and the silicate-bearing ore are considered to have been formed by hydrothermal replacement which when most complete formed the high-grade ore. The rocks replaced include iron formation and chlorite-mica gneiss.

RESERVES AND GRADE OF ORE

GRADE OF ORE

The accompanying table presents the results of chemical analyses of the samples in weighted and summarized form.

Samples of the high-grade ores and iron formation were taken from the diamond-drill cores and some of the outcrops. The cores of the high-grade ore and part of those of the iron formation had been split and one-half removed from the core boxes. Our samples of these were made by taking one to two-inch pieces of the split core at six to twelve inch intervals across the total length sampled in a core box. The generally uniform character of much of the ore lends confidence to the belief that this method, although less accurate than complete core sampling, will give a close approximation of the composition of the ore. Further details of the portions sampled will be given in the drill logs to be included in the final report.

Weighted averages and range in grade of ores
Bomi Hills, Liberia

		Fe	SiO_2	P	S	Number of samples	True thickness
Fresh ore from drill cores							
High grade ore							
Massive, under 2% SiO_2	Average	69.33	1.18	0.072	0.029	22	514
	Range	67.98-70.74	0.61-1.95	0.017-0.135	0.010-0.199		
Silicate bearing, 2%-13% SiO_2	Average	65.93	3.92	0.076	0.042	19	385
	Range	56.78-69.44	2.01-12.95	0.027-0.125	0.008-0.103		
Iron formation	Average	42.11	36.95	0.044	0.029	13	200
	Range	36.79-49.10	32.57-42.08	0.017-0.089	0.019-0.052		
Surface samples and weathered drill core							
High grade ore							
Massive, under 2% SiO_2	Average	69.10	0.61	0.066	0.021	11	225
	Range	66.70-70.40	0.31-1.56	0.017-0.[illegible]	0.008-0.035		
Silicate bearing, 2%-13% SiO_2	Average	65.16	5.91	0.056	0.028	5	55
	Range	62.66-67.10	2.74-9.53	0.011-0.093	0.016-0.040		
Iron formation	Average	45.93	35.39	0.027	0.028	20	150
	Range	33.11-60.56	11.16-41.81	0.009-0.054	0.018-0.067		

Time, labor and equipment were not available for cutting good channel samples of the outcrops. Contiguous chips were taken along a shallow cut across an outcrop, thus obtaining a sample with less validity than one taken by channeling. This work was done by the senior member of the party using hammer and moil. Before taking the sample an attempt was made to remove the oxidized and leached material at the surface. The sample was then taken with much effort given to uniformily chip a shallow trench across the length sampled. Some of the samples obtained in this manner are certainly enriched in iron by partial leaching of gangue minerals and surface enrichment by deposition of limonite. All samples were crushed to pass through a screen of approximately 15 mesh and were then quartered to a final weight of about one pound. Analyses were made by Lerch Brothers, Inc., Hibbing, Minnesota.

Eleven diamond-drill hole st ··ons were found of the fifteen reported to have been drilled. The approxi·ate position of the other four stations is believed to be known. The posi·ion of the stations indicates that the drilling was done to explore ore bodies numbers 1 and 4 and the zone between them. Except in the weathered rocks the core recovery evidently was good. Although all identifying marks have been removed from the drill core boxes by Mr. Hendrik Jordense of the Dutch company, it is considered highly probable that the drill core samples give the approximate composition of ore bodies Nos. 1 and 4 and of the iron formation in their vicinity. The samples from the outcrops were taken chiefly from the smaller ore bodies and iron formation in other parts of the area.

RESERVES

The reserves are divided into two classes: (1) shipping-grade ore, which includes massive magnetite and silicate-bearing ore in place, and surficial talus and canga containing over 50 percent Fe; (2) low-grade magnetite-silicate rock and iron formation that might be suitable for concentration. The division between high-grade massive ore and high-grade silicate-bearing ore was placed at 2 percent silica because this is regarded as about the dividing line between ore which will form outcrops and ore which disintegrates on weathering due to content of silicates. The figure was arrived at by comparison of field information with chemical analyses. The division of high-grade ore into these two classes has thus been made for purposes of ore estimation rather than for technical or economic classification.

The outcrops of massive magnetite give a minimum figure for the thickness of the ore bodies, as has already been indicated (see p. 8), for the stratigraphic thickness of silicate-bearing ore cut by drill holes is about 70 percent of the massive ore encountered. Since all the drill holes are believed to be in ore bodies Nos. 1 and 4, in which minor quantities of silicate-bearing ore are exposed, it is considered that estimating the silicate-bearing ore as equal to 70 percent of the massive ore is conservative, particularly since the ends of some of the ore bodies, where the proportion of silicate-bearing ore probably is larger, were not drilled. Preliminary study of the dip needle survey data gives strong support to this conclusion.

The reserves of the various types of high-grade ore have been divided into two categories, indicated and inferred. The figures for indicated ore are based on dimensions of outcrops or float blocks along the extensions of outcrops which indicate ore essentially in place, and depths to which ore seems assured by the geology. The figures for inferred ore are based on the same surface dimensions as indicated ore, projected to depth to which the ore is likely to go; they do not include the figures for indicated ore. All depths given are measured from the top of the outcrop. Concealed extensions of ore bodies, such as the talus-covered east end of ore body No. 1, have not been included in any of the estimates, and the factor for silicate-bearing ore has been omitted from bodies in which this type of ore is not indicated by exposures or float.

High-grade ore

Ore body No. 1.--Ore body No. 1 is exposed continuously over a length of about 1,500 feet, and the thickness probably ranges from about 45 feet at the west end to 150 feet near the east end. The width of the outcrops is less than the thickness of the massive ore, because the ore body probably dips 80° to 85° northward and the north contact is at least 20 feet and at most 120 feet above the southern contact. The thickness of the ore body in the saddle east of diamond-drill hole A2 is unknown, because the entire area is covered with canga, except for the ore exposures around Monument 3. The canga here overlaps massive ore of the main ore body, and on the knoll to the east contains large blocks of massive ore, even though it stands above the nearby ore outcrop. The exposures at Monument 3 are directly in line with the north edge of the ore body as exposed 250 feet farther east, and are thought to be an extension of it, along a zone of replacement in the iron formation. These relations are believed to justify application of the 70 percent factor for silicate-bearing ore to the thickest part of the ore body, even though the north contact is exposed and the ore in part contains silicates.

The flat at the Drill Camp may be underlain by minable ore. It is covered with float of silicate-bearing ore, and at the west end a low ridge of iron ore float may be traced continuously from the unnumbered drill hole, across the trail, to the main ore outcrop west of drill hole B1. The distribution of float and high magnetic anomalies suggest that the flat is held up by a lens of ore that branches from the main body.

For purposes of calculating reserves the length of the north-west segment of ore body No. 1 is taken as the distance from the south end of the cliff east of Elephant Draw to a block of ore 20 feet thick, standing on edge at the north end of a line of large blocks that apparently are nearly in place.

Ore body No. 2.--Ore body No. 2 is considered as 350 feet long because, although the exposure is not quite that long, large blocks indicate that ore extends at least 100 feet east of the outcrop in thicknesses exceeding 10 feet. An average thickness of 40 feet is used in the calculations, on the premise that the ore dips northward, but much more steeply than the 45° dip in the end of the upper trench would suggest. The width of outcrop at the east end probably does not indicate the true thickness, because all the structures in the ore dip northward, and the hanging wall contact is about 75 feet higher than the footwall. Heavy canga containing blocks of silicate-bearing ore on the ridge crest above the cliff suggests replacement of iron formation by silicate-bearing ore similar to that found in ore body No. 1. Silicate-bearing ore of shipping grade may also be found along the westward extension of the main ore body under the trail at Monument 5.

Ore body No. 3.--Ore body No. 3 is exposed over a length of slightly more than 400 feet, and the thickness indicated by the layering is about 50 feet. However, the layering in parts of the body shows complex folding, and linear structure is shown by cylindrical openings left by leaching of silicates. This raises the possibility that the ore body as a whole may be in the crest of a sharp fold and therefore be relatively shallow. The possibility is lessened by the fact that the ore zone extends eastward around the hill for a known distance of about 700 feet, and is compensated somewhat by extension of the ore an unknown distance under the fault at the top. The ore in the zone east of ore body No. 3 is about 25 feet thick in the exposure at the bend in the slope, and that thickness is used for the zone as a whole; it is all estimated as silicate-bearing ore.

Ore body No. 4.--The exposed portion of the upper part of ore body No. 4 is about 450 feet long, and the exposures of massive ore average about 20 feet in width. The largest exposure, south of dip-needle line 20, stands on edge in a 25 foot cliff which is paralleled on the east by a short rib of massive ore about 15 feet wide. The concealed rock between the ribs probably is silicate-bearing ore, for along dip needle line 20 silicate-bearing and massive ore can be traced almost continuously across a width of 60 feet. The indicated total width of the central part of this ore body, including silicate-bearing ore, therefore is 50 to 60 feet instead of the 20 feet used in calculating the tonnage of massive ore. The dip-needle survey indicates that the deposit extends well beyond the southernmost exposure, and the Dutch thought it worthwhile to drill a hole about 150 feet farther southeast on the line of the ore.

The dimensions of the lower part of ore body No. 4 are calculated as 400 by 20 feet, although the ore tapers to about 10 feet in thickness at the west end. The ore in the flat-lying part of the body is 8 to 10 feet thick, and it, with the concealed extension indicated by the dip-needle survey, should amply compensate for the taper of the ore body.

Ore body No. 5.--Ore body No. 5 has the appearance of a tabular mass 20 to 25 feet thick folded into an asymmetrical anticline that narrows westward.

The south limb dips 80° south or vertical; the north limb dips 20° at the east end and 50° to 60° at the west end of the exposure. The structure of the ore body makes estimation of the amount of ore very uncertain and the figures given in the table perhaps indicate the relative size of the deposit with respect to the other ore bodies more accurately than the actual reserves.

West Hill.--The ore body on the summit of West Hill is a simple lens of high-grade ore about 250 feet long and 40 feet thick; Small pipe-like cavities from which silicates have been leached indicate linear structure parallel to the direction of dip. The linear structure and large accumulation of talus to the south suggest that the ore body may be more persistent in depth than the exposures would indicate.

Talus.--Although iron ore talus covers much of the western half of Bomi Hill probably only a small part would be minable. The ore in the talus is higher in grade and harder than the average in place, because massive magnetite is more resistant to weathering, and more apt to form blocks than silicate-bearing ore, and blocks of silicate-bearing ore have been enriched by leaching or replacement of the silicates by iron oxides. The accumulation of blocks on the slopes west and northwest of Elephant Draw is extraordinarily heavy, and would be readily minable. It seems probable that there the talus averages a minimum of 10 feet in thickness over an area 300 feet wide and 800 feet long immediately west of the ore outcrops, including the 50,000-ton block that forms the west side of Elephant Draw. The two pits at the foot of the slope were sunk to a depth of about 6 feet in sandy red soil between iron ore blocks, without finding evidence that the bottom of the pile had been reached. The figures given in the table are for half the estimated actual depth of talus, to allow 50 percent space for voids. The indicated and inferred tonnages would represent the amount of ore removed from the ore body by erosion from former land surfaces 50 and 85 feet higher, respectively, than the present one.

Talus blocks up to 30 by 20 by 10 feet are scattered over the western and southern slopes of Bomi Hill up to 800 feet from the major ore bodies, and some rather large areas are literally paved with blocks of iron ore.

Canga.--Knowledge of the amount of canga that might be mined is limited, as very little attention has been paid to exploration of this type of ore. Canga is known to be widely distributed, but no attempt was made to map the areas, and thicknesses are known only from the breaks along the lower edges of major deposits. In a few places thicknesses of 15 to 20 feet were seen, but the average thickness of high-grade material probably is less than 10 feet. Because of the high porosity, about 15 cubic feet should be allowed per long ton of ore.

The canga is unusually well exposed in a strip about 1,600 feet long and 200 feet wide, lying parallel to and 400 feet east of ore body No. 4 and the northwest end of ore body No. 1. Along the east edge of this strip the cliffs range from 5 to 18 feet high, and to the west the canga feathers out on the steeper talus covered slopes; an assumed average thickness of 10 feet therefore seems reasonable. If 15 cubic feet of canga in place equal a long ton, this strip contains somewhat over 160,000 tons of ore, a relatively small amount that would probably be comparatively expensive to mine. Therefore, although some canga might be mined, this type of ore is not believed to be an important factor in the total iron ore reserve of Bomi Hill.

MILLING-GRADE ORE

The largest reserve of milling-grade ore is represented by the banded iron formation, but this would probably not be mined until the higher grade silicate-magnetite rocks have been exhausted.

Silicate-bearing ore.--The diamond drill cores contain some appreciable tonnage of semi-friable chlorite-magnetite rock, and surface exposures indicate substantial amounts of schistose silicate-magnetite rock formed by enrichment of iron formation. When fresh, the iron formation is a very dense hard rock that would have to be ground rather fine to free the iron oxides. The silicate-bearing rocks, in contrast, break down rather easily along the cleavages in the schistose minerals, and most of them are also richer in iron. Moreover, these rocks are localized along the edges or extensions of high-grade ore bodies, where they could be sampled and mined along with them. Information regarding reserves of this type of ore is lacking, and although no estimate of indicated tonnage can be made, they are believed to be on the order of a few million tons localized chiefly along the crest of the main part of Bomi Hill.

Iron formation.--The reserve of iron formation averaging about 42 percent Fe is undoubtedly large, and probably measured in many tens of millions of tons, but might easily be overestimated. The exposures in the narrow eastern part of Bomi Hill prove that the iron formation is continuous along the ridge, and the exposure halfway down the north slope would suggest a considerable width, except that numerous granite boulders were found high up on the north slope farther east.

The apparent structural continuity shown on the outcrops along the lower slopes of the main part of Bomi Hill suggests that the iron formation is continuous and homogeneous, and it would be easy to suppose that the entire basin is in iron formation. However, the pit east of the upper part of ore body No. 3 and the pits west of the Drill Camp show that gneisses and schists occur structurally above the main ore bodies. Moreover, the diamond-drill cores are believed to indicate that fully half of the iron formation adjoining the main ore bodies has been partly or completely replaced by chlorite and epidote. Iron formation altered in this fashion probably weathers to red soil or canga similar to that formed on mica gneiss, and certainly would not crop out. Preliminary study of the dip needle survey gives strong support to the belief that the iron formation is continuous across the basin even though outcrops are not abundant.

Summary

It is estimated that approximately 5 million long tons of "indicated" high-grade ore, and over 9 million long tons of "inferred" high-grade ore are present at Bomi Hill. Of this, the massive ore, 8,900,000 tons, is considered to have a composition approximating 67.0-69.0 percent Fe, 1.00-1.50 percent SiO_2, 0.07-0.08 percent P and 0.03-0.04 percent S. The silicate-bearing ore, 5,900,000 tons, is considered to have a composition approximating 64.0-66.0 percent Fe, 3.0-5.0 percent SiO_2, 0.06-0.08 percent P and 0.04-0.05 percent S. The total of over 14 million tons would contain approximately 66.0-67.0 percent Fe, 1.8-3.0 percent SiO_2, 0.06-0.08 percent P and 0.03-0.05 percent S.

The milling-grade ore, chiefly iron formation, is estimated at 75 to 150 million tons of inferred ore. The bulk of the tonnage shown in the table is on the main part of Bomi Hill. The dimensions used for calculating the tonnage at that place, particularly the inferred depth, are regarded as conservative. The grade of this ore is considered to approximate the average obtained from the fresh drill cores; 42.11 percent Fe, 36.95 percent SiO_2, 0.044 percent P and 0.029 percent S.

Reserves of high-grade iron ore, Bomi Hills, Liberia

Ore body	Length	Width or thickness	Area, in sq.ft.	Cu.ft. of ore per long ton	Long tons per foot of depth	Indicated depth	Inferred depth	Massive ore Indicated tonnage	Massive ore Inferred tonnage	Silicate-bearing ore Inferred tonnage	Total
No. 1, Main Section	1,550	45-150	110,000	8	13,750	250	400	3,4[illegible]3,000	2,063,000	3,847,000	9,348,000
No. 1, Northwest portion	700	25-32	20,000	8	2,500	200	400	500,000	500,000	700,000	1,700,000
No. 2	350	40	14,000	8	1,750	200	300	350,000	175,000	368,000	893,000
No. 3	400	50	20,000	8	2,500	100	250	250,000	375,000	438,000	1,063,000
Zone east of No. 3 ore body	700	25	17,500	9	1,940	-	200	-	-	350,000	350,000
No. 4, Upper part	450	20	9,000	8	1.125	100	250	113,000	170,000	198,000	481,000
No. 4, Lower part	400	20	8,000	8	1,000	100	200	100,000	100,000	-	200,000
No. 5	100±	100±	11,200	8	1,400	50	100	70,000	70,000	-	140,000
West Hill	250	40	10,000	8	1,250	100	200	125,000	125,000	-	250,000
Talus west of Elephant Draw	800	300	240,000	8	30,000	5	8-9	150,000	100,000	-	250,000
Canga east of Elephant Draw	1,600±	150±	240,000	15	16,000	-	10	-	160,000	-	160,000
								5,096,000	3,838,000	5,901,000	14,835,000

Reserves of milling grade ore, Bomi Hills, Liberia

Ore body	Length feet	Width or thickness feet	Area in square feet	Cubic feet of ore per long ton	Long tons per foot of depth	Inferred depth	Inferred tonnage
Silicate-bearing ore							
Drill Camp area	275	200	47,000	9	5,222	400	2,090,000
Area north of Ore body No. 2	700	50	35,000	9	3,888	250	970,000
Iron formation							
Bomi Hill, main part	3,200	1,400	4,480,000	10	448,000	200	89,600,000
Bomi Hill, east end	3,200	100	320,000	10	32,000	400	12,800,000
Jupi Hill	600	50	30,000	10	3,000	400	1,200,000
West Hill	1,200	30	36,000	10	3,600	400	1,440,000
							108,100,000